

Effect of knowledge of community health workers on essential newborn health care: a study from rural India

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Accepted 20 December 2010

Background This study explored the relationship between the knowledge of community health workers (CHWs)—*anganwadi* workers (AWWs) and auxiliary nurse midwives (ANMs)—and their antenatal home visit coverage and effectiveness of the visits, in terms of essential newborn health care practices at the household level in rural India.

Methods We used data from 302 AWWs and 86 ANMs and data from recently delivered women (RDW) ($n=13\,023$) who were residents of the CHW catchment areas and gave birth to a singleton live baby during 2004–05. Using principal component analysis, knowledge scores for preventive care and danger signs were computed separately for AWWs and ANMs and merged with RDW data. A multivariate logistic regression model was used to estimate the adjusted effect of knowledge level. A generalized estimating equation (GEE) was used to account for clustering.

Results Coverage of antenatal home visits and newborn care practices were positively correlated with the knowledge level of AWWs and ANMs. Initiation of breastfeeding in the first hour of life (odds ratio 1.97; 95% confidence interval (CI): 1.55–2.49 for AWW, and odds ratio 1.62; 95% CI: 1.25–2.09 for ANM), clean cord care (odds ratio 2.03; 95% CI: 1.64–2.52 for AWW, and odds ratio 1.43; 95% CI: 1.17–1.75 for ANM) and thermal care (odds ratio 2.16; 95% CI: 1.64–2.85 for AWW and odds ratio 1.88; 95% CI: 1.43–2.48 for ANM) were significantly higher among women visited by AWWs or ANMs who had better knowledge compared with those with poor knowledge.

Conclusion CHWs' knowledge is one of the crucial aspects of health systems to improve the coverage of community-based newborn health care programmes as well as adherence to essential newborn care practices at the household level.

Keywords Knowledge level, community health workers, essential newborn health care practices, principal component analysis, logistic regression, generalized estimating equation

KEY MESSAGES

- The greater the knowledge level of community health workers (CHWs), the greater is their antenatal care coverage.
- The greater the knowledge level of CHWs, the better is the adherence to essential newborn care practices at household level in their catchment area.
- Improving newborn health status in rural settings is possible by improving the knowledge level of CHWs.

Introduction

Nearly 4 million neonatal deaths occur globally every year, and about 1 million of these occur in India (Lawn *et al.* 2005). Community health workers (CHWs) have long been used in child survival programmes. Improved neonatal health and reduction in mortality have been observed in many community-based health programmes using CHWs in India and in similar settings in neighbouring countries (Bang *et al.* 2005a; Bang *et al.* 2005b; Baqui *et al.* 2007; Haines *et al.* 2007; Baqui *et al.* 2008a; Kumar *et al.* 2008).

The government has employed multipurpose CHWs to promote various aspects of maternal and child health in India. At the community level, health education and services are provided by two groups of government functionaries—auxiliary nurse midwives (ANMs) and anganwadi workers (AWWs)—from fixed-site facilities as well as through home visits. ANMs are health staff under the Ministry of Health and Family Welfare (MOHFW), Government of India. They serve a population of about 5000 through a health centre and also make outreach services by visiting door-to-door. Their job includes providing counselling and services to pregnant and postpartum mothers, birth attendance, immunization and encouraging family planning acceptance. On the other hand, AWWs are the community-based frontline workers of the Integrated Child Development Scheme under the Ministry of Women and Child Development (MOWCD). They are selected from the community itself and serve one village or a population of approximately 1000. They monitor and promote the growth of children, organize supplementary feeding, help in organizing immunization sessions, distribute vitamin A supplements and iron and folic acid tablets, and refer cases to medical services. AWWs also provide outreach services by visiting door-to-door in the community as agents of social change mobilization for better care of young children, girls and women (Tandon *et al.* 1981; Nanda 1993; Avsm 1995; Government of India 1995; Bhattacharyya *et al.* 2001).

As a crucial link between the population and the government administration, ANMs and AWWs have become a central figure in helping the community to identify and meet the needs of children and women. They form a major component of India's health delivery system. The effectiveness of their performance depends upon their knowledge, attitude and practices, as well as other factors. Studies have shown that the knowledge and skills of these CHWs varies drastically (Udani and Patel 1983; Walia *et al.* 1978; Kant *et al.* 1984; Kapil and Tandon 1990; Daga *et al.* 1993; Tandon 1997). One study found that the average knowledge of the AWWs was adequate (Satpathy *et al.* 1995). However, another study showed wide variation in the knowledge and skills of AWWs regarding different components of their sphere of activity (Chattopadhyay 2004).

Very few studies have examined the knowledge of CHWs with regard to essential newborn health care. There is a dearth of studies that discuss whether better knowledge of CHWs leads to improved work performance and improved compliance at the household level. In an independent evaluation of an Integrated Nutrition and Health Programme we found that, overall, the intervention led to no reduction in mortality, but the home visits by AWWs or ANMs were associated with improvement in newborn care practices and lower mortality (Baqui *et al.* 2008b). In this study we further examine: (i) the relationship between the knowledge level of AWWs and ANMs and antenatal home visits coverage, and (ii) the effect of their knowledge level on essential newborn health care practices at the household level, by analysing CHW and household level data together.

Methods

Data and setting

The study presents data from the endline survey of an independent evaluation of an Integrated Nutrition and Health Programme conducted between January and March 2005. The data collection, intervention and setting have been described in detail elsewhere (Baqui *et al.* 2008b). Briefly, the Integrated Nutrition and Health Programme was a partnership of an international non-governmental organization (NGO), CARE-India, with the Government of India and local NGOs. The programme functioned through the infrastructure of the MOWCD's Integrated Child Development Scheme and the MOHFW. The role of CARE-India was to facilitate the integration and strengthening of the Integrated Child Development Scheme and MOHFW programmes by providing inputs in planning, training and logistics. Both ministries provided infrastructure, including health workers, supplies and supervision. The partnership emphasized use of existing infrastructure, training of CHWs to strengthen counselling and problem-solving skills, home visits to promote behaviour change and complete geographical coverage during critical time-periods (e.g. pregnancy, postnatal period etc.).

The programme was implemented in eight states of India, but the evaluation took place in two districts of rural Uttar Pradesh, which was selected because it is India's largest state and one of the most disadvantaged in terms of health and other developmental infrastructure. A quasi-experimental design with intervention and comparison districts was used. We selected Barbanki as the intervention district in collaboration with CARE-India, and Unnao was selected as the comparison district because analysis of demographic data suggested that Unnao was most comparable to Barbanki in terms of size and

population characteristics. CARE-India facilitated the government programme in the intervention district, Barabanki, while the comparison district, Unnao, received the standard government programme. The newborn care aspects of the intervention were evaluated separately by a group of researchers who were independent of programme implementation.

A household survey was conducted to identify women who had a live birth or stillbirth during the 2 years preceding the survey, referred to as recently delivered women (RDW). RDW were asked detailed questions about the care they received during pregnancy and delivery, their newborn care practices at home, and their socio-economic and demographic characteristics. All women ($n = 13\,023$) whose pregnancy history included a live birth within the 24 months preceding the survey were interviewed. Information on knowledge and practices regarding the antenatal, delivery, postpartum period and newborn care was collected. Also, coverage of antenatal and postpartum visits by CHWs was assessed. Immediate newborn care questions assessed management of the umbilical cord, weighing, bathing and wrapping of the newborn, and breastfeeding initiation. Questions about newborn care also included whether the newborn received a check-up by a skilled health professional.

We also collected data from 302 AWWs and 86 ANMs through structured questionnaires administered during face-to-face interviews. Their knowledge of maternal and newborn health was assessed through an oral quiz. Most of the questions were unprompted and were divided into preventive care and maternal and newborn danger signs. Preventive care questions included, for example, knowing the number of iron, folic acid and vitamin A (IFA) tablets and tetanus toxoid (TT) immunizations that pregnant women should have. Questions related to danger signs included listing of maternal and newborn complications that require medical attention. The ANMs' survey had 19 questions on preventive care and 38 about maternal and newborn danger signs. The AWWs' survey had 12 preventive care questions and 21 about maternal and newborn danger signs (see Appendix 1 for the list of questions). There were common variables such as district, block, sector and *anganwadi* centre (AWC) and sub-centre in both the CHW and RDW data. A unique ID was created to match the catchment area of CHWs to the RDW residing in that area. This paper presents data of 10 390 and 7957 RDW who gave birth to a singleton live baby at home in the calendar years 2004–05 and merged with AWWs and ANMs data, respectively.

Data quality

Data collection was contracted out to a research agency, TNS India. Independent to the agency, 5% of the sample households' data was collected using systematic random sampling by an independent data quality assurance team, and data were matched periodically to ensure the quality of data. Data were entered twice by independent data operators, then matched and checked for internal consistency. The study received ethical approval from the Johns Hopkins University Committee on Human Research as well as the ethics committee of the King George Medical University, Lucknow, India. Informed consent was taken from all respondents prior to interview.

Analysis

A knowledge score was computed separately for AWWs and ANMs through principal component analysis (PCA) (Jolliffe 2002), based on their knowledge of preventive care and maternal and newborn danger signs. Based on knowledge scores obtained from PCA, AWWs and ANMs were divided into three groups—poor, average and better knowledge—and merged with RDW data using a common identity. Altogether, 10 390 and 7957 RDW were merged with the catchment areas of AWWs and ANMs, respectively. Some 2633 and 5033 RDW were not merged because either AWWs or ANMs were not available or their catchment areas were not defined in the data. Some RDW were visited by only an AWW or an ANM, some visited by both an AWW and an ANM, and some received no visits. A total of 7279 RDW not visited by AWWs and 5767 RDW not visited by ANMs were subsequently excluded from the final bivariate and multivariate analysis as our aim was to see the effect of knowledge level of the health workers rather than their visitation. Effects of knowledge level of the AWWs or ANMs were examined separately based on 3109 and 2189 RDW classified into three groups according to the knowledge level of the AWW and ANM, respectively, who visited them.

In statistical analysis, cross-tabulation with a χ^2 test was done to access the significant differences in the covariates. To see the adjusted effect of knowledge level of CHWs on essential newborn care, multivariate analyses were conducted with logistic regression using a generalized estimating equation (GEE) model with an exchangeable correlation structure that controlled for within-group clustering (Liang and Zeger 1983; Zeger et al. 1988). The model also controls for socio-economic and demographic characteristics of mothers, including: age at most recent birth, index child's birth order, mother's education, religion, ethnicity and wealth status. A wealth index was computed by PCA based on household durable goods and household conditions, which were collected in the household survey similar to the National Family Health Survey-3 (IIPS and Macro International 2007). Results are presented as odds ratios (OR) and 95% confidence interval (CI). Statistical analysis was conducted using Stata Version 8 (Stata Corporation 2003).

Results

Overall, less than one-third of women in the study area were visited by either AWWs (30%) or ANMs (28%) during the antenatal period. A significant difference was noted in antenatal visits according to knowledge level of AWWs or ANMs (Figure 1). The better the knowledge of AWWs or ANMs, the higher was the proportion of women visited by them. More than 42% of pregnant women received an antenatal visit by AWWs who had better knowledge compared with only 16% by AWWs who had poor knowledge. The difference in antenatal visits by ANMs was less pronounced according to their knowledge level.

Table 1 presents the distribution of women's socio-demographic characteristics according to visitation status of AWWs and ANMs. AWWs visited slightly more illiterate women, women belonging to non-Hindu households and women in the middle or fourth wealth quintile. The observed

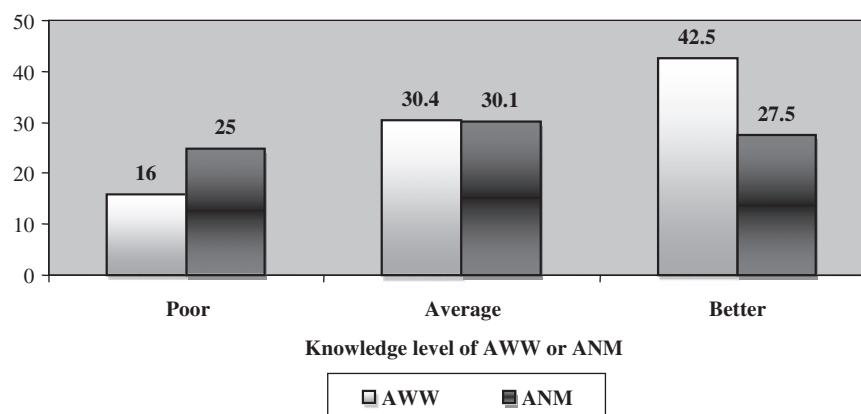


Figure 1 Percentage of pregnant mothers who received an antenatal home visit according to knowledge level of AWW or ANM in the catchment areas

Table 1 Background characteristics of the mothers according to visitation status of AWWs and ANMs during the antenatal period

Characteristics of women	Mothers not visited by AWW	Mothers visited by AWW	χ^2 P value ^a	Mothers not visited by ANM	Mothers visited by ANM	χ^2 P value ^b
Age at most recent birth (years)			0.199			0.847
12–19	16.2	16.0		15.6	15.8	
20–34	74.9	74.0		75.0	74.4	
35–49	8.9	10.1		9.5	9.8	
Birth order			0.037			0.786
1	18.0	16.3		17.6	17.5	
2–3	39.1	38.0		37.7	38.5	
4–5	25.5	27.2		26.7	26.8	
6+	17.4	18.6		18.1	17.2	
Education level			<0.001			0.088
Illiterate	70.5	75.2		72.8	70.6	
Primary school < middle school	13.6	12.9		12.7	13.0	
Middle school	10.6	7.7		9.6	10.3	
High school and above	5.4	4.2		4.9	6.1	
Religion			<0.001			0.003
Hindu	86.7	81.3		85.2	82.5	
Other	13.3	18.7		14.8	17.5	
Caste/tribe			0.029			<0.001
Scheduled caste/scheduled tribe	44.9	44.1		44.7	39.9	
Other backward class	44.0	46.3		44.8	46.1	
Others	11.1	9.7		10.5	14.0	
Wealth quintile			<0.001			<0.001
Lowest	28.7	25.3		27.8	24.7	
Second	15.5	14.1		15.7	12.2	
Middle	19.6	21.8		20.0	21.4	
Fourth	19.2	21.7		20.2	21.4	
Highest	17.1	17.2		16.3	20.4	
Number of women	7279	3111		5767	2190	

^aChi-square significance level for difference in distribution between mothers visited and not visited by AWW.

^bChi-square significance level for difference in distribution between mothers visited and not visited by ANM.

Table 2 Differences in mothers' reported adherence to newborn care practices by knowledge level of AWWs and ANMs who made antenatal home visits

Adherence to newborn care	Mother visited by AWWs having:				Mother visited by ANMs having:			
	Poor knowledge	Average knowledge	Better knowledge	χ^2 P value ⁵	Poor knowledge	Average knowledge	Better knowledge	χ^2 P value ⁶
<i>Proportion of participant mothers who:</i>								
Practised clean cord care¹	29.1	42.7	48.1	<0.001	35.7	45.7	47.0	<0.001
Used clean instrument to cut cord	98.5	98.9	98.9	0.680	99.4	98.9	99.0	0.570
Used clean thread to tie cord	65.4	74.3	78.6	<0.001	64.9	74.0	78.9	<0.001
Applied nothing or only antiseptics on cord	45.9	57.1	63.0	<0.001	47.4	57.6	56.5	<0.001
Practised newborn thermal care in the first 6 hours²	18.4	29.7	34.0	<0.001	14.1	30.0	34.0	<0.001
Practised newborn thermal care in the first 3 days³	13.8	24.9	29.4	<0.001	10.2	25.8	27.6	<0.001
Dried and wrapped newborn	26.0	40.2	45.5	<0.001	20.8	43.8	47.1	<0.001
Delayed newborn bathing in the first 6 hours	41.3	66.0	69.4	<0.001	34.9	60.8	65.4	<0.001
Delayed newborn bathing in the first 1 day	36.7	61.6	66.2	<0.001	30.1	56.1	61.4	<0.001
Delayed newborn bathing in the first 3 days	30.8	54.7	58.6	<0.001	26.4	48.5	52.2	<0.001
Initiated breastfeeding within first hour	33.1	43.4	48.7	<0.001	29.1	40.8	42.3	<0.001
Initiated breastfeeding on first day	55.6	71.9	79.2	<0.001	51.6	72.5	70.6	<0.001
Newborn check-up within the first week of life from skilled providers⁴	7.3	15.7	15.0	<0.001	8.7	19.1	21.5	<0.001
Total number of women	523	1087	1501		667	806	717	

¹Umbilical cord cut with clean instrument (new/boiled blade), tied with sterile thread and applied nothing or only antiseptics on the cord stump.

²Newborn dried and wrapped immediately after delivery and first bath delayed for 6 hours or more.

³Newborn dried and wrapped immediately after delivery and first bath delayed 3 days or more.

⁴Qualified doctor, nurse, lady health visitor or auxiliary nurse midwife.

⁵Chi-square significance level for difference in adherence to promoted behaviours according to AWW's knowledge level.

⁶Chi-square significance level for difference in adherence to promoted behaviours according to ANM's knowledge level.

statistical differences in the socio-demographic characteristics of women according to visitation by AWWs are mainly because of the large sample size and the difference is not significant. ANMs were also observed to visit more non-Hindu women and those belonging to the highest wealth quintile. However, these differences are not significant; there were no significant differences in the women's demographic and educational backgrounds according to visitation status by ANMs. Moreover, no difference was observed in visitation status either by AWWs or ANMs according to women's age and child's birth order. Thus, it is evident that characteristics of women either visited or not visited by an AWW and or an ANM are similar. Women visited by a CHW are representative of the characteristics of women generally in the study area.

Table 2 presents differences in selected newborn care practices according to the knowledge level of AWWs and ANMs who visited women during the antenatal period. All newborn care practices were found to be significantly higher among mothers who were visited during the antenatal period by AWWs or ANMs having better knowledge compared with poor knowledge. For example, clean cord care was practised by 48% of mothers who were visited by AWWs having better

knowledge compared with 29% among those visited by AWWs having poor knowledge ($P \leq 0.001$).

After adjusting for socio-demographic factors, the knowledge level of AWWs emerged as the most important factor in adherence to essential newborn care practices such as initiation of breastfeeding, cord care and thermal care (Table 3). The likelihood of adherence to most of the healthy behaviours such as initiation of breastfeeding during first hours of life (OR 1.97; 95% CI 1.55–2.49), clean cord care (OR 2.03; 95% CI 1.64–2.52) and thermal care in the first 6 hours (OR 2.16; 95% CI 1.64–2.85) was found to be almost double among mothers who were visited by AWWs having better knowledge compared with AWWs having poor knowledge.

ANMs' knowledge level also emerged as the most important factor in adherence to essential newborn care (Table 4). The likelihood of practising most of the healthy behaviours such as initiation of breastfeeding in the first hour of life (OR 1.62; 95% CI 1.25–2.09), practising clean cord care (OR 1.43; 95% CI 1.17–1.75), thermal care in the first 6 hours (OR 1.88; 95% CI 1.43–2.48) and newborn receiving a check-up within the first week of life from a skilled provider (OR 1.78; 95% CI 1.42–2.22) was found to be higher among mothers who were visited by ANMs

Table 3 Logistic regression results showing adjusted effect of knowledge level of AWWs who made antenatal home visits on selected newborn household practices and health care utilization

Knowledge level of AWWs and other characteristics	Initiated breastfeeding within first hours of life		Practised clean cord care		Practised newborn thermal care in first 6 hours		Newborn check-up within first week of life from skilled provider	
	Odds ratio	[95% CI]	Odds ratio	[95% CI]	Odds ratio	[95% CI]	Odds ratio	[95% CI]
Women visited by AWWs having								
Poor knowledge ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Average knowledge	1.62	[1.27, 2.06]	1.73	[1.38, 2.15]	1.91	[1.44, 2.54]	1.66	[1.30, 2.14]
Better knowledge	1.97	[1.55, 2.49]	2.03	[1.64, 2.52]	2.16	[1.64, 2.85]	1.64	[1.28, 2.09]
Age at most recent birth (years)								
12–19 ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
20–34	0.99	[0.88, 1.11]	0.91	[0.81, 1.02]	1.06	[0.94, 1.20]	0.86	[0.74, 1.00]
35–49	0.84	[0.71, 1.00]	0.91	[0.77, 1.09]	1.04	[0.87, 1.25]	0.87	[0.70, 1.08]
Education level								
Illiterate ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Primary school < middle school	0.97	[0.86, 1.11]	0.92	[0.80, 1.05]	1.08	[0.94, 1.24]	1.08	[0.91, 1.28]
Middle school	1.07	[0.90, 1.26]	1.29	[1.08, 1.54]	0.88	[0.73, 1.06]	1.05	[0.84, 1.31]
High school +	1.08	[0.86, 1.36]	1.31	[1.04, 1.65]	0.95	[0.74, 1.21]	0.92	[0.68, 1.25]
Religion								
Hindu ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Others	0.97	[0.85, 1.11]	1.13	[0.99, 1.29]	0.99	[0.86, 1.14]	1.11	[0.94, 1.30]
Caste/tribes								
Scheduled castes/tribes ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Other backward castes	0.93	[0.84, 1.02]	0.89	[0.81, 0.99]	0.93	[0.84, 1.04]	1.04	[0.92, 1.19]
Others	0.92	[0.78, 1.09]	0.76	[0.63, 0.90]	1.07	[0.89, 1.28]	1.07	[0.86, 1.32]
Wealth quintile								
Lowest ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Second	1.01	[0.88, 1.17]	1.00	[0.87, 1.16]	1.07	[0.92, 1.24]	1.03	[0.86, 1.24]
Middle	0.88	[0.78, 0.99]	0.97	[0.85, 1.10]	0.99	[0.86, 1.13]	1.03	[0.88, 1.22]
Fourth	0.94	[0.83, 1.06]	1.03	[0.90, 1.17]	1.14	[1.00, 1.30]	0.93	[0.79, 1.11]
Highest	0.97	[0.84, 1.12]	1.14	[0.98, 1.32]	1.03	[0.88, 1.20]	1.18	[0.98, 1.42]
Number of women	3109		3109		3109		3109	

having better knowledge than those visited by ANMs having poor knowledge.

Discussion

Using data from a large-scale programme evaluation, our study showed that CHWs with higher knowledge levels provide higher coverage of antenatal visits, and that women visited by this group show adherence to essential newborn care practices at household level.

CHWs play a pivotal role in the health status of a rural population due to their close and continuous contact with the rural community. Moreover, due to shortage of adequate health facilities in rural India, CHWs have become a central figure in helping the community to identify and meet their health needs (WHO 2000). However, health workers in many developing countries are poorly motivated, inadequately trained and hence are unproductive.

We found that the knowledge of AWWs and ANMs varies drastically. We also found that if their knowledge level was poor their performance in terms of antenatal home visits was also limited. Studies have shown that knowledge and understanding of some aspects of basic nutrition and health care is of great importance for AWWs' performance (Gujral et al. 1991; WHO 2000). As the AWW is the key person in the programme, her education level and knowledge of nutrition and the guidance she received from the ANMs individually or synergistically is related to her performance in the *anganwadi* centre (Udani and Patel 1983). Regular visits by ANMs or health functionaries to the *anganwadi* centre to guide and help the AWWs, repeated on-the-job training, and frequent and regular interaction between ANMs and AWWs has been shown to be beneficial for the latter's performance (Walia et al. 1978; Sharma 1987). In Sri Lanka, studies have found that a comprehensive 4-day training programme for maternity ward health professionals significantly improves essential newborn

Table 4 Logistic regression results showing adjusted effect of knowledge level of ANMs who made antenatal home visits on selected newborn household practices and health care utilization

Knowledge level of AWWs and other characteristics	Initiated breastfeeding within first hours of life		Practised clean cord care		Practised newborn thermal care in first 6 hours		Newborn check-up within first week of life from skilled provider	
	Odds ratio	[95% CI]	Odds ratio	[95% CI]	Odds ratio	[95% CI]	Odds ratio	[95% CI]
Women visited by ANMs having								
Poor knowledge ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Average knowledge	1.67	[1.29, 2.16]	1.31	[1.07, 1.60]	1.81	[1.37, 2.39]	1.63	[1.30, 2.04]
Better knowledge	1.62	[1.25, 2.09]	1.43	[1.17, 1.75]	1.88	[1.43, 2.48]	1.78	[1.42, 2.22]
Age at most recent birth								
12–19 ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
20–34	0.96	[0.84, 1.10]	1.00	[0.87, 1.16]	1.01	[0.87, 1.17]	0.86	[0.72, 1.02]
35–49	0.86	[0.70, 1.06]	1.06	[0.86, 1.31]	0.98	[0.79, 1.22]	0.88	[0.68, 1.14]
Education level								
Illiterate ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Primary school < middle school	0.99	[0.85, 1.16]	1.08	[0.92, 1.27]	1.10	[0.93, 1.29]	0.94	[0.77, 1.15]
Middle school	1.11	[0.92, 1.33]	1.28	[1.06, 1.54]	0.93	[0.76, 1.15]	1.01	[0.80, 1.28]
High school +	1.19	[0.94, 1.51]	1.66	[1.30, 2.13]	0.98	[0.75, 1.28]	1.03	[0.76, 1.39]
Religion								
Hindu ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Others	1.08	[0.93, 1.27]	1.25	[1.07, 1.47]	1.01	[0.85, 1.19]	1.14	[0.95, 1.38]
Caste								
Scheduled castes/tribes ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Other backward castes	0.89	[0.79, 1.00]	0.97	[0.86, 1.10]	0.96	[0.84, 1.09]	1.02	[0.87, 1.19]
Others	0.81	[0.68, 0.98]	0.89	[0.74, 1.06]	1.02	[0.84, 1.24]	1.09	[0.87, 1.36]
Wealth quintile								
Lowest ^R	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Second	1.02	[0.86, 1.21]	0.97	[0.81, 1.16]	1.17	[0.98, 1.41]	1.07	[0.85, 1.34]
Middle	0.93	[0.80, 1.07]	1.01	[0.86, 1.18]	0.97	[0.82, 1.14]	1.06	[0.87, 1.29]
Fourth	0.99	[0.85, 1.15]	1.06	[0.91, 1.24]	1.14	[0.97, 1.34]	1.03	[0.85, 1.25]
Highest	0.96	[0.82, 1.14]	1.12	[0.95, 1.33]	1.09	[0.91, 1.31]	1.20	[0.98, 1.48]
Number of women	2189		2189		2189		2189	

care (such as immediate skin-to-skin contact, practices on care of umbilical cord and early initiation of breastfeeding) and clinical outcomes of newborns (Senarath et al. 2007a; Senarath et al. 2007b).

In countries like India, where institutional birth covers only one-fifth of the population and very few families reach health professionals for newborn services, the performance and quality of the health system in rural areas depends significantly on CHWs, the multipurpose extension health workers working at the interface between the community and public health system (Satpathy and Venkatesh 2006). Therefore, CHWs (ANMs and AWWs) have become essential for the largely unserved and underserved rural population. Our empirical finding that the performance of CHWs depends largely upon their knowledge level is relevant for prioritizing the ongoing community-based newborn health programmes and for future strategy.

However, the issue of low coverage in our study setting is a matter of concern. Less than one-third of women in the study area were visited by CHWs during the antenatal period.

This issue might be addressed by enhancing CHWs’ knowledge level as, according to our findings, higher knowledge levels of CHWs lead to higher coverage of home visits. Moreover, regular monitoring and support of CHWs by their respective supervisors must be ensured. CHWs’ engagement in other unplanned activities by different governments’ departments and functionaries and their quite low level of remuneration could be other reasons for their low home visit coverage. The Indian government recently also recognized the heavy workload of ANMs and AWWs, which impacts on their outreach services in rural areas. To address this, a new band of community-based functionaries, named Accredited Social Health Activists (ASHA), were introduced through the National Rural Health Mission (NRHM) in 2005, with a goal to improve the availability of and access to quality health care, especially for those residing in rural areas, the poor, women and children (Government of India 2005). There has also been a substantial increase in the remuneration of government staff in 2006 through a new pay commission. These actions have addressed the low coverage of

home visits substantially. Recent evidence from India suggests that antenatal home visit coverage by CHWs has increased substantially following the launch of the NRHM (Khan et al. 2010).

It is interesting to note our finding that even key socio-economic characteristics such as education and wealth have no significant influence on newborn care practices. This may be because traditional practices related to newborn care are so deep-rooted in rural societies they are not possible to change merely by general education and better wealth status. However, targeted behaviour change communication has been found to influence healthy behaviour related to newborn care practices (Baqui et al. 2008a; Kumar et al. 2008).

Some limitations are inherent to this type of cross-sectional survey based on reporting of past behaviour. Assessment of practices in the neonatal period was based on respondents' report, rather than direct observation, which might have led to some recall and reporting error. To minimize this, the recall period was shortened and was only for the mother's last child, born within the last 2 years. Also, an independent data quality assurance system was established to maintain data quality. The evaluation assessed health providers' knowledge but not their skills and performance during home visits or their background characteristics such as age and education which might confound the result.

We conclude that the knowledge level of CHWs (AWWs and ANMs) is a crucial aspect of health systems affecting the coverage of community-based newborn health care programmes, as well as adherence to essential newborn care practices at household level.

Recommendations

Our empirical finding that the knowledge level of CHWs is an important factor in adherence to essential newborn care is of great importance. Improving newborn health status in rural settings is possible by improving the knowledge level of CHWs. Regular education and field-based refresher training programmes for CHWs are crucial to update their knowledge level to serve the community better.

Acknowledgements

We thank the residents of the study districts in Uttar Pradesh who gave their time generously and without complaint. We thank the Government of India and CARE-India colleagues for their care and support. A special thanks to Drs Masee Bateman and Neal Brandes of USAID for their unceasing support and valuable insights and guidance. The study would not have been possible without the hard work and dedication of project staff of CARE-India, TNS-INDIA and Johns Hopkins Bloomberg School of Public Health.

Funding

The project was funded by the United States Agency for International Development (USAID) India Mission, through

Global Research Activity Award No # HRN A-00-96-90006-00 to the Johns Hopkins Bloomberg School of Public Health.

The funding agency had no role in the design, implementation, analysis or interpretation of data, presentation of findings, writing of the report, or in the decision to submit the paper for publication. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

Conflict of interest statement

None declared.

Ethical approval

This research was approved by the Johns Hopkins Bloomberg School of Public Health Committee for Human Research and the King George Medical University institutional review board (FWA00004806).

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Appendix 1

A. Questions used for construction of knowledge score of the ANMs

Sl. No	Questions asked to ANM to assess their knowledge	Correct knowledge
<i>Knowledge on preventive care (maximum 19 points possible)</i>		
1	In which month of pregnancy should a woman start receiving antenatal check-ups?	Within first 3 months
2	How many antenatal check-ups should a pregnant woman receive?	At least three
3	How many TT injections should a woman receive during pregnancy?	At least two
4	In which trimester of pregnancy a pregnant women should have her first antenatal checkup done?	First trimester
5	How many large IFA tablets should a pregnant woman take before delivery?	At least 90 tablets
6	During a home delivery, what five cleans are required to prevent infections?	Use of clean surface Use of clean hands Use of new blade Use of clean thread
7	What advice regarding immediate newborn care should a mother or family receive?	Apply nothing to the cord Immediate breastfeeding Keep the baby warm Minimum handling by others Delay bathing for at least for 3 days
8	What advice regarding newborn care during the first month should a mother or family receive?	Apply nothing on cord Exclusive breast feeding Avoiding pre-lacteals Growth monitoring Identification of complications/problems and their treatment
<i>Knowledge on maternal danger signs (maximum 25 points possible)</i>		
9	What are the complications during pregnancy that need referral for medical treatment?	Bad obstetric history Severe headache Blurred vision Diminished or absent foetal movement High blood pressure High fever Unconsciousness Convulsions Vaginal bleeding Lower abdominal pain Severe anaemia
10	What are the complications in women during delivery that need medical treatment?	Excessive vaginal bleeding Preterm labour High fever Baby in abnormal position Prolonged labour (>12 hours) Retained placenta Convulsions Premature rupture of membrane
11	What are the complications that may develop in a woman after delivery (post-partum period) needing medical treatment?	Massive vaginal bleeding Foul-smelling discharge High fever Severe abdominal pain Convulsions Jaundice

(continued)

Appendix Continued

Sl. No	Questions asked to ANM to assess their knowledge	Correct knowledge
<i>Knowledge on neonatal danger signs (maximum 13 points possible)</i>		
12	What are the complications/conditions of a newborn child that need medical care?	Poor feeding or unable to suckle Diarrhoea High fever Discharge from the cord Red/discharge from eyes Persistent vomiting Skin colour yellow (jaundice) Convulsions Baby won't cry Difficult/fast breathing Chest in-drawing Unable to pass urine Unable to pass stool

B. Questions used for construction of knowledge score of the AWWs

SN	Questions asked to AWW to assess their knowledge	Correct knowledge
<i>Knowledge on preventive care (maximum 12 points possible)</i>		
1	In which month of pregnancy should a woman start receiving antenatal check-ups?	Within first 3 months
2	How many antenatal check-ups should a pregnant woman receive?	At least three
3	How many TT injections should a women receive during pregnancy?	At least two
4	In which trimester of pregnancy a pregnant woman should have her first antenatal checkup done?	First trimester
5	How many large IFA tablets should a pregnant woman take before delivery?	At least 90 tablets
6	During a home delivery, what five cleans are required to prevent infections?	Use of clean surface Use of clean hands Use of new blade Use of clean thread Apply nothing to the cord
7	What is the first feed a mother should give her newborn baby?	First milk/colostrum
8	For how many months should a mother give ONLY breast milk to her child?	Up to 6 months
<i>Knowledge on maternal danger signs (maximum 16 points possible)</i>		
10	What are the complications during pregnancy that need referral for medical treatment?	Bad obstetric history Severe headache Blurred vision Diminished or absent foetal movement High blood pressure Convulsions Vaginal bleeding Lower abdominal pain Jaundice
11	What are the complications in women during delivery that need medical treatment?	Excessive vaginal bleeding Preterm labour Prolonged labour (>12 hours) Convulsions

(continued)

Appendix Continued

SN	Questions asked to AWW to assess their knowledge	Correct knowledge
12	What are the complications that may develop in a woman after delivery (post-partum period) needing medical treatment?	Excessive vaginal bleeding Foul-smelling discharge High fever
	<i>Knowledge on newborn danger signs (maximum 5 points possible)</i>	
13	What are the complications/conditions of a newborn child that need medical care?	Poor feeding or unable to suckle Baby is cold Baby won't cry Difficult/fast breathing Chest in-drawing

Note: Knowledge score has been computed based on PCA and then AWWs and ANMs are divided into three equal groups based on their knowledge level and linked to RDW data file.