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Association of the distance travelled, and the call to hospital arrival time with early neonatal mortality in neonates born to mothers using emergency medical services at term gestation: a retrospective observational study

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ABSTRACT

Background Most neonatal deaths in India occur due to a lack of timely and proper care just before and during delivery. Timely availability of an ambulance for institutional delivery has led to some decrease in this. However, the distance travelled and time taken may affect the outcome.

Objective The objective of this retrospective observational study was to determine if the distance travelled and the call to hospital arrival time are associated with deaths in the early neonatal period (0–7 days postnatal age), in neonates born to mothers who used a centralised emergency medical services (EMS) agency transportation at term gestation.

Design Retrospective observational study.

Setting This was a secondary analysis of a de-identified patient dataset from a previous cohort study on EMS usage by pregnant women, in five Indian states in 2014.

Participants Neonates born to mothers using EMS at ≥37–42 weeks gestation were included as participants. The groups of pregnant individuals with low distance (≤10 km) and time (≤60 min) to hospital arrival vs longer distance or time to hospital arrival were then compared for neonatal death in the first 7 days of life or early neonatal death (ENND), which was the primary outcome. χ^2 test and logistic regression were carried out. Additional analysis was also planned to test the higher cut-offs of distance and time, if the above cut-offs were not found to have a statistically significant association with ENND.

Results There were a total of 1180 neonates meeting the inclusion criteria. Of these, 272 (23%) were born to mothers who travelled ≤10 km (km) and took time ≤60 min to reach the hospital. There were a total of 57 (4.8%) ENNDs of which 14 occurred in the low distance and time group (≤10 km and ≤60 min). There was no statistically significant difference between the groups for ENND (p value=0.8). On additional univariate analysis for the different cut-offs of distance and time separately, it was found that there were lesser odds of ENND for a cut-off of distance ≤60 km (OR 0.28 (95% CI 0.08 to 0.98), p value=0.046) and for a cut-off time ≤120 min (OR 0.36 (95% CI 0.17 to 0.76), p value=0.007). When adjusted for other variables found to be significant on univariate analysis (caesarean section, <4 antenatal visits, maternal tachycardia and twin gestation) a cut-off distance ≤60 km had a trend towards lower odds of ENND (OR 0.31 (95% CI 0.084 to 1.12), p value=0.075) while a cut-off time of≤120 min had a significantly lower odds of ENND (OR 0.37 (95% CI 0.167 to 0.81), p value=0.013). When both of these cut-offs were combined and analysed in the multivariable logistic regression model, the association with ENND was still significant (OR 0.33 (95% CI 0.16 to 0.72), p value=0.005).

Conclusion In neonates born to mothers using EMS at term gestation in India, those with distance travelled by the mother ≤60 km and time taken to reach health facility ≤120 min, had 67% lower odds of ENND compared with those with distance travelled >60 km or time taken >120 min. Further prospective observational studies are required to validate these cut-offs in a larger population.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The dataset covered five Indian states, with a large sample size and good follow-up rates.
⇒ It was however a retrospective secondary analysis of data, limited only to emergency medical services users.
⇒ Further prospective observational studies will be needed to validate these cut-offs.

INTRODUCTION

Neonatal deaths form a major portion of the under-five mortality in India. Early neonatal death (ENND), defined as death within the first 7 days of life, remains a significant public health concern globally. According to the WHO approximately 2.5 million neonates die annually with nearly 75% of these deaths occurring within the first week of life. The Indian Newborn Action Plan aims to prevent neonatal deaths and achieve a single-digit

neonatal mortality rate (NMR) by 2030. However, there are various impediments in the path. Lack of timely access to emergency medical services (EMS) is one among them especially in low-resource settings. Most neonatal deaths occur due to a lack of timely and proper care just before and during delivery.[1] To curb the morbidity and mortality due to perinatal asphyxia, the timely availability of personnel trained in neonatal resuscitation is the need of the hour. However, due to the poor ratio of care providers to sick neonates and the lack of timely availability of EMS for transportation to higher centres, there is still a long way toward the effective implementation of measures for the prevention of ENNDs. The availability of an ambulance for institutional delivery has led to some decrease in these deaths.[2] However, the distance and time taken to arrive at the hospital may affect this outcome.

Most previous studies on the association between proximity to medical facilities and neonatal mortality have been done in upper-middle to high-income countries.[3–7] Ravelli *et al*, in their study in Netherlands of pregnant women at term gestation, found that time ≥20 min, was associated with increased maternal and neonatal mortality.[4] Aoshima *et al*, in their study in Japan, compared the median travel time between the years 2002 and 2006, and the NMR. They found that there were significant reductions in NMR with reduced travel time.[6] However, these findings may not be generalisable to low-middle countries like India, due to variations in healthcare accessibility, population density, topography and literacy, necessitating studies specific to the country or region, to provide the appropriate cut-offs of proximity (distance and time) to healthcare facilities for pregnant individuals and the outcome of their neonates.

Hence, the objective of this retrospective observational study was to determine if the distance travelled and the time taken to reach the health facility, by pregnant individuals were associated with deaths in the early neonatal period and if so, to find their optimal cut-offs.

METHODS

Study design

This was a retrospective observational study and was done using secondary analysis of the de-identified patient dataset available online, of a study previously conducted by Bills *et al*. This previous study was conducted in 2014 on EMS usage by pregnant individuals in five Indian states namely Andhra Pradesh, Assam, Gujarat, Karnataka and Meghalaya, over 6 weeks from February to April 2014.[2] This de-identified dataset contained information regarding the gestational age, maternal clinicodemographic features (age, rural residence, social status, distance travelled, time from call to hospital arrival, maternal anaemia, maternal hypotension, interpregnancy interval, maternal tachycardia, maternal tachypnoea, spontaneous rupture of membranes, bleeding per vaginum, need for caesarean section, need for oxygen support, antenatal visits, primigravida status and twin gestation) and postpartum follow-up status of the neonates on day 2, day 7 and day 45. There was no public or patient involvement in the study design or conduct.

Study participants

Neonates born to mothers using EMS at ≥37 to 42 weeks gestation were included in the current study. As prematurity is already a known cause of increased mortality in the early neonatal period, we wanted to see if in neonates born to mothers using EMS at term gestation, the distance travelled and time taken to reach the hospital had an association with deaths in the early neonatal period (0–7 days of life). Hence, we restricted the study population accordingly. Neonates born to mothers who had interfacility transfer or were born beyond 7 days of using the service were excluded as per the exclusion criteria of the previous study.[2]

Data collection and comparison groups

Data on distance from the hospital and the time taken for arrival at the hospital were used from the de-identified database from a previous study as described already.[2] Those mothers who lived ≤10 km and had call-to-hospital arrival time ≤60 min (low distance and time group) were compared with those with a larger distance or longer time. Additionally, different cut-offs for distance (20, 30, 40, 50 and 60 km) and time (minutes in multiples of 10 from 60 to 120 min) were also analysed for their association with ENND.

Statistical analysis

The continuous outcomes were expressed as mean (SD) or median (IQR) for normally distributed or non-normally distributed data, respectively. The categorical outcomes were expressed as proportions (n (%)). The groups with low distance (≤10 km) and time (≤60 min) vs longer distance or time to hospital arrival were then compared for the primary outcome of ENND, using the χ^2 test and logistic regression. The other cut-offs for distance and time were planned to be analysed if the above cut-offs were not shown to have a significant association with ENND. A multivariable logistic regression analysis was also done to adjust for the maternal and fetal risk factors found to have a significant association with ENND on univariate analysis.

RESULTS

Association between low distance and time group and ENND

The antenatal clinicodemographic characteristics and social status (as defined in the Constitution of India[8]) of the mothers of the neonates included in the study, are shown in table 1. There were a total of 1180 neonates meeting the inclusion criteria. The data on distance travelled were available in 1167 cases which had a variable frequency distribution with maximum mothers travelling 11–20 km (table 2). 391 neonates were born to mothers who travelled ≤10 km. The median time taken from call

Table 1 Demographic and antenatal details of the mothers using emergency medical services at term gestation, in five Indian states

Baseline characteristics	n=1180		
State of origin	State	n	%
	Andhra Pradesh	327	27.71
	Assam	163	13.81
	Gujarat	381	32.29
	Karnataka	281	23.81
	Meghalaya	28	2.37
Economic status	Pink card (income >11 000 rupees)	337 (28.95%)	
	White card (income <11 000 rupees)	827 (71.05%)	
Social status*	Backward caste	426 (36.19%)	
	Scheduled caste	209 (17.76%)	
	Scheduled tribe	304 (25.83%)	
	Other caste	238 (20.22%)	
Age at first pregnancy	Age group	n	%
	15–19	160	23.81
	20–24	457	68.01
	25–29	52	7.74
	30–34	3	0.45
Age at current pregnancy	Age group	n	%
	15–19	59	5
	20–24	665	56.36
	25–29	360	30.51
	30–44	96	8.14
Vaginal bleeding	86 (7.29%)		
Rupture of membranes	354 (30%)		
Hypotension in mother	15 (1.3%)		

*Defined as per the Constitution of India.[8]

Table 2 The distance travelled from home to hospital by mothers using emergency medical services at term gestation

Distance travelled in km	n	%
0–10	391	33.5
11–20	433	37.1
21–30	215	18.42
31–40	80	6.86
41–50	27	2.31
51–60	15	1.29
61–100	6	0.51

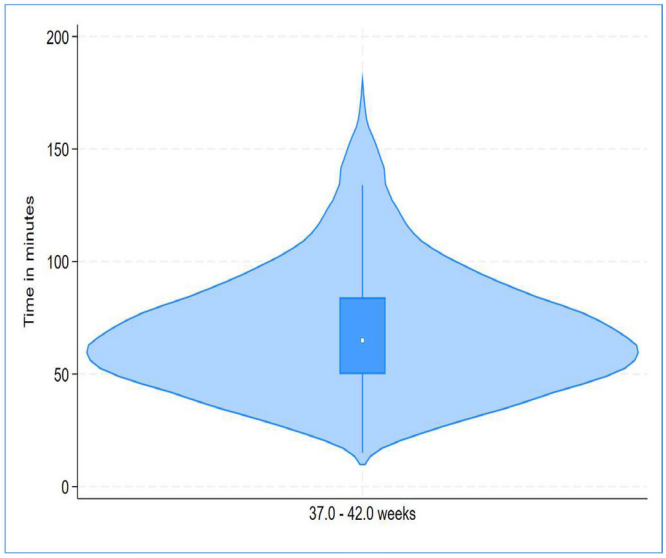

Figure 1 Vioplot of time taken (in minutes) from call to hospital arrival, by mothers using emergency medical services at term gestation.

to hospital arrival was 65 min (IQR: 50–84) (figure 1). 493 neonates were born to mothers with arrival time ≤60 min. 272 (23%) had both criteria fulfilled (≤10 km and ≤60 min). A total of 57 (4.8%) of these neonates died in the early neonatal period, out of which 14 deaths occurred in the low distance and time group. There was no statistically significant difference between the groups in terms of ENND (p value=0.8).

Analysis of various cut-offs for distance and time and ENND

On further logistic regression analysis for association of various cut-offs of distance and time, it was found that a travel distance ≤60 km (OR 0.28 (95% CI 0.08 to 0.98), p value=0.046) and a call to hospital arrival time of ≤120 min (OR 0.36 (95% CI 0.17 to 0.76), p value=0.007) were associated with lower odds of ENND. None of the other cut-offs reached statistical significance (table 3). When adjusted for maternal demographic factors like social status, residence in the rural-tribal area and teenage pregnancy, a distance cut-off of ≤60 km was still associated with lower odds of ENND (adjusted OR (aOR) 0.278 (95% CI 0.079 to 0.98), p value=0.047). Similarly, when adjusted for the same factors, a time cut-off of ≤120 min was still associated with lower odds of ENND (aOR 0.35 (95% CI 0.16 to 0.75), p value=0.007).

On univariate analysis of other baseline clinicodemographic factors, for their association with ENND, only <4 antenatal visits, need for caesarean section, maternal tachycardia and twin gestation had a significant association with ENND (table 4). A multivariable logistic regression analysis adjusting for these factors revealed that a distance cut-off ≤60 km versus >60 km, had a trend towards lower odds of ENND (OR 0.31 (95% CI 0.084 to 1.12), p value=0.075). Similarly, a cut-off time from call to hospital arrival of ≤120 min versus >120 min, had 63% lower odds of ENND (OR 0.37 (95% CI 0.167 to 0.81), p value=0.013). When both of these cut-offs were combined (distance ≤60 km and time ≤120 min) and

Table 3 Different cut-offs of distance and time and their association with early neonatal death

	OR	95% CI	P value
Distance in km			
≤20	0.93	0.53 to 1.66	0.817
≤30	1.17	0.49 to 2.78	0.721
≤40	0.71	0.25 to 2.04	0.529
≤50	0.51	0.15 to 1.74	0.285
≤60	0.28	0.08 to 0.98	0.046*
Time in minutes			
≤60	1	0.59 to 1.72	0.984
≤70	1.12	0.65 to 1.92	0.688
≤80	1.09	0.60 to 1.97	0.773
≤90	0.83	0.44 to 1.56	0.559
≤100	0.71	0.35 to 1.44	0.348
≤110	0.54	0.26 to 1.14	0.106
≤120	0.36	0.17 to 0.76	0.007*

P value reached statistical significance.

compared with higher distance or time cut-off, the odds of ENND were still significantly less (OR 0.33 (95% CI 0.16 to 0.72), p value=0.005). Power calculation for a cut-off distance of 60 km and a cut-off time of 120 min for the outcome of ENND in the given cohort, showed a power of 83.39%.

Table 4 Univariate analysis of baseline demographic and clinical factors for association with early neonatal death

Demographic or clinical risk factor	OR	95% CI	P value
Teenage pregnancy	1.45	0.5 to 4.16	0.485
Rural/tribal residence	1.06	0.38 to 3.02	0.905
Poor social status	1.06	0.54 to 2.07	0.871
Maternal Anaemia	0.49	0.12 to 2.08	0.338
Maternal systolic hypotension	2.83	0.34 to 23.3	0.335
Interpregnancy interval ≤3 years	0.81	0.36 to 1.77	0.597
Maternal tachycardia	2.56	1.21 to 5.42	0.014*
Spontaneous rupture of membranes	1	0.56 to 1.79	0.994
Bleeding per vaginum	0.99	0.35 to 2.80	0.985
Twin gestation	5.54	1.99 to 15.44	0.001*
Caesarean section	3.32	1.69 to 6.51	<0.001*
Maternal need for oxygen support	1.33	0.73 to 2.41	0.348
Less than four antenatal visits	1.75	1.01 to 3.04	0.045*
Primigravida	1.3	0.76 to 2.22	0.333
Maternal tachypnoea	1.32	0.61 to 2.85	0.484

P value<0.05.

DISCUSSION

Principal findings

Easy and early accessibility to healthcare services is vital in reducing maternal, and neonatal mortality. Our study aimed to evaluate the association between distance travelled, time taken to reach hospital by pregnant individuals and ENNDs. A cut-off time of ≤120 min was found to be associated with lower odds of ENND and is in agreement with the geographical proximity indicator in WHO core global health indicators.[9] A distance cut-off ≤60 km had a trend towards lower odds of ENND when compared with higher distance travelled but did not reach statistical significance. A combined cut-off of distance travelled and time taken of ≤60 km and ≤120 min had a lower odds of ENND when compared with those with a higher distance or time.

Important similarities and differences from previous studies

The impact of travel time and distance covered by pregnant individuals for delivery, on neonatal mortality has not been studied in India. Observational studies from high-income countries have shown variable results on the association between proximity to hospitals and neonatal mortality. A few of these studies have shown that a time cut-off as less as 20 min could affect neonatal mortality and an increase in distance travelled led to an increase in neonatal mortality.[3–6] However, a systematic review and meta-analysis of studies in high income countries, that took a cut-off time of 60 min has not shown any significant association with neonatal morbidities and perinatal mortality.[10]

Observational studies from low-middle- and low-income countries from Vietnam, Ethiopia and Burkina Faso found that there was an increase in neonatal mortality with an increase in distance from health facility.[11–13] However, a study from Malawi did not find any association between distance to care and early neonatal mortality.[14] A study from Rwanda showed that longer time taken for travel to district hospital from health centre (>90 min) to have significantly worse neonatal outcomes (APGAR<7 at 5 min or death).[15] A study from Nigeria found that the mean travel time of mothers with still births was twice as those with live births.[16] Also, cut-off time of >60 min was found to increase the odds of stillbirth by 12 times compared with a cut-off time of <15 min in this study. A study from Sierra Leone found lower perinatal mortality for travel time ≤120 min in mothers with caesarean section delivery.[17] These differences may be attributed to regional variations in the quality of healthcare and the underlying risk factors in included study participants. These findings also emphasise the importance of conducting region specific observational studies for exploring the appropriate cut-offs for proximity to healthcare facilities for pregnant individuals to have better neonatal outcomes. In our study a cut-off time ≤120 min was independently associated with lower odds of ENND compared with a longer time taken by pregnant individuals to reach the health facility.

Strengths and weaknesses

Our study was done using a de-identified dataset that covered five Indian states, with a large sample size with good follow-up rates.[2] However, it was a retrospective study with data only limited to EMS users. In this dataset, among the gestation strata 37–42 weeks analysed in the current study, 95.7% of neonates were born within 48 hours of usage of the emergency services by their mothers. However, the exact time of delivery after the arrival of the mother at the hospital has not been detailed in the dataset. 69 (5.8%) neonates were born before arrival at the hospital. The dataset provided the status of the neonate by day 7 and day 42 follow-up. However, the exact cause and time of death have not been elucidated. Hence, further prospective observational studies, are required to externally validate the findings of this study.

Implications of the findings

Our study aimed at identifying the optimum proximity cut-off to the hospital for a pregnant individual in India, for improving neonatal outcomes. These cut-offs (distance and time) would help re-assign the EMS for timely transportation to health facilities. They would also guide the reallocation of resources of the country towards healthcare infrastructure (enhanced referral systems, upgradation of road networks, increase health facilities equipped with people trained in neonatal resuscitation, subsidised transport costs for pregnant women) to meet these desired cut-offs, hence preventing transfer delays, and ultimately decreasing the NMR.

Unanswered questions and future research

These cut-offs of distance and time, must be externally validated in future prospective studies in a larger population, irrespective of EMS usage, and stratified as per socioeconomic status and regional accessibility to healthcare facilities. Also, in addition to neonatal mortality, association with need for resuscitation, level of sickness and other neonatal morbidities in the postnatal period, needs to be explored.

CONCLUSION

In neonates born to mothers using EMS at term gestation in India, those with distance travelled by the mother ≤60 km and time taken to reach health facility ≤120 min, had 67% lower odds of ENND compared with those with distance travelled >60 km or time taken >120 min. Further prospective observational studies are required to validate these cut-offs.

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Contributors RD conceptualised the research question, did the statistical analysis and made the first draft of the manuscript. KKP and SS did the literature review and made important revisions to the manuscript. The final manuscript was approved by RD, KKP and SS for publication. RD, KKP and SS agree to be accountable for the accuracy and integrity of the work. RD is responsible for the overall content (as guarantor).

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