Published in final edited form as:
Arch Pediatr Adolesc Med. 2008 July ; 162(7): 603–608. doi:10.1001/archpedi.162.7.603.

Impact of Maternal and Birth Attendant Hand-washing on Neonatal Mortality in Southern Nepal

Victor Rhee, M.H.S.[1], **Luke C. Mullany, Ph.D.**[1], **Subarna K. Khatry, M.B.B.S.**[2], **Joanne Katz, Sc.D.**[1], **Steven C. LeClerq, M.P.H.**[1,2], **Gary L. Darmstadt, M.D.**[1], and **James M. Tielsch, Ph.D.**[1]

1 *Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA.*

2 *Nepal Nutrition Intervention Project – Sarlahi, Kathmandu, Nepal.*

Abstract

Objective—Over 95% of neonatal deaths occur in developing countries, approximately 50% at home. Few data are available on the impact of hand-washing practices by birth attendants or caretakers on neonatal mortality. The objective was to estimate the association of birth attendant and maternal hand-washing practices on neonatal mortality in rural Nepal.

Design—Observational prospective cohort study.

Setting—Sarlahi District in rural, southern Nepal.

Participants—Newborn infants were originally enrolled in a community-based trial assessing the impact of skin and/or umbilical cord cleansing with chlorhexidine on neonatal mortality in southern Nepal.

Main Exposures—Questionnaires were administered to mothers on days 1 and 14 post-delivery to identify care practices and risk factors for mortality and infection. Three hand-washing categories were defined: 1) birth attendant hand-washing with soap and water before assisting with delivery; 2) maternal hand-washing with soap and water or antiseptic before handling the baby; and 3) combined birth attendant and maternal hand-washing.

Outcome Measures—Mortality within the neonatal period.

Results—23,662 newborns were enrolled and followed through 28 days of life. Birth attendant hand-washing was associated with a statistically significant lower mortality among neonates (RR_{Adj}=0.81, 95% CI: 0.66−0.99) as was maternal hand-washing (RR_{Adj}=0.56, 95% CI: 0.38−0.82).

Corresponding Author: James M. Tielsch, Ph.D. Department of International Health Johns Hopkins Bloomberg School of Public Health 615 N. Wolfe Street, Room W5009 Baltimore, Maryland 21205−2103 Tel: 410−955−2436 Fax: 410−955−2029 Email: jtielsch@jhsph.edu.

Author Contributions:

Dr. James M. Tielsch had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Mullany, Katz, LeClerq, Darmstadt, Tielsch
Acquisition of data: Mullany, Khatry, Katz, LeClerq, Tielsch
Analysis and interpretation of data: Rhee, Mullany, Katz, Darmstadt, Tielsch
Drafting of the manuscript: Rhee, Katz, Darmstadt, Tielsch
Critical revision of the manuscript for important intellectual content: Rhee, Mullany, Khatry, Katz, LeClerq, Darmstadt, Tielsch
Statistical analysis: Rhee, Mullany, Katz
Obtained funding: Darmstadt, Tielsch
Administrative, technical, or material support: Khatry, LeClerq, Tielsch
Study supervision: Mullany, Khatry, Katz, LeClerq, Tielsch

Conflict of Interest Statement There were no conflicts of interest for any of the authors.

There was a 41% lower mortality among neonates exposed to both hand-washing practices (RR_{Adj}= 0.59 (95% CI: 0.37−0.94).

Conclusions—Birth attendant and maternal hand-washing with soap and water were associated with significantly lower neonatal mortality. Measures to improve/promote birth attendant and maternal hand-washing could improve neonatal survival.

Keywords

Neonatal mortality; hand washing; Nepal

Introduction

Although major achievements have been made in reducing mortality in under-5 children, less progress has been made in reducing neonatal mortality (1). About 4 million neonatal deaths occur each year, over 99% in low and middle-income countries. About half of these deaths occur at home where mothers receive little or no perinatal care (2-3). These neonatal deaths are attributable primarily to infections, prematurity and birth asphyxia (3).

Current evidence suggests that universal provision of low-cost interventions could reduce this burden by up to 70% (4). These interventions include maternal tetanus toxoid immunization, clean delivery and cord care, resuscitation of the newborn, early initiation of exclusive breastfeeding, prevention and management of hypothermia, skin to skin care and community-based pneumonia case management. In addition, the WHO has recommended hand-washing with clean water and soap before and after handling the infant in the postnatal period to prevent infection (5).

Over 150 years have elapsed since Semmelweis first demonstrated the importance of hand-washing for the prevention of obstetrical nocosomial infection (6). Hand-washing has also been shown to reduce the risk of gastrointestinal infections, pneumonia, and nocosomial infections (7-19). A recent meta-analysis estimated that hand washing could reduce the risk of diarrhea by 42−44% in older preschool age children (20). Despite the strong evidence for reduced incidence of infection due to hand-washing, few estimates are available to quantify the potential impact of hand-washing practices by birth attendants or care-takers in developing country settings on mortality and morbidity in the neonatal period. As a part of community-based trials of skin and umbilical cord cleansing with chlorhexidine on neonatal mortality and morbidity, we had the opportunity to examine the strength of association of hand-washing behaviors and risk of neonatal death.

Methods

The data for this secondary analysis come from a nested pair of double-masked, placebo-controlled, cluster randomized, community-based trials conducted in Sarlahi District of southern Nepal. These trials evaluated the impact of skin and umbilical cord cleansing with chlorhexidine on neonatal mortality and omphalitis. Descriptions of the study population, recruitment and randomization procedures, skin and cord treatment regimens, and follow-up activities have been reported previously (21-22). In summary, pregnant women were approached for enrollment in mid-pregnancy by local female staff. Study procedures were explained and oral informed consent obtained. All women received iron-folic acid supplements, a single dose of albendazole, weekly vitamin A supplementation, and a clean birthing kit consisting of a small bar of soap, clean razor blade, string, plastic disc and a piece of plastic sheeting. At the time of enrollment, women were counseled on appropriate prenatal nutrition and health issues, clean and safe birthing practices including handwashing by the birth attendant before delivery and by the mother prior to handling her baby, newborn thermal control

and hygienic care of the umbilicus. This prenatal counseling session lasted approximately 30 −40 minutes and used specially developed visual aids. Infants born alive between September 2002 and March 2005 and alive at one or more home visits by workers during the postnatal period were eligible for enrollment. In March 2005, the study's Data Safety and Monitoring Board recommended that all infants receive the active interventions (single full-body skin cleansing and multiple-day cord cleansing with chlorhexidine). For this analysis, all live births occurring between the start of the trials and including the post-randomization phase (through January, 2006) were included.

Enrolled newborns were visited up to 11 times on days 1−4, 6, 8, 10, 12, 14, 21, and 28. At each home visit, workers recorded the vital status of the child, signs of omphalitis and other morbidities, and measured axillary temperature. On the first visit and 2 weeks later, field workers administered a questionnaire to identify neonatal care practices and potential risk factors for neonatal morbidity. The questionnaire on day 1 focused on the delivery of the newborn and immediate newborn care practices including birth attendant hand-washing practices, as well as measurement of birth weight. Birth attendant hand washing was defined as a positive response to the question “Did the person assisting with delivery wash their hands with soap and water before delivery?” Gestational age was estimated as time since the last menstrual period, based on maternal report at enrolment and on the Day 1 visit. The questionnaire on day 14 assessed the duration and frequency of various newborn care practices since birth, including maternal hand-washing prior to handling the infant. Maternal hand washing was defined as a response of “sometimes” or “always” to the question “Do you wash your hands with soap and water, antiseptic, or nim before handling the baby?” Infants who had specific sets of signs and symptoms at the time of household visits were referred to the local health system for care. Maternal hand-washing status was not assessed for infants who died prior to the first post-delivery study visit. All infants alive at 28 days were discharged from the study.

The primary outcome variable for this analysis was all cause mortality from enrolment through 28 days. Binomial regression with a log link function was used to model the relative risk of death by hand-washing status of the birth attendant and the mother. Similar models were used to control for confounding and explore potential interactions. Additional analyses were conducted restricting the dataset to those infants who were first enrolled on days 2, 3, and 7 to determine the effect of hand-washing behavior after the exclusion of early neonatal deaths.

Statistical analyses were conducted using STATA Version 9.2 (Stata Corp. Inc., College Station, TX). This study received ethical approval from the Nepal Health Research Council and the Committee on Human Research of the Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland and is registered at Clinicaltrials.gov (NCT00109616).

Results

A total of 23,662 live births occurred between September 1st, 2002 and January 31st, 2006 and were eligible for enrollment in the study. Over 90% of births occurred at home or outdoors during transport to a facility. The median time to the first study visit was 19.3 hours and 63% were first visited within 24 hours. Less than 5% of eligible subjects were not enrolled for various reasons including being unable to meet the mother and newborn within the first 28 days of life, refusal, emigration, and infant death prior to the first study visit. Maternal hand-washing status was not available for infants who died prior to the first post-delivery study visit. Characteristics of the study population are presented in Table 1. There were slightly more males than females enrolled and approximately 70% were from the Madeshi ethnic group. Only about a quarter of mothers had ever attended primary school and other socioeconomic indicators classified this

population as poor, even for rural Nepal. Approximately 30% of infants were low birth weight (< 2500 g) and about 18% were preterm (Table 1).

The overall mortality rate among enrolled infants was 32.1 per 1,000 live births. Birth attendants washed their hands prior to delivery for 59.2% of live births, whereas only 14.8% of mothers reported washing their hands with soap and water or antiseptic prior to handling their infant (Table 2). Neonatal mortality was significantly lower among infants whose birth attendant and/or mother washed their hands with soap and water or antiseptic. Newborns whose birth attendant washed hands before assisting with delivery had a 25% lower risk of death compared to newborns whose birth attendant did not wash her hands [Relative Risk (RR)=0.75, 95% Confidence Interval (CI): 0.65−0.86] (Table 2). Infants whose mothers washed their hands prior to handling their infant had a 60% lower risk of neonatal death compared to those whose mothers did not wash their hands (RR=0.40, 95% CI: 0.28−0.59) (Table 2). These effects were not independent as shown by the combined effect of both the birth attendant and mother washing their hands (RR=0.44, (95% CI: 0.28−0.68) (Table 2). Excluding the 271deaths that occurred prior to the first post-delivery study visit made only modest changes to the estimates of the effects of birth attendant hand-washing behavior (Table 2).

The population attributable risk percent for hand-washing by the birth attendant assisting with delivery was 12.2% (31.9 − 28.0 / 31.9 = 12.2%). Among those infants who survived the first few days of life, the population attributable risk percent associated with maternal hand-washing with soap and water or antiseptic prior to the handling of their neonate was 55.8% (19.9 − 8.8 / 19.9 = 55.8%).

Stratified analyses were conducted to evaluate the presence of confounding or effect modification. Potential confounders were identified from various maternal, infant and care-practice covariates. Some of these covariates have a recognized association with neonatal mortality or neonatal infection (e.g. birthweight, gestational age, cord cleansing with chlorhexidine (21-23)). Binomial regression with a log link function was used to model the RR of these covariates with neonatal mortality. Similar models were created to estimate the association of these covariates with birth attendant and maternal hand-washing behaviors.

There was no evidence for effect modification of the association of hand-washing behavior on risk of mortality by sex or treatment group assignment. However, hand-washing behaviors tended to have larger effects on mortality among infants with indicators of higher underlying risk such as Madeshi ethnicity, low birthweight, preterm birth, low maternal education, and those without a latrine in the household, although the strength of evidence for interaction was only modest (Table 3).

Adjustment for a number of potentially confounding variables including birth weight (LBW), gestational age, mother's age, receipt of colostrum, breastfeeding initiation time and treatment groups did not materially change the association of birth attendant hand-washing and neonatal mortality (adjusted RR=0.80, 95% CI: 0.65−0.98). After adjusting for these same covariates, the magnitude of the association of maternal hand-washing and neonatal mortality was reduced from a 60% reduction to a 44% reduction (adjusted RR=0.56, 95% CI: 0.38−0.82). Similarly, the strength of the association with combined birth attendant and maternal hand-washing was reduced from a 56% to a 41% reduction in mortality (adjusted RR=0.59, 95% CI: 0.37−0.93).

In addition, RRs were calculated conditioned on survival of infants until days 2, 3 and 7 (Table 4). This was done to evaluate the impact of each hand-washing exposure after the exclusion of early deaths. It was initially hypothesized that excluding these deaths would show a greater impact of birth attendant hand-washing relative to the impact of maternal hand-washing, because the majority of very early neonatal deaths may be due to causes that might not be readily impacted by hand-washing, such as birth asphyxia, prematurity or congenital

abnormalities. However, this was not supported by the data as there was little change in the relative risks after removing these early deaths (Table 4). There was also no substantive change in the relative risk of death associated with maternal hand-washing as early deaths were excluded (Table 4).

Discussion

These data provide evidence that birth attendant and maternal hand-washing are associated with markedly lower risk of mortality among neonates in southern Nepal after accounting for other risk factors for mortality. The adjusted risk of death was 19% lower among newborns whose birth attendants washed hands before assisting with delivery, and 44% lower among newborns whose mothers sometimes or always washed hands with soap and water or antiseptic prior to the handling of their child. The effects of birth attendant and maternal hand-washing, however, were not independent. Among newborns exposed to both birth attendant and maternal hand-washing, the risk of death was 41% lower.

Hand-washing appears to be more beneficial among infants with characteristics that are associated with poorer outcomes, such as low socioeconomic status, low birthweight and preterm birth. For instance, the benefit of hand-washing on neonatal mortality was greater among LBW infants compared with normal weight infants (Table 3). While the strength of evidence for effect modification was weak, this trend was evident for other covariates as well. Mortality due to infection likely makes up a greater proportion of deaths among infants with these characteristics. The trend seen here is consistent with the hypothesis that hand-washing reduces overall exposure of the newborn to potentially invasive pathogens, and thus impacts on mortality due to infection.

Our results are consistent with previous data on the impact of hand-washing on reductions in infectious diseases such as diarrhea and pneumonia (9-10,19). However, most of these studies were conducted in older children and there is little information on the impact of hand-washing in the neonatal period. A strength our study is its focus on the neonatal period where it fills an important gap in our knowledge of the protection offered by hand-washing in high risk environments.

Hand washing behavior by mothers and traditional birth attendants in this population has been a focus of educational efforts during prenatal counseling in our studies for a number of years. Given the implied social acceptability of hand washing, it may be that women who report washing their hands remain different from those who don't on important characteristics related to mortality that were unmeasured in this study (e.g. skin to skin care) and unadjusted for in the analysis. This residual confounding together with our dependence on subjective reporting of hand washing behavior could explain part or all of the remaining protective effect observed in this report (24-25). Given that we have adjusted for some important confounding factors and that association in higher risk infants were even stronger, we think it unlikely that this would compromise the findings in this study.

A significant limitation of our analysis is the forced exclusion of very early deaths in the assessment of maternal and combined maternal and birth attendant hand-washing. In these latter two analyses, the appropriate interpretation is that maternal hand-washing was associated with reduced mortality among infants who survived the first few days of life.

It has been estimated that 30,000 newborns die each year in Nepal during the neonatal period where the neonatal mortality rate is approximately 39 deaths per 1,000 live births (26). Furthermore, the WHO has estimated that 39% of deaths among neonates in Nepal are attributable to pneumonia, meningitis, sepsis/septicemia, and diarrheal disease (27). Our data suggest that a substantial proportion of these deaths may be preventable with routine hand-

washing practices. If the population attributable risk percentages of between 12% and 56% observed in our study can be applied to the 4 million annual neonatal deaths world wide, promotion of appropriate hand-washing practices in developing countries like Nepal may have a tremendous impact in reaching Millennium Development Goal 4 (28).

Birth attendant hand-washing with soap and water is well accepted as the standard of care in developed country settings. In developing countries, where most births take place at home, the concept of washing with soap before delivery to protect against infection is not well understood (29). In agreement with Curtis' recommendations for future research, new and existing approaches to hand-washing promotion need to be further evaluated (20). As hand-washing behaviors are notably complex, indicators are also needed to evaluate and validate the compliance of hand-washing promotion when moved from research to programs and policy.

Acknowledgements

This study was conducted by the Department of International Health, Bloomberg School of Public Health, Johns Hopkins University (JHU), Baltimore, Maryland, under grants from the National Institutes of Health, Bethesda, Maryland (HD 44004, HD 38753), the Bill and Melinda Gates Foundation, Seattle, Washington (810−2054), and Cooperative Agreements between JHU and the Office of Health and Nutrition, US Agency for International Development, Washington DC (HRN-A-00-97-00015-00, GHS-A-00-03-000019-00). Commodity support was provided by Procter and Gamble Company, Cincinnati, Ohio.

The above mentioned funding agencies had no role in the design and conduct of the study, the collection, management, analysis, and interpretation of the data, or in preparation, review, or approval of this manuscript.

These data were presented previously at the Pediatric Academic Societies Meeting, Toronto, Canada, May 2007.

References

1. Lawn JE, Cousens S, Darmstadt GL, Paul V, Martines J. Why are 4 million newborn babies dying every year? Lancet 2004;364:2020. [PubMed: 15582058]
2. Zupan, J.; Aahman, E. Perinatal mortality for the year 2000: estimates developed by the WHO. World health Organization; Geneva: 2005.
3. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: When? Where? Why? Lancet 2005;365:891–900. [PubMed: 15752534]
4. Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L. Evidence-based, cost-effective interventions: how many newborn babies can we save? Lancet 2005;365:977–88. [PubMed: 15767001]
5. WHO. Care of the Umbilical Cord: A Review of the Evidence. World Health Organization; Geneva: 1998.
6. Semmelweis, IP. Die Aetiologie der Begriff und die Prophylaxis des Kindbettfiebers. C.A. Hartleben's Verlags-Expedition; Pest-Wein-Leipzig: 1861. p. 1543
7. Khan M. Interruption of shigellosis by handwashing. Transactions of the Royal Soc Trop Med Hyg 1982;76:164–68.
8. Black R, Dykes A, Andersons K, et al. Handwashing to prevent diarrhoea in day-care centers. Am J Epidemiol 1981;113:445–51. [PubMed: 7211827]
9. Shahid N, Greenough WB, Huq MI, Rahman N. Hand washing with soap reduces diarrhoea and spread of bacterial pathogens in a Bangladesh village. J Diarrhoeal Dis Res 1996;14:85–89. [PubMed: 8870400]
10. Luby SP, Agboatwalla M, Painter J, et al. Combining drinking water treatment and hand washing for diarrhoea prevention, a cluster randomised controlled trial. Trop Med Intern Health 2006;11(4):479–489.
11. Luby SP, Agboatwalla M, Feikin DR, et al. Effect of handwashing on child health: a randomised controlled trial. Lancet 2005;366:225–33. [PubMed: 16023513]

12. Roberts L, Jorm L, Patel M, Smith W, Douglas R, McGilchrist C. Effect of infection control measures on the frequency of diarrheal episodes in child care: a randomized, controlled trial. Pediatrics 2000;105:743–46. [PubMed: 10742314]

13. Barros A, Ross D, Fonseca W, Williams L, Moreira-Filho D. Preventing acute respiratory infections and diarrhoea in child day care centres. Acta Paediatrica 1999;88:1113–18. [PubMed: 10565459]

14. Gorter AC, Sandiford P, Pauw J, Morales P, et al. Hygiene behaviour in rural Nicaragua in relation to diarrhoea. Intern J Epidemiol 1998;27(6):1090–100.

15. Velema J, van-Wijnen G, Bult P, van-Naerssen T, Jota S. Typhoid fever in Ujung Pandang, Indonesia: high-risk groups and high-risk behaviours. Trop Med and Intern Health 1997;2:1088–94.

16. Hussein-Gasem M, Dolmans W, Keuter M, Djokomoeljanto R. Poor food hygiene and housing risk factors for typhoid fever in Semarang, Indonesia. Trop Med and Intern Health 2001;6:484–90.

17. Roberts L, Jorm L, Patel M, Smith W, Douglas R, McGilchrist C. Effect of infection control measures on the frequency of upper respiratory infection in child care: a randomized, controlled trial. Pediatrics 2000;105:738–42. [PubMed: 10742313]

18. Won SP, Chou HS, Hsieh WS, et al. Handwashing program for the prevention of nocosomial infections in a neonatal intensive care unit. Infect Cont and Hosp Epidemiol 2004;25(9):742–6.

19. Peterson EA, Roberts L, Toole MJ, Peterson DE. The effect of soap distribution on diarrhea: Nyaminthuthu Refugee Camp. Intern J Epidemiol 1998;27(3):520–4.

20. Curtis V, Cairncross S. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. Lancet Infect Dis 2003;3(5):275–81. [PubMed: 12726975]

21. Mullany LC, Darmstadt GL, Khatry SK, et al. Topical applications of chlorhexidine to the umbilical cord for prevention of omphalitis and neonatal mortality in southern Nepal: a community-based, cluster-randomised trial. Lancet 2006;367:910–918. [PubMed: 16546539]

22. Tielsch JM, Darmstadt GL, Mullany LC, Khatry SK, Katz J, LeClerq SC, Shrestha S, Adhikari R. Impact of newborn skin-cleansing with chlorhexidine on neonatal mortality in southern Nepal: a community-based, cluster-randomized trial. Pediatrics 2007;119(2):e330–40. [PubMed: 17210728]

23. Mullany LC, Darmstadt GL, Khatry SK, et al. Risk factors for umbilical cord infection among newborns of southern Nepal. Am J Epidemiol 2007;165:203–211. [PubMed: 17065275]

24. Manun'Ebo M, Cousens S, Haggerty P, Kalengaie M, Ashworth A, Kirkwood B. Measuring hygiene practices: a comparison of questionnaires with direct observations in rural Zaire. Trop Med Int Health Nov;1997 2(11):1015–21. [PubMed: 9391503]

25. Curtis V, Cousens S, Mertens T, Traore E, Kanki B, Diallo I. Structured observations of hygiene behaviours in Burkina Faso: validity, variability, and utility. Bull WHO 1993;71(1):23–32. [PubMed: 8440034]

26. Ministry of Health and Population - Nepal, New ERA, Macro International, Inc.. Nepal Demographic and Health Survey 2006. Ministry of Health and Population, New ERA, and Macro International, Inc.; Kathmandu, Nepal:

27. WHO. Mortality Country Fact Sheet 2006 (Nepal). World Health Organization; Geneva: 2006.

28. Department of Economic and Social Affairs, United Nations Secretariat. The Millennium Development Goals Report 2007. United Nations; New York: 2007.

29. Darmstadt GL, Syed U, Patel Z, Kabir N. Review of domiciliary newborn care practices in Bangladesh. J Health Pop Nutr 2006;24:380–393. [PubMed: 17591335]

Table 1

Selected Characteristics by Birth Attendant Hand-Washing

		Birth Attendant Hand-Washing	
	Variable	**Yes[A] N (%)**	**No[B] N (%)**
Sex	Male	6,931 (52.3)	5,264 (50.6)
	Female	6,324 (47.7)	5,143 (49.4)
Ethnic group[1]	Hills (Pahadi)	3,898 (29.4)	2,729 (26.2)
	Plains (Madeshi)	9,143 (69.0)	7,503 (72.1)
Maternal Education[2]	None	9,574 (72.2)	8,414 (80.9)
	Any	3,668 (27.7)	1,984 (19.1)
Electricity in House[3]	No	9,533 (71.9)	8,078 (77.6)
	Yes	3,501 (26.4)	2,161 (20.8)
Latrine at House[4]	None	11,197 (84.5)	9,306 (89.4)
	Any latrine	1,826 (13.8)	907 (8.7)
Ownership	Rice paddy land[5]	6,761 (51.0)	4,958 (47.6)
	Cattle[6]	8,084 (61.0)	6,090 (58.5)
	Radio[7]	4,162 (31.4)	2,820 (27.1)
	TV[8]	2,645 (20.0)	1,569 (15.1)
	Bicycle[9]	7,146 (53.9)	5,209 (50.1)
	Median time to first study visit	18.4 hours	20.5 hours
	Visited within 24 hours	8,817 (37.3)	6,080 (25.7)
	Breastfed within 12 hours after delivery	5,558 (41.9)	3,964 (38.1)
	Infant given colostrum[10]	10,535 (79.5)	8,090 (77.7)
	Used Clean Blade to Cut Umbilical Cord	12,447 (93.9)	8,576 (82.4)
Birth weight[11]	<2,500 g	3,771 (28.5)	3,013 (29.0)
	≥2,500 g	9,253 (69.8)	6,724 (64.6)
Gestational age	<37 weeks	2,275 (17.2)	2,045 (19.7)
	≥37 weeks	10,980 (82.8)	8,362 (80.4)
Skin cleansing treatment	Chlorhexidine	8,451 (63.8)	6,331 (60.8)
	Placebo	4,804 (36.2)	4,076 (39.2)
Cord cleansing Treatment	Chlorhexidine	6,366 (48.0)	4,938 (47.5)
	Education Only	3,897 (29.4)	3,142 (30.2)
	Soap and Water	2,992 (22.6)	2,327 (22.4)

Total missing information for each characteristic:

1A 214 (1.6%), 1B 175 (1.7%)

2A 13 (0.1%), 2B 9 (0.1%)

3A 221 (1.7%), 3B 168 (1.6%)

4A 232 (1.8%), 4B 194 (1.9%)

5A 320 (2.4%), 5B 265(2.6%)

6A 223 (1.7%), 6B 170 (1.6%)

7A 225 (1.7%), 7B 170 (1.6%)

8A 222 (1.7%), 8B 169 (1.6%)

9A 226 (1.7%), 9B 168 (1.6%)

10A 361 (2.7%), 10B 374 (3.6%)

11A 231 (1.7%), 11B 670 (6.4%)

Table 2

Unadjusted Association of Birth Attendant and Maternal Hand-Washing Behavior and Neonatal Mortality

		Total				Excluding Early Deaths[2]			
		Deaths	**Births**	**Rate[1]**	**RR (95% CI)**	**Deaths**	**Births**	**Rate[1]**	**RR (95% CI)**
Birth Attendant Hand-washing	**Yes**	371	13,255	28.0	0.75 (0.65–0.86)	240	13,124	18.3	0.81 (0.68–0.98)
	No	342	9,123	37.5	1.00	202	8,982	22.5	1.00
Maternal Hand-washing[3]	**Yes**					30	3,403	8.8	0.40 (0.28–0.58)
	No					427	19,592	21.8	1.00
Combined Hand-washing[3]	**Yes**					21	2,267	9.3	0.44 (0.28–0.68)
	No					413	19,520	21.2	1.00

[1] Rate per 1000 live births.

[2] Early deaths are defined as those occurring prior to the first data collection visit after delivery by study staff.

[3] Early deaths are excluded in the maternal hand-washing and combined hand-washing analyses.

Table 3

Unadjusted Association of Hand-Washing Behavior and Neonatal Mortality by Selected Characteristics of the Population

	Birth Attendant Hand-Washing	Maternal Hand-Washing	Combined Hand-Washing
Variable	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**
Birth weight			
<2,500 grams	0.64 (0.50−0.82)	0.50 (0.31−0.81)	0.41 (0.21−0.78)
≥2,500 grams	1.34 (0.92−1.97)	0.56 (0.30−1.05)	0.77 (0.40−1.48)
Test for interaction	p = 0.001	p = 0.76	p = 0.17
Ethnic group			
Hills (Pahadi)	0.93 (0.66−1.30)	0.60 (0.32−1.09)	0.83 (0.44−1.57)
Plains (Madeshi)	0.73 (0.62−0.86)	0.38 (0.24−0.61)	0.33 (0.18−0.61)
Test for interaction	p = 0.21	p = 0.25	p = 0.04
Gestational age			
<37 weeks	0.67 (0.54−0.82)	0.30 (0.15−0.62)	0.24 (0.09−0.64)
≥37 weeks	0.87 (0.71−1.05)	0.52 (0.34−0.80)	0.62 (0.38−1.01)
Test for interaction	p = 0.08	p = 0.20	p = 0.09
Maternal education			
None	0.76 (0.65−0.89)	0.37 (0.23−0.59)	0.40 (0.22−0.70)
Any formal education	0.83 (0.57−1.20)	0.56 (0.30−1.03)	0.62 (0.31−1.24)
Test for interaction	p = 0.69	p = 0.29	p = 0.32
Latrine at home			
No	0.75 (0.65−0.87)	0.36 (0.23−0.55)	0.38 (0.23−0.64)
Yes	0.88 (0.51−1.54)	0.90 (0.41−2.00)	0.90 (0.37−2.17)
Test for interaction	p = 0.58	p = 0.04	p = 0.10

Table 4

Adjusted Associations of Birth Attendant and Maternal Hand-Washing with Neonatal Mortality Beginning at Selected Times Since Delivery

	Birth Attendant		Maternal		Combined	
Conditioned on Survival at Day:	**Unadjusted RR (95% CI)**	**Adjusted* RR (95% CI)**	**Unadjusted RR (95% CI)**	**Adjusted* RR (95% CI)**	**Unadjusted RR (95% CI)**	**Adjusted* RR (95% CI)**
0 (total)	0.75 (0.65−0.86)	0.81 (0.66−0.99)	0.40 (0.28−0.58)	0.56 (0.38−0.82)	0.44 (0.28−0.68)	0.59 (0.37−0.94)
2	0.72 (0.58−0.89)	0.72 (0.57−0.91)	0.46 (0.30−0.69)	0.59 (0.39−0.90)	0.44 (0.26−0.73)	0.55 (0.32−0.95)
3	0.77 (0.60−0.98)	0.78 (0.61−1.02)	0.50 (0.32−0.79)	0.66 (0.42−1.02)	0.44 (0.25−0.79)	0.58 (0.32−1.03)
7	0.74 (0.55−1.01)	0.75 (0.54−1.03)	0.67 (0.41−1.08)	0.83 (0.51−1.35)	0.57 (0.30−1.09)	0.70 (0.37−1.33)

*Adjusted for body wash treatment, cord cleansing treatment, birth weight, gestational age, maternal age, the receipt of colostrum, and breast-feeding initiation time.