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Effectiveness of Home-based Management of Newborn Infections by Community Health Workers in Rural Bangladesh

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Abstract

Background—Infections account for about half of neonatal deaths in low-resource settings. Limited evidence supports home-based treatment of newborn infections by community health workers (CHW).

Methods—In one study arm of a cluster randomized controlled trial, CHWs assessed neonates at home using a 20-sign clinical algorithm and classified sick neonates as having very severe disease or possible very severe disease. Over a two-year period, 10 585 live births were recorded in the study area. CHWs assessed 8474 (80%) of the neonates within the first week of life and referred neonates with signs of severe disease. If referral failed but parents consented to home treatment, CHWs treated neonates with very severe disease or possible very severe disease with multiple signs, using injectable antibiotics.

Results—For very severe disease, referral compliance was 34% (162/478 cases), and home treatment acceptance was 43% (204/478 cases). The case fatality rate was 4.4% (9/204) for CHW treatment, 14.2% (23/162) for treatment by qualified medical providers, and 28.5% (32/112) for those who received no treatment or who were treated by other unqualified providers. After controlling for differences in background characteristics and illness signs among treatment groups, newborns treated by CHWs had a hazard ratio of 0.22 (95% confidence interval 0.07–0.71) for death during the neonatal period and those treated by qualified providers had a hazard ratio of 0.61 (95% confidence interval of 0.37–0.99), compared with newborns who received no treatment or were treated by untrained providers. Significantly increased hazards ratios of death were observed for neonates with convulsions (HR 6.54; 95% CI 3.98–10.76), chest in-drawing (HR 2.38, 95% CI 1.29–4.39), temperature < 35.3°C (HR 3.47, 95% CI 1.30–9.24), unconsciousness (HR 7.92, 95% CI 3.13–20.04).

Conclusions—Home treatment of very severe disease in neonates by CHWs was effective and acceptable in a low-resource setting in Bangladesh.

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Keywords

neonatal; infection; sepsis; community health workers; Bangladesh

INTRODUCTION

Of the estimated 9.7 million annual global deaths among children less than 5 years of age, about 38% take place within the neonatal period.(1) Sepsis, pneumonia and other serious infections account for about 36% of all neonatal deaths and about 50% in high mortality settings.(2–4) It has been estimated that postnatal care, including identification and management of pneumonia and other serious infections, could avert 17–39% of neonatal deaths if implemented at 90% coverage, and greater reductions in mortality could be achieved if these interventions were packaged with other antenatal and intrapartum interventions.(5,6) However, there is an urgent need to define feasible strategies for managing newborn infections within specific health systems.(5,7)

The World Health Organization has promoted the diagnosis and management of serious infections of children under five years of age through the use of simple algorithms and standardized treatment regimens, a strategy called Integrated Management of Childhood Illness (IMCI) (8,9), and more recently a seven-sign algorithm was proposed for identifying serious illness in the first 2 months of life.(10) Although IMCI has generally been implemented by professional health workers at health facilities, some evidence suggests that childhood illnesses can be identified, referred or treated by community health workers (CHWs) outside of health facilities.(11–16) Few studies, however, have reported treatment outcomes for CHW referral and treatment of newborn infections and other serious illnesses.

We evaluated two service delivery strategies of a package of maternal and neonatal health interventions, home-care and community-care, in an estimated 500 000 population in rural northeast Bangladesh, using a cluster-randomized controlled trial design. (17) In the home-care arm, trained CHWs assessed neonates through early postnatal home visits and managed sick neonates, including referral of neonates with signs of infection; if referral failed but parents consented to home treatment, CHWs treated neonates with injectable antibiotics. We have previously reported that in the home-care arm, neonatal mortality was reduced from 46.9 deaths per 1000 live births at baseline to 29.2 per 1000 during the last six months of the 30-month intervention.(17)

We report here the relative effectiveness of neonatal infection management by CHWs, qualified medical providers, and other types of providers or no treatment, using surveillance data that CHWs collected while assessing, referring, and treating neonates in the home-care study arm.

MATERIALS AND METHODS

Setting

Health care in Bangladesh is provided by health centers and hospitals managed by the government's Ministry of Health and Family Welfare, non-governmental organizations, and both trained and untrained private sector providers. At the community level, two government health workers, a family welfare assistant and a health assistant, together serve a population of 6000–7000. At the first level facility, outpatient clinics called Union Health and Family Welfare Centres, staffed by family welfare visitors, medical assistants or physicians, serve a population of about 20 000. Medical assistants have three years of training and family welfare visitors have 18 months of training, including training in attending normal childbirth and treatment of minor childhood illnesses. At the second level of facility care, sub-district

hospitals, with both inpatient and outpatient facilities, are staffed by nurses, family welfare visitors, and physicians, and serve a population of 200 000.

At baseline, less than 50% of pregnant women received an antenatal check-up, 91% of births took place at home and only 22% of newborns received a check-up within the first month of life.(18,19)

Intervention and Study Design

The intervention package and service delivery strategies of the project, known as Projahnmo 1, have been described in detail elsewhere.(18) Briefly, in the home-care model, one female CHW per 4000 population was recruited through a NGO partner. The CHWs had at least a 10^{th} grade education and received six weeks of training. Midway through the intervention, a three-day refresher training was conducted. One field services supervisor provided ongoing training, support, and supervision to a group of six to eight CHWs. The supervisors' work schedule was organized so that they spent at least two days per month accompanying each CHW in their respective group, evaluating her work performance using a structured checklist for observations and providing immediate feedback. CHWs also had the opportunity to discuss field problems and to obtain feedback in fortnightly group meetings with the senior supervisors.

CHWs conducted pregnancy surveillance and calculated expected dates of delivery based on reported last menstrual period and visited families twice during pregnancy to promote antenatal care and birth and newborn care preparedness. CHWs assessed newborns on days 1, 3 and 7 of life, using a 20-sign clinical algorithm, and classified illnesses as very severe disease, possible very severe disease with multiple signs or possible very severe disease with a single sign, based on the signs observed and symptoms reported by caregivers (Figure 1). If CHWs judged newborns to have very severe disease or possible very severe disease with multiple signs, CHWs referred sick newborns to government sub-district hospitals; the sub-district hospitals were located an average of 8.5 km from study participants' homes. Some families did not go to the sub-district hospital but sought care from a private qualified doctor instead. If families were unable to comply with referral but consented to home treatment, CHWs treated newborns using injectable procaine penicillin and gentamicin for 10 days, free of charge.(17, 20) Newborns classified as having possible very severe disease with a single sign were referred; however, if the family was not able to comply with referral, the CHWs treated local skin and umbilical cord infections with gentian violet and made follow-up visits to reassess the infant as described in Figure 1, but did not offer treatment with injectable antibiotics. CHWs were required to visit all neonates diagnosed with very severe disease or possible very severe disease with multiple signs daily to complete the 10-day course of antibiotic therapy and to reinforce referral. Information on other types of care received was based on self-report by families to CHWs. Although no routine visit was scheduled after the first week of life until the end of the neonatal period, families were taught to identify signs of infection and to seek care for them from the CHW or a health facility.

This study received ethical approval from the Johns Hopkins Bloomberg School of Public Health's Committee on Human Research, and the Ethical Review Committee of the International Centre for Diarrhoeal Disease Research, Bangladesh. Informed consent was obtained from all individual study participants.

Data Collection and Data Quality Assurance

CHWs in the home-care arm maintained records of all antenatal birth and newborn care preparedness and postnatal visits, and made a final visit to all households between days 29 and 35 of birth to ascertain survival status of live-born infants. Information was collected on socio-demographic factors, pregnancy history, routine antenatal care, birth and newborn care

preparedness activities, delivery and newborn care practices, danger signs in newborns, and referral and management of newborn illnesses. Field supervisors checked the accuracy of data collection in the field and routinely checked CHWs' records before they were entered into a database. To maintain the accuracy of the data on neonatal mortality, field supervisors made independent home visits to all homes with a reported neonatal death and to a random sample of households with a surviving neonate. Problems with data quality were addressed at the time they were found and during routine fortnightly group meetings with CHWs.

Data Analysis, Main Outcome Measures

For analysis we utilized prospective data from the CHWs' visit records for 10 585 live births that occurred between January 2004 and December 2005. The distribution of timing of identification of each illness category (very severe disease, possible very severe disease with multiple signs and possible very severe disease with single sign) was calculated by day of life. The type of treatment received was initially categorized into four treatment types: (a) government sub-district hospital or a private sector doctor with an MBBS degree ("medically qualified provider"); (b) CHWs; (c) other providers, which included homeopathic doctors, "village doctors" who lack formal medical training, religious healers, pharmacists and others; and (d) no treatment, which included no care outside of that provided by the newborn's family. Later, categories (c) and (d) were combined because the numbers treated were small and the case fatality rates were similar. Treatment type was assigned hierarchically so that all newborns who were taken to a qualified provider were included in that category, even if they were initially treated in the home by CHWs or taken to another provider. Likewise, all neonates who were not treated by qualified medical providers but were treated by CHWs were included in the CHW treatment group, even if families also sought care from unqualified providers. Case fatality rates and 95% confidence intervals (CI) were calculated by illness severity category and treatment type.

We then restricted our analysis to cases of very severe disease and examined the degree to which the difference in case fatality rates could be a result of differences in socioeconomic status or other risk factors (e.g., preterm, multiple births) or signs and symptoms of presenting illness. A three-level household wealth index was created based on an additive score for materials used to construct the house's roof, walls and floor. Mother's and father's mean years of education were based on information reported to the CHWs. Gestational age was calculated in weeks by subtracting the date of the first day of the last menstrual period from date of delivery; births were considered preterm if they occurred before 37 weeks of gestational age. The presence of convulsions, fever, hypothermia, fast breathing, severe chest in-drawing, unconsciousness, many or severe skin pustules and umbilical redness extending to the skin was based on the CHWs' assessment. Differences in distribution of background characteristics by treatment type were compared using Fisher's exact test or ANOVA as appropriate.

Hazard Ratios (HR) and 95% confidence intervals (CIs) were calculated with a frailty hazards model using neonatal mortality as the outcome .(21) Due to the cluster-randomized study design, variance estimates were adjusted for clustering effect at the union level. We first calculated unadjusted HR and 95% CI. We then developed an adjusted model including type of provider, household wealth index scores as a measure of socioeconomic status, preterm birth status, and the presence of the following signs and symptoms: convulsions, chest indrawing, temperature <35.3°C and unconsciousness. The illness signs and symptoms included in the model were chosen because their distribution was significantly different by treatment type and they were positively associated with neonatal mortality.

Stata Version 9.0 (College Station, TX, USA) was used for data analysis.

RESULTS

CHWs assessed 8474 (80%) of the neonates within the first week of life and classified 478 cases as having very severe disease, 131 as possible very severe disease with multiple signs and 820 as possible very severe disease with a single sign (Table 1). One-third of the very severe disease cases were identified by the second day of life, and 67% by day 8 (Figure 2). Overall incidence rates were 5.6% for very severe disease, 1.5% for possible very severe disease with multiple signs and 9.7% for possible very severe disease with single sign (Table 1). Rates of referral compliance to qualified medical providers were 34% for very severe disease, 25% for possible very severe disease with multiple signs and 10% for possible very severe disease with single sign. CHWs treated 43% of very severe disease cases and 37% of possible very severe disease with multiple signs cases and provided follow-up visits for 64% of cases categorized as possible very severe disease with single sign. The case fatality rates for very severe disease were 14.2% (95% CI 9.2–20.5%) among cases treated by medically qualified providers, 4.4% (95% CI 2.0–8.2%) among those treated by CHWs, 32.0% among those treated by other providers (95% CI 14.9–53.5%) and 27.6% (95% CI 18.5–38.2%) among those who received no care. Of the 25 cases of very severe disease that were treated by "other" providers (i.e. village doctors, pharmacists, etc.) 2 received oral antibiotics, 3 received injectable antibiotics and 7 received other medications.

The distribution of household wealth and risk factors differed by treatment type; the poorest third of households were more likely to be treated by CHWs and newborns who received treatment from unqualified "village" doctor and non-CHW providers were more likely to be preterm or twins or multiple births (Table 2). Neonates treated by CHWs were more likely to have fast breathing or temperature ≥38.4°C or many or severe skin pustules and less likely to have convulsions or temperature ≤ 35.3°C (Table 2). Significantly higher hazards ratios of death were observed for neonates with convulsions (HR 6.54; 95% CI 3.98–10.76), chest in-drawing (HR 2.38, 95% CI 1.29–4.39), temperature ≤ 35.3°C (HR 3.47, 95% CI 1.30–9.24) or unconsciousness (HR 7.92, 95% CI 3.13–20.04).

Treatment by CHWs for very severe disease was associated with a significantly lower HR for death, compared to those treated by unqualified providers or who received no treatment, in both the unadjusted (HR 0.13, 95% CI: 0.06–0.26) and adjusted analyses (HR 0.22, 95% CI: 0.07–0.71) (Table 3). Treatment by medically qualified providers compared to other providers/no treatment was also associated with significantly lower hazards ratio of death in the unadjusted model (HR 0.44, 95% CI 0.32–0.60) as well as in the adjusted model (HR 0.64, 95% CI 0.37–0.99).

Among those diagnosed with very severe disease, consent and receipt of CHW treatment increased from 35% (28/81 cases) during the first six months of 2004 to 44% (69/159 cases) during the last six months of 2005, while the proportion of newborns treated by unqualified providers or receiving no treatment declined from 28% (23/81 cases) to 16% (25/159 cases) (Figure 3). Care seeking from a medically qualified provider was 37% (30/81 cases) during the first 6 months of the intervention, 26% (38/144 cases) and 31% (29/94 cases) during the next two 6–month periods, and then rose to 41% (65/159 cases) during the last 6 months.

DISCUSSION

We have presented data on outcomes for neonates categorized by CHWs during routine household surveillance into three categories of severe illness, according to the clinical signs and symptoms present and by the type of treatment received. CHWs referred all neonates with signs of serious illness but only 34% of the very severe disease cases complied with referral and were treated by qualified providers. The CHWs treated 43% of the very severe disease

cases and the remaining cases received care from untrained providers or did not receive any care. CHW treatment was associated with the lowest case fatality rate and no complications were reported. Moreover, the community appeared increasingly to accept the treatment provided by this new cadre of health workers.

This large study ensured data quality through routine field supervision and ongoing training in data collection methods, allowing collection of relatively unique data at the community level. One weakness of the study is that it was based on observational data; however, randomizing neonates with signs of illness to the various treatment types would not be ethical. Information on the incidence of illness and on treatment outcomes should be interpreted in light of the fact that this was an intervention trial that provided both preventive and curative care and that surveillance for newborn illnesses was conducted on a specified schedule. CHWs referred all sick newborns to government health facilities, and refresher training in treating neonatal infections was provided for staff at those facilities as part of the intervention. Nonetheless, we were unable to fully assess whether government facilities adhered to the recommended treatment regimen of parenteral gentamicin and procaine penicillin for 10 days. Another potential limitation of the analysis is that we did not control for birth weight, as we were unable to obtain birth weights for 21% of live births; instead we controlled for gestational age.

This study's intervention design is similar to the Gadchiroli study in India, but the schedule for postnatal visits, algorithm to assess neonates, and treatment protocol differed. During a 7-year intervention that included both preventive and curative care, Bang et al (22) classified all newborns with at least 2 of 7 signs of infection into a single category called sepsis with a reported incidence of 10.5%. Village health workers treated 91% of suspected sepsis cases with injectable gentamicin and oral trimethoprim sulfamethoxazole with a case fatality rate of 6.9%. This is comparable to our finding that CHW treatment resulted in a 3.1% case fatality rate among those judged to need antibiotic treatment, although we relied on a two-tiered algorithm in which antibiotic treatment was recommended for those with one or more of the very severe disease signs or two or more of the possible very severe disease signs. Other studies and reviews suggest that CHWs can successfully identify and treat signs of pneumonia and other serious illnesses among under-5 children.(12–14,23–26)

According to our algorithm, 16.8% of newborns had at least one sign of illness, but only 7.1% had indications for parenteral antibiotics. The remaining cases had a case fatality rate of 1%, suggesting that most required no antibiotic treatment. This further sub-categorization of illness by level of severity may represent an important improvement of the algorithm, as it could reduce the potential for unnecessary treatment of minor illnesses with parenteral antibiotics, but this finding needs to be confirmed in other settings. The development of a 7-sign IMCI algorithm by WHO to identify young infants, including neonates in the first week of life, in need of referral care is promising,(10) but the findings from this facility-based study may not be readily applicable for community based surveillance and management of neonatal illnesses. However, we have recently identified a similar 6-sign algorithm that performed comparably to the 7-sign IMCI algorithm with minor modifications when used during routine household surveillance for neonatal illness in another study location in Bangladesh(14).

The case fatality rates for those treated by qualified health care providers and those treated by CHWs were statistically similar because of wide confidence intervals; however, the hazards ratios were quite different. We recognize that families of neonates with more severe illnesses might have been more likely to comply with referral to qualified providers, and we made efforts to control for this by including the signs of illnesses in the adjusted analysis. Other reasons for a trend towards higher mortality among qualified providers could be that families delayed seeking care, and thus the level of illness severity became greater, or they complied poorly with the recommended treatment, two factors that have been reported in other studies.(27–

32) Among neonates with very severe disease, 38% of those treated by qualified providers were treated by private sector providers, not government facilities (data not shown). The preference for using private sector providers has been noted by other researchers, (27,28,33–36) despite some evidence that quality of care in private sector may diverge from standard treatment regimens.(29,30) Because of the hierarchical assignment of treatment type in our analysis, the category of neonates treated by qualified providers may have included treatment failures by CHWs. However, if we included all cases treated by CHWs, regardless of whether they were also treated by qualified providers, the CFR for very severe disease would be 5.2%, and for possible very severe disease with multiple signs would be 0%.

These findings add to the limited body of evidence that CHWs can effectively treat neonatal illnesses, suggesting that in settings where the health system is weak and care seeking is low, a phased implementation of home or community-based management should be considered, as suggested in the Lancet neonatal survival series.(5) In Bangladesh, government community-based health workers give injectable contraceptives to mothers and immunizations to children, so precedent exists for the provision of injections in the household by CHWs.

Nonetheless, home-based care cannot replace functioning health systems with improved access and quality of care. Strengthening health facilities would be essential to sustainable implementation of home-based care, including orientation of providers and improving availability of antibiotics and other supplies, as was done in this study. Improvements in the quality of facility-based services and improved access to skilled birth attendance are complementary goals to the promotion of home-based care.

It may be argued that although home treatment is effective, it may be difficult to implement at scale. For example, our CHWs received 6 weeks of training. However, we recruited a new cadre of workers with no background in health care, thus, training of existing health workers might be less time-consuming. Moreover, a substantial portion of the training was spent on the data collection methods necessary for research purposes, which would be reduced in a programmatic setting. In addition, the 20-sign algorithm we used may be too complex compared the 7-sign algorithm used in the WHO young infant study[10] or the 6-sign algorithm identified for use at community level during household surveillance in Bangladesh.(14)

Some of the minimum requirements for home-based management of neonatal infections include a strong monitoring and evaluation component, supportive supervision, an enabling policy environment and a policy decision to implement home-based management. Community education and mobilization would be required to create awareness and demand for services. A mechanism would be needed to identify pregnant women and newborns so that the local health workers could assess the newborn soon after birth. Initial implementation of home-based care should ideally be conducted in an operations research mode, in order to identify potential barriers to large scale programmatic implementation, to design and evaluate methods to overcome barriers and to test strategies for maintaining appropriate quality assurance. Careful planning and appropriate technical assistance to key stakeholders would be essential prior to large scale dissemination and scale-up of this strategy.

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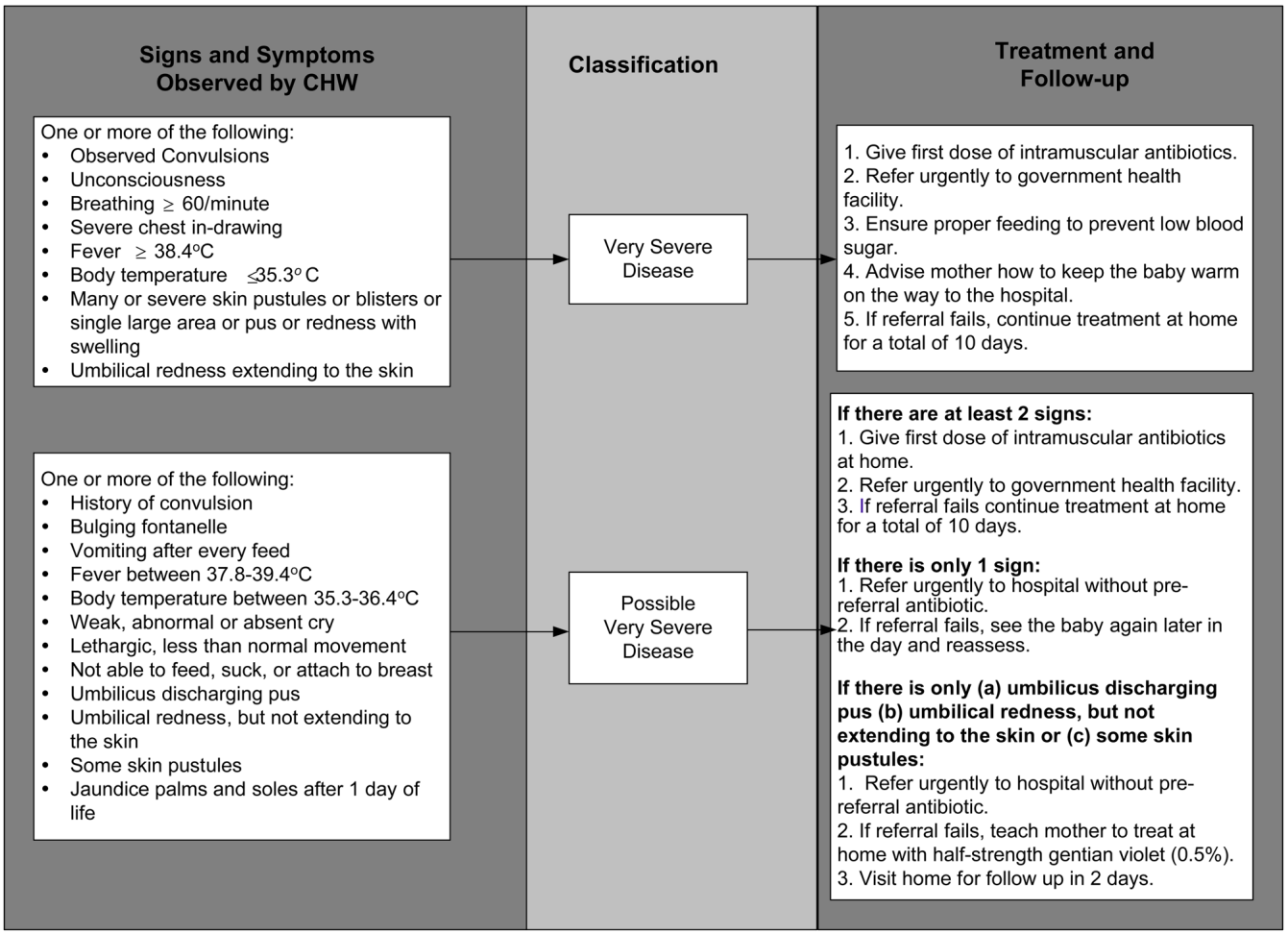

Figure 1.
Guidelines for assessment of neonates and management of sick neonates by community health workers

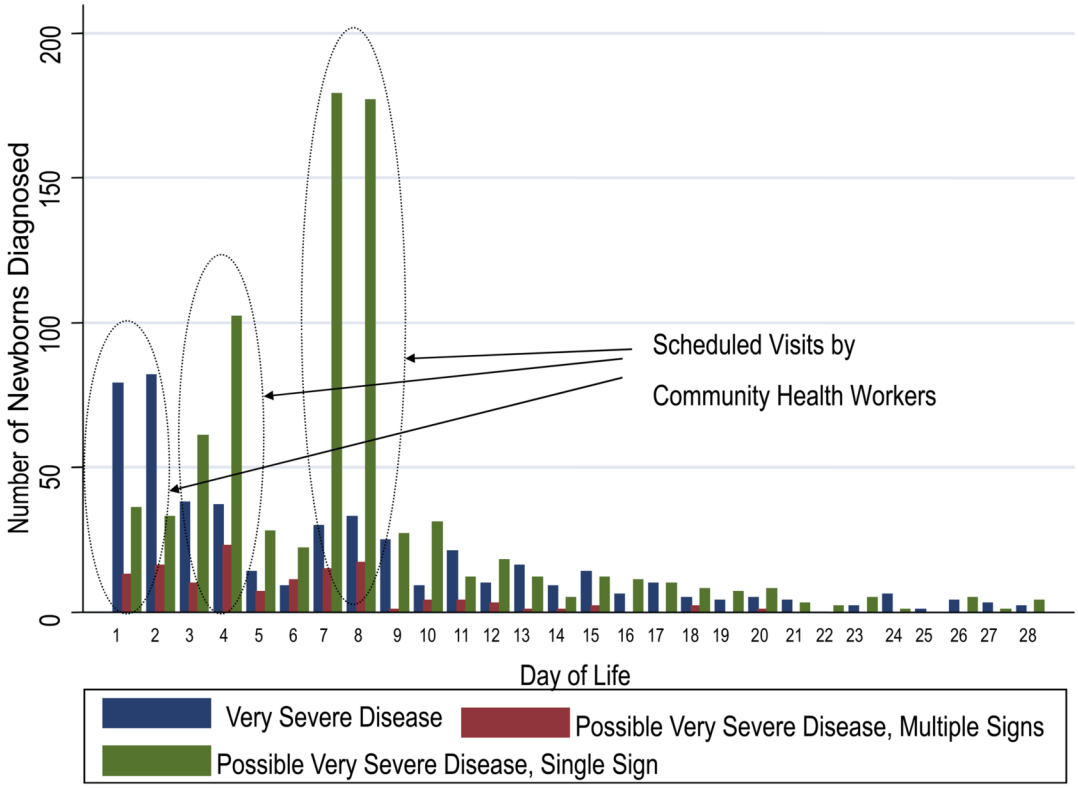

Figure 2.
Timing of identification of neonatal infections by community health workers

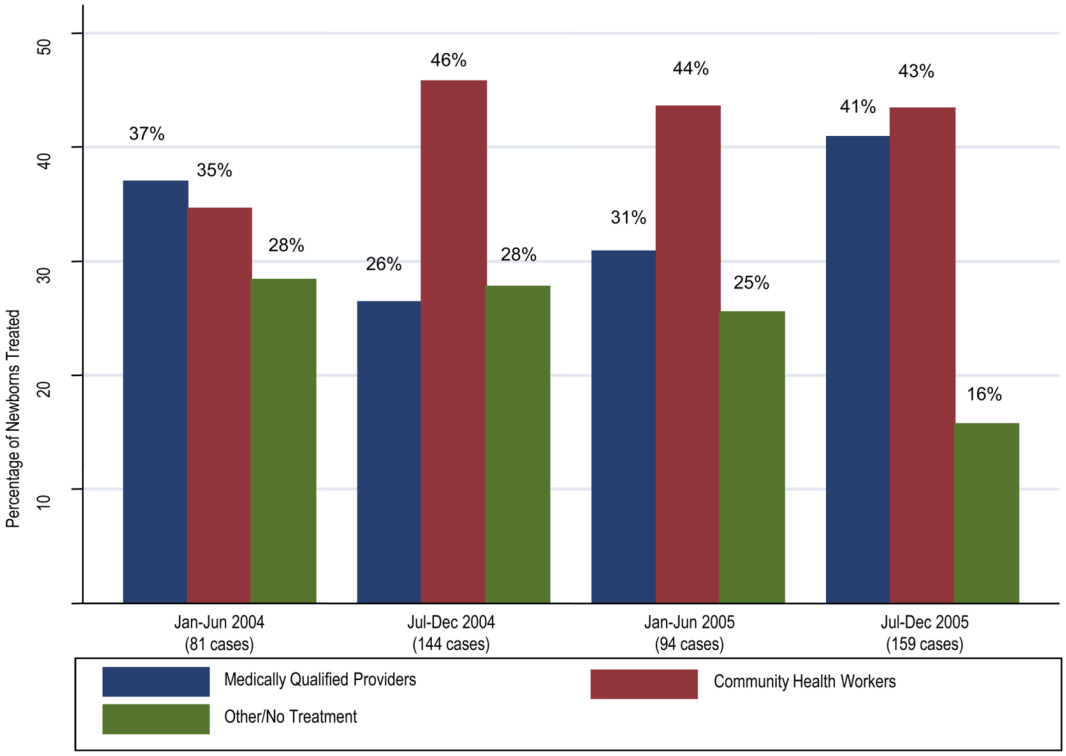

Figure 3.
Treatment Received for Very Severe Infection by Six-Month Intervals

Table 1

Incidence and case fatality rate (CFR) and 95% confidence interval (CI) by provider type, among all live births 2004–2005 assessed by community health workers (n=8,474)

	Very Severe Disease		Possible Very Severe Disease, Multiple Signs		Possible Very Severe Disease, Single Sign	
	Number of Cases (Deaths)	**CFR (95% CI)**	**Number of Cases (Deaths)**	**CFR (95% CI)**	**Number of Cases (Deaths)**	**CFR (95% CI)**
All Cases Identified	478 (64)	13.4% (10.3–16.4%)	131 (11)	8.4% (3.6–13.2%)	820 (8)	1.0% (0.9–3.0%)
Distribution of Treatment Received:						
Medically qualified providers*	162 (23)	14.2% (9.2–20.5%)	32 (1)	3.1% (0.08–16.2%)	79 (0)	0.0% (0–4.6%)
Community health workers	204 (9)	4.4% (2.0–8.2%)	49 (0)	0.0% (0.0–7.2%)	522 (2)	0.4% (0.05–1.38%)
Other providers**	25 (8)	32.0% (14.9–53.5%)	12 (1)	8.3% (0.2–38.5%)	35 (2)	5.7% (0.7–19.1%)
No care outside the home	87 (24)	27.6% (18.5–38.2%)	38 (9)	23.7% (11.4–40.2%)	184 (4)	2.2% (0.6–5.5%)
Incidence per 100 live births	5.6		1.5		9.7	

*Sub-district hospital or MBBS-qualified doctor in private practice.

**Includes village doctors, pharmacists and homeopaths.

Table 2

Background characteristics of and signs and symptoms present among newborns with very severe disease by treatment type (n=478)

	Medically qualified providers	Community health workers	Others or no treatment
Distribution of Household Wealth Index (%)			
Lowest Third	46.3	64.2**	60.7
Middle Third	35.2	26.0	32.1
Highest Third	18.5	9.8	7.1
Mother's mean years of education completed (SD)	3.1 (3.5)	3.1 (3.2)	2.3 (3.1)
Father's mean years of education completed (SD)	3.5 (3.6)	2.8 (3.3)	2.9 (3.7)
% Pregnancy complications	10.5	10.8	6.2
% Primigravida	21.6	15.7	21.4
% Preceding birth interval <18 months	9.2	12.2	17.9
% Preterm	19.8	23.0**	36.6
% Male sex	59.3	59.3	60.7
% Multiple birth	4.9	3.9*	11.6
Mean age at death in days (SD)	7.3 (7.3)	6.3 (6.7)	4.3 (4.0)
Signs/symptoms	Number (%)	Number (%)	Number (%)
Convulsions	15 (9.3)	4 (2.0)**	8 (7.1)
Temperature ≥ 38.4°C	18 (11.1)	32 (15.7)*	7 (6.2)
Temperature <35.3° C	27 (16.7)	18 (8.8)**	56 (50.0)
Respiratory rate ≥ 60 per minute	112 (69.1)	148 (72.5)**	45 (40.2)
Severe chest in-drawing	11 (6.8)	9 (4.4)	8 (7.1)
Unconsciousness	3 (1.8)	4 (2.0)	3 (2.7)
Many or severe skin pustules/blisters	18 (11.1)	32 (15.7)**	5 (4.5)
Umbilical redness extending to the skin	7 (4.3)	5 (2.4)	3 (2.7)
Number of cases	162	204	112

Fisher's exact test:

* p<0.05,

** p<0.01

Table 3

Unadjusted and adjusted hazard ratios and confidence intervals for neonatal mortality by treatment type

	Unadjusted	Adjusted
Treatment Provider		
Medically qualified providers	0.44 (0.32–0.60)	0.60 (0.37–0.99)
Community health workers	0.13 (0.06–0.26)	0.22 (0.07–0.71)
Others or no treatment	1.0	1.0
Household Wealth Index		
Poorest Third	1.0	1.0
Middle Third	0.54 (0.35–0.83)	0.72 (0.38–1.36)
Highest Third	0.28 (0.12–0.65)	0.52 (0.27–1.03)
Preterm Birth	2.35 (1.52–3.64)	1.48 (1.05–2.05)
Symptoms/signs		
Convulsions	8.69 (3.40–22.25)	6.54 (3.98–10.76)
Chest in-drawing	4.79 (2.29–10.01)	2.38 (1.29–4.39)
Temperature < 35.3°C	6.27 (2.99–13.16)	3.47 (1.30–9.24)
Unconsciousness	5.53 (1.45–21.09)	7.92 (3.13–20.04)