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Antenatal iron/folic acid supplements, but not postnatal care, prevents neonatal deaths in Indonesia: analysis of Indonesia Demographic and Health Surveys 2002/2003 – 2007 (a retrospective cohort study)

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Abstract

Objective
This study aimed to assess the contribution of postnatal services to the risk of neonatal mortality, and the relative contributions of antenatal iron/folic acid supplements and postnatal care in preventing neonatal mortality in Indonesia.

Design
Retrospective cohort study

Setting and participants
Data used in this study were the 2002-2007 Indonesia Demographic and Health Surveys, nationally representative surveys. The pooled data provided survival information of 26,591 most recent live-born infants within the five-years prior to each interview.

Primary outcomes
Primary outcomes were early neonatal mortality, i.e. deaths in the first week, and all neonatal mortality, i.e. deaths in the first month of life. Exposures were antenatal iron/folic acid supplementation and postnatal care from days 1-7. Potential confounders were community, socio-economic status and birthing characteristics and perinatal health care. Cox regression was used to assess the association between study factors and neonatal mortality.

Results
Postnatal care services were not associated with newborn survival. Postnatal care on days 1-6 after birth did not reduce neonatal death (HR=1.00, 95% CI: 0.55-1.83, p=1.00) and early postnatal care on day 1 was associated with an increased risk of early neonatal death (HR=1.27, 95% CI: 0.69-2.32, p=0.44) possibly reflecting referral of ill newborns. Early postnatal care on day 1 was not protective for neonatal deaths on days 2 to 6 whether provided by doctors (HR 3.61, 95% CI: 1.54-8.45, p<0.01), or by midwives or nurses (HR 1.38, 95% CI: 0.53-3.57, p=0.512). In mothers who took iron/folic acid supplements during pregnancy, the risk of early neonatal death was reduced by 51% (HR=0.48, 95% CI: 0.30-0.79, p<0.01).

Conclusions
We found no protective effect of postnatal care against neonatal deaths in Indonesia. However, important reductions in the risk of neonatal death were found for women who reported use of antenatal iron/folic acid supplements during pregnancy.

Article summary

Article Focus

- Iron/folic acid supplements during pregnancy have been reported to protect against neonatal death.
- Postnatal care services are also claimed to be important to prevent neonatal mortality.
- This study aimed to examine the relative importance of antenatal iron/folic acid supplements and postnatal care services in improving neonatal survival in Indonesia.

Key Messages

- Postnatal care did not protect against neonatal and early neonatal deaths after adjusting for the effects of iron/folic acid supplements.
- Iron/folic acid supplements consistently prevented neonatal death and early neonatal deaths (on the first day and after the first day of delivery).
- Programs aimed at reducing neonatal mortality in Indonesia need to place more emphasis on iron/folic acid supplementation during pregnancy.
- Further research is needed to understand the reasons for the lack of impact of postnatal are on neonatal mortality in Indonesia.

Strengths and Limitations

- Data were taken from two nationally representative surveys with large samples and high response rates.
- The survey used a retrospective cohort design in which the mother recalled the health services exposures that occurred prior to the outcome of interest - neonatal death.
- Recall bias was reduced by restricting the analysis to the last birth within five years prior to the interview.
- An important limitation was that mothers were not randomized to receive iron/folic acid supplements or postnatal care so there remains a possibility of residual confounding.
- Our analyses were limited by the lack of information about components of the postnatal care delivered.

Introduction

Of 7.7 million child deaths in 2010 worldwide, approximately 3.1 million were neonatal deaths.[1] Approximately 75% of neonatal deaths occur in the early neonatal period, or the first seven days after delivery and 50% occur in the first 24 hours.[2] Failure to reduce neonatal deaths might prevent countries from attaining their fourth Millennium Development Goal that is to reduce child mortality by two thirds by 2015.[2-5] Interventions to reduce the number of neonatal deaths are important especially in developing countries.[2 6]

Infants of mothers who receive antenatal care services have a reduced risk of neonatal deaths.[7 8] Antenatal services include a pregnancy check up by health personnel, provision of iron/folic acid supplements, tetanus toxoid vaccination and health education and counseling. In Indonesia, pregnant women are recommended to attend at least four antenatal visits.[9] The 2007 Indonesia Demographic and Health Survey (IDHS) showed that only 66% of women had four antenatal visits, lower than the national target of 90%.[10] The Ministry of Health also reported a wide discrepancy of antenatal care utilization across provinces.[9] DKI Jakarta has the highest (96%) and Papua Province the lowest (38%) percentage of women attending all visits.[9]

Iron/folic acid supplements reduce the risk of neonatal mortality.[11-14] In Indonesia, pregnant women should receive 90 tablets of iron/folic acid supplements, which has been used as an indicator of the quality of antenatal care services.[9] Nonetheless, in 2008 only 48% of pregnant women received this dose.[9]

Postnatal care services are important in preventing neonatal mortality.[15-19] Adequate postnatal care is considered vital since most neonatal deaths occur within the first week of life. WHO and UNICEF recommend at least two visits for home births within the first week of the infants' life; whereas for babies delivered in health care facilities, the first home visit should be immediately the baby comes home.[20] In Bangladesh, neonatal deaths were significantly lower amongst infants who had a postnatal home visit on the first two days after delivery.[18] However there was no significant reduction of the risk of neonatal death in newborns with their first postnatal visit after the second day of life. In Indonesia, three postnatal home visits have recently been recommended to replace the previous postnatal schedule of two visits with an additional visit in the first week of life.[21]

These findings highlight the need for further examination of the roles of iron/folic acid supplements and postnatal care services in improving neonatal survival. Our aim was to assess the relative contribution of antenatal iron/folic acid supplements and postnatal care services in reducing the risk of neonatal death.

Methods

Data sources

Data of the 2002/2003 and 2007 Indonesia Demographic and Health Surveys (IDHS) were available .[22] A multi-stage, stratified, cluster random sampling was used to collect demographic and health information by interviewing ever married women in reproductive age (15-49 years) and ever married men (15-54 years). Three questionnaires used were used. The Household Questionnaire collected information about the economic status of each household. The Women's Questionnaire collected information about socio-demographic characteristics and health-related information, including use of antenatal, delivery and postnatal services and child and maternal deaths. The Men's Questionnaire collected information about men's socio-demographic and health information. The IDHS is designed to produce estimates at the national, provincial, and urban/rural level.[23]

In this pooled analysis, survival information from 26,591 most recent live-born infants within the five-years prior to each interview was used, consisting of 12,646 infants from the 2002 IDHS and 13,945 from the 2007 IDHS. Participation in IDHS has an average response rate of 97%.

Primary outcome and study variables

The primary outcome was early neonatal death defined as death during the first week of life (days 1-7). All neonatal death was defined as deaths occurring during the first month life (days 1-31).

Iron/folic acid supplement was the reported use of any iron/folic acid during pregnancy. The commonly used formulation in Indonesia is iron 60 mg and folic acid 0.25 mg. This variable was based on question of, "*For how many days during this pregnancy did you [mother] take the iron?*" A mother was classified as using antenatal iron/folic acid supplements if they reported taking iron/folic acid tablets for at least a day during pregnancy, although our analysis did not analyse in specific the number of days mothers took iron supplements.

Postnatal care services received by infants in the first six days of life were based on three questions, (1) *"After (NAME) was born, did a health professional or a traditional birth attendant check on his/her health?"*, (2) *"How many days or weeks after delivery did the first check take place?"* and (3) "*Who checked on (NAME)'s health at that time?*" For (3), options were (a) health personnel, i.e. general doctor, obstetrician, paediatrician, nurse, midwife (b) traditional birth attendant, (c) other. Three postnatal care variables were constructed: a two-category variable of (1) no postnatal care or postnatal care after day 7 and (2) postnatal care services from day 1-7 delivered by any care provider (trained or untrained). Secondly, a four-category variable consisting of (1) no postnatal care, or postnatal care after day 7, (2) postnatal care from day 1-7 by a doctor/specialist/ paediatrician, (3) postnatal care from day 1-7 by a nurse/midwife/village midwife, and (4) postnatal care from day 1-7 by untrained personnel (traditional birth attendants). Thirdly, a three-category variable consisting of (1) no postnatal care/postnatal care after day 7 or (2) postnatal care on day 1 and (3) from day 2-7 by any type of care provider. During data collection, women were recommended to have at least two postnatal care services, once during day 1-7 and once during days 8-28 after delivery.

Potential confounding factors

A framework of factors which might potentially affect child survival in developing countries was adapted for the analysis.[24] Sixteen potential confounders were classified into two groups: (1) demographic, socio-economic status and birthing characteristics, and (2) perinatal health care services.

In the first group, twelve variables were region, type of residence (urban/rural), average paternal year of schooling in the cluster, maternal year of education, household wealth index, maternal age at childbirth, child sex, combined birth rank and interval, maternal desire for pregnancy, reported delivery complications (including prolonged labor, excessive vaginal bleeding, fever/foul smelling and convulsions) and combined birth size and duration of pregnancy.

In the second group, two study variables (antenatal iron/folic acid supplements and postnatal care) and use of five perinatal health services (antenatal care, mode of delivery, delivery attendance and place of delivery) were included. Antenatal care services refer to preventive health services provided by health personnel, such as doctors, midwives, or village midwives, during pregnancy. Duration of the recall period between date of childbirth and interview was also included in multivariate models.

Household wealth index used 11 variables from the pooled datasets including source of drinking water, type of toilet, main material of wall, floor, availability of electricity, possession of radio, television, fridge, bicycle, motorcycle, and car. Principal component analysis was used to assign weights to create an indicator of household economic status.[25]

A variable of combined birth rank/ birth interval was constructed with five-categories, i.e. first birth rank infants, second/third birth rank infants with previous birth interval of more than two years, second/third rank infants with previous birth interval of less than or equal to two years, fourth birth rank infants with previous birth interval of more than two years, and fourth birth rank infants with previous birth interval of less than or equal to two years.

In the analyses, birth size replaced birth weight due to 19% of infants not weighed at birth. There is a close correlation between mother's assessment of child size and birth weight.[26]

Statistical analysis

Cox regression was used to examine the association between neonatal mortality and study factors with multivariable analyses to examine associations between early neonatal mortality and study factors after controlling for covariates.

In multivariable analysis, a multi-stage model was implemented. At the first stage, community, socio-economic status and birthing characteristics, year of IDHS survey and days of recollection period, were entered. Backward elimination was used to remove non-significant factors (P>0.05). Two variables, year of IDHS survey and days of recollection period were selected a priori to be retained in the model to adjust for secular trends.

At the second stage, use of perinatal health care service characteristics including use of iron/folic acid supplements and postnatal care services were entered with backward elimination to remove non-significant factors. Two postnatal care services variables were entered, one at a time, to assess their association with the study outcome. Variables for delivery attendance were retained regardless of significance.

A similar modelling strategy was used to examine predictors of neonatal mortality. In the final models, the same sets of variables were retained for both neonatal and early neonatal deaths. Regression models were also used for early neonatal mortality occurring on the day of birth (day 1) and after day of delivery (days 2-7).

Data were analysed using STATA/MP version 10.00 (Stata Corporation, College Station, TX, USA). Cox regression models were adjusted for sampling weights and the cluster design.

Results

There were 26,591 live-born singleton infants most recently born to each mother in the prior 5 years, with 219 early neonatal deaths and 290 neonatal deaths. Although neonatal deaths decreased from 115 (IDHS 2002/2003) to 104 (IDHS 2007), the proportion of early neonatal death on the first day of life increased from 47% to 50%.

Table 1 shows community, socio-economic status and birthing characteristics. Multivariable analyses showed that type of residence (urban/rural), household wealth index, and maternal age at childbirth, presence of delivery complications and birth size of the child were significantly associated with early neonatal deaths.

Perinatal health care service characteristics are presented in Table 2. There was an increased utilization of antenatal services, trained delivery attendants, institutional deliveries, and postnatal services in the last ten years. However, the use of iron/folic acid supplements decreased from 69% (IDHS 2002/2003) to 67% (IDHS 2007).

There was no significant protective effect of postnatal care services regardless of the timing of the service. Table 3 shows no effect of postnatal care by any provider in the first week of life (HR=1.00, 95% CI: 0.55-1.83, p=1.00). In the univariable analysis the use of postnatal care services showed protection for early neonatal deaths, although not significant (HR=0.79, 95% CI: 0.44-1.43, p=0.44); however, when use of iron/folic acid supplements was included, this effect disappeared. Similar findings were observed for the effect of postnatal care services according to the timing of the care (Table 3, Model 2) There was an increased hazard ratio for infants who received care by any provider on the day of delivery (HR=1.27, 95% CI: 0.69-2.32, p=0.44), although not significant. There was a change in the direction of early postnatal care services provided after birth (day one) on early neonatal deaths when use of iron/folic acid supplements was included in the model.

When antenatal care service was added back into the final model, the result remained essentially the same with use of iron/folic acid being protective of neonatal deaths (HR= 0.51, 95% CI: 0.31-0.82, p=0.01) and use of postnatal care having no effect on neonatal deaths (HR=1.00, 95% CI: 0.55-1.83, p=1.00).

Using the same variables, analyses of perinatal care services for all neonatal mortality (1-31 days) showed similar findings (Table 4). An increased hazard ratio (HR=1.21, 95% CI: 0.70-2.09, p=0.49) was associated with infants who received postnatal care by any provider in the first week of life (Model 1). The hazard ratio of postnatal care services also changed direction from being protective (HR=0.98, 95% CI: 0.58-1.65, p=0.93) against neonatal mortality in the univariable analyses, to an increased risk after adjusting for iron/folic acid supplements. When the effect of early postnatal care services (on day 1) was examined, there was no significant protection of postnatal care in univariable (HR=1.09, 95% CI: 0.63-1.87, p=0.76) or multivariable analysis (HR=1.43, 95% CI: 0.83-2.47, p=0.49) after adjusting for iron/folic acid supplements (Model 2). When antenatal care service was added back into the final model for all neonatal deaths, the results did not change (data not shown).

In contrast, we found the benefit of iron/folic acid supplements was consistently present across all models. Antenatal use of these supplements significantly reduced the risk of early neonatal death by 49% to 51% (Table 3) and all neonatal deaths by 48% to 49% (Table 4).

Figure 1 presents the results of the multivariable analyses for early neonatal deaths according to the provider of postnatal care services. For all providers, postnatal care in the first week of life did not protect infants from neonatal death. There was a tendency for infants who received care from trained providers to have a slightly higher risk and untrained providers a slightly lower risk of neonatal death, perhaps reflecting referral of ill newborns.

There was a significant interaction between postnatal care services and urban/rural residence. In urban areas there was no significant protective effect of postnatal care on early neonatal deaths amongst infants receiving postnatal care within the first week of life either by medical doctors (HR=0.94, 95% CI: 0.31-2.85, p=0.92), nurse or midwives (HR=0.88 95% CI: 0.28-2.73, p=0.83), or traditional birth attendants (HR=0.94, 95% CI: 0.24-3.64, p=0.93). However, in rural areas, the risk for early neonatal deaths increased significantly in infants who received postnatal care from medical doctors (HR=5.44, 95% 1.84-16.11, p<0.01) but infants who received care from traditional birth attendants had a lower risk (HR=0.38, 95% CI: 0.16-0.90, p=0.03). There was no significant interaction between place of delivery or delivery complications and postnatal care services.

Figure 2 shows neonatal deaths on the day of delivery. There was no protection for day 1 death from postnatal care provided by midwives/nurse or traditional birth attendants. There was a significantly increased risk in infants who received postnatal care services from medical doctors (HR=3.61, 95% CI: 1.54-8.45, p<0.01).

Figure 3 shows the effect of postnatal care services on the day of delivery on the risk of neonatal deaths day 2-7. There was no protective effect of postnatal care services provided immediately after delivery. An increased hazards ratio was associated with postnatal care services on the day of delivery, although borderline significant (HR=2.05, 95% CI: 0.95-4.42, p=0.07). However, there was an increased risk when postnatal care was first delivered beyond the first day after delivery (HR=2.47, 95% CI: 1.06-5.78, p=0.04).

Discussion

Main findings

Using data from two nationally representative surveys, we found no protective effect of postnatal care services for newborn survival after adjusting for the effects of iron/folic acid supplements. An increased risk of early neonatal death on the day of delivery was associated with postnatal care services from medical doctors, which might be related to referral bias. The strongest evidence of a lack of protective effect of postnatal care for neonatal deaths was our failure to show any protective effects for postnatal care delivered on the first day of life, for subsequent neonatal deaths in both early and overall neonatal periods. In contrast, we confirmed the protective role of iron/folic acid supplements during pregnancy. The risk of early neonatal death was reduced by 51% when mothers took iron/folic acid during pregnancy and this result remained unchanged when use of antenatal care was included in the model. Iron/folic acid supplements were consistently found to prevent early neonatal deaths on the first day (60% reduction) and after the first day of delivery (48% reduction). Similar findings were observed for all neonatal deaths, with a 49% reduction in risk of death with iron/folic acid supplementation.

Strengths and limitations

Data were from two nationally representative surveys with large samples and high response rates.[10 27] To increase validity, we used multivariable analyses to adjust for potential risk factors at the individual, household, and community levels, and adjusted for perinatal health care services, such as type of delivery attendant. The restriction of the analysis to the last birth within five years should have reduced recall errors[28 29] and we further adjusted for time between the recalled birth and the interview in all models.

Despite taking account of many confounders, an important limitation was that mothers were not randomized to receive iron/folic acid supplements or postnatal care so there remains a possibility of residual confounding. Furthermore, our analyses were limited by the lack of information about components of the postnatal care delivered. Only surviving mothers were interviewed and this might have led to an underestimate of neonatal deaths, considering the association between maternal and neonatal mortality.[30] The selection of confounders was also determined by the availability of information in the datasets. The cross sectional data collected implies concurrent measurement of exposure and outcome, which would limit interpretation of causality. However the use of iron/folic acid was recalled by the mother as an exposure antecedent to neonatal death and thus has an appropriate timing element. Similarly, the postnatal care on the first day of life was antecedent to neonatal deaths on days 2-7. The wide ranging interview with the mother that covered many different topics is likely to have reduced differential recall by mothers with and without neonatal deaths.

Comparison with other studies

After adjusting for significant predictors including antenatal care services and iron/folic acid supplements, we did not find any protective effect of early provision of postnatal care services on neonatal deaths. The change of direction in the effect of postnatal care services provided by nurses and midwives after adjustment for iron/folic acid supplements signifies a stronger effect of the supplements which confounded the effects of postnatal care services on neonatal survival. This indicates the need to adjust for use of antenatal iron/folic acid when evaluating the impact of interventions to reduce neonatal deaths.

A key part of the evidence used by WHO/UNICEF[31] to recommend wide use of postnatal care to reduce neonatal deaths was a cluster-randomised trial in Sylhet District, Bangladesh that reported a reduction in neonatal mortality by 34% with home care, in which community health workers made antenatal and postnatal home visits.[16] However, in Mirzapur, Bangladesh, a cluster-randomised trial using the same home-based postnatal care intervention, evaluated with the same methodologies, failed to find any improvement in neonatal mortality compared to usual programs.[32] This difference in impact of postnatal care home visits might be explained by a larger increase in the percentage of pregnant women using iron/folic acid supplements in the intervention group in the Sylhet trial (43% at baseline to 84% at endline) compared to the Mirzapur trial (from 48% to 56%). Data from the Sylhet trial has been used to assess the effect of the timing of the first postnatal care home visit by trained community health workers.[18] This study used data from health workers' records of the home care treatment arm. Although 97% of the women in this group received at least one antenatal home visit,[18] the endline survey[16] for the trial revealed 84% of the women in the home care treatment arm reported any use of iron/folic acid supplements but the number of supplements used was not reported. In the analyses that found home postnatal care within the first two days of life significantly reduced neonatal mortality there was no adjustment made for use of antenatal iron/folic acid. It is possible that earlier postnatal care was associated with greater use of antenatal iron/folic acid and could have confounded these results.

In Nepal[33], a community-based participatory intervention to increase use of perinatal care services and "consultations for difficulties in pregnancy and the newborn period", also showed a reduction in the neonatal mortality rate in intervention clusters; however as in Bangladesh, there was an increased proportion of women taking iron/folic supplement in the intervention group that might have accounted for the reduced mortality. Two other trials of community-based interventions to increase use of perinatal health services including postnatal care, reported significant reductions in newborn deaths but also demonstrated increased uptake of antenatal care, although they did not specifically report use of iron/folic acid supplements.[17 19] Finally a classic quasi-experiment in India[15] in which female village health workers were trained to detect ill newborns and initiate treatment for sepsis, also had a health education component that included nutrition in pregnancy. Two thirds of the pregnant women in the intervention area received education in groups and 76% in individual home visits. No results of the impact of this component on the women's nutrition including use of iron/folic acid supplementation were reported.

Our findings highlight the need for studies, including randomized controlled trials, to examine the impact of different schedules of postnatal care services on neonatal mortality after carefully controlling for differential use of antenatal iron/folic acid before any benefits are ascribed to postnatal care intervention. This is not the case in studies[16 18 33] used to support the recommendation for use of postnatal care to reduce neonatal deaths in low and middle income countries. A useful starting point would be to re-analyse these trials adjusting for the effect of use of iron/folic acid on risk of neonatal death. The assessment of the most effective schedule of postnatal visits is important to prevent unnecessarily increased workloads for health personnel in resource limited settings. The possibility of focusing postnatal visits only on the first day after delivery has been suggested, given the importance of the early days of life for an infant's survival.[5]

The increased risk of neonatal death associated with postnatal care services, especially for deaths on the first day of delivery can be explained by a referral bias since families are more likely to seek professional help when medical complications occur. These findings might also reflect the slow referral system in rural areas particularly if only extremely ill infants are referred to health professionals. This indicates the need to re-examine the recommendations of adding further postnatal care services in the first week of an infant's life prior to obtaining stronger evidence that additional investment in perinatal health care services will provide substantial benefit in improving neonatal survival.

Our analysis confirmed the benefit of iron/folic acid supplements against neonatal deaths, as previously reported in a cluster randomized trial from China[13] and other observational epidemiological studies.[11 12 14 26 34] It has been postulated that infants benefit from these supplements through an increase of gestation and birth weight, and reduction in preterm delivery as well as from the prevention of birth asphyxia.[11 13 14] A recent observational study using IDHS data has reported that the protective effect of iron/folic acid supplements also extends through the first year of life although protection progressively decreased with increasing age.[35] This study also found an increase in the number of iron/folic acid supplements consumed was associated with an increase in protection from child death. The long-term benefit of iron/folic acid supplements has also been reported in rural Nepal with reduced mortality amongst children less than seven years with maternal supplementation.[36]

Although iron/folic acid supplements have been included in routine antenatal care, poor adherence to the daily supplementation regime remains a problem in Indonesia, as shown by the low percentage of pregnant women consuming all of the recommended 90 tablets.[9 10] Problems of supply and compliance[37-39] should be addressed to increase uptake. In Indonesia, distribution of supplements is mainly through antenatal care services. As a consequence, women who underutilize antenatal care services, who are most likely to be in greatest need, do not receive supplements. Distribution needs to be improved to reach women in areas with limited access to care services. The traditional birth attendants, who are still highly utilized by women in remote areas,[10 40] should be involved in public health programs to distribute iron/folic acid in areas with limited access to health services.

Conclusion

In our analyses postnatal care provided no protection from neonatal death in Indonesia. This indicates the need to revisit the current priority given to postnatal care as a tool for reducing neonatal deaths and the recommendation to add visits to postnatal care schedule. Our findings highlight the important role of iron/folic acid supplementation for reducing the risk of neonatal death and the need for more investments in this intervention to accelerate reductions in neonatal mortality. Our findings about the relative impact of postnatal and antenatal iron/folic acid supplements, on neonatal survival are important for planning interventions to reduce newborn deaths in Indonesia and other low and middle income countries. Research is needed to compare the benefits of early and extended use of iron/folic acid with different timing and frequency of postnatal services to assess the relative benefit and effectiveness of these services.

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Competing interest

None declared

Details of contributors

CRT and MJD contributed equally to this work. Both authors participated in the design of the study, performed the data analysis and interpretation, and prepared and reviewed the manuscript. Both authors approved the final version of the manuscript to be published.

Exclusive licence

Data sharing statement

Data used in this study are available at the Measure DHS website (http://www.measuredhs.com/data/available-datasets.cfm). There is no additional data available.

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Table 1. Frequency distribution, unadjusted and adjusted Hazard Ratios (H(t)) of demographic, socio-economic status and birthing characteristics at the community and individual level for early neonatal (day 1-7 after birth) mortality, IDHS 2002/2003 and 2007

VARIABLE	N	(%)	Unadjusted[1] H(t)	Unadjusted[1] (95% CI)	Unadjusted[1] p	Adjusted[1,2] H(t)	Adjusted[1,2] (95% CI)	Adjusted[1,2] p
Year of survey								
IDHS 2002/2003	12646	(47.6)	1.00			1.00		
IDHS 2007	13945	(52.4)	0.88	(0.56 - 1.39)	0.59	0.89	(0.57 - 1.39)	0.60
COMMUNITY LEVEL FACTORS								
Region								
Java-Bali region	15486	(58.2)	1.00					
Sumatera	5615	(21.1)	1.06	(0.63 - 1.77)	0.83			
Eastern Indonesia	5490	(20.6)	1.09	(0.70 - 1.71)	0.70			
Type of residence								
Urban	11776	(44.3)	1.00			1.00		
Rural	14815	(55.7)	0.79	(0.50 - 1.24)	0.30	0.57	(0.33 - 0.97)	0.04
Average paternal years of schooling	Mean ± SE = 8.43 ± 0.07		0.98	(0.90 - 1.06)	0.60			
HOUSEHOLD AND INDIVIDUAL LEVEL FACTORS								
Maternal marital status								
Currently married	25953	(97.6)	1.00					
Formerly married	638	(2.4)	1.68	(0.50 - 5.70)	0.40			
Maternal year of education	Mean ± SE = 8.01 ± 0.07		0.98	(0.93 - 1.03)	0.43			
Household wealth index	Mean ± SE = 0·23 ± 0.04		0.90	(0.81 - 0.99)	0.03	0.85	(0.75 - 0.96)	0.01
Maternal age at childbirth	Mean ± SE = 27.19 ± 0.07		1.05	(1.01 - 1.09)	0.02	1.05	(1.01 - 1.09)	0.01
Child sex								
Female	12764	(48.0)	1.00					
Male	13827	(52.0)	1.42	(0.89 - 2.29)	0.15	1.53	(0.93 - 2.51)	0.09
Birth rank and birth interval								
1^{st} rank	10751	(40.4)	1.00					
$2^{nd}/3^{rd}$ rank, interval > 2 yrs	9139	(34.4)	1.14	(0.62 - 2.10)	0.66			
$2^{nd}/3^{rd}$ rank, interval $\leq$ 2 yrs	1570	(5.9)	1.14	(0.44 - 2.93)	0.79			
$\geq 4^{th}$ rank, interval > 2 yrs	4443	(16.7)	1.88	(1.02 - 3.47)	0.04			
$\geq 4^{th}$ rank, interval $\leq$ 2 yrs	687	(2.6)	1.95	(0.88 - 4.32)	0.10			
Desire for pregnancy								
Wanted then	21560	(81.1)	1.00					
Wanted later	2907	(10.9)	1.15	(0.55 - 2.42)	0.71			
Wanted no more	2044	(7.7)	1.53	(0.67 - 3.51)	0.31			

VARIABLE	N	(%)	Unadjusted[1] H(t)	(95% CI)			p	Adjusted[1,2] H(t)	(95% CI)			p
Delivery complications												
No	15253	(57.4)	1.00					1.00				
Yes	11007	(41.4)	1.68	(1.04	-	2.72)	0.03	1.73	(1.08	-	2.77)	0.02
Birth size												
Average-sized	13912	(52.3)	1.00					1.00				
Smaller than average	3552	(13.4)	4.34	(2.66	-	7.09)	<0.001	4.33	(2.64	-	7.12)	<0.001
Larger than average	8206	(30.9)	0.85	(0.43	-	1.69)	0.64	0.80	(0.39	-	1.63)	0.54

All figures were weighted for the sampling probability
[1] *Data on 3307 cases were missing and they were excluded from the analysis.*
[2]*Model also adjusted for recall period*

Table 2. Frequency distribution for perinatal health care service characteristics, IDHS 2002/2003 and 2007

VARIABLE	N	(%)	Year of IDHS	
			2002/2003	2007
Use of antenatal services				
No	1914	(7.2)	8.0	6.5
Yes	24483	(92.1)	91.2	92.8
Mode of delivery				
Non Caesarean section	25007	(94.0)	96.0	92.3
Caesarean section	1509	(5.7)	4.0	7.2
Delivery attendance				
Untrained delivery attendants	7712	(29.0)	32.5	25.8
Trained delivery attendants	18847	(70.9)	67.3	74.2
Place of delivery				
Non-health facility	14674	(55.2)	59.0	51.8
Health facility	11839	(44.5)	40.8	47.9
Use of iron/folic acid supplements				
Never/don't know	7482	(28.1)	27.7	28.5
Any iron/folic acid supplements	17958	(67.5)	68.7	66.5
PNC on the first day of life by ANY providers				
No PNC or 7+PNC	5349	(20.1)	20.0	20.3
Day 0- 6 PNC by any provider	21225	(79.8)	80.0	79.7
PNC in the first week of life by ANY providers				
No PNC or 7+PNC	5349	(20.1)	20.0	20.3
PNC 0-6 by doctors/OBGYN/ paediatrician	2858	(10.8)	10.1	11.3
PNC 0-6 by nurse/midwife/village midwife	13941	(52.4)	51.0	53.7
PNC 0-6 by traditional birth attendant	4426	(16.6)	18.9	14.6
Day in the first week of life by ANY providers(2)				
No PNC or 7+PNC	5786	(21.8)	23.4	20.3
Day 0 PNC	13000	(48.9)	43.5	53.8
Day 1-6 PNC	7791	(29.3)	33.0	25.9

All calculations are weighted for the sampling probability
**) recall variable is included in the model*

Table 3. **Unadjusted and adjusted Hazard Ratios (H(t)) of perinatal health care service characteristics for early neonatal (day 1-7 after birth) mortality, IDHS 2002/2003 and 2007**

VARIABLE	Unadjusted H(t)	Unadjusted (95% CI)	Unadjusted p	Adjusted (Model 1)[1] H(t)	Adjusted (Model 1)[1] (95% CI)	Adjusted (Model 1)[1] p	Adjusted* (Model 2)[2] H(t)	Adjusted* (Model 2)[2] (95% CI)	Adjusted* (Model 2)[2] p
Use of antenatal services									
No	1.00								
Yes	0.55	(0.27 - 1.13)	0.10						
Mode of delivery									
Non Caesarean section	1.00								
Caesarean section	1.75	(0.76 - 4.05)	0.19						
Delivery attendants									
Untrained delivery attendants	1.00			1.00					
Trained delivery attendants	1.12	(0.68 - 1.86)	0.66	1.51	(0.77 - 2.94)	0.23	1.46	(0.75 - 2.83)	0.27
Place of delivery									
Non-health facility	1.00								
Health facility	1.03	(0.64 - 1.65)	0.91						
Use of iron/folic acid (IFA) supplements									
Never / don't know	1.00			1.00			1.00		
Any IFA	0.48	(0.30 - 0.79)	<0.01	0.51	(0.31 - 0.82)	0.01	0.49	(0.30 - 0.79)	<0.01
Day 1-6 PNC by any care providers[1]									
No PNC or day 7+PNC	1.00			1.00					
Day 1- 6 PNC by any provider	0.79	(0.44 - 1.43)	0.44	1.00	(0.55 - 1.83)	1.00			
Day 1 PNC by any care providers[2]									
No PNC or 7+PNC	1.00						1.00		
Day 1 PNC by any provider	0.96	(0.52 - 1.76)	0.90				1.27	(0.69 - 2.32)	0.44
Day 2-6 PNC by any provider	0.76	(0.37 - 1.56)	0.45				0.91	(0.44 - 1.90)	0.80

All results are weighted for sampling probability. Data on 3307 cases were missing and they were excluded from the analysis.
[1] Model 1 examined the effects of Day 1-7 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child, and child size at birth based on mother's subjective assessment.
[2] Model 2 examined the effects of Day 1 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child, and child size at birth based on mother's subjective assessment.

Table 4. Unadjusted and adjusted Hazard Ratios (H(t)) of perinatal health care service characteristics for all neonatal (1-31 days) mortality, IDHS 2002/2003 and 2007

VARIABLE	Unadjusted H(t)	Unadjusted (95% CI)	Unadjusted p	Adjusted[*] (Model 1) H(t)	Adjusted[*] (Model 1) (95% CI)	Adjusted[*] (Model 1) p	Adjusted[*] (Model 2) H(t)	Adjusted[*] (Model 2) (95% CI)	Adjusted[*] (Model 2) p
Use of antenatal services									
No	1.00								
Yes	0.40	(0.21 - 0.77)	0.01						
Mode of delivery									
Non Caesarean section	1.00								
Caesarean section	2.06	(0.94 - 4.53)	0.07						
Delivery attendance									
Untrained delivery attendants	1.00			1.00			1.00		
Trained delivery attendants	0.92	(0.58 - 1.44)	0.70	1.05	(0.57 - 1.93)	0.88	1.03	(0.57 - 1.87)	0.93
Place of delivery									
Non-health facility	1.00								
Health facility	0.97	(0.64 - 1.48)	0.89						
Use of iron/folic acid supplements									
Never / don't know	1.00			1.00			1.00		
Any iron/folic acid	0.51	(0.33 - 0.79)	<0.01	0.52	(0.33 - 0.82)	0.01	0.51	(0.32 - 0.81)	0.01
Day 1-6 PNC by any care providers									
No PNC or day 7+PNC	1.00			1.00					
Day 1- 6 PNC by any provider	0.98	(0.58 - 1.65)	0.93	1.21	(0.70 - 2.09)	0.49			
Day 1 PNC by any care providers									
No PNC or 7+PNC	1.00						1.00		
Day 1 PNC by any provider	1.09	(0.63 - 1.87)	0.76				1.43	(0.83 - 2.47)	0.20
Day 2-6 PNC by any provider	1.06	(0.56 - 1.97)	0.87				1.22	(0.64 - 2.34)	0.54

All results are weighted for sampling probability. [1] *Data on 3307 cases were missing and they were excluded from the analysis.*

[1] *Model 1 examined the effects of Day 1-7 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, sex of the child, delivery complications, child size at birth, delivery attendants and use of iron/folic acid supplements.*

[2] *Model 2 examined the effects of Day 1 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, sex of the child, delivery complications, child size at birth, delivery attendants and use of iron/folic acid supplements.*

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Figure 1. **Effects of iron-folic acid supplementation and postnatal care services on early neonatal mortality, IDHS 2002/2003 and 2007**

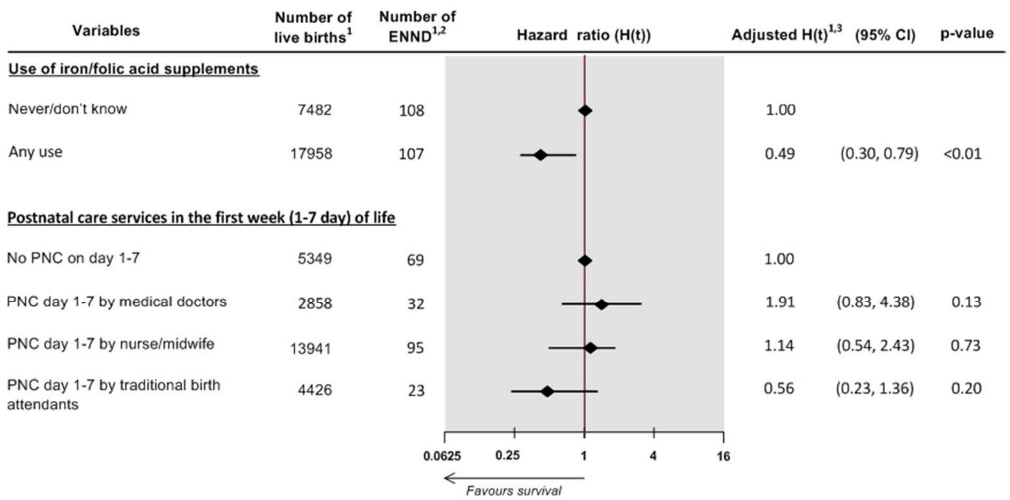
Note:
[1] Weighted for the sampling probability, [2] ENND = early neonatal death, [3] Model obtained by using Cox Proportional Hazards regression analysis and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child and child size at birth based on mother's subjective assessment. All values are weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. See Web Table 1 for details of this model.

Figure 2. **Effects of iron-folic acid supplementation and postnatal care services on early neonatal deaths occurring on the day of delivery (day 1), IDHS 2002/2003 and 2007**

Note:
[1] Weighted for the sampling probability, [2] ENND = early neonatal death, [3]Model obtained by using Cox Proportional Hazards regression analysis and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child and child size at birth based on mother's subjective assessment. All values are weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. See Web Table 2 for details of this model.

Figure 3. **Effects of iron-folic acid supplementation and postnatal care services on early neonatal deaths occurring after the day of delivery (day 2-7), IDHS 2002/2003 and 2007**

Note:
[1] Weighted for the sampling probability, [2] ENND = early neonatal death, [3] Model obtained by using Cox Proportional Hazards regression analysis and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child and child size at birth based on mother's subjective assessment. All values are weighted for the sampling probability. Data on 3290 cases were missing and they were excluded from the analysis.



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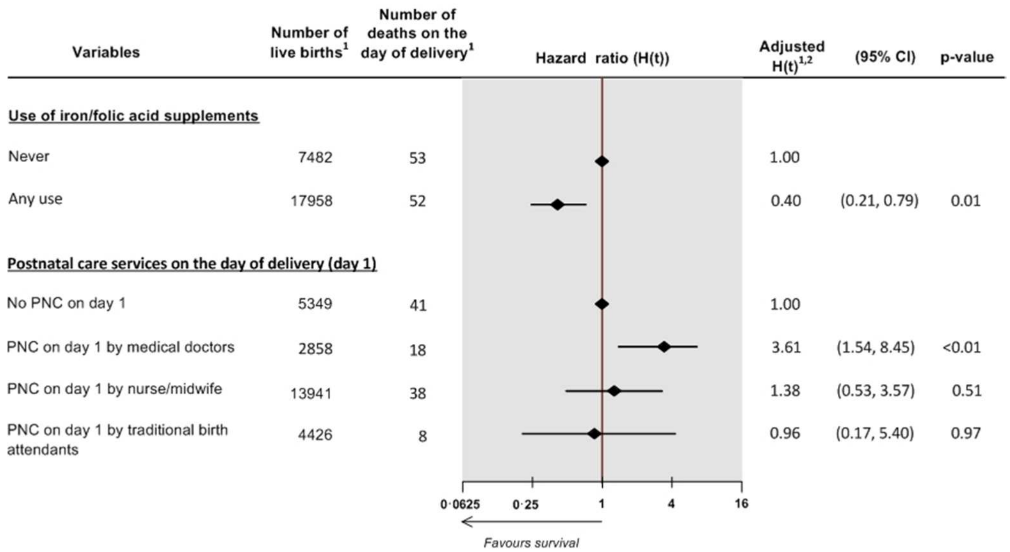

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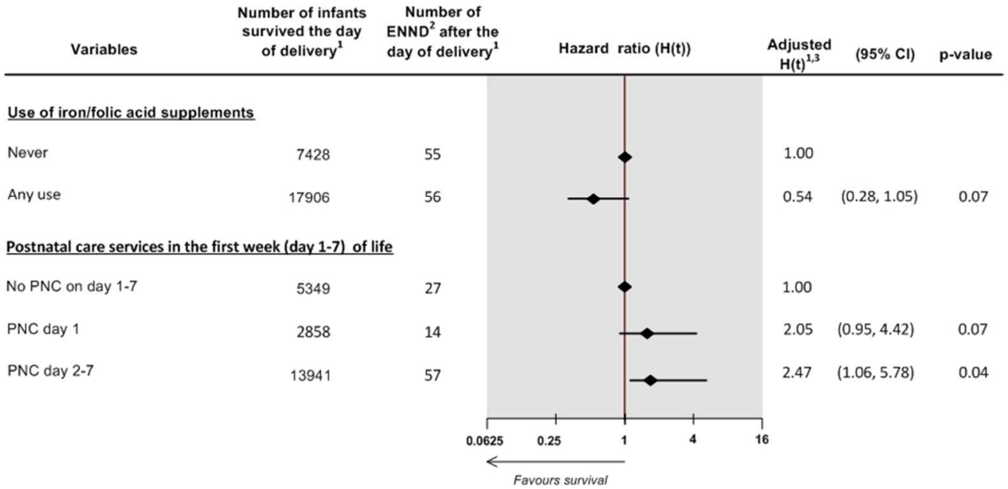

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Web Table 1. Multivariable analyses using socio-demographic, birth characteristics and pregnancy and health services factors for all early neonatal deaths (results used for Figure 1)

VARIABLE	Unadjusted H(t)	Unadjusted 95% CI	Unadjusted p	Adjusted* H(t)	Adjusted* 95% CI	Adjusted* p
Year of survey						
IDHS 2002/2003	1.00			1.00		
IDHS 2007	0.88	0.56 - 1.39	0.59	0.89	0.57 - 1.39	0.60
COMMUNITY LEVEL FACTORS						
Region						
Java-Bali region	1.00					
Sumatera	1.06	0.63 - 1.77	0.83			
Eastern Indonesia	1.09	0.70 - 1.71	0.70			
Type of residence						
Urban	1.00			1.00		
Rural	0.79	0.50 - 1.24	0.30	0.57	0.33 - 0.97	0.04
Average paternal years of schooling	0.98	0.90 - 1.06	0.60			
SOCIO ECONOMIC DETERMINANTS						
Maternal marital status						
Currently married	1.00					
Formerly married	1.68	0.50 - 5.70	0.40			
Maternal year of education	0.98	0.93 - 1.03	0.43			
Household wealth index	0.90	0.81 - 0.99	0.03	0.85	0.75 - 0.96	0.01
PROXIMATE DETERMINANTS						
Maternal age at childbirth	1.05	1.01 - 1.09	0.02	1.05	1.01 - 1.09	0.01
Child sex						
Female	1.00					

VARIABLE	Unadjusted H(t)	Unadjusted 95% CI	p	Adjusted* H(t)	Adjusted* 95% CI	p
Male	1.42	0.89 - 2.29	0.15	1.53	0.93 - 2.51	0.09
Birth rank and birth interval						
1st rank	1.00					
2nd/3rd rank, interval > 2 yrs	1.14	0.62 - 2.10	0.66			
2nd/3rd rank, interval < 2 yrs	1.14	0.44 - 2.93	0.79			
> 4th rank, interval > 2 yrs	1.88	1.02 - 3.47	0.04			
> 4th rank, interval < 2 yrs	1.95	0.88 - 4.32	0.10			
Desire for pregnancy						
Wanted then	1.00					
Wanted later	1.15	0.55 - 2.42	0.71			
Wanted no more	1.53	0.67 - 3.51	0.31			
Delivery complications						
No	1.00			1.00		
Yes	1.68	1.04 - 2.72	0.03	1.73	1.08 - 2.77	0.02
Birth size						
Average-sized	1.00			1.00		
Smaller than average	4.34	2.66 - 7.09	<0.001	4.33	2.64 - 7.12	<0.001
Larger than average	0.85	0.43 - 1.69	0.64	0.80	0.39 - 1.63	0.54
PERINATAL HEALTH CARE SERVICES						
Use of antenatal services						
No	1.00					
Yes	0.55	0.27 - 1.13	0.10			
Mode of delivery						
Non Caesarean section	1.00					
Caesarean section	1.75	0.76 - 4.05	0.19			

VARIABLE	Unadjusted H(t)	Unadjusted 95% CI	Unadjusted p	Adjusted* H(t)	Adjusted* 95% CI	Adjusted* p
Delivery attendance						
Untrained delivery attendants	1.00			1.00		
Trained delivery attendants	1.12	0.68 - 1.86	0.66	1.03	0.47 - 2.30	0.93
Place of delivery						
Non-health facility	1.00					
Health facility	1.03	0.64 - 1.65	0.91			
Use of iron/folic acid (IFA) supplements						
Never / don't know	1.00			1.00		
Any IFA	0.48	0.30 - 0.79	<0.01	0.49	0.30 - 0.79	<0.01
Day 1-7 PNC by any care providers						
No PNC on day 1-7	1.00			1.00		
PNC day 1-7 by doctors/OBGYN/ paediatrician	1.41	0.68 - 2.92	0.36	1.91	0.83 - 4.38	0.13
PNC 1-7 by nurse/midwife/village midwife	0.76	0.41 - 1.42	0.40	1.14	0.54 - 2.43	0.73
PNC 1-7 by traditional birth attendant	0.50	0.21 - 1.20	0.12	0.56	0.23 - 1.36	0.20

Note:
All figures were weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. Model also adjusted for recall period

Web Table 2. Multivariable analyses using socio-demographic, birth characteristics and pregnancy and health services factors for neonatal deaths occurring on the day of delivery (day 1 deaths) (results used for Figure 2)

VARIABLE	Unadjusted			Adjusted*		
	H(t)	95% CI	p	H(t)	95% CI	p
Year of survey						
IDHS 2002/2003	1.00			1.00		
IDHS 2007	0.78	0.36 - 1.67	0.52	0.91	0.48 - 1.72	0.77
COMMUNITY LEVEL FACTORS						
Region						
Java-Bali region	1.00					
Sumatera	1.00	0.45 - 2.21	1.00			
Eastern Indonesia	1.16	0.55 - 2.42	0.70			
Type of residence						
Urban	1.00			1.00		
Rural	0.46	0.23 - 0.92	0.03	0.31	0.14 - 0.68	0.00
Average paternal years of schooling	0.95	0.85 - 1.06	0.33			
SOCIO ECONOMIC DETERMINANTS						
Maternal marital status						
Currently married	1.00					
Formerly married	1.41	0.26 - 7.60	0.69			
Maternal year of education	1.03	0.96 - 1.10	0.41			
Household wealth index	0.87	0.77 - 0.99	0.03	0.78	0.67 - 0.91	0.00
PROXIMATE DETERMINANTS						
Maternal age at childbirth	0.99	0.93 - 1.05	0.67	1.03	0.97 - 1.09	0.33

Child sex						
Female	1.00					
Male	1.69	0.73 - 3.91	0.22	1.51	0.70 - 3.25	0.30
Birth rank and birth interval						
1st rank	1.00					
2nd/3rd rank, interval > 2 yrs	1.56	0.59 - 4.10	0.37			
2nd/3rd rank, interval ≤ 2 yrs	1.39	0.34 - 5.71	0.65			
≥ 4th rank, interval > 2 yrs	0.84	0.33 - 2.10	0.71			
≥ 4th rank, interval ≤ 2 yrs	2.21	0.59 - 8.30	0.24			
Desire for pregnancy						
Wanted then	1.00					
Wanted later	1.19	0.44 - 3.23	0.73			
Wanted no more	0.33	0.12 - 0.88	0.03			
Delivery complications						
No	1.00					
Yes	1.33	0.61 - 2.88	0.48	1.45	0.73 - 2.90	0.29
Birth size						
Average-sized	1.00					
Smaller than average	3.38	1.52 - 7.52	<0.01	4.10	1.95 - 8.59	0.00
Larger than average	0.91	0.28 - 2.99	0.88	0.84	0.27 - 2.57	0.76
PERINATAL HEALTH CARE SERVICES						
Use of antenatal services						
No	1.00					
Yes	0.73	0.26 - 2.05	0.56			
Mode of delivery						
Non Caesarean section	1.00					

Caesarean section	2.15	0.60 - 7.69	0.24			
Delivery attendance						
Untrained delivery attendants	1.00			1.00		
Trained delivery attendants	1.69	0.71 - 3.98	0.23	1.63	0.50 - 5.32	0.42
Place of delivery						
Non-health facility	1.00					
Health facility	1.41	0.65 - 3.03	0.39			
Use of iron/folic acid (IFA) supplements						
Never / don't know				1.00		
Any IFA	0.78	0.31 - 1.95	0.60	0.40	0.21 - 0.79	0.01
First day PNC by any care providers						
No PNC on day 1				1.00		
PNC day 1 by doctors/OBGYN/paediatrician	6.95	2.42 - 19.95	<0.001	3.61	1.54 - 8.45	0.00
PNC day 1 by nurse/midwife/village midwife	2.13	0.78 - 5.86	0.14	1.38	0.53 - 3.57	0.51
PNC day 1 by traditional birth attendant	1.72	0.30 - 9.84	0.54	0.96	0.17 - 5.40	0.97

Note:
All figures were weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. Model also adjusted for recall period

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Antenatal iron/folic acid supplements, but not postnatal care, prevents neonatal deaths in Indonesia: analysis of Indonesia Demographic and Health Surveys 2002/2003 – 2007 (a retrospective cohort study)

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Abstract

Objective
This study aimed to assess the contribution of postnatal services to the risk of neonatal mortality, and the relative contributions of antenatal iron/folic acid supplements and postnatal care in preventing neonatal mortality in Indonesia.

Design
Retrospective cohort study

Setting and participants
Data used in this study were the 2002-2007 Indonesia Demographic and Health Surveys, nationally representative surveys. The pooled data provided survival information of 26,591 most recent live-born infants within the five-years prior to each interview.

Primary outcomes
Primary outcomes were early neonatal mortality, i.e. deaths in the first week, and all neonatal mortality, i.e. deaths in the first month of life. Exposures were antenatal iron/folic acid supplementation and postnatal care from days 1-7. Potential confounders were community, socio-economic status and birthing characteristics and perinatal health care. Cox regression was used to assess the association between study factors and neonatal mortality.

Results
Postnatal care services were not associated with newborn survival. Postnatal care on days 1-6 after birth did not reduce neonatal death (HR=1.00, 95% CI: 0.55-1.83, p=1.00) and early postnatal care on day 1 was associated with an increased risk of early neonatal death (HR=1.27, 95% CI: 0.69-2.32, p=0.44) possibly reflecting referral of ill newborns. Early postnatal care on day 1 was not protective for neonatal deaths on days 2 to 6 whether provided by doctors (HR 3.61, 95% CI: 1.54-8.45, p<0.01), or by midwives or nurses (HR 1.38, 95% CI: 0.53-3.57, p=0.512). In mothers who took iron/folic acid supplements during pregnancy, the risk of early neonatal death was reduced by 51% (HR=0.48, 95% CI: 0.30-0.79, p<0.01).

Conclusions
We found no protective effect of postnatal care against neonatal deaths in Indonesia. However, important reductions in the risk of neonatal death were found for women who reported use of antenatal iron/folic acid supplements during pregnancy.

Article summary

Article Focus

- Iron/folic acid supplements during pregnancy have been reported to protect against neonatal death.
- Postnatal care services are also claimed to be important to prevent neonatal mortality.
- This study aimed to examine the relative importance of antenatal iron/folic acid supplements and postnatal care services in improving neonatal survival in Indonesia.

Key Messages

- Postnatal care did not protect against neonatal and early neonatal deaths after adjusting for the effects of iron/folic acid supplements.
- Iron/folic acid supplements consistently prevented neonatal death and early neonatal deaths (on the first day and after the first day of delivery).
- Programs aimed at reducing neonatal mortality in Indonesia need to place more emphasis on iron/folic acid supplementation during pregnancy.
- Further research is needed to understand the reasons for the lack of impact of postnatal are on neonatal mortality in Indonesia.

Strengths and Limitations

- Data were taken from two nationally representative surveys with large samples and high response rates.
- The survey used a retrospective cohort design in which the mother recalled the health services exposures that occurred prior to the outcome of interest - neonatal death.
- Recall bias was reduced by restricting the analysis to the last birth within five years prior to the interview.
- An important limitation was that mothers were not randomized to receive iron/folic acid supplements or postnatal care so there remains a possibility of residual confounding.
- Our analyses were limited by the lack of information about components of the postnatal care delivered.

Introduction

Of 7.7 million child deaths in 2010 worldwide, approximately 3.1 million were neonatal deaths.[1] Approximately 75% of neonatal deaths occur in the early neonatal period, or the first seven days after delivery and 50% occur in the first 24 hours.[2] Failure to reduce neonatal deaths might prevent countries from attaining their fourth Millennium Development Goal that is to reduce child mortality by two thirds by 2015.[2-5] Interventions to reduce the number of neonatal deaths are important especially in developing countries.[2 6]

Infants of mothers who receive antenatal care services have a reduced risk of neonatal deaths.[7 8] Antenatal services include a pregnancy check up by health personnel, provision of iron/folic acid supplements, tetanus toxoid vaccination and health education and counseling. In Indonesia, pregnant women are recommended to attend at least four antenatal visits.[9] The 2007 Indonesia Demographic and Health Survey (IDHS) showed that only 66% of women had four antenatal visits, lower than the national target of 90%.[10] The Ministry of Health also reported a wide discrepancy of antenatal care utilization across provinces.[9] DKI Jakarta has the highest (96%) and Papua Province the lowest (38%) percentage of women attending all visits.[9]

Iron/folic acid supplements reduce the risk of neonatal mortality.[11-14] In Indonesia, pregnant women should receive 90 tablets of iron/folic acid supplements, which has been used as an indicator of the quality of antenatal care services.[9] Nonetheless, in 2008 only 48% of pregnant women received this dose.[9]

Postnatal care services are important in preventing neonatal mortality.[15-19] Adequate postnatal care is considered vital since most neonatal deaths occur within the first week of life. WHO and UNICEF recommend at least two visits for home births within the first week of the infants' life; whereas for babies delivered in health care facilities, the first home visit should be immediately the baby comes home.[20] In Bangladesh, neonatal deaths were significantly lower amongst infants who had a postnatal home visit on the first two days after delivery.[18] However there was no significant reduction of the risk of neonatal death in newborns with their first postnatal visit after the second day of life. In Indonesia, three postnatal home visits have recently been recommended to replace the previous postnatal schedule of two visits with an additional visit in the first week of life.[21]

These findings highlight the need for further examination of the roles of iron/folic acid supplements and postnatal care services in improving neonatal survival. Our aim was to assess the relative contribution of antenatal iron/folic acid supplements and postnatal care services in reducing the risk of neonatal death.

Methods

Data sources

Data of the 2002/2003 and 2007 Indonesia Demographic and Health Surveys (IDHS) were available .[22] A multi-stage, stratified, cluster random sampling was used to collect demographic and health information by interviewing ever married women in reproductive age (15-49 years) and ever married men (15-54 years). Three questionnaires used were used. The Household Questionnaire collected information about the economic status of each household. The Women's Questionnaire collected information about socio-demographic characteristics and health-related information, including use of antenatal, delivery and postnatal services and child and maternal deaths. The Men's Questionnaire collected information about men's socio-demographic and health information. The IDHS is designed to produce estimates at the national, provincial, and urban/rural level.[23]

In this pooled analysis, survival information from 26,591 most recent live-born infants within the five-years prior to each interview was used, consisting of 12,646 infants from the 2002 IDHS and 13,945 from the 2007 IDHS. Participation in IDHS has an average response rate of 97%.

Primary outcome and study variables

The primary outcome was early neonatal death defined as death during the first week of life (days 1-7). All neonatal death was defined as deaths occurring during the first month life (days 1-31).

Iron/folic acid supplement was the reported use of any iron/folic acid during pregnancy. The commonly used formulation in Indonesia is iron 60 mg and folic acid 0.25 mg. This variable was based on question of, "*For how many days during this pregnancy did you [mother] take the iron?"* A mother was classified as using antenatal iron/folic acid supplements if they reported taking iron/folic acid tablets for at least a day during pregnancy, although our analysis did not analyse in specific the number of days mothers took iron supplements.

Postnatal care services received by infants in the first six days of life were based on three questions, (1) *"After (NAME) was born, did a health professional or a traditional birth attendant check on his/her health?"*, (2) *"How many days or weeks after delivery did the first check take place?"* and (3) "*Who checked on (NAME)'s health at that time?*" For (3), options were (a) health personnel, i.e. general doctor, obstetrician, paediatrician, nurse, midwife (b) traditional birth attendant, (c) other. Three postnatal care variables were constructed: a two-category variable of (1) no postnatal care or postnatal care after day 7 and (2) postnatal care services from day 1-7 delivered by any care provider (trained or untrained). Secondly, a four-category variable consisting of (1) no postnatal care, or postnatal care after day 7, (2) postnatal care from day 1-7 by a doctor/specialist/ paediatrician, (3) postnatal care from day 1-7 by a nurse/midwife/village midwife, and (4) postnatal care from day 1-7 by untrained personnel (traditional birth attendants). Thirdly, a three-category variable consisting of (1) no postnatal care/postnatal care after day 7 or (2) postnatal care on day 1 and (3) from day 2-7 by any type of care provider. During data collection, women were recommended to have at least two postnatal care services, once during day 1-7 and once during days 8-28 after delivery.

Potential confounding factors

A framework of factors which might potentially affect child survival in developing countries was adapted for the analysis.[24] Sixteen potential confounders were classified into two groups: (1) demographic, socio-economic status and birthing characteristics, and (2) perinatal health care services.

In the first group, twelve variables were region, type of residence (urban/rural), average paternal year of schooling in the cluster, maternal year of education, household wealth index, maternal age at childbirth, child sex, combined birth rank and interval, maternal desire for pregnancy, reported delivery complications (including prolonged labor, excessive vaginal bleeding, fever/foul smelling and convulsions) and combined birth size and duration of pregnancy.

In the second group, two study variables (antenatal iron/folic acid supplements and postnatal care) and use of five perinatal health services (antenatal care, mode of delivery, delivery attendance and place of delivery) were included. Antenatal care services refer any to preventive health services provided by health personnel, such as doctors, midwives, or village midwives, during pregnancy. Duration of the recall period between date of childbirth and interview was also included in multivariate models.

Household wealth index used 11 variables from the pooled datasets including source of drinking water, type of toilet, main material of wall, floor, availability of electricity, possession of radio, television, fridge, bicycle, motorcycle, and car. Principal component analysis was used to assign weights to create an indicator of household economic status.[25]

A variable of combined birth rank/ birth interval was constructed with five-categories, i.e. first birth rank infants, second/third birth rank infants with previous birth interval of more than two years, second/third rank infants with previous birth interval of less than or equal to two years, fourth birth rank infants with previous birth interval of more than two years, and fourth birth rank infants with previous birth interval of less than or equal to two years.

In the analyses, birth size replaced birth weight due to 19% of infants not weighed at birth. There is a close correlation between mother's assessment of child size and birth weight.[26]

Statistical analysis

Cox regression was used to examine the association between neonatal mortality and study factors with multivariable analyses to examine associations between early neonatal mortality and study factors after controlling for covariates.

In multivariable analysis, a multi-stage model using a hierarchical approach was applied.[27] Using this approach, the association between distal variables with study outcomes can be assessed without improper adjustment by intermediate variables through which the distal variables might affect the outcomes. At the first stage, community, socio-economic status and birthing characteristics, year of IDHS survey and days of recollection period, were entered. Backward elimination was used to remove non-significant factors (P>0.05). Two variables, year of IDHS survey and days of recollection period were selected a priori to be retained in the model to adjust for secular trends.

At the second stage, use of perinatal health care service characteristics including use of iron/folic acid supplements and postnatal care services were entered with backward elimination to remove non-significant factors. Two postnatal care services variables were entered, one at a time, to assess their association with the study outcome. Variables for delivery attendance were retained regardless of significance.

A similar modelling strategy was used to examine predictors of neonatal mortality. In the final models, the same sets of variables were retained for both neonatal and early neonatal deaths. Regression models were also used for early neonatal mortality occurring on the day of birth (day 1) and after day of delivery (days 2-7).

Data were analysed using STATA/MP version 10.00 (Stata Corporation, College Station, TX, USA). Cox regression models were adjusted for sampling weights and the cluster design.

Results

There were 26,591 live-born singleton infants most recently born to each mother in the prior 5 years, with 219 early neonatal deaths and 290 neonatal deaths. Although neonatal deaths decreased from 115 (IDHS 2002/2003) to 104 (IDHS 2007), the proportion of early neonatal death on the first day of life increased from 47% to 50%.

Table 1 shows community, socio-economic status and birthing characteristics. Multivariable analyses showed that type of residence (urban/rural), household wealth index, and maternal age at childbirth, presence of delivery complications and birth size of the child were significantly associated with early neonatal deaths.

Perinatal health care service characteristics are presented in Table 2. There was an increased utilization of antenatal services, trained delivery attendants, institutional deliveries, and postnatal services in the last ten years. However, the use of iron/folic acid supplements decreased from 69% (IDHS 2002/2003) to 67% (IDHS 2007).

There was no significant protective effect of postnatal care services regardless of the timing of the service. Table 3 shows no effect of postnatal care by any provider in the first week of life (HR=1.00, 95% CI: 0.55-1.83, p=1.00). In the univariable analysis the use of postnatal care services showed protection for early neonatal deaths, although not significant (HR=0.79, 95% CI: 0.44-1.43, p=0.44); however, when use of iron/folic acid supplements was included, this effect disappeared. Similar findings were observed for the effect of postnatal care services according to the timing of the care (Table 3, Model 2) There was an increased hazard ratio for infants who received care by any provider on the day of delivery (HR=1.27, 95% CI: 0.69-2.32, p=0.44), although not significant. There was a change in the direction of early postnatal care services provided after birth (day one) on early neonatal deaths when use of iron/folic acid supplements was included in the model.

When antenatal care service was added back into the final model, the result remained essentially the same with use of iron/folic acid being protective of neonatal deaths (HR= 0.51, 95% CI: 0.31-0.82, p=0.01) and use of postnatal care having no effect on neonatal deaths (HR=1.00, 95% CI: 0.55-1.83, p=1.00).

Using the same variables, analyses of perinatal care services for all neonatal mortality (1-31 days) showed similar findings (Table 4). An increased hazard ratio (HR=1.21, 95% CI:

0.70-2.09, p=0.49) was associated with infants who received postnatal care by any provider in the first week of life (Model 1). The hazard ratio of postnatal care services also changed direction from being protective (HR=0.98, 95% CI: 0.58-1.65, p=0.93) against neonatal mortality in the univariable analyses, to an increased risk after adjusting for iron/folic acid supplements. When the effect of early postnatal care services (on day 1) was examined, there was no significant protection of postnatal care in univariable (HR=1.09, 95% CI: 0.63-1.87, p=0.76) or multivariable analysis (HR=1.43, 95% CI: 0.83-2.47, p=0.49) after adjusting for iron/folic acid supplements (Model 2). When antenatal care service was added back into the final model for all neonatal deaths, the results did not change (data not shown).

In contrast, we found the benefit of iron/folic acid supplements was consistently present across all models. Antenatal use of these supplements significantly reduced the risk of early neonatal death by 49% to 51% (Table 3) and all neonatal deaths by 48% to 49% (Table 4).

Figure 1 presents the results of the multivariable analyses for early neonatal deaths according to the provider of postnatal care services. For all providers, postnatal care in the first week of life did not protect infants from neonatal death. There was a tendency for infants who received care from trained providers to have a slightly higher risk and untrained providers a slightly lower risk of neonatal death, perhaps reflecting referral of ill newborns.

There was a significant interaction between postnatal care services and urban/rural residence. In urban areas there was no significant protective effect of postnatal care on early neonatal deaths amongst infants receiving postnatal care within the first week of life either by medical doctors (HR=0.94, 95% CI: 0.31-2.85, p=0.92), nurse or midwives (HR=0.88 95% CI: 0.28-2.73, p=0.83), or traditional birth attendants (HR=0.94, 95% CI: 0.24-3.64, p=0.93). However, in rural areas, the risk for early neonatal deaths increased significantly in infants who received postnatal care from medical doctors (HR=5.44, 95% 1.84-16.11, p<0.01) but infants who received care from traditional birth attendants had a lower risk (HR=0.38, 95% CI: 0.16-0.90, p=0.03). There was no significant interaction between place of delivery or delivery complications and postnatal care services.

Figure 2 shows neonatal deaths on the day of delivery. There was no protection for day 1 death from postnatal care provided by midwives/nurse or traditional birth attendants. There was a significantly increased risk in infants who received postnatal care services from medical doctors (HR=3.61, 95% CI: 1.54-8.45, p<0.01).

Figure 3 shows the effect of postnatal care services on the day of delivery on the risk of neonatal deaths day 2-7. There was no protective effect of postnatal care services provided immediately after delivery. An increased hazards ratio was associated with postnatal care services on the day of delivery, although borderline significant (HR=2.05, 95% CI: 0.95-4.42, p=0.07). However, there was an increased risk when postnatal care was first delivered beyond the first day after delivery (HR=2.47, 95% CI: 1.06-5.78, p=0.04).

Discussion

Main findings

Using data from two nationally representative surveys, we found no protective effect of postnatal care services for newborn survival after adjusting for the effects of iron/folic acid supplements. An increased risk of early neonatal death on the day of delivery was associated with postnatal care services from medical doctors, which might be related to referral bias. The strongest evidence of a lack of protective effect of postnatal care for neonatal deaths was our failure to show any protective effects for postnatal care delivered on the first day of life, for subsequent neonatal deaths in both early and overall neonatal periods. In contrast, we confirmed the protective role of iron/folic acid supplements during pregnancy. The risk of early neonatal death was reduced by 51% when mothers took iron/folic acid during pregnancy and this result remained unchanged when use of antenatal care was included in the model. Iron/folic acid supplements were consistently found to prevent early neonatal deaths on the first day (60% reduction) and after the first day of delivery (48% reduction). Similar findings were observed for all neonatal deaths, with a 49% reduction in risk of death with iron/folic acid supplementation.

Strengths and limitations

Data were from two nationally representative surveys with large samples and high response rates.[10 28] To increase validity, we used multivariable analyses to adjust for potential risk factors at the individual, household, and community levels, and adjusted for perinatal health care services, such as type of delivery attendant. The restriction of the analysis to the last birth within five years should have reduced recall errors[29 30] and we further adjusted for time between the recalled birth and the interview in all models.

Despite taking account of many confounders, an important limitation was that mothers were not randomized to receive iron/folic acid supplements or postnatal care so there remains a possibility of residual confounding. Furthermore, our analyses were limited by the lack of information about components of the postnatal care delivered. Only surviving mothers were interviewed and this might have led to an underestimate of neonatal deaths, considering the association between maternal and neonatal mortality.[31] The selection of confounders was also determined by the availability of information in the datasets. The cross sectional data collected implies concurrent measurement of exposure and outcome, which would limit interpretation of causality. All information used in this analysis was based on the mothers' recollection and therefore might be subject to recall and misclassification bias. However, this may occur equally to all information provided about perinatal health services. The effect of this misclassification bias, if present, would most likely have led to an apparently reduced effect measure for both iron/folic acid and postnatal care services on neonatal mortality. Moreover, the use of iron/folic acid was recalled by the mother as an exposure antecedent to neonatal death and thus has an appropriate timing element. Similarly, the postnatal care on the first day of life was antecedent to neonatal deaths on days 2-7. The wide ranging interview with the mother that covered many different topics is likely to have reduced differential recall by mothers with and without neonatal deaths.

Comparison with other studies

After adjusting for significant predictors including antenatal care services and iron/folic acid supplements, we did not find any protective effect of early provision of postnatal care services on neonatal deaths. The change of direction in the effect of postnatal care services provided by nurses and midwives after adjustment for iron/folic acid supplements signifies a stronger effect of the supplements which confounded the effects of postnatal care services on neonatal survival. This indicates the need to adjust for use of antenatal iron/folic acid when evaluating the impact of interventions to reduce neonatal deaths.

A key part of the evidence used by WHO/UNICEF[32] to recommend wide use of postnatal care to reduce neonatal deaths was a cluster-randomised trial in Sylhet District, Bangladesh that reported a reduction in neonatal mortality by 34% with home care, in which community health workers made antenatal and postnatal home visits.[16] However, in Mirzapur, Bangladesh, a cluster-randomised trial using the same home-based postnatal care intervention, evaluated with the same methodologies, failed to find any improvement in neonatal mortality compared to usual programs.[33] This difference in impact of postnatal care home visits might be explained by a larger increase in the percentage of pregnant women using iron/folic acid supplements in the intervention group in the Sylhet trial (43% at baseline to 84% at endline) compared to the Mirzapur trial (from 48% to 56%). Data from the Sylhet trial has been used to assess the effect of the timing of the first postnatal care home visit by trained community health workers.[18] This study used data from health workers' records of the home care treatment arm. Although 97% of the women in this group received at least one antenatal home visit,[18] the endline survey[16] for the trial revealed 84% of the women in the home care treatment arm reported any use of iron/folic acid supplements but the number of supplements used was not reported. In the analyses that found home postnatal care within the first two days of life significantly reduced neonatal mortality there was no adjustment made for use of antenatal iron/folic acid. It is possible that earlier postnatal care was associated with greater use of antenatal iron/folic acid and could have confounded these results.

In Nepal[34], a community-based participatory intervention to increase use of perinatal care services and "consultations for difficulties in pregnancy and the newborn period", also showed a reduction in the neonatal mortality rate in intervention clusters; however as in Bangladesh, there was an increased proportion of women taking iron/folic supplement in the intervention group that might have accounted for the reduced mortality. Two other trials of community-based interventions to increase use of perinatal health services including postnatal care, reported significant reductions in newborn deaths but also demonstrated increased uptake of antenatal care, although they did not specifically report use of iron/folic acid supplements.[17 19] Finally a classic quasi-experiment in India[15] in which female village health workers were trained to detect ill newborns and initiate treatment for sepsis, also had a health education component that included nutrition in pregnancy. Two thirds of the pregnant women in the intervention area received education in groups and 76% in individual home visits. No results of the impact of this component on the women's nutrition including use of iron/folic acid supplementation were reported.

Our findings highlight the need for studies, including randomized controlled trials, to examine the impact of different schedules of postnatal care services on neonatal mortality after carefully controlling for differential use of antenatal iron/folic acid before any benefits are ascribed to postnatal care intervention. This is not the case in studies[16 18 34] used to support the recommendation for use of postnatal care to reduce neonatal deaths in low and middle income countries. A useful starting point would be to re-analyse these trials adjusting for the effect of use of iron/folic acid on risk of neonatal death. The assessment of the most effective schedule of postnatal visits is important to prevent unnecessarily increased workloads for health personnel in resource limited settings. The possibility of focusing postnatal visits only on the first day after delivery has been suggested, given the importance of the early days of life for an infant's survival.[5]

The increased risk of neonatal death associated with postnatal care services, especially for deaths on the first day of delivery can be explained by a referral bias since families are more likely to seek professional help when medical complications occur. These findings might also reflect the slow referral system in rural areas particularly if only extremely ill infants are referred to health professionals. This indicates the need to re-examine the recommendations of adding further postnatal care services in the first week of an infant's life prior to obtaining stronger evidence that additional investment in perinatal health care services will provide substantial benefit in improving neonatal survival.

Our analysis confirmed the benefit of iron/folic acid supplements against neonatal deaths, as previously reported in a cluster randomized trial from China[13] and other observational epidemiological studies.[11 12 14 26 35] It has been postulated that infants benefit from these supplements through an increase of gestation and birth weight, and reduction in preterm delivery as well as from the prevention of birth asphyxia.[11 13 14] A recent observational study using IDHS data has reported that the protective effect of iron/folic acid supplements also extends through the first year of life although protection progressively decreased with increasing age.[36] This study also found an increase in the number of iron/folic acid supplements consumed was associated with an increase in protection from child death. The long-term benefit of iron/folic acid supplements has also been reported in rural Nepal with reduced mortality amongst children less than seven years with maternal supplementation.[37]

Although iron/folic acid supplements have been included in routine antenatal care, poor adherence to the daily supplementation regime remains a problem in Indonesia, as shown by the low percentage of pregnant women consuming all of the recommended 90 tablets.[9 10] Problems of supply and compliance[38-40] should be addressed to increase uptake. In Indonesia, distribution of supplements is mainly through antenatal care services. As a consequence, women who underutilize antenatal care services, who are most likely to be in greatest need, do not receive supplements. Distribution needs to be improved to reach women in areas with limited access to care services. The traditional birth attendants, who are still highly utilized by women in remote areas,[10 41] should be involved in public health programs to distribute iron/folic acid in areas with limited access to health services.

Conclusion

In our analyses postnatal care provided no protection from neonatal death in Indonesia. This indicates the need to revisit the current priority given to postnatal care as a tool for reducing neonatal deaths and the recommendation to add visits to postnatal care schedule. Our findings highlight the important role of iron/folic acid supplementation for reducing the risk of neonatal death and the need for more investments in this intervention to accelerate reductions in neonatal mortality. Our findings about the relative impact of postnatal and antenatal iron/folic acid supplements, on neonatal survival are important for planning interventions to reduce newborn deaths in Indonesia and other low and middle income countries. Research is needed to compare the benefits of early and extended use of iron/folic acid with different timing and frequency of postnatal services to assess the relative benefit and effectiveness of these services.

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Competing interest

None declared

Details of contributors

CRT and MJD contributed equally to this work. Both authors participated in the design of the study, performed the data analysis and interpretation, and prepared and reviewed the manuscript. Both authors approved the final version of the manuscript to be published.

Exclusive licence

Data sharing statement

Data used in this study are available at the Measure DHS website (http://www.measuredhs.com/data/available-datasets.cfm). There is no additional data available.

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Table 1. Frequency distribution, unadjusted and adjusted Hazard Ratios (H(t)) of demographic, socio-economic status and birthing characteristics at the community and individual level for early neonatal (day 1-7 after birth) mortality, IDHS 2002/2003 and 2007

VARIABLE	N	(%)	Unadjusted[1] H(t)	Unadjusted[1] (95% CI)	Unadjusted[1] p	Adjusted[1,2] H(t)	Adjusted[1,2] (95% CI)	Adjusted[1,2] p
Year of survey								
IDHS 2002/2003	12646	(47.6)	1.00			1.00		
IDHS 2007	13945	(52.4)	0.88	(0.56 - 1.39)	0.59	0.89	(0.57 - 1.39)	0.60
COMMUNITY LEVEL FACTORS								
Region								
Java-Bali region	15486	(58.2)	1.00					
Sumatera	5615	(21.1)	1.06	(0.63 - 1.77)	0.83			
Eastern Indonesia	5490	(20.6)	1.09	(0.70 - 1.71)	0.70			
Type of residence								
Urban	11776	(44.3)	1.00			1.00		
Rural	14815	(55.7)	0.79	(0.50 - 1.24)	0.30	0.57	(0.33 - 0.97)	0.04
Average paternal years of schooling	Mean ± SE = 8.43 ± 0.07		0.98	(0.90 - 1.06)	0.60			
HOUSEHOLD AND INDIVIDUAL LEVEL FACTORS								
Maternal marital status								
Currently married	25953	(97.6)	1.00					
Formerly married	638	(2.4)	1.68	(0.50 - 5.70)	0.40			
Maternal year of education	Mean ± SE = 8.01 ± 0.07		0.98	(0.93 - 1.03)	0.43			
Household wealth index	Mean ± SE = 0·23 ± 0.04		0.90	(0.81 - 0.99)	0.03	0.85	(0.75 - 0.96)	0.01
Maternal age at childbirth	Mean ± SE = 27.19 ± 0.07		1.05	(1.01 - 1.09)	0.02	1.05	(1.01 - 1.09)	0.01
Child sex								
Female	12764	(48.0)	1.00					
Male	13827	(52.0)	1.42	(0.89 - 2.29)	0.15	1.53	(0.93 - 2.51)	0.09
Birth rank and birth interval								
1st rank	10751	(40.4)	1.00					
2nd/3rd rank, interval > 2 yrs	9139	(34.4)	1.14	(0.62 - 2.10)	0.66			
2nd/3rd rank, interval ≤ 2 yrs	1570	(5.9)	1.14	(0.44 - 2.93)	0.79			
≥ 4th rank, interval > 2 yrs	4443	(16.7)	1.88	(1.02 - 3.47)	0.04			
≥ 4th rank, interval ≤ 2 yrs	687	(2.6)	1.95	(0.88 - 4.32)	0.10			
Desire for pregnancy								
Wanted then	21560	(81.1)	1.00					
Wanted later	2907	(10.9)	1.15	(0.55 - 2.42)	0.71			
Wanted no more	2044	(7.7)	1.53	(0.67 - 3.51)	0.31			

VARIABLE	N	(%)	Unadjusted[1] H(t)	(95% CI)	p	Adjusted[1,2] H(t)	(95% CI)	p
Delivery complications								
No	15253	(57.4)	1.00			1.00		
Yes	11007	(41.4)	1.68	(1.04 - 2.72)	0.03	1.73	(1.08 - 2.77)	0.02
Birth size								
Average-sized	13912	(52.3)	1.00			1.00		
Smaller than average	3552	(13.4)	4.34	(2.66 - 7.09)	<0.001	4.33	(2.64 - 7.12)	<0.001
Larger than average	8206	(30.9)	0.85	(0.43 - 1.69)	0.64	0.80	(0.39 - 1.63)	0.54

All figures were weighted for the sampling probability
[1] *Data on 3307 cases were missing and they were excluded from the analysis.*
[2]*Model also adjusted for recall period*

Table 2. Frequency distribution for perinatal health care service characteristics, IDHS 2002/2003 and 2007

VARIABLE	N	(%)	Year of IDHS	
			2002/2003	2007
Use of antenatal services				
No	1914	(7.2)	8.0	6.5
Yes	24483	(92.1)	91.2	92.8
Mode of delivery				
Non Caesarean section	25007	(94.0)	96.0	92.3
Caesarean section	1509	(5.7)	4.0	7.2
Delivery attendance				
Untrained delivery attendants	7712	(29.0)	32.5	25.8
Trained delivery attendants	18847	(70.9)	67.3	74.2
Place of delivery				
Non-health facility	14674	(55.2)	59.0	51.8
Health facility	11839	(44.5)	40.8	47.9
Use of iron/folic acid supplements				
Never/don't know	7482	(28.1)	27.7	28.5
Any iron/folic acid supplements	17958	(67.5)	68.7	66.5
PNC on the first day of life by ANY providers				
No PNC or 7+PNC	5349	(20.1)	20.0	20.3
Day 0- 6 PNC by any provider	21225	(79.8)	80.0	79.7
PNC in the first week of life by ANY providers				
No PNC or 7+PNC	5349	(20.1)	20.0	20.3
PNC 0-6 by doctors/OBGYN/ paediatrician	2858	(10.8)	10.1	11.3
PNC 0-6 by nurse/midwife/village midwife	13941	(52.4)	51.0	53.7
PNC 0-6 by traditional birth attendant	4426	(16.6)	18.9	14.6
Day in the first week of life by ANY providers(2)				
No PNC or 7+PNC	5786	(21.8)	23.4	20.3
Day 0 PNC	13000	(48.9)	43.5	53.8
Day 1-6 PNC	7791	(29.3)	33.0	25.9

All calculations are weighted for the sampling probability
**) recall variable is included in the model*

Table 3. Unadjusted and adjusted Hazard Ratios (H(t)) of perinatal health care service characteristics for early neonatal (day 1-7 after birth) mortality, IDHS 2002/2003 and 2007

VARIABLE	Unadjusted			Adjusted (Model 1)[1]			Adjusted* (Model 2)[2]		
	H(t)	(95% CI)	p	H(t)	(95% CI)	p	H(t)	(95% CI)	p
Use of antenatal services									
No	1.00								
Yes	0.55	(0.27 - 1.13)	0.10						
Mode of delivery									
Non Caesarean section	1.00								
Caesarean section	1.75	(0.76 - 4.05)	0.19						
Delivery attendants									
Untrained delivery attendants	1.00			1.00					
Trained delivery attendants	1.12	(0.68 - 1.86)	0.66	1.51	(0.77 - 2.94)	0.23	1.46	(0.75 - 2.83)	0.27
Place of delivery									
Non-health facility	1.00								
Health facility	1.03	(0.64 - 1.65)	0.91						
Use of iron/folic acid (IFA) supplements									
Never / don't know	1.00			1.00			1.00		
Any IFA	0.48	(0.30 - 0.79)	<0.01	0.51	(0.31 - 0.82)	0.01	0.49	(0.30 - 0.79)	<0.01
Day 1-6 PNC by any care providers[1]									
No PNC or day 7+PNC	1.00			1.00					
Day 1- 6 PNC by any provider	0.79	(0.44 - 1.43)	0.44	1.00	(0.55 - 1.83)	1.00			
Day 1 PNC by any care providers[2]									
No PNC or 7+PNC	1.00						1.00		
Day 1 PNC by any provider	0.96	(0.52 - 1.76)	0.90				1.27	(0.69 - 2.32)	0.44
Day 2-6 PNC by any provider	0.76	(0.37 - 1.56)	0.45				0.91	(0.44 - 1.90)	0.80

All results are weighted for sampling probability. Data on 3307 cases were missing and they were excluded from the analysis.

[1] *Model 1 examined the effects of Day 1-7 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child, and child size at birth based on mother's subjective assessment.*

[2] *Model 2 examined the effects of Day 1 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child, and child size at birth based on mother's subjective assessment.*

Table 4. **Unadjusted and adjusted Hazard Ratios (H(t)) of perinatal health care service characteristics for all neonatal (1-31 days) mortality, IDHS 2002/2003 and 2007**

VARIABLE	Unadjusted			Adjusted* (Model 1)			Adjusted* (Model 2)		
	H(t)	(95% CI)	p	H(t)	(95% CI)	p	H(t)	(95% CI)	p
Use of antenatal services									
No	1.00								
Yes	0.40	(0.21 - 0.77)	0.01						
Mode of delivery									
Non Caesarean section	1.00								
Caesarean section	2.06	(0.94 - 4.53)	0.07						
Delivery attendance									
Untrained delivery attendants	1.00			1.00			1.00		
Trained delivery attendants	0.92	(0.58 - 1.44)	0.70	1.05	(0.57 - 1.93)	0.88	1.03	(0.57 - 1.87)	0.93
Place of delivery									
Non-health facility	1.00								
Health facility	0.97	(0.64 - 1.48)	0.89						
Use of iron/folic acid supplements									
Never / don't know	1.00			1.00			1.00		
Any iron/folic acid	0.51	(0.33 - 0.79)	<0.01	0.52	(0.33 - 0.82)	0.01	0.51	(0.32 - 0.81)	0.01
Day 1-6 PNC by any care providers									
No PNC or day 7+PNC	1.00			1.00					
Day 1- 6 PNC by any provider	0.98	(0.58 - 1.65)	0.93	1.21	(0.70 - 2.09)	0.49			
Day 1 PNC by any care providers									
No PNC or 7+PNC	1.00						1.00		
Day 1 PNC by any provider	1.09	(0.63 - 1.87)	0.76				1.43	(0.83 - 2.47)	0.20
Day 2-6 PNC by any provider	1.06	(0.56 - 1.97)	0.87				1.22	(0.64 - 2.34)	0.54

All results are weighted for sampling probability. [1] *Data on 3307 cases were missing and they were excluded from the analysis.*
[1] *Model 1 examined the effects of Day 1-7 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, sex of the child, delivery complications, child size at birth, delivery attendants and use of iron/folic acid supplements.*
[2] *Model 2 examined the effects of Day 1 PNC by any care providers and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, sex of the child, delivery complications, child size at birth, delivery attendants and use of iron/folic acid supplements.*

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Figure 1. **The association between iron-folic acid supplementation and postnatal care services with early neonatal mortality, IDHS 2002/2003 and 2007**

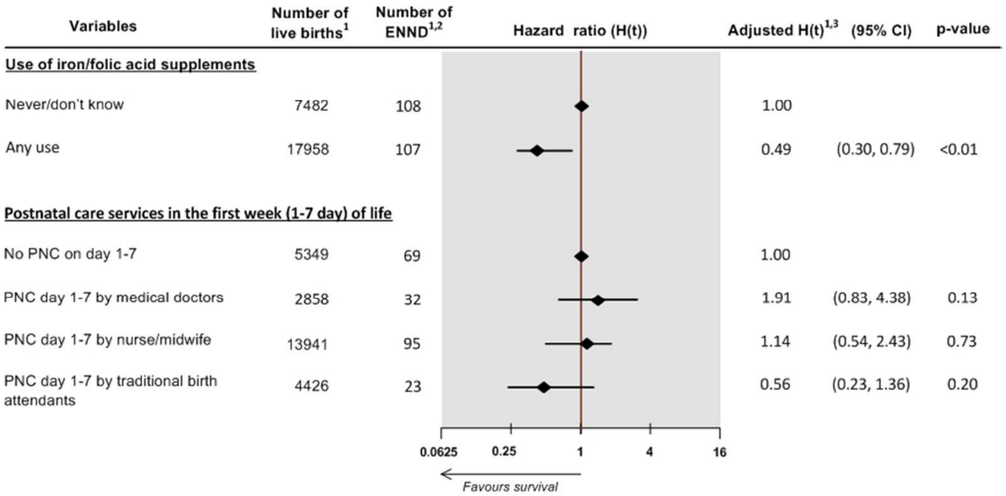
Note:
[1] Weighted for the sampling probability, [2] ENND = early neonatal death, [3] Model obtained by using Cox Proportional Hazards regression analysis and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child and child size at birth based on mother's subjective assessment. All values are weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. See Web Table 1 for details of this model.

Figure 2. **The association between iron-folic acid supplementation and postnatal care services with early neonatal deaths occurring on the day of delivery (day 1), IDHS 2002/2003 and 2007**

Note:
[1] Weighted for the sampling probability, [2] ENND = early neonatal death, [3]Model obtained by using Cox Proportional Hazards regression analysis and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child and child size at birth based on mother's subjective assessment. All values are weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. See Web Table 2 for details of this model.

Figure 3. **The association between iron-folic acid supplementation and postnatal care services with early neonatal deaths occurring after the day of delivery (day 2-7), IDHS 2002/2003 and 2007**

Note:
[1] Weighted for the sampling probability, [2] ENND = early neonatal death, [3] Model obtained by using Cox Proportional Hazards regression analysis and adjusted for duration of recall period at interview, year of survey, type of residence, household wealth index, maternal age at childbirth, presence of complication at delivery, sex of the child and child size at birth based on mother's subjective assessment. All values are weighted for the sampling probability. Data on 3290 cases were missing and they were excluded from the analysis.



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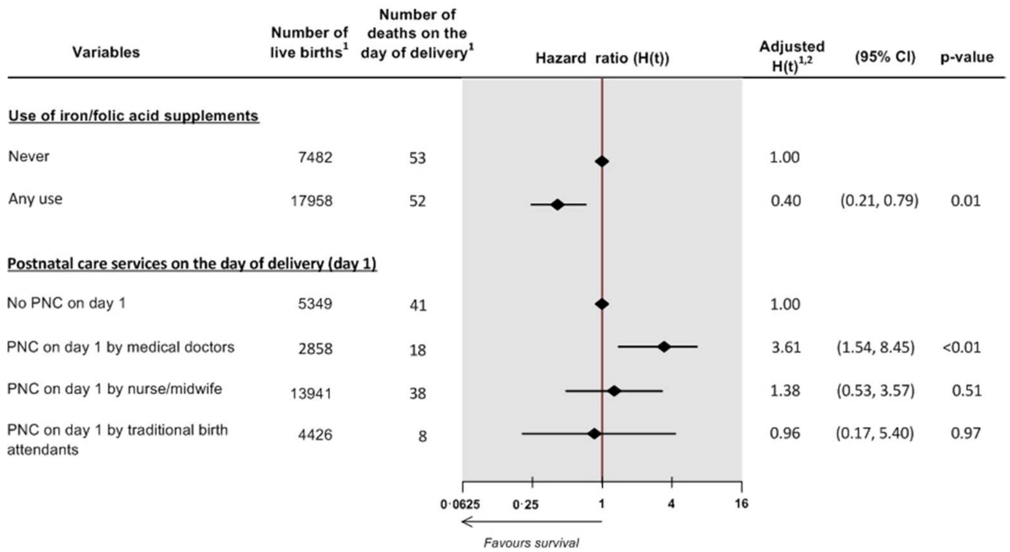

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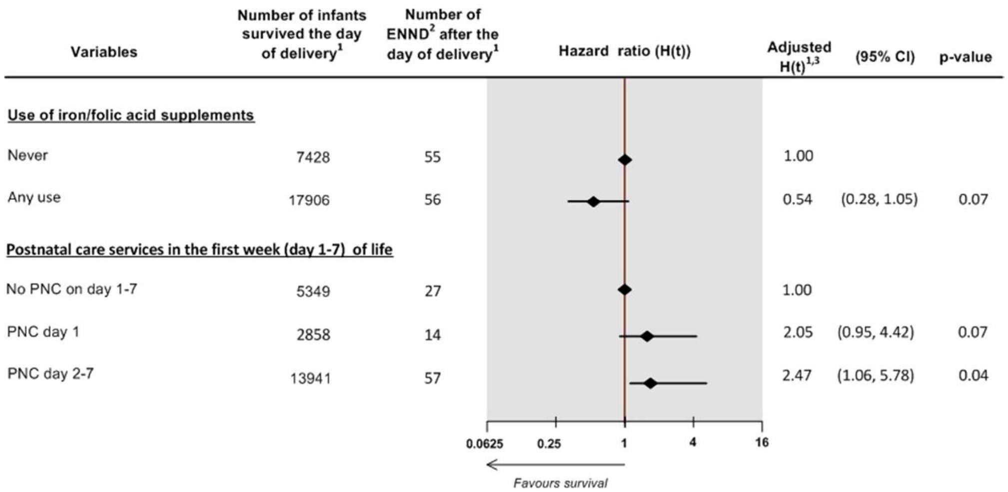

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Web Table 1. Multivariable analyses using socio-demographic, birth characteristics and pregnancy and health services factors for all early neonatal deaths (results used for Figure 1)

VARIABLE	Unadjusted H(t)	Unadjusted 95% CI	Unadjusted p	Adjusted* H(t)	Adjusted* 95% CI	Adjusted* p
Year of survey						
IDHS 2002/2003	1.00			1.00		
IDHS 2007	0.88	0.56 - 1.39	0.59	0.89	0.57 - 1.39	0.60
COMMUNITY LEVEL FACTORS						
Region						
Java-Bali region	1.00					
Sumatera	1.06	0.63 - 1.77	0.83			
Eastern Indonesia	1.09	0.70 - 1.71	0.70			
Type of residence						
Urban	1.00			1.00		
Rural	0.79	0.50 - 1.24	0.30	0.57	0.33 - 0.97	0.04
Average paternal years of schooling	0.98	0.90 - 1.06	0.60			
SOCIO ECONOMIC DETERMINANTS						
Maternal marital status						
Currently married	1.00					
Formerly married	1.68	0.50 - 5.70	0.40			
Maternal year of education	0.98	0.93 - 1.03	0.43			
Household wealth index	0.90	0.81 - 0.99	0.03	0.85	0.75 - 0.96	0.01
PROXIMATE DETERMINANTS						
Maternal age at childbirth	1.05	1.01 - 1.09	0.02	1.05	1.01 - 1.09	0.01
Child sex						
Female	1.00					

VARIABLE	Unadjusted H(t)	Unadjusted 95% CI			Unadjusted p	Adjusted* H(t)	Adjusted* 95% CI			Adjusted* p
Male	1.42	0.89	-	2.29	0.15	1.53	0.93	-	2.51	0.09
Birth rank and birth interval										
1st rank	1.00									
2nd/3rd rank, interval > 2 yrs	1.14	0.62	-	2.10	0.66					
2nd/3rd rank, interval < 2 yrs	1.14	0.44	-	2.93	0.79					
> 4th rank, interval > 2 yrs	1.88	1.02	-	3.47	0.04					
> 4th rank, interval < 2 yrs	1.95	0.88	-	4.32	0.10					
Desire for pregnancy										
Wanted then	1.00									
Wanted later	1.15	0.55	-	2.42	0.71					
Wanted no more	1.53	0.67	-	3.51	0.31					
Delivery complications										
No	1.00					1.00				
Yes	1.68	1.04	-	2.72	0.03	1.73	1.08	-	2.77	0.02
Birth size										
Average-sized	1.00					1.00				
Smaller than average	4.34	2.66	-	7.09	<0.001	4.33	2.64	-	7.12	<0.001
Larger than average	0.85	0.43	-	1.69	0.64	0.80	0.39	-	1.63	0.54
PERINATAL HEALTH CARE SERVICES										
Use of antenatal services										
No	1.00									
Yes	0.55	0.27	-	1.13	0.10					
Mode of delivery										
Non Caesarean section	1.00									
Caesarean section	1.75	0.76	-	4.05	0.19					

VARIABLE	Unadjusted H(t)	95% CI			p	Adjusted* H(t)	95% CI			p
Delivery attendance										
Untrained delivery attendants	1.00					1.00				
Trained delivery attendants	1.12	0.68	-	1.86	0.66	1.03	0.47	-	2.30	0.93
Place of delivery										
Non-health facility	1.00									
Health facility	1.03	0.64	-	1.65	0.91					
Use of iron/folic acid (IFA) supplements										
Never / don't know	1.00					1.00				
Any IFA	0.48	0.30	-	0.79	<0.01	0.49	0.30	-	0.79	<0.01
Day 1-7 PNC by any care providers										
No PNC on day 1-7	1.00					1.00				
PNC day 1-7 by doctors/OBGYN/ paediatrician	1.41	0.68	-	2.92	0.36	1.91	0.83	-	4.38	0.13
PNC 1-7 by nurse/midwife/village midwife	0.76	0.41	-	1.42	0.40	1.14	0.54	-	2.43	0.73
PNC 1-7 by traditional birth attendant	0.50	0.21	-	1.20	0.12	0.56	0.23	-	1.36	0.20

Note:
All figures were weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. Model also adjusted for recall period

Web Table 2. Multivariable analyses using socio-demographic, birth characteristics and pregnancy and health services factors for neonatal deaths occurring on the day of delivery (day 1 deaths) (results used for Figure 2)

VARIABLE	Unadjusted H(t)	Unadjusted 95% CI	Unadjusted p	Adjusted* H(t)	Adjusted* 95% CI	Adjusted* p
Year of survey						
IDHS 2002/2003	1.00			1.00		
IDHS 2007	0.78	0.36 - 1.67	0.52	0.91	0.48 - 1.72	0.77
COMMUNITY LEVEL FACTORS						
Region						
Java-Bali region	1.00					
Sumatera	1.00	0.45 - 2.21	1.00			
Eastern Indonesia	1.16	0.55 - 2.42	0.70			
Type of residence						
Urban	1.00			1.00		
Rural	0.46	0.23 - 0.92	0.03	0.31	0.14 - 0.68	0.00
Average paternal years of schooling	0.95	0.85 - 1.06	0.33			
SOCIO ECONOMIC DETERMINANTS						
Maternal marital status						
Currently married	1.00					
Formerly married	1.41	0.26 - 7.60	0.69			
Maternal year of education	1.03	0.96 - 1.10	0.41			
Household wealth index	0.87	0.77 - 0.99	0.03	0.78	0.67 - 0.91	0.00
PROXIMATE DETERMINANTS						
Maternal age at childbirth	0.99	0.93 - 1.05	0.67	1.03	0.97 - 1.09	0.33

Child sex						
Female	1.00					
Male	1.69	0.73 - 3.91	0.22	1.51	0.70 - 3.25	0.30
Birth rank and birth interval						
1st rank	1.00					
2nd/3rd rank, interval > 2 yrs	1.56	0.59 - 4.10	0.37			
2nd/3rd rank, interval ≤ 2 yrs	1.39	0.34 - 5.71	0.65			
≥ 4th rank, interval > 2 yrs	0.84	0.33 - 2.10	0.71			
≥ 4th rank, interval ≤ 2 yrs	2.21	0.59 - 8.30	0.24			
Desire for pregnancy						
Wanted then	1.00					
Wanted later	1.19	0.44 - 3.23	0.73			
Wanted no more	0.33	0.12 - 0.88	0.03			
Delivery complications						
No	1.00					
Yes	1.33	0.61 - 2.88	0.48	1.45	0.73 - 2.90	0.29
Birth size						
Average-sized	1.00					
Smaller than average	3.38	1.52 - 7.52	<0.01	4.10	1.95 - 8.59	0.00
Larger than average	0.91	0.28 - 2.99	0.88	0.84	0.27 - 2.57	0.76
PERINATAL HEALTH CARE SERVICES						
Use of antenatal services						
No	1.00					
Yes	0.73	0.26 - 2.05	0.56			
Mode of delivery						
Non Caesarean section	1.00					

Caesarean section	2.15	0.60 - 7.69	0.24			
Delivery attendance						
Untrained delivery attendants	1.00			1.00		
Trained delivery attendants	1.69	0.71 - 3.98	0.23	1.63	0.50 - 5.32	0.42
Place of delivery						
Non-health facility	1.00					
Health facility	1.41	0.65 - 3.03	0.39			
Use of iron/folic acid (IFA) supplements						
Never / don't know				1.00		
Any IFA	0.78	0.31 - 1.95	0.60	0.40	0.21 - 0.79	0.01
First day PNC by any care providers						
No PNC on day 1				1.00		
PNC day 1 by doctors/OBGYN/paediatrician	6.95	2.42 - 19.95	<0.001	3.61	1.54 - 8.45	0.00
PNC day 1 by nurse/midwife/village midwife	2.13	0.78 - 5.86	0.14	1.38	0.53 - 3.57	0.51
PNC day 1 by traditional birth attendant	1.72	0.30 - 9.84	0.54	0.96	0.17 - 5.40	0.97

Note:
All figures were weighted for the sampling probability. Data on 3307 cases were missing and they were excluded from the analysis. Model also adjusted for recall period