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Incidence of intrapartum stillbirth and associated risk factors in tertiary care setting of Nepal: a case-control study

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Abstract

Background: Each year, 1.2 million intrapartum stillbirths occur globally. In Nepal, about 50 % of the total number of stillbirths occur during the intrapartum period. An understanding of the risk factors associated with intrapartum stillbirth will facilitate the development of preventative strategies to reduce the associated burden of death. This study was conducted in a tertiary-care setting with the aim to identify risk factors associated with intrapartum stillbirth.

Methods: A case-control study was completed from July 2012 to September 2013. All women who had an intrapartum stillbirth during the study period were included as cases, and 20 % of women with live births were randomly selected upon admission to create the referent population. Relevant information was retrieved from clinical records for case and referent women. In addition, interviews were completed with each woman to determine their demographic and obstetric history.

Results: During the study period, 4,476 women were enrolled as referents and 136 women had intrapartum stillbirths. The following factors were found to be associated with an increased risk for intrapartum stillbirth: poor familial wealth quintile (Adj OR 1.8, 95 % CI-1.1–3.4); less maternal education (Adj OR, 3.2 95 % CI-1.8–5.5); lack of antenatal care (Adj OR, 4.8 95 % CI 3.2–7.2); antepartum hemorrhage (Adj OR 2.1, 95 % CI 1.1–4.2); multiple births (Adj. OR-3.0, 95 % CI- 1.9–5.4); obstetric complication during labor (Adj. OR 4.5, 95 % CI-2.9–6.9); lack of fetal heart rate monitoring per protocol (Adj. OR-1.9, 95 % CI 1.5–2.4); lack of partogram use (Adj. OR-2.1, 95 % CI 1.1–4.1); small-for-gestational age (Adj. OR-1.8, 95 % CI-1.2–1.7); preterm birth (Adj. OR-5.4, 95 % CI 3.5–8.2); and being born preterm with a small-for-gestational age (Adj. OR-9.0, 95 % CI 7.3–15.5).

Conclusion: Being born preterm with a small-for-gestational age was associated with the highest risk for intrapartum stillbirth. Inadequate fetal heart rate monitoring and partogram use are preventable risk factors associated with intrapartum stillbirth; by increasing adherence to these interventions the risk of intrapartum stillbirth can be reduced. The association of the lack of appropriate antenatal care with intrapartum stillbirth indicates that quality antenatal care may improve fetal health and outcomes.

Trial registration: ISRCTN97846009

Abbreviations: AdjOR, Adjusted odds ratio; AGA, Appropriate for gestational age; ANC, Antenatal care attendance; FHRM, Fetal heart rate monitoring; SGA, Small-for-gestational age

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Plain English summary

Stillbirth during labor (intrapartum stillbirth) is a global problem. In Nepal, more than half of stillbirth takes place during labor. Identifying risk factors associated with intrapartum stillbirth may provide evidence to develop preventive strategies.

A research study was conducted at a tertiary level hospital in Nepal, Paropakar Maternity and Women's Hospital, to identify risk factors associated with stillbirth occurring during labor. The study was conducted from July 2012 to September 2013. Relevant information was retrieved from clinical records and interviews were completed with each woman to determine their demographic and obstetric history.

The study found the woman from women from poorer families had higher risk for intrapartum stillbirth. Similarly, uneducated woman without antenatal care, woman who had obstetric complications during pregnancy and labor had associated risk of intrapartum stillbirth. Woman whose labor progress was not adequately assessed using partogram and fetal heart rate not monitored as per standard had risk for intrapartum stillbirth. Further results show that small and premature babies had the highest risk of stillbirth.

Conclusion: Being born prematurely and small had the highest risk for intrapartum stillbirth. Inadequate fetal heart rate monitoring and partogram use are preventable risk factors associated with intrapartum stillbirth; by increasing compliance to these interventions the risk of intrapartum stillbirth might be reduced.

Background

In many societies, and on the worldwide policy agenda, stillbirths are not accounted for despite the fact that each stillbirth is a tragedy for mothers and their families [1, 2]. Although the global burden of disease measurement does not include stillbirths, 2.65 million stillbirths (delivered at ≥ 1000 g or ≥ 28 weeks of gestation) occur annually [3, 4]. Ninety eight percent of third trimester stillbirths occur in low- and middle-income countries, with more than three quarters of them in South Asia and sub-Saharan Africa [1]. The period surrounding labor and delivery represents the time of highest risk, when 45 % of all stillbirths occur [1]. With improvements in the quality of intrapartum care in high-income countries, most of these stillbirths have been averted [5–7]. Of the total number of stillbirths that occur in South Asia, 57 % are during the intrapartum period [1]. Variation in the rate of intrapartum stillbirth within countries is wide and depends upon the readiness of health facilities to provide intrapartum care, as well as the preparedness of the birth attendant for each delivery. Identifying risk factors for intrapartum stillbirth, and delays in the quality of care provided, is

critical to identify appropriate interventions to reduce intrapartum stillbirth.

Maternal health is closely related to newborn health, and there are a number of risk factors for poor maternal health that have been linked to poor fetal outcomes [8]. Two systematic reviews done by Lawn et al. [9] and Di Mari et al. [10], have revealed several risk factors for third trimester stillbirth including: adolescent or elderly pregnancy; grand multi-parity; poor maternal nutrition, such as low body mass index or severe anemia; maternal medical conditions during pregnancy; exposure to toxic substances, such as tobacco, use of biomass for cooking or environmental toxins; and socio-economic deprivation, i.e., poor access to health-care services during pregnancy, either due financial barriers or inadequate access to information [9, 10].

However, there are few studies from low-income countries identifying preventable risk factors for intrapartum stillbirth, especially in settings where obstetric care is readily available [11]. Population-based studies conducted in low- and middle-income countries have shown that obstetric complications during the intrapartum period, such as preeclampsia, fetal mal-presentation, prolonged labor, preterm delivery, or cesarean section, are associated with intrapartum stillbirth [12–14]. A population-based study in Ghana revealed that poverty constituted the highest risk for intrapartum stillbirth, and furthermore, that this risk was not influenced by health care utilization [15]. A systematic review by Lawn et al. [16] examining risk factors for intrapartum stillbirth indicated that intrapartum stillbirth is preventable, as 25–67 % are primarily due to preventable intrapartum complications, such as prolonged labor [16]. If effective interventions are implemented at the facility level, it is likely that a number of these stillbirths could be prevented. Similarly, hospital-based audits in several low-income countries have demonstrated that more than 25 % of intrapartum stillbirths could have been prevented with improved obstetric care [17–20].

Identifying preventable risk factors for intrapartum stillbirth in low-income countries like Nepal is important as the current rate of intrapartum stillbirth is 13.4 per thousand deliveries, and these stillbirths account for 55 % of the total stillbirth rate [1]. Over the past 10 years, there has been a slow decline in the number of intrapartum stillbirths, accompanied by an increase in institutional delivery, with more than 60 % of Nepali women now delivering at a health facility [4, 21–25]. Thus, understanding the risk factors for intrapartum stillbirth in the health facility setting, and developing strategies to reduce the number of preventable risk factors is critical.

The aim of this study was to identify preventable risk factors associated with intrapartum stillbirth in a tertiary care setting in Nepal.

Methods

Study design

We used a case–control study design nested within a larger prospective cohort study. All women delivering in the hospital were included in the source population, from which 20 % were randomly selected to be in the referent population. This 20 %, i.e. the referent population, was selected at the time of their admission to the hospital using a lottery technique. All women experiencing an intrapartum stillbirth during the study period were included in the case population. Any antepartum stillbirth occurring in the referent population was excluded from this study; while any intrapartum stillbirth that occurred in the referent population was excluded from that population and re-categorized for inclusion in the case population. The sample size of this study was based on calculations used in the larger prospective cohort study, which aimed to detect a 20 % reduction in perinatal mortality with a statistical power of 80 % and a level of significance of 5 %.

Ethical approval for this study was obtained from the Institutional Review Committee at Paropakar Maternity and Women's Hospital, the Nepal Health Research Council (reg. 37/2012) and from Uppsala University (Sweden) (dnr. 2012/267), as part of a larger cohort study evaluating the impact of a Helping Babies Breathe quality improvement cycle on perinatal mortality [26]. The study was registered as clinical trial under the registration number: ISRCTN 97846009. The protocol for the study can be accessed from <http://bmcpediatr.biomedcentral.com/articles/10.1186/1471-2431-12-159>. Written consent was received from each of the study participants prior to their inclusion.

Study setting

We conducted this study at Paropakar Maternity and Women's Hospital; a tertiary, government-funded hospital located in Kathmandu, Nepal. The hospital has about 22,000 deliveries each year, with an institutional intrapartum stillbirth rate of nine per thousand births [27]. The hospital provides comprehensive maternal care services delivered by obstetricians, medical doctors and nurse midwives. The clinical protocol designed for the assessment of women coming to the hospital for delivery and completed upon their admission includes: ascertainment of gestational age and assessment of fetal heart sound, obstetric complication, and stage of labor. Based on these assessments, and the risk category assigned, each woman was then transferred to one of three different delivery units for intrapartum care. This study was conducted over a period of 15 months from July 2012 to September 2013.

Participants

In this study, all intrapartum stillbirths occurring after hospital admission, i.e. among women who were in labor

with detectable fetal heart sounds upon admission, were included as cases. Women that had fetal death at admission, i.e. absence of fetal heart sounds, were excluded. Similarly, antepartum stillbirths occurring prior to the onset of labor were also excluded from the case population. All women who were randomly selected to be in the referent population were included in this population if they had a live birth. Antepartum stillbirths were also excluded from the referent population.

Data collection

A surveillance system was set up by recruiting 12 female surveillance officers to be stationed in the admission, delivery, and postnatal units. Any woman admitted to the hospital for delivery was marked in the surveillance registry. From this sampling frame, study participants were randomly selected using a lottery technique. Specifically, an opaque jar with 100 balls was kept in the admission unit, of which 80 were white and 20 were yellow. Upon each admission, a ball was drawn from the opaque jar; if a yellow ball was selected, the woman was enrolled into the study as part of the referent population. When a woman was selected as part of the referent population, she was tracked from the point of admission through her discharge to assess labor progression and birth outcomes.

The surveillance team in the delivery unit observed all deliveries together with referent population. When intrapartum stillbirth occurred in the delivery unit, the surveillance officers enrolled the woman with intrapartum stillbirth into the study as part of the case population. Woman in case population was tracked from delivery through her discharge. Women in case population (intrapartum stillbirth) had also received the same rigorous observations during labor and birth as the women in referent population. Information collected for women in case and referent population remained the same. For both the referent and case populations, information on parity, previous obstetric and medical history, care received during the current pregnancy, obstetric or medical complications during this pregnancy, and intrapartum care was retrieved from clinical record forms. Surveillance team members conducted interviews at the time of discharge with each woman using a questionnaire designed to assess the woman's social, demographic and household information.

After receiving the completed clinical record and interview forms from the surveillance officers, a research manager checked each form for completeness. Additionally, 10 % of clinical record forms were checked against the primary data source to ensure data accuracy. Data entry officers reassessed the completeness of all forms, recoded open-ended response questions, and entered the data from each checked form into a CS-Pro database. To prevent data loss, indexing of all collected forms was performed. After data entry and data cleaning in the CS-Pro

database was completed, the dataset was exported to SPSS 17 for data analysis.

Variables

Intrapartum stillbirth was defined as the delivery of any fetus after 22 weeks of gestation, or with a birth weight more than 500 g, who had detectable fetal heart sounds upon admission, but died during the intrapartum period and thus had an Apgar score of 0 at 1 and 5 min, without signs of maceration. Intrapartum stillbirth cases were retrieved from the clinical journal [1].

Antepartum stillbirth was defined as the delivery of any non-viable fetus after 22 weeks of gestation, or with a birth weight more than 500 g, with an Apgar score of 0 at 1 and 5 min and signs of maceration, or absent fetal heart sound before the initiation of labor [1].

Maternal age was categorized into five-year intervals.

Maternal education was categorized into two groups as women who had 5 years or less than 5 years of education (primary education), and those who had six or more years of education (secondary education or higher).

Ethnicity was categorized into groups according to the social caste system within Nepal [28] as most advantaged (Brahmin/Chettri); relatively advantaged Janajatis (Newar, Gurung and Thakali); relatively disadvantaged Janajatis; relatively disadvantaged non-Dalit; most disadvantaged (Dalit and Muslim).

Wealth index was used as a measure of socioeconomic position and constructed according to the nationally representative health surveys (Demographic Health Surveys), to compare socioeconomic inequalities [29, 30]. During interviews with each mother, data was collected on ownership of durable assets (e.g. car, refrigerator, bicycle, radio, television), housing characteristics (e.g. number of rooms, dwelling floor and roof materials, toilet facilities), and access to services (e.g. electricity supply, drinking water source). Using the scores from the first principal component analysis, a wealth index (asset index) was constructed. Based on the value of this index, individuals were sorted and population quintiles were established using cut-off values. These quintiles were then ranked from bottom to top as poorest, poorer, middle, richer and richest [31].

Antenatal care attendance was determined based on whether a mother attended any antenatal care (ANC) visits during which she received a clinical examination, counseling, and medication (if needed) from a skilled provider as per guidelines. ANC was categorized into two groups as those who attended at least one ANC visit, and those who did not receive any ANC at all.

Parity was based on the number of times a woman had previously given birth after the age of viability, i.e. 22 weeks, including both live and still births [32]. Parity was categorized into three groups including primiparous, multiparous (1–2) or multiparous (3 or more).

Previous stillbirth was categorized as whether the women had any stillbirth in a previous pregnancy(s), or not.

Antepartum hemorrhage was defined as vaginal bleeding prior to the onset of labor. This was categorized into two groups as those having any antepartum hemorrhage, or none.

Hypertensive disorder of pregnancy was defined as a maternal diastolic blood pressure of 90 mmHg or more in two consecutive assessments, which were at least four hours apart, during pregnancy. This was categorized as those having the condition in the current pregnancy, or not.

Medical complication during pregnancy was considered present in women having diabetes mellitus, severe anemia (Hb <7 gm/L), or epilepsy during the current pregnancy.

Multiple birth included women pregnant with more than one fetus.

Obstetric complication during delivery was defined as any complication that a woman had during the intrapartum period [33], including:

Hypertensive disorder Classified by maternal diastolic blood pressure greater than or equal to 90 mmHg in two separate recordings

Mal-presentation Presentation of the fetus in any position besides vertex, i.e. with the top of the head appearing first

Prolonged labor Cervical dilation that does not move beyond 4 cm after eight hours of regular contractions, or cervical dilation lying to the right of the alert line on the partogram; and

Prolapsed cord Characterized by the presence of the umbilical cord in the birth canal below the fetal presenting part, or at the vagina following the rupture of membranes.

Fetal Heart Rate Monitoring (FHRM) per protocol was considered adequate when the fetal heart rate was measured at least every half an hour using the auscultation technique, during the intrapartum period. Any labor in which fetal heart rate was not monitored within every half an hour was categorized as non-adherent to protocol.

Adherence to partogram use was considered adequate when the partogram was used, i.e. filled in for the progress of cervical dilation and descent of the head, every half an hour to assess the progression of labor. Any case where labor progression was not adequately monitored using the partogram was categorized as non-adherent.

Gestational age of the baby was categorized into two groups as preterm or term according to the following definitions:

Preterm birth which included babies born before 37 completed weeks of gestation, estimated by the date of the mother's last menstrual period or based on clinical examination of the newborn

Term birth which included babies who were born at, or after, 37 completed weeks of gestation, estimated by the mother's last menstrual period or based on clinical examination of the newborn.

Weight for gestational age at birth was categorized into two groups as small- or appropriate- for gestational age according to the following definitions:

Small-for-gestational age (SGA) which included babies whose birth weight was less than the 10th percentile according to the appropriate gestational age and sex-specific reference population standards [34]

Appropriate for gestational age (AGA) which included babies whose birth weight was greater than or equal to the 10th percentile according to the appropriate gestational age and sex-specific reference population standards [34].

Statistical analysis

The comparison of demographic and obstetric characteristics of the women in the referent and case populations was performed using Pearson's chi-square test for categorical variables, along with Fisher's exact test. Means and medians of maternal age were also compared. The following variables were compared between the case and referent populations: maternal age (categorical), maternal education, ethnicity, wealth quintile, ANC attendance, parity, previous stillbirth, antepartum hemorrhage, hypertensive disorder during pregnancy, medical disorder during pregnancy, multiple births, obstetric complications during labor, FHRM per protocol, use of partogram, mode of delivery, sex of baby, weight for gestational age at birth, gestational age of baby and a combination variable including both weight for gestational age and gestational age at birth.

Univariate logistic regression was used to determine the level of association between different demographic/obstetric characteristics and intrapartum stillbirth that showed a difference ($p < 0.001$) in the chi-square analysis, between the referent and case populations. Multivariate logistic regression analysis was then conducted to determine the level of association between the demographic or obstetric characteristics and intrapartum stillbirth for those with a significant association in the univariate model.

To the greatest extent possible, missing data was minimized; however, there were missing data for some background characteristics of the mothers. We used the multiple imputation method to deal with this data that was missing at random [35].

Results

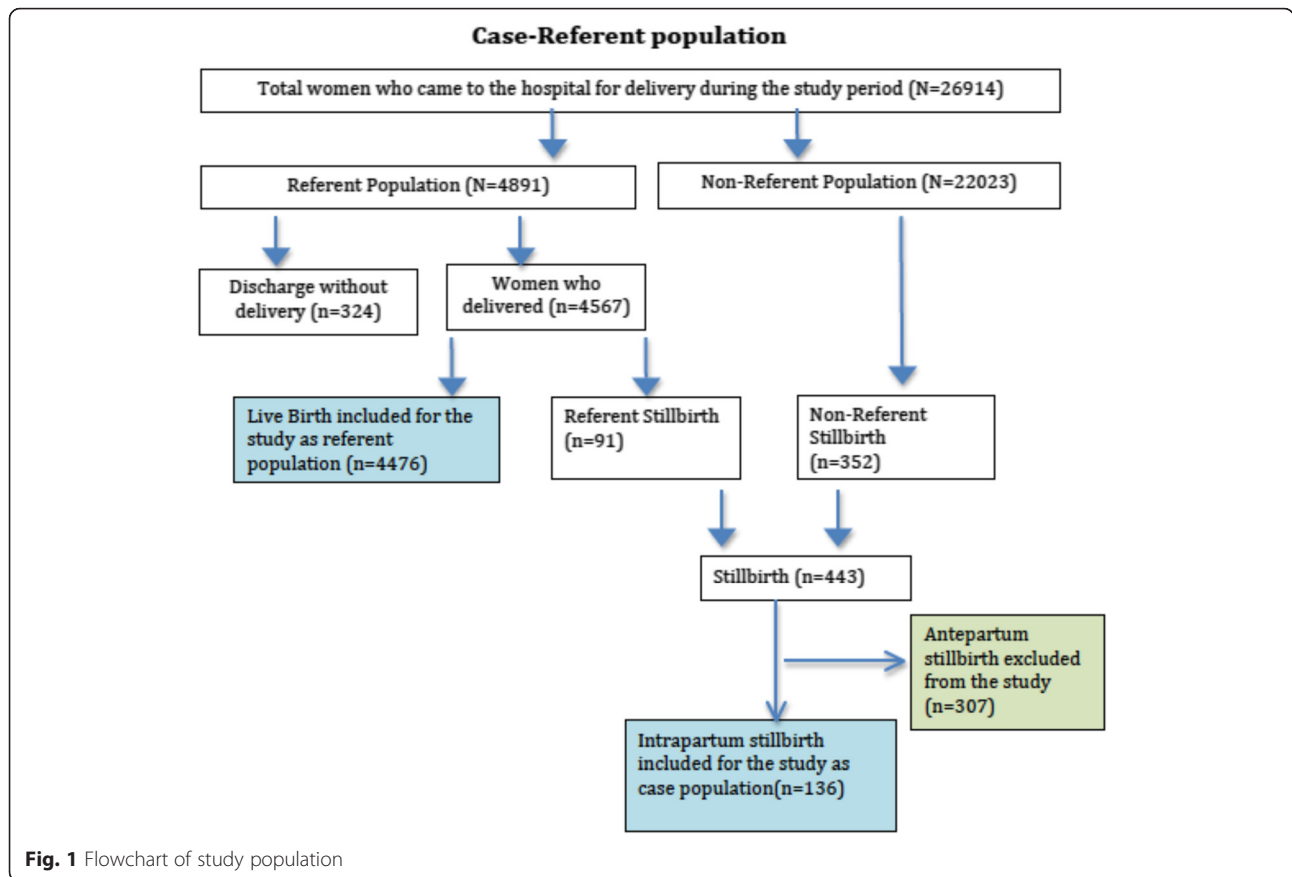
During the study period a total of 26,914 women came to the hospital for delivery, of which 4,891 were selected to be in the referent population; however, of these, 324 mothers were discharged without delivering. Of the total referent population who delivered at the hospital, 4,476 infants were live-born and 91 were stillborn. Among the non-referent population there were 352 stillbirths. Thus, during the study period, 443 stillbirths occurred among the referent and non-referent populations combined, giving a stillbirth rate of 17.6 per thousand deliveries. Of

the 443 stillbirths, 136 (30.7 %) were intrapartum stillbirths, giving an intrapartum stillbirth rate of 5.3 per thousand deliveries (Fig. 1). In a quarter of the observed deliveries, FHRM was performed according to protocol, whereas partogram use was per protocol in 50 % of deliveries.

Table 1 shows the demographic and obstetric characteristics of women in both the referent and case populations. The mean age of mothers in the case and referent populations were 25.7 and 23.7 years, respectively. The median age of mothers in the referent population was 23 versus 24 years in the case population. Differences between the two population groups were significant in the following categories: maternal age, education, wealth status, ANC, and parity. Significant differences were also seen between the case and referent populations in the presence of previous stillbirth, antepartum hemorrhage, hypertensive disorder during pregnancy, multiple birth, obstetric complication during labor, FHRM as per protocol, partogram use, mode of delivery, weight for gestational age, gestational age of the baby, and the combination of weight for gestational age and gestational age.

The univariate logistic regression analysis showed an association between the following risk factors and intrapartum stillbirth: increasing maternal age; being from the poorest wealth quintile; lack of ANC; increasing parity; incidence of antepartum hemorrhage or hypertensive disorder during pregnancy; having multiple births; the presence of obstetric complications during labor; inadequate adherence to FHRM protocol; non-use of the partogram during labor; delivery by cesarean section; having an infant who is SGA, an infant who was preterm, or an infant who was born both SGA and preterm (Table 2).

Multivariate analysis was then performed with all significant (as determined by univariate analysis above) risk factors included in the multivariate model. Women with less education were three times more likely to have an intrapartum stillbirth as compared to those who had more education (AdjOR, 3.2 95 % CI-1.8–5.5). Women who did not attend any ANC checkups faced a five-fold increased risk for intrapartum stillbirth compared to those who went for at least one checkup (AdjOR, 4.8 95 % CI 3.2–7.2). Women from the poorest families were two times more likely to have an intrapartum stillbirth as compared to women from higher wealth quintiles (AdjOR 1.8, 95 % CI-1.1–3.4). Women who experienced antepartum hemorrhage had a two-fold higher risk of intrapartum stillbirth than women who did not (AdjOR 2.1, 95 % CI 1.1–4.2). Women who had multiple births were three times more likely to have an intrapartum stillbirth than women who had single births (Adj. OR-3.0, 95 % CI- 1.9–5.4). Women who had any obstetric complication during the labor period were four times more likely to experience intrapartum stillbirth (AdjOR-4.5, 95 % CI 2.9–6.9). Women whose FHRM was not done per protocol and those for whom a partogram



was not used were two times more likely to have an intrapartum stillbirth (AdjOR-1.9, 95 % CI 1.5–2.4; and AdjOR-2.1, 95 % CI 1.1–4.1). Intrapartum stillbirths were two times more likely when the infant was SGA compared to AGA (AdjOR-1.8, 95 % CI-1.2–1.7). Intrapartum stillbirths were five times more likely to be delivered preterm than at a term gestational age (AdjOR-5.4, 95 % CI 3.5–8.2). Infants who were born preterm with a SGA had a nine-fold increased risk for intrapartum stillbirth compared to those delivered at term who were AGA (AdjOR-9.0, 95 % CI 7.3–15.5) (Table 2).

Discussion

Our study examined various demographic and obstetric risk factors and their association with intrapartum stillbirth in a tertiary hospital setting in Nepal. Women who delivered a SGA infant prematurely had the highest risk for intrapartum stillbirth. Poor women with less education and poor utilization of ANC also had an increased risk for intrapartum stillbirth. Women who experienced antepartum hemorrhage, had multiple births or obstetric complications during labor also had a higher risk for intrapartum stillbirth. Finally, women who did not receive adequate care during the intrapartum period, i.e. sub-standard FHRM and lack of labor progression monitoring

with a partogram, were also more likely to have had an intrapartum stillbirth.

Although findings from hospital-based studies may have limited generalizability at the population level, the lack of a periodic national perinatal health survey or a vital registration system in Nepal necessitates the use of hospital-based studies as one of the best available options to identify burden of disease in this setting. The information gathered from these studies is vital for the improvement of various clinical practices, including care given during the intrapartum period; additionally, the information can also be used to improve care at the community level, through the translation of best practice to these settings. One possible limitation of this study is the potential for under-reporting or a lack of reporting of maternal obstetric or medical conditions, especially in women facing the bereavement of delivering a stillborn infant. Similarly, not all women, even those who attended an ANC visit, received screening for medical and/or obstetric complications during pregnancy, so there could be an additional under-reporting of these conditions. Another limitation was the timing of enrollment of women in referent and case population. The women in referent population were enrolled at the time of admission while the women in case population were enrolled at the time

Table 1 Demographic and obstetric characteristics of referent women with live births and women with intrapartum stillbirth

Variable	Referent Live Birth (N = 4476)	Intrapartum Stillbirth (N = 136)	P-value*
Maternal age in years			
Mean ± SD	23.7 ± 4.4	25.7 ± 6.3	
Median (IQR)	23.0 (20–26)	24.0 (20–30)	
	n (%)	n (%)	
Maternal age (5-year interval)			
< 20	1224 (27.3)	34 (25.0)	<i>p</i> < 0.001
20–25	1957 (43.7)	45 (33.1)	
26–30	973 (21.7)	28 (20.6)	
> 30	322 (7.2)	29 (21.3)	
Maternal education			
Primary education (5 years) or less	1459 (32.6)	17 (12.5)	<i>p</i> < 0.001
Six years of education or more	3017 (67.4)	119 (87.5)	
Ethnicity			
Brahmin/Chhetri (hill or terai)	1733 (38.7)	42 (30.9)	<i>p</i> = 0.278
Relatively advantaged Janajatis	812 (18.1)	22 (16.2)	
Disadvantaged Janajatis	1293 (28.9)	48 (35.3)	
Non-Dalit (terai)	369 (8.2)	12 (8.8)	
Dalit (hill and terai)	235 (5.3)	11 (8.1)	
Muslim	34 (0.8)	1 (0.7)	
Wealth quintile			
Poorest	787 (19.0)	16 (34.0)	<i>p</i> < 0.01
Poorer	805 (19.5)	11 (23.4)	
Middle	864 (20.9)	7 (14.9)	
Richer	837 (20.2)	7 (14.9)	
Richest	845 (20.4)	6 (12.8)	
Antenatal Care Attendance			
At least one visit	3904 (87.2)	79 (58.1)	<i>p</i> < 0.001
No ANC	572 (12.8)	57 (41.9)	
Parity			
Primipara	2418 (54.0)	64 (47.1)	<i>p</i> < 0.001
Multipara (1–2)	1869 (41.8)	51 (37.5)	
Multipara (3 or more)	189 (4.2)	21 (15.4)	
Previous stillbirths			
No	4380 (97.9)	130 (95.6)	<i>p</i> = 0.08
Yes	96 (2.1)	6 (4.4)	
Antepartum hemorrhage			
No	4352 (97.2)	118 (86.8)	<i>p</i> < 0.001
Yes	124 (2.8)	18 (13.2)	
Hypertensive disorder during pregnancy			
No	4167 (93.1)	121 (89.0)	<i>p</i> = 0.05
Yes	309 (6.9)	15 (11.0)	
Medical disorder during pregnancy			
No	4262 (95.2)	127 (93.4)	<i>p</i> = 0.2
Yes	214 (4.8)	9 (6.6)	

Table 1 Demographic and obstetric characteristics of referent women with live births and women with intrapartum stillbirth (Continued)

Multiple birth			
No	4438 (99.2)	126 (92.6)	$p < 0.001$
Yes	38 (0.8)	10 (7.4)	
Obstetric complication during labor ^a			
No	3965 (88.6)	69 (50.7)	$p < 0.001$
Yes	511 (11.4)	67 (49.3)	
Fetal Heart Rate monitoring as per protocol			
Yes	1100 (24.6)	9 (6.6)	$p < 0.001$
No	3376 (75.4)	127 (93.4)	
Use of Partogram			
Yes	2272 (50.8)	15 (11.0)	$p < 0.001$
No	2204 (49.2)	121 (89.0)	
Mode of delivery			
Vaginal	3464 (77.4)	92 (67.6)	$p = 0.007$
C-section	1012 (22.6)	44 (32.4)	
Sex of newborn			
Female	2103 (47.0)	52 (38.2)	$p = 0.45$
Male	2373 (53.0)	84 (61.8)	
Weight per gestational age			
Appropriate-for-gestational age	2796 (62.5)	73 (53.7)	$p < 0.02$
Small-for-gestation age	1680 (37.5)	63 (46.3)	
Gestational age			
< 37 weeks	4113 (91.9)	74 (54.4)	$P < 0.001$
≥ 37 weeks	363 (8.1)	62 (45.6)	
Gestational age and weight per gestational age			
AGA and ≥ 37 weeks	2542 (56.8)	34 (25.0)	$p < 0.001$
SGA and ≥ 37 weeks	1604 (35.8)	40 (29.4)	
AGA and < 37 weeks	254 (5.7)	39 (28.7)	
SGA and < 37 weeks	76 (1.7)	23 (16.9)	

* p -value determined by Pearson's chi-square test or Fisher's exact test

^aObstetric complications during labor included: antepartum hemorrhage, hypertensive disorder, mal-presentation, prolonged labor, and cord prolapse

of delivery. Another potential limitation is that the population-based reference standards used for defining birth weight for gestational age were not specific to Nepal, as no such standards exist; therefore, these reference standards were based on a U.S. population.

A study in Gambia by Ha et al. [15] showed a similar increase in the risk for intrapartum stillbirth among women whose families were subjected to socio-economic deprivation, potentially because poorer women receive sub-optimal pregnancy care. These women may not possess adequate resources to be able to afford the out-of-pocket expenses associated with screenings during pregnancy, and some may not even be able to access a skilled provider to receive an ANC checkup [15].

ANC plays a vital role in the maintenance or management of a woman's health during pregnancy, and many women who lack access to ANC checkups are at an increased risk of intrapartum stillbirth. Our results are consistent with other studies done in Gambia and Zimbabwe [12, 36]. ANC provided by a skilled provider can help women to better understand the growth and development requirements of their fetus and the support it needs during this time, as well as to increase their awareness of the importance of maintaining an adequate health and nutritional status throughout pregnancy [37, 38]. ANC checkups also provide a platform for a discussion with women on how to prepare for delivery, identify potential danger signs during pregnancy and labor, and understand when it is time to

Table 2 Demographic and obstetric factors associated with intrapartum stillbirth

Variables*	Crude Odds Ratio* (95 % CI)	Adjusted Odds Ratio (95 % CI)
Maternal age (linear)	1.1 (1.0–1.1)	1.0 (0.9–1.1)
Maternal education		
Primary education or less	3.4 (2.0–5.7)	3.2 (1.8–5.5)
Second education or more	1	
Wealth quintile		
Non-poor	1	
Poor	1.6 (1.0–2.7)	1.8 (1.1–3.4)
Antenatal care		
At least one ANC visit	1	
No ANC	4.9 (3.5–7.0)	4.8 (3.2–7.2)
Parity		
Primi	1	
Multi-para	1.6 (1.4–1.8)	1.2 (1.0–1.5)
Antepartum hemorrhage		
No	1	
Yes	5.4 (3.2–9.1)	2.1 (1.1–4.2)
Hypertensive disorder during pregnancy		
No	1	
Yes	1.7 (1.0–2.9)	0.9 (0.5–1.8)
Multiple birth		
No	1	
Yes	9.3 (4.5–19.0)	3.0 (1.9–5.4)
Obstetric complication during intrapartum period		
No	1	
Yes	7.5 (5.3–10.7)	4.5 (2.9–6.9)
Fetal Heart Rate monitoring as per protocol		
Yes	1	
No	4.6 (2.3–9.1)	1.9 (1.5–2.4)
Use of partogram		
Yes	1	
No	8.3 (4.9–14.2)	2.1 (1.1–4.1)
Mode of delivery		
Vaginal	1	
Cesarean-section	1.6 (1.1–2.4)	0.8 (0.7–1.0)
Weight per gestational age		
Appropriate-for-gestational age	1	
Appropriate-for-gestational age	1.4 (1.0–2.0)	1.8 (1.2–1.7)
Small-for-gestation age		
Gestational age		
< 37 weeks	9.5 (6.7–13.5)	5.4 (3.5–8.2)
≥ 37 weeks	1	

Table 2 Demographic and obstetric factors associated with intrapartum stillbirth (*Continued*)

Gestational age and weight per gestational age		
SGA and < 37 weeks	11.8 (7.1–19.5)	9.0 (7.3–15.5)
Others		

*Variables selected based on significant differences ($p < 0.001$) shown between the case and referent populations by Pearson's chi-square test or Fisher's exact test

a Crude odds ratio determined through univariate logistic regression analysis for likelihood of intrapartum stillbirth

seek care because delivery is imminent [39, 40]. Less educated women may have less access to and understanding of this valuable information, a lack of which has consistently been identified as a risk factor for intrapartum stillbirth in both high- and low-income countries [13, 41]. ANC checkups provide a valuable method for improving the understanding of mothers about pregnancy, birth preparedness, danger signs, and care seeking; and furthermore facilitate open discussion between the mother and her skilled provider.

Obstetric complications occurring during labor or delivery, including mal-presentation or prolonged labor, can cause detrimental, and potentially irreversible, insults to the fetus during the intrapartum period, potentially leading to death [11, 42]. These intrapartum stillbirths might have been averted if better obstetric care and fetal and maternal monitoring were available. In settings where FHRM is sub-optimal and partograms are not used to monitor labor progression, the risk of death further increases [43].

Multiple births have been associated with maternal morbidities, such as preterm labor and antepartum hemorrhage; in fact, the majority of twin pregnancies are associated with the delivery of SGA babies. Furthermore, in some cases, multiple births can lead to death of the fetus during the antepartum and intrapartum periods [44–46]. Studies have shown that women with multiple pregnancies who receive adequate obstetric care during pregnancy and the intrapartum period, have fewer adverse outcomes [47].

As shown in this study and several other previous studies, preterm delivery combined with having a SGA carries the highest risk for intrapartum stillbirth, with the risk of death increasing in very premature deliveries [41, 48, 49].

One of the key finding from our study is that sub-optimal use of FHRM and a partogram for the monitoring of labor progression are each associated with intrapartum stillbirth. A potential reason for this is that high-risk deliveries, such as those involving fetal distress, are not identified, which can lead to intrapartum insults on the fetus. Similarly, interventions required to prevent or manage prolonged labor, or other obstetric complications during

labor, cannot be detected in a timely manner if a partogram is not used to monitor the progression of labor. Complications, such as prolonged labor, mal-presentation of the fetus, or maternal medical condition, can lead to severe fetal compromise during the intrapartum period and thus to intrapartum stillbirth, which might have been prevented in a tertiary care setting where emergency obstetric care is available.

Inadequate adherence to standardized protocols for intrapartum monitoring can be due to a multitude of factors. These factors may include: inadequate institutional leadership and/or support to improve clinical practice, shortages of staff, poor knowledge on the use of the partogram or FHRM, heavy workload for an inadequate number of staff, or inadequate understanding of the relevance and importance of the use of a partogram in preventing obstructed labor, as shown by studies in Africa [50–53]. Further research in this area is critical, and should explore potential contextual barriers preventing adherence to standard protocols, with the aim of identifying evidence-based interventions that facilitate improved adherence to these protocols.

Conclusion

Our study has identified the combination of preterm birth and SGA as carrying the highest risk for intrapartum stillbirth, and highlights several other preventable risk factors associated with intrapartum stillbirth. In doing so, we have also highlighted the need for early implementation of adequate preventive strategies; including the proper use of FHRM and the partogram in order to better identify potential complications during the intrapartum period. As an effort to reduce the preventable burden of intrapartum stillbirth, the government of Nepal could use a two-pronged approach: first, efforts must be made to improve the quality of care provided during the antenatal and intrapartum periods, and second, conscious efforts are also needed to decrease the gap in equity and to promote an equitable distribution of antenatal and intrapartum health-care services, so that poor and marginalized populations are not left behind. The losses that families face as a result of stillbirth have been recognized and target goals for the reduction of these losses have been set as part of the recent global agenda, with the aim to reduce the number of stillbirths to 10 or less per 1,000 deliveries by 2035. Adequate prevention and management of identified risk factors constitute major steps in the reduction of the number of intrapartum-related stillbirths.

Acknowledgements

We would like to thank Viktoria Nelin for editorial assistance on the manuscript and Ravi Vitrakoti for his role as project manager. We thank Dr. Dhan R Aryal, Dr. Sheela Verma, Dr. Jyoti R Dhakwa, Dr. Naresh P KC, Dr. Kamal R Sharma and Dr. Geha Nath Baral for their input in the study protocol and design. We thank Ms. Maiya Manandhar and her team for leading the training of trainers for HBB. We also sincerely acknowledge Mr. Amar Amatya, the surveillance officers, data

entry officers and data management officer for their efforts in making this study possible. The group is very grateful to the mothers who participated in the study.

Funding

Laerdal Foundation for Acute Medicine (Stavanger, Norway) and Swedish Society of Medicine supported this study as part of a larger study evaluating the impact of a simplified neonatal resuscitation protocol on birth outcomes and health worker performance. The funding agency had no influence on the conceptualization or design of the study.

Availability of data and materials

Data supporting the findings can be made available on request.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Authors' contributions

AK, MM, JW and UE conceptualized and designed the study. AK was the principal applicant for funding. AK was responsible for the data collection and data management. AK, JE, UE and MM were responsible for the data analysis and drafting of the manuscript. JG, GNB and KB reviewed and provided input to the draft manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Ethical Review Board of Nepal Health Research Council (reg. 37/2012) as part of a larger cohort study evaluating the impact of a Helping Babies Breathe quality improvement cycle on perinatal mortality. Written consent was obtained from the participants.

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Received: 27 September 2015 Accepted: 23 August 2016

Published online: 31 August 2016

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