Epidemiological Profile and Spatio-Temporal Pattern of Infant Deaths in a District of North India during 2016-2019

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Abstract

Background: Infant mortality is an important health indicator of a population given its strong link to socioeconomic status, health service access, and quality and maternal health. The declining trend of Infant Mortality Rate has been observed in India where it reduced from 89 deaths per 1000 live births in 1990 to 28 deaths per 1000d live births in 2019. Most of the studies regarding the trend of infant mortality are state-based, however, state-level infant mortality has masked the intradistrict clustering of individual infant deaths. Hence, this study was planned with an objective to study the trend of infant mortality at the district level. **Material and Methods:** A retrospective study was conducted in the district Rohtak of Haryana using the data collected regarding infant deaths. The collected data regarding addresses were geocoded. The resulting layer was then analyzed using QGIS v3.10. The descriptive data was analyzed using SPSS v20.0. **Result:** In total, 1336 infant deaths during the study period were included. A declining trend of infant mortality was observed over the study period. The number of grids (25 km^2) reduced from 18 in 2016 to 10 in 2019 depicting a reduction in the areas with more than expected count. **Conclusion:** This study emphasizes on the importance of using the geographic information science technique in identifying local hotspots within the district so as to find areas that need more support and observation.

Keywords: Geographic information science, hotspots, India, infant mortality, spatiotemporal, trend

Introduction

Infant mortality is an important health indicator of a population given its strong link to socioeconomic status, health service access, and maternal health. It reflects the effect of economic and social conditions on the health of mothers and newborn babies, as well as the effectiveness of the health systems in a country/region.[1] Infant mortality, measured as Infant Mortality Rate (IMR) is the probability of a child born in a specific year or period dying before reaching the age of one year. Infant Mortality Rate is expressed mathematically as the number of children dying before one year of age per 1000 of live births during a fixed time period.[2]

Globally, there is a decreasing trend in IMR from 65 deaths per 1000 live births in 1990 to 28 deaths per 1000 live births in 2019. A similar declining trend of IMR has also been observed in India where it reduced from 89 deaths per 1000 live births in 1990 to 38 deaths per 1000 live births in 2015 to further reduce to 28 deaths per 1000 live births in 2019.[3] Even with the declining trend, India's national average is still far from achieving the United Nation's Sustainable development Goals (SDG) goal to reduce the Neonatal Mortality Rate to a value set as 12 deaths per 1000 live births.[4]

In India, there is a wide variation of IMR among states and further among districts also, with the highest IMR at 48 per 1000 live births in Madhya Pradesh to the lowest at 4 per 1000 live births in Nagaland.[5] Reduction in infant mortality is the major focus of India's maternal and child programs. It has been observed that there is an existing urban–rural gap in infant deaths with a wide variation over both space and time.[6] Similarly, inequalities in health outcomes or access to services and benefits can occur across space and time. Infant mortality

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serves as an important indicator of social and economic well-being, hence this always remains the thrust area for both the researchers and policymakers.

Geographic information system and geospatial analysis have evolved over time to help policymakers in making informed decisions. The ability of the spatial analysis to identify the existing and potential clusters aids in better allocation of resources and intervention to such areas for effective utilization of available resources improving cost-effectiveness of the policy or program.[1,7]

Most of the studies conducted to evaluate the spatiotemporal pattern regarding infant mortality are based on IMR and very scarce studies are available which are based on individual infant deaths. Mostly, the studies regarding the trend of infant mortality are state-based, however, state-level infant mortality has masked the intradistrict clustering of individual infant deaths. Studies regarding the spatiotemporal trend of infant mortality are scarce in this particular study area. Hence, this study was planned with an objective to study the trend of infant mortality at the district level and to identify the hotspot areas and intradistrict clustering of infant mortality.

Methodology

A data-based retrospective study was carried out in the district Rohtak of Haryana, having a population of around five and a half lakh and an area of 1745 km^2 from January 2021 to May 2021. The study included all the infant deaths that occurred during 2016–2019 in the study area with a permanent address of Rohtak district using the universal sampling technique. Infant death in the migrant population or those belonging to different state/district and those with incomplete addresses or for which desired details could not be collected were excluded from the study. The data regarding infant deaths from 2016 to 2019 was collected using a proforma recording the address, age at death, gender, and cause of death of the deceased from the records of all the subcenters and urban health posts of the study area. The permanent addresses containing house number, colony, city, state, and country were entered in a Google spreadsheet. These addresses were then geocoded to obtain latitude and longitude by using the add-on plugin "Geocode by awesome table." The geocoded addresses were then projected on a map in QGIS version 3.10 software.

The descriptive data was analyzed using SPSS v 20.0 and was reported as frequency and percentages. Mann Whitney *U*-test was used to find the difference between the survival period of infants according to their place of residence. For spatial analysis, the study area was divided into grids of 5 km × 5 km (25 km^2). The counts of death were calculated in each grid for each year and those grids with more than the expected count for that particular year were highlighted. The expected number of infant deaths per grid for each year was calculated by dividing the number of infant deaths in each year by the surface area of the study region (1745 km^2) and multiplying it by 25, giving us the expected number of infant deaths for each grid of 25 km^2 area for random distribution of deaths.

Observations

In total, 1336 infant deaths over the four years were included in the study. It was observed that, throughout the study period, male infant deaths were more as compared to females on yearly basis with around 17% of difference among them over the four-year period. On yearly basis, maximum deaths (60.78%) were occurring in the urban area as compared to the rural area. On the basis of caste, maximum deaths (77.09%) were reported among the general caste as described in Table 1.

It was observed that during 2016, the maximum number of deaths occurred in the month of June followed by May and August. In 2017, the maximum number of deaths occurred in the month of September and November. In 2018, the maximum number of deaths occurred in the month of January, while in 2019, the maximum deaths occurred in April and January. Over the four years study duration, it was observed that maximum deaths were concentrated from October to January months as described in Figure 1.

Regarding the place where infant deaths occurred, it was observed that there is a decline in the infant deaths occurring at home from around 45.7% in 2017 to 2.7% in 2019. It was observed that the maximum proportions of infant deaths every year were classified under others and not known category. Other than this, the maximum proportion of deaths were reported to have died from sepsis (24.55%) followed by asphyxia (8.16%). Overall, for the study period, the maximum infants were observed to have died of sepsis as the single-known cause of death as depicted in Table 2.

It was observed that the maximum proportion of infant deaths occurring each year constituted by neonatal deaths (>70%) and among the neonatal deaths, the maximum was accounted to early neonatal deaths as depicted in Table 2. It was observed that, on yearly basis, the mean duration of survival is less in rural settings as compared to urban settings and this association was found to be statistically significant (P-value <0.05) for every year as described in Table 3. No statistically

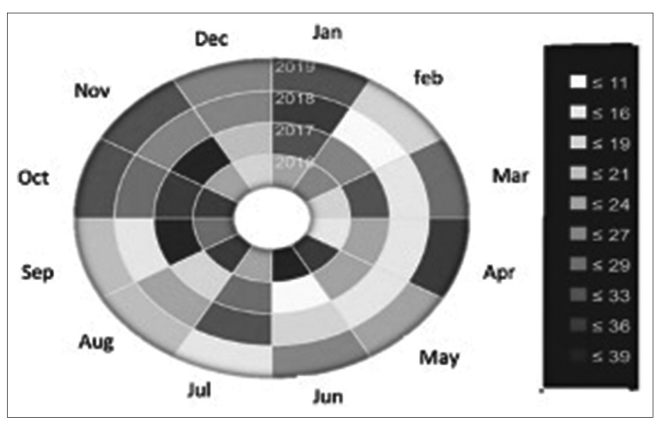

Figure 1: Calendar heat chart (months over years) of infant deaths that occurred during the study period

Table 1: Year-wise distribution of Infant deaths as per the sociodemographic variables

Sociodemographic variable	Year				Total
	2016 (*n*=317) *n* (%)	2017 (*n*=414) *n* (%)	2018 (*n*=311) *n* (%)	2019 (*n*=294) *n* (%)	
Gender					
Male	180 (56.8)	246 (59.4)	184 (59.2)	172 (58.5)	782 (58.53)
Female	137 (43.2)	168 (40.6)	127 (40.8)	122 (41.5)	554 (41.47)
Residence					
Urban	187 (59)	263 (63.5)	204 (65.6)	158 (53.7)	812 (60.78)
Rural	130 (41)	151 (36.5)	107 (34.4)	136 (46.3)	524 (39.22)
Caste					
General	221 (69.7)	339 (81.9)	216 (69.5)	254 (86.4)	1030 (77.09)
OBC	19 (6.0)	23 (5.6)	30 (9.6)	23 (7.8)	95 (7.11)
SC	51 (16.1)	25 (6.0)	35 (11.3)	13 (4.4)	124 (9.28)
ST	8 (2.5)	7 (1.7)	2 (0.6)	-	17 (1.27)
Others	18 (5.7)	20 (4.8)	28 (9)	4 (1.4)	70 (5.24)

Table 2: Year-wise distribution of infant deaths based on variables related to infant deaths

Variable	2016 *n* (%)	2017 *n* (%)	2018 *n* (%)	2019 *n* (%)
Place where death occurred				
Home	66 (20.8)	189 (45.7)	26 (8.4)	8 (2.7)
Government Hospital	247 (77.9)	221 (53.4)	282 (90.7)	283 (96.3)
Private Hospital	4 (1.3)	3 (0.7)	2 (0.6)	2 (0.7)
In Transit	-	1 (0.2)	1 (0.3)	1 (0.3)
Cause of death				
Asphyxia	22 (6.9)	31 (7.5)	31 (10)	25 (8.5)
Hypothermia	10 (3.2)	4 (1.0)	6 (1.9)	2 (0.7)
Low Birth Weight	23 (7.3)	19 (4.6)	17 (5.5)	22 (7.5)
Sepsis	82 (25.9)	72 (17.4)	91 (29.2)	83 (28.2)
Others	108 (34.1)	214 (51.7)	147 (47.3)	153 (52)
Cause not known	72 (22.7)	74 (17.8)	19 (6.1)	9 (3.1)
Infant death period				
Early neonatal	205 (64.7)	326 (78.7)	202 (65)	235 (79.93)
Late neonatal	26 (8.2)	31 (7.49)	32 (10.29)	29 (9.86)
Post neonatal	86 (27.1)	57 (13.77)	77 (24.76)	30 (10.2)

Table 3: Distribution of infant deaths according to the difference in survival period according to residence type

Year	Residence of address	Age at death (in days)		
		N	Mann Whitney *U* value	*P*
2016	Rural	130	10523	0.037*
	Urban	187		
2017	Rural	151	16698.5	0.003*
	Urban	262		
2018	Rural	107	9403	0.043*
	Urban	204		
2019	Rural	136	8942	0.013*
	Urban	158		

*Significant

significant (P-value >0.05) association was observed between the gender of deceased and caste, gender and place of residence, and gender and type of death facility over the four years.

The spot maps of infant deaths are depicted in Figure 2. On spatiotemporal assessment, it was observed that the number of grids (25 km^2) with more than the expected number of infant deaths were 18 in 2016, 13 in 2017, and 10 each in 2018 and 2019. The number of grids was observed to decrease from 2016 to 2019 as described in Figure 3.

Discussion

This study observed that infant deaths were more among males as compared to females. This finding is in line with the data provided by the World Health Organization, where the total number of infant deaths reported in 2019 in India was more among males as compared to females.[8] Regarding the type of facility where death occurred, there was decreasing trend in deaths occurring at home whereas, the increasing trend was observed in proportion of deaths occurring at hospital facilities. This could be accounted to better utilization of health services and more deaths in the hospital reflects that a large number of infants requiring critical care were being admitted to the hospitals.

Regarding the causes of infant deaths as reported, there was a decreasing trend in the proportion of infant deaths reported as a cause not known from 22.7% in 2016 to 3.1% in 2019. This reflects upon the better classification of deaths and also indirectly reflects upon improvement in verbal autopsy procedure of infant deaths. Among the known causes, the maximum deaths each year were due to sepsis followed by asphyxia which is similar to that reported by the study conducted by Rai *et al.*[9] in north India where, around one-third of infant deaths were accounted for sepsis and asphyxia. The maximum proportion of deaths was during the neonatal period, which corresponds to 72.08% on an average over the study duration, which is similar to findings of the sample registration system statistical report 2018 where the percentage of neonatal deaths to infant deaths was reported as 72.5% for Haryana

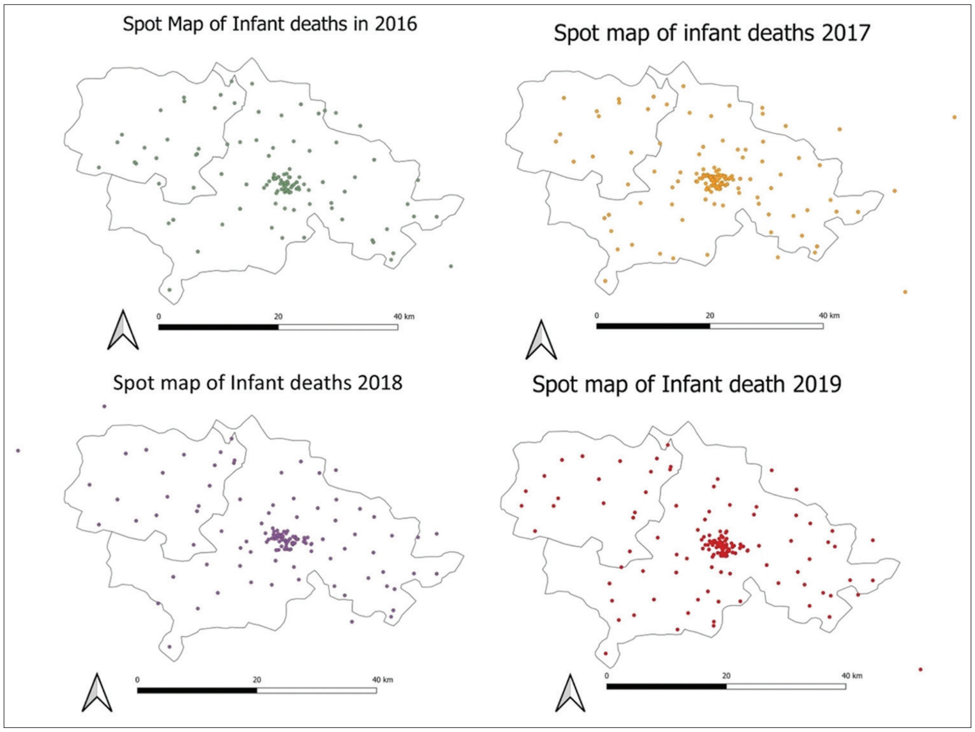

Figure 2: Spot map of infant deaths during the study period from 2016 to 2019

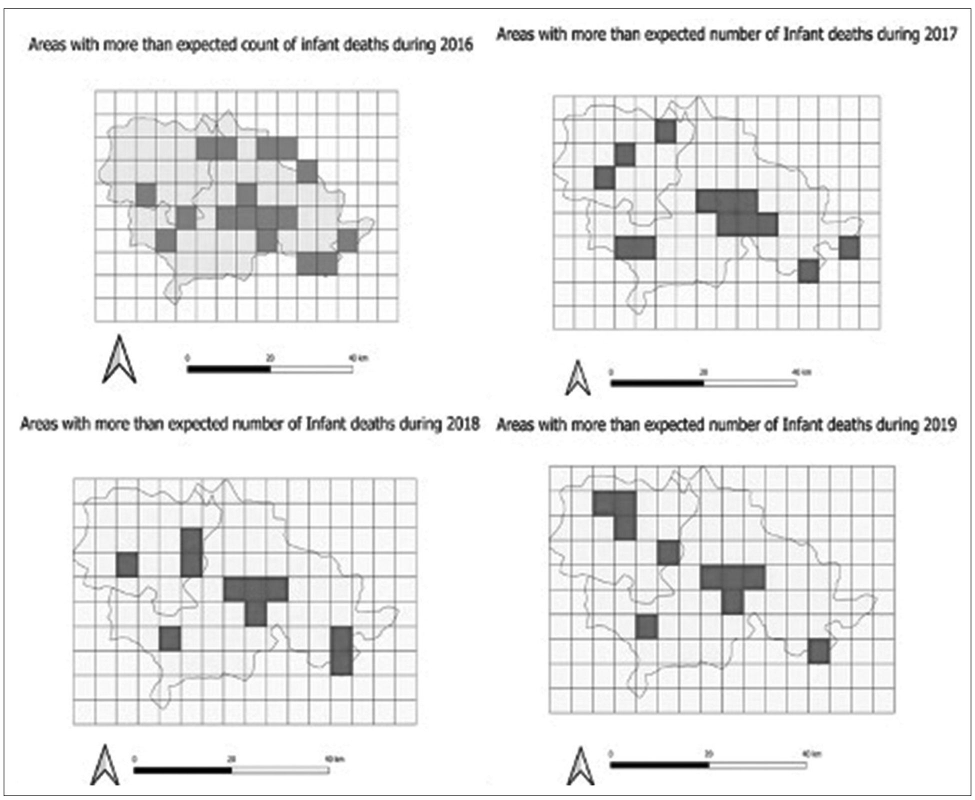

Figure 3: Areas with more than expected number of infant deaths of infant mortality during the study period from 2016 to 2019

and 71.7% for India.[10] In the neonatal period, the maximum proportion of deaths were occurring in early neonatal period. This finding was similar to the study conducted by Rai *et al.*[9] in north India, Sankar *et al.*[11] in India where the proportion of early neonatal deaths was reported as 72.7% and 75%, respectively. The studies conducted by Soumyashree *et al.*[12] in Belagavi reported 82.5% of deaths in early neonatal period. The difference in the observation could be accounted for the reason that the latter study was single-center hospital-based with a lesser sample size as compared to the present study which utilized data from the entire district.

The survival period was observed to be lower in rural areas as compared to that in urban areas. The studies conducted by Van de Poel *et al.*[13] and Tiruneh *et al.*[14] in Sub Saharan African countries using demographic and health survey data, also reported the similar finding of higher infant mortality in rural areas as compared to urban areas. This could be due to better availability of health services in urban areas and more awareness regarding utilization of healthcare services in urban areas as compared to that in rural areas.

Regarding the spatial patterns and aggregation of cases, the number of grids of 25 km^2 with more than expected counts of infant deaths has decreased from 18 in 2016 to 10 in 2019. This improvement in the reduction of the areas with more deaths could be accounted to better healthcare facilities and better utilization of services under maternal and child health programs. Some regions were hotspots, constantly every year.

This study has some limitations. First, those infant deaths with incomplete addresses were excluded from the study which could have affected the result. Second, there were no ward or village-level shapefiles available, which might have helped in analyzing, clustering at ward or village level in the district, and to analyze local indicators of spatial autocorrelation statistics. Despite various limitations, this study has various implications. This mapping could help us in identifying the areas which need more focus, to prevent them from developing as hotspot areas in the coming times. Spatiotemporal analysis like this also gives us an insight of the performance of various regions at the subdistrict level.

The future scope of this study includes finding the reasons for the areas emerging as hotspots so as to prevent the clustering of infant deaths in the future.

Conclusion

This study emphasizes on the importance of using the GIS technique in identifying local hotspots within the district so as to find areas which need more support and observation. This may further help us in identifying areas of hotspots to study the local factors responsible for the development of such hotspots. The use of GIS techniques for mapping infant deaths could prove an important monitoring measure and would also open new areas for research into underlying determinants like environmental factors which are less explored areas.

Ethical approval

Ethical approval was obtained from the Institutional Ethical Committee of Pt. B.D. Sharma PGIMS, Rohtak.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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