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Did professional attendance at home births improve early neonatal survival in Indonesia?

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Background Early neonatal mortality has been persistently high in developing countries. Indonesia, with its national policy of home-based, midwife-assisted birth, is an apt context for assessing the effect of home-based professional birth attendance on early neonatal survival.

Methods We pooled four Indonesian Demographic and Health Surveys and used multivariate logistic regression to analyse trends in first-day and early neonatal mortality. We measured the effect of the context of delivery, including place and type of provider, and tested for changes in trend when the 'Midwife in the Village' programme was initiated.

Results Reported first-day mortality did not decrease significantly between 1986 and 2002, whereas early neonatal mortality decreased by an average of 3.2% annually. The rate of the decline did not change over the time period, either in 1989 when the Midwife in the Village programme was initiated, or in any year following when uptake of professional care increased. In simple and multivariate analyses, there were no significant differences in first-day or early neonatal death rates comparing home-based births with or without a professional midwife. Early neonatal mortality was higher in public facilities, likely due to selection. Biological determinants (twin births, male sex, short birth interval, previous early neonatal loss) were important for both outcomes.

Conclusions Decreasing newborn death rates in Indonesia are encouraging, but it is not clear that these decreases are associated with greater uptake of professional delivery care at home or in health facilities. This may suggest a need for improved training in immediate newborn care, strengthened emergency referral, and continued support for family planning policies.

Keywords Early neonatal mortality, Indonesia, skilled birth attendant, home-based birth

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KEY MESSAGES

- Between 1986 and 2002, early neonatal mortality in Indonesia decreased by an average of 3.2% annually. Deaths on the first day of life did not decrease significantly during this period.
- Although the Midwife in the Village programme in Indonesia has greatly increased skilled attendance at birth, particularly among the poor, this study could not identify an association between attendance by a professional midwife at home-based births and decreasing newborn death rates in Indonesia.
- These results suggest a need for increased attention to immediate newborn care and emergency referral in the midwifery curriculum, as well as continued support for the Indonesian family planning programme, as short birth intervals were significantly associated with increased risks of first day and early neonatal mortality.

Introduction

Neonatal mortality in the developing world continues to be an urgent global problem. Over 4 million children die within the first month of life, accounting for more than 38% of under-five deaths globally (Lawn *et al*. 2005; Zupan and Aahman 2005). While mortality among children between the ages of 1 month and 5 years dropped by one-third over the past two decades, neonatal mortality fell only by one-quarter (Lawn *et al*. 2005). Moreover, most of that decrease was among *late* neonatal deaths; little improvement has been made in early neonatal mortality (deaths within the first 7 days of life), which constitutes 75% of neonatal deaths (World Health Organization 2005). It is unlikely that the target for Millennium Development Goal #4, which calls for a two-thirds decrease in underfive mortality by 2015, will be met in many countries unless substantial progress is made in reducing these newborn deaths.

Recent reviews of the evidence have shown that many neonatal deaths—especially late neonatal deaths, which are mainly due to infections—could be averted with inexpensive, relatively simple interventions (Lawn *et al*. 2005). These include maternal tetanus immunization, clean delivery practices, thermal control of the newborn, early breastfeeding, and home-based treatment of infections (Bang *et al*. 2005; Bhutta *et al*. 2005; Lawn *et al*. 2005). Interventions to prevent early neonatal deaths, while not necessarily technologically complex, are more likely to require clinically trained providers. Such strategies include treatment with corticosteroids during preterm labour, use of a partograph to monitor labour, emergency obstetric care for maternal complications, and newborn resuscitation (Bhutta *et al*. 2005; Darmstadt *et al*. 2005; Lawn *et al*. 2005; Weiner *et al*. 2003). Good-quality care during the intrapartum and immediate postpartum period is especially crucial for early newborn survival (Kusiako *et al*. 2000; Weiner *et al*. 2003).

Darmstadt *et al*. (2005) have estimated that a skilled birth care package could reduce neonatal mortality by 20–30%. Of interest is whether such care can be effectively provided at the community level, since approximately half of all births and most early neonatal deaths in developing countries occur in the home (Costello *et al*. 2004; Bhutta *et al*. 2005). Indonesia provides an apt context for exploring whether skilled birth attendance in the home improves newborn survival. Indonesia launched the ''*Bidan di Desa*'' or Midwife in the Village programme in 1989 to increase the proportion of deliveries managed by trained professional midwives (Shiffman 2003). While concern for Indonesia's high maternal mortality ratio was the impetus for the programme, the newborn figured clearly among the movement's objectives (Ministry of Health 1994). By 1996, more than 50 000 young women had graduated from a 1-year midwifery training programme and been posted to almost every village in the country (Centre for Health Data 1997), providing prenatal, delivery and postpartum care in the home as well as in lower-level health centres.

Since its inception, the statutory curriculum for Midwife in the Village training has included 'first aid for abnormal newborn babies and those who were born requiring emergency medical attention . . .' (Ministry of Health 1995). The curriculum in the early phase of the Midwife in the Village programme included monitoring the progress of labour, drying and wrapping the baby, facilitating immediate breastfeeding, antibiotic eye prophylaxis, and applying suction when necessary. In 1996, after several small-scale evaluations suggested Village Midwives were unable to provide both basic midwifery care and care for obstetric and neonatal emergencies (McDermott and Wirth 1997; Ministry of Health *et al*. 1998; Arifin *et al*. 1999; Hull *et al*. 1999; Centre for Health Research 2001), the Ministry of Health introduced a 3-year competency-based midwifery training for new midwives, which specifically addressed newborn resuscitation and other newborn interventions. In 1999, a competency-based in-service training programme was designed to enhance the skills of the first wave of midwives with only 1 year of midwifery training, and again placed greater emphasis on the newborn than had been provided during their pre-service training (Department of Reproductive Health 2004). Thus, it appears that there has been increasing attention to newborn health and survival in the midwifery curriculum over time.

In this paper, we use existing Demographic and Health Survey (DHS) data from Indonesia to assess whether the presence of a professional birth attendant at home deliveries was associated with improved newborn survival between 1986 and 2002. We investigate whether there were changes in early neonatal mortality trends that coincided with the implementation of the Midwife in the Village programme. We also measure whether there was a difference in early neonatal mortality rates for home births with and without a professional birth attendant, using multivariate logistic regression to control for major confounders. Finally we explore whether changes in mortality occurred at different rates for births at home and in public and private facilities, hypothesizing that a programme effect is less plausible if mortality trends were the same regardless of delivery context. These three analytic approaches taken together allow us to explore evidence for the effectiveness of the Midwife in the Village intervention for early newborn survival in Indonesia.

Methods

Data

We analysed four Indonesian Demographic and Health Surveys conducted in 1991, 1994, 1997 and 2002/3. DHS are based on nationally representative samples of women of reproductive age, with detailed questions regarding live births in the 3 or 5 years prior to interview. The datasets are available to the public at www.measuredhs.com. We pooled the files into one cross-sectional dataset and analysed live births occurring during the 5 years prior to each survey interview. Women interviewed in these four surveys reported 67 544 live births between May 1986 and April 2003. We excluded the small sample of 126 births that occurred in 2003. An additional 1507 births (2.2% of the sample) were excluded because information about their delivery context or socio-economic status was missing. The final analytic sample size was 65 921 live births.

Variables

We analysed deaths during the first 24 hours after birth (day 0, 'first-day deaths', $N = 399$) and during the first week (days 0–6, 'early neonatal deaths', $N = 1060$). These two outcomes overlap. We conducted a sensitivity analysis defining early neonatal deaths to include day 7 (which would have added 186 deaths), but this did not meaningfully alter our results.

To model socio-economic status, we developed a principal components wealth index following the methodology proposed by Filmer and Pritchett (2001). The principal components analysis was conducted in the pooled household-level DHS data files, which are representative of the entire Indonesian population in the 4 survey years. Variables used in the principal components analysis included source of drinking water, main material of the floor, type of toilet, availability of electricity, and ownership of bicycle, radio or motorcycle. Since our goal was to control for improvements in the population's overall economic status over time, we created 'fixed' wealth quintiles across the pooled data, rather than calculating separate survey-specific quintiles. The result is that more of the sample from the earlier surveys is concentrated in the bottom two quintiles, while more of the sample from the later surveys is concentrated in the top two quintiles. Other dimensions of socio-economic status were represented by mother's education and urban/rural residence.

To control for fertility and biological factors, we also included the mother's parity and age at delivery, whether she delivered twins, her experience of a previous early neonatal death, the preceding birth interval, the child's sex, and the child's size at birth (as reported by the mother). The delivery location and provider (henceforth 'delivery context') were represented by four dummy variables: home birth with no professional attendant ($N = 34 617$), home birth with professional attendant (nurse, midwife or doctor; $N = 13 139$), public sector health facility birth ($N = 5776$), or private facility birth ($N = 12 389$). The most qualified attendant present was coded. Public facilities included government hospitals, health centres and health posts, while private facilities included private hospitals, clinics, and private doctors' or midwives' practices. Although the 2002/3 survey changed the previous coding procedure and listed births occurring in a midwife's home as private facility births, for consistency across the surveys we coded all deliveries that occurred in a midwife's home ($N = 2956$) as home births with professional attendant.

Analysis

All statistical analyses were conducted using Stata version 9 and were adjusted for clustering and sample weights using Stata's 'svy' complex survey commands. We tested unadjusted associations between the predictor variables and each outcome using Pearson's survey-adjusted F-tests. We then worked in an iterative fashion to construct adjusted multivariate logistic regression models, using Wald tests to assess the statistical significance of predictor variables. Linear trends with 'splines' (breakpoints where the slope of the trend changed) were used to model time trends. To allow for the possibility that the Midwife in the Village programme took several years to begin having an effect on early neonatal deaths—but without knowing *a priori* exactly when this effect might be observable—we tested for changes in the slope of the time trend in each year, beginning in 1989 when the programme was initiated and then in every subsequent year. This was done to detect any acceleration in the decline of mortality rates coinciding with the programme's initiation. We also tested for interactions between linear time trends and the delivery context to determine whether the risk of first-day or early neonatal mortality was changing at the same rate in all contexts. All numbers and percentages described in the paper have been adjusted for sampling weights.

Results

Time trends for first-day and early neonatal deaths

There was a slight decrease in the odds of first-day deaths between 1986 and 2002, but the change was not statistically significant (Figure 1). When modelled with a linear trend in a survey-adjusted simple logistic regression, the odds ratio per year was 0.98 (95% CI, 0.95–1.02, $P = 0.40$), corresponding to a projected decrease from 7.1 to 6.0 first-day deaths per 1000 live births (as represented by the lower dotted line in Figure 1). Using linear splines, we tested for a change in the slope of a linear trend in 1989 and also in every subsequent year. There was no significant change in the slope of the trend in any year (data not shown).

The odds of an early neonatal death decreased significantly over the time period (Figure 1), by an average of 3.2% per year when modelled with a linear time trend (OR = 0.97 [0.95–0.99], $P = 0.002$). This is equivalent to a projected decrease from 20.1 to 14.7 deaths per 1000 live births from 1986–2002 (represented by the upper dotted line in Figure 1). However, there was no significant change in the

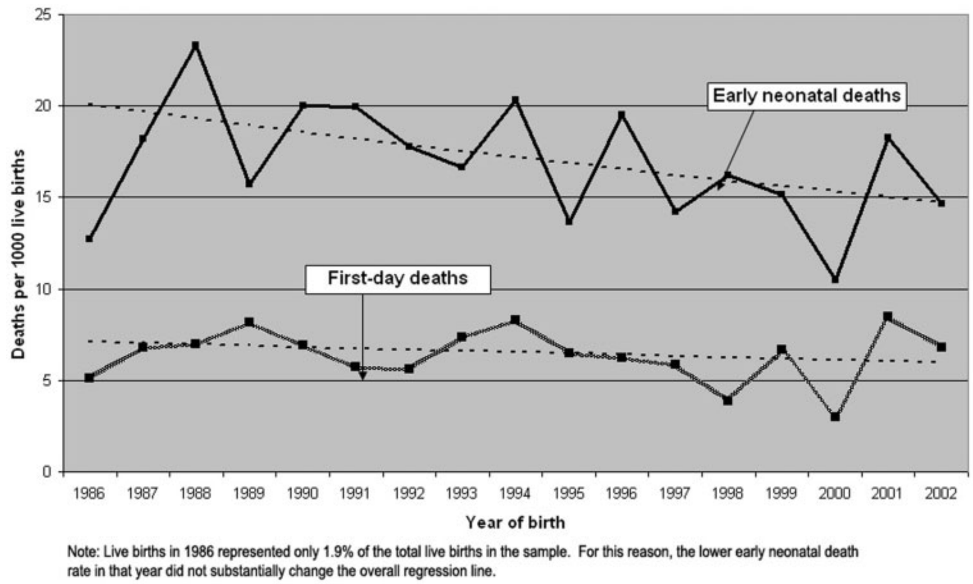

Figure 1 Trends in first-day (day 0) and early neonatal (days 0–6) deaths, Indonesia Demographic and Health Surveys, 1986–2002

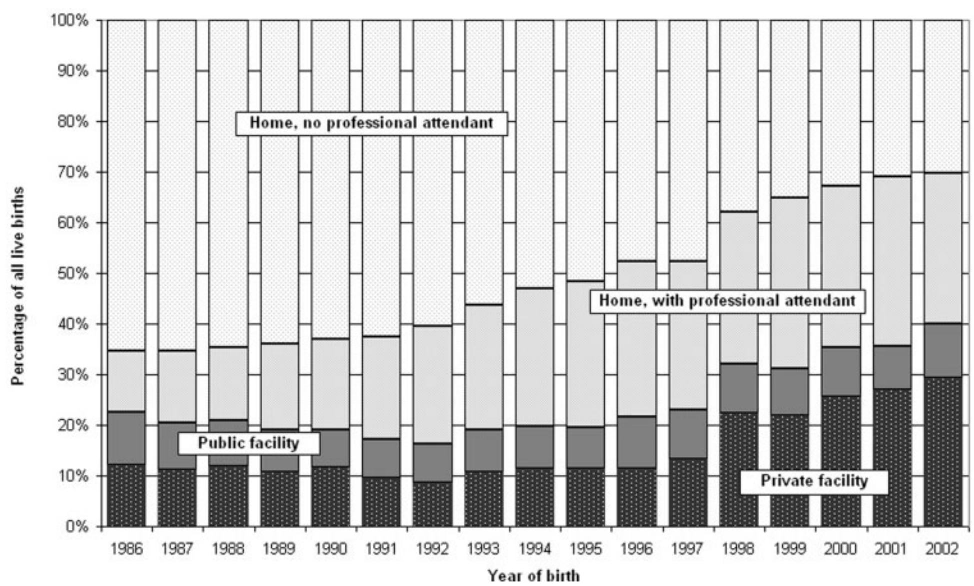

Figure 2 Trends in the distribution of live births by delivery context, Indonesia Demographic and Health Surveys, 1986–2002

slope of this trend in 1989 or in any other year (data not shown).

Differences in death rates by delivery context

From 1986–2002, there was a substantial increase in percentage of home births with a professional attendant (from 12% to 30% of all births), while there was a dramatic decrease in percentage of births at home with no professional attendant (from 65% to 30% of all births) (Figure 2). There was little change in usage of public facilities (approximately 11%), and a dramatic increase in usage of private facilities (from 12% to 29%).

The socio-economic profile of women using each delivery context was very different (Table 1). Women delivering at home with no professional attendant were predominantly from the poorest two quintiles, while women delivering with professional attendants at home were mainly from the third and fourth quintile. Those using public and private facilities were mainly from the wealthiest two quintiles.

Using a survey-adjusted simple logistic regression, there was no significant difference in first-day death rates comparing home births with a professional attendant to home births without a professional attendant ($P = 0.69$; Table 2). Observed early neonatal death rates for home births with a professional present were slightly lower than for home births with no professional, but this difference was not statistically significant ($P = 0.32$). For both outcomes, rates of mortality

Table 1 Distribution of births in each delivery context by wealth quintiles (row %)

Delivery context	Wealth quintile: Poorest quintile	Second quintile	Middle quintile	Fourth quintile	Richest quintile	Total	N
Home, no professional	36%	28%	20%	13%	4%	100%	34 617
Home, with professional	12%	18%	24%	27%	20%	100%	16 110
Public facility	6%	11%	20%	27%	36%	100%	5776
Private facility	3%	7%	15%	27%	49%	100%	9419
Total	**23%**	**21%**	**20%**	**19%**	**17%**	**100%**	**65 921**

Note: The quintile cut-points are representative of all households in the population. Because families in the lower quintiles tend to have more children than families in the upper quintiles, the quintiles do not have equal numbers of live births.

Table 2 Time trends and death rates by delivery context ($N = 65\,921$)

	First-day deaths		Early neonatal deaths	
	Deaths per 1000 live births	Crude ORs (95% CI)	Deaths per 1000 live births	Crude ORs (95% CI)
Yearly time trend, 1986–2002	–	0.98 (0.95–1.02)	–	0.97 (0.95–0.99)
Delivery context				
Home, no professional	5.7	1.00 (–)	16.2	1.00 (–)
Home, with professional	6.1	1.08 (0.74–1.57)	14.4	0.89 (0.70–1.12)
Public facility	9.3	1.64* (1.01–2.67)	22.8	1.42* (1.01–1.98)
Private facility	5.4	0.94 (0.59–1.50)	14.4	0.89 (0.65–1.21)
Total	**6.1**		**16.1**	

*$P < 0.05$.

were significantly higher in public facilities ($P = 0.04$ for both outcomes).

Changes in key confounding factors over time

During the time period covered by these four surveys, Indonesia underwent substantial demographic changes. The percentage of live births born to women of parity 5 or greater dropped from 21% in the 1991 survey to 13% by the 2002/3 survey. Mean birth intervals increased by 16 months, and mothers' average age at delivery increased from 25.9 to 26.8. There was no consistent trend in newborn sizes at birth, as reported by the mother. Overall, approximately one-third of mothers reported that their infant was large or very large, 14% that the infant was small or very small, and 52% that the infant was of average size.

Multivariate results for time trends and delivery context

We next used multivariate logistic regression to control for a linear time trend and other confounding variables that might have affected newborn death rates in the Indonesian context, as well as the delivery context (Table 3). For first-day deaths, controlling for other potential confounders had little effect on time trend variables. There was still no significant change in first-day death rates during this time period (OR = 0.98 [0.94–1.02], $P = 0.29$), and there were no significant differences in death rates among the different delivery contexts (joint $P = 0.53$). Socio-economic factors (represented by wealth quintile, mother's education, and residence) had no significant effect. The effects of biological and fertility factors were most important and in the expected direction: longer preceding birth intervals, larger size at birth, and female sex were significantly associated with decreased risk of first-day deaths, while twin births and previous experience of an early neonatal death correlated with increased risk.

Controlling for confounding variables did not substantially affect the observed decrease in early neonatal death rates over this time period (Table 3). The odds of an early neonatal death declined significantly by an average of 3.2% per year in the adjusted analysis (OR = 0.97 [0.95–0.99], $P = 0.004$). No significant difference could be detected between the risk of death at home births with a professional and home births with no professional present ($P = 0.52$). However, the risk of death was still significantly higher in public facilities ($P = 0.01$) compared with home births without a professional present. As with first-day deaths, wealth quintile, maternal education and urban/rural residence did not play a measurable role in the risk of early neonatal death. Very small newborns, twins and males were more likely to die in the first week. Risk was highest for the youngest and oldest mothers, those who had experienced a previous early neonatal death, and those with a short preceding birth interval.

Interactions between time trends and delivery context

Finally we allowed for different rates of change in the risk of each outcome by delivery context, comparing both unadjusted and multivariate models. We found no significant differences among these rates of change for either outcome across any of the delivery contexts, in either the unadjusted or multivariate models. It is interesting to note that the decreases in early neonatal deaths were only significant for home births without

Table 3 Logistic regression results for first-day and early neonatal deaths: extended multivariate models ($N = 65\,921$)

	First-day deaths		Early neonatal deaths	
	Adjusted OR	95% CI	Adjusted OR	95% CI
Yearly time trend, 1986–2002	0.979	(0.94–1.02)	0.968**	(0.95–0.99)
Delivery context				
Home, no professional attendant	1.00	–	1.00	–
Home, professional attendant	1.17	(0.77–1.79)	1.09	(0.84–1.41)
Public facility	1.54	(0.83–2.88)	1.59*	(1.10–2.30)
Private facility	1.05	(0.60–1.84)	1.20	(0.82–1.75)
Socio-economic factors				
Wealth quintiles				
Quintile 1 (poorest)	1.00	–	1.00	–
Quintile 2	1.00	(0.62–1.61)	0.96	(0.75–1.22)
Quintile 3	0.89	(0.52–1.54)	0.85	(0.63–1.14)
Quintile 4	1.40	(0.78–2.53)	1.26	(0.91–1.74)
Quintile 5 (wealthiest)	0.81	(0.38–1.74)	0.76	(0.50–1.17)
Mother's education				
None	1.00	–	1.00	–
Primary	1.10	(0.60–2.04)	0.93	(0.70–1.24)
Secondary	0.99	(0.48–2.02)	0.95	(0.66–1.37)
Higher	0.52	(0.14–1.98)	0.54	(0.26–1.10)
Residence				
Rural	1.00	–	1.00	–
Urban	0.99	(0.65–1.49)	0.92	(0.71–1.19)
Fertility factors				
Mother's parity				
Parity 1	1.00	–	1.00	–
Parity 2–4	1.08	(0.69–1.69)	1.41*	(1.05–1.90)
Parity 5–8	0.75	(0.38–1.48)	1.21	(0.80–1.82)
Parity 9 or more	0.56	(0.19–1.61)	1.41	(0.78–2.55)
Preceding birth interval				
<2 years	1.00	–	1.00	–
2–3 years	0.35**	(0.19–0.65)	0.65**	(0.47–0.90)
3–4 years	0.65	(0.36–1.16)	0.61**	(0.43–0.86)
≥ 4 years	0.46**	(0.27–0.79)	0.57**	(0.42–0.78)
Mother's age at delivery				
Age (years)	0.99	(0.82–1.21)	0.81**	(0.72–0.91)
Age squared	1.0004	(0.997–1.004)	1.004**	(1.002–1.01)
Biological factors				
Previous early neonatal deaths				
None	1.00	–	1.00	–
One or more	3.89***	(2.36–6.43)	3.01**	(2.27–3.98)
Twins				
Singleton delivery	1.00		1.00	
Twin delivery	3.14**	(1.55–6.36)	4.21**	(2.82–6.28)
Sex of child				
Male child	1.00	–	1.00	–
Female child	0.72*	(0.52–0.99)	0.73**	(0.61–0.88)

(*continued*)

Table 3 Continued

	First-day deaths		Early neonatal deaths	
	Adjusted OR	95% CI	Adjusted OR	95% CI
Size of child at birth[†]				
Very large	1.00	–	1.00	–
Larger than average	2.10*	(1.01–4.37)	1.40	(0.81–2.42)
Average	1.73	(0.87–3.44)	1.50	(0.88–2.53)
Smaller than average	4.01***	(1.91–8.43)	3.25**	(1.86–5.66)
Very small	18.76***	(8.42–41.80)	15.60**	(8.69–28.00)
Don't know	4.54**	(1.89–10.87)	2.52**	(1.32–4.81)

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

[†]As reported by mother.

Table 4 Logistic regression results for first-day and early neonatal deaths: interactions between time trends and delivery contexts ($N = 65\,921$)

	First-day deaths		Early neonatal deaths	
Linear time trends by delivery context	OR	95% CI	OR	95% CI
Odds ratio per year, home, no professional attendant	0.99	(0.95–1.04)	0.96*	(0.93–0.99)
Odds ratio per year, home, professional attendant	0.97	(0.91–1.04)	0.97	(0.93–1.02)
Odds ratio per year, public facility	0.99	(0.89–1.10)	1.00	(0.95–1.06)
Odds ratio per year, private facility	0.94	(0.85–1.05)	0.95	(0.90–1.01)

*$P < 0.05$.

Note: These models were also adjusted for wealth quintile, mother's education, urban/rural residence, previous early neonatal deaths, parity, age, sex of the child, preceding birth interval, twin births and size at birth. *P*-values and confidence intervals indicate whether the trend was significantly different from the null (OR = 1.00). There were no significant differences among trends by delivery context.

a professional attendant. There was no significant decrease in early deaths among births in public facilities, and observed decreases in early neonatal deaths for home births with a professional attendant and in private facilities were not statistically significant. Table 4 displays time trends by delivery context, excerpted from the multivariate models.

Discussion

We used three analytic approaches to examine whether the initiation of the Midwife in the Village programme, and specifically the increased use of professional attendants at home births, resulted in lower first-day and early neonatal mortality rates in Indonesia. Our results are mixed. Deaths on the first day after birth, those which most plausibly could have been prevented via the assistance of a professional birth attendant, did not decrease significantly between 1986 and 2002. Early neonatal death rates did drop significantly—an important success—although our findings do not provide evidence that the drop was associated with professional attendance at home births. First, there was no acceleration in the rate of decrease in early neonatal mortality when the Village Midwife programme was instituted, either in 1989 or at any point in the 1990s; the decline was steady throughout the period. Second, early neonatal mortality rates observed among home births attended by a professional were not significantly lower than those where no professional was present, and the small advantage disappeared (and was in fact reversed) when important confounding factors such as wealth quintile, education and biological factors were adjusted for using multivariate regression. Finally, there was no significant difference in the rate of decline in early neonatal mortality among the delivery contexts.

The strengths of this analysis include the 17-year time period covered by the Demographic and Health Surveys, their very large sample sizes (over 65 000 live births), and their representativeness achieved via carefully implemented sampling methods. We also had access to a wealth of analytic variables that allowed us to control for key biological and socio-economic confounders. We used multiple methods to examine the research question and confirm our findings. Nonetheless, it is important to note that there is likely to be selection bias in a mother's choice of birth attendant and delivery location in models of newborn mortality. Some factors that may influence the choice of delivery context could not be controlled for using these data. These factors may be cultural (preferences for a traditional birth attendant); behavioural (leading those with problem pregnancies—or who experience complications during delivery—to seek a facility-based provider, and those at lower risk of newborn death to deliver at home); environmental (proximity to health facilities); and programmatic (purposive placement of village midwives in under-resourced communities) (Frankenberg *et al*. 2005; Makowiecka *et al*. 2008). Failure to control for unobserved or unmeasurable confounders can lead to endogeneity or selection bias and thus biased regression coefficients (Zohoori and Savitz 1997). Without a controlled experiment—for instance, assigning women randomly to different delivery contexts—or the availability of an instrumental variable, it is impossible to fully eliminate this endogeneity.

A few other limitations should be noted. The time series prior to the introduction of the Midwife in the Village programme is relatively short, and we may not have had the power to compare death rates before and after its introduction. It is also worth noting that increased uptake of professional delivery care only became apparent in the early 1990s, and was largely due to more women giving birth in private facilities (Hatt *et al.* 2007). While DHS data are of high quality relative to many developing country data sources, it is important to recognize that newborn deaths are likely to be under-reported. Some newborn deaths may be classified as stillbirths (not included in the DHS) and vice versa, and many deliveries that result in a stillbirth or early neonatal death may go unreported altogether (Stanton *et al.* 2006). Ideally we would analyse intrapartum stillbirths along with first-day deaths since good midwifery care might defer intrapartum deaths until the first day of life. More generally, early neonatal mortality rates estimated via large sample surveys have not been validated. Small numbers of first-day deaths in our data may have led to some non-significant results in the multivariate regressions.

The 1991 data lacked information on self-reported complications during delivery, which meant that this variable could not be included in our pooled data regressions. Failure to control for obstetric complications could introduce selection bias, since women who otherwise would deliver at home may call a village midwife or be referred to a health facility once they develop a complication. However, in comparable regressions run on the surveys from 1994, 1997 and 2002, the inclusion of self-reported obstetric complications did not substantially alter the odds ratios for delivery context or other variables. The highest first-day and early neonatal death rates were observed in public facilities, even though these were utilized primarily by women from the higher wealth quintiles. This may reflect the selection bias mentioned above, if women with higher-risk deliveries were more likely to deliver in public hospitals. Disproportionate use of publicly subsidized hospital care by higher-income Indonesians has also been documented elsewhere (Saadah *et al.* 2000). However, if village midwives were indeed referring more high risk women to health facilities (either during antenatal care or complicated labour), and these referrals were effectively reducing early neonatal mortality rates, we would expect to have seen a change in the slope of the mortality time trend lines when the Midwife in the Village programme was being rolled out.

As of 2002, Indonesia's neonatal mortality rate (20 per 1000 live births) was estimated to be similar to the average for Southeast Asia (19 per 1000 live births) and substantially lower than countries such as Cambodia, Myanmar and Laos (Badan Pusat Statistik 2003; World Health Organization 2006). It is possible that the observed benefits to newborn survival of skilled attendance at delivery might have been greater, had they been applied in a context with higher newborn mortality.

It is worth re-emphasizing that early neonatal mortality in Indonesia decreased by almost one-third between 1986 and 2002. This is impressive by any standard. What can account for the observed decreases that is not explained by the delivery context or any of the socio-economic, fertility or biological factors included in our models? One possibility is general improvements in access to health care through the Village Midwife programme. Research has shown that the addition of a village midwife to a community resulted in increased birth weights, increased height-for-age among children, and increased body mass indices for reproductive-age women (Frankenberg and Thomas 2001; Frankenberg *et al.* 2005). Frankenberg *et al.* (2005) posit that these results were due to increased duration of unsupplemented breastfeeding, increased use of outpatient care, and better maternal nutrition in midwife-served areas. Still, it is puzzling that these effects would not have translated into a change in the slope of the early neonatal mortality trend at some point in the 1990s. Another explanation for the decrease is that the wealth quintile, maternal education and urban/rural variables may not have captured all dimensions of the population's socio-economic status. General reductions in poverty across Indonesia (Badan Pusat Statistik *et al.* 2001) could have led to improved neonatal outcomes. The expansion of health care infrastructure, better water and sanitation, and improved transportation networks could all have contributed to reduced mortality as well.

Our inability to document that the increased presence of professional birth attendants at home births reduced early neonatal mortality rates in Indonesia is disappointing, especially since the Midwife in the Village programme *has* increased access to professional delivery care among rural poor women (Hatt *et al.* 2007). Despite the Midwife in the Village programme's expressed aim of improving newborn as well as maternal health, a greater emphasis on immediate postpartum care of the newborn appears to be needed (Setiarini *et al.* 2003). Although there is a standard national curriculum for midwifery training, it is not clear to what extent this standard curriculum is applied in each midwifery school; the content of the training programme may vary between schools. Additional training in newborn resuscitation and referral procedures may be required: in a recent review, Indonesian midwifery academies were urged to enhance the clinical skills of students, with 'priority . . . given to neonatal resuscitation . . . and making effective referrals of women and newborns when an emergency occurs' (Department of Reproductive Health 2004). It is also of concern that the Ministry of Health's ability to regulate midwifery training and practice has declined since decentralization in 2001.

Conclusion

Although early neonatal mortality in Indonesia decreased by an impressive amount between 1986 and 2002, we are unable to document that the increased presence of professional birth attendants at home births led to this decrease. Our findings suggest that midwife training on postpartum care for the newborn may be in need of strengthening. Improved training should be coupled with improvements to the quality of hospital care for newborns, especially in public sector facilities where little improvement in early mortality rates was observed over the time period in this study. Overall, policy efforts to encourage birth spacing, delayed initiation of childbearing, and small family sizes—in other words, continued support for Indonesia's successful family planning programmes—should be continued, since these factors are still highly significant determinants of first-day and early neonatal deaths.

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