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Workforce Interventions to Deliver Postnatal Care to Improve Neonatal Outcomes in Low- and Lower-Middle-Income Countries: A Narrative Synthesis

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Abstract

Reducing neonatal mortality rates in low- and lower-middle-income countries (LMICs) requires postnatal interventions to be delivered through an appropriately prepared and supported workforce. This review examines health workforce interventions that deliver integrated packages of postnatal care to improve neonatal outcomes in LMICs. We conducted a structured search of peer-reviewed articles published during 2003-2014 that investigated the delivery of postnatal interventions by formal and lay health workers. We selected 13 studies and analyzed them using a narrative synthesis methodology. This review observed a wide divergence among studies regarding the outcomes as well as the approaches and duration of workforce training and staff supervision. Except 4, all studies observed a significant reduction in neonatal mortality. On the other hand, teams of lay health workers appear to be more effective in improving neonatal outcomes. Further improvement in the performance of health care providers may require emphasis on workforce interventions such as competency assessment, the acquisition of appropriate skills, and supervisory guidelines. Nevertheless, the heterogeneity and limited number of studies do not allow us to arrive at definitive conclusions, and we recommend the need for the harmonization of future studies, with uniformity of outcome measures and cost analyses.

Keywords

human resources for health, health care provider, neonatal morbidity, neonatal mortality, postnatal intervention, supervision, training, workforce intervention

Introduction

Neonatal mortality—death within the first 28 days of life—is a serious global health issue with approximately 2.76 million deaths each year.[1] Most of these deaths occur in low- and lower-middle-income countries (LMICs), where antenatal and postnatal care use is low, and many

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women give birth without skilled attendants.[2] Thus, health interventions, delivered by competent, motivated, and well-supported health workers can lower the neonatal mortality rates in LMICs.[3,4]

Health interventions that play an essential role in reducing neonatal mortality include antenatal, intrapartum, and postnatal care. Key antenatal interventions include tetanus toxoid immunization, syphilis screening and treatment, antibiotics for urinary tract infection/sexually transmitted disease/asymptomatic bacteriuria, prevention and treatment of preeclampsia/eclampsia, and malaria prevention.[3] Studies examining different components of antenatal care have observed a significant reduction in neonatal mortality of up to 69%.[5-10] Crucial intrapartum interventions include clean delivery practices, vaginal and newborn skin antisepsis, antibiotics for preterm premature rupture of membranes, and corticosteroids for preterm labor and cesarean section.[3] One study has indicated that evidence-based intrapartum intervention packages (at 90% coverage) can prevent 2 to 3 times more neonatal deaths than those related to antenatal care.[3] Finally, important postnatal intervention packages include resuscitation of newborn baby, breastfeeding, prevention and management of hypothermia, kangaroo mother care, and community-based pneumonia case management.[3] Studies indicate that home-based postnatal care interventions can prevent as many as 70% of newborn deaths.[11-14]

The available information on the cost-effectiveness of interventions at different phases of maternal and child health (MCH) appear to be scarce in the literature. A study on the WHO Afro-D subregion (Africa with high child and high adult mortality) showed that the average cost per neonatal and maternal years of life lost and years lived with disability were USD47.12, USD19.00, and USD17.59 for antenatal, emergency obstetric, and essential neonatal care, respectively.[3] Although emergency obstetric care and essential neonatal care are only components of intrapartum and postnatal interventions, this indicates that postnatal interventions can be a cost-effective way to reduce neonatal mortality in LMICs.

Postnatal interventions in LMICs are delivered by a wide range of health workers, including community health workers (CHWs), midwives, nurses, and doctors. Increases in the density of such health workers can improve infant and child survival.[15] Again, health workers' performance can be improved through multifaceted interventions, including the provision of training, written guidelines, and supervision, which however, requires the assessment of training as well as identification of the contextual factors.[16-19]

Previous systematic reviews have assessed the effectiveness of CHWs/lay health workers in delivering curative and preventive interventions for MCH.[20-23] However, there is no systematic review that examines workforce interventions to best support health workers in delivering postnatal interventions in LMICs. Against this background, this article reports the findings of a narrative synthesis of peer-reviewed articles to understand the effectiveness of the health workforce. We specifically aim to identify health workforce interventions that deliver integrated packages of postnatal care to improve the neonatal outcomes in LMICs.

Methods

Because of the heterogeneous nature of the methodologies of selected studies, this review used a narrative synthesis approach.[24] Thus, we report the characteristics, context, quality, and findings of selected research articles according to a standard format. Unlike a descriptive review, a narrative synthesis methodology uses a systematic approach involving structured summaries, where the extracted data are elaborated on and then contextualized.

Search Protocol

A Population, Interventions, Comparators, Outcomes, Study design (PICOS) question was formed to guide this review.[25] The PICOS question was, "How have the health care providers

Table 1. Postnatal Interventions for Newborns.[a]

Postnatal Interventions (Newborn)	Referral Level	First Level	Community
Immediate thermal care (immediate drying, warming, skin to skin, delayed bathing)	X	X	X
Initiation of exclusive breastfeeding (within first hour)	X	X	X
Hygienic cord and skin care	X	X	X
Neonatal resuscitation with bag and mask (professional health worker)	X	X	—
Case management of neonatal sepsis, meningitis, and pneumonia	X	X	—
Kangaroo mother care for preterm babies and for babies weighing less than 2000 g	X	X	—
Management of newborns with jaundice	X	X	—
Surfactant to prevent respiratory distress syndrome in preterm babies	X	—	—
Continuous positive airway pressure to manage babies with respiratory distress syndrome	X	—	—
Extra support for feeding small and preterm babies	X	X	—
Presumptive antibiotic therapy for newborns at risk of bacterial infection	X	—	—

[a]A global review of the key interventions related to reproductive, maternal, newborn and child health (RMNCH).[2]

been trained and supervised to deliver integrated packages of postnatal care that have led to improved neonatal outcomes in LMICs?" Health care providers in this review included both formal health workers (eg, auxiliary nurses and midwives, registered nurses and midwives, and doctors) and lay health workers (eg, CHWs, village health workers [VHWs], and traditional birth attendants [TBAs]). Lay health workers had no formal professional or paraprofessional tertiary education and were usually provided on-the-job training by formal health professionals.[20]

This study aimed to investigate health workforce interventions such as the provision of training, supervision, and teamwork. We considered studies on neonates as participants who were born in LMICs. Relying on the WHO guidelines, an intervention was considered postnatal if it included any intervention listed in Table 1.[2] Studies considered in this review investigated the delivery of integrated packages of these interventions. Outcomes of interest included the neonatal mortality rate (NMR) and/or perinatal mortality rate (PMR) or morbidity. Randomized trials and quasiexperimental, observational, and descriptive studies were eligible for inclusion.

We concentrated only on recent health intervention programs and searched MEDLINE, PubMed, Scopus, ScienceDirect, Web of Science, CINAHL, and Google Scholar for peer-reviewed articles in English (Table 2). We undertook this review in 2015, and like other reviews,[26,27] we selected a 12-year period (2003 to 2014) to ensure an analysis of the most contemporary research. The following Medline MeSH subject headings were used: *postnatal intervention* or *postnatal care* or *postnatal check-up* and *neonates* or *newborn* or *neonatal* and *Developing countries*, and augmented by the key words *health personnel* or *health care provider* or *health worker* or *lay health worker* or *community health worker*.

We initially retrieved 512 articles and screened these articles as per the PICOS question. Following the screening process, 43 articles remained and were examined in more detail. At this stage, studies were excluded (listed in Appendix A) for not being an integrated interventions packages (10 articles), not satisfying the outcome of interest (12 articles), not associated with the appropriate postnatal intervention (4 articles), no stated intervention (2 articles), being a pilot study (1 article for which the final study was included in this review), and being a study protocol

Table 2. Articles Retrieved From the Databases Searched.

Database	Articles Retrieved
MEDLINE	59
PubMed	124
Scopus	173
ScienceDirect	87
Web of Science	35
CINAHL	20
Google Scholar	14
Total	512

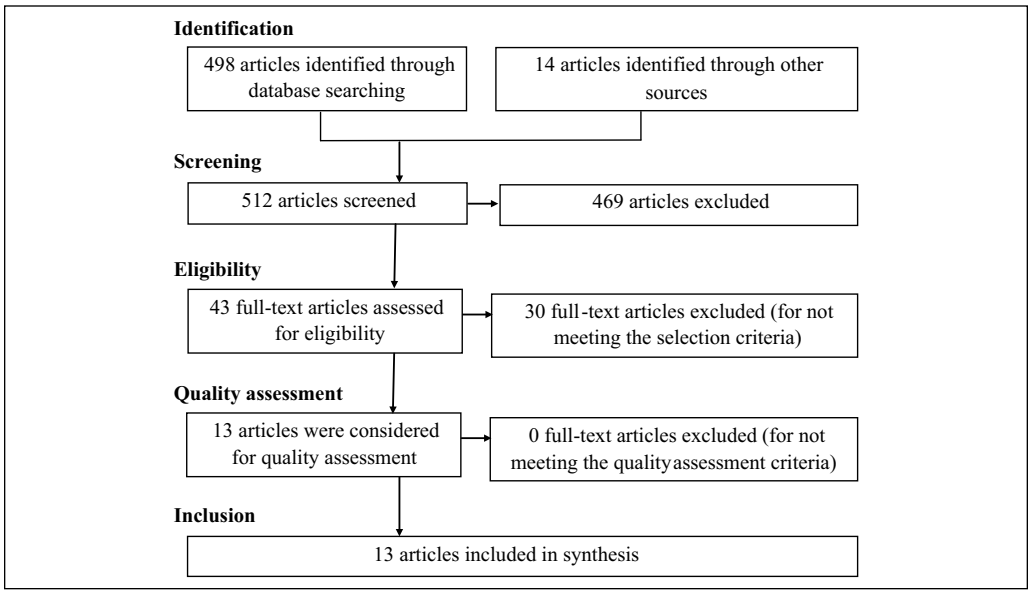

Figure 1. Literature review process.

(1 article). Thus, a total of 13 articles were selected for quality assessment. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was used to report the review process (Figure 1).[28]

Quality Assessment

The quality of the selected articles was assessed using the Effective Public Health Practice Project (EPHPP) tool for quantitative studies.[29] The studies were scored as strong, moderate, and weak with regard to the selection bias, study design, confounders, blinding, data collection methods, withdrawals/dropouts, intervention integrity, and analyses. All 13 articles in our analysis either had no (8 studies) or 1 (5 studies) weak rating in one of the components.

Data Extraction and Synthesis

Data were extracted systematically from the findings sections of all articles and directed by the PICOS question. The characteristics of all studies, including the context and method were

examined. Tables were used to collate aspects of the studies and the contents of the cells discussed, among authors. A textual narrative approach to the analysis of the study findings was undertaken as described by Lucas et al.[30] This involved a commentary approach to the description and comparison of data that was grouped into various categories. These categories (type of health workers, workforce interventions, and postnatal interventions) were informed by the literature and examined in relation to postnatal outcomes.[2,31] Data were then synthesized by combining studies with similar types of health workers and patterns identified across and within articles. All the authors reviewed the selected articles.

Results

All 13 articles in this review are summarized in Table 3. Among these articles, 9 focused on South Asia,[11-14,32-36] 3 on Africa,[37-39] and 1 on countries from Asia, Africa, and Latin America.[40] The majority of the studies (7) were cluster randomized controlled trials (RCTs).[12-14,35,36,38,39] Other study designs include cluster controlled trial (not randomized), quasiexperimental, and active baseline (an improvement over the before-after controlled study design).[11,34,37] The remaining study had 2 parts: the first part involved a before-after intervention design and the other part relied on a cluster RCT design.[40] To deliver the postnatal intervention packages, selected studies involved a range of health workers, including lay health workers (CHWs, VHWs, TBAs, community mobilizers, unqualified medical practitioners, MCH promotion workers, community-based surveillance volunteers [CBSVs], community health committees [CHCs], and volunteers) and formal health workers (lady health workers [LHWs], auxiliary nurses, midwives, and physicians). We categorized the health workers as individual lay health workers, teams of lay health workers, teams of lay and formal health workers, and formal health workers and then presented our groupwise findings according to workforce interventions, performance including contribution to neonatal health outcomes, and cost-effectiveness.

Training and Supervision

Individual Lay Health Workers. Studies by Gill et al[38] and Kirkwood et al[39] investigated the contribution of individual lay health workers, who conducted home visits in improving neonatal outcomes. Gill et al[38] provided a 1-week training to TBAs in the intervention area through interactive lectures, demonstrations, and small group sessions. Before the final selection, TBAs had to successfully complete a one-on-one skill assessment. On the other hand, Kirkwood et al[39] provided a 9-day training, including a 2-day refresher course to the CBSVs. The CBSVs were supervised through individual monthly meetings and group supervision meetings held every 2 months.

Teams of Lay Health Workers. Five articles[11,12,32,33,35] concentrated on workforce initiatives for teams of lay health workers in which VHWs/CHWs, together with the TBAs, contributed to the delivery of antenatal and postnatal care through home visits. VHWs in Bang et al,[11] who had 5 to 10 years of schooling, received a classroom-based 36-day training program that was spread over a year and practiced their skills in the community over the training period.[41] Moreover, they attended a 3-day workshop on the management of babies who did not cry/breathe at birth.[42] In contrast, TBAs in the study were trained on clean and safe home deliveries and mouth-to-mouth resuscitation of babies.[42] CHWs in Baqui et al[12] received a 6-weeks hands-on supervised training course in tertiary-care hospitals and in households. CHWs in Darmstadt et al,[35] who had at least 10 years of schooling, received a 36-day training course through didactic sessions, videos, and practice on newborn babies in hospitals.[43] Moreover, TBAs in these studies received a 2-day orientation program on the aim of the study and newborn care practices. Baqui et al[12] additionally employed community mobilizers who promoted birth and newborn-care messages through group

Table 3. Summary of Studies Included in the Synthesis.

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
Individual lay health workers				
• Reference: Gill et al[38] • Objective: To determine whether training of traditional birth attendants (TBAs) to manage several common perinatal conditions could reduce neonatal mortality • Setting: Lufwanyama, Zambia • Study design: cluster RCT	TBAs	• Training: TBAs in the intervention area received 1 week of training on a modified version of the neonatal resuscitation protocol through interactive lectures, demonstrations, small group sessions, and skills practice using infant manikins. They had to complete a one-on-one skill assessment satisfactorily. Moreover, refresher workshops were held every 3 to 4 months throughout the study period in both intervention and control areas. TBAs in the intervention area needed to attend competency assessment in every workshop. Members of the study team trained TBAs. • Supervision: not discussed	• Promoted a modified version of the neonatal resuscitation protocol • Provided antibiotics (single-dose amoxicillin) with facilitated referral of infants to health centers, if needed	1. The NMR reduced by 45% among live-born infants delivered by intervention birth attendants compared with control birth attendants (RR = 0.55; 95% CI = 0.33, 0.90) 2. The maximum reductions in mortality were in the first 24 hours after birth (RR = 0.40; 95% CI = 0.19, 0.83) 3. The NMR during the first week of life reduced by 44% (RR = 0.56; 95% CI = 0.32, 1.01) 4. Deaths caused by birth asphyxia, delivered by intervention birth attendants, were reduced by ○ 63% (RR = 0.37; 95% CI = 0.17, 0.81) and ○ 81% (RR = 0.19; 95% CI = 0.07, 0.52) within the first 2 days after birth
• Reference: Kirkwood et al[39] • Objective: To test home visits strategy by assessing the effect on all-cause NMR and ENC practices • Setting: BrongAhafo Region, Ghana • Study design: Cluster RCT	Community-based surveillance volunteers (CBSVs)	• Training: CBSVs received a total of 9 days of training over 8 months in 3 phases, including refresher training for 2 days. • Supervision: Individual sessions held each month with observation of home visit and supportive feedback. Group supervision meetings held every 2 months	1. Made 2 home visits during pregnancy 2. Made 3 postnatal visits in the first week of neonate's life (day 1, 3, and 7) ○ to promote ENC practices, ○ to weigh and assess babies for danger signs, and ○ to refer if required	1. The NMR reduced by 8% in intervention zones compared with control zones (RR = 0.92; 95% CI = 0.75, 1.12) 2. The post–day 1 NMR reduced by 15% in intervention zones compared with control zones (RR = 0.85; 95% CI = 0.64, 1.13)
Teams of lay health workers				
• Reference: Bang et al[11] • Objectives: To evaluate the effect of home-based neonatal care (HBNC) on neonatal and infant mortality • Settings: Gadchiroli, India • Study design: Clustered controlled trial (not randomized)	Female village health workers (VHWs) and trained TBAs	• Training: VHWs, who had 5 to 10 years of schooling, received 36 days of classroom-based training, spread over a period of 1 year (3 days in each month), including practicum periods in the community (about 2 births in each month). VHWs also attended a 3-day workshop on managing babies who did not cry or breathe at birth, followed by a review and assessment workshop held after 2 months. TBAs in the intervention villages were trained on clean and safe home delivery and on mouth-to-mouth resuscitation of babies	• Attended delivery, along with the TBAs • Encouraged the family and the TBAs for referral when necessary • Assessed the baby immediately after birth • Managed birth asphyxia, used bag and mask if necessary • Initiated early and exclusive breast feeding • Injected vitamin K 1 mg, on the day of birth • Provided thermal care of the neonate	1. The NMR in the intervention area declined from 62 (1993 to 1995) to 25 (2001 to 2003) per 1000 live births 2. The NMR increased in the control area from 58 (1993 to 1995) to 64 (2001 to 2003) per 1000 live births 3. The reduction in the intervention area compared with the control area was as follows: ○ NMR = 44 points (70%; 95% CI = 59%, 81%) ○ Early NMR = 24 points (64%; 95% CI = 49%, 79%) ○ Late NMR = 20 points (80%; 95% CI = 64%, 95%).

(continued)

Table 3. (continued)

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
		• Supervision: intensive field supervision (twice in a month) was conducted as an extension of training and support • Teamwork: VHWs worked with the cooperation of TBAs	• Took extra care if the baby was in high-risk status • Conducted repeated home visits (8-12 times) during neonatal period to ensure breastfeeding, thermal care, and hygiene and to monitor the baby for any infection • Provided early diagnosis and treatment of neonates with sepsis, including administration of 2 antibiotics—co-trimoxazole and gentamicin • Offered home-based care of LBW or preterm neonates • Performed weekly weighing, problem solving, advising and helping mother • Provided referral service when necessary	○ Stillbirth rate: 16 points (49%; 95% CI = 31%, 66%) ○ PMR: 38 points (56%; 95% CI = 44%, 68%) 4. The cause-specific NMR (1995 to 1996 vs 2001 to 2003) decreased by ○ Sepsis: 89.8% (95% CI = 78.6%, 101.0%) ○ Asphyxia: 53.3% (95% CI = 23.8%, 82.8%) ○ Prematurity: 38.0% (95% CI = 4.3%, 71.6%)
• Reference: Bang et al[32] • Objective: To evaluate the effect of HBNC on neonatal morbidities by comparing the early period against the late period in the intervention arm of the trial • Settings: Gadchiroli, India • Study design: Clustered controlled trial (not randomized)	Female VHWs and trained TBAs	• Training: VHWs, who had 5 to 10 years of schooling, received 36 days of classroom-based training, spread over a period of 1 year (3 days in each month), including practicum periods in the community (about 2 births in each month). VHWs also attended a 3-day workshop on managing babies who did not cry or breathe at birth, followed by a review and assessment workshop held after 2 months. TBAs in the intervention villages were trained on clean and safe home delivery and mouth-to-mouth resuscitation of babies.	In 1995-1996 • Attended home deliveries conducted by TBAs • Made 8 home visits to observe the newborn baby during the neonatal period • In 1996-1997 • VHWs gave advise on and demonstrated neonatal care to mothers, at home • Identified neonatal morbidities such as asphyxia, prematurity, birth weight <2000 g, sepsis, hypothermia, breastfeeding problems, conjunctivitis, skin infections, umbilical sepsis, and fever	1. The mean number of morbidities per 100 neonates in 1995-1996, 1996-1997, and 1997-1998 was 228, 170, and 115, respectively (a reduction of 49.6%; $P < .001$), and it showed a dose-response relationship with the multiple interventions in HBNC 2. The changes in the incidence of morbidities were as follows: ○ Infections: from 61.6 to 27.5 (−55%; $P < .001$) ○ Care-related morbidities: (asphyxia, hypothermia, feeding problems) from 48.2 to 26.3 (−45%; $P < .001$) ○ Low birth weight: from 41.9 to 35.2 (−16%; $P < .05$) ○ Preterm birth and congenital anomalies: remained unchanged

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Table 3. (continued)

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
		• Supervision: intensive field supervision (twice in a month) was conducted as an extension of training and support. A physician made home visits (in every fortnight) to all neonates to ensure quality and recorded parallel observations on 119 consecutive neonates independently to evaluate the quality. • Teamwork: VHWs worked in cooperation with the TBAs	• Treated illnesses appropriately • Advised hospitalization for serious illness In 1997-1998 • Introduced intensive health education	
• Reference: Baqui et al[12] • Objective: To promote neonatal health through 2 service-delivery strategies: a home-care model and a community-care model • Settings: Sylhet, Bangladesh • Study design: Cluster RCT	Female community health workers (CHWs), female and male community mobilizers, and female volunteers (usually TBAs)	• Training: CHWs received a 6-week hands-on training in a tertiary-care hospital and in households. They again attended a 3-day refresher training in the middle of the intervention. TBAs in the home care and community care arm had attended a 2-day orientation program on cleanliness during delivery, maternal danger signs, and newborn care. Refresher training was provided to government health workers in home care, community care, and the comparison arm. • Supervision: A group of 6 to 8 CHWs were supervised by each field supervisor who, in every month, spent at least 2 days with each CHW to provide feedback on their work. In fortnightly group meetings, CHWs could also discuss the field problems with senior supervisors. • Teamwork: CHWs and community mobilizers worked in the home care arm. Female volunteers were recruited in the community care arm and worked with community mobilizers	Home care arm • CHWs ○ Made both antenatal and postnatal (first, third, and seventh days of birth) home visits to promote birth and newborn care preparedness ○ Assessed newborns and classified illnesses as very severe disease (VSD) or possible VSD ○ Referred to hospitals if required ○ Treated sick neonates at home if families were unable to comply with referral ○ Visited daily to complete the 10-day course of antibiotic therapy ○ Reinforced referral if neonates diagnosed with possible VSD with one sign Community-care arm ○ Female and male community mobilizers promoted birth and newborn-care messages through group meetings only	In the past 6 months of the 30-month intervention 1. NMR 29.2 per 1000 live births (home-care arm) 2. NMR 45.2 per 1000 live births (community care) 3. NMR 43.5 per 1000 live births (comparison arms) 4. NMR reduced by 34% in the home-care arm compared with comparison arm (adjusted RR = 0.66; 95% CI = 0.47, 0.93) 5. No mortality reduction was observed in the community-care arm (adjusted RR = 0.95; 95% CI = 0.69, 1.31)

(continued)

Table 3. (continued)

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
• Reference: Baqui et al[33] • Objective: to assess the relative effectiveness of neonatal infection management by CHWs, qualified medical providers, and other types of providers • Settings: Sylhet, Bangladesh • Study design: nested in cluster RCT	CHWs and community mobilizers	• Training: CHWs received 6 weeks hands-on training in a tertiary-care hospital and in households. They also received a 3-day refresher training in the middle of the intervention. TBAs in the home-care and community-care arm had received a 2-day orientation program on cleanliness during delivery, maternal danger signs, and newborn care. Refresher training was provided to government health workers. • Supervision: a group of 6 to 8 CHWs were supervised by each field supervisor who, in every month, spent at least 2 days with each CHW to provide feedback on their work. In fortnightly group meetings, CHWs could also discuss the field problems with senior supervisors • Teamwork: CHWs and community mobilizers worked in the home-care arm	• Made both antenatal and postnatal (first, third, and seventh days of birth) home visits to promote birth and newborn care preparedness • Assessed newborns and classified illnesses as having VSD or possible VSD • Referred to hospitals if required • Treated sick neonates at home if families were unable to comply with referral • Visited daily to complete the 10-day course of antibiotic therapy • Reinforced referral if neonates were diagnosed with possible VSD with 1 sign	1. Case fatality rate for VSD ○ 4.4% (95% CI = 2.0%, 8.2%) if treated by CHWs ○ 14.2% (95% CI = 9.2%, 20.5%) if treated by qualified medical providers ○ 32.0% (95% CI = 14.9%, 53.5%) if treated by other unqualified providers ○ 27.6% (95% CI = 18.5%, 38.2%) if no treatment outside home 2. Compared with newborns who received no treatment/were treated by untrained providers, the adjusted HR of death during the neonatal period was ○ 0.22 (95% CI = 0.07, 0.71) if treated by CHWs ○ 0.61 (95% CI = 0.37, 0.99) if treated by qualified providers
• Reference: Darmstadt et al[35] • Objective: to evaluate a delivery strategy for newborn interventions • Setting: Mirzapur, Bangladesh • Study design: cluster RCT	CHWs and TBAs	• Training: CHWs who had at least 10 years of schooling and received 36 days of training (with 6 days of field practice) through didactic sessions, videos, and practice on sick and healthy newborn babies. CHWs started field work after the evaluation of their assessment on 5 neonates. They also received refresher training in each fortnight. TBAs in intervention union attended a 2-day orientation session on the aims of projects, ENC practices, and indicators for referral of newborns and mothers • Supervision: field supervisors monitored CHWs through a standard checklist/ guideline. In each union, 1 field supervisor met with 6 CHWs (about 6 hours in each fortnight) to review their work and provide refresher training • Teamwork: not discussed	• Promoted antenatal care • Promoted birth planning • Distributed clean delivery kit • Promoted new born care preparedness (drying and wrapping the baby, immediate breastfeed after birth, delaying bathing, cord care and monitoring the baby for signs of infection) • Made 3 postnatal home visits (on days 2, 5, and 8 after birth) to negotiate preventive care practices • Assessed newborns for illness and referred to hospitals • Treated sick neonates at home if families refused to be referred	Adjusted mortality hazard ratio in the intervention arm, compared with the comparison arm • Baseline 1.02 (95% CI = 0.80, 1.30) • Endline 0.87 (95% CI = 0.68, 1.12)

(continued)

Table 3. (continued)

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
Teams of lay and formal health workers • Reference: Baqui et al[34] • Objective: to assess the impact of the newborn health component of a large-scale community-based integrated nutrition and health program • Settings: Uttar Pradesh, Northern India • Study design: quasiexperimental design	Auxiliary nurse-midwives, maternal and child health promotion (*anganwadi*) workers, and community volunteers (change agents)	• Training: All 3 types of health workers received a 6-day training on the care of mothers and newborn babies • Supervision: not discussed • Teamwork: auxiliary nurse-midwives worked in health centers as well as made home visits. *Anganwadi* workers promoted maternal, newborn, and child health from fixed sites (*anganwadi* center) and through home visits. Change agents worked with *anganwadi* workers	Prenatal • Home visit by all 3 types of health workers to provide counseling on preventive care, nutrition, preparedness for child birth, and health-care use for complications Delivery • Encouraged families to call auxiliary nurse-midwife or trained TBA to attend delivery Postnatal • Auxiliary nurse-midwife, *anganwadi* worker, and change agent visited immediately after birth to provide counseling on breastfeeding, ENC (thermal care, hygiene, clean cord care), maternal and newborn danger signs, and health-care use, and follow-up visits for sick, premature, or LBW neonates	1. NMR decreased by 34% within the group of women who received a postnatal visit within 28 days of delivery (NMR = 35.7; 95% CI = 29.2, 42.1) compared with the group who received no visit (NMR = 53.8; 95% CI = 48.9, 58.8) 2. NMR decreased by 25% within the group of women who received a postnatal visit within 3 days of delivery (NMR = 40.2; 95% CI = 31.8, 48.6) compared with those who did not receive any visit (NMR = 53.8; 95% CI = 48.9, 58.8)
• Reference: Bhutta et al[13] • Objective: to evaluate the effectiveness of a community-based intervention package, principally delivered through LHWs working with TBAs and CHCs, for reduction of perinatal and neonatal mortality • Settings: Hala and Matiari subdistricts, Pakistan • Study design: cluster RCT	Lady health workers (LHWs), TBAs/*dais*, and community health committees (CHCs)	• Training: regular LHWs, who had at least 8 years of schooling, received a 15-month training on preventive newborn care, including 3 months of didactic training and monthly refresher sessions. LHWs in the intervention area received an extra 6-day training. *Dais* had an optional 3-day training program on basic newborn care. *Dais* could also attend the community education session led by LHWs. • Supervision: regular LHW program supervisors and trainers supervised the LHW training. The training program for *dais* was developed with the assistance of Directorate of Health staff. Community mobilizers from Aga Khan University, Pakistan, helped LHWs in identifying community volunteers to form CHCs.	• LHWs visited mothers twice during pregnancy, within 24 hours of birth and on days 3, 7, 14, and 28 after birth • LHWs worked on promotion of antenatal care and maternal health education, use of clean delivery kits, facility births, immediate newborn care, identification of danger signs, and promotion of care seeking	1. NMR reduced by 15% in intervention clusters compared with control groups (RR = 0.85; 95% CI = 0.76, 0.96) 2. Early NMR reduced by 14% in intervention clusters compared with control groups (RR = 0.86; 95% CI = 0.75, 0.98) 3. Stillbirths reduced by 21% in intervention clusters compared with control clusters (RR = 0.79; 95% CI = 0.68, 0.92)

(continued)

Table 3. (continued)

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
		• Teamwork: LHWs were encouraged to work with TBAs as a team. CHCs were also formed to work with LHWs to promote maternal and newborn care		
• Reference: Bhandari et al[36] • Objective: to evaluate the Indian Integrated Management of Neonatal and Childhood Illness (IMNCI) program, which integrates improved treatment of illness for children with home visits for newborn care, to inform its scale-up • Setting: Haryana, India • Study design: cluster RCT	CHWs (*anganwadi* workers and accredited social health activists), auxiliary nurse midwives, and physicians	• Training: CHWs (*anganwadi* workers and accredited social health activists) and auxiliary nurse midwives received 8 days of IMNCI training and physicians from the government health system received 11 days of IMNCI training. Private health care providers and TBAs received 6 hours and 4 hours of orientation training, respectively. • Supervision: supervisors, trained in IMNCI and supervision skills, supervised CHWs and nurses • Teamwork: *anganwadi* workers and accredited social health activists, auxiliary nurse midwives, and physicians worked together	1. Improved skills to promote newborn care practices ○ CHWs were trained to conduct postnatal home visits and women's group meetings 2. Improved case management skills ○ physicians, nurses, and CHWs were trained to treat or refer sick newborns and children 3. Strengthened health system to implement IMNCI ○ supply of drugs and supervision were strengthened	1. NMR was lower in the intervention clusters than in control clusters (HR = 0.91; 95% CI = 0.80, 1.03) 2. NMR beyond the first 24 hours of birth was significantly lower in the intervention clusters than in control clusters (HR = 0.86; 95% CI = 0.79, 0.95) 3. The perinatal mortality rate was significantly lower in the intervention clusters (HR = 0.89; 95% CI = 0.78, 1.00); the effect of the intervention was seen only for home births 4. A significant interaction found between the place of birth and the effect of the intervention for all mortality outcomes except post-NMR
• Reference: Carlo et al[40] • Objective: to evaluate the community-based interventions design to reduce the number of neonatal/perinatal deaths • Setting: rural communities in 6 countries (Argentina, Democratic Republic of Congo, Guatemala, India, Pakistan, and Zambia) • Study design: before-and-after design (WHO ENC Course) • Cluster RCT (Neonatal Resuscitation Programme [NRP])	Birth attendants (TBAs, nurses, midwives, and physicians)	• Training • ENC course ○ Used a train-the-trainer model, in which experienced trainers first trained master trainers, who then trained community coordinators (physicians or nurses). Next, the community coordinators trained the birth attendants before the baseline period. After the baseline period, an experienced WHO trainer taught master trainers on ENC. The master trainers then taught the community coordinators, who finally trained the birth attendants. ○ Birth attendants received a 3-day training on the differentiation between still birth and early neonatal death, clinical assessments like APGAR scores, adult education before the baseline period, and a 3-day training on ENC after the baseline data collection	• WHO ENC promotion (focuses on routine neonatal care, resuscitation, thermoregulation, breastfeeding, skin-to-skin care, care of the small baby, and common illnesses) • Modified version of the American Academy of Paediatrics NRP (except in Argentina)	1. ENC course ○ No significant reduction in 7-day NMR compared with the baseline period for all causes (RR = 0.99; 95% CI = 0.81, 1.22) or perinatal death ○ Significant reduction in the rate of stillbirth (RR = 0.69; 95% CI = 0.54, 0.88) 2. NRP ○ Compared with control clusters, no reduction in 7-day NMR, perinatal death and stillbirth

(continued)

Table 3. (continued)

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
		• NRP ○ An experienced trainer trained the birth attendants, and they received 3 days of in-depth hands-on training on the modified version of the American Academy of Paediatrics NRP. A refresher course was conducted 6 months later • Supervision: Not discussed • Teamwork: Not discussed		
• Reference: Kumar et al[14] • Objective: to develop an intervention of behavior change management, with a focus on prevention of hypothermia, aimed at modifying practices and reducing neonatal mortality • Setting: Uttar Pradesh, India • Study design: cluster RCT	CHWs (*saksham sahayaks*), newborn stakeholders (traditional newborn care providers and birth attendants, unqualified medical practitioners, and health system workers), and community volunteers (*saksham karta*)	• Training: CHWs, who had at least 12 years of schooling, received both classroom-based and apprenticeship-based field training over 7 days on knowledge, attitudes, and practices related to ENC. Suitable CHWs were closely mentored by regional program supervisors for an additional week before the final selection • Supervision: regional programme supervisors, responsible for 6-7 CHWs, supervised their team through daily meetings. Moreover, performances of CHWs were assessed and monitored by supervisors through spot checks during home visits. Besides these, all regional teams met on monthly program meetings to share their experiences • Teamwork: newborn-care stakeholders and community volunteers enhanced and supported the activities of the CHWs. Newborn-care stakeholders within the community had access to newborn babies during the first 4-9 days after delivery for working with families to ensure adherence to the intervention. Community volunteers played a role in program advocacy and supported families with knowledge, skills, and resources. CHWs met with newborn-care stakeholders and community volunteers to discuss experiences and strategies on separate monthly meetings	Intervention group 1: received preventive package of interventions for ENC, through 2 antenatal and 2 postnatal home visits, which included • birth preparedness • clean delivery • cord care and skin care • thermal care (STS) • breastfeeding promotion • danger sign recognition • careseeking from trained provider Intervention group 2: received an ENC package similar to the group 1 but additionally used a liquid crystal hypothermia indicator (ThermoSpot)	Compared with controls, 1. NMR was reduced by 54% in the group with ENC intervention only (RR = 0.46; 95% CI = 0.35, 0.60) 2. NMR was reduced by 52% in the ENC plus ThermoSpot intervention group (RR = 0.48; 95% CI = 0.35, 0.66) 3. Perinatal deaths were reduced by 41% in the group with ENC intervention only (RR = 0.59; 95% CI = 0.47, 0.74) 4. Perinatal deaths were reduced by 38% in the ENC plus ThermoSpot intervention group (RR = 0.62; 95% CI = 0.47, 0.81)

(continued)

Table 3. (continued)

Reference, Objective, Setting, and Study Design	Types of Health Worker	Workforce Interventions	Postnatal Interventions	Findings
Formal health workers • Reference: Carlo et al[37] • Objective: to examine the effectiveness of 2 training programs on the incremental reduction of 7-day NMRs for low-risk institutional deliveries • Setting: community health clinics in Zambia (Lusaka and Ndola) • Study design: the active baseline design (an improvement over the before-after controlled study design)	Midwives who performed deliveries in low-risk, first-level, urban, community health clinics	• Training • ENC course ○ Used a train-the-trainer model, in which experienced researchers first trained midwives to become research nurses, who then trained practicing midwives (with a 3-year college degree in midwifery) before the baseline period. A WHO officer and 2 experienced trainers taught research nurses on the ENC course after the baseline data collection. These research nurses then trained all practicing midwives. ○ Research nurses received 5 days of training on research concepts, differentiation between still birth and early neonatal death, clinical assessments, and APGAR scores before the baseline period and 5 days of training on the ENC course after baseline data collection. Research nurses then trained practicing midwives (3 years' college degree in midwifery) • NRP ○ After ENC training data collection, an experienced instructor trained the research nurses on NRP, and subsequently, they trained all midwives ○ Research nurses received 5 days in-depth hands-on training on NRP, and then, they trained practicing midwives • Supervision: not discussed	• WHO ENC course (universal precautions and cleanliness, routine neonatal care, resuscitation, thermoregulation, breastfeeding, kangaroo care, care of small infants, and common illnesses) • American Academy of Paediatrics NRP (in-depth basic resuscitation)	1. All-cause, 7-day NMR decreased by 41% after ENC training (RR = 0.59; 95% CI = 0.48, 0.77); decreases in rates of deaths attributable to birth asphyxia and infection 2. The 7-day NMR was decreased further after NRP training, after correction for loss to follow-up monitoring

Abbreviations: ENC, essential newborn care; LBW, low birth weight; NMR, neonatal mortality rate; PMR, perinatal mortality rate; RCT, randomized controlled trial; RR, risk ratio; WHO, World Health Organization.

meetings and provided refresher training to government health workers. Intensive supervision was provided to health workers in all these studies, which involved the provision of feedback and the evaluation of quality work performance.

Teams of Lay and Formal Health Workers. Five studies[13,14,34,36,40] investigated the contribution of team work by lay and formal health workers in reducing neonatal mortality. Baqui et al[34] investigated services of MCH promotion (*anganwadi*) workers, auxiliary nurse-midwives, and community volunteers, of which the first 2 were government-sponsored functionaries. All 3 groups in the intervention area that conducted home visits received 6 days of training on maternal and newborn care.

Bhandari et al[36] delivered the intervention through both home visits and the health center, and employed CHWs, auxiliary nurse midwives, and government physicians; the former 2 groups received 8 days of training, whereas the latter group received 11 days of training. Private health care providers and TBAs received 6 hours and 4 hours of orientation training, respectively. Supervisors with training on the program and supervision skills supervised CHWs and nurse midwives.[36]

The study by Bhutta et al[13] employed a team of LHWs, TBAs/*dais*, and CHCs and delivered intervention through home visits. Regular LHWs, who had at least 8 years of schooling, received training on preventive newborn care for a period of 15 months, including a 3-month didactic training and monthly refresher sessions. The LHWs in the intervention area received an extra 6 days of training on maternal and newborn care. The LHW training was supervised by regular LHW program supervisors and trainers. Community mobilizers from a local university helped LHWs identify community volunteers, who were encouraged to form CHCs to assist the LHWs.[13]

Birth attendants who made home visits in Carlo et al[40] (TBAs, nurses, midwives, and physicians) received 3 days of training before the baseline period and 3 days of ENC training after the baseline period. In the other part of the study, birth attendants additionally received 3 days of training on a modified version of the American Academy of Paediatrics Neonatal Resuscitation Program.[40]

Kumar et al[14] employed CHWs, newborn stakeholders, and community volunteers. CHWs, who had at least 12 years of schooling, were trained using 7 days of classroom and apprenticeship-based field exercises on ENC. In addition to daily and monthly program meetings, the performances of CHWs were assessed and monitored by supervisors through spot checks during their home visits.[14]

Formal Health Workers. The study by Carlo et al[37] used a train-the-trainer model, in which research nurses received a 5-day training before the baseline period and a 5-day training on ENC after the baseline period; they then trained the practicing midwives with 3 years of college degree in midwifery and worked in the community health clinic. After the completion of the ENC training, research nurses again received 5 days of training on the neonatal resuscitation program and subsequently trained the practicing midwives.

Neonatal Health Outcomes

Individual Lay Health Workers. Gill et al[38] reported that trained TBAs, in comparison with existing services, contributed to a 45% reduction in NMR with maximum reductions occurring for the first 24 hours after birth. On the other hand, trained CBSVs in Kirkwood et al[39] contributed to reducing NMR by only 8%, compared with usual services.

Teams of Lay Health Workers. Bang et al[11] observed that VHWs played a significant role in the reduction of NMR by 70%, including early NMR (64%) and PMR (56%), compared with the usual care provided in the local health system. Furthermore, Bang et al[32] reported the contribution

of VHWs in the reduction of neonatal morbidities through the delivery of intervention. The mean number of morbidities was found to decrease over the years (49.6%) alongside an increase in the delivery of multiple interventions, indicating a dose-response relationship.

Baqui et al[12] observed a 34% reduction in NMR for the CHWs who worked through home visits but did not observe any contribution of community mobilizers. In a nested study from the same trial, Baqui et al[33] found that case fatality rates were lower for CHW-treated cases (4.4%) compared with that for qualified medical providers (14.2%) and unqualified providers/no treatment (28.5%). Darmstadt et al[35] found no contribution of CHWs (who worked with TBAs).

Teams of Lay and Formal Health Workers. Interventions in Baqui et al[34] contributed to reduce NMR by 34% for the women who received at least 1 postnatal visit within 28 days compared with the women who received no visit. In contrast, interventions in Carlo et al[40] did not affect either the 7-day NMR or perinatal death. The study by Bhandari et al[36] concluded that the intervention significantly reduced neonatal deaths beyond the first 24 hours after birth by 14%. Interventions in Bhutta et al[13] resulted in a significant reduction in NMR (15%), including early NMR (14%). The ENC intervention in Kumar et al[14] significantly reduced both neonatal deaths (54%) and perinatal deaths (41%). The study also observed a significant reduction in NMR (52%) for the ENC plus ThermoSpot group.

Formal Health Workers. ENC-trained midwives contributed to reducing the 7-day NMR by 41%, compared with the regular-trained midwives.[37] Midwives trained on the neonatal resuscitation program also contributed to reducing NMR.

Cost-effectiveness

Individual Lay Health Workers. Gill et al[38] did not report cost-effectiveness of the program but referred to Sabin et al,[44] which estimated the cost of avoiding each neonatal death as $1866, $591, and $3024 for the base, optimistic, and conservative scenarios, respectively. It should be noted that Kirkwood et al[39] did not report any cost-effectiveness analysis.

Teams of Lay Health Workers. An article not included in this review revealed that the cost of intervention package delivered by VHWs in Bang et al[11] was US$5.30 per averted newborn death.[45] Estimated cost of the home-care intervention delivered by CHWs in Baqui et al[12] was US$2995 (including health systems strengthening costs) per averted neonatal death. Note that Darmstadt et al[35] did not report any cost of averting neonatal deaths.

Teams of Lay and Formal Health Workers. No study in this group included a cost-effectiveness analyses.

Formal Health Workers. The intervention costs of the study by Carlo et al[37] were $208 per life saved.[46]

Discussion

Our systematic review revealed a range of workforce interventions to improve health workers' performance in delivering postnatal care to neonates. Key findings in this review demonstrated the differences among the studies with regard to workforce interventions and associated neonatal outcomes (Table 4). For example, the duration of the training programs ranged from 6 days to 6 weeks, dispersed over a maximum period of 12 months. Differences in approaches to training, supervision, and assessment as well as in the components of postnatal interventions also observed resulted in the

Table 4. Key Findings of Studies From This Review.

		Workforce Intervention			Postnatal Intervention					NMR Reduction
Reference	Types of Health Workers	Training	Supervision	Team Work	A[a]	B[a]	C[a]	D[a]	E[a]	Percentage
Gill et al[38]	TBAs	✓				✓				45
Kirkwood et al[39]	CBSVs	✓	✓		✓					8
Bang et al[11]	VHWs and TBAs	✓	✓	✓	✓					70
Bang et al[32]	VHWs and TBAs	✓	✓	✓	✓					50[b]
Baqui et al[12]	CHWs, community mobilizers, and volunteers	✓	✓	✓	✓					34
Baqui et al[33]	CHWs and community mobilizers	✓	✓	✓	✓					4[c]
Darmstadt et al[35]	CHWs and TBAs	✓	✓		✓					13
Baqui et al[34]	Auxiliary nurse-midwives, *anganwadi* workers, and volunteers	✓		✓	✓					34[d]
Bhutta et al[13]	LHWs, TBAs/*dais*, and CHCs	✓	✓	✓	✓					15
Bhandari et al[36]	CHWs, auxiliary nurse midwives, and physicians	✓	✓	✓				✓		9
Carlo et al[40]	Birth attendants	✓					✓			1
Kumar et al[14]	CHWs, newborn stakeholders, and community volunteers	✓	✓	✓					✓	Group1: 54; group 2: 52
Carlo et al[37]	Midwives	✓					✓			41

Abbreviations: CBSV, community-based surveillance volunteers; CHC, community health committee; CHW, community health worker; LHW, lady health worker; TBA, traditional birth attendants; VHW, village health worker.
[a]A: promoted a variety of ENC practices and referred newborn babies to health centers, if assessed danger sign; B: promoted a modified version of neonatal resuscitation protocol and provided antibiotics with referral to health centers, if needed; C: promoted WHO ENC practices and a modified version of the American Academy of Paediatrics Neonatal Resuscitation Protocol; D: promoted newborn care practices, improved case management skills, and strengthened health system; E: intervention group 1, promoted ENC practices; intervention group 2, promoted ENC plus ThermoSpot intervention.
[b]Morbidity reduction.
[c]Case fatality rate—treated by CHWs.
[d]Within the group of women who received a postnatal visit within 28 days of delivery.

heterogeneity in findings across studies. Four studies did not find any significant impact, whereas others observed a significant reduction in NMR, with the rates varying from 8% to 70%.

This review has investigated issues related to workforce intervention for different health cadres in LMICs, which may have contributed to improved neonatal health. Such issues include training, supervisory mechanisms, competency assessment, appropriate skill, and workforce challenges. Below, in connection to the studies under review, we categorize these issues as workgroup specific and general, and discuss each separately.

Workgroup-Specific Issues of Health Intervention

Individual Lay Health Workers. Gill et al[38] employed a single-component intervention (training only), with competency assessment of TBAs and observed a significant reduction in NMR. In contrast, Kirkwood et al[39] employed a multifaceted intervention (training and supervision) without competency assessment and did not observe any significant reduction in NMR. It indicates that, while individual lay health workers might play a role in the reduction of neonatal mortality, a better outcome might require competency assessment of the workforce. Nevertheless, the functions of the lay health workers and the delivered interventions were different between these 2 studies. Therefore, studies with more comparable interventions are essential to conclude about their effect on neonatal health.

Teams of Lay Health Workers. All 5 articles in this group were supported by multifaceted workforce interventions, but only Darmstadt et al[35] considered the assessment of health worker competencies and used standardized guideline–based supervisory monitoring. However, the study found no impact of intervention, which could be a result of a skill mismatch, where CHWs received training in the management of neonatal sepsis, whereas around 60% of deaths in the intervention area were attributed to birth asphyxia and prematurity. In contrast, Baqui et al[12] found a significant reduction on NMR using a package of similar interventions. All other articles also observed a significant improvement in neonatal morbidity and mortality. Thus, the evidence supports the hypothesis that teams of lay health workers can contribute to preventing neonatal morbidity and mortality. This may be a result of a shortage in adequately trained formal health workers in LMIC. However, studies identified here need to be examined carefully before designing any workforce intervention.

Teams of Lay and Formal Health Workers. Among the 5 studies in this group, 3 used multifaceted interventions,[13,14,36] whereas 2 included a single-component intervention.[34,40] None of these studies described the assessment of health worker competencies and guidelines for supervisory activities, and only 2 studies observed a significant reduction in the overall NMR.[13,14] A lack of linkages between lay and formal health workers might be responsible for the weak performance of the team. Again, comparable studies are needed to make any conclusive remarks because the team composition and workforce interventions vary across the studies.

Formal Health Workers. Only Carlo et al[37] employed formal health workers and used a single-component workforce intervention. It suggests that training may play a significant role in reducing NMR. Although the finding is consistent with a recent study on midwifery training, more comparable studies are required to conclude about the role of training.[46]

General Issues of Health Workers Intervention

Multifaceted interventions are more effective in improving performance compared with single-component interventions.[19,47] With the exception of 4 studies, all studies included in this review used multifaceted interventions. Supervision is also important to improve health workers' performance.[19,48-50] Quality supervision that involves support, feedback, and monitoring can improve health workers' job satisfaction, motivation, and professional development, which ultimately enhances their performances.[19,49] A majority of the studies in our review emphasized intensive supervision that included feedback and evaluation of work quality. Although guideline and staff participation can improve supervision, only the study by Darmstadt et al[35] mentioned this.[48]

Competency assessment was also an important component of training packages.[47] In our review, only 2 studies[35,38] reported the use of competency assessment of health workers as part of training for CHWs and TBAs. A recent review on training resources for CHWs found that nearly half of the training packages did not include competency assessment.[47] Acquisition of appropriate knowledge and skills required to detect relevant clinical signs may enhance the performance of health workers. A mismatch between clinical skills training and health needs could have occurred in the study by Darmstadt et al,[35] which found no impact of intervention.

Workforce challenges in LMICs such as heavy workloads, night visits, traveling outside the local area, familial opposition, and dissatisfaction with pay might affect the performance of health workers directly and also indirectly through workforce turnover.[51,52] For example, CHWs in Baqui et al[12] only attended 5% of deliveries because of a lack of timely communication, long commuting distances, and a high volume of work. Similar difficulties were also experienced by CHWs in Darmstadt et al.[35]

Limitations

We identified a number of limitations of this review. First, little information was available on how the workforce was managed in some studies included in this review. Some articles do not describe workforce interventions in detail, and information concerning workforce components was sought from related articles that reported on other aspects of the same study. Second, most of the studies did not include an analysis of the cost of the interventions and programs that are required to identify what workforce interventions are cost-effective in delivering postnatal cares. As a result, we focused on neonatal health outcomes to draw conclusions about the effect of interventions. Third, selected studies may suffer from a publication bias because most of the published studies only report positive results. Finally, the results rely on a relatively small number of studies, which makes it difficult to draw definite conclusions.

Conclusions

This review examines a variety of health workforce interventions with a range of health workers trained in delivering postnatal care for improving neonatal health in LMICs. We find that further improvements in the performance of health care providers require more emphasis on workforce intervention components such as competency assessment, acquisition of appropriate skill, quality supervision, and workforce challenge. In our review, teams of lay health workers appear to be more effective in reducing neonatal mortality and morbidity compared with other groups. This indicates that employing lay health workers can be a good way to combat neonatal mortality in a weak health system. However, the heterogeneity and limited number of available studies do not allow definitive conclusions to be drawn regarding the impact of workforce interventions.

This review highlights the importance of training guidelines and points toward the need for developing standard training guidelines for the health workers. We also recommend including cost-benefit analyses in future studies, which are important to evaluate and compare the effectiveness of the interventions. Harmonization of future studies, with uniformity of outcome measures and cost analyses, can be useful in comparing the impact of workforce interventions in reducing the neonatal mortality in LMICs. This would allow data from different sources to be combined and compared to facilitate a better understanding of appropriate intervention measures. A useful point is that most of the studies in this review rely on the Asia-Pacific region, which makes our study more relevant for designing workforce interventions in this area, where a vast number of neonatal mortality occurs.

Appendix A

Table A1. Characteristics of Excluded Studies.

Reference	Reasons for Exclusion
1. Ahmed S, Mitra SN, Chowdhury AM, Camacho LL, Winikoff B, Sloan NL. Community Kangaroo Mother Care: implementation and potential for neonatal survival and health in very low-income settings. *J Perinatol.* 2011;31:361-367	
2. Arifeen SE, Mullany LC, Shah R, et al. The effect of cord cleansing with chlorhexidine on neonatal mortality in rural Bangladesh: a community-based, cluster-randomised trial. *Lancet.* 2012;379: 1022-1028	

(continued)

Table A1. (continued)

Reference	Reasons for Exclusion
3. Jokhio AH, Winter HR, Cheng KK. An intervention involving traditional birth attendants and perinatal and maternal mortality in Pakistan. *N Engl J Med*. 2005;352:2091-2099	Not being an integrated interventions package
4. Lawn JE, Mwansa-Kambafwile J, Horta BL, Barros FC, Cousens S. "Kangaroo mother care" to prevent neonatal deaths due to preterm birth complications. *Int J Epidemiol*. 2010;39:i144-i154	
5. 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	
6. Mullany LC, Katz J, Li YM, et al. Breast-feeding patterns, time to initiation, and mortality risk among newborns in southern Nepal. *J Nutr*. 2008;138:599-603	
7. Rao P, Udani R, Nanavati R. Kangaroo mother care for low birth weight infants: a randomized controlled trial. *Indian Pediatr*. 2008;45:17-23	
8. Sharma D, Gathwala G. Impact of chlorhexidine cleansing of the umbilical cord on cord separation time and neonatal mortality in comparison to dry cord care-a nursery-based randomized controlled trial. *J Matern Fetal Neonatal Med*. 2013:1-4	
9. Soofi S, Cousens S, Imdad A, Bhutto N, Ali N, Bhutta ZA. Topical application of chlorhexidine to neonatal umbilical cords for prevention of omphalitis and neonatal mortality in a rural district of Pakistan: a community-based, cluster-randomised trial. *Lancet*. 2012;379:1029-1036	
10. Tielsch JM, Darmstadt GL, Mullany LC, et al. Impact of newborn skin-cleansing with chlorhexidine on neonatal mortality in southern Nepal: a community-based, cluster-randomized trial. *Pediatrics*. 2007;119:e330-e340	
1. Azad K, Barnett S, Banerjee B, et al. Effect of scaling up women's groups on birth outcomes in three rural districts in Bangladesh: a cluster-randomised controlled trial. *Lancet*. 2010;375:1193-1202	Not associated with the appropriate postnatal intervention
2. Darmstadt GL, Saha SK, Ahmed A, et al. Effect of topical treatment with skin barrier-enhancing emollients on nosocomial infections in preterm infants in Bangladesh: a randomised controlled trial. *Lancet*. 2005;365:1039-1045	
3. Darmstadt GL, Saha SK, Ahmed ANU, et al. Effect of skin barrier therapy on neonatal mortality rates in preterm infants in Bangladesh: a randomized, controlled, clinical trial. *Pediatrics*. 2008;121:522-529	
4. Manandhar DS, Osrin D, Shrestha BP, et al. Effect of a participatory intervention with women's groups on birth outcomes in Nepal: cluster-randomised controlled trial. *Lancet*. 2004;364: 970-979	
1. Baqui A, Arifeen S, Darmstadt G, et al. Differentials in neonatal mortality in two adjacent rural areas of Bangladesh: lessons for neonatal health interventions. *Global Public Health*. 2008;3: 366-382	No stated intervention
2. Darmstadt GL, Hussein MH, Winch PJ, Haws RA, Gipson R, Santosham M. Practices of rural Egyptian birth attendants during the antenatal, intrapartum and early neonatal periods. *J Health Popul Nutr*. 2008;26:36	

(continued)

Table A1. (continued)

Reference	Reasons for Exclusion
1. Baqui AH, Rosecrans AM, Williams EK, et al. NGO facilitation of a government community-based maternal and neonatal health programme in rural India: improvements in equity. *Health Policy Plan*. 2008;23:234-243 2. Bari S, Mannan I, Rahman MA, et al. Trends in use of referral hospital services for care of sick newborns in a community-based intervention in Tangail District, Bangladesh. *J Health Popul Nutr*. 2006;24:519-529 3. Callaghan-Koru JA, Seifu A, Tholandi M, et al. Newborn care practices at home and in health facilities in 4 regions of Ethiopia. *BMC Pediatr*. 2013;13:198 4. Darmstadt G, Kumar V, Yadav R, et al. Introduction of community-based skin-to-skin care in rural Uttar Pradesh, India. *J Perinatol*. 2006;26:597-604 5. Darmstadt GL, El Arifeen S, Choi Y, et al. Household surveillance of severe neonatal illness by community health workers in Mirzapur, Bangladesh: coverage and compliance with referral. *Health Policy Plan*. 2010;25:112-124 6. Darmstadt GL, Saha SK, Choi Y, et al. Population-based incidence and etiology of community-acquired neonatal bacteremia in Mirzapur, Bangladesh: an observational study. *J Infect Dis*. 2009;200:906-915 7. Kumar V, Kumar A, Das V, et al. Community-driven impact of a newborn-focused behavioral intervention on maternal health in Shivgarh, India. *Int J Gynaecol Obstet*. 2012;117:48-55 8. McClure EM, Carlo WA, Wright LL, et al. Evaluation of the educational impact of the WHO Essential Newborn Care course in Zambia. *Acta Paediatr*. 2007;96:1135-1138 9. Mannan I, Rahman SM, Sania A, et al. Can early postpartum home visits by trained community health workers improve breastfeeding of newborns? *J Perinatol*. 2008;28:632-640 10. Nalwadda CK, Waiswa P, Kiguli J, et al. High compliance with newborn community-to-facility referral in Eastern Uganda: an opportunity to improve newborn survival. *PLoS One*. 2013;8:e81610 11. Opiyo N, Were F, Govedi F, Fegan G, Wasunna A, English M. Effect of newborn resuscitation training on health worker practices in Pumwani Hospital, Kenya. *PLoS One*. 2008;3:e1599 12. Syed U, Asiruddin S, Helal MS, Mannan II, Murray J. Immediate and early postnatal care for mothers and newborns in rural Bangladesh. *J Health Popul Nutr*. 2006;24:508	Not satisfying the outcome of interest
Bhutta ZA, Memon ZA, Soofi S, Salat MS, Cousens S, Martines J. Implementing community-based perinatal care: results from a pilot study in rural Pakistan. *Bull World Health Organ*. 2008;86:452-459	Pilot study for which the final study was included in this review
Mullany LC, El Arifeen S, Winch PJ, et al. Impact of 4.0% chlorhexidine cleansing of the umbilical cord on mortality and omphalitis among newborns of Sylhet, Bangladesh: design of a community-based cluster randomized trial. *BMC Pediatr*. 2009;9:67	Study protocol

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3. 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;365:977-988.
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