REVIEW ARTICLE

Does Facility-Based Newborn Care Improve Neonatal Outcomes? A Review of Evidence

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Context: Facility based newborn care is gaining importance as an intervention aiming at reduction of neonatal mortality.

***Objective*:** To assess different factors that affect effectiveness of facility based newborn care on neonatal outcomes.

***Evidence acquisition*:** Electronic search using key search engines along with search of grey literature manually. Observational and interventional studies published between 1966- Aug 2010 in English having a change in neonatal mortality as an outcome measure were considered.

***Results*:** A total of 40 articles were fully reviewed for generating synthesized evidence. All were observational studies. The exposure variables that affected neonatal outcomes were grouped into three categories- regionalization of perinatal care (17 articles), strengthening of lower level neonatal facilities (12), and other miscellaneous factors (11). Regionalization played a key role in advancing newborn care practices. It increased *in-utero* transfer of high risk newborns and improved survival outcomes especially for very low birth weight neonates at level III facilities. It led to reduction in neonatal mortality owing primarily to enhanced survival of low birth weight infants. Strengthening of lower level units contributed significantly in reducing neonatal mortality. High patient volume (>2,000 deliveries/ year), inborn status, availability of referral system and inter-facility transfers, and adequate nursing care staff in neonatal units also demonstrated protective effect in averting neonatal deaths.

Conclusions: Countries investing in facility based newborn care should give impetus to establishing regionalized systems of perinatal care. Strengthening of lower level units with high case loads, can yield optimal reduction in NMR.

Key words: *Efficacy, Evaluation, Mortality rate, Newborn Outcome, Regionalization*.

Every year 70% of neonatal deaths take place because simple yet effective interventions do not reach those who need them the most. Coverage of interventions is low, progress in scaling up is slow, and inequity is high [1]. This gap is due to poor coverage within the health system, shortage of health care providers, and issues related to access to referral services. While community-based research is receiving attention and investment, rigorous evaluation and research on facility-based interventions is lagging behind [2]. Appropriate linkage and coordination are pertinent with facility-based care for achieving successful gains in community-based interventions.

Facility based care includes essential care at birth and care of sick babies in different facilities. Stratification of various levels according to the ability of the units to handle cases has been devised. While it is desirable to see babies receiving care at appropriate facilities, designing such a model and operationalizing it within the health system is a challenge. It is understood that very high-risk babies should get the highest level of care but investment would vary accordingly. It is thus imperative to learn from experiences of different facilities in diverse settings in the context of facility based neonatal interventions. The learning will be vital as to how different models have tackled and improved neonatal outcomes and challenges confronted by these facilities.

This review is undertaken to assess different factors that affect neonatal outcomes in facilities providing newborn care. It also aims to synthesize evidence on parameters that influence the performance of the facilities.

METHODS

All observational and interventional studies that have documented the establishment of neonatal facilities and their functioning have been considered. Interventions relating to setting up/managing/upgrading facility based newborn care include essential care at birth in facilities, special care for sick newborns, follow up of neonates admitted with any illness and care of neonates in post natal wards.

Inclusion criteria: Facility based care in developing country setting, and evaluation of regionalized system of perinatal care in both developing and developed countries. Articles on community based newborn care and on impact of level III care facilities in developed countries with reference to management/ treatment of specific illnesses were excluded.

Outcome measures: Primary outcome of this search was neonatal and perinatal mortality among hospitalized newborns and when available, at the population level.

Search strategy and study selection

All publications in English between 1966 and August, 2010 in any scientific journal were considered. Electronic searches were using Pubmed, IndMed, BioMed Central, Cochrane, PopLine and Google. Besides, websites of national and international organizations working on neonatal health (National Neonatology Forum, WHO, Save the newborn, UNICEF) were screened. Grey literature and journal hand searching were done to explore more information.

Search was done using the following keywords- neonates/newborns, facility/hospital/ SCNU/secondary level care, and survival/ reduction in mortality/reduction in morbidity. This was done by two primary reviewers independently. The search criteria were mutually agreed upon prior to the actual search. After a preliminary exercise, all the citations were screened by both the reviewers independently. The citations selected by both/ any of them were considered for abstract review. These were reviewed independently by both of them and the final list of the selected abstracts prepared. In case of disagreement on the selection of any study abstract, it was settled by mutual discussion and advice sought from a Senior Investigator of the team. The full articles of the selected abstracts were reviewed by the reviewers. All the studies relied on data retrieved from their usual records, births and death certificates.

The key findings were pooled together. A summary measure could not be calculated owing to heterogeneity in study designs and quality and different ways in which outcomes were expressed. Reporting of findings was done as per MOOSE guidelines (***Appendix* 1**).

Based on the review of the shortlisted papers, we classified the interventions for improving neonatal outcomes into three groups *viz.* (*i*) Regionalization of perinatal care (17 studies); (*ii*) Strengthening of level I/II facilities (12 studies); and (*iii*) Studies assessing the impact of health system factors such as - inborn/outborn status, size and volume of the unit, referral transport and availability of human resources on neonatal outcomes (11 studies).

RESULTS

Regionalization

Regionalization implies the development, within a geographic area, of a coordinated, cooperative system of maternal and perinatal healthcare in which, by mutual agreements between hospitals and physicians and based upon population needs, the degree of complexity of maternal and perinatal care each hospital is capable of providing is identified so as to accomplish the following objectives: quality of care to all pregnant women and newborns, maximal utilization of highly trained perinatal personnel and intensive care facilities, and assurance of reasonable cost effectiveness.

Different studies have used different nomenclature and designations for different units [6,7]. By and large, level III were defined as the units which provided specialized services like ventilatory support, level II as units that could manage neonates more than 1500g and provide intermediate care,and level I as the units that could manage low risk neonates. Level II care includes supportive care, feeding of low birth weight neonates, management of sepsis, asphyxia and pathological jaundice and stabilization of neonates before referring to level III care.

Many authors have reported experience with various models of regionalized perinatal services [6-9]. Most observers have found it difficult to relate perinatal outcome to regionalization, since controlled clinical trials of perinatal care and regionalization are not acceptable [10]. These have correlated morbidities and mortalities arising out of high-risk deliveries. As a consequence of regionalization, more high-risk deliveries and very low birth weight (VLBW) births were managed at higher level units with advanced technology [11,12]. Regionalization resulted in increased emphasis on transfer of at risk mothers to perinatal centres, as reported from 17 NICUs in Canada before delivery of the infant, instead of transferring infants after they were born [13]. Similar findings were reported from all level II and III units in New Zealand where around 3% of infants were high-risk infants [14]. The outcomes were better for inborn babies with VLBW as compared to outborn babies (OR= 1.7; 1.2-2.5).

In addition to early *in utero* transfer of high risk infants, developments were also noted in intensifying transport mechanisms after birth from lower to higher level units. In Portugal in-hospital deliveries increased from 74% to 90%. Despite great increase in intra-uterine transport, Portuguese Neonatal transport system with its own neonatal team also succeeded in stabilizing the

newborn before transport [7]. It was also suggested that several intermediate care units should be set up and suitably developed to minimize unnecessary admissions to the tertiary neonatal centers [15].

In the evolutionary process of regionalization, well established system for infant transport and availability of trained staff and user friendly technology have allowed the rapid growth of community NICU. This sometimes attracted births away from regional NICUs giving rise to 'deregionalization' [6]. The number of deliveries especially high risk, increased at these facilities. This sometimes resulted in a substantial disadvantage to VLBW babies as noted in California. Data from a similar study also indicated that 69% of infants <2000 g birth weight were born outside a regional NICU reflecting the extent of deregionalization [16].

A total of 17 studies were selected for the review under this heading that considered change in neonatal/ perinatal mortality as the outcome.[3-4, 6-7, 10-12, 16-25] Out of these, 1 was a cohort/ prospective study, 2 studies have documented the impact before and after regionalization was established and the rest have analyzed the secondary data as retrieved from the usual records. Authors have expressed the change in NMR in many different ways. While some have compared the risk of dying at a level III or level II with level I unit in the form of odds ratio, others have given the absolute reduction in NMR or PMR across various birth weight categories and across different levels. Comparison of the reduction in NMR/ PMR was not possible because of differing time frames and difference in the ways NMR or PMR were expressed.

There was a decline in numbers of LBW/ VLBW babies being born in level I hospitals with no change in the incidence of LBW babies. More referrals of high risk cases to higher centres (level III) through improved transportation have resulted in a decline in NMR in level I units [3,7,10,17,20-22,24]. Proportion of VLBW babies born in community hospitals increased by 25.7% in California over 7 years [6]. In Ontorio, neonatal transfer rate increased by 19.7% in 2 years among babies weighing 500-1499 g while it reduced by 3.1% among babies weighing 1500-2499 g [22]. More than 45% of VLBW babies were born in level III units in Washington and Wales [24]. The proportion of VLBW (< 1500 g) and moderately LBW (1500- 2499 g) infants delivered at level III hospitals was higher in states with formal system of perinatal regionalization [11,12]. This improved the outcome of babies admitted to level I units.

A concomitant increase in NMR in higher centers was observed initially followed by a decline, as regionalization matured. NMR increased by 1.4% per year initially for 5-7 years followed by a phase of decline that varied from 0.8% to 1.6% per year in various studies [4,7,10,11,19,23]. On the whole, there was a net decline in NMR (0.4 to 0.65% per year) and a decline in PMR by 0.6- 1.0% each year [10,11].

Reduction in NMR in most of cases was owing to a decline in mortality among LBW infants, more so for neonates weighing between 1000- 2500 grams. Mortality among LBW babies reduced by 3-4% per year while it ranged from 1.45 to 4.2% per year among VLBW babies [6,7,20]. In yet another study, it was found that 80% reduction in NMR resulted due to improved survival of LBW babies [8]. However, inconsistent evidence was also provided by a study executed in Alaska that concluded that perinatal care regionalization (for infants 1500-2499 g birth weight) is unlikely to substantially lower LBW infant mortality [25]. Though the study pointed out mother-infant pairs who received all care at single tertiary care center had a lower mortality rate than those who received some care at a non-tertiary care center, this study suffered with myriad methodological limitations- low sample size, lower deaths reported and also mortality was considered as sole outcome in the study.

Performance of level II/I units

Secondary (level II) units provide a useful link in the health system to promote regionalization. Evidence supports that if these units are developed, they may considerably provide good perinatal care and contribute to reductions in NMR. In a regionalized system, the policy is to transfer almost all preterm babies to higher referral units (level III). This way, investment in sophisticated technology could be limited to chosen units. On the other hand in places where regionalization is still not present, upgradation of level II could impact NMR favorably.

A total of 12 studies documented the impact of non-tertiary units, five of which are from developed countries [26-38] (***Web Table* II**). While six of them focused on level II units, two described about the upgradation from level I to III, two described level II units, one both level I and II combined and one did not mention any level. Number of units and time frame differed for every study although the impact was expressed as reduction in NMR and/ or PMR in every study. Most of these documented the impact on low birth weight category but the cut-offs used were not uniform. Significant reduction in NMR was seen in most of the units [26-27, 29-31,33]. While the rate of decline varied from 1.2- 2.5% per year in developed nations, the impact was greater in developing countries

where it varied from 6-10% per year [27, 29-31,33,35]. Greatest impact was seen in the early neonatal mortality rate [27,29]. Experience from Norway; however, suggests that the neonatal death rate remained static while fetal death rate declined from 14.8 to 6.6% between 1976 and 1989 (P<0.001) [28].

Within a year of upgradation of an ICU in Ghana from level II to level III, there was a significant reduction in the survival of normal birth weight with birth asphyxia, no change for non- asphyxiated normal birth weight and significantly improved survival of LBW babies [35]. Reduced survival of asphyxiated inborn after NICU refurbishment may have been due to referral of moribund asphyxiated babies from the labor ward because labor ward neonatal deaths reduced by 47% after NICU refurbishment. The high mortality among outborn asphyxiated NBW may have been due to mode of transportation to NICU.

The impact was most apparent for LBW/VLBW babies but not for ELBW babies. Experience worldwide have shown that level II units can contribute maximally towards bringing down the mortality rate among LBW babies, especially those weighing between 1000-1500g [26-27,30,36]. With improved performance in the functioning, the NMR among infants >1500 g can match that of a level III unit. However, NMR among VLBW infants have yielded mixed results. While New York demonstrated an increase in survival among VLBW babies, the same was not seen in India [36,37]. The main features that affect this outcome are better provision of care, increased stay of LBW infants, and higher rates of inborn deliveries [38].

Proportion of VLBW births is a strong predictor of NMR in these units.Rates of inborn VLBW babies have a strong independent influence on NMR. Dooley suggested that for every 1% increase in proportion of hospital's VLBW births, there is an increase of 2/1000 in NMR. Perinatal surveillance data for 3 years (1990-93) was analyzed in Illinios to identify the elements in the infrastructure of a regionalized network that had independent effects on the variation in mortality among non tertiary units (level I, II). Maternal socioeconomic behavior risk alone explained 73% of the variation in the hospital fetal death rates and 38% of that in hospital neonatal mortality rates. When controlling for maternal socio-behavioral risk, rates of inborn VLBW deliveries (P<0.001) and neonatal transport (P=0.01) had independent effects on the variation in hospital fetal death rate; rates of inborn VLBW deliveries (P<0.001), neonatal transport (P<0.001) and proportion of VLBW infants transported out (P=0.029) had independent effects on the variation in hospital neonatal mortality rate. Maternal transport, on the other hand, had no effect in the final models contrary to the belief that favorable perinatal outcomes are facilitated with delivery of at-risk neonate [38].

Other Factors Affecting NMR Reduction

Size and volume of the unit and admissions

Patient volume of the neonatal care units seems to influence the mortality. A total of 6 studies were reviewed that compared the volume of the unit with the NMR and 3 studies that showed the influence of inborn/ outborn status on the outcome.

In general, units with more than 2000 deliveries/ year influence NMR favorably. In USA, for instance, infants <2000 g had twice the mortality rate in facilities with less than 2000 deliveries/y when compared to those born in facilities >2000 deliveries, while little difference exists between obstetric volume groups for infants >2000g [12]. The same study, through log linear regression modeling, showed that when birth weight and maternal risk were controlled, obstetrical volume added minimal explanatory power to level of nursery care. The study was challenged due to small sample size and narrowly defined networks.

Evidence from California, using data from ten years 1991-2000, showed that lower levels of care and lower volumes were associated with significantly higher odds ratios of death as compared to high level of care and high volume of VLBW (>100/ year) adjusted for risk factors[39]. Risk adjusted mortality for infants who were born in hospitals with large (average census >/= 1500) community NICU (level II) was not statistically significant compared to regional NICU (OR= 1.11; 0.87-1.43) [16].

Women living in areas where the most frequently used delivery unit had less than 2000 annual deliveries had 1.2 (95% CI= 1.1- 1.3) times the risk of experiencing neonatal death compared to women living in areas where the most frequently used delivery unit had more than 2000 deliveries per year according to Norwegian Medical Birth Registry. The relative risk of neonatal death in geographical areas with more than 3000 annual births was 0.8 (95% CI 0.7-0.9) compared with areas where none delivered in such large units. The highest risk of stillbirths was found in municipalities with a high proportion of births occurred in the smallest units [40]. The NMR was lowest for maternity units with 2001-3000 annual births, steadily increased with decreasing size of the maternity unit to around twice that for units with <100 births per year. (OR=2.1; 95% CI 1.6- 2.8) [41]. A population based data from Germany revealed that

neonatal mortality among infants (< 1500 g) admitted to NICUs was 12.2% in small NICUs and 10.2% in large NICUs. Stratification according to gestational age revealed the greatest impact on mortality for infants of <29 weeks [42].

Besides, having a birth in same facility (being inborn) exerts a protective factor conferring better chances for survival later in life. In a survey in Canada, outborn infants had significantly high unadjusted incidence of mortality and more serious illnesses [13]. Similar findings were also observed in Ghana and USA [35,38]. More importantly, prevalence of LBW/ VLBW among inborn admissions critically acts as a determining factor.

Referral system and transport

As an aid to regionalization, referral system and inter-facility transfers can also substantially influence NMR. Only 4 studies were found that could correlate an efficient referral transport with reduction in NMR.

In UK in 1979-80, nearly 40% of neonates could not be referred because of overcrowding or lack of equipment or lack of suitably trained nurses. The survival rate of babies who were transferred was slightly more than twice than that of a group of babies of similar birth-weights who were not transferred [43]. There was a marked drop in outborn mortality among infants weighing more than 1000 g before and after initiating a neonatal transport system in US. Also, there was an increased rate of outborn admissions in this referral unit [19].

The association between duration of inter-facility transport and perinatal mortality has also been reviewed. A cross-sectional study from India showed that neonates with a long duration of transport had 79% higher odds of death than those transported for a short duration, after adjusting for confounding factors [44]. A cohort study conducted in Osaka, Japan between 1980-2000 reported a strong evidence that those transported for more than 90 mins had more than twice the rate of neonatal death (RR 2.26, 95% CI 1.26- 4.04) and some evidence that those transported for between 60 and 89 minutes had 80% higher rate of neonatal deaths (RR 1.81, 95% CI 1.07-3.06), both compared with those transported for between 30 and 59 minutes. A 14% raised RR was observed for those transported for < 30 minutes. This could be due to the fact that because of their condition, severaly ill neonates could be transported faster than less severely ill neonates [45].

Human resources

Human resources, especially the staff nurses, form the backbone of a neonatal unit can affect NMR and as evident from five studies. Analysis of data about perinatal mortality and indicators at maternity hospitals showed that pediatric staff ratios were inversely related to in-house mortality rates. Risk of neonatal mortality has been shown to be independently related to staffing-levels in NICU, such that the odds of mortality significantly increased when one nurse cared for more than 1.7 newborns [46].

Deficiency of nursing staff in intensive care units poses an additional challenge of infections due to poor adherence to asepsis. In a neonatal special care unit in USA, infant: nurse ratio and infant census were the key determinants of nosocomial infections. The incidence rate of clustered infection was 16 times higher during periods when infant: nurse ration exceeded 7 [47]. In a Special Care Baby Unit in Barbados, shortage of staff had fostered deterioration in handwashing technique leading to outbreaks [48].

The neonatal mortality rate in US has been found to be lower in regions with 4.3 neonatologists per 10,000 births than in those regions with 2.7 neonatologists per 10,000 births. Further increase in the number of neonatologists was not associated with greater reduction in the risk of deaths. Lack of resident medical staff, especially at night and over weekends, contributed to increased SCBU mortality, as reported from Uganda. Perinatal mortality data from West Midlands suggest that neonatal mortality was less when high-risk babies were born in maternity homes with improved staffing ratios [49].

DISCUSSION

The review brings into light three broad categories of interrelated strategies that can influence NMR– regionalization of neonatal care, strengthening of level I/ II facilities, and improvement in health systems. The current review indicates that as regionalization evolves and matures, the proportion of high risk deliveries decrease in less specialized units while there is a concomitant increase in more specialized centres. The increased proportion of high risk deliveries occurring in specialized units gets translated into an overall improved neonatal survival.

All the studies reviewed relied on data retrieved from their usual records, births and death certificates The advantages are that in developed nations, filing of births and death records tends to be complete. Moreover, data are collected in a single office and they have been collected for many years and allow comparisons of relatively large population over long periods of time. The disadvantages, however, are that some parameters like gestational age, time of death etc. may be inaccurately

recorded. Another problem is the possible underreporting of neonatal deaths [3]. In yet another study, it was revealed that only 73% of the records could be retrieved [4].

India and other developing countries with relatively weaker healthcare systems are increasingly investing in strengthening neonatal units to address high neonatal mortality. The review does show that these investments can decrease neonatal mortality significantly. However, to have significant and sustained impact at the population level, it is much more important to concentrate on the system in which the units are functioning. Apart from strengthening these units in isolation, it is critical to establish linkages with the lower and higher centers to optimally utilize the resources at a level where it is required the most. The review has shown that strengthening of level I/II units can have a great impact on the survival of LBW/VLBW babies but not for ELBW babies. This probably could be addressed in specialized units in a regionalized set up. Performance of level II units is strongly influenced by the proportion of VLBW births. By appropriately referring such pregnancies to higher levels, where the outcomes are likely to be better, the performance of individual units can also be improved.

While developing countries are investing resources in improving facility based care, it is imperative to look beyond establishing the standalone Special Care Newborn Units to having a system of networked facilities providing different levels of perinatal care. Such a "regionalized" system will have clear mechanisms to transfer high-risk pregnancies to appropriate levels. Currently, this is being accorded priority in many countries but it is important to consider that *in-utero* transfers have better outcomes than *ex-utero* transfers, as suggested by the review.

The study suffers from certain limitations. Owing to the heterogeneity of the studies, quantitative assessment of bias could not be ascertained. It was also difficult to provide an overall estimate of the gains achieved by investing on facility-based newborn care. Due to problems with translation, non-English articles were excluded. The quality of each studies included with was not assessed as per the guidelines laid down, since very few of them were actually research studies conducted under controlled conditions. There was a reliance on secondary data primarily due to the ease of data collection. This also means that the results can be generalized.

To conclude, the synthesized evidence from this review points out the critical components of facility based neonatal interventions. Advancements in neonatal care practices if cocooned with developing regionalized care, has promising potential in averting neonatal deaths. Based on the review, it appears that such a regionalized system will have following important constituents highlighted in the box. The review components provide a critical insight for nations that are in process of scaling up facility-based newborn interventions and adopting strategies to address unfinished agenda of high neonatal mortality.

Important constituents of a regionalized system

- A network of perinatal care units that provide different levels of perinatal care
- All high risk births will be transported *in-utero* to the higher levels of care
- All units conducting about 2000 deliveries per year to be strengthened to provide level II newborn care. Key element is availability of adequate, skilled human resources, especially nurses.
- A well-functioning transport system connecting the facilities that provide different levels of care, in-utero transport, where the risk is predictable, and emergency transport where such a risk is not predictable.

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