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Neonatal Mortality: Incidence, Correlates and Improvement Strategies

Sajjad ur Rahman[1,3] and Walid El Ansari[2,3]
[1]*Weill Cornell Medical College, Doha*
[2]*Faculty of Applied Sciences,*
University of Gloucestershire, Gloucester
[3]*Lead Principal Investigator PEARL Study**
[1]*State of Qatar*
[2]*United Kingdom*

1. Introduction

1.1 Aim

The current chapter provides a review of definitions, incidence, correlates and global magnitude of neonatal mortality. The chapter also presents evidence based strategies to improve neonatal survival particularly in resource constrained developing countries.

The neonatal period (birth to 28th day of life) is the most vulnerable and high-risk time in lifebecause of the highest mortality and morbidity incidence in human life during this period. An estimated 40percent of deaths in children less than five years of age occur during the first 28 days of life (WHO, 2011a). The remaining 60 percent of deaths occur during the subsequent 1800 days of the first five years of life. The average daily mortality rate during the neonatal period is close to 30 fold higher than during the postnatal period (one month to one year of age). During 2010, an estimated 7.7 million children under five years of age died worldwide (Rajaratnam et al., 2010). This included 3.1 million neonatal deaths, 2.3 million post neonatal deaths (age one month to one year) and 2.3 million childhood deaths (age 1-4 years).

The neonatal period is the extra uterine continuum of intrauterine foetal life separated by birth, which is the time when umbilical cord is severed. During the intrauterine period, foetal life is dependent on its connection with the uterus through the placenta and umbilical cord. The neonatal period is the beginning of an independent extra uterine life. The transition from foetal to neonatal life is usually very smooth in a full term newborn baby (37-41 weeks gestation), born through a normal uncomplicated vaginal delivery, which is the case in the vast majority of births. However, the process can be complicated either because of problems in the mother, foetus, placenta, environment, the procedures of birth, or any combination of these factors leading to neonatal mortality and / or morbidity. The neonatal mortality is not only a strong indicator of neonatal, perinatal and maternal health

*Perinatal Neonatal Outcomes Research Study in the Arabian Gulf (PEARL Study)

in any given country, region or population; it is also a very big challenge for the health strategists and perinatal health care planners.

2. Definitions

2.1 Neonatal, post neonatal and Infant mortality

In infants (age 0-364 days), the first 28 days of life (day 0 to day 27) after birth are known as neonatal period (WHO, 2011a), and day 28 to day 364 as post neonatal period (Rowley, 1994). The neonatal mortality rate (NMR) is defined as the number of neonatal deaths (during the first 28 completed days of life) per one thousand live births in a given year or other period (WHO, 2011b). The Post Neonatal Mortality Rate (PNMR) is defined as the number of post neonatal deaths (from day 28 of life till the first birth day) per one thousand live births per year or other given period (WHO, 2011b). The Neonatal and Post neonatal mortality together constitutes the Infant Mortality which is defined as the number of infant deaths from birth to one year of age per 1000 live births during the same period. Infant Mortality Rate (IMR) is a very strong indicator of child health in a country, region or population and is used as a yard stick of progress in health care improvement.

2.2 Early and late neonatal mortality

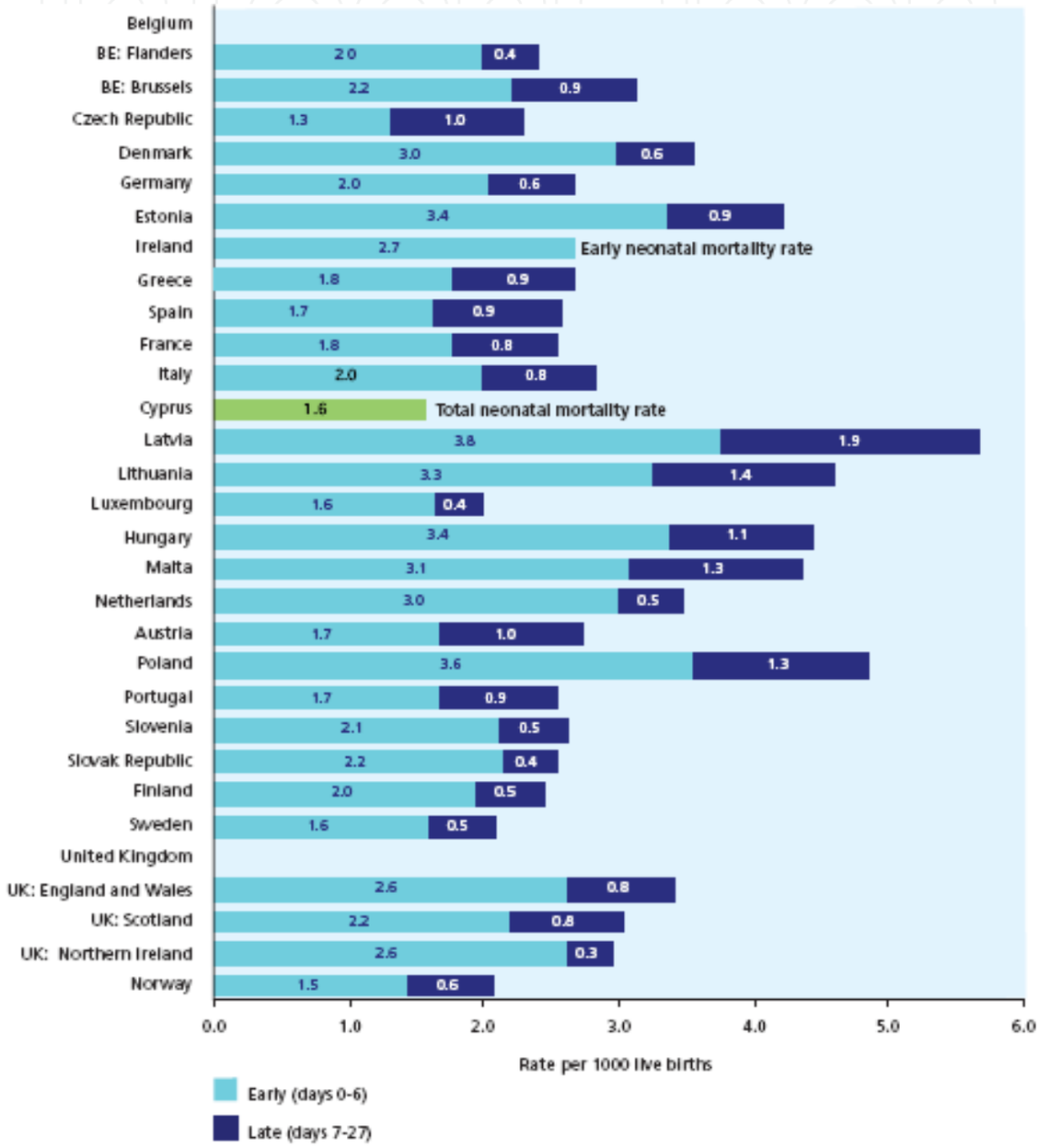
The neonatal period is further sub-divided into early and late neonatal periods (WHO, 2011b). Early neonatal period corresponds to the first seven completed days of life (day 0 to 6) while the late neonatal period lasts from day 7 to day 27. The majority of problems during the early neonatal period are causally related with the foetal life or the birth process; while most problems during late neonatal life are acquired. Early Neonatal Mortality Rate (ENMR) is defined as the number of neonatal deaths during the first seven days of life per 1000 live births in a given year or any other period. Late Neonatal Mortality Rate (LNMR) is defined as the number of neonatal deaths between day seven and day 27 of life per 1000 live births in a given year or any other period. Most neonatal deaths occur during early neonatal period. Globally some three quarters of neonatal deaths happen in the first week after birth (Zupan & Aahman, 2005). In Europe the early neonatal deaths range from 58 percent (Czech Republic) to 89 percent (Northern Ireland) (Euro-Peristat, 2008). The ENMR in Europe is 1.5 to 3.8 and the LNMR is 0.3 to 1.9 per one thousand live births (Fig. 1).

Within the Early neonatal period, mortality is highest (25-45 percent) on day one of life (Lawn et al., 2005) and decreases as the age advances in number of days (Fig. 2). The Euro-Peristat project (2008) reported a trend of shifting mortality from early to late neonatal period among European countries. This is probably because of better and improved perinatal care for very sick babies at the time of birth and immediate postnatal period.

2.3 Perinatal mortality

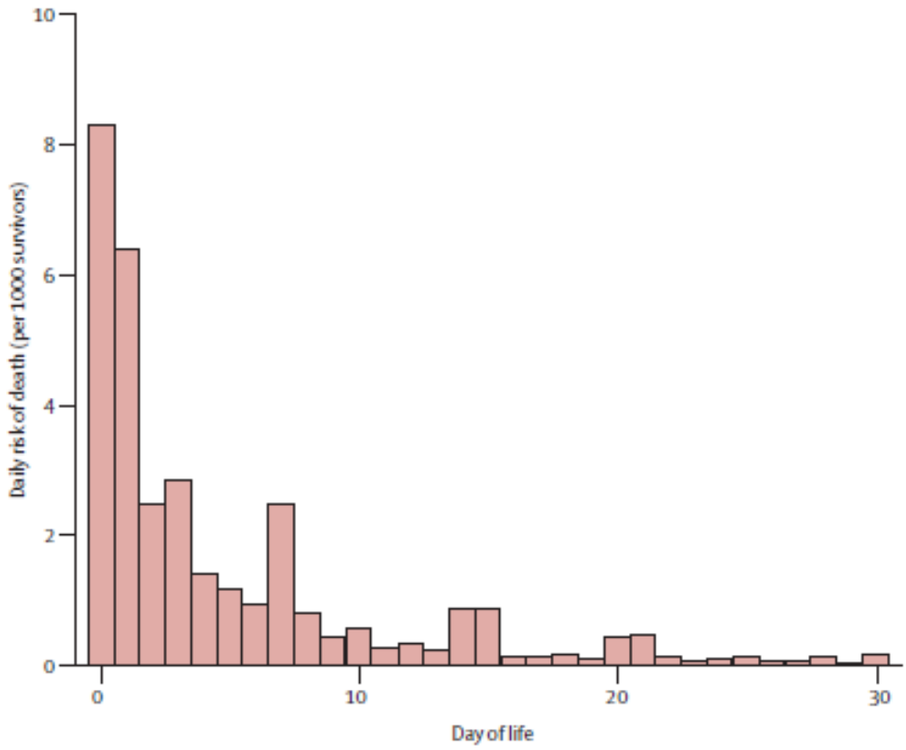
The intrauterine foetal period, in combination with early neonatal period is called Perinatal period. Therefore, combined foetal and early neonatal deaths constitute Perinatal Mortality. Foetal death before or during birth (antepartum or intra partum respectively) is also designated as still birth. Foetal deaths in the second trimester (< 28 weeks gestation) are designated as early foetal deaths while foetal deaths in third trimester (≥ 28 weeks gestation)

are designated as late foetal deaths (Fig 3). Perinatal Mortality Rate (PMR) is defined as a sum of still births (foetal deaths) and early neonatal deaths in a given period of time per 1000 total live plus still births during the same period in the same population. Since the definition of foetal period varies in individual countries, ranging from 16 to 28 weeks of gestation, the definition of Perinatal Period also varies from country to country (Euro-Peristat Project, 2008).



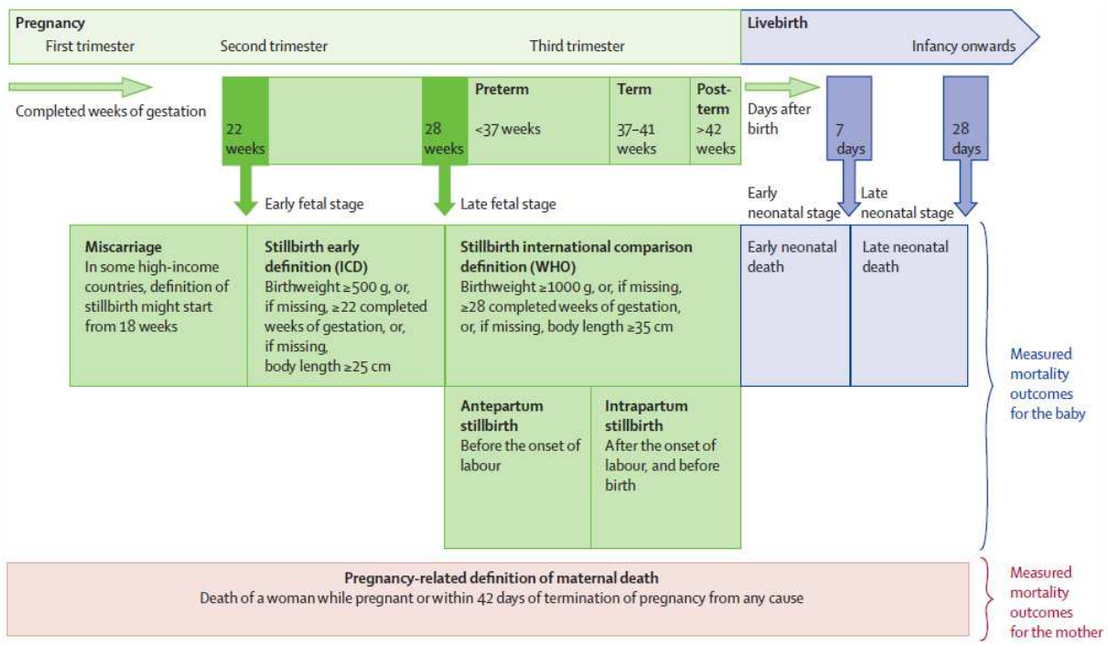
Source: Euro-Peristat 2008, with permission of the Europeristat Project Team

Fig. 1. Early and Late Neonatal Mortality Rates among European countries.



Source: Lawn, 2005 with permission of the authors and publishers

Fig. 2. Daily risk of death during first month of life based on analysis of 10048 neonatal deaths during 1995-2003.



Source: Lawn, J E. (2011)

Fig. 3. Maternal, Fetal, Neonatal and Perinatal Mortality during and after Pregnancy.

The International Classification of Diseases 10th revision (ICD-10), by WHO, defines foetal deaths using one of the three criteria in the following order; a birth weight of 500 grams or more; if birth weight is unknown, a gestational age of 22 weeks or more; and if both these criteria are unknown, a crown heel length of 25 cm or more. In some countries e.g. Australia, not only the foetal period is extended down to 20 weeks gestation and 400 grams birth weight; the perinatal period is also extended by including the whole neonatal period (day 0-27) instead of early neonatal period (Australian Bureau of Statistics 2009). These variations make inter country and regional comparisons of still birth rate and perinatal mortality rates very difficult. Therefore, for international comparisons, WHO recommends reporting of late foetal deaths (third trimester stillbirths at ≥ 1000 grams birth weight, ≥ 28 weeks gestation, ≥ 35 cm body length). PMR, in association with Maternal, Foetal and Neonatal Mortality Rates, is a very strong indicator of Maternal and Newborn care in any country /population (Fig 3).

3. Neonatal mortality: The global magnitude of the problem in 2011

The 2010 toll of global neonatal deaths ranges from 3.1 million per year (Rajaratnam, 2010) to 3.4 million per year (Population Reference Bureau, 2010). These estimates are based on varying data collection tools and statistical methods. Table1 shows that, of the 140 million babies born worldwide, 90percent were born in low-income countries and 10% in high-income countries while approximately 99percent of neonatal deaths occur in low income countries and 1percent in high income countries. Every minute seven newborn babies die worldwide (415 newborn babies every hour). The vast majority of neonatal deaths occur in South Asia and Sub Saharan Africa. Half of the 3.3 million neonatal deaths in 2009 were in five countries: India, Nigeria, Pakistan, China and Democratic Republic of Congo. Neonatal mortality constitutes 40percent of Under-5 Mortality and approximately 57percent of Infant Mortality (Black et al., 2010; WHO, 2011b).

Population / Indicator	World	High Income Countries	Low Income Countries
Population	6.9 Billion	1.24 Billion	5.66 Billion
Births per year	140 Million	14 Million	126 Million
Infant Deaths per year	6.38 million	80,133	6.3 Million
Neonatal deaths per year	3.6 million	45,700	3.4 million
Neonatal Deaths per day	9970	125	9845
Neonatal deaths per minute	7	0.11	6.89

Neonatal deaths calculated as 57% of Infant deaths
Source: Population Reference Bureau 2010

Table 1. Global Births and Neonatal Deaths 2010.

The global neonatal mortality rate ranges from as low as 1/1000 (e.g. Japan, Singapore) to as high as 53/1000 (e.g. Somalia, Afghanistan) (WHO, 2011). Among the WHO regions (Table 2), the African region has the highest average NMR (36/1000) and the European region the lowest average NMR (7/1000). The NMR ranges from 2-5 per one thousand live births in most European and other high income countries (Euro-Peristat, 2008). Although South East Asia has the second highest average NMR (31/1000), the highest absolute number of neonatal deaths occurs in this region because of population density. India alone contributes one quarter of global neonatal deaths. Combined, the African and South East Asian regions are sites of two thirds of global neonatal deaths (Lawn, 2005 & WHO, 2011). The global

analyses of neonatal deaths are based on estimates because most neonatal deaths occur at home and are unrecorded in any formal registration system. Therefore, the global toll of neonatal deaths is probably much worse than what appears in published reports.

WHO Region	Regional NMR	Lowest NMR (Countries)	Median NMR (Countries)	Highest NMR (Countries)
African Region	36	7 (Seychelles) 9 (Mauritius)	39 (Nigeria) 42 (Angola)	51 (D R Congo) 50 (Mali)
South East Asia Region	31	8 (Thailand/Maldives) 9 (Sri Lanka)	19 (Indonesia) 18(Democratic People's Republic of Korea)	34 (India/Bhutan) 33 (Lesotho)
Eastern Mediterranean Region	30	4 (Qatar/ UAE) 6 (Bahrain)	20 (Morocco) 37 (Sudan)	53 (Afghanistan/Somalia) 42 (Pakistan)
Western Pacific Region	11	1 (Japan / Singapore) 3 (Australia)	11 (China) 15 (Philippines)	30 (Cambodia) 26 (Papua New Guinea)
Region of Americas	9	3 (Cuba) 4 (USA/Canada)	12 (Brazil/Colombia) 17 (Guatemala)	27 (Haiti) 23 (Trinidad and Tobago)
European Region	7	1 (Andorra/Iceland) 3 (UK/Austria)	12 (Turkey) 15 (Kazakhstan)	24 (Tajikistan) 20 (Turkmenistan)

Source: World Health statistics 2011, WHO

Table 2. Global Neonatal Mortality Rates 2011.

Over the last decade the neonatal deaths have gained an increasing importance on the world wide policy agenda because neonatal mortality now accounts for 41percent of Under 5 Childhood Mortality, which, according to WHO's millennium development goal (MDG) # 4 must be reduced by two thirds by 2015. Unfortunately, an equal number of babies die before birth. These still born babies are neither counted in the MDG's, nor in the Global Burden of Disease (GBD) metrics by WHO. Hence still births remain an invisible entity, though, during 2008, the estimated global number of still births was 2.65 million with an uncertainty range of 2.08 million to 3.79 million. (Lawn, J E. 2011). Although global neonatal mortality has improved significantly over the last two decades, the Perinatal mortality remains rather static, even in high income countries, because still birth rate has declined only by 14.5percent (from 22.1/1000 in 1995 to 18.9/1000 in 2009). (Cousens, S. 2011)

4. Neonatal mortality in low birth weight, preterm and non viable babies

The increasing survival of low birth weight and preterm babies over the last three decades has brought many challenges in estimating the true neonatal mortality and generating comparative analyses between countries and regions. Similar difficulties occur when babies are delivered at the limits of viability or born with lethal congenital anomalies. Various aspects of these issues are discussed in the following section.

4.1 Birth weight and neonatal mortality

The association between birth weight and mortality is among the strongest in epidemiology (Bosso, 2006). Although birth weight alone may not be the cause of mortality, the association is robust. Babies weighing less than 1,500g have a mortality risk at least 100-fold higher than babies at the optimum weight (the weight associated with the lowest mortality).Babies with a low birth weight are also at higher risk of long-term cognitive and motor impairments (Wilcox,

2001). Therefore birth weight is used as a very strong indicator to predict an individual baby's intact survival. The proportion of babies with a birth weight < 2500g is also used very widely as an indicator for assessing the population at risk, and historical series exist for many countries (Euro-Peristat, 2008). The relative risk (RR) of neonatal mortality decreases with increasing birth weight. According to PEARL Study's recent comparative analysis of birth weight specific neonatal mortality between the State of Qatar and Vermont Oxford Network (VON) expanded data base, the decline in RR is very sharp between birth weight categories 500g to 1500g (Table 3). As compared to babies with normal birth weight (≥ 2500g), the RR of mortality is 25 times, 17 times and 5.5 times higher (p <0.001) in babies with birth weight between 500- 750 g, 751-1000g and 1001-1500g respectively. In babies with birth weight > 1500g the RR is 1.5 times higher (p <0.001) (Salameh K, 2011).

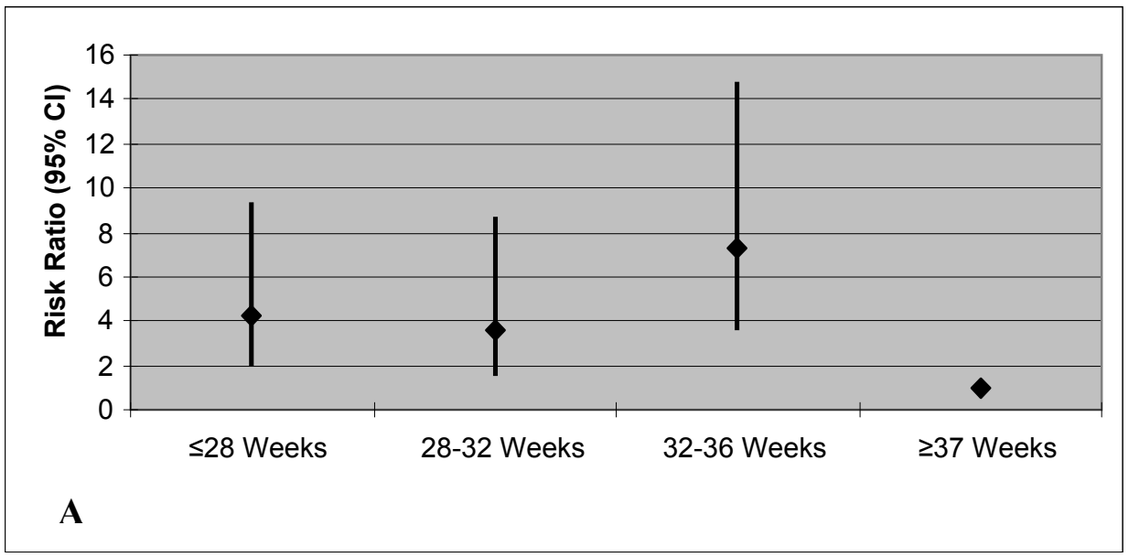
Birth Weight (Grams)	Qatar 2010 n (%)	RR(95% CI) * *P*	VON 2007 n (%)	RR(95% CI)** *P*
501-750	15 (44.1)	24.7(13.5-45.4) <0.001	3938 (44.4)	25.1(23.6-27.4) <0.001
751-1000	15 (30)	16.8(8.9-31.7) <0.001	1668 (14.2)	7.9(7.4-8.8) <0.001
1001-1500	16 (9.8)	5.5(2.8-10.7) <0.001	1366 (4.9)	2.7(2.6-3.1) <0.001
1501-2000	7 (2.7)	1.5(0.6-3.6) 0.357	340 (2.5)	1.4(1.3-1.6) <0.001
2001-2500	9 (3)	1.7(1.1-5.5) 0.053	356 (2.2)	1.2(1.1-1.4) 0.001
≥2500	17 (1.7)	1	762 (1.7)	1

* Category wise (vertical) comparison of RR of Mortality Qatar 2010
** Category wise (vertical) comparison of RR of Mortality VON 2007

Table 3. The RR of mortality for each birth weight category as compared with normal birth weight (≥ 2500g) category:
State of Qatar (2010) and Vermont Oxford Network (2007) expanded data base.

4.2 Gestational age and neonatal mortality

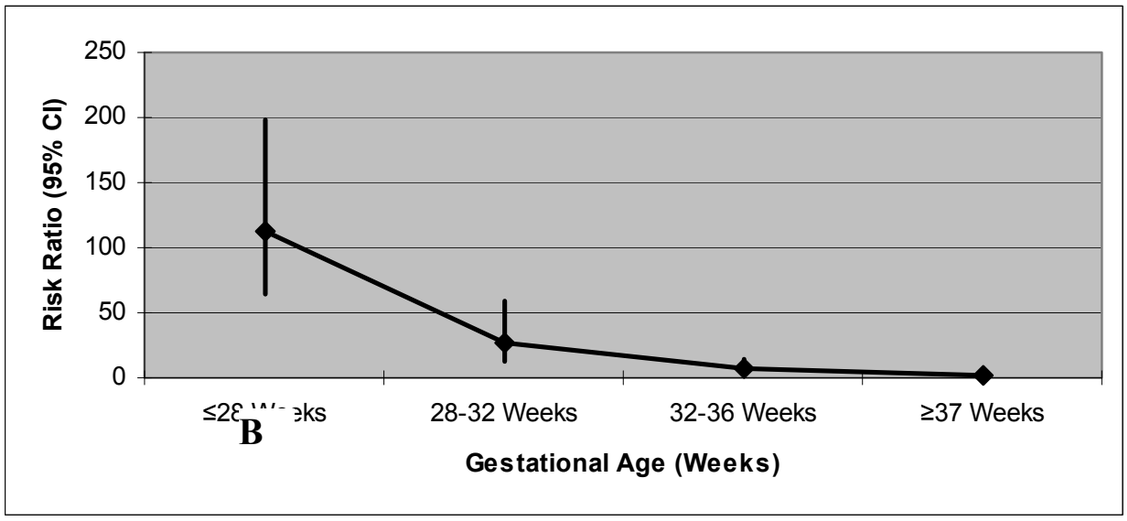
Preterm deliveries are a major cause of neonatal deaths. Worldwide, prematurity and its complications constitute 12percent of global under five mortality and 30percent of neonatal mortality (Figs. 5). In absolute numbers, this makes approximately one million neonatal deaths per year. In high income countries, which have low neonatal mortality rates, prematurity is the biggest cause of neonatal mortality. In low income countries, which have high neonatal mortality rates, the proportion of deaths due to prematurity drops with increasing NMR. This fall is due to the large number of deaths from infections in high NMR countries. In a country with a very high NMR, the risk of death due to prematurity is still three times higher than a country with low NMR (Lawn et al., 2005). This is due to very limited resources and very high number of neonatal deaths in high NMR countries. The NMR is inversely proportional to the gestational age: the smaller the gestation age, the higher the mortality. PEARL Study's recent analysis (Rahman et al., 2011) has shown that the relative risk (RR) of death decreases significantly with increasing gestational age which is shown in Fig. 4A below.



(Source: Rahman et al., 2011)

Fig. 4. A. Gestational Age wise Relative Risk of Neonatal Mortality
Relative risk calculated by taking immediate next category as reference.

When compared with babies born at term (Fig. 4B), the relative risk (RR) of mortality is 113.17, (95% CI 64.45-198.7;*P*<0.0001) among extremely preterm babies (≤ 28 weeks gestation), 26.4 (95% CI 11.91-58.55, *P*<0.0001) among very preterm babies (28^{+1}-32 weeks gestation) and 7.32 (95% CI 3.63-14.75; *P*<0.0001) among moderately preterm babies (32^{+1}-36^{+6} weeks).



(Source: Rahman et al., 2011)

Fig. 4. B. Gestational Age wise Relative Risk of Neonatal Mortality Relative Risk calculated by taking Term babies (last category) as reference.

4.3 Adjusted neonatal mortality

For full term babies (≥ 37 weeks), the neonatal period extends from birth till 28th day of life. However, the exact duration of neonatal period for preterm babies is not well established. With the increasing survival of extremely preterm babies, it is becoming important to establish some rules to adjust for the duration of prematurity and calculate adjusted neonatal mortality rates. This will render the comparative analyses between neonatal units, countries and individual studies more homogenous. The exact estimate of gestational age at birth has always been a challenge both for obstetricians and neonatologists. Traditionally, the first day of maternal last menstrual period (LMP) has served as a basis for this estimation.

However, the accuracy of LMP can be doubtful in many cases. LMP combined with obstetric ultrasound during antenatal visits provide better estimates. However, antenatal care and the facility to undertake a reliable obstetric ultrasound may not always be available, particularly in disadvantaged localities/communities. A postnatal assessment of the baby by an experienced paediatrician using standard scoring test e.g. Ballard's Scoring System, can provide a better estimate in doubtful cases. In PEARL Study, we have used all three methods (LMP, Obstetric USS and Ballard's scoring system) to estimate the correct gestational age in doubtful cases (Rahman et al., 2011).

Gestation (Weeks)	Adjustment for Prematurity	+ Term Neonatal Period	Total Neonatal Period
24	90 days	+ 28 days	118 days
25	83 days	+ 28 days	111 days
26	76 days	+ 28 days	104 days
27	69 days	+ 28 days	97 days
28	62 days	+ 28 days	90 days
29	55 days	+ 28 days	83 days
30	48 days	+ 28 days	76 days
31	41 days	+ 28 days	69 days
32	34 days	+ 28 days	62 days
33	27 days	+ 28 days	55 days
34	20 days	+ 28 days	48 days
35	13 days	+ 28 days	41 days
36	6days	+ 28 days	34 days

Table 4. PEARL Study method of estimation of adjusted neonatal mortality.

In order to estimate the adjusted neonatal mortality for PEARL Study, we adopted the following rules. For all preterm babies, the neonatal period is extended in order to compensate for their prematurity. For example, a baby born at 24 completed weeks of gestation is born 90 days earlier before he/she would have been term (37 completed weeks of gestation). After becoming term (at 37 weeks), the baby's neonatal period will be counted, like any other term baby i.e. for another 28 days. This will make up a total of 118 days of neonatal period for a baby born at 24 completed weeks of gestation. During this extended neonatal period (118 days), the baby usually stays in neonatal intensive care unit (NICU). In case the baby dies during this period, his/her death is classified as neonatal death.

However, some extremely preterm babies stay in NICU longer than their adjusted neonatal period usually due to complications of prematurity and/or of intensive care procedures. In this case, their death after the adjusted neonatal period is classified as post neonatal death.

During the adjusted neonatal period, the first seven days will be considered as early neonatal period irrespective of the gestation at birth and the rest of the adjusted neonatal period as late neonatal period. Therefore, for an extremely preterm baby born at 24 weeks of gestation, the total neonatal period will be 118 days with first seven days counted as early neonatal period and the remaining 111 days counted as late neonatal period. Table 4 depicts a working table developed by The PEARL study in order to adjust the neonatal period for preterm babies born at various gestational ages, and to calculate their adjusted neonatal mortality rates for valid comparative analyses with other studies.

4.4 Limits of viability and neonatal mortality

The survival of preterm babies has improved exponentially over the last three decades resulting in gradual lowering of the limits of viability from 28 weeks to 24 weeks in 1990's, and most recently to 22 weeks (Euro-Peristat, 2008). However, the practice varies in individual countries and population groups. Evans and Levene (2001) reported that studies can exaggerate neonatal survival by 100percent at 23 weeks and 56percent at 24 weeks. This is a major issue in high income countries, which routinely provide care to extremely preterm babies born at the limits of viability. Therefore, while estimating and comparing neonatal mortality between countries, it is important to remove selection bias at the limits of viability. The WHO and UNICEF's annual neonatal mortality reports exclude babies <1000 grams and < 28 weeks gestation from each country's data to generate a reasonable comparison for low income countries, which do not provide care to extremely preterm and extremely low birth weight babies due to resource constraints (UNICEF, 2011).

4.5 Futility and neonatal mortality

Some babies are either very sick or extremely premature at birth or may be born with lethal congenital anomalies incompatible with life. These babies may not be resuscitated in labour room or provided intensive care because of futility. These neonatal deaths, which usually occur in labour and delivery suites, may not be reported in unit-based studies (Evans & Levene, 2001). Similarly legal frameworks, clinical guidelines and practice of termination of pregnancies varies widely between countries and cultural groups, which affects overall perinatal and neonatal mortality (Papiernik et al., 2008). These variations in policy and practice generate variations between populations of very preterm births among countries. In the MOSAIC Study cohort (Europe), pregnancy terminations constituted between 1 and 21.5percent of all very preterm births and between 4 and 53percent of stillbirths. Most terminations were due to congenital anomalies (Papiernik et al., 2008).

4.6 Corrected neonatal mortality

The neonatal mortality, calculated after excluding babies born alive at limits of viability or ones with extremely low birth weight (< 500g) or babies with lethal congenital anomalies, is called Corrected Neonatal Mortality (Lau et al., 1985). The reporting of corrected neonatal mortality makes inter country comparisons more rational (Euro-Peristat, 2008). The WHO

and UNICEF exclude babies with a birth weight < 1000g and < 28 weeks gestation in their annual reports of global neonatal mortality rates (UNICEF, 2011).

5. Plurality and neonatal mortality

Twin and multiple births are associated with higher neonatal mortality and morbidity. A large population based study of twin births from United States and Australia (Scher, A.I. 2002) has shown that twins have an approximately five fold increased risk of foetal death, seven fold increased risk of neonatal death, and four fold increased risk of cerebral palsy (CP) as compared to singletons. However, at birth weight < 2500 g, twins generally did better than singletons, both with respect to mortality and CP rates. Second born twins and twins from same sex pairs were at increased risk of early death but not of CP. Twins from growth discordant pairs and twins whose co-twin died were at increased risk of both mortality and CP. The highest rates of CP were in surviving twins whose co twin was either born (4.7 percent), or died shortly after birth (6.3 percent) or had CP (11.8 percent). In the Euro-Peristat project (2008), multiples were four to eight times likely to die as compared to singletons (Fig. 5). Although the incidence of twin deliveries has increased with the introduction of assisted reproductive technology, perinatal mortality is about 40percent lower after assisted as compared with natural conception (Helmerhorst et al., 2004).

6. Socioeconomic correlates of neonatal mortality

Improvement in neonatal and perinatal survival comes as part of a package of development of human society, which is a multifaceted process involving social, economic, cultural, educational and health care development. PEARL Study, in its recent study (Rahman, S. 2010), has shown that reduction in poverty, increase in maternal education, and improved perinatal health care are associated with improved maternal, neonatal and perinatal survival. A number of other sociocultural factors e.g. ethnicity and consanguinity are also associated with increased neonatal mortality.

6.1 Poverty and neonatal mortality

Extreme poverty is the world's biggest killer and the greatest cause of ill health and suffering across the globe (Kevany, 1996). Infant mortality, a very strong outcome indicator of ill health, is most sensitive to poverty (Jahan, 2008). Hence, increased socioeconomic development is associated with a consistent decline in infant mortality (Rahman et al., 2010). A recent study from Netherlands (Agyemang, C. 2009) has shown that neighbourhood income and deprivation are related to Small for Gestational Age (SGA) birth (OR 1.32, 95% CI 1.04-1.68). Another recent study from Japan has reported increased risk of early spontaneous abortions among women who smoke (OR 2.39, 95% CI 1.26-4.25) and women who work outside their home (OR 1.65, 95% CI 1.17-2.35).

The global estimates show that the neonatal mortality is highest in low-income countries (Table 5,) and consistently declines with increasing regional income (WHO, 2011). During 2009, the average NMR in low-income countries (36/1000) was nine times higher than the average NMR in high-income countries (4/1000) and 1.5 times the global NMR (24/1000). During 1990-2009, the NMR decreased by 23.4percent in low-income countries, compared to 33.3percent in high-income countries and 27.3percent worldwide (WHO, 2011).

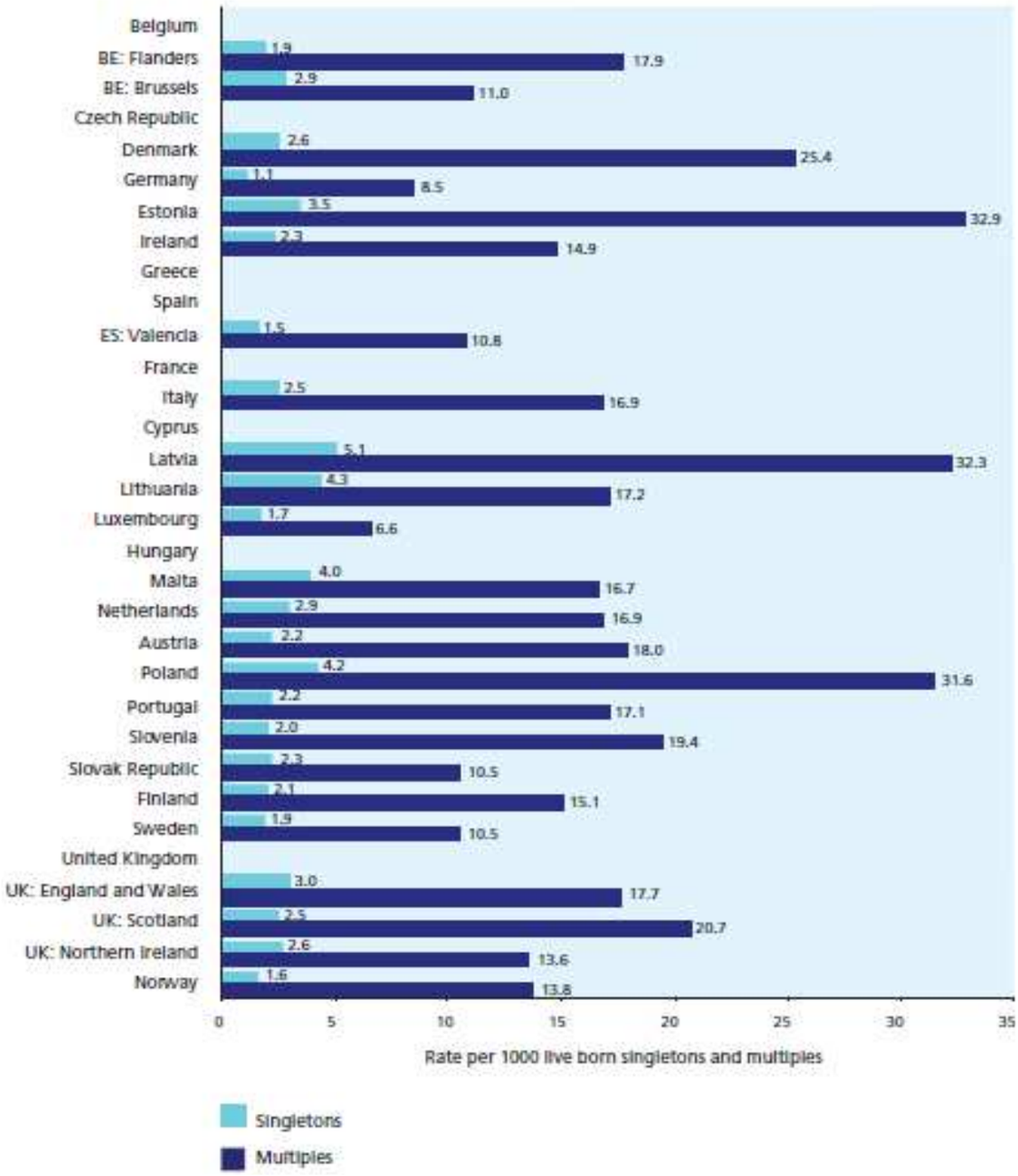


Fig. 5. Neonatal Mortality Rates (per 1000) in singleton and multiple births in Europe (Euro-Peristat, 2008).

Income Group	Neonatal Mortality Rate (per 1000 live births)		
	1990	2000	2009
Low Income	47	42	36
Lower Middle Income	36	32	26
Upper Middle Income	21	16	11
High Income	6	4	4
Global	33	29	24

Table 5. Neonatal Mortality by economic regions (WHO, 2011).

6.2 Maternal education and neonatal mortality

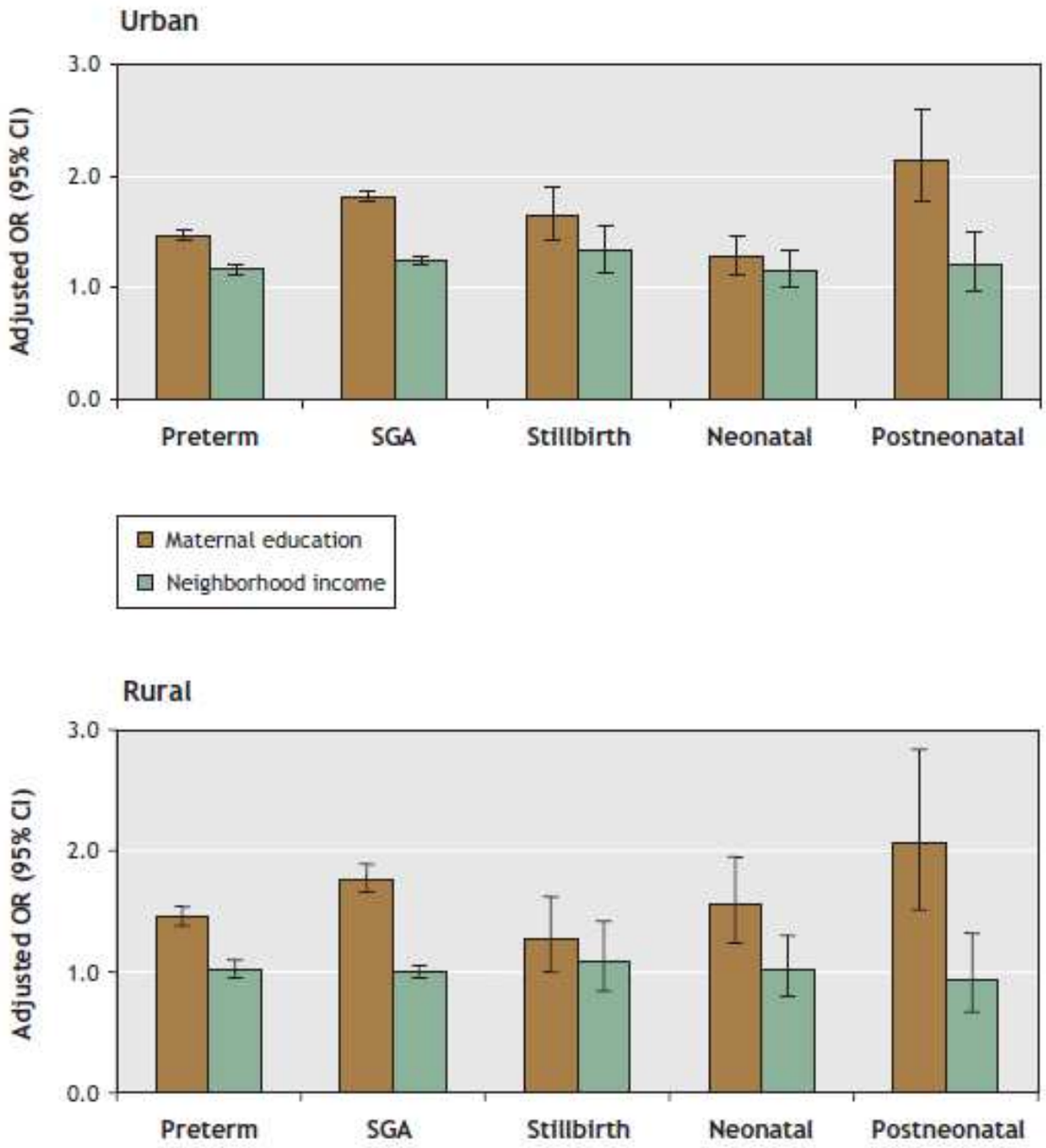
Maternal education is a very important socioeconomic indicator, which has known association with stillbirth, preterm births, low birth weight babies and neonatal and post neonatal mortality, which was confirmed by a ten years (1991-2000) population study based on birth certificate analysis from Quebec, Canada (Zhong-Cheng, L. 2006). The study also confirmed that the effects of maternal education were stronger than, and independent of, neighbourhood income (Fig. 6). Pregnant women with a low educational level have a nearly two fold higher risk of preterm birth than women with a high educational level (Jansen, P.W. 2009). The women with low educational attainment come from disadvantaged backgrounds with multiple adverse correlates. A recent study from Sweden (Sundquist, J. 2011) has shown that the Odds Ratio (OR) of giving birth to a Small for Gestation (SGA) infant for women living in high versus low deprivation neighbourhood was 0.38 (95% CI 1.32-1.44, p<0.001). Women with the highest risk of giving birth to an SGA infant were older; never married, widowed or divorced; had low family incomes; and/or the lowest educational attainment.

6.3 Ethnicity and neonatal mortality

The correlation between maternal ethnicity and neonatal mortality is variable. An Australian study (Ruan et al., 2011) found no influence of ethnicity on neonatal mortality (Caucasian, Asian, Indigenous and Polynesian Maori groups). However, ethnicity did influence foetal and neonatal growth and morbidity. Conversely, studies from multi ethnic European populations found an association between ethnicity and neonatal mortality. A study from Denmark (Villadsen et al., 2008), based on 23 years (1981-2003) data from a population registry (n = 1333452) described higher foetal and infant mortality among Turkish , Pakistani and Somali population as compared to the Danish population. The excess risk of mortality was not attributable to socioeconomic condition. A similar population based study from Brussels (Racape et al., 2010) reported increased perinatal mortality in particular ethnic groups, independent of socioeconomic status and maternal characteristics.

6.4 Consanguinity and neonatal mortality

Consanguinity has a known association with congenital anomalies, preterm births (Mumtaz G, 2010) and perinatal wastage (Assaf S, 2009). The global birth defects report by March of Dimes provides evidence to this. The Arab countries have the highest rates of birth defects. The same countries have the highest rates of consanguinity (40-70percent in general and up to 100percent in some tribes). With limited practice of antenatal terminations, these countries continue to have high neonatal and perinatal mortality rates (Salameh K 2009).



Source: (Zhong-Cheng, L. 2006)

Fig. 6. Adverse birth outcomes in Urban and Rural Quebec: A comparison of mothers not having graduated from high school with those having completed community college or some university, and mothers from poorest neighbourhood compared with mothers from richest neighbourhood.

7. Calculation and reporting of neonatal mortality

7.1 Period neonatal mortality and cohort neonatal mortality

Neonatal mortality is usually estimated as period mortality (all neonatal deaths per 1000 births during a specific period of time). In period mortality, the neonatal deaths include babies who were born immediately prior to the period but died as a neonate during the study period. On the other hand, the period mortality excludes those babies who were born at the end of the study period but died as neonate after the study period had ended. In general, the gain of deaths in the beginning of the study is balanced by the loss of deaths at the end of the study with little, if any, statistical difference. However, a true estimate of neonatal mortality can be done only by a cohort neonatal mortality, which includes only neonatal deaths per 1000 total births during a selected period. This necessitates the follow-up of the birth cohort until the end of the neonatal period of the last-born baby in the cohort.

This may take a few months in case of extremely preterm babies in which neonatal mortality needs adjustment for the time these preterm babies were born preterm. It is very important to report the exact definition of a given cohort during the publication of institution based neonatal mortality data. Some cohorts can be very selective e.g. cohorts which exclude babies < 500g at birth, or babies with lethal congenital anomalies or babies born alive but not resuscitated because of futility or non viability. Therefore, studies with very selective cohorts usually report significantly higher neonatal survival (Evans & Levene, 2001). This can be a significant problem at the limits of viability. Evans and Leven (2001), analyzed 67 studies (survival outcomes of 55 cohorts of < 28 weeks gestation babies) and estimated that the survival was exaggerated by 100percent at 23 weeks and 56percent at 24 weeks of gestation between the studies (p<0.01).

7.2 Adjusted and corrected neonatal mortality

The neonatal mortality is adjusted for prematurity and corrected for futility and lethal congenital anomalies for comparative purposes (see section 5.3 and 5.6 above for details).

8. Causes of neonatal mortality

The most recent global estimate of causes of child mortality (Black et al., 2010) suggested that 41percent of deaths in 2008 were due to neonatal deaths (Fig 7). The causes of neonatal mortality are divided into direct and indirect causes of mortality.

8.1 Direct causes of neonatal mortality

According to the global estimates by Black et al. (2010), the most important causes of neonatal mortality (Table 6) were complications of preterm birth (12percent, 1.033 million deaths), birth asphyxia (9percent, 0.814 million deaths), sepsis (6percent, 0.521 million deaths) and pneumonia (4percent, 0.386 million deaths). Despite a continuous increase in the population of children < 5 years, their mortality rate is declining. However, the decline in mortality is greater in children aged between 1-59 months than in neonates (0-27 days). Hence the proportion of neonatal deaths increased from 37percent in 2000-03 to 41percent in 2008. Thus, the main causes of neonatal death – preterm birth complications, birth asphyxia,

sepsis and pneumonia – have become even more important. The distribution of causes of neonatal death varies by regions and countries, correlating with the degree of neonatal mortality (Fig. 8). In very high neonatal mortality settings, almost 50percent of deaths are due to severe infection, tetanus and diarrhoea. In low neonatal mortality settings, sepsis and pneumonia account for < 20percent of deaths, while tetanus and diarrhoea become almost non-existent as a cause of neonatal death.

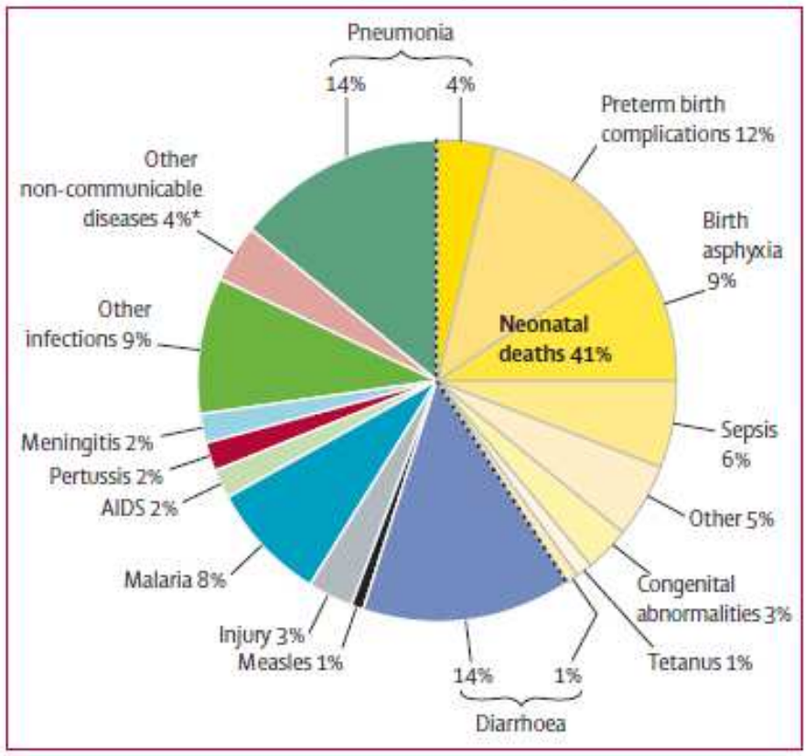
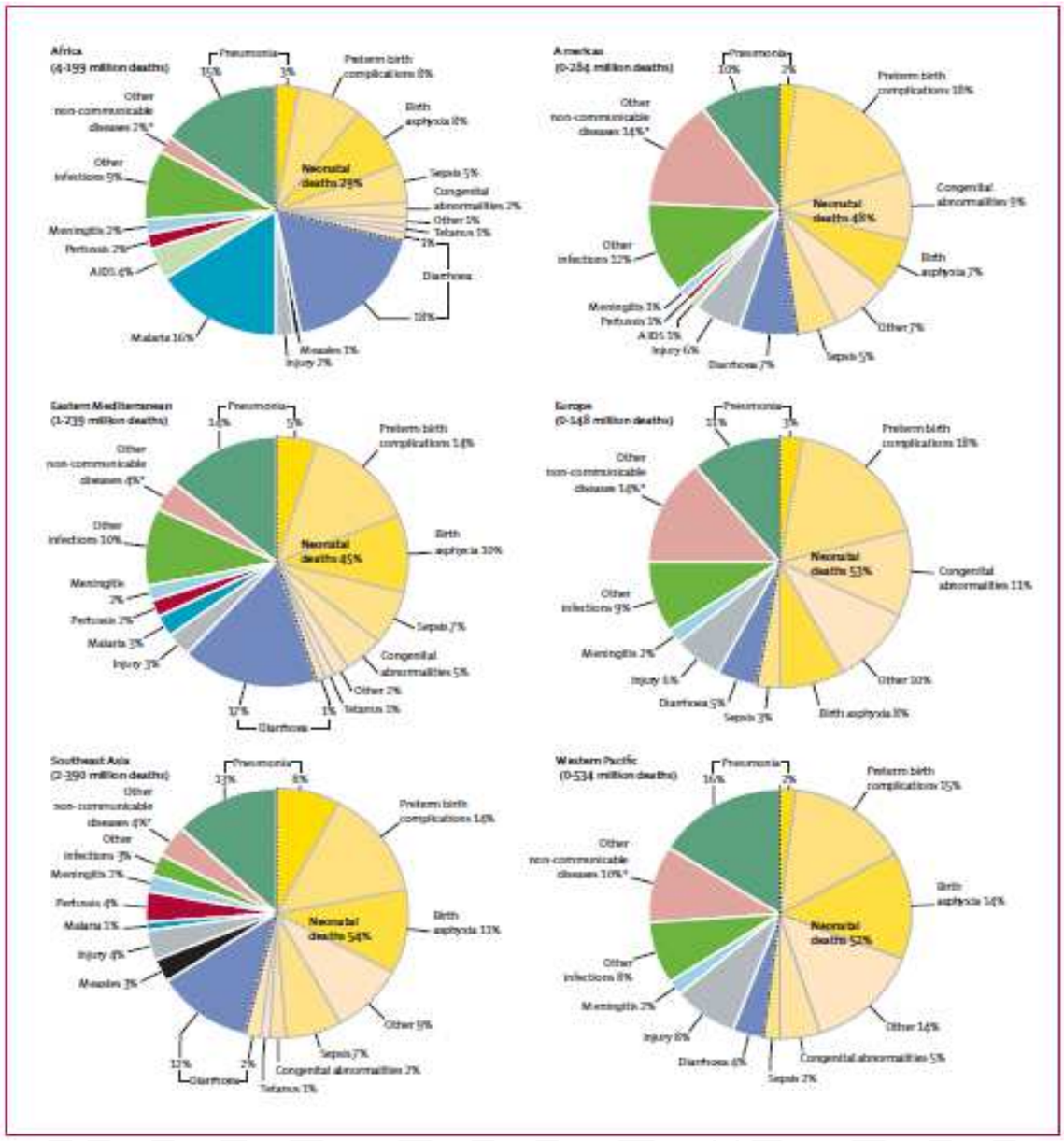


Fig. 7. Global Causes of Neonatal (0-27 days) and Child (1-59 months) Mortality, Source: (Black, 2010).

Cause of Neonatal Death (0-27 days)	Estimated Number (UR; millions)
Preterm birth complications	1.033 (0.717-1.216)
Birth asphyxia	0.814 (0.563-0.997)
Sepsis	0.521 (0.356-0.735)
Other	0.409 (0.318-0.883)
Pneumonia	0.386 (0.264-0.545)
Congenital abnormalities	0.272 (0.205-0.384)
Diarrhea	0.079 (0.057-0.211)
Tetanus	0.059 (0.032-0.083)
Total Global Neonatal Deaths	**3.573 million**

(UR: Uncertainty Range is defined as 2.5-97.5 centile) Source: (Black, 2010)

Table 6. Estimated global number of Neonatal deaths by cause 2008.



Source: (Black 2010)

Fig. 8. Regional Causes of Neonatal (0-27 days) and Child (1-59 months) Mortality.

The risk of neonatal death due to severe infections and asphyxia in very high neonatal mortality countries as compared to low neonatal mortality countries is about 11 and 8 fold respectively (Lawn et al., 2005). Although the proportion of deaths due to prematurity drops with increasing NMR, the risk of mortality due to prematurity is three times higher in high neonatal mortality countries as compared to low neonatal mortality countries (Lawn et al., 2005). The causes of neonatal death may also vary within the same country depending upon the socioeconomic status of the regional population and access to health care services.

8.2 Indirect causes of neonatal deaths

A number of indirect maternal and perinatal determinants affect neonatal outcomes. Maternal health before, during and after pregnancy, conditions at the time of labour and delivery and post natal care of babies play a significant role in reducing neonatal mortality. Jehan et al. (2009), have documented direct and indirect determinants of neonatal mortality in a recent population based study from Pakistan, which has the third highest NMR in the world. PEARL study has also documented similar determinants of neonatal mortality (Table 7) in the State of Qatar which has very low NMR (4/1000).

Variable	Dead N=44	Alive N=117	Odds Ratio (95%CI)	P- value
Fetal growth				
AGA	30(78.9)	91(78.4)	1 ref	
SGA	7(18.4)	7(6.0)	3.0(1.1-9.4)	0.028
LGA	1(2.6)	18(15.5)	0.2(0.1-1.3)	
Birth weight				
<2500g	32(72.7)	14(12.1)	19.4(8.2-46.2)	<0.001
≥2500 g	12(27.3)	102(87.9)	1 ref	
Gestational age				
<37 weeks	27(62.8)	12(10.3)	14.8(6.2-34.8)	<0.001
≥37 weeks	16(37.2)	105(89.7)	1 ref	
Presentation at birth				
Cephalic	29(82.9)	113(96.6)	1 ref	0.009
Breech	6(17.1)	4(3.4)	5.8(1.5-22.0)	
Mode of delivery				
Vaginal	24(54.5)	88(75.2)	1 ref	0.012
C-Section	20(45.5)	29(24.8)	2.5(1.2-5.2)	
APGAR Score (1 minute)				
≤6	26(61.9)	1(0.9)	*	<0.001
>6	16(38.1)	116(99.1)		
APGAR score (5 minutes)				
≤6	14(32.6)	0	*	<0.001
>6	29(67.4)	117(100)		
Delivery room resuscitation				
Yes	27(65.9)	7(6.0)	1 ref	<0.001
No	14(34.1)	110(94.0)	30.3(11.1-82.3)	

(Source: PEARL study Statistics 2011)
(* Valid odds ratio not calculated due to very few numbers in one category, ref=reference category, p value based on chi square or fisher exact test where the expected cell count is <5, odds ratio based on univariate logistic regression)

Table 7. Determinants of neonatal mortality, State of Qatar 2011.

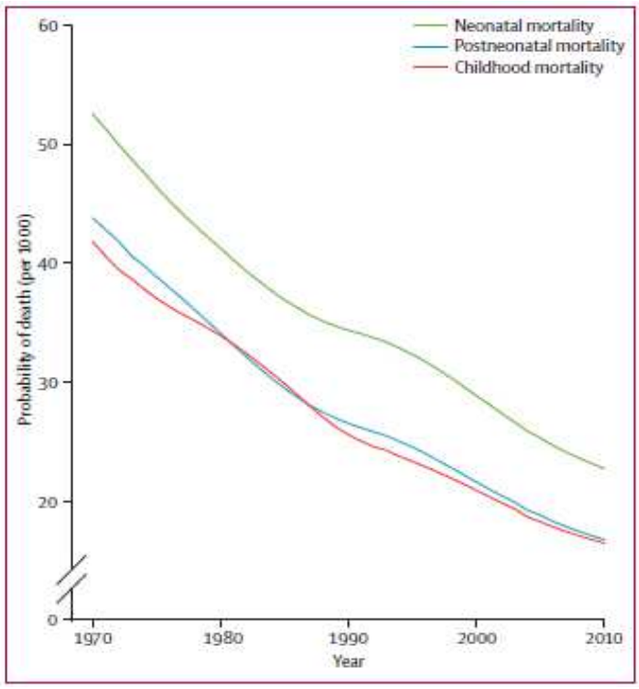
9. Global trends in neonatal mortality (1970-2010)

Childhood mortality is a major concern for health care strategists, policy makers and planners. Although worldwide, the childhood mortality rates, including neonatal mortality rates, have declined since 1960s (Fig. 9, 10 & 11), the progress made has been alarmingly slow. This was recognized in the United Nation's Millennium Summit in 2000 which lead to the incorporation of Millennium Development Goal # 4 (MDG 4) in the World Millennium Declaration.

MDG 4 requires two thirds reduction in the deaths of children aged < 5 years by 2015. This required a reduction of childhood mortality at a rate of 4.4percent per year. According to a recently published review on reduction in neonatal, post neonatal, childhood and under five mortality by Rajaratnam et al. (2010); although significant progress has been made towards achieving MDG 4, many countries will fail to achieve the target by 2015. The two most recent annual World Health statistics published by WHO (2010 and 2011a) have also confirmed this fact.

From 1990 to 2010, the global rate of decline has been 2.1percent per year for neonatal mortality, 2.3percent for post neonatal mortality, and 2.2percent for childhood mortality against the required rate of 4.4percent per year. The under 5 mortality has been reduced from 16 million in 1970 to 11.9 million in 1990 to 7.7 million in 2010 which is more than 52% reduction in mortality over four decades (Fig. 9), despite an increase in total births by 16percent during the same period (Rajaratnam et al., 2010). Within the world regions, the reduction in under 5 mortality (all three components -- neonatal, post neonatal and childhood) is uneven (Fig. 10).

In 1970, South Asia and Sub Saharan Africa together accounted for 55 percent of all child mortality.



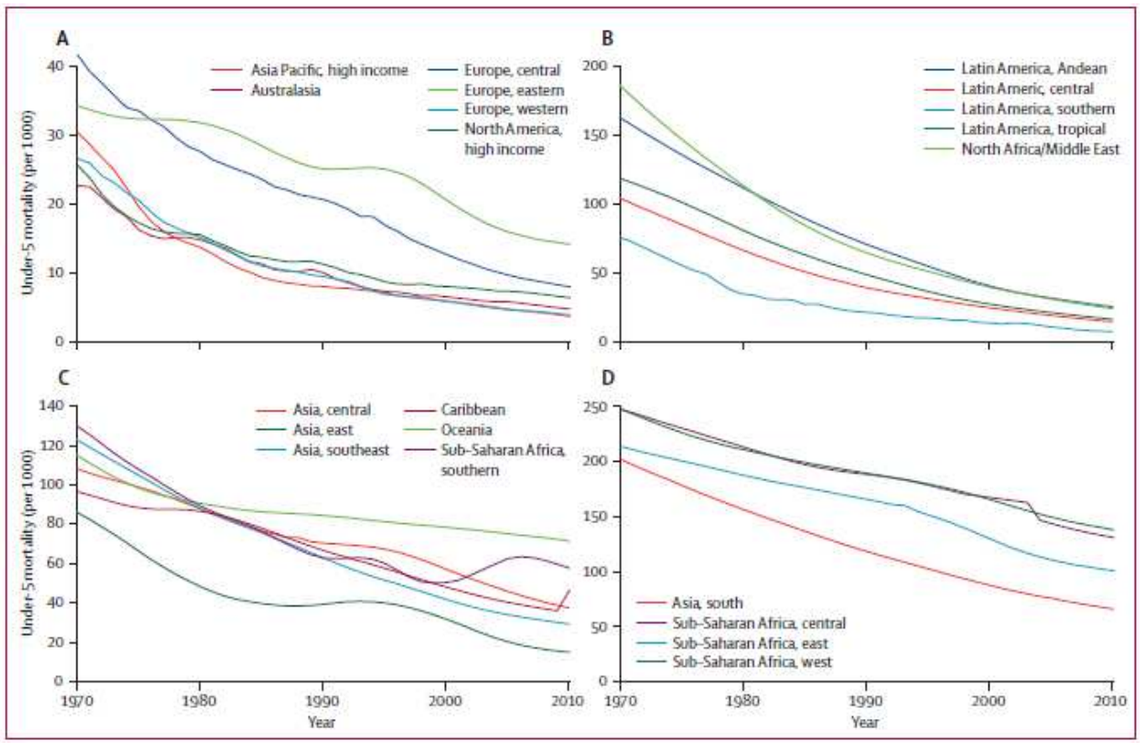
(Source: Rajaratnam et al., 2010)

Fig. 9. Worldwide neonatal, post neonatal and childhood mortality from 1970-2010.

In 2010, they accounted for more than 82percent (33percent in South Asia and 49.6percent in Sub Saharan Africa). The regions of Caribbean and Latin America, North Africa and Middle East, East and South East Asia have achieved 63percent reduction in child hood mortality between 1970 and 2010.

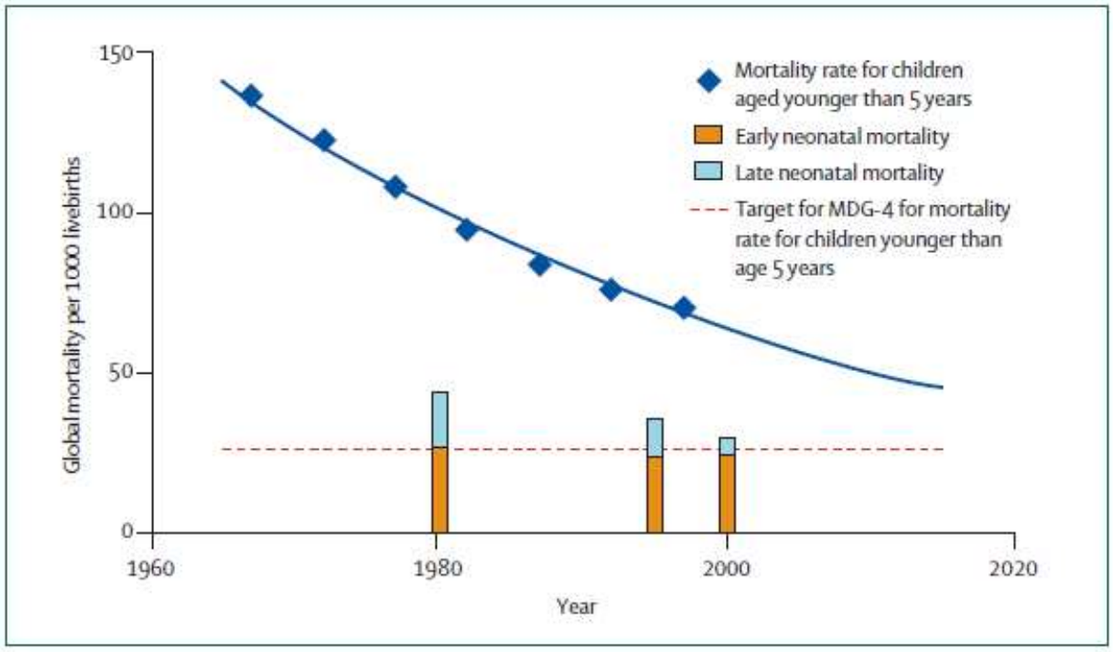
Some countries, e.g. the State of Qatar, have done exceptionally well by achieving all MDG's by 2007; just half way towards the target year 2015 (Qatar Statistics Authority, 2008). This is due to exceptional socio economic development and investment in perinatal health care in Qatar (Rahman et al., 2010).

Other countries (e.g. Sri Lanka, Nicaragua, Moldova, Indonesia, Honduras, Vietnam) have also done exceptionally well in reducing their neonatal mortality even though they have an annual GDP per capita < US $ 5000 (Martines et al., 2005). The improvement in Under 5 mortality has also been uneven between its three components. Most of the improvement has been in post neonatal (1-12 months) and childhood (1-5 years) mortality with slower progress in reducing neonatal mortality (Fig.9). Between 1970 and 2010, the global NMR decreased by 57percent (from 53/1000 in 1970 to 23/1000 in 2010); post neonatal mortality rate by 62percent and childhood mortality rate by 60percent. This decline resulted in neonatal mortality constituting 28 percent and 40 percent of Under 5 mortality in 2000 and 2010 respectively as opposed to 23percent in 1980. (Lawn et al., 2005; WHO, 2011a). Within the neonatal mortality, the decline in late neonatal mortality has been more significant than declines in early neonatal mortality (Fig. 11).



(Source: Rajaratnam, 2010)

Fig. 10. Regional neonatal, post neonatal and childhood mortality from 1970-2010.



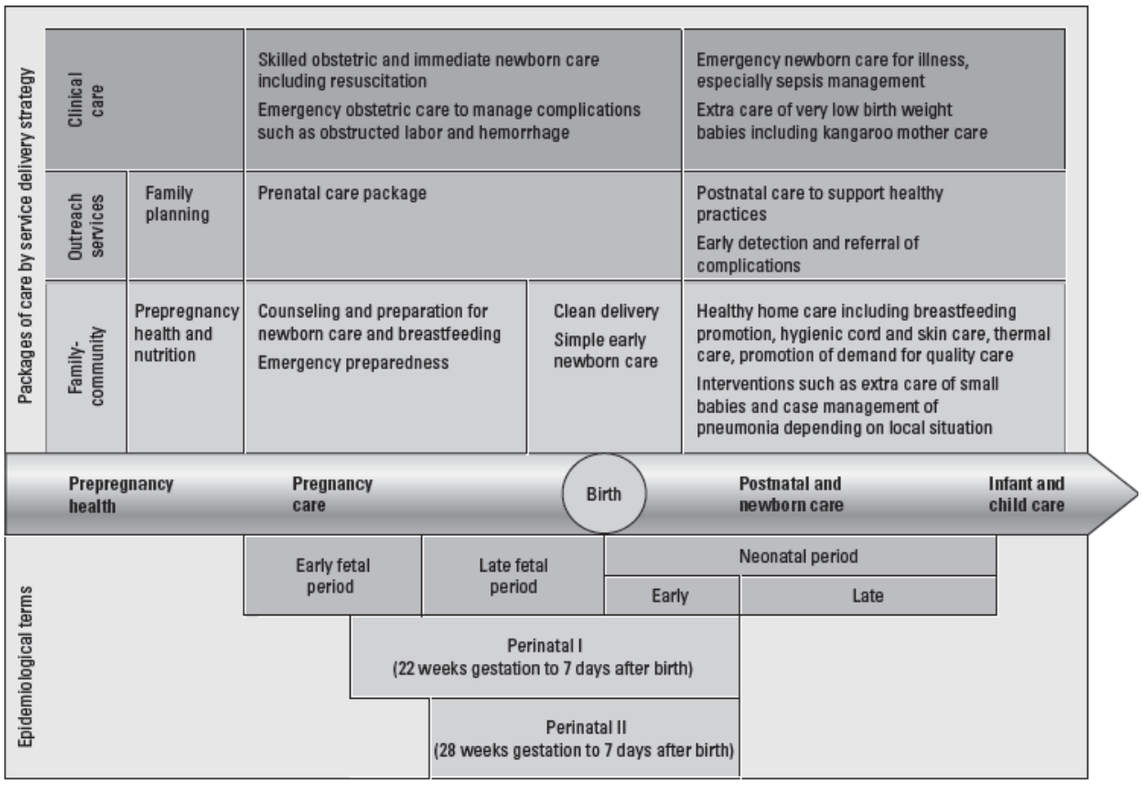
(Source: Lawn 2005)

Fig. 11. Meeting MDG-4: Trends in under 5 Mortality and Neonatal Mortality (Total, Early and Late) between 1965 & 2010.

10. Strategies to reduce neonatal mortality

Ever since the Millennium Declaration was announced, intense efforts began to achieve MDG's within the target period of 15 years (2000-2015). MDG-4 brought together individuals, organizations and media to draw comprehensive plans to ensure two thirds reduction in under 5 childhood mortality by 2015. Since 99 percent of childhood deaths occur in developing countries, which have constrained resources, the interventions must be cost effective, community based and within the reach of every citizen, particularly the urban, deprived and disadvantaged populations (The Lancet Neonatal Survival series, 2005). Significant progress has been made in reducing Under 5 childhood mortality over the last decade (2000-2010), though the progress towards reduction of neonatal deaths has been slow (Bhutta et al., 2010). A rapid progress is not only desirable; it remains a major challenge for the next five years (2011-2015).

Reduction of neonatal mortality is not a phenomenon in isolation. Improved neonatal survival should be seen as part of wider package (Fig 12) which should not only include care before, during and after pregnancy; it should also address wider issues of socioeconomic development including reduction in poverty and increased maternal education (Rahman 2010).



(Source: Lawn 2006)
Perinatal 1: for neonatal data collection as per International Classification of Diseases Version-10 (ICD-10); Perinatal II: for international comparison of date as recommended by WHO

Fig. 12. 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.

The Perinatal Health Care model developed by Lawn et al (2006) places neonatal mortality within the broad context of maternal and child health care. Strategies to reduce neonatal mortality should cover the whole continuum of care from maternal health before and during pregnancy to delivery, and early neonatal care to child health programmes (Fig. 12 middle bar). The model proposes three streams of service delivery strategies: clinical care, outreach services and family-community levels (Fig. 12 Upper part).

The clinical care strategies emphasize on provision of emergency and basic services in facilities and circumstances where minimum resources are available. The family planning strategies not only cater to prenatal health; they also take care of complications after delivery. Family-community level strategies include education and awareness of parents, families and public at large in health practices including clean delivery, breast feeding, basic newborn care and emergency preparedness. The model also highlights reporting of perinatal mortality for comparative analysis using WHO standards and alternative standards (Fig 12 Lower part). The model is extremely useful for low income countries which are struggling to reduce their very high burden of neonatal and perinatal mortality.

Looking at the whole picture of continuum of care, the first week of life is the most important period because 75percent of neonatal and 50percent of maternal deaths occur

during this period. Maximum health coverage should be provided over these first seven days, particularly in disadvantaged and poor communities (Lawn et al., 2006). While the three direct causes of neonatal death (prematurity, asphyxia and sepsis) must be addressed, the indirect causes of neonatal deaths (low birth weight, poor maternal health, inadequate health care system, poverty and illiteracy) should also be addressed at all levels.

The State of Qatar is unique in having achieved all its MDG's by 2007 and hence provides an ideal model for study. The improved maternal, neonatal and perinatal survival in Qatar provides an example of how addressing wider community issues e.g. reduction in poverty, socioeconomic development, clean drinking water, sanitation, pest control, increased maternal education, investment in maternal and child health, high coverage antenatal and postnatal care, childhood vaccination and access to health care, can dramatically improve reproductive outcomes (Rahman 2010). Qatar's trends of maternal, neonatal and perinatal mortality since 1974 also provide an evidence that major reductions in mortality can be achieved through low cost community based interventions and not by high cost institutional investment. This gives a very strong message to low income countries that a lot can be achieved within their constrained resources.

10.1 Interventions to reduce neonatal mortality

Lawn and colleagues (2006) developed and categorized interventions to reduce neonatal mortality (Table 8), which addresses all periods of the continuum of care (pregnancy, intrapartum, postpartum and neonatal period). Some of these interventions are universally applicable because of their cost, feasibility and impact on mortality; others are more complex and are applicable only in relevant situations. This model led to the development of packages of intervention (Table 9) for universal scale up newborn care. These packages start from the family-community level and are carried over as essential, extra and emergency newborn care packages.

The Countdown to 2015 project (Bhutta et al., 2010) for maternal, newborn, and child survival monitors coverage of priority interventions to achieve MDG's for Child mortality and maternal health. The project has most recently reported on 26 key interventions in 68 countries, which account for more than 90percent burden of maternal and child mortality (Bhutta et al., 2010).

The median coverage of 20 interventions in 68 countries is shown in Fig. 13. According to this report, 19 countries were on track, 47 had accelerated and 12 countries showed decelerated progress in reducing childhood mortality. Progress towards reduction of neonatal mortality has been slow and maternal mortality remains high in most of these countries. However, there is strong evidence that rapid progress is possible. Focused and targeted interventions can reduce inequities related to socioeconomic status and gender. No country can afford not to seriously address neonatal care (Martinez et al., 2005).

Although NMR's are generally inversely correlated with GDP per capita; several low-income countries (e.g. Honduras, Indonesia, Moldova, Nicaragua, Sri Lanka, Vietnam) have achieved excellent reductions in their neonatal mortality rates (Fig. 14). Success is possible in low-income countries without the use of expensive high technology newborn care. The countries which have achieved excellent neonatal survival rates did so long before any expensive technology was introduced. In England, the NMR fell from more than 30/1000 in

1940 to 10/1000 in 1975, a reduction linked to the introduction of free antenatal care, improved care during labour, and availability of antibiotics (Mac Farlane et al., 1999). The State of Qatar achieved huge reduction in its NMR during the era of low cost, **community-based** interventions, backed by socioeconomic development (Rahman et al., 2010).

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 to women to reduce births to their desired number and to avoid pregnancy after age 45 Prevention, identification, and management of sexually transmitted diseases [A] • 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]	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]

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)
	• prenatal counseling and preparation for breastfeeding [C]		
• Extra care for those at • risk of complications	Extra prenatal care (more frequent visits, more skilled caregiver) if	External cephalic version for breech presentation at 36 weeks [A]	Malaria endemic :
	• multiple pregnancy or abnormal lie (breech or transverse) [RF A]	Fetal growth monitoring [A]	• intermittent presumptive treatment monthly after 20 weeks [A]
	• pregnancy-induced hypertension or preeclampsia [RF A]		• insecticide-treated bednets [B based on effect on LBW, not on NMR]
	• diabetes [RF A]		Hookworm infestation prevalent:
	• severe anemia [RF A]		• presumptive treatment with mebendazole [B]
	• previous fetal or neonatal death [RF A]		
• Emergency for those with complications (first referral level and above)	Management of emergencies, including	In utero transfer of high-risk pregnancies [B]	Iodine deficiency prevalent:
	* preeclampsia or eclampsia [A]		* iodine supplementation [B]
	* bleeding in pregnancy [A *]		Famine:
	* uterine infection [RF A]		* targeted food supplementation [B]
			Group B streptococcus prevalent:
			* screening and treatment [A]
Birth	Skilled care in labor, including	Supportive companion in labor [A]	Mother HIV positive:
* Essential	* monitoring progress of labor (partograph), maternal and fetal well-being [A]		• Antiretroviral therapy [A]
	* infection control [A *]		
	Newborn resuscitation if required [A *}		

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]	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	**Newborn resuscitation** if required [A*] 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 newborn care for all newborns, including	Trained breastfeeding counselors undertaking home visits [A]	Hepatitis B prevalent: Give hepatitis B immunization early [A]
Essential	early and exclusive breastfeeding [B]	Vitamin K (cost-effective as prophylaxis for all babies in transition countries) [B]	Mother HIV positive: provide counseling and support for feeding choices [C]
	warmth provision and avoidance of bathing	Routine newborn screening programs for sickle cell disease, glucose 6	
	during first 24 hours [C]	phosphate dehydrogenase deficiency [B]	
	infection control including cord care and hygiene [B]		

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)
	postpartum vitamin A provided to mother [B]		
	eye antimicrobial provided to prevent ophthalmia [A]		
	information and counseling for home care and emergency preparedness [C]		
Extra Care	Extra care for small babies (preterm or term IUGR) and multiple births, severe congenital abnormalities:	Provide special or intensive care for preterm babies [A]	Mother with tuberculosis: keep baby with mother and give isoniazid prophylaxis
	extra attention to warmth, feeding support, and early identification and management of complications [B]		Mother with syphilis: treat the baby even if symptomatic [A]
	kangaroo mother care [A: morbidity not mortality data]		
	vitmain K injection [B]		
Emergency	Emergency care providing specific and supportive care according to evidence-based guidelines for the following:	Provide special care for sick and small babies using skilled nurses and a higher nurse-to-patient ratio [B]	
	severe infections [A]		
	neonatal encephalopathy (following acute intrapartum insult)		
	severe jaundice or bleeding [A *]		
	neonatal tetatnus		

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. Source: Authors, based on extensive literature review. References detailed on http://www.fic.nih.gov/dcpp/

Table 8. Interventions to Reduce Fetal and Neonatal Mortality by timing of intervention and by Scalability of Intervention.

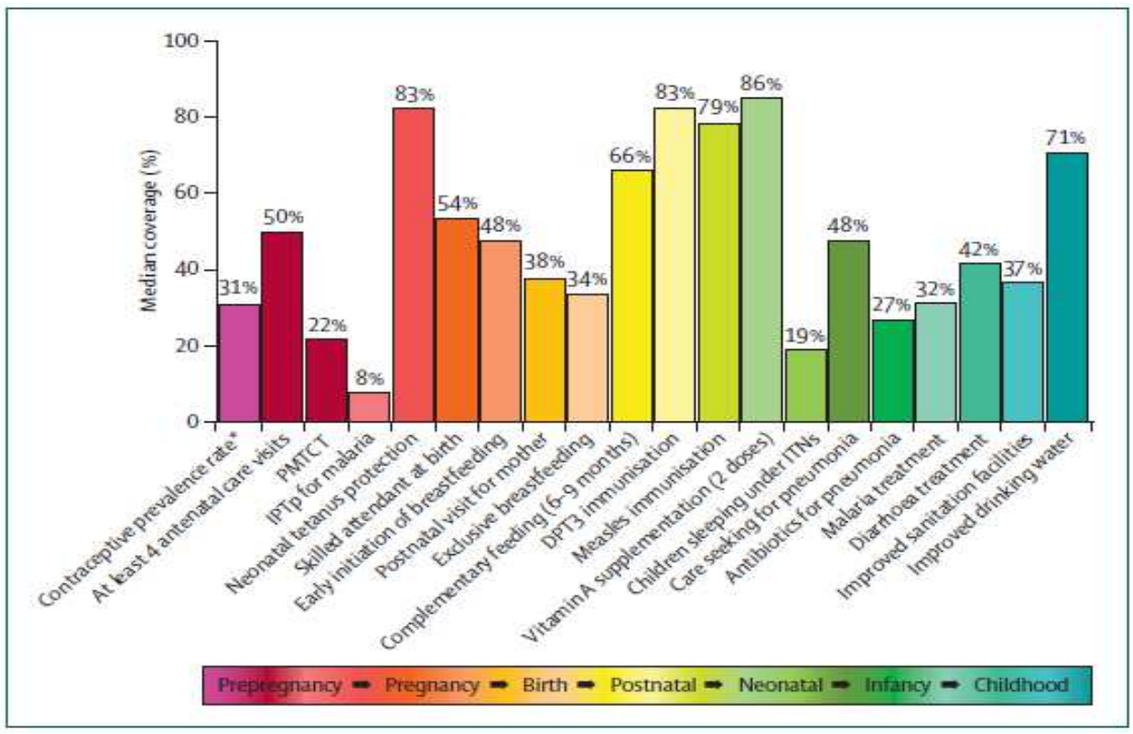
Intervention package	Contents	Number of target population per year (millions)	Implementation Strategy	Estimated current coverage (percent)		Reduction in all-cause NMR (percent)	Comments on evidence
				South Asia	Sub Saharan Africa		
Family-community care of the newborn at home after birth	Healthy home 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 breast-feeding, 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 new borns	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

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		
Neonatal packages plus MCH package	Neonatal packages as above, in addition to family planning, prenatal care, and comprehensive obstetric car 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 other 2005: Knippenberg and others 2005; Lawn Cousens, and Zupan 2005

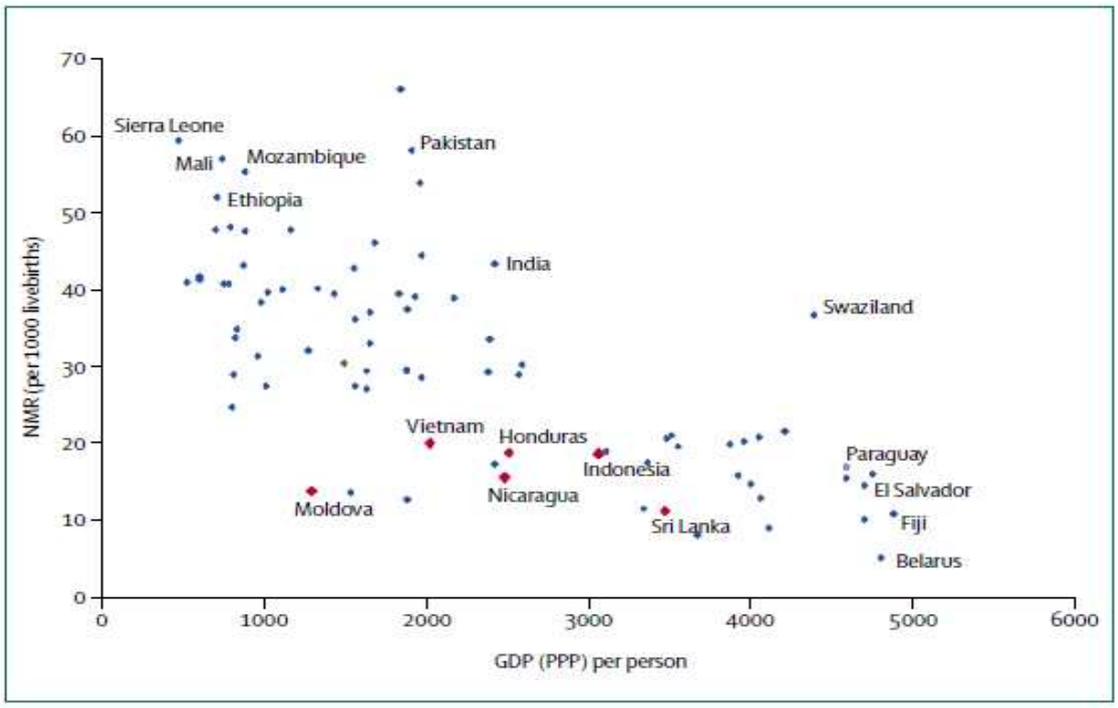
Note: The range of reduction of all-cause NMRs given for each package is independent of the others; hence the total is greater than 100 percent.

Table 9. Packages for Universal Scale-up of Newborn Care.



Source: (Bhutta et al., 2010)

Fig. 13. Median coverage for effective maternal, newborn and child interventions in 68 countries accounting for more than 90% of maternal and child deaths worldwide.



(Source: Martines, et al., 2005)

Fig. 14. Correlation between neonatal mortality and GDP per Capita < USD 5000 (in year 2000).

11. Challenges to the reduction in neonatal mortality and the way forward

Reduction of neonatal mortality has become the most significant challenge as the world progresses in its fight to reduce Under 5 childhood mortality. Socioeconomic and developmental in-equalities combined with low political priority of maternal and child health in most parts of the world, remain significant contributors of neonatal mortality. Poverty, illiteracy and lack of public awareness further intensify the grave situation. These wide spectrum challenges require a unified approach by the governments, public as well as the international organizations (Bhutta et al., 2010).

12. Case studies

Sri Lanka, Brazil and The State of Qatar are presented in separate panels as stories of success. These countries are excellent case studies in reducing neonatal mortality rates and achieving MDG 4 in resource constrained environment.

Sri Lanka – Achievement of excellent NMR using community based primary health care services

Sri Lanka had a population of 20 million with a GDP(PPP) per person of US $3470 in year 2000 when the NMR had already fallen to 10/1000. During this time, more than 6.6percent of the population was living on an income of < US$1 a day. Public expenditure on education and health was 1.3 percent and 1.8percent of GDP, respectively. The female literacy rate was high at 90percent. The first neonatal intensive care unit opened in mid-1980s in Colombo when the NMR was already < 20. In 1999, there were just 40 incubators and five neonatal intensive care units in the country. The great decline in neonatal mortality shown was not due, therefore, to the availability of high technology facilities, but was the result of sustained inputs into and use of primary care services and facilities in the government sector. Starting in 1913, health services for rural communities started receiving special attention in Sri Lanka. Midwives were posted to the rural areas to provide both home and institutional care. By 1996, there was one midwife for a population of 3000-5000. Outreach antenatal care is provided by these midwives, with antenatal coverage of almost 100percent in 1999. In 1996, 86percent of deliveries were in government hospitals, where a cadre of 2500 skilled hospital midwives attend services free of charge. There is also equitable and easy access to health care facilities throughout Sri Lanka. The average distance from every house to a health facility is 1.4 km, and from smaller hospital to the more advanced hospitals is only about 5 km. Government health facilities are used by both the poor and the rich, and efforts have been made to maintain high quality of service. (Source: Martinez et al., 2005)

Brazil – Moving from a high mortality country to achieving MDG's beyond targets

Brazil is a high mortality country that is on target to achieve MDG-4. In children < 5 years old, mortality has been dropping by about 5percent a year since 1990, which is substantially faster than the 4.4percent yearly reduction needed to reach the MDG target. Currently, 22 of every 1000 children die before their fifth birthday. The prevalence of underweight children < 5 years dropped from 5.7 percent in 1990, to 1.7 percent in 2006, and stunting fell from 19.9percent to 7.1percent in the same period. Overall progress has been accompanied by a sharp reduction in inequalities between socioeconomic quintiles. In 1996, about 30percent of all births to mothers in the poorest quintile did not receive skilled care, but by 2007, coverage was universal. Likewise, stunting prevalence fell from 40percent to 10percent in children in the poorest quintile between 1989 and 2007, remaining stable at around 3-5 percent in the richest quintile. These examples are only two of many indications of reproductive, maternal, newborn, and child health for which equity has improved in the past two decades.

Brazil's successful reduction of inequities cannot be attributed solely to one factor. Although economic growth has been moderate since 1990, income distribution has improved strikingly in recent years. A nationwide tax-based Unified Health System without any user fees was launched in 1989, and geographical targeting has guided deployment of family health teams of doctors, nurses, and community health workers in the poorest areas of the country. As a result, primary health-care coverage e.g. by skilled birth attendants, is now almost universal. Additionally, conditional cash transfer programmes cover about a third of the population, and several health sector initiatives-including immunization, HIV/AIDS control, and breast feeding promotion activities-have been highly successful. Perhaps more than any one policy or initiative, the reduction of regional and socio economic disparities in health and development has been a central element in Brazil's political agenda for the past 20 years, and this approach is now starting to bear fruit. (Source: Bhutta et al., 2009)

The State of Qatar – An exceptional example of achieving all MDG's by 2007

The State of Qatar stands unique among the world countries by having achieved all MDG's by 2007. The State provides universal access to health care including Maternal and Child Health care. A shift from home to hospital deliveries took place during 1970's. Since 1980, Qatar has achieved almost 100% coverage of its pregnancies and deliveries by trained birth attendants. Since 1974 a trained person has seen almost 100% of the newborn babies. The level of childhood immunization, which was 80% in 1980, reached 96-100% by 1986. The state had only three cases of neonatal tetanus in 1980 and one case in 1986. Since then there has been no recorded case of neonatal tetanus in Qatar. The Maternal Mortality Ratio (MMR) remained zero in 1993, 1995 and then from 1998 until 2000. For the rest of the years, MMR has been approximately 10/100,000. The major decline in Qatar's neonatal and perinatal mortality took place during the 1970's. By 1976 Qatar's NMR was 12/1000 and PMR 20/1000, both achieved by using very basic low cost neonatal technology (neonatal resuscitation, temperature control using incubators, infection control, fluid balance, breast feeding and care of low birth weight babies). Between 1974 and 1993 Qatar's overall per capita health expenditure increased only by 19%. During 1993-2008 Qatar's per capita health expenditure increased by 137%. This was the era of using very expensive high-tech neonatal intensive care, which resulted in the decline of NMR from 8.3 to 4.4.
Qatar's remarkable achievement of maternal, neonatal and perinatal survival was not a phenomenon in isolation. It has evolved as a part of the global socioeconomic and cultural changes in the society; the most important being reduction in poverty and increase in female literacy. Poverty, measured by the ratio of those with an income of < US$1 a day, has long been eliminated in Qatar. The state has a high rate as well as a high level of Female literacy (> 99%). Qatar's standard of living is very high with abundant across the board supply of clean drinking water, efficient sewerage, drainage, pest control, environmental control, public health awareness programs, communication, electricity and transportation facilities. The state of Qatar is a very good model to illustrate the fact that Neonatal Perinatal Survival is part of a package of development of human society which is a multifaceted process involving social, economic, cultural, educational and health care development. (Source: Rahman et al., 2010)

13. Conclusions

Although significant progress has been made in reducing childhood mortality over the last four decades; the progress in achieving targeted reduction in neonatal mortality remains very slow. The evidence shows that the targets are achievable with the use of packages of simple, cost effective and feasible interventions without the use of very high and expensive technology. Over the remaining one third period to achieve MDG 4 (2011-2015), newborn care must be placed on top priority, without which any further significant reduction in childhood mortality will remain a dream.

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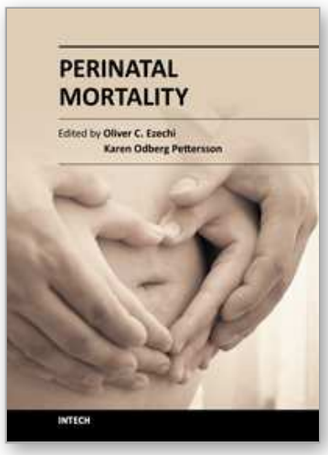

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This book is a compendium of important topics related to perinatal mortality. It has been written for anyone who is interested in perinatal medicine and wishes to be part of the global strategy for prevention and control of perinatal mortality. It covers variety of subjects using simple language that can easily be understood by most health workers and those interested in quality health care. Postgraduate students in midwifery, obstetrics and paediatrics will also find it a very useful companion.

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