Original Article

Perinatal Mortality and its Causes in a Rural Block in Tamil Nadu, Southern India: A Community-Based Nonconcurrent Cohort Study

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Abstract

Background: Globally, over 130 million babies are born every year, and almost 8 million die before their first birthday. Data on perinatal mortality (PM) and its various causes are lacking in many parts of the world including India. **Objectives:** This study aimed to estimate stillbirth (SB), early neonatal, and PM rates and its causes over the last decade in a rural development block, India. **Materials and Methods:** This is a nonconcurrent cohort study, analyzing the births, SBs, and early neonatal deaths between January 2008 and December 2017. The World Health Organization-PM classification was used to allocate causes of death as well as maternal risk factors. Birth weights were classified using standard growth charts. **Results:** There were 20,704 births after 28 weeks gestation and where the fetus weighed more than 1000 g of which 285 were SBs. There were 20,419 live births with 229 early neonatal deaths. There was a significant decline in PM rate from 32 per 1000 to 11 per 1000. There was a decrease in the small for gestational age fetuses from 20% to 12.5%. The main cause for SBs was antepartum hypoxia (34.4%) and fetal growth disorders (26.3%). Complications of intrapartum events contributed to 32.8% of the early neonatal deaths. **Conclusion:** Steady decline in PM rate and in the number of small for gestational age fetuses over 10 years was seen. Pregnancy registration and follow-up help in giving us a better understanding of the causes of PM.

Keywords: Causes of perinatal mortality, lower-middle-income countries, pregnancy registration, stillbirths

Introduction

Globally, over 130 million babies are born every year, and more than 10 million infants die before their fifth birthday, almost 8 million before their first.[1,2] Most of the infant deaths occur soon after birth: many of them in the first 28 days (neonatal deaths) and most of those during the first 7 days (early neonatal deaths [ENDs]). The World Health Organization (WHO) has defined stillbirth (SB) as when a baby is born with no signs of life with a birth weight over 1000 g, gestational age is more than or equal to 28 weeks, and/or, body length more than 35 cm.[3] Perinatal mortality (PM) includes both SBs and ENDs.

Globally, there were 2.6 million SBs in 2015, out of which 1.3 million occurred during labor and delivery.[4] India had 590,000 SBs in 2015, which globally was highest in number.[5] The Every Newborn Action Plan from the WHO has a target of 12 or fewer SBs per 1000 deliveries by 2030.[6] In 2014, as part of the India Newborn Action Plan, the Indian government adopted a target of <10 SBs per 1000 births by 2030, the first-ever national SB-prevention target.[7]

High-risk factors during the antenatal period such as gestational diabetes mellitus and pregnancy-induced hypertension contribute to PM.[8,9] The main objective of this study was to estimate SB, early neonatal, and PM rates and its causes using pregnancy registration over the last decade in a rural development block from Vellore, Tamil Nadu, southern India. The study also attempts to explore changes and understand factors associated with the burden of PM.

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Materials and Methods

Kaniyambadi comprises a mostly rural population of about 116,454 (2020) in 80 villages of Tamil Nadu, South India. Primary and secondary health care services for these villages have been provided by the Community Health and Development (CHAD) program of Christian Medical College, Vellore, in addition to the services provided by the government. Surveillance of perinatal processes and outcomes is monitored through the same four-tiered system that delivers health services with specific health workers in charge of health services as well as surveillance. Every week the part-time community health workers report (orally) to the health aide about marriages, couples eligible for contraception, pregnancies, deliveries, births, deaths, morbidity, and immunization in the village. This information is tabulated by the health aide on standardized forms which will later be checked by the nurse on her fortnightly visit to the village and subsequently by the area doctor. The data provided by the health aide are entered into a computerized database, which provides bi-weekly outputs to health aides and monthly and annual reports to managers. The cause of death is looked into by the health aide and public health nurse by home visits as well as information from medical records. The doctor in charge of the area will also ascertain the cause of death by a home visit. For all the deaths including SB and ENDs, verbal autopsies are conducted by the health aides. These were coded by physicians according to the International Classification of Diseases-PM (ICD-PM) using the narratives of the health aides.[10]

This study included information on all births in Kaniyambadi from 2008 to 2017. Fetal weights were classified according to Intergrowth 21 charts.[11] Growth charts for our population were available only from 32 weeks and the 10th centiles were comparable to the Intergrowth standards.[12] Gestational age was calculated from the last menstrual period in most cases.

Results

During the period of study 2008–2017, 21,444 women registered for antenatal care. About one-third (34%) of these women registered prior to 12 weeks. Two hundred and nine had multiple gestations. There were 20,704 births after 28 weeks gestation where the fetus weighed more than 1000 gm. Among the women registered, 2269 (11%) had at least one abortion in the past.

The mean age of the mothers was 23.9 years (minimum age of 16 and maximum age of 48 years). Baseline characteristics of the women are described in Table 1.

Among the births, <1% delivered at home and 16.6% delivered in tertiary level hospitals. Ten thousand four hundred and twenty-eight women delivered in CHAD. Among the deliveries, 75.7% were normal deliveries and the overall cesarean section rate was 17.5%. Majority of the babies (48.6%) were born full term. Small for gestational age babies comprised 15% of the total births. Gestational age was not available in a few patients who had delivery elsewhere.

Over the years, the number of women delivering in primary health centers has come down from 36.2% to 15.7%, while those delivering in tertiary care centers have gone up from 10.8% to 25.1%. The cesarean rates have increased from 14.9% in 2008 to 21.4% in 2017 with the primary lower segment cesarean section rate increasing from 10.9% to 16.3%. The instrumental deliveries have also shown a steady increase from 4.1% to 9.1%. The number of small for gestational age has decreased over the years from 20% in 2008 to 12.5% in 2017. The Chi-square for trends was significant ($P < 0.001$).

There were 20,419 live births, 20,190 were alive at the end of 7 days. There were 285 SBs and 229 ENDs. Over the years, SB rate has declined. The SB rate varies from 21 per 1000 to 6 per 1000 from 2008 to 2017 with an average SBR of 14 per 1000. The END varied from 16 to 5 per 1000. The overall PM rate changed from 32 per 1000 in 2008 to 11 per 1000 in 2017. Figure 1 shows the trends in PM.

The main cause for SBs can be attributed to antepartum hypoxia (34.4%) and disorders related to fetal growth (26.3%). Acute intrapartum events contribute to 21.1% of the SBs but are the major contributor to ENDs (32.8%). When further looking into those in the group where the cause was antepartum hypoxia, 23.6% of them were small for gestation. Intrapartum events related to fetal growth also contributed to 6.7% of the SBs. In the category of unspecified antepartum causes, 20% were small for gestation. Inappropriate fetal growth contributes to 33% of the SBs.

The PM in relation to different risk factors is shown in Table 2. PM rate (PMR) in the age group 35 years and more is 20. PMR was highest among those with abnormal presentation (181) and hypertension (89). A quarter of all pregnancies had at least one high-risk factor. If the mother had any one risk factor, the PMR was 41. The most common risk factor was anemia ($n = 1843$, 8.8%). The maternal causes which contribute to PM have been classified using ICD-PM classification [Table 3]. The association of various risk factors with SBs and ENDs is examined. The significant risk factors include maternal hypertension, multiple fetuses, abnormal presentation, prematurity, inappropriate growth for gestation, and breech delivery for both SBs and ENDs [Table 4].

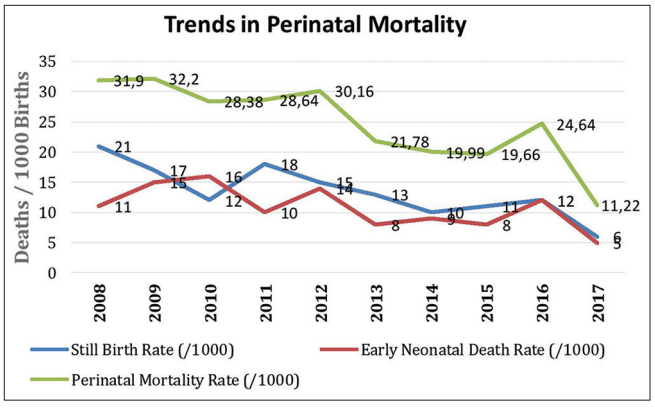

Figure 1: Trends in Perinatal mortality

Table 1: Birth details of women in the study population

Characteristics	Category	Births (percentage out of total births from 2008 to 2017)*, *n* (%)	SB, *n* (%)	END, *n* (%)	Live at 7 days, *n* (%)	PMR/1000 live births
Age (years)	<20	1932 (9.3)	23 (1.2)	37 (1.9)	1872 (96.9)	31.66
	20-24	10,895 (52.6)	153 (1.4)	124 (1.1)	10,618 (97.5)	25.72
	25-29	5973 (28.8)	78 (1.3)	49 (0.8)	5846 (97.9)	21.44
	30-34	1546 (7.5)	24 (1.6)	19 (1.2)	1503 (97.2)	28.16
	35 and above	358 (1.7)	7 (2.0)	0	351 (98)	19.53
Gravida	1	9781 (47.2)	148 (1.5)	135 (1.4)	9498 (97.1)	29.34
	2	7610 (36.8)	79 (1.0)	59 (0.8)	7472 (98.2)	18.28
	3	2421 (11.7)	39 (1.6)	25 (1.0)	2357 (97.4)	26.71
	4	673 (3.2)	13 (1.9)	6 (0.9)	654 (97.2)	28.49
	5 and above	219 (1.1)	6 (2.7)	4 (1.8)	209 (95.4)	46.51
Place of delivery	Home	149 (0.7)	5 (3.4)	2 (1.3)	142 (95.3)	48.61
	PHC/HSC	6125 (29.6)	38 (0.6)	52 (0.8)	6035 (98.5)	14.79
	CHAD/GH (secondary level)	10,994 (53.1)	145 (1.3)	109 (1.0)	10,740 (97.7)	23.41
	CMC/GVMC (tertiary level)	3436 (16.6)	97 (2.8)	66 (1.9)	3273 (95.3)	48.82
Mode of delivery	Normal vaginal	15,672 (75.5)	231 (1.5)	148 (0.9)	15,293 (97.6)	28.54
	Cesarian section	3614 (17.5)	23 (0.6)	58 (1.6)	3533 (97.8)	22.56
	Forceps	303 (1.5)	3 (1.0)	4 (1.4)	296 (97.7)	23.33
	Breech	96 (0.5)	26 (27.1)	13 (13.5)	57 (59.4)	557.14
	Suction cup	1019 (4.9)	2 (0.2)	6 (0.6)	1011 (99.2)	7.87
Maturity	Preterm (<36.6 weeks)	2117 (10.2)	178 (8.4)	120 (5.7)	1819 (85.9)	153.69
	Term (37-41.6 weeks)	17,741 (85.8)	102 (5.7)	102 (0.6)	17,537 (98.9)	11.56
	Postterm (42 and above)	826 (4)	5 (0.6)	7 (0.8)	814 (98.5)	14.62
Growth	Small for gestation	3118 (15)	64 (3.0)	65 (2.1)	2959 (94.9)	52.58
	Appropriate for gestation	17,186 (83)	157 (0.9)	158 (0.9)	16871 (98.2)	18.0
	Macrosomia	188 (0.9)	5 (2.7)	1 (0.5)	182 (96.8)	32.59

*The percentages are calculated as from the total births. SB: Stillbirth, END: Early neonatal death, PMR: Perinatal mortality rate, CHAD: Community health and development, PHC: Primary health centre, HSC: Health screening centre, GH: Government hospital, GVMC: Government vellore medical college, CMC: Christian medical college

Table 2: Perinatal mortality rate and its association with various risk factors

Risk factor	Live, *n* (%)	SB, *n* (%)	END, *n* (%)	Total live birth	PMR
Previous preterm delivery	297 (96.7)	5 (1.6)	5 (1.6)	302	33.11
Previous SB/END	729 (94.8)	28 (3.6)	12 (1.6)	741	53.98
Previous LSCS	1242 (98.5)	11 (0.9)	8 (0.6)	1250	15.2
Short stature (<145 cm)	420 (96.6)	10 (2.3)	5 (1.1)	425	35.29
Pregnancy after prolonged period of inability to conceive	176 (97.2)	3 (1.7)	2 (1.1)	178	28.09
Age >/=35 (years)	351 (98)	7 (2.0)	0	351	19.94
Anaemia (hemoglobin <10 g)	1778 (96.5)	37 (2.0)	28 (1.5)	1792	36.27
Abnormal presentation	266 (83.6)	31 (9.7)	21 (6.6)	287	181.18
In multiple pregnancy, number of women are taken and not number of babies	189 (0.9)	3 (1.1)	19 (8.3)	407	54.05
Heart disease	99 (97.1)	2 (2.0)	1 (1.0)	100	30
Hypertension (gestational/essential)	581 (91.6)	38 (6.0)	15 (2.4)	596	88.93
Diabetes (gestational/preexisting diabetes)	306 (99.0)	2 (0.6)	1 (0.3)	307	9.77
Any one risk factor	4976 (96.0)	119 (2.3)	88 (1.7)	5064	40.87
No known antepartum risk	15,214 (98)	166 (1.1)	141 (0.9)	15,355	19.99

SB: Stillbirth, END: Early neonatal death, PMR: Perinatal mortality rate, LSCS: Lower segment cesarian section

Discussion

In our study, we reported 20,419 live births, 285 SBs, and 229 ENDs. The PM rate showed a decline from 32 per 1000 in 2008 to 11 per 1000 in 2017. SB rate declined from 21 per 1000 in 2008 to 6 per 1000 in 2017. This is probably the first report of pregnancy outcomes in a population with pregnancy registration in a lower-middle-income countries (LMIC). In India, the Sample Registration System estimates for the year 2016 a SB rate of about 3 per 1000 births. These data are taken from birth registers. This is also lower than reported in

Table 3: Maternal risk factors and perinatal outcome

Risk factor	Live, *n* (%)	SB, *n* (%)	END, *n* (%)	Total, *n* (%)	Live births	PMR
M1: Placenta/cord related						
APH - placenta praevia/abruption	10 (45.5)	9 (40.9)	3 (13.6)	22 (0.1)	13	
Cord prolapse/compression	12 (42.9)	9 (32.1)	7 (25.0)	28 (0.1)	19	
Chorioamnionitis	1 (25.0)	3 (75)	0	4 (0.03)	1	
Total	23 (42.6)	21 (38.9)	10 (18.5)	54 (0.3)	33	939.39
M2: Maternal complications of pregnancy						
Multiple pregnancy (births)	373 (88.8)	13 (3.1)	34 (8.1)	420 (2)	407	
Mal-presentation before labour	223 (84.2)	26 (9.8)	16 (6)	265 (1.3)	239	
Premature rupture of membrane	0	3 (60)	2 (40)	5	2	
Total	596 (87)	39 (5.7)	52 (7.6)	685 (3.3)	646	140.87
M3: Labour related						
Instrumental delivery	1307 (98.9)	5 (0.4)	10 (0.8)	1322 (6.4)	1317	
Caesarian section	3533 (97.8)	23 (0.6)	58 (1.6)	3614 (17.5)	3591	
Breech extraction	57 (59.4)	26 (27)	13 (13.5)	96 (0.5)	70	
Total	4897 (97.3)	54 (1.0)	81 (1.6)	5032 (24.3)	4978	27.12
M4: Maternal medical/surgical						
Hypertension*	570 (91.4)	38 (6)	15 (2.4)	623 (3.1)	596	
Diabetes	306 (99)	2 (0.6)	1 (0.3)	309 (1.5)	307	
Cardiac	99 (97)	2 (1.9)	1 (0.9)	102 (0.5)	100	
Ruptured uterus	0	1 (50)	1 (50)	2 (0.02)	1	
Other unspecified medical	0	3 (100)	0	3 (0.03)	3	
Total	975 (93.8)	46 (4.4)	18 (1.7)	1039 (5)	993	94.45
M5: No risk						
	14,534 (98)	172 (1.2)	118 (0.8)	14,824 (71.6)	14,652	19

SB: Stillbirth, END: Early neonatal death, PMR: Perinatal mortality rate, APH: Antepartum hemorrhage

other LMICs. The estimate provided by the Lancet SB series for India is 22 per 1000 live births. Our data provide a more accurate picture as the pregnancies are followed up from registration till delivery.

There are specific measurement challenges due to misclassification between SBs and ENDs.[13] Underreporting of SBs in vital registration data is well-documented in both high income and LMIC. The underreporting may be as high as 20% or more.[14] In this health program (CHAD), pregnant women are registered early and are followed up until they deliver, and consequently a lesser chance of missing data. This is one of the strengths of the study. We have also recorded a larger number of SBs when compared to ENDs. This is similar to data from six developing countries.[15] To date, only two low-income countries – Egypt[16] and Pakistan – have reported causes of SBs following a verbal autopsy in their Demographic Health Survey.

The National Family Health Survey the NFHS 4 survey showed an increase in births in public facilities from 48.1% in NFHS 3 to 66.7%. This is more in the rural setting compared to the urban setting.[17]

At least 25% of the pregnancies had some risk factor. Anemia was most common (8.9%) and hypertension was seen in 3% of the pregnancies. Universal screening for diabetes was initiated only in 2019. The number of gestational diabetics picked up would be less than expected. Hypertension in the mother also had an increased PMR. This is similar to Ngoc *et al*. who described preterm delivery and hypertensive disorders as the most common obstetric problems leading to PM.[15]

In our study, the major cause for SBs was antepartum hypoxia (34.4%) which was usually a presumed diagnosis. Among these fetuses, 23.6% were small for gestation. Disorders related to fetal growth also contributed to 26.3% of the SBs. A similar study done earlier also demonstrated that fetal growth restriction and preterm births are responsible for high rates of low birth weight in the South Asian population.[18] We have taken the definition of growth restriction as those which are <10th centile for that particular gestation. This is the traditional definition though a more accurate one would be when the fetus does not reach its genetic potential. For this, one needs to assess the fetus at birth for its fat and or muscle mass and compare it to standard graphs. We generally tend to underestimate the role of growth restriction in SBs because of the traditional definition.

The proportion of intrapartum SBs was 30.6%, of which the acute intrapartum events including hypoxia contributed 21.1%. Intrapartum events contributed to 32.8% of the neonatal deaths. The distribution of fresh SBs and macerated SBs can also give us an idea of the proportion of intrapartum SBs. Macerated SBs reflect the quality of antenatal care and fetal growth during the antenatal period. We had 144 (0.7%) macerated SBs and 95 (0.5%) fresh SBs. The proportion of intrapartum SBs varies from 10.0% (range: 5.5%–18.4%) in developed regions to 59.3% (range: 32.0%–84.0%) in South Asia.[19] To reduce

Table 4: Association of high-risk factors with stillbirths and early neonatal deaths

Variables	Live birth, *n* (%)	SB			END		
		n (%)	Unadjusted OR (95% CI)[@]	Adjusted OR (95% CI)[@]	*n* (%)	Unadjusted OR (95% CI)[$]	Adjusted OR (95% CI)[$]
Age (years)							
≥35	351 (98.0)	7 (2)	1.44 (0.68-3.07)	1.51 (0.69-3.31)	0	0.99 (0.98-0.99)	-
<35	20,068 (98.6)	278 (1.4)			229 (1.1)		
HT							
Yes	596 (93.9)	38 (6.1)	5.12 (3.6-7.27)	3.56 (2.37-5.36)	15 (2.5)	2.37 (1.39-4.02)	1.69 (0.96-2.97)
No	19,823 (98.8)	247 (1.2)			214 (1.1)		
DM							
Yes	306 (99.4)	2 (0.6)	0.46 (0.11-1.85)	0.57 (0.14-2.41)	1 (0.3)	0.29 (0.04-2.04)	0.34 (0.05-2.38)
No	19,884 (98.6)	283 (1.4)			228 (1.1)		
Cardiac							
Yes	99 (98)	2 (2)	1.44 (0.35-5.85)	1.33 (1.61-6.25)	1 (1)	0.89 (0.12-6.41)	0.94 (0.13-7.03)
No	20,319 (98.6)	283 (1.4)			228 (1.1)		
Multiple foetus							
Yes	373 (96.6)	13 (3.4)	2.35 (1.34-4.4)	3.18 (1.16-6.44)	34 (8.4)	2.54 (1.44-4.4)	1.9 (1.27-3.01)
No	20,012 (98.6)	272 (1.3)			195 (104)		
Previous SB/END							
Yes	729 (96.3)	28 (3.7)	2.91 (1.96-4.14)	3.18 (1.61-6.25)	12 (1.6)	1.48 (0.82-2.65)	1.34 (0.71-2.53)
No	19,461 (98.7)	257 (1.3)			217 (1.1)		
Short stature							
Yes	425 (97.7)	10 (2.3)	1.71 (0.9-3.24)	1.95 (1.01-3.79)	5 (1.2)	1.05 (0.43-2.56)	1.15 (0.46-2.83)
No	19,994 (98.6)	275 (1.4)			275 (1.4)		
Place of delivery							
Tertiary	-	-	-	-	66 (2)	2.09 (1.57-2.79)	1.49 (1.09-2.03)
Primary/secondary/home	-	-			163 (1)		
Growth							
Inappropriate to gestation	17,029 (99.1)	157 (0.9)	3.35 (2.6-4.32)	4.59 (3.46-6.29)	66 (2.1)	2.24 (1.68-2.99)	2.65 (1.95-3.62)**
Appropriate to gestation	3207 (97.0)	99 (3)			158 (0.9)		
Maturity							
Preterm (<37 weeks)	1939 (91.1)	178 (8.4)	15.33 (12.4-20.22)	16.89 (12.8-22.27)	120 (6.2)	11.11 (8.58-14.46)	9.79 (7.29-13.15)
Term (≥37 weeks)	18,460 (99.4)	107 (0.6)			109 (0.6)		
Breech delivery							
Yes	70 (72.9)	26 (27.1)	29.18 (18.3-46.53)	11.39 (6.52-19.92)	13 (18.6)	21.29 (11.47-39.4)	7.8 (3.86-15.87)
No	20,349 (98.7)	259 (1.3)			216 (1.1)		

[@]SB versus live birth, [$]END versus live birth. OR: Odds ratio, CI: Confidence interval, HT: Hypertension, DM: Diabetes mellitus, SB: Stillbirth, END: Early neonatal death

preventable intrapartum SBs, there is a need to improve access to high-quality intrapartum care. In our setting, we found that intrapartum complications contribute to 32.8% of neonatal deaths, followed by prematurity (26.6%).

Autopsies, placenta tissue histology, and fetal serological studies are not performed in many LMICs. In their study on causes of SBs in South Africa, Madhi SA *et al.* performed histological analysis of placenta and fetal blood culture and found congenital infections responsible for 19% of SBs.[20] This is a limitation in our study as we have not performed any of these investigations to assign the cause of death.

Globally, about 5%–15% of SBs are contributed to a congenital cause.[13] In our study, 5.3% of SBs were attributed to congenital causes. Among the neonatal deaths, 21.8% were attributed to congenital causes. This high proportion may be due to the late diagnosis of anomalies and the inability to terminate them due to existing laws in our country.

The global epidemics of obesity and noncommunicable diseases, notably hypertension and diabetes, are affecting pregnancies in all regions, especially when combined with advanced maternal age.[21] There are estimates that attribute about 10% of SBs to these three disorders.[19] Primary prevention of these disorders along with improved detection and management of affected women where possible before pregnancy will help improve perinatal outcomes.

The use of Doppler in low-risk women has helped in identifying women at risk for unexplained SBs in a study in South Africa.[22] Routine ultrasound in an LMIC setting did not appear to reduce adverse outcomes for babies or the frequency of health-care services used by mothers and babies.[23] One

Cochrane review concluded that introducing routine ultrasound in resource-limited health-care settings could place a burden on depleted resources and take away from areas that would otherwise benefit.[24]

This being a community-based study, there were a few data missing such as gestational age in some pregnancies. The study has also relied on physicians attributing the cause of death after going through detailed verbal autopsies.

Conclusion

Data collection through pregnancy registration can strengthen accountability for SBs. A systematic and thorough collection of causes of SBs will help us further target areas where we can improve antenatal as well as intrapartum care.

Institutional Review Board granted approval for the project (IRB 11888 [Retro] dated 27.2.2019).

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Conflicts of interest

There are no conflicts of interest.

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