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RESEARCH

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Inpatient care of small and sick newborns: a multi-country analysis of health system bottlenecks and potential solutions

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Abstract

Background: Preterm birth is the leading cause of child death worldwide. Small and sick newborns require timely, high-quality inpatient care to survive. This includes provision of warmth, feeding support, safe oxygen therapy and effective phototherapy with prevention and treatment of infections. Inpatient care for newborns requires dedicated ward space, staffed by health workers with specialist training and skills. Many of the estimated 2.8 million newborns that die every year do not have access to such specialised care.

Methods: The bottleneck analysis tool was applied in 12 countries in Africa and Asia as part of the *Every Newborn* Action Plan process. Country workshops involved technical experts to complete the survey tool, which is designed to synthesise and grade health system “bottlenecks” (or factors that hinder the scale up) of maternal-newborn intervention packages. For this paper, we used quantitative and qualitative methods to analyse the bottleneck data, and combined these with literature review, to present priority bottlenecks and actions relevant to different health system building blocks for inpatient care of small and sick newborns.

Results: Inpatient care of small and sick newborns is an intervention package highlighted by all country workshop participants as having critical health system challenges. Health system building blocks with the highest graded (significant or major) bottlenecks were health workforce (10 out of 12 countries) and health financing (10 out of 12 countries), followed by community ownership and partnership (9 out of 12 countries). Priority actions based on solution themes for these bottlenecks are discussed.

Conclusions: Whilst major bottlenecks to the scale-up of quality inpatient newborn care are present, effective solutions exist. For all countries included, there is a critical need for a neonatal nursing cadre. Small and sick newborns require increased, sustained funding with specific insurance schemes to cover inpatient care and avoid catastrophic out-of-pocket payments. Core competencies, by level of care, should be defined for monitoring of newborn inpatient care, as with emergency obstetric care. Rather than fatalism that small and sick newborns will die, community interventions need to create demand for accessible, high-quality, family-centred inpatient care, including kangaroo mother care, so that every newborn can survive and thrive.

Background

Severely sick newborns, including those with infections, severe intrapartum insults, severe jaundice or those who are too small to maintain their body temperature or to breathe or to feed actively, will require inpatient care to

survive. This paper forms part of a series on high quality maternal and newborn care and examines bottlenecks and solutions specific to the provision of newborn inpatient care for small and sick babies.

The first 28 days of life is a vulnerable time for newborns, with an estimated 2.8 million babies dying during the first month of life worldwide in 2013 [1]. The main causes of death include direct complications of prematurity (36%), intrapartum events (previously called birth

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asphyxia) (23%), and infections (23%) [2,3]. Nearly three-quarters of all neonatal deaths occur in the first week of life [3]. The highest risk of death or serious morbidity occurs among the 10 million born at term with low birth weight (<2500 g) [4] and the 15 million born pre-term (before 37 completed weeks of gestation) each year [5]. Many lives could be saved, and morbidity prevented, through a combined health systems approach [6] along the continuum of care, with identification of those at high risk and timely provision of quality inpatient and supportive care [7]. Strengthening of existing facility-based systems for the care of vulnerable newborns is the most effective approach for saving newborn lives [8] and is central to achieving the goals of the *Every Newborn* Action Plan (ENAP) [9].

Inpatient care is usually delivered across three levels (Figure 1) and refers to the facility-based care of newborns focused on both treatment and prevention of infection and further complications. Prevention includes protection from hypothermia (ensuring warmth) and hospital acquired infection, as well as the provision of adequate nutrition (often with nasogastric or cup feeding), with the overall goal of establishing exclusive breastfeeding where possible. Treatment, where available, centres on the management of common neonatal conditions including respiratory distress syndrome (RDS), neonatal infections, hyperbilirubinaemia, feeding difficulties [7] and the prevention and treatment of retinopathy of prematurity (ROP) [10]. Advanced treatment for other important conditions, such as necrotising enterocolitis (NEC), patent ductus arteriosus (PDA), correctable congenital anomalies and broncho-pulmonary dysplasia (BPD) may also be undertaken. Basic newborn care (providing cleanliness, warmth and support for breastfeeding) is essential for all babies, including timely resuscitation for up to 10% of babies that may require resuscitation at birth [11] and is covered elsewhere in this series [12]. Inpatient care for small or sick babies includes two cornerstone components: Kangaroo Mother Care (KMC) and sepsis case management, which are also considered elsewhere in this series [13,14]. While in a well-functioning health system all three levels of care will be available (Figure 1), many small babies can be managed without provision of any higher level neonatal intensive care and can be looked after in special care units [7]. Currently, however, over three quarters of babies born in Sub-Saharan Africa and Southern Asia cannot access special care if they were to require it (Figure 2).

High quality inpatient care for sick neonates includes careful monitoring by trained health professionals with a sound understanding of the physiological and psychosocial needs of the small or sick newborn baby and their families. A recent DELPHI exercise estimated that optimal supportive care in a hospital Special Care Baby Unit

(SCBU) could avert 70% of neonatal deaths due to pre-term birth complications, and that 90% could be averted with availability of hospital Neonatal Intensive Care Units (NICUs) [6]. Whilst coverage of these inpatient care packages are near universal in high-income settings, both the coverage and the quality of care available in middle-and low-income settings are highly variable [15]. The provision of high quality nursing and inpatient medical care of small and sick newborns not only saves lives, but could also help to facilitate more rapid discharges from health facilities, leading to better short and long-term morbidity outcomes for these babies, including reduction of BPD and ROP. This need is reflected by the current burden of long term disability in survivors following preterm birth being greatest in middle income countries, particularly where coverage of inpatient neonatal care has expanded without due attention to the quality of care provided [10].

Inadequate care in facilities can be caused by a number of constraints usually related to health worker shortages and poorly equipped facilities, compounded by a lack of specific knowledge and competencies in dealing with small and sick newborns amongst existing clinicians and nursing staff [9,16]. Facility-based neonatal care frequently remains under-prioritised and under-funded in many parts of the world, particularly in low and middle income countries (LMIC). Few standardised indicators exist to measure quality of newborn care in facilities and challenges remain to improve the metrics and core competencies [17]. Inadequacies in supplies and safe use of medicines and equipment (including effective phototherapy and case management for sick neonates) are common problems despite the fact that evidence-based interventions exist that can be delivered in resource-constrained environments [18].

The vision of providing quality care to sick newborns is part of a wider global movement - the United Nations (UN) Secretary General Global Strategy in 2010 [19] called for innovative approaches to provide quality care for mothers and newborns, using coordinated research and the formulation of accountability mechanisms through the Commission on Information and Accountability for Women's and Children's Health (COIA). Published in 2014, *The Lancet Every Newborn Series* (<http://www.thelancet.com/series/everynewborn>) demonstrated the progress that has been made, even in challenged settings, and outlined the urgent steps still needed to improve newborn survival. The Lancet papers proposed a package of integrated quality interventions [16,20] - the Every Mother, Every Newborn (EMEN) initiative - that have been outlined in the Every Newborn Action Plan (ENAP) alongside specific actions and ambitious targets for newborn survival [9]. This paper aims to interrogate country-level data on "bottlenecks" to quality care and to




Tertiary	<h3>Neonatal Intensive Care</h3> <p>For babies including ventilation</p> 	<p>Place</p> <ul style="list-style-type: none"> • A special ward that includes neonatal care facilities • Incubators, resuscitaires • Space for kangaroo mother care* and supporting breastfeeding
	<p>People</p> <ul style="list-style-type: none"> • Nurses with specialised neonatal skills • High nurse-newborn ratio e.g. 1:1 in the UK • At least one doctor with specialised neonatal training 	<p>Equipment and commodities</p> <p>In addition to special care equipment and commodities (see below)</p> <ul style="list-style-type: none"> • Availability of Continuous Positive Airway Pressure, Intermittent Positive Pressure ventilation and monitoring equipment • Surfactant therapy for extremely premature newborns, if appropriate
	<p>Support system</p> <ul style="list-style-type: none"> • 24 hour laboratory support • Transport and safe referral if needed • Space for mother and family to stay close to their baby 	
Secondary	<h3>Special Care</h3> <p>For small & sick newborns</p> 	<p>Place</p> <ul style="list-style-type: none"> • A specific room or specially allocated corner of a warm facility, with specific areas for resuscitation, stabilisation and space for kangaroo mother care* • Incubators/resuscitaires overhead heaters
	<p>People</p> <ul style="list-style-type: none"> • Specialised nursing and midwifery staff • High nurse/midwife to newborn ratio e.g. 1:4 in United Kingdom 	<p>Equipment and commodities</p> <ul style="list-style-type: none"> • Feeding support with nasogastric tubes and Intravenous fluids • Infection prevention and management, including antibiotics • Some access to oxygen provision (with pulse oximetry), and effective phototherapy for jaundice case management
	<p>Support system</p> <ul style="list-style-type: none"> • Space and support for mothers including place to express breast milk 	
Primary	<h3>Basic Care*</h3> <p>For all newborns</p> 	<p>Place</p> <ul style="list-style-type: none"> • Basic facility or home birth with skilled attendance
	<p>People</p> <ul style="list-style-type: none"> • Midwifery and nursing staff 	<p>Equipment and commodities</p> <ul style="list-style-type: none"> • No specialised equipment (apart from bag and mask for resuscitation when required).
	<p>Support system</p> <ul style="list-style-type: none"> • Warmth, cleanliness and breastfeeding support 	

Figure 1 Inpatient care of small and sick babies, showing health system requirements by level of care. Red text signifies tracer indicator for bottleneck tool analysis. *See Vesel et al (2015) Kangaroo mother care, Enweronu-Laryea et al (2015) Basic newborn care and resuscitation, and Simen-Kapeu et al (2015) neonatal sepsis. Neonatal intensive care image source: Getty images/Save the Children. Special care for small and sick newborns image source: Ian Hurley/Save the Children. Basic care for all newborns image source: Jonathan Hyams/Save the Children.

draw out innovative solutions, in order to aid the formulation of country led health plans and strengthen the capacity of health systems to respond to the needs of small and sick newborns.

Objectives of this paper are to:

1. Use a 12-country analysis to explore health system bottlenecks affecting the scale up of inpatient supportive care for small and sick newborns
2. Present the solutions to overcome the most significant bottlenecks including learning from the

12-country analyses, literature review and programme experience

3. To discuss policy and programmatic implications and propose priority actions for programme scale up.

Methods

This study used quantitative and qualitative research methods to collect information, assess health system bottlenecks and identify solutions to scale up of maternal and newborn care interventions in 12 countries:

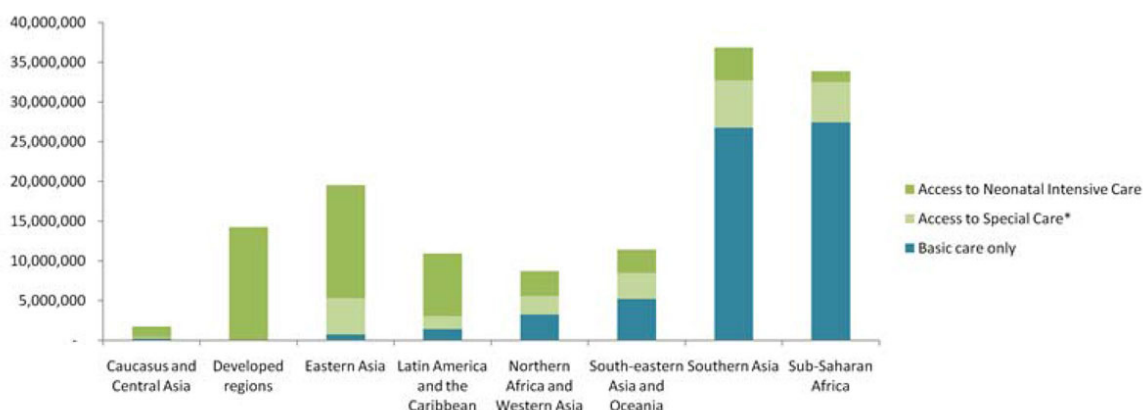


Figure 2 Estimated coverage of neonatal care by region of the world and level of care. *By Special Care Baby Unit, this is the highest level of care available (i.e. no Neonatal Intensive Care). Data source: Adapted from Beyond Newborn Survival: The Global Burden of Disease due to Neonatal Morbidity. Estimates of neonatal morbidities and disabilities at regional and global levels for 2010: introduction, methods overview, and relevant findings from the Global Burden of Disease study. *Pediatric Research*; December 2013, Volume 74, (Supplement 1).

Afghanistan, Cameroon, Democratic Republic of Congo (DRC), Kenya, Malawi, Nigeria, Uganda, Bangladesh, India, Nepal, Pakistan and Vietnam.

Data collection

The maternal-newborn bottleneck analysis tool (additional file 1) was developed to assist countries in the identification of bottlenecks to the scale up and provision of nine maternal and newborn health interventions across the seven health system building blocks as described previously [16,20]. The tool was utilised during a series of national consultations supported by the global *Every Newborn* Steering Group between July 1st and December 31st 2013. The workshops for each country included participants from national ministries of health, UN agencies, the private sector, non-governmental organisations (NGOs), professional bodies, academia, bilateral agencies and other stakeholders. For each workshop, a facilitator oriented on the tool coordinated the process and guided groups to reach consensus on the specific bottlenecks for each health system building block. This paper, seventh in the series, focuses on the provision of inpatient care of small and sick newborns.

Tracer interventions were defined for each package to focus the workshop discussion. For the purpose of this bottleneck analysis, three interventions required for the treatment of common neonatal conditions were included as tracer items for the package of inpatient care: safe oxygen administration, intragastric tube feeding (IGTF) and the provision of intravenous (IV) fluids (Figure 3). Oxygen therapy is a mainstay treatment for small and sick babies, with respiratory compromise commonly seen in RDS (following preterm birth, neonatal pneumonia and neonatal sepsis) and respiratory

failure being an important mechanism in most neonatal deaths [3]. Developmental immaturity of the preterm newborn (especially those born before 34 weeks gestation), or severe illness in a more mature neonate, may limit their ability to coordinate sucking and swallowing required for successful exclusive breastfeeding. In these instances, intragastric feeding is a commonly used low-tech intervention to deliver nutrition, using expressed breast milk where possible. In addition, many of the most small and sick newborns will require administration of IV fluids to prevent dehydration as a result of insensible water loss, and to manage the delicate fluid, electrolyte and glucose balance, especially in the first days after birth [21,22].

Safe implementation and monitoring of these interventions can be challenging, especially in low-resource settings. The list of tracers is not exhaustive and other important interventions, notably, effective phototherapy for the treatment of hyperbilirubinaemia (Figure S2, additional file 2), basic newborn care and resuscitation [12], KMC [13] and management of neonatal sepsis [14] are covered by other sections of the bottleneck analysis tool.

Data analysis methods

Data received from each country were analysed and the graded health system building blocks were converted into heat maps (Figures 4 and 5). Bottlenecks for each health system building block were graded using one of the following options: not a bottleneck (=1), minor bottleneck (=2), significant bottleneck (=3), or **very** major bottleneck (=4) (Figure 5). We first present the number of countries from which workshops participants categorised health system bottlenecks as significant or very

Safe oxygen administration

Involves the use of an appropriate delivery mechanism with adequate monitoring to ensure that babies maintain appropriate oxygen levels. Common interfaces used are nasal prongs/cannula, head box, Continuous Positive Airway Pressure (CPAP) or in a small proportion of the most severe cases, mechanical ventilation. All babies require the monitoring of oxygen levels using pulse oximetry to ensure optimum and safe levels of oxygen are delivered to maximise survival and minimise potential damage [54, 55]. There has been substantial debate around the optimal oxygenation levels for sick neonates. Hyperoxia may lead to brain injury and in premature neonates can lead to retinopathy of prematurity (ROP). The highest risk of ROP is in neonates born at <32 weeks, however ROP can occur in sick neonates born at up to 36 weeks gestational age where inadequate attention is given to safe oxygen delivery[62]. Conversely, hypoxemia can lead to brain injury, renal failure, pulmonary hypertension and necrotising enterocolitis (NEC). As targeting lower O₂ saturation levels (85-90%) decreases risk of ROP, but increases the risk of mortality, current recommendation is to target levels 90-95% - especially in very premature infants[63]. Finally, oxygen administration relies on safe mechanisms for storage (including consideration of fire risk) and containers for its delivery (oxygen concentrators or blenders).

Intragastric feeding

Refers to the administration of milk feeds through a small plastic tube[64]. The tube should be passed by a trained individual, usually a nurse, through the nose (naso-gastric) or mouth (oro-gastric) directly into the stomach. For many infants, particularly very small and sick newborns, it will be undesirable to commence enteral feeds at the full volume needed to meet their nutritional needs. The immature gut and renal systems may have limited capacity to tolerate milk feeds and balance electrolytes – particularly sodium. Where full enteral feeding is not tolerated, intravenous fluids or total parenteral nutrition (TPN) may be considered, in settings where these are available.

Safe administration of IV fluids

Intravenous fluids are most commonly administered through venous cannulae inserted by trained medical or nursing staff. They require careful monitoring of the insertion site for signs of infection, as well as meticulous monitoring of fluid intake and output, including serum electrolytes, urine output and daily records of weight [21, 65]. Intravenous fluids should be administered with caution, complemented by enteral milk feeds where feasible. They should be discontinued as soon as possible as they do not provide adequate nutrition and small and sick infants are at high risk of NEC, broncho-pulmonary dysplasia and exacerbation of respiratory or cardiac illness through fluid overload [22, 65].

Figure 3 Definitions of tracer indicators for inpatient care of small and sick newborn bottleneck analysis tool. For more details see the complete bottleneck analysis in the additional file 2.

major, by mortality contexts (Neonatal Mortality Rate (NMR) <30 deaths per 1000 live births and NMR ≥30 deaths per 1000 live births) and region (countries in Africa and countries in Asia) (Figure 4). We then developed a second heat map showing the specific grading of health system bottlenecks for each country (Figure 5).

Context specific solutions to overcome challenges to scaling up inpatient care identified in all countries were categorised into thematic areas and then linked to the specific bottlenecks in the results section (Table 1/ Table S1, additional file 2). We undertook a literature review to identify further case studies and evidence-based solutions for each defined thematic area (Additional file 2). For more detailed analysis of the steps taken to analyse the intervention specific bottlenecks, please refer to the overview paper [20].

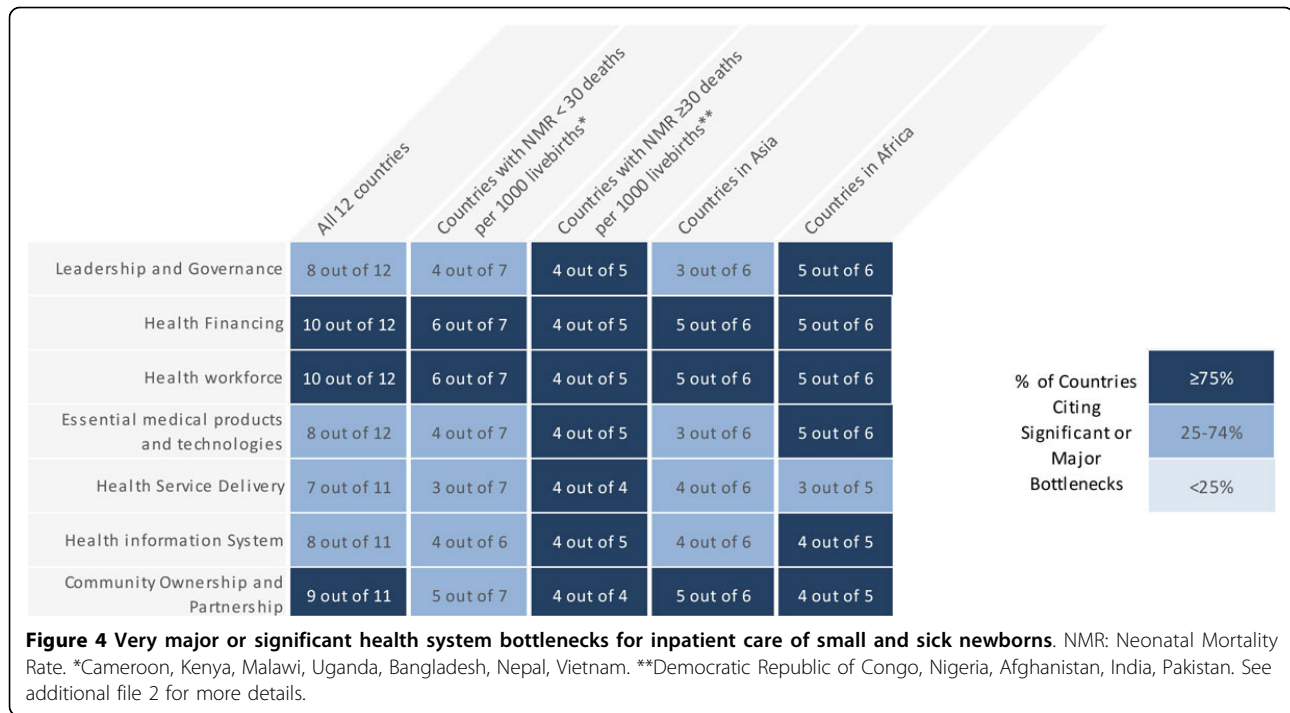
Results

Our analysis identified bottlenecks across seven health system building blocks relating to the inpatient supportive care of small and sick newborns. Twelve countries submitted their responses to the inpatient care of small

and sick newborns bottleneck tool. Afghanistan, Cameroon, Democratic Republic of Congo (DRC), Kenya, Malawi, Nigeria, Uganda, Bangladesh, Nepal and Vietnam returned national level responses. Pakistan provided subnational data from all provinces, Gilgit-Baltistan, Azad Jammu and Kashmir, excluding two tribal territories. India returned subnational data from three states: Andhra Pradesh, Odisha and Rajasthan.

DRC did not provide a grade for health service delivery and community ownership and partnership; and Malawi did not provide a grade for health information systems. In these cases the country was removed from the sample for the quantitative grading of that building block, but included for all other building blocks; their examples of described bottlenecks were still included in the analysis and presented in the results. Afghanistan listed their bottlenecks and completed rating for all building blocks, but did not propose any solutions.

The solution themes are summarised by health system building block in Table 1 (with more details in additional file 2). Care of small and sick newborns is a newborn intervention area highlighted by all country workshop



participants as a major challenge to health systems, especially when considered in comparison with other intervention areas studied in the workshop. Grading according to the number of countries that reported very major or significant health system bottlenecks for inpatient supportive care for small and sick newborns is shown in Figure 4. Overall, the health systems building blocks with the most frequently reported very major or significant bottlenecks were health financing (10 out of 12 countries), health workforce (10 out of 12 countries), followed by community participation (9 out of 11 countries), suggesting these may be priority areas within which to tackle barriers to the scale up of inpatient care for small and sick newborns. As expected, building blocks were rated more poorly in countries with higher NMR. African countries reported a higher number of major and significant bottlenecks, but Afghanistan had the highest level of very major bottlenecks and Malawi had the lowest graded bottlenecks, as shown in Figure 5.

Leadership and governance bottlenecks and solutions

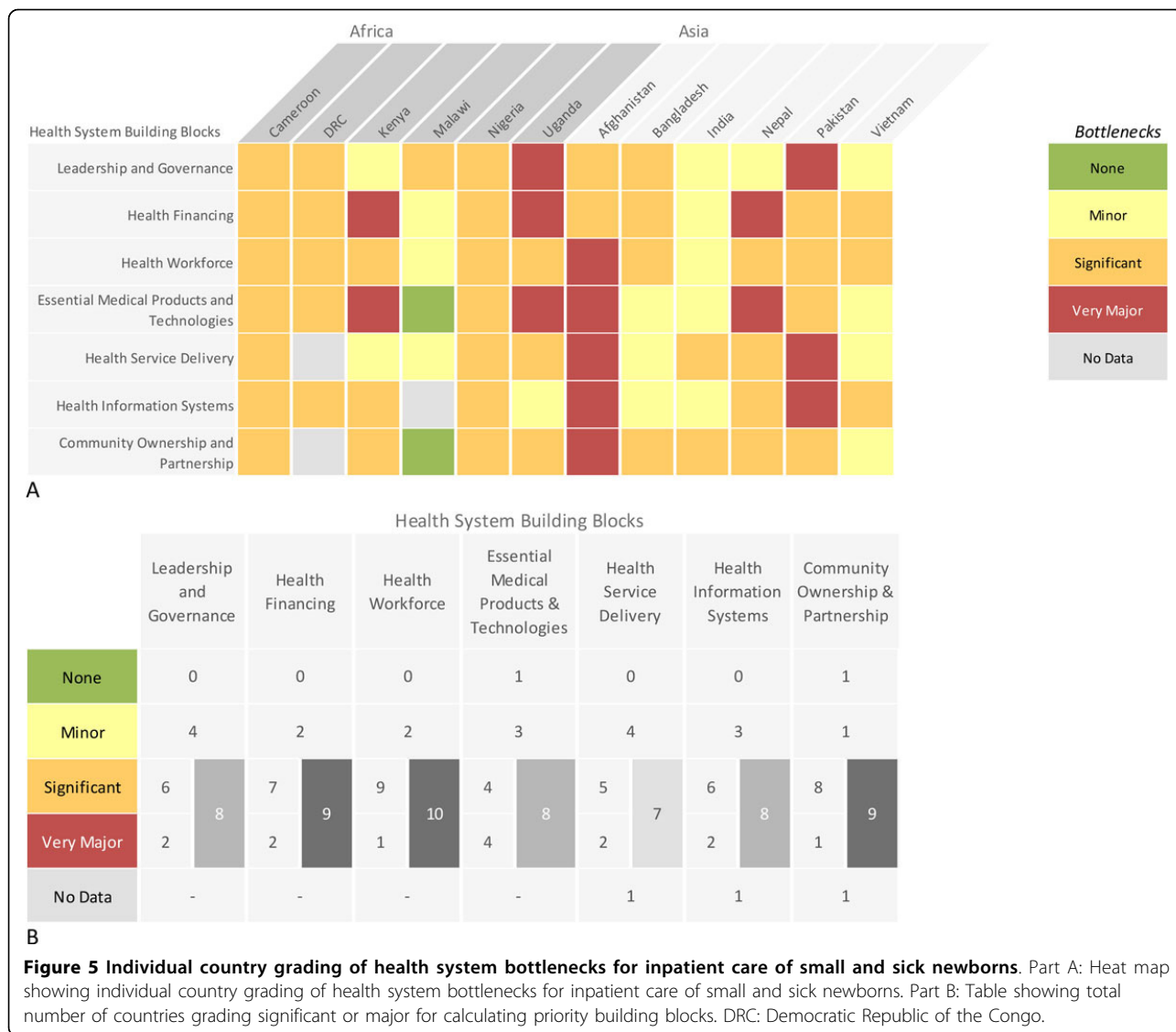
The first building block, leadership and governance, was considered to have very major or significant bottlenecks across 5 of the African countries, and 3 of the Asian countries (Figure 4). Countries in both regions commonly identified a lack of national level advocates (including policy makers, key individuals within professional bodies, academics and national institutions) for advancement of quality care for newborns. At the

governance level, country workshop participants highlighted lack of supportive policies for care of small and sick babies. Specifically, workshop participants noted that their existing policies were not inclusive of the key supportive and organisational policies for newborn care, such as well-defined, rational referral systems, discharge criteria and standardised levels of care at the district and peripheral level. Policy documents in circulation amongst senior officials were not always disseminated to the managers at lower levels of the health service and did not always incorporate guidelines with important components of special care for newborns, such as supportive policies, guidelines for breastfeeding and family centred care (Table 1/ Table S1, additional file 2).

Solutions proposed by country teams centred on the need for targeted advocacy and political will. They focused on improving the organisational and supportive structures for sick newborns at the policy and governance level and building local champions. Country workshop teams proposed reviewing the existing organisational policies and guidelines at a central level and ensuring these were disseminated to all levels of the health system (Table 1/ Table S2, additional file 2).

Health financing bottlenecks and solutions

Health Financing bottlenecks were frequently graded as needing significant work for inpatient care of newborns - 10 out of all 12 country teams (Figure 4) graded it as very major or significant, with only Malawi and India perceiving there to be only minor bottlenecks (Figure 5).



Revenue collection for newborn health, and competing calls for financing of other areas of healthcare, was clearly viewed as a barrier, and insufficient earmarked funds at the facility was impeding their ability to provide quality care to sick newborns. Participants specifically described a lack of designated funding for laboratory support and to purchase supplies such as blood components, antibiotics and other equipment for newborns, such as oxygen cylinders. The most frequently described health financing challenges pertain to prohibitive user-fees and insurance policies that do not cover inpatient care of newborns showing that families are frequently put at risk of severe financial hardship in the event of a baby being born small or sick (Table 1/ Table S1, additional file 2).

Country workshop participants proposed solutions including the need to increase amount of earmarked

funding available for sick newborns and the need to mobilise and advocate for increased funding at the health system level. Participants also proposed more innovative funding mechanisms in order to remove the prohibitive user fees placed on care of sick newborns, either through more comprehensive health insurance, community-based finance or mutual health schemes (Table 1/ Table S2, additional file 2).

Health workforce bottlenecks and solutions

Almost all countries identified the lack of trained personnel in neonatal care in quantity and quality (knowledge, training, skills) and 10 out of 12 graded these bottlenecks as significant (Figure 4), with Afghanistan grading their bottlenecks as very major (Figure 5). Poor supervision and the need for specialist and refresher training in

Table 1. Summary of solution themes and proposed actions for inpatient care for small and sick newborns

Health system building blocks	Solution Themes	Proposed actions
Leadership and Governance	<i>Advocacy and political will Improve organisation structures Review and disseminate guidelines</i>	<ul style="list-style-type: none"> • Active involvement of national advocates (professional bodies, academic, policy makers) for care of sick newborns • Increase number of special care units and spaces in facilities for newborns • Develop national policies and guidelines for referral systems, organisational standards for sick newborn care
Health Financing	<i>Budget allocation Innovative funding and removal of user fees</i>	<ul style="list-style-type: none"> • Increase and sustain funding for sick newborns, earmark funds within facilities caring for newborns • Expand existing maternal health schemes (end-user incentives, insurance schemes, voucher schemes) to cover inpatient care of newborns • Long term vision and health systems approach towards universal coverage for healthcare
Health Workforce	<i>Recruitment and Retention Competency based training Task shifting</i>	<ul style="list-style-type: none"> • Develop neonatal nursing cadre with agreed standards and benchmarks • Strategies to incentivise neonatal health workers • Develop job descriptions, appropriate remuneration and career development pathways for health workers caring for newborns • Scale up of simplified, skilled based training programmes on infection prevention, feeding, provision of warmth and family centred care for newborns • Maximising existing resources, including nurses, lower level health workers and communities
Essential Medical Products and Technologies	<i>Essential medical list Logistic system strengthening and forecasting</i>	<ul style="list-style-type: none"> • Update and implement the essential medical list to include oxygen • Inclusion of neonatal equipment and drugs in logistics systems • Strengthen oxygen systems at national and local level
Health Service Delivery	<i>Increase service delivery and rationalise service distribution Quality improvement and assurance Improve working conditions</i>	<ul style="list-style-type: none"> • Special care baby units (or dedicated area) in every district hospital • Decentralisation of inpatient neonatal care, stable babies cared for in KMC units • Develop and harmonise quality assurance tools and carry out quality assessment of neonatal units • Provide supportive supervision and mentoring • Improve remuneration and incentives (see also, health workforce), working hours, food provision and facilities to stay
Health Information System	<i>Strengthening and integration of HMIS Development of indicator definitions, reporting systems, tools and Scale up audits and registers</i>	<ul style="list-style-type: none"> • Integrate newborn indicators into national health information systems • Define and harmonise newborn indicators, especially care of sick newborns • Regular mortality audits in all special care and neonatal intensive care units.
Community Ownership and Participation	<i>Accessibility of information and community awareness Improve care seeking and linkages Male involvement</i>	<ul style="list-style-type: none"> • Sensitisation on importance of newborn inpatient care and entitlements to care • Use of community volunteers, local champions and leaders • Develop local transportation solutions for families, improve patient experience in facilities and develop family-centred guidelines • Male role models in the community, inclusive policies and frameworks in facilities • Education on maternal and newborn health targeted at men

neonatal skills were overarching challenges. Countries described difficulties recruiting specialist staff to work in remote areas and staffing disparities between urban and rural areas; 8 countries specified that problems in the health workforce stemmed from the lack of competency-based training and refresher training for the health workforce managing small babies, especially at the lower levels of the health system. Regarding task shifting, some countries noted that often only physicians are authorised to carry out tasks that could be performed by lower level health workers, such as prescribing oxygen or antibiotics. Other countries indicated that job descriptions were not clear in roles and responsibilities for those providing care to sick newborns, which is particularly relevant for neonatal nurses. Country workshop participants underlined that the motivation for neonatal nurses and other

professionals to provide high quality care to sick babies was low (Table 1/ Table S1, additional file 2) and that incentives and remuneration were insufficient, leading to poor health worker attitudes, ineffective communication and poor compliance with infection control procedures.

Participants recognised that to remove health workforce bottlenecks, detailed health worker mapping of those caring for sick newborns was needed to identify the resources available and where tasks could be rapidly shifted to make more rational use of the existing workforce. Workshop participants also proposed improving working conditions, motivation and skills through more structured pre-service and in-service training and more appropriate remuneration for neonatal skills, including rewarding those prepared to work in rural areas (Table 1/ Table S2, additional file 2).

Essential medical products and technologies bottlenecks and solutions

The provision of essential medical products and technologies was graded as having very major bottlenecks by a third of all country workshop participants (Figure 4). The Essential Medicine List (EML) was a commonly described bottleneck; participants noted that the EML lacked the commodities required for special care of newborns, such as oxygen and IV fluids and was not implemented at the national level. Many participants described general stock-outs of neonatal equipment, especially cannulas and drugs (specifically antibiotics) and lack of availability of specialist equipment, such as continuous positive airway pressure (CPAP) and portable radiographs. Participants reported that weak and inaccurate information systems underpinned this problem, limiting the ability of facilities to forecast the demand for oxygen, fluids and the maintenance supplies needed for provision of quality inpatient supportive care (Table 1/ Table S1, additional file 2).

Solutions to the essential medical products and technology bottlenecks started with a need to update the EML to reflect the essential commodities needed for sick newborns (oxygen, antibiotic and IV fluids). Following this, workshop participants recognised a need for improving and building logistics management capacity to support the health system to manage inventories and prevent stock-outs (Table 1/ Table S2, additional file 2).

Health service delivery bottlenecks and solutions

Service delivery was described as a challenge in all the countries with higher mortality contexts (Figure 4). Workshop participants described the limited number of facilities available to provide any type of services or inpatient care for sick or low birth weight babies, particularly at lower levels of the system. Poor enabling environments, undersized and outdated buildings, and lack of resource capacity for both delivery of care and provision of family-centred supportive care for babies in the public sector were commonly described. Five countries highlighted the limited space in health facilities for the special care of sick newborns. This included potential space for mothers to stay with their baby or lack of nurseries or side rooms for sick babies. Other country workshop teams described quality improvement as a major challenge due to inadequate monitoring or lack of quality improvement tools, poor mentoring and supervision, and poor implementation of clinical guidance and cot-side care plans for all staff caring for newborns (Table 1/ Table S1, additional file 2).

Country workshop participants recognised that the number of facilities or, at least, dedicated spaces for sick newborns needed to be increased and that service

delivery needed to be rationalised. In alignment with the health workforce bottlenecks, teams suggested that quality assurance tools, quality improvement strategies (including care protocols), and improved mentorship and supervision for those delivering care to newborns could help to improve service delivery (Table 1/ Table S2, additional file 2).

Health information system bottlenecks and solutions

The lack of health information and standardised, well-defined indicators to measure interventions for sick newborns is a central issue being tackled within the ENAP [9]. Most participants from higher mortality contexts graded it as a significant or very major bottleneck to the provision of quality care in facilities (Figure 5). Specific barriers to quality improvement in facilities included the absence of effective mortality audits in facilities, lack of both coverage and process indicators and registers on sick newborns with the existing data were not well managed. In other settings, participants recognised the need for strengthening and integration of newborn facility-based care indicators into their national HMIS (Table 1/ Table S1, additional file 2).

Country workshop participants stated a need for clear definitions for indicators and harmonising these indicators such that national Health Management Information Systems (HMIS) can be strengthened and include select indicators for sick newborns. This would require improved measurement tools, reporting systems and use of appropriate software. Participants highlighted a need for capacity building within health information to support the appropriate disaggregation, dissemination and reporting of sick newborn data. Teams also suggested scaling up regular mortality audits for neonatal units (Table 1/ Table S2 and S3, additional file 2).

Community ownership and partnership bottlenecks and solutions

The community ownership and partnership building block was graded as having significant or very major bottlenecks in three-quarters of countries (Figure 4). Malawi was the only country for which workshop participants graded this building block as having no bottlenecks (Figure 5). Workshop participants specified a wide range of issues largely related to a lack of general information and awareness in communities about sick babies. Limited knowledge of the treatment processes and the severity of newborn illness, including poor awareness of the civil rights of babies born sick or low birth weight to access care, were highlighted. There were a number of access related problems reported, including poor referral and transport systems and inability to access facilities either due to cost or availability. For mothers

in the community, participants described the lack of female decision-making power, loss of wages due to caring for a sick newborn and lack of privacy in facilities (Table 1). Lack of involvement of men was mentioned by six countries partially related to poor awareness and engagement of the wider community on issues related to sick newborns (Table 1/ Table S3, additional file 2).

Solutions for community ownership were wide-ranging, but were themed around improving the accessibility of information for carers and the services for small and sick newborns. Participants suggested a need for greater community awareness of the needs for sick and small newborns in order to improve demand, compliance and patient experience; specifically, encouraging male involvement and increased participation of the community in processes to improve family centred care in facilities (through development of materials, tapping into community groups and developing mutual health type schemes) (Table 1/ Table S2, additional file 2).

Discussion

This paper has presented an analysis and synthesis of bottlenecks and solutions for one of six key intervention packages to reduce neonatal mortality worldwide reviewed in this series of papers; inpatient care for small and sick newborns. Previous analysis of the bottleneck data showed that amongst all intervention packages explored, inpatient care has some of the highest graded bottlenecks hindering scale-up [16], with very major or significant bottlenecks being reported across all health systems building blocks. Whilst inpatient care for the small and sick newborn forms part of the overall care along the continuum from pre-pregnancy to childhood, these findings are timely and this issue is new on the global agenda. Complications from preterm birth are now the leading cause of death in children under five [1]. Previous experience from high income settings has shown that initial provision of low-tech supportive inpatient care and case management, followed by full high-tech neonatal intensive care, has played an important role in reducing overall neonatal mortality [23]; therefore, in order to further reduce the burden of death due to prematurity, strategies to provide comprehensive, high quality inpatient care for small and sick newborns must be developed.

The methodology used in the bottleneck analyses employed a unique consultative and participatory approach to bring together a wide range of partners and players in newborn health. Rather than the top down approach employed by many research initiatives, this data collection and analysis methodology focused on eliciting information from ground-level field implementation, as perceived by stakeholders and experts in 12 countries with the highest burden of neonatal mortality.

This has helped the data to capture context specific challenges and has enabled participants to share their experiences and work together to identify innovative solutions. The grading process encouraged the workshop participants to reach consensus on the perceived challenges and generate a quantitative measure of the perceived bottlenecks to delivering care to this vulnerable sub-population. Rather than reporting on systematic reviews or results from randomised trials, this paper aims to facilitate programmatic learning through the South-to-South exchange. This paper has brought together a wide range of programmatic experience and technical expertise in neonatal care from across the globe to inform programme managers and policy makers in multiple settings facing a range of health system challenges in delivering high quality, facility-based care to small and sick newborns.

Health systems seek to ensure that individuals in need of care receive high quality health services without the risk of financial catastrophe. This analysis identified three priority health systems building blocks with substantial barriers to implementation of facility-based care for small and sick newborns: health workforce and health financing followed by community ownership and partnership. Solution themes, including examples from literature review and programme learning, are discussed in detail below.

Health workforce priority actions

A worldwide nursing shortage exists in both high and low resource settings [24,25]. For small and sick newborns this is not simply a shortage of qualified individuals; there is a critical human resource gap for a neonatal nursing cadre, with almost no neonatal nursing training programmes outside of high income countries (Figure 6). Neonatal nurses are the backbone of newborn inpatient care, as both providers of frontline care to the newborns and their families, but also through extended roles such as the advanced neonatal nurse practitioners (ANNPs) [26,27]. To improve neonatal outcomes, particularly in those countries which account for the highest newborn death and morbidity rates, nurses need to be recruited and offered specialised training in how to care for small and sick newborns, and be provided with ongoing resources to enable them to give consistent high quality care. There are other factors at institutional and country level including inadequate allocation of resources for a health workforce, inadequate workforce planning, poor retention strategies, ineffective use of existing nursing staff, and poor working conditions [16,28].

Skills-based/competency based training

Almost all countries in the workshop highlighted the lack of skills-based training programmes for health

Nurses caring for small and sick newborns are in a unique position to improve their chance of survival and ability to thrive. Despite the vital role for nurses in the care of a sick newborn, neonatal nursing is not an internationally recognised cadre.

What is a neonatal nurse?

The role of a neonatal nurse includes the provision of care for newborn infants born with a variety of problems ranging from prematurity, birth defects, infection, and surgical problems within an individualised, developmentally supportive and family-centred framework (<http://www.nann.org>). However, even across high income countries, there is no agreed definition for neonatal nurses, but it is viewed as a highly skilled nursing speciality that requires years of hand-on experience and is usually attached to specific academic and clinical training schemes.

Health workforce planning. How many neonatal nurses do we need?

Currently, there is a global shortage of neonatal nurses [24]. The survival of premature infants in facilities has been linked to the number of qualified neonatal nurses working per shift [66] and very sick or extremely premature newborns require higher staff to patient ratios than other areas of paediatric care. Intensive care newborns often require one-on-one care and special care babies require a ratio of approximately 1 to 4 [25]. There are a lack of international standards on the number of nurses needed or defined staffing ratios and benchmarks. There are a small number of countries that provide specialised academic and formal training for nurses, most of which are high-income countries. As nurses constitute the largest component of the health care system, it is imperative that planning for neonatal nursing skills is incorporated into wider human resource and health workforce plans. International health workforce market analysis is needed to examine the impact of migration and retention of nursing workforce. Where neonatal nurses are trained, resources should also be directed to motivate retention including valuing their role, recognising ongoing training needs and protect them from rotation out into other sub-specialities [67]. Individual countries can work towards improving quality and efficiency of care by more strategic and intentional delegation at the local and country levels. There is a need to review the efficiency of current workforce support at the local and country levels and review the current delivery of care.

Qualifications

Training in skills specific to the needs of the newborn is required, with corresponding accreditation. Accreditation is important to provide recognition and to promote increased responsibility as well as to assist with staff retention through increased job satisfaction, potentially higher salaries and the prevention of nursing staff rotation, which is common in many low and middle income settings.

The development of special neonatal certificates, training courses and advanced neonatal nurse practitioners (ANNP) has gained traction, especially in high income settings, but not without challenges. For example, ANNPs have been shown to be effective, but some programmes report the sentiment that ANNPs feel they are substituting junior doctors rather than being valued as an alternative approach to high quality service provision for newborns [68], leading to low morale. In low and middle income countries, at the district and community level, education and training of nurses working with newborn infants within community-hospital-community network systems with integration of community healthcare workers, and in some settings, use of volunteers is possible [69]. Other options include organisation or co-ordination of overseas programs involving visits by experienced trained neonatal nurses to low resource settings to provide mentoring, education, and sharing of information with the ultimate goal of building in country capacity.

All institutions can increase the basic quality and speciality of neonatal nursing programmes. These strategies require financial and political support and a shared vision for neonatal nursing and care between professional institutions. Better data capture on neonates in facilities, including follow up data, is urgently needed so that standards of practice and quality of care can be carefully evaluated [68]. Extraction information on the nursing workforce is essential to describe who, where, and how neonatal nurses work (noting that many nurses are not permitted to provide such data without government or institutional approval). Further research is needed to examine neonatal nursing education and distribution of the workforce in relationship to neonatal outcomes. There is a global need to establish an international competency based standards for neonatal nursing supported by appropriate regulatory processes and mechanisms [24] that support this vital cadre to improve neonatal survival and outcomes.

Figure 6 Neonatal nursing as part of national human resource planning. ANNP: Advanced Neonatal Nurse Practitioner.

workers caring for small and sick babies. Qualitative work on the barriers to nurse education for those caring for sick newborns has found that educational programmes focusing on neonatal skills are often inconsistent, poorly structured, or may require long, off-site training courses making them inaccessible for large numbers of lower level hospitals or SCBUs [29]. Survive

and Thrive is a private and public partnership with the American Academy of Pediatrics and has developed educational programmes focused on newborns. Essential Care of the Small Baby (ECSB) [30] is to be released in early 2015 and addresses skills such as nasogastric feeding and prevention of infection and skin-to-skin care through a cooperative learning approach. Learning

techniques used by ECSB are skills-based and focused on small group work, using simulation methodology and role-play to practice technical and communication skills. Knowledge is tested through multiple-choice questions and Observed Structured Clinical Evaluations (OSCEs). Such pre-service and in-service training programmes are available and could be scaled-up within health worker training, even in lower resourced settings, as they do not rely on electricity supplies (being flip-chart based) and make use of low-cost simulation models. Well-designed programmes focused on neonatal clinical skills have been shown to be effective and improve health provider knowledge and practice [31], but will require supervision systems and regular refresher training to sustain and update skills [32].

Task shifting

The World Health Organization (WHO)'s recommendations on optimising the roles of health workers aim to address critical health workforce shortages that slow progress towards the health-related Millennium Development Goals [33]. A more rational distribution of tasks and responsibilities among cadres of health workers can significantly improve both access and cost-effectiveness - for example, by training and enabling 'mid-level' and 'lay' health workers to perform specific interventions otherwise provided only by cadres with longer (and sometimes more specialised) training. These recommendations are intended for health policy-makers, managers and other stakeholders at a regional, national and international level. WHO hopes that countries will adapt and implement them to meet local needs. The recommendations were developed through a formal, structured process including a thorough review of available evidence. Specific examples that have been taken up include nursing auxiliaries or health care assistants supporting and maintaining KMC [33]. In Malawi, ward attendants have been involved in supporting KMC [34] and health surveillance assistants have been trained to promote facility-based care for sick newborns [35]. ECSB training incorporates task shifting to mothers, when appropriate, for basic skills such as nasogastric feeding and providing basic care to a small baby looked after in a facility [30].

Recruitment and retention

Once health workers have the skills needed to care for small and sick babies, recruitment and retention strategies are needed to supervise and motivate, which is especially important for rural and hard to reach postings. Innovative recruitment and retention strategies have been implemented with success in some settings. Thailand has historically used a bonding system to improve recruitment of health workers for rural areas. Newly qualified health professionals, including doctors and cadres of nurses are required to spend a mandatory time period in rural postings. On completion, professional qualifications can be

upgraded. Evidence suggests this has led to a substantial increase in the numbers of trained professionals in rural areas and is partially responsible for the impressive health gains in Thailand in the last 25 years [36,37].

In addition to task shifting there are other immediate, interim strategies that can be put in place. These could include improving conditions for the workforce through incentives [38] (financial, educational or other), relieving staff of other duties, improving daily working conditions (break areas, food vouchers, accommodation on-site or nearby) [39] and improving job satisfaction through structured supervision and mentoring efforts [32]. Non-rotation of staff out of neonatal care is an important strategy to prevent neonatal staff being shifted annually within the hospital from department to department or into other specialties (Figure 6).

Health financing priority actions

Budget allocation

Whilst the health financing issues faced by many low-income countries are due to the lack of financial resources for health and development overall, and are not unique to the newborn [40], those newborns requiring inpatient care are at greater risk due to their need for specialised facility-based care. Newborns are relatively neglected in official development assistance [41] and specialised, intensive care is often perceived as prohibitively expensive. A strong economic case, including the relative burden of newborn mortality globally, and the argument for prevention of long-term morbidities, is required to advocate for the earmarking of funds specifically for developing and sustaining high quality inpatient newborn care. The issue of health financing is explored in greater detail in paper 1 of this series [20].

Innovative funding and removal of user fees

The birth of a small or a sick baby can be financially catastrophic for families. Shifting from a reliance on out-of-pocket payment to prepayment and risk pooling is a critical part of the health financing transition that most countries go through as they get richer [42]. Limited risk pooling means that insurance and depth of coverage is a common problem for families. Removal of user fees in the public sector is a first step, but has associated risks and challenges and must be replaced by alternative health financing mechanisms that could include: social health insurance, community based health insurance and government supply side financing [43]. The success of these schemes is dependent on the context within the countries where they are implemented. Rwanda's community financing scheme is backed by compulsory government payments into the scheme and stringent pooling of donor funds [44]. Provision of coverage for inpatient newborn care within insurance schemes or voucher and incentive systems is a neglected

area, with often only delivery and basic newborn care being covered. Attention to successful schemes that already exist in countries could partially ameliorate the risk of financing catastrophe for families when a baby is born small or sick, rather than introducing new schemes for sick newborns that may further fragment health financing systems. Sick newborn care is frequently not covered by maternity packages or maternal health financing schemes (e.g. Nepal vouchers scheme), yet has potentially large expenses associated with it. Schemes using prospective case-based systems for inpatient care - as in Kyrgyzstan [36] could be adapted to give higher priority to newborn inpatient and special care. Further implementation research is needed for innovative funding mechanisms to identify factors that may facilitate their success and provide recommendations for their implementation in different settings.

Community ownership and partnership priority actions

Whilst reported bottlenecks to high quality inpatient newborn care are similar across regions, individual communities differ in their geographical and socio-cultural structures and available resources. Enabling maximum effect through tailor-made solutions for a given community will require empowering solutions from a grassroots level.

Community awareness

Lack of demand for quality newborn inpatient care may reflect the fatalistic assumption that all small and sick babies will die [27]. Across settings, country teams highlighted the lack of awareness in communities about sick newborns, the treatment processes and their civil rights to access health services. Most country teams reported a lack of awareness of the severity of newborn illness and knowledge that timely, high quality care can save newborn lives. In some contexts, such as India, there are specific care-seeking barriers for newborn girls. The workshops participants' perceptions strongly suggest there is a lack of strategic, targeted health education on newborn health across settings and that sensitisation and local community education efforts are needed to reduce fatalism and increase care-seeking and demand. Mobilisation of communities using women's community groups has been shown to have a positive effect on a range of maternal and newborn health outcomes, including the potential to reduce neonatal mortality in a number of settings [45-47]. There is a clear role for community volunteers, local role models and community leaders to raise awareness on issues surrounding newborn health and the care of sick newborns.

Improve care seeking and transport linkages

Qualitative study of the local barriers and solutions for care-seeking in child health in Kenya, Nigeria and Niger highlighted important factors on perceived awareness

and the subsequent demand for care [48]. Lack of trust in health services, perceptions that treatment is ineffective and experience of poor quality of care were perceived as important in reducing demand for care. Health services that are out-of-stock, negative experiences with health workers, or poor communication between staff and families, especially mothers, may be detrimental to the care of the newborn. Facilities may need to focus on community strategies to improve the patient experience in facilities, especially for mothers. It is critical for the mother to spend time with the sick newborn wherever possible, therefore, local hospital policy guidelines that encourage family-centred care and take into account the local and cultural family structure are vital for mothers to be able to participate in the care of their newborns. Local transport systems are needed to facilitate access between the community and facility, especially when newborns are in the facility for long periods of time. Within the facility, task shifting to mothers, in addition to the necessary support for breastfeeding and expressing milk, can play an important part in empowering mothers and securing the linkages between the family and inpatient care [49,50].

Male involvement

Half of the countries in the workshop specifically reported that there was a lack of male involvement in the care of sick newborns. Individual, family, community, societal and policy factors are previously identified barriers to male involvement during pregnancy and birth [51]. Qualitative research suggests men often lament their lack of involvement or understanding of maternal and newborn health issues [48] - an area that is often seen as dominated exclusively by females. Empirical research confirms that for pregnancies that are wanted and where men are more educated, men are more likely to be involved in maternity related care [52]. The care of sick newborns is no different and tackling barriers to male involvement is an issue that spans the care continuum from family planning to the care of a sick newborn in a facility. Men often control family finances or have a stronger influence on decision-making. Women may be removed from their usual schedules when their newborn is sick, leading to potential for neglecting other commitments (whether work or household related) and, therefore, may need additional support. Use of male role models in the community may help to facilitate this transition away from maternal and newborn health being viewed as an exclusively female domain. Using lessons learned from Prevention of Mother To Child Transmission (PMTCT) research [53], interventions to increase male involvement in newborn care include addressing hospital policies and staff attitudes in facilities to allow for culturally sensitive, inclusive policies for men and families, such as special

visiting hours and supporting fathers to participate in KMC [13].

Other priority actions

As highlighted in the analysis, very major or significant bottlenecks were reported across all building blocks. Solution themes for three of these building blocks have been discussed in detail above and more details on the country-specific bottlenecks for each health system building block are available in the additional file 2. A few other bottlenecks described were especially relevant to inpatient care. For example, India and Pakistan stressed the shortfall in supply of oxygen due to demand and supply gaps. Improving oxygen systems within health facilities is key to enable widespread availability when required. Oxygen cylinders are still commonly used in many facilities in low and middle-income settings, however they are expensive, require filling up regularly and are difficult to transport. Where power supplies are reliable, oxygen concentrators can provide a consistent and inexpensive source of oxygen. In view of the emerging epidemic of ROP [10], the use of oxygen in any setting should be carefully monitored using pulse oximetry and safe delivery mechanisms to ensure optimum and safe saturation levels [54,55], as described in Figure 3. The safe and systematic use of oxygen, as with all drugs, needs to involve training and supervision of nurses, doctors, technicians and administrators [56] and appropriate documentation is needed. Commonly prescribed antibiotics for small and sick newborns, such as gentamicin, which has potentially adverse effects related to dosage and interval [57] need particular attention to safety, especially where therapeutic drug monitoring is not possible [58]. A number of country teams highlighted newborn inpatient care health information bottlenecks. A recent assessment of facility-based neonatal care in Kenya highlighted how poor data were potentially undermining the quality of practice [59], especially affecting the assessment of gestational age and symptoms of severe illness. At a national level, efforts are needed to strengthen the HMIS and to develop basic indicator definitions for monitoring inpatient care with core competencies and standards for small and sick newborns by levels of care [17]. At the facility level, there is a clear need for improved documentation, registration and incorporating the use of regular mortality audits [60].

Limitations

The data generated from the workshop came from the subjective and consensus views of participating national stakeholders, including government representatives and experts. The quality and amount of information extracted

from these workshops varied depending on the level of knowledge of participants about health system issues and facilitation. In addition, bottlenecks were reported as perceived bottlenecks relative to the other health system building blocks under exploration. There may be instances where known health system challenges or deficits based on robust quantitative data may be in conflict with the perceived bottleneck grading. This may be due to the method of grading relative to other health system building blocks, or that participants place higher subjective value on other areas of their health system. An additional explanation is that groups' may view certain building block areas as easier challenges to overcome based on their knowledge of their setting and expertise in the specific newborn intervention being discussed. The tool is comprehensive and detailed, which is one of its strengths. However, it also may have caused some *workshop fatigue*, particularly towards the end of the workshop where teams discussed and recorded solutions. For example, for the inpatient care questionnaires, Afghanistan completed the bottleneck portion of the questionnaires, but did not submit any solutions. The analysis focused only on three tracer items: safe oxygen, IGTF and the provision of IV fluids. Other specific components of inpatient neonatal care may have different bottlenecks and solutions, for example, identification of and effective phototherapy for neonatal hyperbilirubinaemia [61] (Figure S2, additional file 2).

Future agenda

Improving inpatient newborn care will require a health systems approach and some countries are recognising this need. For example, the securing of political, professional and financial commitment in India has led to substantial increases in provision of quality inpatient newborn care (Figure 7). Previously, particularly in low-income settings, much investment has occurred in delivering public health and community-based interventions to improve newborn outcomes. This has led to important gains in outcomes, especially in settings with the highest neonatal mortality rates. However, as seen historically in high income countries, to reduce neonatal mortality further, attention is first required on improved supportive case management (which for the smallest and sickest newborns will require inpatient care) and then should be followed by the introduction and scale-up of neonatal intensive care [62].

Specific areas for action have been highlighted above, with many of these bottlenecks being critical to address to enable provision of quality inpatient newborn care (Figure 8). Interdisciplinary linkages and a focus on better quality data will help identify areas for improvement so that teams delivering care to small and sick newborns

Rationale

India, with an annual birth cohort of 26 million, accounts for highest number of stillbirths and neonatal deaths in the world. The current neonatal mortality rate (NMR) of India is 28 per 1000 live births, which means 748,000 newborns die each year [1]. The NMR in rural areas (33 per 1000 live births) is twice that in urban areas (16 per 1000 live births) [70]. The Government of India, through the launch of the National Rural Health Mission in 2005, has made significant efforts to promote institutional deliveries by providing conditional cash transfer under Janani Suraksha Yojna (JSY)* and provision of free transport and care for pregnant women to reduce out of pocket expenses under Janani Shishu Suraksha Karyakram (JSSK)**. These efforts contributed to an increase to 73% institutional births in 2009[71]. Despite this progress, suboptimal quality of care during birth alongside a lack of specialised care for small and sick newborns remains a major challenge to newborn survival.

Approach taken

India has focused on strengthening facility-based newborn care through the establishment of special newborn care units (SNCUs) at district level and newborn stabilisation units (NBSUs) at block level. These are linked with home visits and referrals by 0.9 million Accredited Social Health Activist (ASHA) workers focusing on both home deliveries and community follow up of both newborns delivered in hospitals and those discharged from SNCUs. The National Health Mission budget for state and districts has a separate budget line for facility based newborn care with earmarked resources for facility-based care, including operational costs, human resources, drugs and provision for record keeping and data management. To address the access barriers and reduce out of pocket expenses, free health care for pregnant women and infants, including diagnostics, treatment and drugs, has been made an entitlement. In order to attract and retain workforce, states like Madhya Pradesh have successfully used walk-in interviews, performance based incentives, difficult area allowances, enforcement of service bonds and flexibility in place of posting based on individual preference.

Innovations: Education of health care professionals with evidence-based guidelines, using standardised tools, on-site job aids and skill building is a daunting task for such a large and diverse country. WHO Collaborating Centre at All India Institute of Medical Science (AIIMS) has designed smart phones as an innovative point of care tool for management of sick newborns and e-learning as a distance learning strategy for continuing education. To aid the implementation of corrective actions for sick newborns, a real time online data monitoring system has been developed by UNICEF and will be scaled-up nationally to monitor performance of all SNCUs and tracking after discharge till one year. A national cell has been established to support capacity building, monitor data quality and to interpret data for policy and programmatic use.

Looking Beyond survival Rashtriya Bal Suraksha Karyakram (RBSK)*** programme aims at identifying birth defects, disabilities and developmental delays with both community and facility screening, and provision of early intervention clinics at district level.

Results

All these efforts have resulted in operationalisation of 575 SNCUs and 1810 NBSUs, with states like Madhya Pradesh, Rajasthan, Andhra Pradesh, Tamil Nadu and Orissa achieving near universal coverage of SNCUs following prescribed standards at district level. However, there are still issues of inadequate human resources in these states with slower progress in Chattisgarh, Jharkhand, Bihar and Uttar Pradesh. The monitoring system currently has 13 states with 350 SNCUs inputting online data and more than 650,000 newborns are registered in the national database. The current inpatient mortality in existing SNCUs was 10% in 2013-14[72]. Whilst this is not due to health system changes alone, the NMR of India, which had been stagnant at 37 per 1000 from 2004 to 2006, has shown a 17% decline during 2008 to 2012[70].

Future directions

There is a need to accelerate coverage in states where progress is slow, and to focus on quality of care and improving long-term outcomes once scale-up has been achieved. To achieve this, the system needs to reduce the case load in SNCUs by expediting establishment of kangaroo mother care wards for care of stable preterm babies, address high mortality due to respiratory distress by up scaling coverage of antenatal steroids, use of continuous positive airway pressure (CPAP) across all SNCUs and continue to develop innovative approaches and tools for capacity building of the health workforce, including implementation research to evaluate progress. In view of high load of preterm and sick babies with risk factors for ROP, the provision of ROP screening and treatment needs to be implemented. The scale-up of the real-time data system for online monitoring will be completed by mid-2015 for the whole country making it the largest database for small and sick newborns globally. All these issues have been emphasised under the India Newborn Action Plan (INAP)[73], which has set target for a single digit NMR by 2030. This will be achievable only with sustained work towards good coverage of quality interventions for newborns, including those that are small and sick.

Figure 7 India's health systems approach to improving inpatient care for small and sick newborns. *Janani Suraksha Yojna (JSY): a conditional cash transfer to promote institutional delivery); **Janani Shishu Suraksha Karyakram (JSSK): reducing out of pocket expenses by making free health care an entitlement; ***Rashtriya Bal Suraksha Karyakram (RBSK): looks at developmental delays and disabilities, birth defects and deficiencies, covering age group of 0-18 years of age. Other abbreviations: AIIMS: All India Institute of Medical Science; ASHA: Accredited Social Health Activist; CPAP: Continuous Positive Airway Pressure; India Newborn Action Plan (INAP); NMR: Neonatal Mortality Rate; NBSU: Newborn Stabilisation Units; ROP: Retinopathy of Prematurity; SNCU: Special Newborn Care Unit; UNICEF: United Nations International Children's Emergency Fund; WHO: World Health Organization.

Key messages

- Each year, there are an estimated 15 million preterm newborns, many of which do not have access to inpatient care when needed. Inpatient care for small and sick newborns includes the provision of warmth, feeding support, safe oxygen therapy and effective phototherapy, with prevention and treatment of infections. This requires dedicated ward space, staffed by health workers with specialist training and skills.
- Bottlenecks to the scale up of inpatient care are reported across all health system building blocks; countries that graded their bottlenecks most severely were Uganda, Afghanistan, Nepal and Pakistan.
- The health system bottlenecks graded highest by the 12 countries in the analysis were within health workforce and health financing, followed by community ownership and partnership.

Key action points

- Current health workforce effectiveness for inpatient newborn care could be improved through skills-based training for health workers, considering the potential for task shifting. There is a critical human resource gap for a neonatal nurse cadre, with almost no training programmes outside high income countries; this links to the current policy investment for midwives.
- Rather than catastrophic out of pocket payments, addressing health financing bottlenecks for newborn inpatient care requires specific, planned and sustained funding at a national level. Small and sick newborns need appropriate insurance covering their care, similar to the mechanisms for emergency obstetric care.
- Addressing community bottlenecks will require a shift in attitude away from the fatalistic assumption that all small newborns will die, towards increased awareness and demand for quality inpatient care. This should be accessible and family centred, using local resources, involving mothers through kangaroo mother care and long-term follow up for the vulnerable survivors.

Figure 8 Key messages and action points for inpatient care of small and sick newborns.

can plan and implement changes. Ongoing data monitoring helps the team recognise their improvement and identify specific areas to focus on in the future, so that the exercise is an ongoing cycle. The EMEN package [16] will be crucial to this process.

Conclusions

Whilst major bottlenecks to the scale-up of quality inpatient newborn care are present, in many cases, effective solutions exist. Currently, there is a large grass roots commitment to improving care around the time of birth to end preventable maternal and newborn deaths and stillbirths, and to improve healthy outcomes as part of the ENAP [9]. Improving availability and quality of inpatient newborn care has been identified as an important area to achieve the aims of this plan, providing potential for political, professional and financial support to develop and scale-up solutions to these bottlenecks. We must build on this momentum, using knowledge of what works to ensure action, so that every small and sick newborn baby has access to timely, high quality and family-centred inpatient care as required to survive and thrive.

Additional material

Additional file 1: Bottleneck tool questionnaire.

Additional file 2: Supplementary tables, figures and literature search strategy.

List of abbreviations

ANNP: Advanced Neonatal Nurse Practitioner; BPD: Broncho-Pulmonary Dysplasia; COIA: Commission on Information and Accountability; CPAP: Continuous Positive Airway Pressure; DRC: Democratic Republic of Congo; ECSB: Essential Care of the Sick Baby; EMEN: Every Mother, Every Newborn; EML: Essential Medicines List; ENAP: Every Newborn Action Plan; HIC: High income countries; IGTF: Intra Gastric Tube Feeding; IV: Intra-Venous; JSSK: Janani Shishu Suraksha Karyakram; KMC: Kangaroo Mother Care; LBW: Low birth weight; LIC: Low income countries; LMIC: Low and Middle Income Countries; NBSU: Newborn Stabilization Unit; NEC: Necrotising Enterocolitis; NICU: Neonatal Intensive Care Unit; NMR: Neonatal Mortality Rate; NGO: Non-Governmental Organisation; OSCE: Observed Structured Clinical Evaluation; PDA: Patent Ductus Arteriosus; PMTCT: Prevention of Mother to Child Transmission (PMTCT); ROP: Retinopathy of Prematurity; RDS: Respiratory Distress Syndrome; SCBU: Special Care Baby Unit; SNCU: Special Newborn Care Unit; UN: United Nations; UNICEF: United Nations International Children Emergency Fund; WHO: World Health Organization.

Competing interests

The authors have not declared competing interests. The assessment of bottlenecks expressed during consultations reflects the perception of the

technical experts and may not be national policy. The authors alone are responsible for the views expressed in this article and they do not necessarily represent the decisions, policy or views of the organisations listed, including WHO.

Authors' contributions

SGM was responsible for the analysis and writing process with HB and JEL who oversaw the analysis, writing and reviews of the paper drafts. KED along with the ENAP & UNICEF teams, were responsible for the overall coordination of the bottleneck analysis tool development, country consultation process, and reviews of the paper drafts. AS-K was responsible for the tool development and substantial contributions to the data analysis. All named authors contributed sections of text and approved the final manuscript.

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References

1. UN-IGME: **Levels and trends in child mortality: Report 2014**. New York, USA: UN-Interagency group for child mortality estimation; 2014.
2. Lee AC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, et al: **National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010**. *The Lancet Global Health* 2013, **1**(1):e26-e36.
3. Lawn JE, Blencowe H, Oza S, You D, Lee AC, Waiswa P, et al: **Every Newborn: progress, priorities, and potential beyond survival**. *Lancet* 2014, **384**(9938):189-205.
4. Katz J, Lee AC, Kozuki N, Lawn JE, Cousens S, Blencowe H, et al: **Mortality risk in preterm and small-for-gestational-age infants in low-income and middle-income countries: a pooled country analysis**. *Lancet* 2013, **382**(9890):417-25. Epub 2013/06/12.
5. Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller AB, Narwal R, et al: **National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications**. *Lancet* 2012, **379**(9832):2162-72.
6. Bhutta ZA, Das JK, Bahl R, Lawn JE, Salam RA, Paul VK, et al: **Every Newborn: Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost?** *Lancet* 2014, Epub 2014/05/24.
7. Lawn JE, Davidge R, Paul VK, von Xylander S, de Graft Johnson J, Costello A, et al: **Born too soon: care for the preterm baby**. *Reprod Health* 2013, **10**(Suppl 1):S5. Epub 2013/01/01.
8. Lawn JE, Kinney MV, Black RE, Pitt C, Cousens S, Kerber K, et al: **Newborn survival: a multi-country analysis of a decade of change**. *Health policy and planning* 2012, **27**(Suppl 3):iii6-28.
9. WHO, UNICEF: **Every Newborn: An action plan to end preventable newborn deaths** Geneva: World Health Organisation. 2014, [cited September 2014]. Available from: http://www.who.int/maternal_child_adolescent/topics/newborn/every-newborn-action-plan-draft.pdf.
10. Blencowe H, Lawn JE, Vazquez T, Fielder A, Gilbert C: **Preterm-associated visual impairment and estimates of retinopathy of prematurity at regional and global levels for 2010**. *Pediatric research* 2013, **74**(Suppl 1):35-49. Epub 2013/12/25.
11. Wall SN, Lee AC, Niermeyer S, English M, Keenan WJ, Carlo W, et al: **Neonatal resuscitation in low-resource settings: what, who, and how to overcome challenges to scale up?** *Int J Gynaecol Obstet* 2009, **107**(Suppl 1):S47-62, S3-4. Epub 2009/10/10.
12. Enweronu-Laryea Christabel, Dickson EKIM, Moxon GSarah, Simen-Kapeu Aline, Nyange Christabel, Niermeyer Susan, Bégin France, Sobel LHoward, Lee CCAnne, von Xylander Ritter Severin, Lawn EJoy: **Basic newborn care and neonatal resuscitation: a multi-country analysis of health system bottlenecks and potential solutions**. *BMC Pregnancy Childbirth* 2015, **15**(Suppl 2):S4.
13. Vesel Linda, Bergh Anne-Marie, Kerber Kate, Valsangkar Bina, Mazia Goldy, Moxon GSarah, Blencowe Hannah, Darmstadt LGary, de Graft Johnson Joseph, Dickson EKIM, Ruiz Peláez Gabriel Juan, von Xylander Ritter Severin, Lawn EJoy, On behalf of the KMC Research Acceleration Group: **Kangaroo mother care: a multi-country analysis of health system bottlenecks and potential solutions**. *BMC Pregnancy Childbirth* 2015, **15**(Suppl 2):S5.
14. Simen-Kapeu Aline, Seale CAnna, Wall Steve, Nyange Christabel, Qazi AShamim, Moxon GSarah, Young Mark, Liu Grace, Darmstadt LGary, Dickson EKIM, Lawn EJoy: **Management of neonatal infections: a multi-country analysis of health system bottlenecks and potential solutions**. *BMC Pregnancy Childbirth* .
15. Blencowe H, Vos T, Lee AC, Phillips R, Lozano R, Alvarado MR, et al: **Estimates of neonatal morbidities and disabilities at regional and global levels for 2010: introduction, methods overview, and relevant findings from the Global Burden of Disease study**. *Pediatric research* 2013, **74**(Suppl 1):4-16. Epub 2013/12/25.
16. Dickson KE, Simen-Kapeu A, Kinney MV, Huicho L, Vesel L, Lackritz E, et al: **Every Newborn: health-systems bottlenecks and strategies to accelerate scale-up in countries**. *Lancet* 2014, **384**(9941):438-54.
17. Moxon GSarah, Ruysen Harriet, Kerber JKate, Amouzou Agbessi, Fournier Suzanne, Grove John, Moran CALLisyn, Vaz MELara, Blencowe Hannah, Conroy Niall, Gülmezoglu Metin A, Vogel PJoshua, Rawlins Barbara, Sayed Rubayet, Hill Kathleen, Vivio Donna, Qazi Shamim, Sitrin Deborah, Seale CAnna, Wall Steve, Jacobs Troy, Ruiz Peláez Gabriel Juan, Guenther Tanya, Coffey SPatricia, Dawson Penny, Marchant Tanya, Waiswa Peter, Deorari Ashok, Enweronu-Laryea Christabel, Arifeen El Shams, Lee CCAnne, Mathai Matthews, Lawn EJoy: **Count every newborn; a measurement improvement roadmap for coverage data**. *BMC Pregnancy Childbirth* 2015, **15**(S2):S8.
18. 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**(9463):977-88.
19. UN: **Global Strategy for Women's and Children's Health**. New York, U.S.A.: United Nations; 2010.

20. Dickson KE, Kinney MV, Moxon SG, Lawn JE, Asthon J, Zaka N, et al: **Scaling up quality care for mothers and newborns around the time of birth: an overview of methods and analyses of intervention-specific bottleneck and solutions.** *BMC Pregnancy Childbirth* 2015, **15**(Suppl 2):S1.
21. Meeks EH M, Yeo H: In *Nursing the neonate*. Wiley-Blackwell; Yeo H 2010.
22. Rennie J: *Rennie & Robertson's Textbook of Neonatology*. 5 edition. Churchill Livingstone; 2012.
23. Lawn JE, Kinney MV, Belizan JM, Mason EM, McDougall L, Larson J, et al: **Born too soon: accelerating actions for prevention and care of 15 million newborns born too soon.** *Reprod Health* 2013, **10**(Suppl 1):S6, Epub 2014/03/15.
24. Premji SS, Spence K, Kenner C: **Call for neonatal nursing specialization in developing countries.** *MCN The American journal of maternal child nursing* 2013, **38**(6):336-42, quiz 43-4. Epub 2013/06/25.
25. Bliss: **Save our special care babies; save our specialist nurses: A Bliss report on cuts to frontline care for vulnerable babies.** London, UK: Bliss; 2011.
26. Smith SL, Hall MA: **Advanced neonatal nurse practitioners in the workforce: a review of the evidence to date.** *Archives of disease in childhood Fetal and neonatal edition* 2011, **96**(2):F151-5, Epub 2011/02/15.
27. Mason E, McDougall L, Lawn JE, Gupta A, Claeson M, Pillay Y, et al: **Every Newborn: From evidence to action to deliver a healthy start for the next generation.** *Lancet* 2014, **384**(9941):455-67, Epub 2014/05/24.
28. Buchan J, Aiken L: **Solving nursing shortages: a common priority.** *Journal of Clinical Nursing* 2008, **17**(24):3262-8.
29. Campbell-Yeo M, Deorari A, McMillan DD, Singhal N, Vatsa M, Aylward D, et al: **Educational barriers of nurses caring for sick and at-risk infants in India.** *International nursing review* 2014, Epub 2014/08/19.
30. Singhal N: **Essential Care for the Small Baby.** *Pediatrics AaO* 2014.
31. Shrestha S, Petrini M, Turale S: **Newborn care in Nepal: the effects of an educational intervention on nurses' knowledge and practice.** *International nursing review* 2013, **60**(2):205-11, Epub 2013/05/23.
32. Brantuo MN, Cristofalo E, Mehes MM, Ameh J, Brako NO, Boahene F, et al: **Evidence-based training and mentorship combined with enhanced outcomes surveillance to address the leading causes of neonatal mortality at the district hospital level in Ghana.** *Trop Med Int Health* 2014, **19**(4):417-26, Epub 2014/02/06.
33. WHO: **WHO recommendations: Optimizing health worker roles to improve access to key maternal and newborn health interventions through task shifting.** WHO, Geneva; 2012.
34. Zimba E, Kinney MV, Kachale F, Waltensperger KZ, Blencowe H, Colbourn T, et al: **Newborn survival in Malawi: a decade of change and future implications.** *Health policy and planning* 2012, **27**(Suppl 3):iii88-103.
35. Callaghan-Koru JA, Nonyane BA, Guenther T, Sitrin D, Ligowe R, Chimbalanga E, et al: **Contribution of community-based newborn health promotion to reducing inequities in healthy newborn care practices and knowledge: evidence of improvement from a three-district pilot program in Malawi.** *BMC Public Health* 2013, **13**:1052, Epub 2013/11/10.
36. Balabanova D, Mills A, Conteh L, Akkazieva B, Banteyerga H, Dash U, et al: **Good Health at Low Cost 25 years on: lessons for the future of health systems strengthening.** *Lancet* 2013, **381**(9883):2118-33, Epub 2013/04/12.
37. Wibulpolprasert S, Pengpaibon P: **Integrated strategies to tackle the inequitable distribution of doctors in Thailand: four decades of experience.** *Hum Resour Health* 2003, **1**(1):12, Epub 2003/12/03.
38. Eichler R, Agarwal K, Askew I, Iriarte E, Morgan L, Watson J: **Performance-based incentives to improve health status of mothers and newborns: what does the evidence show?** *J Health Popul Nutr* 2013, **31**(4 Suppl 2):36-47, Epub 2014/07/06.
39. Mbemba G, Gagnon MP, Pare G, Cote J: **Interventions for supporting nurse retention in rural and remote areas: an umbrella review.** *Hum Resour Health* 2013, **11**:44, Epub 2013/09/13.
40. WHO: **The World Health Report: Health systems financing; the path to universal coverage.** Geneva: WHO; 2010.
41. Darmstadt GL, Kinney MV, Chopra M, Cousens S, Kak L, Paul VK, et al: **Every Newborn: Who has been caring for the baby?** *Lancet* 2014, **384**(9938):174-88.
42. Fan VY, Savedoff WD: **The health financing transition: a conceptual framework and empirical evidence.** *Social science & medicine* 2014, **105**:112-21.
43. Gilson L, McIntyre D: **Removing user fees for primary care in Africa: the need for careful action.** *BMJ* 2005, **331**(7519):762-5, Epub 2005/10/01.
44. Logie DE, Rowson M, Ndagije F: **Innovations in Rwanda's health system: looking to the future.** *Lancet* 2008, **372**(9634):256-61.
45. Fottrell E, Azad K, Kuddus A, Younes L, Shaha S, Nahar T, et al: **The effect of increased coverage of participatory women's groups on neonatal mortality in Bangladesh: A cluster randomized trial.** *JAMA pediatrics* 2013, **167**(9):816-25.
46. Manandhar DS, Osrin D, Shrestha BP, Mesko N, Morrison J, Tumbahangphe KM, et al: **Effect of a participatory intervention with women's groups on birth outcomes in Nepal: cluster-randomised controlled trial.** *Lancet* 2004, **364**(9438):970-9.
47. Tripathy P, Nair N, Barnett S, Mahapatra R, Borghi J, Rath S, et al: **Effect of a participatory intervention with women's groups on birth outcomes and maternal depression in Jharkhand and Orissa, India: a cluster-randomised controlled trial.** *Lancet* 2010, **375**(9721):1182-92.
48. Bedford KJ, Sharkey AB: **Local barriers and solutions to improve care-seeking for childhood pneumonia, diarrhoea and malaria in Kenya, Nigeria and Niger: a qualitative study.** *PLoS one* 2014, **9**(6):e100038, Epub 2014/06/28.
49. Blencowe HK M: **"Task-shifting" to reduce neonatal mortality in a tertiary referral hospital in a developing country.** *Arch Dis Child* 2009, **94**(Suppl 1):A49-A51.
50. Shields L, Zhou H, Pratt J, Taylor M, Hunter J, Pascoe E: **Family-centred care for hospitalised children aged 0-12 years.** *Cochrane database of systematic reviews* 2012, **10**:CD004811.
51. Alio AP, Lewis CA, Scarborough K, Harris K, Fiscella K: **A community perspective on the role of fathers during pregnancy: a qualitative study.** *BMC Pregnancy Childbirth* 2013, **13**:60.
52. Olayemi O, Bello FA, Aimakhu CO, Obajimi GO, Adekunle AO: **Male participation in pregnancy and delivery in Nigeria: a survey of antenatal attendees.** *J Biosoc Sci* 2009, **41**(4):493-503.
53. Ditekemena J, Koole O, Engmann C, Matendo R, Tshetu A, Ryder R, et al: **Determinants of male involvement in maternal and child health services in sub-Saharan Africa: a review.** *Reprod Health* 2012, **9**:32.
54. Duke T, Subhi R, Peel D, Frey B: **Pulse oximetry: technology to reduce child mortality in developing countries.** *Ann Trop Paediatr* 2009, **29**(3):165-75, Epub 2009/08/20.
55. Blencowe H, Lawn JE, Vazquez T, Fielder A, Gilbert C: **Preterm-associated visual impairment and estimates of retinopathy of prematurity at regional and global levels for 2010.** *Pediatr Res* 2013, **74**(Suppl 1):35-49.
56. Duke T, Graham SM, Cherian MN, Ginsburg AS, English M, Howie S, et al: **Oxygen is an essential medicine: a call for international action.** *Int J Tuberc Lung D* 2010, **14**(11):1362-8.
57. Mulhall A, de Louvois J, Hurley R: **Incidence of potentially toxic concentrations of gentamicin in the neonate.** *Arch Dis Child* 1983, **58**(11):897-900.
58. English M, Mohammed S, Ross A, Ndirangu S, Kokwaro G, Shann F, et al: **A randomised, controlled trial of once daily and multi-dose daily gentamicin in young Kenyan infants.** *Arch Dis Child* 2004, **89**(7):665-9.
59. Aluvaala J, Nyamai R, Were F, Wasunna A, Kosgei R, Karumbi J, et al: **Assessment of neonatal care in clinical training facilities in Kenya.** *Arch Dis Child* 2015, **100**(1):42-7.
60. Kerber JKate, Mathai Matthews, Lewis Gwyneth, Flenady Vicki, HM Erwich Jaap Jan, Segun Tunde, Aliganyira Patrick, Abdelmegeid Ali, Allanson Emma, Roos Nathalie, Rhoda Natasha, Lawn EJoy, Pattinson Robert: **Counting every stillbirth and neonatal death to improve quality of care for every pregnant woman and her baby.** *BMC Pregnancy Childbirth* 2015, **15**(S2):S9.
61. Slusher JM, Zipursky A, Bhutani VK: **A global need for affordable neonatal jaundice technologies.** *Semin Perinatol* 2011, **35**(3):185-91.
62. Shah PK, Narendran V, Kalpana N, et al: **Aggressive posterior retinopathy of prematurity in large preterm babies in South India.** *Archives of disease in childhood Fetal and neonatal edition* 2012, **97**(5):F371-F375.
63. Saugstad OD, Aune D, et al: **Optimal oxygenation of extremely low birth weight infants: a meta-analysis and systematic review of the oxygen saturation target studies.** *Neonatology* 2014, **105**(1):55-63.
64. Rahi M, Taneja DK, Misra A, Mathur NB, Badhan S, et al: **Newborn care practices in an urban slum of Delhi.** *Indian J Med Sci* 2012, **97**(5):F371-F375.
65. Modi N: *Rennie & Robertson's Textbook of Neonatology*. 5 edition. Churchill Livingstone; 2012.

66. Hamilton KE, Redshaw ME, Tarnow-Mordi W, *et al*: **Nurse staffing in relation to risk-adjusted mortality in neonatal care.** *Archives of disease in childhood Fetal and neonatal edition* 2005, **90**(3):F99-F103.
67. Kalyan G, Vatsa M, *et al*: **Neonatal Nursing: An Unmet Challenge in India.** *Indian Journal of Pediatrics* 2014.
68. Hall D, Wilkinson AR, *et al*: **Quality of care by neonatal nurse practitioners: a review of the Ashington experiment.** *Archives of disease in childhood Fetal and neonatal edition* 2005, **90**(3):F195-F200.
69. Premji SS, Spence K, Kenner C, *et al*: **Call For Neonatal Nursing Specialization in Developing Countries.** *MCN, American Journal of Maternal Child Nursing* 2013, **38**(6):336-342.
70. Government of India: **Sample Registration System (SRS) Bulletins 2013.** 2013, Available from: http://censusindia.gov.in/vital_statistics/SRS_Bulletins/Bulletins.aspx.
71. Government of India, UNICEF: **The Coverage Evaluation Survey 2009 (CES-2009). UNICEF and the Government of India, 2009.** 2009.
72. Government of India: **Ministry of Health and Family Welfare: Annual Report 2014.** 2014, Available from: <http://mohfw.nic.in/index1.php?lang=1&level=2&sublinkid=4454&lid=2939>.
73. Government of India: **India Newborn Action Plan (INAP).** Ministry of Health and Family Welfare. 2014.

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