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INTRAPARTUM-RELATED DEATHS: EVIDENCE FOR ACTION 6

Perinatal mortality audit: Counting, accountability, and overcoming challenges in scaling up in low- and middle-income countries

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ABSTRACT

Background: In high-income countries, national mortality audits are associated with improved quality of care, but there has been no previous systematic review of perinatal audit in low- and middle-income settings. *Objectives:* To present a systematic review of facility-based perinatal mortality audit in low- and middle-income countries, and review information regarding community audit. *Results:* Ten low-quality evaluations with mortality outcome data were identified. Meta-analysis of 7 before-and-after studies indicated a reduction in perinatal mortality of 30% (95% confidence interval, 21%–38%) after introduction of perinatal audit. The consistency of effect suggests that audit may be a useful tool for decreasing perinatal mortality rates in facilities and improving quality of care, although none of these evaluations were large scale. Few of the identified studies reported intrapartum-related perinatal outcomes. Novel experience of community audit and social autopsy is described, but data reporting mortality outcome effect are lacking. There are few examples of wide-scale, sustained perinatal audit in low-income settings. Two national cases studies (South Africa and Bangladesh) are presented. Programmatic decision points, challenges, and key factors for national or wide scale-up of sustained perinatal mortality audit are discussed. As a minimum standard, facilities should track intrapartum stillbirth and pre-discharge intrapartum-related neonatal mortality rates. *Conclusion:* The effect of perinatal audit depends on the ability to close the audit loop; without effectively implementing the solutions to the problems identified, audit alone cannot improve quality of care.

1. Introduction

Each year an estimated 904 000 neonates die soon after birth as a result of intrapartum-related neonatal death, previously loosely termed "birth asphyxia" [1]. These deaths are closely linked to at least 1.02 million intrapartum stillbirths occurring during the time of labor, giving a total of nearly 2 million stillbirths and neonatal deaths related to acute intrapartum events, primarily in low- and middle-income countries [2]. In addition, an unknown number of "near-miss" babies survive the hypoxic event, only to suffer long-term impairments that prevent attainment of their educational potential [3]. When these deaths occur in high-income countries, they are usually reported and investigated. In low-income countries most neonates are born and die without any record [4]. Peer reviewed literature has drawn attention to the absence of reliable data for births, deaths, and causes of death, and the need to count and account for these deaths to set priorities for action and strengthen health systems [5].

While neonatal deaths due to infection and preterm complications have solutions that can potentially be taken to scale [6], even in weak health systems [7], solutions for intrapartum-related outcomes are more challenging and require strengthening the quality and responsiveness of the health system at all levels [8]. Mortality audit and feedback appears to be a promising tool to address delays and suboptimal care practices, given that lack of progress in addressing both neonatal and maternal deaths is often attributed to the need for better individual case management around the time of birth. However, the

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use of audit has been limited in low- and middle-income countries, and yet this is where 98% of the world's maternal deaths, stillbirths, and neonatal deaths occur.

National enquiries into maternal deaths, stillbirths, and neonatal deaths have been used in high-income countries for decades [9]. In low-income countries, experience with mortality audit has been tried primarily at the facility level, often limited to tertiary or referral centers, and has more commonly focused on maternal deaths, notably influenced by the World Health Organization's "Beyond the Numbers" guide for reviewing maternal deaths in low-resource settings [10]. Perinatal mortality audit has been used less frequently and its implementation in low-income countries a community research site. However, there are notable examples of audit at scale in such countries. Furthermore, given that 60 million births occur outside facilities each year, there are a growing number of strategies for examining avoidable factors outside facilities and even conducting mortality audits at the community level.

1.1. Objective

This paper is the sixth in a series that focuses on reduction of intrapartum-related neonatal deaths. Here we present the results of a systematic review of perinatal mortality audit in low- and middle-income settings to facilitate health system strengthening, particularly at the time of birth, and examine the effect on perinatal outcomes, particularly intrapartum-related, where data allow. We intentionally focus on the potential for wide-scale, sustainable implementation in low- and middle-income settings, discussing two national case studies.

2. What is perinatal mortality audit?

The principal aim of audit in the healthcare setting is to identify deficiencies and address them to improve the quality of care provided [9]. Audit can be a means to increase efficiency, or improve patient satisfaction, or to save lives. Types of audit include:

- *Structural audit*, which includes an examination of the resources in the system;
- *Satisfaction audit* involving surveys or focus groups to obtain users' views about the quality of care they have received;
- *Process audit* to assess case management;
- *Outcome audit* to identify the end results of care.

Perinatal audit has been defined as: "The systematic, critical analysis of the quality of perinatal care, including the procedures used for diagnosis and treatment, the use of resources and the resultant outcome and quality of life for women and their babies" [11]. Outcome audit is often the first priority to determine a profile of facility-based causes of death. The outcome in perinatal mortality audit is death. It is simpler to use as there is little difficulty in defining the end point compared, for example, with morbidity. In the future, as perinatal mortality rates improve in low-income settings, there will be a need to focus on morbidity or "near miss" as an outcome for audit. Neonatal "near-miss" definitions have been used either for a specific condition like neonatal encephalopathy, or neonatal care in general [12–14].

In an ideal situation, the quality of care provided to all babies would be assessed. Focusing on deaths and making every death count is a justifiable alternative—but it is more feasible in high-income settings where perinatal deaths account for around 0.5% of births, compared with low-income countries where perhaps 10% of births may result in perinatal death, and the health staff are already few and under pressure. One facility-based audit in Tanzania found that among 385 perinatal deaths, 3 mothers died [15]. Where perinatal mortality is high, the assumption is that the factors related to each individual death are widespread and not particular to the specific case. Thus, the correction of factors involved in one death has the potential to improve the quality of care for many pregnant women and babies. This assumption may be less valid in high-income settings and some middle-income countries when related to maternal death, where deaths may be linked to fewer modifiable factors [16].

This paper focuses on perinatal mortality audit. The classic audit cycle can be adapted for perinatal audit with 6 steps, forming a circle or ideally an upward spiral of continuous improvement (Fig. 1):

Step 1: Identify perinatal deaths as well as ensure all births are recorded.

Step 2: Collect information on causes of death and avoidable or modifiable factors using a standard classification system.

Step 3: Analyze the results and generate mortality rates and trends over time.

Step 4: Recommend solutions to address modifiable factors.

Step 5: Implement recommendations arising from the modifiable factors identified.

Step 6: Evaluate and refine the process.

Information on clinical history, case management, and findings are captured either on paper or electronically. These data can remain at the point of collection or be compiled regionally or nationally for analysis and review. Either all cases or a selection of cases are discussed at a multidisciplinary meeting with a purpose toward improving future management rather than assigning blame [17].

Outcome audit can be combined with an analysis of factors contributing to avoidable deaths, modifiable factors, or substandard care. Wilkinson defines an avoidable death as one that is "judged to be directly due to an error or omission on the part of the health service" [18]. To determine which deaths could have been avoidable, a criterion-based audit is used to measure quality of care against explicit standards [19]. The term "modifiable factors" is preferred as a positive alternative to "avoidable factors" in many settings to indicate that there is an action that can be taken to correct the problem. Recognizing modifiable factors could open pathways to primary or secondary prevention of the identified causes of death or near misses.

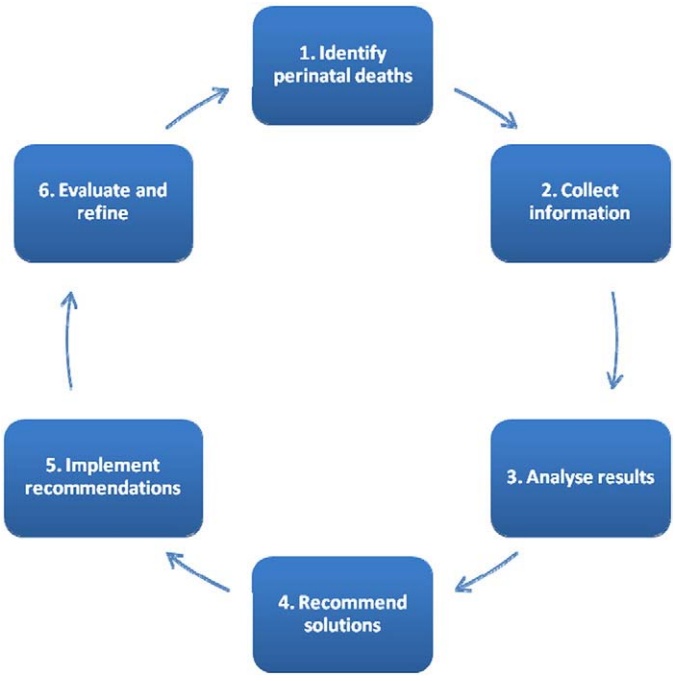

Fig. 1. Six-step cycle for perinatal mortality audit.

3. Evidence for audit

Searches of the following medical literature databases were conducted: PubMed, Popline, EMBASE, LILACS, IMEM, African Index Medicus, Cochrane, and WHO documents. The details of the search strategy and selection criteria for inclusion of papers are described in detail in the first paper in this series [8]. Keyword searches relevant for this paper included "perinatal," "neonatal," "stillbirth," "asphyxia,"

Table 1
Evidence for the impact of facility-based perinatal audit in low- and middle-income countries.

Intervention and type of study (data order)	Setting	Skilled birth attendance	Mortality effect (% reduction)					Outcome notes	Investigator and year
			SBR	ENMR	PMR[a]	NMR	MMR		
Comparison of avoidable perinatal deaths in hospital between 1971–76 and 1977–79.	Iringa, Tanzania, Lugarawa hospital, population of 75 000 (1971–1979)	24%	–	–	***44%***	–	–	1971–76 audit data showed high rate of avoidable intrapartum stillbirths. PMR declined with use of a partograph and standard protocols	Van Roosmalen [50] 1989
Before and after evaluation of maternal and child health project with regular audit and self appraisal. Crude birth rate declined 28% during intervention period, and primary focus was on family planning.	Lahore, Pakistan. 8 urban and 2 rural areas with population ~6000 (1984–1987)	–	–	–	**–**	–	61% [x]	[x]Number of cases not given. Infant mortality rate 41% reduction	Awan et al. [51] 1989
Examination of the effect of a routine, internal audit of perinatal deaths to identify avoidable factors.	Lebowa, a South African district hospital and clinics (10 months)	–	–	–	***31%****	–	–	*Perinatal deaths with potential avoidable factors decreased from 30% to 13%	Wilkinson [32] 1991
Data from the delivery register summarized at weekly meetings and then complied. 1982 data capture of perinatal deaths incomplete. Cesarean deliveries increased from 7% to16%.	Maputo, Mozambique. Maputo Central Hospital with 134 408 births registered (1982–1991)	>90%	61%[+]	–	***20%***[x]	–	–	[+]Intrapartum SBR only [x]Overall PMR remained constant – attributed to Mozambique war and an increase in fetal deaths due to STIs. PMR declined from 1983 (first year with full data collection) compared with 1990 (last year before war effect). Paper reports 20%, data gives 17% Most effect on IP SBs	Bugalho and Bergstrom [36] 1993
Retrospective assessment of perinatal audit over 2 years utilizing the Identification, Cause, Avoidable Factor (ICA) solution system on perinatal deaths (n=1060).	Port Elizabeth, South Africa. Central referral hospital and 2 district hospitals with 22 585 deliveries assessed (1991–1992)	_	55%*	_	***24%***	_	_	*Intrapartum fetal deaths	Ward et al. [52] 1995
Internal audit of deliveries >1000 g with avoidable factors defined and analyzed and software system tested.	Pretoria, South Africa. Urban population (1992–1994)	>90%	–	–	***38%***	–	–	Pilot for later scale-up of PPIP system in South Africa	Pattinson et al. [45] 1995
Assessment of quality of care improvement based on audit recommendations from perinatal deaths (n=653) involving rearrangement of the district maternity service, implementing protocols, and regular in-service education.	Hlabisa, South Africa. Hlabisa Hospital, 8 village clinics, and 20 mobile clinic points with 21 112 consecutive births (May 1991–Dec 1995)	–	–	–	***39%***	–	–	Proportion of perinatal deaths occurring in clinics decreased over this time from 17% in 1995 to 6.3% in 1991. PMR reduced 39% from 1992 (when number of high-risk deliveries stabilized – previously all high-risk deliveries transferred out to other facilities) to 1995	Wilkinson et al. [18] 1997
Description of rates and causes of perinatal mortality using classification according to Wigglesworth classification.	Kathmandu, Nepal. Teaching hospital (2003–2005)	–	–	56%	38%	*	–	*Intrapartum-related neonatal deaths from decreased from 41% to 13% Cesarean deliveries from 26% to 30% over this period Excluded from meta as inadequate numerator/ denominator data in the paper	Shrestha et al. [53] 2006
Weekly multi-disciplinary perinatal mortality reviews with classification of modifiable factors.	Kampala, Uganda. Nsambya Hospital (2008–2009)	56%	–	–	32%	–	–	Excluded from meta as inadequate numerator/ denominator data available	Byaruhanga and Nakibuuka (unpublished)
Perinatal mortality audit using South African PPIP software and cases presented at monthly multi-disciplinary meetings.	Bangladesh. LAMB Hospital, 23 731 babies >1000 g. (2001–2008)	32%	34%	1%	***26%***	–	–	Most of the reduction in PMR was related to SBR reduction	Mussell et al. (unpublished)

Abbreviations: SBR, stillbirth rate; ENMR, early neonatal mortality rate; PMR, perinatal mortality rate; NMR, neonatal mortality rate; MMR, maternal mortality ratio; PPIP, Perinatal Problem Identification Programme.

[a] PMR data in bold italics included in meta-analysis (see Fig. 2) also with 95% confidence intervals.

"mortality audit," and "death audit." Each study was assessed and graded according to the CHERG adaptation [20] of the GRADE technique [21]. We conducted a random effects meta-analysis using STATA version 10.0 statistical software (STATA Corp, College Station, TX, USA) and report the Mantel-Haenszel pooled risk ratio and corresponding 95% confidence interval (CI).

Assessment of the impact of perinatal mortality audit is complex because the audit cycle and implementation of recommended actions are rarely carried out as part of a randomized trial [22] and other factors may also contribute to a measured reduction in mortality. One recent systematic review of interventions to prevent stillbirths identified 1 review and 12 intervention studies on the impact of perinatal mortality audit, with the majority from high-income countries. The authors reported some evidence of benefit of mortality audit through changes in clinical practice and strongly recommended the practice of mortality audit where practical [23].

3.1. Perinatal mortality audit at the facility level

3.1.1. Evidence of mortality effect

Facility-based mortality audit often begins with a single individual or team coordinating data collection and review meetings that are most commonly conducted at referral or academic centers. A number of studies from high-income settings have shown that perinatal mortality audit is feasible and effective in reducing deaths [24–31]. There are fewer studies from low- and middle- income countries. Ten studies reporting the impact of facility-based perinatal mortality audit on maternal, perinatal, or infant outcomes were identified, including two unpublished datasets identified through conference proceedings (Table 1). All recorded a reduction in deaths following the introduction of perinatal mortality audit, which raises the issue of publication bias as an audit with no measured change is less likely to be published or presented.

Seven low quality or very low quality before-and-after studies were identified that reported improvements in perinatal mortality and with adequate numerator and denominator data. The quality of evidence was upgraded to low/moderate since the effect sizes were very consistent and the studies were from multiple regions. These studies were combined in a random effects meta-analysis with a resultant relative risk of 0.70 (95% CI, 0.62–0.79) (Fig. 2).

3.1.2. Experience in perinatal audit process and sustainability

Perinatal mortality audit in a rural district hospital in Eastern Cape, South Africa, was associated with a significant reduction in avoidable perinatal deaths over a 10-month period in 1991. Perinatal mortality fell by 32% and avoidable factors reduced from 28% to 13% of perinatal deaths [32]. The mortality audit process informed the intervention strategies, an important part of which was training midwives to advanced diploma status using the distance-learning Perinatal Education Programme [33]. More recently, Murchison Hospital in KwaZulu-Natal province has seen a substantial decline in perinatal deaths after commencement of a mortality audit process in 2003. This included introducing the Perinatal Problem Identification Programme (PPIP), which involves a database for perinatal mortality audits and monthly perinatal mortality meetings, conducted in a no-fault atmosphere. Meeting attendance was compulsory for all healthcare providers in the hospital and a representative from each clinic. Mortality meetings were accompanied by in-service training on the use of the partograph, interpreting fetal heart rate patterns, neonatal resuscitation, and newborn care. Midwives displayed perinatal care indices on bar charts on the wall of their labor ward, and these were updated monthly after the mortality meeting. The total perinatal mortality rate (PMR) decreased from 42 per 1000 births in 2003 to 29 per 1000 births in 2007/08. Early neonatal mortality rate (ENMR) declined by half and deaths due to intrapartum asphyxia and trauma showed a 26% reduction (from 8.7 to 6.4 per 1000 births) [34].

In North-West Bangladesh, LAMB is a 150-bed general hospital, which includes a comprehensive emergency obstetric care unit that is part of an integrated rural health and development project serving a community population of 600 000 with 13 Safe Delivery Units with obstetric first aid, bringing care closer to home. In the region, the use of skilled birth attendance was 32% in 2007, which was higher than the national average of 18%. Since January 2001, all maternal and perinatal (>1000 g birth weight) deaths have been audited. Primary obstetric and final causes of death are coded and modifiable factors are identified by a consultant obstetrician. Cases with learning points are presented at a monthly multidisciplinary meeting in a confidential and non-blame environment. Data are analyzed using South Africa's PPIP software. From January 2001 to December 2008, 23 731 neonates were born at LAMB Hospital. The perinatal mortality rate at the facility was 75 per 1000 births and stillbirths accounted for two-thirds of perinatal deaths (47 per 1000 births). Of the stillbirths 46% were dead on admission to the facility and another 18% died in labor after admission. Facility perinatal mortality and stillbirth rates have decreased significantly since the introduction of audit (Table 1, Fig. 3). The data show an increase in mortality around 2003, which is likely to be a measurement artefact due to improved information capture. The decreases between 2001 and 2008 are statistically significant for the stillbirth rate (χ^2 for linear trend = 25.8; $P<0.001$) and overall perinatal mortality (χ^2 for linear trend = 22.6; $P<0.001$). The leading causes of perinatal mortality are hypoxia (48%), preterm birth complications (22%), and infection (15%). Probable modifiable factors were present in 45% of cases and possible modifiable factors in 80% of

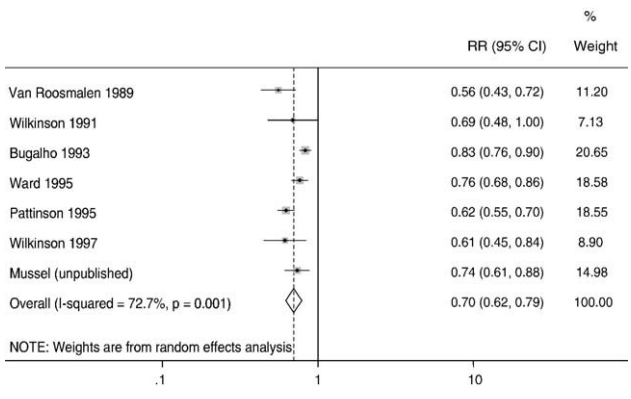

Fig. 2. Meta-analysis of the effect on perinatal mortality rate associated with introduction of perinatal audit in low- and middle-income countries. Notes: Bugalho 1993: Results from 1983 (the first year of full data collection) to 1990 (the last year before the effects of the civil war). Wilkinson 1997: Results comparing 1992 (when number of high-risk deliveries stabilized – previously all high-risk deliveries transferred out to other facilities) with 1995.

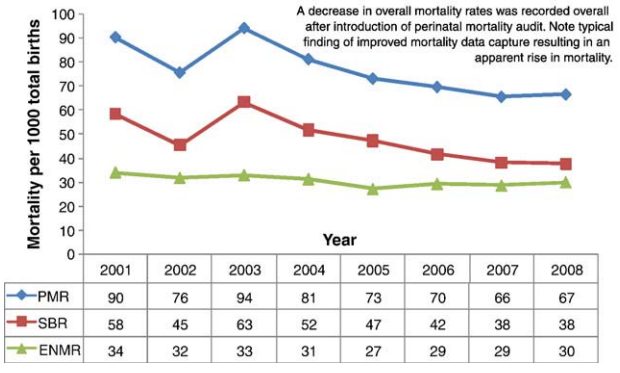

Fig. 3. Perinatal and early neonatal mortality rate and stillbirth rate at LAMB Hospital, Bangladesh. Abbreviations: PMR, perinatal mortality rate; SBR, stillbirth rate; ENMR, early neonatal mortality rate.

Table 2
Community audit – small scale examples from Africa and Asia.

Verbal and social autopsy in research settings
Guinea pathway to survival The Guinea Ministry of Health together with Save the Children and BASICS conducted a verbal and social autopsy of 330 deaths among children younger than 5 years old in Mandiana, Guinea, from October 1998 through September 1999 [54]. As well as mortality rates and direct causes, the delays along the pathway to survival were assessed. Almost two-thirds (61%) of children were never taken to a health facility before death, although most sought some care outside the home. The lowest care-seeking was for "birth asphyxia" with only 9% being taken outside the home compared with 83% for pneumonia and 76% for diarrhea. Over one-third of children who visited a health facility received average to poor treatment. This study did not examine stillbirths.
Uganda social autopsy A pilot project in the Makerere University-operated Iganga/Mayuge Demographic Surveillance Site (DSS) investigated the care-seeking delays and causes contributing to 64 neonatal deaths using social autopsy. A panel of 2 physicians employed verbal autopsy using a hierarchical model to determine direct causes of newborn deaths. The leading causes of death were sepsis or pneumonia (20/64, 31%) and birth asphyxia (19/64, 30%), preterm births (16/64, 25%), and in 6 cases (9%) a cause of death could not be determined. In addition social autopsy was used as a tool to supplement the direct cause-of-death data to understand modifiable factors at household/community and health facility levels. They used a modified "3 delays" model [55] to identify the delays contributing to newborn death. Delay 1 (delay in deciding to seek care outside the home) was the greatest contributor to death (32/64, 50%), followed by delay 2 (delay in transportation to the health facility) (19/64, 30%), whereas delay 3 (delay in receiving care after arriving at a facility) contributed to (13/64, 20%) of deaths. Among the 19 intrapartum-related ("birth asphyxia") deaths, the distribution of delays was similar (7 deaths for delay 1 and 6 deaths for each of delays 2 and 3) .There were more intrapartum-related deaths in health facilities (11/19) than in the community (8/19). However, the study had limitations, including a small number of newborn deaths and excluding stillbirths. The process was descriptive, and did not link back to community action, although this will be included in the larger newborn care study commencing in the same site.
Participatory audit involving the community
Community audit in Uttar Pradesh A community level "Social Audit for Community Action" was conducted in rural Uttar Pradesh [56]. Community members from 152 villages were asked to recall the causes of deaths among children under 5 years in the prior year and identify preventive measures that could have been taken by the family or community. Intrapartum-related events accounted for 13.5% of neonatal deaths. Delay in recognizing the seriousness of the problem and arranging for transport and funds were identified as major contributors of neonatal deaths and to be targeted for behavior change by the community mobilizers. Another study to examine the feasibility of community audit was undertaken in Shivgarh, Uttar Pradesh, India involved in-depth interviews with family members of deceased neonates, and focus group with family and community members [38]. Approaches involved the community in identifying avoidable factors in each death and discussing solutions. Community neonatal death audit was found to be acceptable and feasible. Presence of an educated/experienced community member or health worker served as a catalyst.

cases. Leading modifiable factors were patient related: not initiating prenatal care (32%), delay in seeking medical attention in labor (17%). Medical personnel-associated avoidable factors included not detecting fetal distress in the intrapartum period despite intermittent fetal monitoring. One strategy identified through audit that has improved patient management has been the improvement of clinical guidelines [35]. There is still the ongoing challenge of a large burden of perinatal deaths in the comprehensive emergency obstetric care facility, and the unaddressed emotional burden on staff.

Perinatal mortality audit can be sustained and effective in low-resource settings. One study from Maputo Central Hospital, Mozambique, analyzed changes in mortality over 10 years of maternal and perinatal mortality audit through weekly meetings and regular feedback of perinatal data via wall charts [36]. Over this time period, a 61% reduction in intrapartum fetal deaths and a 20% reduction in perinatal mortality overall were recorded. While many factors may have played a role, the authors cite frequent open communication between obstetric and pediatric staff and involvement of staff at all levels as contributing to this large decline.

Nsambya Hospital, a large tertiary mission hospital in Kampala, Uganda, has been conducting maternal audits for several years, and introduced perinatal and under-5 mortality audits in 2008. Weekly perinatal death reviews were conducted by a team of midwives, pediatricians, administrators, and obstetricians to identify gaps, mistakes, and cause of death. A total of 120 perinatal deaths were audited, almost equally split between macerated stillbirths, fresh stillbirths, and neonatal deaths. "Birth asphyxia" or intrapartum-related neonatal deaths accounted for around 30% of the neonatal deaths. The introduction of perinatal audit was associated with a 32% reduction in perinatal mortality rate from 62 per 1000 total births in 2007 to 42 per 1000 total births in 2008 (Table 1) [37].

3.2. Perinatal mortality audit at the community level

Sixty million women around the world still give birth at home each year and in low-income countries the majority of births and perinatal deaths occur at home or soon after admission. Babies that die at home are often not captured in any health records. Social audits may be used at the community level as a tool to identify strategies for community motivation of behavior change, or for addressing delays and promoting linkages for care. Community audit can be difficult to implement because of multiple role-players, but if conducted in a culturally acceptable and participatory process, audit is feasible, empowering, and may lead to behavior change [38]. This can be a descriptive process to gather information, as seen in Guinea and Uganda, or a participatory activity involving community members in implementing change as in rural Uttar Pradesh, India (Table 2). Verbal and social autopsy are tools used in community-level perinatal mortality audit to ascertain the cause of death profile as well as contextual factors such as care-seeking delays related to these deaths. An audit cycle is used to translate that information into recommendations and action, involving community members in the quality improvement process.

In Malawi, the "Safe Motherhood from below" project used a local music and drama troop to facilitate community meetings to discuss maternal and early infant deaths, and discuss actions needed to avoid another death. For example, discussing the death of a woman caused by infection after surgical delivery in hospital led to improvements in the hospital sterilizing equipment, a new refrigerator for the blood bank, and the provision of antibiotics to rural clinics so that treatment could be commenced earlier [39].

In the "Mother Care Indonesia" project, both facility and community maternal and perinatal mortality audits were conducted as part of a district-based strategy to reduce mortality and improve care [40]. A sector-wide approach was undertaken that involved community members, such as village and religious leaders, in discussing the deaths and possible solutions. The audits led to changes in obstetric practice including better drug and equipment supply to village midwives. Unfortunately, although the paper describes the inclusion of perinatal deaths in the process, results are only given for maternal deaths.

4. Considerations for implementing and scaling up audit

4.1. Getting to scale with perinatal audit: national case studies

In some cases, the audit process is led at the national level with central coordination. This often involves a directive that health facilities must be involved in audit and often involves confidentiality. Confidential enquiries and "near-miss" audits into maternal deaths have been employed successfully at national level in a limited number of low/middle-income countries, including South Africa and Malaysia. There is less evidence for wide-scale quality improvement arising from a national process for perinatal audits, but there are lessons to be learned.

In the UK, the national Confidential Enquiry into Stillbirths and Deaths in Infancy (CESDI), established in 1992, provides an annual overview of the numbers and causes of stillbirth and infant deaths, together with a detailed enquiry. The process identifies approximately 10 000 deaths annually in England, Wales, and Northern Ireland. Public recommendations for action are made on the basis of the findings of the enquiries. The additional social and political pressure of public reports has mobilized national attention, and resulted in channeling more resources to the problems identified [41].

In South Africa, the growth of PPIP has come from the ground up by committed individuals who wanted a tool to help improve patient care. Following the lead of the National Committee for Confidential Enquiries into Maternal Deaths in South Africa, PPIP is linked to a wide-scale national process (see Panel 2 at the end of the paper). Leadership for PPIP is currently being transferred to national and provincial departments of health with an aim to introduce perinatal mortality audit to all sites that conduct births. In 2007, the audit committees in South Africa for perinatal, maternal, and child deaths came together to facilitate a national process to harmonize the recommendations detailed in each of the 3 audit reports in a summary publication [42]. This process resulted in national media coverage and was linked to the set-up of national-level committees for maternal, perinatal, and child deaths. Other countries in the region are asking for support looking to scale-up audit, including support from the African Union and partners. Despite national support and continued roll-out to sites, there are still challenges with sustaining implementation.

Similarly, it has been shown that confidential, non-blame audit is possible in Bangladesh (see Panel 3 at the end of the paper). Health professionals together with development partners and the Government of Bangladesh joined together in 2004 to introduce perinatal mortality audit in 5 pilot sites. Training, supervision, and advocacy for perinatal mortality audit were provided with a view toward expanding perinatal mortality audit to all government health facilities.

In Uganda, a national maternal mortality audit committee has been set up under the Ministry of Health's National Road Map for Maternal and Neonatal Health. Recently, the Ministry of Health has expanded this to integrate maternal and neonatal death audits and scale up countrywide. The process has started with the national, regional, and district hospitals. Initial experience shows that health workers are interested in the process. However, there are challenges, mainly related to resources for scaling up training as well as follow-up of trained sites to ensure sustainability of the process.

4.2. Sustainability and effectiveness of perinatal audit

There are a number of options available and decisions to consider in terms of both design and implementation when instituting perinatal mortality audit, particularly to maximize the likelihood of reaching wide-scale coverage, with sustainability and linking to change (Figs. 3 and 4). Initiation may vary from one facility to a whole country, although even with a plan for national scale-up, the process must start in a few facilities first. Choices regarding the scope of outcomes covered and methods of data collection (paper-based or electronic) will depend on local factors. Although a wider scope that encompasses maternal, newborn and child health (MNCH), a larger scale, and the use of data outside health facilities would be a more comprehensive approach, this is a much more ambitious remit. A phased approach—for example, adding perinatal to more established maternal audit—may be more achievable. One recommendation is to start by tracking intrapartum stillbirths and pre-discharge intrapartum-related neonatal deaths as a minimum indicator of the quality of obstetric care [43].

Sustainability is a challenge. Audit may be initiated by donors or research projects in one facility or area without government involvement or plans to reach wide scale. Ongoing meetings, data collection, and change depend on local champions, local and national ownership and leadership, a feasible data collection system and a method of disseminating the information (see Panel 2). Audit is most effective if all levels of staff are involved in the process of case review and putting forth recommendations [17]. At the same time, audit is time-consuming and requires commitment and motivation of staff at various levels. In particular, the emotional impact on staff working in an environment with high perinatal mortality has been raised as an issue in Bangladesh. In Nsambya Hospital, Uganda both good events (e.g. a successful severe birth asphyxia rescue) and bad ones (e.g. a death) are reviewed in order to keep staff motivated (personal communication, Romano Byaruhanga). Staff turnover could be a

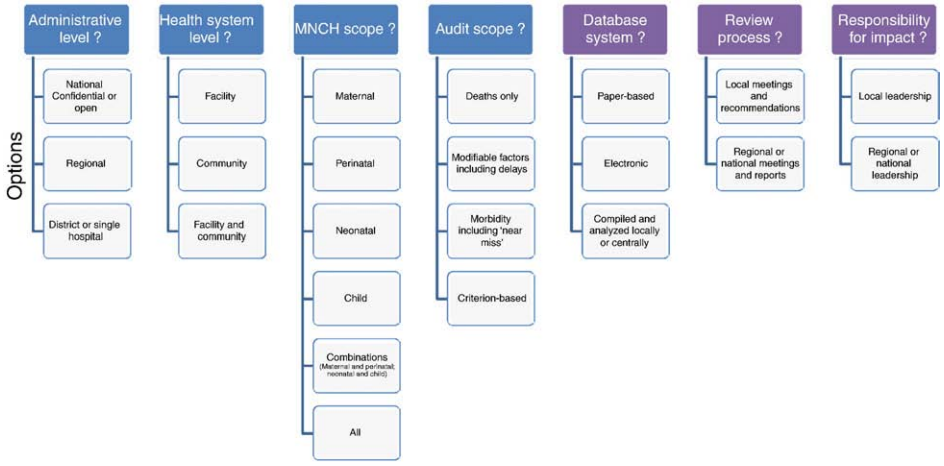

Fig. 4. Considerations around initiating and scaling up perinatal mortality audit.

contributing factor to lack of sustainability. In Murchison Hospital, South Africa throughout the process the doctor-in-charge of the labor ward, the senior midwife, and the information officer remained in the same positions, possibly contributing to the ongoing high quality of PPIP data collected.

Community-level audit can be part of a dialogue between the broader health system, involving health facilities and communities [38]. Similarly, community involvement has been identified as a crucial component of improving facility-based care and a feedback mechanism for communicating patient-related modifiable factors [44]. Potential entry points for community audit can include facility audit itself, in which every death is also audited at the community level. Other entry points can include community-based vital registration systems (which identify pregnancies, births, and deaths) and may include a cadre of multi-purpose community health workers that is already present in many low/middle-income countries. One project in Uganda, as part of maternal death audits, trained health workers to audit every maternal death in health facilities [45]. This was then followed-up by community mobilization, sensitization, and dialogue in the affected villages. Through this initiative it became common to identify many maternal deaths that were not previously identified. In some communities this led to improving the quality of care in some health facilities, e.g. by posting of a midwife, supervision of a traditional birth attendant, and equipping of maternity health units. Confidentiality is difficult in the village setting, opening up blame of either affected families or care givers as negligent. Other challenges include inability for communities to effect change due to lack of empowerment, and lack of comparability of data due to nonstandard tools or definitions.

Impact is dependent on the ability to close the audit cycle. Problems are often identified and solutions suggested, but the changes are not implemented effectively. The whole audit cycle is necessary, but the fifth step of implementing recommendations is crucial to saving lives. This step requires strong leadership and support from health service managers. Self-criticism is difficult, perhaps especially among health professionals. One potential pitfall in mortality audit is to overemphasize the responsibility of the mother or family in delaying to seek appropriate care. One facility-based perinatal mortality audit in Tanzania found that the majority (73%) of perinatal deaths were linked to a crucial delay within the health facility [15].

While perinatal mortality audit has been shown to improve overall perinatal mortality and also intrapartum stillbirths, reducing intrapartum-related neonatal deaths appears to be especially challenging (Table 1). Even within long-standing Confidential Enquiries into Maternal Deaths in the UK, some recommendations result in immediate service improvements, yet other recommendations may be repeated report after report without action [9]. Since the CESDI has combined with the National Institute for Health and Clinical Excellence (NICE), and more recently is being run by the National Patient Safety Agency, the recommendations have been more likely to be implemented [41]. In South Africa, despite a significant reduction in neonatal deaths (106 per 1000 live births in 2003 to 73 per 1000 live births in 2007, $P<0.05$) between 1–2 kg, in all 35 hospitals with serial PPIP data for 5 or more years there was no significant reduction in deaths due to "birth asphyxia." Intrapartum-related perinatal deaths are the top cause of death in rural areas, and second only to preterm birth overall. Avoidable factors were identified in 83% of such deaths, including missed diagnosis of fetal distress and delays of over an hour in undertaking cesarean delivery.

4.3. Cost of perinatal mortality audit

National perinatal mortality audit is achievable even amidst budget constraints. The running cost of the South Africa PPIP process at national level by the South African Medical Research Council with some donor input is approximately US $35 000 per year. This cost includes software program maintenance and development costs, office running costs, collating data, printing bi-annual reports, and attendance at provincial workshops and technical task team meetings. Over 1000 healthcare professionals have been trained in the use of PPIP, mostly through donor funding. Approximately 4 hours per month is spent by clerks entering data, but there is a much larger undocumented cost involved in staff collecting cases and preparing for the mortality and morbidity meetings. The major input is the time to collect and analyze the data, and the opportunity costs of staff time to attend mortality meetings and enquiry panels. At regional or national level, it might be more efficient to select a random sample of all cases across a region or reviewing all cases in a single unit where an excess of cases has been identified [46]. The cost of implementing the changes identified by audit is part of ongoing system improvement and should result in more targeted investment and efficient use of services as a result of the audit.

4.4. Research and data gaps

Local perinatal mortality audits function best as a quality improvement exercise, rather than an epidemiological tool. Amalgamation of data to generate mortality rates and causes of death generated from audit should not be used as nationally representative unless the vast majority of births and deaths occur in health facilities and the data collection is systematic. Perinatal mortality audits can miss late neonatal deaths and deaths that occur after discharge, thereby giving a false impression of the overall neonatal mortality rate. While perinatal mortality rates are the commonly used indicator for these audits, stillbirths and neonatal mortality rates should be analyzed and reported separately to address the different solutions they may require. Furthermore, causes of death will be different in facilities to those that occur in the population as a whole and national priority-setting can be misled if facility-based information alone is used as input data.

The quality of the mortality data collected is also crucial for ensuring that information connects to the right solutions. Even within facilities, without post mortems, determining the cause of death can be difficult guesswork. The concepts and tools described for maternal audit in the WHO's "Beyond the Numbers" guide can also be applied to perinatal audit [10]. Case definitions for hierarchy and cause of death should be included in all perinatal audit reports, such as those developed for neonatal by the United Nations Expert Group (Child Health Epidemiology Reference Group) [47,48]. Standardized, easy-to-use classification systems are needed, particularly for classifying stillbirths because over 35 classification systems are currently in use [49]. A new system is being developed in conjunction with the WHO International Classification of Diseases unit to allow comparability of low- and high-income country data, and to allow cross-tabulation with maternal complications [49]. More standardized social autopsy evaluations are also needed and teams from Uganda, Kenya, Ghana, and Guinea Bissau are working together to standardize social autopsy tools linked to the INDEPTH network (www.indepth-network.org).

The effectiveness and feasibility of audit, particularly to address delays in accessing maternal and newborn care has been demonstrated. However, stillbirths have often been excluded in community audits because of social and cultural constraints that need to be quantified [49]. More research is needed to investigate how to operationalize linkages between community and facility perinatal mortality audits and their effect on changing quality of care.

5. Conclusions

Perinatal mortality audit involves different approaches in different settings, varying from community or clinical meetings following an individual death, to a computerized data entry system assessing thousands of deaths with national level notification. While perinatal mortality audit is often associated with high-income hospital settings,

it has great potential in low-resource settings and also appears to be feasible at the community level, although there are limited experiences as yet. Our new meta-analysis of 7 before-and-after studies in low- and middle-income countries indicates a reduction in perinatal mortality of 30% (95% CI, 21%–38%) after introduction of facility-based perinatal audit. These are low or very low quality studies but, because of consistency of effect across 7 studies in different regions, and all the studies being from low- or middle- income countries, the evidence GRADE may be increased to moderate [20]. Hence, despite the complexities of assessing the impact of perinatal mortality audit, there is increasing evidence to recommend it as a process to facilitate improvement in perinatal mortality outcomes.

Intrapartum-related neonatal deaths are consistently one of the most common causes of neonatal deaths, and in low-income settings, stillbirths also have a large component of intrapartum causation [2]. There is some evidence to suggest that these deaths specifically have decreased through perinatal mortality audit. Given the sensitivity of mother and baby to delays in accessing care and the well-documented challenges with quality of intrapartum care, there is obvious value in a process identifying these and targeting them with solutions. However, based on the limited data available here, it appears more difficult to implement changes to reduce intrapartum-related neonatal deaths than for intrapartum stillbirths.

The public health impact of perinatal mortality audit depends upon scale of operation and sustainability, which are reliant on motivating health workers, having champions, and involving stakeholders at all levels, as well as a locally feasible data collection system. There are lessons to be learned from the widespread experience of maternal mortality audit that is more frequently implemented at national scale.

There is untapped potential for perinatal mortality audit to identify and address deadly delays and modifiable factors in care around the time of birth that lead to intrapartum stillbirths and intrapartum-related neonatal deaths, as well as to maternal deaths. However, without effectively implementing local solutions or national recommendations to close the audit cycle, audit alone cannot save lives or improve quality of care.

6. Conflict of interest

The authors have no conflicts of interest to declare.

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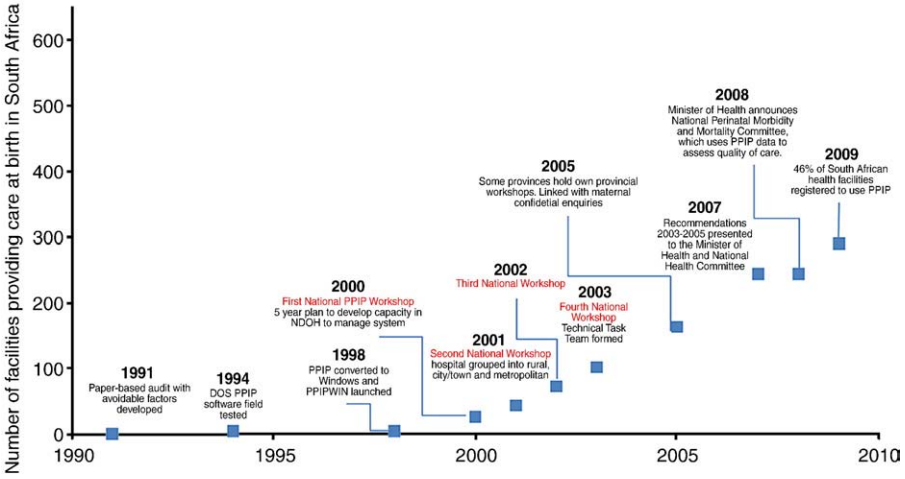
Panel 1. National process toward scaling up perinatal mortality audit in South Africa

There are 664 healthcare facilities that conduct deliveries in South Africa, and in 2009, 305 (46%) of these health facilities have been registered with Perinatal Problem Identification Programme (PPIP), a computer-based perinatal audit system. The database in 2006–07 had information on almost 40% of all births in South Africa and 35% of all sites conducting births. The national *Saving Babies* reports and recommendations based on PPIP findings are presented to the Minister of Health via a national committee appointed to make recommendations for priorities to reduce the perinatal mortality. The system is gradually becoming institutionalized as the data become increasingly used (Panel 1. Fig. 1).

So far, 146 (48%) sites have submitted data in 2009, including 35 sites with continuous data for 5 or more years, 16 that stopped at some point and restarted, and 38 are new registrations with no new data yet. Some 48 sites have not responded for this year and 73 sites (24% of those registered) are known to have stopped collecting data. The main reason for discontinuing the process has been the removal of the driving force behind the process within the institution, either by promotion to another position, rotation within the hospital or resignation from the public service. PPIP is voluntary and database maintenance at each audit site is performed by doctors and midwives as an integral part of clinical practice. The sites that use PPIP were trained in its use by other PPIP users. Recently some of the country's 9 provinces have appointed provincial coordinators that visit PPIP sites to sustain the process and help promote change based on the data.

Factors contributing to successful scale-up and sustainable implementation

- *Champions:* Interested healthcare providers have driven the process in their hospitals, in their provinces, or nationally. These champions have been obstetricians, midwives, and pediatricians.
- *National Department of Health links*: This has facilitated the spread of the program to all of the provinces and provided a method of communicating the recommendations to the Department so that they can impact on their strategic planning.



Panel 1. Fig. 1. Timeline for scale up of national perinatal audit in South Africa (1991–2009).

- *Collaborative network:* In 1981 a group of pediatricians, obstetricians, epidemiologists, midwives, and neonatal nurses initiated an annual meeting to identify priorities in perinatal care in South Africa. This group has continued to meet annually and expand, providing an effective communication network where the data can be presented and discussed, promoting ongoing improvements and use for PPIP, as well as enabling recruitment of new PPIP sites.
- *Computer-based user-friendly tool:* PPIP was developed from a paper-based audit system to a computer program that is continually being improved. The software is free and can be downloaded from the web site (www.ppip.co.za). A system provides support for users.
- *Compilation and dissemination of reports and recommendations:* Initially annual and now biannual reports were produced by the group and were sent to all sites conducting births. Funders covered the costs of meetings to produce the reports and of printing. The report was disseminated by the National Department of Health.

Panel 2. National process toward scaling up perinatal audit in Bangladesh

Although over 90% of births in Bangladesh occur at home, complicated cases are often referred to health facilities with an imperative to improve facility outcomes for mothers and babies. During the first annual International Perinatal Congress in Dhaka, February 2003, the government and many stakeholders explored the potential for perinatal mortality audit in Bangladesh. The South African PPIP software and process was presented for consideration for adaptation. Later meetings were held with key stakeholders, existing data collection systems were reviewed, and LAMB Hospital Bangladesh shared their experience of using PPIP for the previous 3 years.

The government of Bangladesh selected 5 pilot facilities based on capacity to provide emergency obstetric care and to represent varying levels of the health system. A 3-day training course was created by LAMB for health workers from these pilot facilities. The training provided the software and job aids as well as an exploration of values involved in perinatal mortality audit, such as accuracy, honesty, and an acknowledgement that every life matters. A 1-day Training of Trainers course was subsequently developed. Follow-up visits were made to each of the facilities to monitor progress and to gather feedback from users. This feedback led to the creation of a birth register and an easy-to-read wall poster to assist with PPIP data entry. In response to challenges with the PPIP software where computer access is limited, a paper-based system was developed.

Perinatal mortality audit has now expanded to 22 health facilities in Bangladesh. In 2006, an assessment was conducted of the first 17 facilities. Several challenges were identified:

Challenge	Proposed solution
Communication between teams	Complete perinatal death records depend on communication between the obstetric unit where births and stillbirths occur and the pediatric unit where neonatal deaths occur. One forum for this is the monthly facility coordination meeting, but this may not involve all the necessary staff.
Fear of blame	Staff fear failure and embarrassment for wrongdoing. Managers of perinatal audit meetings shifted focus from blame to learning.
Extra work for already over-stretched health staff	Filling out audit forms and monthly meetings can be seen as an additional burden. To recognize the extra effort, a token compensation (Tk. 500, or US $8) was paid monthly to the focal person at each pilot facility.
Software issues	Computer-based data collection and analysis relies on trained staff and requires capacity for updating and troubleshooting the software. Ultimately, the objective is more for health workers to properly record deaths than to learn how to use specific software and technology must be appropriate to the setting. If collation is required, it should be done centrally.
Inability to address modifiable factors	Even when audit runs well, many health facilities have a high patient load and are under-staffed. Drugs and supplies logistics may not be reliable. Change requires involvement of higher level decision makers.

While the expansion of perinatal mortality audit in Bangladesh has not yet reached desired levels, there is high level commitment to the process of counting every death. The Director General of Health has recently called for notification of all maternal and perinatal deaths in facilities using a modified version of the perinatal mortality audit form. The Ministry of Health and Family Welfare of Bangladesh included perinatal mortality audit in its 3-year policy document, in-service training, and annual program implementation plans. The introduction of perinatal mortality audits has led to increased awareness of the need for accurate record keeping, a better understanding among health workers of the data in their own facilities, and in several facilities quality of care for mothers and newborns is improving.