

Original Research Article

Effectiveness of Female Community Health Volunteers in the Detection and Management of Low-Birth-Weight Infants in Nepal

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Conflict of interest

We do not have any conflicts of interest to declare.

Abstract

Introduction: Low birth weight (LBW) is a major risk factor for neonatal death. However, most neonates in low-income countries are not weighed at birth. This results in many LBW infants being overlooked. Female community health volunteers (FCHVs) in Nepal are non-health professionals who are living in local communities and have already worked in a field of reproductive and child health under the government of Nepal for more than 20 years. The effectiveness of involving FCHVs to detect LBW infants and to initiate prompt action for their care. was studied in rural areas of Nepal.

Methods: FCHVs were tasked with weighing all neonates born in selected areas using color-coded spring scales. Supervisors repeated each weighing using electronic scales as the gold standard comparator. Data on the relative birth sizes of the infants, as assessed by their mothers, were also collected and compared with the measured weights. Each of the 205 FCHVs involved in the study was asked about the steps that she would take when she came across a LBW infant, and knowledge of zeroing a spring scale was also assessed through individual interviews. The effect of the background social characteristics of the FCHVs on their performance was examined by logistic regression. This study was nested within a community-based neonatal sepsis management intervention surveillance system, which facilitated an assessment of the

performance of the FCHVs in weighing neonates, coverage of FCHVs' visits, and weighing of babies through maternal interviews.

Results: A total of 462 babies were weighed, using both spring scales and electronic scales, within 72 h of birth. The prevalence of LBW, as assessed by the gold standard method, was 28%. The sensitivity of detection of LBW by FCHVs was 89%, whereas the sensitivity of the mothers' perception of size at birth was only 40%. Of the 205 FCHVs participating in the study, 70% of FCHVs understood what they should do when they identified LBW and very low birth weight (VLBW) infants. Ninety-six percent could describe how to zero a scale and approximately 50% could do it correctly.

Seventy-seven percent of FCHVs weighed infants at least once during the study period, and 19 of them (12%) miscategorized infant weights. Differences were not detected between the background social characteristics of FCHVs who miscategorized infants and those who did not. On the basis of maternal reporting, 67% of FCHVs who visited infants had weighed them.

Conclusions: FCHVs are able to correctly identify LBW and VLBW infants using spring scales and describe the correct steps to take after identification of these infants. Use of FCHVs as newborn care providers allows for utilization of their logistical, geographical, and cultural strengths, particularly a high level of access to neonates, that can

complement the Nepalese health care system. Providing additional training to and increasing supervision of local FCHVs regarding birth weight measurement will increase the identification of high-risk neonates in resource-limited settings.

Keywords

female community health volunteer, low birth weight, Nepal, spring scale, weighing

Introduction

Low birth weight (LBW) is a known risk factor for neonatal death[1-7]. However, well-organized programs for determining infant birth weight are often lacking in rural areas of low-income countries, where most infants are born at home. In such areas, the infant's relative size at birth, as assessed by the mother, is often the only available indicator of birth weight [8]. Thus, LBW and the conditions experienced by many LBW infants in these areas often go undetected[8-10]. The establishment of a system for identifying LBW infants in community settings is, therefore, needed.

One country in which such a system is needed is Nepal. According to the 2011 National Demographic and Health Survey (DHS), 64% of infants born in Nepal were not weighed at birth[11]. Among the infants weighed and whose weight could either be recalled by their mothers or had been recorded in writing, 12% were LBW infants. This appears to reflect improvement from the previous DHS in 2006, which found that 83% of infants were not weighed at birth and the prevalence of LBW infants was 17%[12]. However, previous studies have suggested that the prevalence of LBW infants, as determined from birth records, might not reflect the true prevalence of LBW in the population because most infants weighed are born to mothers with a higher socioeconomic status

living in urban areas[13, 14]. Indeed, the prevalence of LBW was reported to be 43% by one study conducted in Nepal from 1998 to 2001[15] and 25% and 28% by 2 studies conducted in 2004[16, 17]; these percentages are much higher than those reported by the DHS. Such observations suggest that a nationwide mechanism for accurately and reliably detecting and caring LBW infants is needed.

Spring scales have been shown to be effective in the identification of LBW infants in community settings[17, 18]. During a trial of a community-based neonatal sepsis-management intervention program in Dhanusha district, Nepal[19], Female Community Health Volunteers (FCHVs) were involved in weighing newborns at birth using spring scales to identify LBW infants and to assist their mothers in making follow-up visits and/or referring infants to health facilities if they showed any signs of distress. FCHVs are a cadre of approximately 50,000 local volunteers selected by a local mother's group to address reproductive and child health issues under the auspices of Nepal's Ministry of Health. They have been operating since 1988[20]. They attend two 9-day basic initial training sessions and a 5-day refresher training session every 5 years. As these volunteers are found in every geographical/administrative unit called Village

Development Committees (VDCs) throughout Nepal and live within the community, they have good access to newborns.

The current study was designed to determine whether the use of FCHVs to detect LBW infants and initiate prompt, appropriate action for those infants' care is feasible, with the understanding that FCHVs already engage in numerous child health care activities throughout the nation. This study specifically examined (1) the sensitivity and specificity of the measurements obtained by FCHVs using spring scales and compared them with the sensitivity and specificity of the maternal assessments of infant size, (2) their knowledge of appropriate management of LBW and very low birth weight (VLBW) infants and the skill of FCHVs in zeroing spring scales, and (3) FCHV performance and coverage of FCHV visits and weight measurement. The overall goal of this study was to provide evidence of the feasibility of interventions that may lead to a decrease in neonatal mortality in resource-limited settings.

Methods

Study setting

This cross-sectional study was conducted in the Dhanusha district of Nepal between

February and May 2011 as part of a cluster randomized controlled trials. The larger study was entitled “A cluster-randomized controlled trial to test the effectiveness of women’s groups for neonatal survival and improved maternal and infant nutrition and of community-based neonatal sepsis management for neonatal survival”. The overall aim was to assess the impact of community-based activities implemented by FCHVs on neonatal mortality in Dhanusha district from April 2008 to April 2011[19]. Dhanusha is a *Terai* (plains) district in the central region of Nepal, has a population of approximately 777,000, 89% of which live in rural areas[21, 22]. In the central *Terai* region, approximately 67% of women are reported to deliver their babies at home[11]. Dhanusha district comprises 1 municipality and 101 VDCs. Each VDC has a population of 4,000 to 17,000; operates 1 health facility staffed by government-employed community health workers, including Auxiliary Health Workers, Auxiliary Nurse Midwives, and Village Health Workers; and is divided into 9 wards served by 1 FCHV.

FCHV activities

After being informed of a birth at home, FCHVs visited and weighed infant(s) using a spring scale (Super Samson Spring Balance; Salter Brecknell, India). This scale, a 28-cm long, 120-g device, indicates the weight of an infant using a color-coded system by which red indicates that an infant weighs 0 to 1999 g; yellow, 2000 to 2499 g; and green, ≥ 2500 g. Using recording forms containing 3 pictures of spring scales with their indicators colored green, yellow, or red, the FCHVs selected the picture of the spring

scale that corresponded with the color of the indicator that they observed upon weighing each infant. Thus, even FCHVs unable to read were able to classify the neonates into the 3 categories, namely, normal birth weight (NBW, ≥ 2500 g), LBW (2000–2499 g), or VLBW (<2000 g) infants. VLBW infants were defined as infants weighing below 2000 g in this study. This weight range was based on the results of Yasmin et al. who indicated that the mortality rate of infants weighing below 2000 g is higher than those weighing 2000–2499 g in South Asia[23]. In addition, Darmstadt et al. also defined infants below 2000 g as VLBW in an Indian study of weight measurement using spring scales[18].

The FCHVs had received training on using the spring scales during a 5-day training program on neonatal sepsis-management provided by local health workers in 2007, with refresher training in 2008. From their training, they were aware that the weight displayed on the scale before zeroing was 100 g, requiring them to zero the scale prior to weighing the infant and after attaching the weighing sling and cloth; otherwise, the total weight of an infant could be overestimated, risking misidentification of a LBW infant as a NBW infant.

The FCHVs were tasked with identifying every birth in their working area, obtaining a birth weight within 24 hours where possible, and visiting each baby 3–4 times to check

for danger signs of sepsis[19]. For the purposes of this study, after an FCHV had weighed an infant, she immediately reported the result to a supervisor by telephone. Then a supervisor re-weighed the infant as soon as possible using a calibrated digital scale with 10-g gradations (SECA 834[®] produced by SECA, Hamburg, Germany) to assess whether the FCHV had correctly categorized the infant. Each study supervisor had more than 4 years of experience as a health care worker in community health services.

As part of their 5-day training session, the FCHVs had also learned the protocol for management of LBW and VLBW infants. For each LBW infant, they had been instructed to inform the mother that her infant was smaller than normal and show her how to identify any signs of illness or weakness. In addition to the normal follow-up visits 3, 14, and 28 days after birth for NBW infants, they conducted a follow-up visit 7 days after birth to determine if the infant showed any signs of infection. If a LBW infant showed any of 10 danger signs which suggests neonatal sepsis during any of the visits or had been categorized as VLBW, the FCHV was to immediately refer the mother to a health facility.

Data collection

FCHV determination of weight using a spring scale: After an FCHV had weighed an infant using a spring scale, the infant was re-weighed by a supervisor using a calibrated digital scale to determine the accuracy of the FCHV's measurement. The measurement provided by the digital scale was considered the gold standard with which the accuracy of the FCHV's measurement and the maternal assessment of relative size at birth was assessed.

Maternal assessment of relative birth size: When visiting mothers to weigh their neonates using an electronic scale, supervisors asked them to describe their initial perception of their infants' relative birth size as *very small*, *smaller than normal*, *normal*, or *larger than normal*. By this means, supervisors could ascertain whether mothers could correctly identify LBW infants.

Assessment of FCHV skill, protocol knowledge, and FCHV characteristics: To assess the level of FCHV knowledge regarding management of LBW and VLBW infants and spring-scale usage, supervisors conducted interviews with all the FCHVs. They asked FCHVs to describe the protocol for weighing infants, to demonstrate their

knowledge of zeroing a spring scale; and provide data regarding their age, literacy level, work experience, and training history.

FCHV performance: To assess FCHV performance, 10 new mothers within each VDC per month were questioned regarding antenatal, delivery, and postnatal practices throughout the study period. This dataset was created as part of the broader study, as described previously[19]. Data regarding maternal recall of whether an FCHV had visited and weighed each neonate were extracted from this larger dataset.

Statistical analyses

The sensitivity and specificity of the spring-scale measurements, as well as maternal perceptions of relative birth size, were calculated by comparing them to the respective electronic- scale measurements. FCHV performance in terms of correct- and mis-categorisation of birth weight category was analyzed using logistic regression. First univariate logistic regressions were conducted with correct categorization as the dependent variable and age, literacy, work experience, training received and number of infants weighed as explanatory variables. Then the effect of each of the explanatory variables in turn was adjusted for all the others together as potential confounders in a

multiple logistic regression model. All data were analyzed using Stata 11 software (College Station, TX, USA).

Ethical considerations

This study was approved by the Nepal Health Research Council and the ethics committee of the Institute of Child Health and Great Ormond Street Hospital for Children, UK. As preliminary research had revealed that most women in our study areas are illiterate and that requesting a signature or thumbprint for written consent is not culturally acceptable, study information was provided orally, and consent for participation was obtained orally at the time of data collection.

Results

FCHV characteristics

Table 1 shows the demographics and work experience of the 205 FCHVs examined in the study. Demographically, the FCHVs were of a mean age of 47 years and represented a range of predominantly plains ethnicities, primarily Hindu, Maithili-speaking. In terms of education, skills, and employment, nearly 75% were illiterate or barely literate, more than 90% had worked as FCHVs for more than 5 years,

almost 70% had 20 years of work experience as FCHVs, and 53% could reach the farthest point in their assigned areas within 30 min by foot.

Sensitivity and specificity of birth-weight screening by FCHVs

A total of 462 infants were weighed using both spring and electronic scales within 72 h of birth. On average, each FCHV weighed 3 infants (range, 1–11 infants) over the sampling period. The mean time from birth to weight measurement was 12 h for the FCHVs and 22 h for the supervisors, yielding a mean time difference in FCHV and supervisor measurement of 10 h (range, 0–54 h).

The prevalence of LBW was 28%, based on the electronic scale weights. On the other hand, the prevalence of LBW, based on spring scale weights, was 25%, including false positives (Table 2). The sensitivity of the spring scales for detecting LBW was 89%, with a specificity of 99%. Similarly, the sensitivity and the specificity of identifying VLBW by a spring scale was 86% and 100%, respectively (Table 2). The lag time between spring- and electronic-scale measurement of miscategorized infants ranged from 0 to 29 h, with 17 of the 20 miscategorized infants being weighed within 10 h.

Sensitivity and specificity of maternal perception of infant size

The prevalence of LBW according to maternal perception of infant size as small was 12%, with a sensitivity of 40% and a specificity of 99% (Table 3). The sensitivity and specificity of maternal detection of VLBW were 52% and 99%, respectively.

FCHV knowledge and skills

All FCHVs were able to specify which spring-scale color indicated NBW, LBW, and VLBW infants. Seventy percent of FCHVs could describe the protocol for managing both LBW and VLBW infants, 15% could describe the management of either LBW or VLBW infants and 15% could not describe either protocol. Among FCHVs with reading ability, 80% could describe the correct action to take upon identification of high-risk infants, while 66% of those with no or poor reading skills could answer their response. , Ninety-six percent of the FCHVs were able to zero the scales when asked to demonstrate weighing an infant to their supervisor. Among those who were able to zero scales, 46% zeroed the spring scales using a wrapping cloth and sling, as they had been taught during their training; 22% using only a sling; and 28% using neither a sling nor wrapping cloth.

FCHV performance

Using a subset of the surveillance dataset of the cRCT, which covered the period between April 2008 and April 2011[19], FCHVs visited 44% of the infants born in their assigned areas and weighed 67% of the infants whom they had visited. Review of the dataset for the present study reveals that 157 of the 205 (77%) FCHVs weighed at least 1 infant using a spring scale and then contacted their supervisor to reweigh the infant using an electronic scale during the study period of February to May 2011. The remaining 48 (23%) FCHVs either did not contact their supervisor after conducting a spring-scale measurement or did not weigh any infants during the data-collection period. Among the 157 FCHVs who performed at least 1 spring-scale measurement, 19 categorized the observed weights incorrectly, but only 1 did so twice during the study period. No differences in odds of weight miscategorization were found in relation to FCHV background characteristics or the number of infants weighed (Table 4).

Discussion

Analysis of the study data revealed the prevalence of LBW was 25% when determined by spring-scale measurement, 28% by electronic-scale measurement, and 12% by maternal perception of infant size. Considering electronic-scale measurement as the

gold standard, the sensitivity of LBW detection by the FCHVs using spring-scale measurement was 89%, while that using maternal perception was only 40%. Although maternal perception of relative birth size has been widely used to estimate birth weight, analysis of its reliability has yielded mixed results[8, 11, 13, 14, 24, 25]. The results of this study indicate that use of maternal perception may lead to underestimation of the true prevalence of LBW and VLBW, and weight determination by FCHVs using spring scales is a much more accurate means of measurement that provides a more realistic indication of the prevalence of LBW and VLBW infants.

Identifying LBW and VLBW infants is necessary but not sufficient of caring for these infants; such identification must be followed by provision of prompt, appropriate care for vulnerable LBW and VLBW infants. Most FCHVs demonstrated that they knew the correct actions to take after identifying LBW or VLBW infants, including providing appropriate information to the mothers and working as mediators between the mothers of at-risk infants and their local health care facilities. Data on whether the FCHVs had actually referred LBW and VLBW infants to health care facilities and whether the mothers visited these facilities with their at-risk infants were not available at the time of this study and will be reported in the trial paper.

Besides improving the accuracy of birth-weight measurement and prompting the use of appropriate care measures, use of FCHV weighing of infants at birth has several advantages. First, as FCHVs are already engaged in many reproductive and child health interventions in each VDC in Nepal, recruiting new people and establishing a new system to conduct birth-weight measurement would be unnecessary in any new childcare program. In previous studies of the weighing of infants using spring scales, the workers examined were newly hired and intensively managed throughout the course of the programs[17, 18]; these tasks require provision of additional resources in terms of time and funding which is often not feasible or sustainable in resource-limited settings. Current strategies for strengthening health care systems emphasize the integration of new programs into an existing system in order to utilize available resources, rather than adding completely new programs or investing in new resources[26, 27]. Thus, utilizing FCHVs, an existing resource, to fulfill a new responsibility in the community, accords with this concept.

Second, FCHVs can overcome multiple barriers that may negatively affect weighing of newborn infants in remote, rural communities. Two such barriers are Nepal's

mountainous terrain and the poor transportation system, which makes timely visits to the homes of neonates difficult for government health workers, who are thus not usually tasked with this responsibility. Unlike professional health care workers, who typically do not live in the communities that they serve in and are often not prepared or able to make home visits, the FCHVs examined lived in or near the communities and could make home visits relatively easily. Specifically, our study showed that 53% of the FCHVs were able to arrive at the homes of clients within 30 min, and 75% were able to do so within 60 min. They were thus able to determine a neonate's weight within the first half-day of life, a critical period for survival of underweight neonates, as death typically occurs during the first few postnatal days[28]. Such promptness is also important for correctly categorizing infant weight, as breastfed neonates typically lose 3% to 7% of their birth weight within the first week of life[29, 30]. Additionally, as cultural limitations would make it difficult or impossible for male health care workers to visit the maternal home within many rural areas of Nepal, employing a group of women who are well known within the community for this purpose increases the likelihood of obtaining infant weight data in these areas.

No statistically significant differences were found between the background characteristics of the FCHVs who had miscategorized infants and those who had not. Although the sample size was small, the results indicate that FCHV background variables, including age, literacy, training, and work experience, may not be very influential in determining how well FCHVs are able to conduct their tasks. However, when asked to describe the protocol, a greater percentage of the literate FCHVs correctly described the actions that they should take when they encountered with a high-risk infant. Thus, literacy may be important for program effectiveness and sustainability, and the FCHV system may benefit if a greater number of literate women are recruited.

Some FCHVs in our study did not have the required level of knowledge and skills for the correct use of spring scales, leading some to zero the scale improperly, which may have led to overestimation of infant weight. Among the miscategorized cases, 85% (17 of 20) were overestimation of weight. One possible reason for such lack of accuracy may have been the lag of 3 to 4 years between the FCHVs' training and their application of their training to conduct weight measurement. Another reason may have been the provision of only minimal on-going supervision of birth-weight measurement to ensure that it was

being properly conducted. As supervision has been reported to improve the performance of health care workers[31], allocation of more resources for more intensive supervision could improve FCHV performance, as has been shown in other studies involving the use of spring scales[17, 18]. Although frequent on-site supervision is extremely difficult due to the geography of the study area, the integration of field level training and demonstration into the existing FCHV scheme, where possible, would likely be beneficial.

Regarding the detection of VLBW neonates, the sensitivity and specificity using spring scales was 86% and 100%, respectively. Although conclusions are impossible to make due to the small sample size, our results indicate that spring-scale measurement may be an effective means of identifying a group of infants at even a higher risk of death than LBW infants. Further studies should focus on analysis of the sensitivity of the detection of VLBW infants using spring scales and the effectiveness of possible interventions that may be taken-up by FCHVs for such infants.

Conclusions

The results of this study suggest that FCHVs can accurately identify LBW and VLBW

infants using spring scales and that most have the knowledge necessary to take prompt action for the appropriate care of these infants. As use of FCHVs as newborn care providers allows for utilization of their logistical, geographical and cultural advantages, including a high level of access to infants, it has great potential to complement the Nepalese health care system. The establishment of a regular system of training and supervision involving more outreach of government health workers in the community would likely further improve the performance of FCHVs and increase the effectiveness of this means of caring for high-risk infants in resource-limited settings.

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Table 1. Demographics of female community health volunteers (N = 205)

Variable	N (%)
Age (years)	
<30	12 (5%)
30–39	27 (13%)
40–49	64 (31%)
50–59	78 (39%)
≥60	24 (12%)
Caste	
High caste ^a	32 (16%)
Mid-range caste ^b	85 (41%)
Low caste ^c	88 (43%)
Religion	
Hindu	192 (94%)
Muslim	8 (4%)
Buddhist	5 (2%)
Reading ability	
Reads easily	50 (24%)
Reads with difficulty/unable to read	155 (76%)
Underwent training for community-based neonatal sepsis management	
Yes	195 (95%)
No	10 (5%)
Years working as an FCHV	
<1	3 (2%)
1–4	15 (7%)
5–9	22 (11%)
10–19	25 (12%)
≥20	140 (68%)
Time required to reach farthest house in working area (min)	
<10	7 (4%)
10–29	101 (49%)
30–59	60 (29%)
≥60	37 (18%)

^aHigh/more advantaged castes: Brahmin, Bhumihaar, Kaysth, and Chettri

^bMid-range/less disadvantaged castes: Yadav, Koiri, and Sudi/Teli

^cLow/more disadvantaged castes: Janjati, Mandal, Muslim, Dalit, and others

Table 2. Identification of low birth weight and very-low-birth-weight infants by electronic- and spring-scale measurement

a) LBW

		Electronic scale		Total N (%)
		LBW (<2499 g)	NBW (≥2500 g)	
Spring scale	Positive (yellow or red)	114	3	117 (25.3%)
	Negative (green)	14	331	345 (74.7%)
Total		128	334	462
%		27.7%	72.3%	

b) VLBW

		Electronic scale		Total
		VLBW (<1999 g)	LBW or NBW (≥2000 g)	
Spring scale	Positive (red)	18	0	18 (3.9%)
	Negative (yellow or green)	3	441	444 (96%)
Total		21	441	462
%		4.5%	95.5%	

LBW, low birth weight; VLBW, NBW, normal birth weight; very low birth weight

Table 3. Comparison of use of maternal assessment and electronic-scale measurement in infant weight categorization

a) Categorization of infants as low birth weight or normal birth weight

		Electronic-scale measurement		Total
		LBW	NBW	
		(<2499 g)	(≥2500 g)	
Maternal perception	Positive (very small/smaller than normal)	51	5	56 (12.1%)
	Negative (about average/larger than most babies)	77	329	406 (87.9%)
Total		128	334	462
%		27.7%	72.3%	

b) Categorization of infants as very low birth weight or low/normal birth weight

		Electronic-scale measurement		Total
		VLBW	LBW or NBW	
		(<1999 g)	(≥2000 g)	
Maternal assessment	Positive (very small)	11	4	15 (3.2%)
	Negative (smaller than normal/average/larger than most babies)	10	437	447 (96.8%)
Total		21	441	462
%		4.5%	95.5%	

LBW, low birth weight; VLBW, NBW, normal birth weight; very low birth weight

Table 4. Demographics of female community health volunteers who miscategorized birth weights and those who correctly weighed and categorized at least one infant

	FCHVs who mis-categorized infants		FCHVs who correctly weighed and categorized ≥ 1 infant		Adjusted odds ratio of miscategorization		p value
	n	(%)	n	(%)	OR	(95% CI)	
Reading ability							
Reads easily	6	(31.6)	32	(23.2)	1.00		0.54
Reads with difficulty/ unable to read	13	(68.4)	106	(76.8)	0.70	(0.23–2.14)	
Age (years)							
<50	8	(42.1)	71	(51.5)	1.00		0.17
≥ 50	11	(57.9)	67	(48.5)	2.14	(0.72–6.36)	
Received sepsis-management training							
Yes	16	(84.2)	131	(94.9)	1.00		0.18
No	3	(15.8)	7	(5.1)	3.17	(0.58–17.4)	
Working experience (years)							
<5	4	(21.1)	11	(8.0)	1.00		0.21
≥ 5	15	(78.9)	127	(92.0)	0.37	(0.08–1.72)	
Number of babies weighed							
<3	6	(31.6)	73	(52.9)	1.00		0.57
≥ 3	13	(68.4)	65	(47.1)	1.35	(0.48–3.85)	

FCHV, female community health volunteer