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RESEARCH ARTICLE

Infant mortality differentials among the tribal and non-tribal populations of Central and Eastern India

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Abstract: Higher infant mortality among tribal populations in India is well-documented. However, it is rare to compare factors associated with infant mortality in tribal populations with those in non-tribal populations. In the present paper, Cox proportional hazards models were employed to examine factors influencing infant mortality in tribal and non-tribal populations in the Central and Eastern Indian states using data from the District Level Household Survey-III in 2007-2008. Characteristics of mothers, infants, and households/communities plus a program variable reflecting the place of pregnancy registration were included in the analyses. We found that the gap in infant mortality between tribal and non-tribal populations was substantial in the early months after birth, narrowed between the fourth and eighth months, and enlarged mildly afterwards. Cox regression models show that while some factors were similarly associated with infant mortality in tribes and non-tribes, distinctive differences between tribal and non-tribal populations were striking. Sex of infants, breastfeeding with colostrum, and age of mother at birth acted similarly between tribes and non-tribes, yet factors such as state of residence, wealth, religion, place of residence, mother's education, and birth order behaved differently. The program factor was non-significant in both tribal and non-tribal populations.

Keywords: infant mortality, scheduled tribes, non-tribes, Central and Eastern India, DLHS-III, Cox hazards model

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1. Introduction

1.1 Literature Review

Infant mortality is an important domain of community health care and is considered as one of the most important indicators of socio-economic development (Stockwell, Swanson, and Wicks, 1988). It also explains the social and political milieu. Frequently, infant mortality is used to compare health status at the country or social class levels (Bicego and Boerma, 1993; Subramanian, Nandy, and Irving, 2006). In India, social class has been considered as a proxy for socio-economic status and poverty, and it has a substantial impact on infant health and mortality. One of the social classes in India, scheduled tribe (ST), has been an integral part of the country's population for a long time. A majority of the ST population lives in the North-Eastern, Central, and Eastern parts of the country. According to the 2011 census, STs accounted for more than 20% of the population in the Central and Eastern states of Madhya Pradesh, Odisha, Jharkhand, and Chhattisgarh. These four states are highly focused on because most of their indicators related to maternal and child health are poor (Annual Health Survey [AHS], 2011).

The tribes of Central and Eastern India have a traditional style of living, and their way of life is completely devoid of modern health facilities. The majority of the tribal population is generally poor and concentrated in rural India. Due to this, awareness about population dynamics, health and nutrition among different tribal groups in India is limited yet important (Deb, Basu, Balgir *et al*., 2001). Because of striking differences in socio-economic status and cultural practices between tribes and non-tribes, the maternal and child health status of tribal populations is different from that of non-tribal populations. For example, the average Indian child had 25% lower likelihood of dying under the age of five years compared with *adivasi* (tribal) children born in 2001–2005 (Das, Kapoor, and Nikitin, 2010). According to the third round of the National Family Health Survey (NFHS, 2005–2006), in rural areas where a majority of *adivasi* children live, *adivasi* contributed about 11% of all births and almost one-fourth of all deaths under the age of five years. Children born to women from scheduled castes (SCs) and scheduled tribes have higher mortality rates than children born to women from other backward classes and other classes (i.e., general/advanced classes). Children born to women from non-backward classes and non-tribes have by far the lowest rates of infant and child mortality (NFHS, 1998–1999). A nationally representative study of India based on the 1981 census also indicated that under-five mortality in the lower STs and SCs was significantly higher than that among the non-tribal population (Das, Hall, Kapoor *et al.*, 2014). Previous studies also showed that mother's education, household head's religion, caste/tribe membership, and economic level of the household (indicated by ownership of consumer goods) had a substantial effect on infant mortality (e.g., Murthi, Guio, and Dreze, 1995).

The 2005–2006 NFHS data for Odisha showed a significant disparity in neonatal, infant, and under-five mortality rates by tribal, wealth, and education status (Sharma, Sarangi, Kanungo *et al.*, 2009). Infant mortality rates (IMRs) are higher among the STs and they are mainly determined by poverty, low levels of education, and poor access/utilization of health services (World Bank, 2007). A longitudinal survey in the tribal dominated Bolangir district in Odisha found that the villagers took a young child to the hospital only when his or her condition was critical (van Dillen, 2006). The STs in Jharkhand are mostly located in rural and remote areas where access to maternal and child health-related services is very limited and the use is further restricted by their own traditional beliefs and taboos (Singh and Ram, 2006). About three-fourths of the infant deaths among tribes occurred during the neonatal period in Madhya Pradesh (Pandey, 1988; Pandey and Tiwari, 2001). Tribes lag behind the general population in Madhya Pradesh on key health indicators by about three decades (Pandey, 1988). Antenatal care is not a common practice among primitive tribes (Pandey and Tiwari, 2001) and tribal women usually do not utilize public health services. Studies have even shown that there is a cyclicality of neonatal deaths among Tribes (Shah and Dwivedi, 2011). Women from villages near the health centers utilize primary health centers only in case of emergency (Marwar and Jain, 1997). One study demonstrated that the utilization of maternal and child healthcare services is very limited among the tribes of Madhya Pradesh (Sharma, 2010).

The poverty rate is high among STs in Madhya Pradesh and Chhattisgarh (NSSO, NSO, and MOSPI, 2011). The Central region also demonstrates high IMRs among ST populations and the situation is worse among the primitive tribal groups such as Birhor, Korwa, Abhujmaria, Kamar and Baiga in Chhattisgarh (Dhar, 2013). Higher birth order could be one of the reasons for higher infant deaths among the ST community. In a recent study, Sahu *et al*. (2015) found that birth order and birth interval were significantly associated with infant and child mortality among STs in rural India during 1992–2006 (Sahu, Nair, Singh *et al.*, 2015). They found that the risk of infant mortality was higher in first order births. For the period of 1992–1993, babies with birth order four or more had 40% lower risk of death during infancy compared with first birth order babies in the same period. However, a study on the utilization of maternal health services suggested that higher mortality risk among first order births could be linked with the early childbearing trends and lower utilization of maternity services in developing countries like India (Singh, Rai, Alagarajan *et al.*, 2012).

Until the late 20th century, child mortality and fertility rates for the tribes were lower than those for non-tribes. However, as these tribes acculturate more into the non-tribal society, it will lead to a gradual erosion of their gender equality and lower fertility and mortality patterns (Maharatna, 2000). Differentials in fertility and mortality patterns within India by caste and tribal status have received greater attention over the last few decades (Maharatna, 2000; Murthi, Guio and Dreze, 1995; Planning Commission, 2011; Registrar General of India [RGI], 2011; Registrar General of India [RGI], 2014). Many research papers published in 2010–2015 predicted that India was unlikely to meet the fourth and fifth United Nations Millennium Development Goals (MDGs) related to infant mortality and maternal mortality set for the year of 2015 (Lozano, Wang, Foreman *et al.*, 2011; Reddy, Pradhan, Ghosh *et al.*, 2012; United Nations [UN], 2015). Reality confirmed their predictions. Reddy *et al.* (2012) argued that the fourth MDG target of achieving an IMR of 28 per thousand by 2015 would be achievable only by 2023–2024 if the declines follow exponential trends. They attributed this delayed achievement of the fourth MDG to the high infant mortality in the poorer states such as Madhya Pradesh/Chhattisgarh, Bihar/Jharkhand, Uttar Pradesh/Uttarakhand, Rajasthan, and Assam.

Earlier demographic and anthropological literature sought to find factors affecting infant mortality among tribes by focusing on these states individually. There were very few comprehensive studies focusing on the entire region and comparing the factors affecting the survival status of infants in both tribes and non-tribes. The present paper focuses on the impacts of different factors affecting the tribes and non-tribes, leading to inequality in infant mortality in Central and Eastern India. It becomes relevant because this region is one of the major contributors to high infant mortality in India. In view of the United Nations sustainable development goals (SDGs) and the goal of the Government of India under the Twelfth Five Year Plan to reach the rate of 25 infant deaths per 1,000 live births by 2017, the present study attempts to understand infant mortality and its correlates among tribal and non-tribal populations in Central and Eastern regions of the country which are known for both high mortality and fertility. Below, we provide some basic information about the distribution of the tribal population in India before we describe our data sources and methods.

1.2 Spatial Distribution of Tribal Population

The tribal population in the country is 104.5 million in the 2011 census, constituting 8.6% of the total population, with 90% living in rural areas (RGI, 2011). There are certain pockets in India where tribes are much larger in number. Madhya Pradesh (14.6%), Maharashtra (10%), Odisha (9.1%), Gujarat (8.5%), Rajasthan (8.8%), Jharkhand (8.2%), Chhattisgarh (7.5%), Andhra Pradesh (5.6%), West Bengal (5%), and Karnataka (4%) are the states that have the largest shares of STs (RGI, 2011; Ministry of Tribal Affairs [MOTA], 2013). These states accounted for more than 80% of the total ST population of the country; Madhya Pradesh, Odisha, Jharkhand, and Chhattisgarh alone contributed 40% (Marwar and Jain, 1997). Apart from North-Eastern states, Madhya Pradesh (21.1%), Jharkhand (26.2%), Odisha (22.8%), and Chhattisgarh (30.6%) are the only states in the country where the tribal population accounted for more than 20% of the state total population (RGI, 2011). These four states score low on demographic and developmental indicators. For example, Madhya Pradesh, which is the second largest state in India, contributes the most to the infant deaths (RGI, 2014) in the country. These four states belong to the low development states category in the Human Development Index for the country (Planning Commission, 2011).

Though the reduction in infant mortality in the region in the last 15 years is impressive, it is still high in view of the national estimates (44 infant deaths per 1,000 live births) and mortality differentials exist with the tribal dominated areas of India. Belonging to a social group, however, is not an independent risk factor for mortality; its effect on mortality appears to be moderated through other social, economic, and environmental factors.

2. Data and Methods

2.1 Sources of Data

This study used data from the third round of the District Level Household Survey (DLHS-III) conducted by the Government of India during 2007–2008. It utilized pregnancy history files for ever married women (aged 15–49 years) including questions related to the outcome of their pregnancy and the birth and death of each of their children born since January 2004 until the date of survey. The pregnancy history file was also used to compute infant deaths. We did not take multiple births of a pregnancy of a mother for analysis since the multiple births are relatively rare. The detailed sampling procedure and data quality were available in the official document released by the International Institute for Population Sciences (2010).

2.2 Measurements

2.2.1 Tribes and Non-Tribes

The caste variable was recoded into two categories: scheduled tribes (STs) and non-tribes. The non-tribes category included scheduled caste (SC), other backward classes, and others classes (i.e., other than SC/ST/OBC classes). The entire analysis was based on these two categories only in order to estimate mortality differentials between tribes and non-tribes.

2.2.2 Other Factors Associated with Infant Mortality

To identify important factors affecting infant and child mortality among the tribal and non-tribal populations of Central and Eastern parts of India, a set of possible factors was considered but only variables that met either of the following two criteria were considered in the analyses. Firstly, there is at least a moderate bivariate association ($p < 0.05$) between the selected factor and infant mortality for at least one out of four states studied. Secondly, in some cases, importance was given to the theoretical rather than purely statistical association. The theoretical association refers to the inclusion of factors in the present study which prior literature has evidenced to be associated with infant mortality. For example, at the individual level, the risk of death of a child is influenced to a great extent by factors related to the mother: her education; her situation prior to and post pregnancy; care received before, during, and after pregnancy; location of birth; birth order; and care received by the child during the first few years of his or her life. Apart from that, the anthropological literature has also focused on access to health care for India's *adivasi*. The evidence from the grassroots highlights distinct problems in tribal areas because of higher poverty, poorer health, and lower education as compared to non-tribal areas. There is a wide acknowledgment that excessive childhood mortality in tribes is partly due to poverty and partly due to poor access to services.

Overall, we used the following variables in the model which are categorized as follows. Mother-specific variables include mother's age, mother's education, and feeding colostrum. Infant-specific variables include birth order and sex of the infant. Household/community-specific variables include state of residence, place of residence, religion, and the wealth index. Program variable includes place of a pregnancy registration.

Mother's age was classified into three categories: 15–24 years, 25–34 years, and 35+ years. Many studies have suggested that the age of the mother is a strong predictor affecting the survival chances of an infant. Hence, we categorized age of the mother into categories in such a manner so that the risk attributable to mother's age gets captured properly. Mother's highest years of schooling was classified into four categories: illiterate, primary school, secondary school, and high school or above. The question of mother's highest years of schooling was only asked by those women who responded "yes" to the question of whether the woman ever attended a school. In this case we found that out of 119,530 total women in the overall sample, around 56% reported that they never attended a school. So, in the illiterate category we included both the women who never attended school as well as women who responded that they had zero years of schooling. Mother's education reduces the risk of infant death substantially because educated women tend to take care of all the nutritional requirements of the child in the initial years of life and will also understand the importance of exclusive breastfeeding and immunization schedules.

There are many well-established theories showing that higher fertility is associated with higher risk of infant death (Das, Kapoor and Nikitin, 2010). Thus, we classified birth order into two categories: 1–2 births versus 3 or more births. The wealth index was created using household assets, amenities, and durable goods. In the DLHS-III, a household was comprised of a person or group of persons who usually live, eat together, and share a common kitchen. Combining household amenities (such as access to safe drinking water, electricity, improved sanitation, fuel used for cooking, type of house, per capita space in the house), assets (owns house, owns agricultural land and ownership of certain animals like cow/buffalo, camels, horses/donkeys, goats, sheep, chicken/ducks, and pigs) and durables (such as a mattress, pressure cooker, chair, sofa set, cot or bed, table, electric fan, radio or transistor, black and white television, color television, sewing machine, mobile and other telephone, computer, refrigerator, washing machine, watch or clock, bicycle, motorcycle or scooter, animal-drawn cart, car, tractor, water pump, and thresher), a wealth index is computed at the national level and divided into quintiles. The factor loading to amenities, assets and durables derived by factor analysis was used for the computation of the wealth index (factor analyses were not shown). Households were categorized from the poorest to the richest groups corresponding to the lowest to the highest quintiles. For analytical purposes, it was re-categorized into three categories: poor, middle, and rich.

For tribes, religion was classified into three categories as Hindu, Christian, and others, while for non-tribes it was grouped as Hindu, Muslim, and others. The reason for such a division was because many of the tribes in this region have converted to Christianity. Furthermore, we considered the place of a pregnancy registration as a very important program factor because it covers women who will further receive or use other healthcare services (such as ante-natal care visits, tetanus injection, and health related information) once she gets registered. The question related to the place of pregnancy registration was asked for the last pregnancy and for both live as well as still births. The place of pregnancy registration with the service provider was categorized into three categories: not registered, registered in a government facility, and registered in a private facility.

2.3 Analytical Strategy

First, we tried to examine whether STs or non-tribes had a higher risk of infant mortality. Nelson-Aalen analysis allows comparison of populations through their hazards curves. The relative hazards curves for tribal and non-tribal populations were drawn in order to get a preliminary idea about the groups in which infants are at higher risk in the Central and Eastern regions. When studying the various groups in terms of cumulative hazards functions, the Nelson-Aalen estimator is preferred to the Kaplan-Meier estimator (Cleves, Gould, Gutierrez *et al.*, 2008). We also plotted the hazard estimates for the two groups over the 12 month analysis period. The main purpose of this graph is to show the pattern of variation in risk of infant death between tribes and non-tribes.

Second, a log rank test was applied to examine whether there was statistically significant difference between the survival curve/distributions of two groups. It is a nonparametric test and appropriate to use when the data are right-skewed and censored. The log rank test statistic compared the estimates of the hazard functions of the tribal and non-tribal populations at each observed time point of the event.

Finally, the Cox proportional hazards model (Cox, 1972) was applied to examine the effect of various socio-economic and demographic covariates on the risk of infant death among both tribes and non-tribes. In the Cox model, the dependent variable is the length of exposure (from the date of the initial observation to the date of the event). In our analysis the event variable is infant death, which is coded 0 as "no infant death" and 1 as "infant death" (i.e., death occurred within 12 months of birth). We have seen the impact of various covariates separately for tribes and non-tribes. We tested the proportionality assumption by using Schoenfeld residuals and found that no variable violated the proportionality assumption. All analyses were performed using Stata13.0.

3. Results

3.1 Sample Description

Table 1 shows that around 54,584 live births occurred to 119,534 women from January 2004 (i.e., the reference period for tracking births in the study) to the date of the DLHS-III in 2007–2008. In the DLHS-III in 2007–2008, 86% of the population in Central and Eastern India resided in rural areas and most of them (around 90%) were Hindus. For tribes, 95% of their populations were based in rural areas, while the corresponding figure for non-tribes was 80%. This indicates that there was a large homogeneity in culture among tribes due to sharing of similar types of place of residence. The wealth differentials between tribal and non-tribal populations showed non-tribes as better off than tribes, with 88% of tribe members found to be poor but only 53% for non-tribes; the percentage of the rich among non-tribes was seven times more than that among tribes. This shows that a wide disparity existed in terms of the distribution of wealth between tribes and non-tribes.

In our sample, around three-fourths of tribe women were illiterate, while for non-tribes it was less than 50%. The proportion of tribe women with an educational attainment of high school or above was less than 2%, smaller than for non-tribe women, which was more than 8%. We included one program factor (i.e., place of pregnancy registration) in our analysis. In India (including the Central and Eastern Indian region), private health care centers have much better facilities than public ones but with higher cost of accessibility. In our sample, we found that the proportion of pregnancies registered at a private healthcare center was higher among non-tribes than among tribes.

3.2 Cumulative Hazards Rates

Figures 1 and 2 represent the Nelson-Aalen cumulative hazards rate curve for tribal and non-tribal populations for the Central and Eastern regions of India and for each state. The curves reveal that infants in tribes were at higher risk of death in the first year of life both in the entire region and within each state. Variation across states shows that in Madhya Pradesh the cumulative hazards rates of both groups were close, meaning that the risk of infant death is similar between tribes and non-tribes. In the remaining three states, the hazards rates were higher for tribes and remained higher during the first year of life. This indicates that the disparity in risk of infant death existed during the first year of life between the tribal and non-tribal populations in the states of Jharkhand, Odisha, and Chhattisgarh. The largest disparity in hazards between tribes and non-tribes was found in Chhattisgarh (Figure 2).

Figure 3 highlights the hazards rates by age of the child after birth for both tribes and non-tribes. The pattern of curves was quite similar for both groups. The curve for both groups (tribes and non-tribes) shows that in the very early days of birth, the risk of death was quite high. Later, the mortality risk decreased with increased age of the child till 4 months, the level of risk remained constant between 5 to 10 months for both groups, and increased thereafter. However, the hazards curve for tribes remained above the hazards curve of non-tribes for the entire period.

The log rank test confirmed that children of tribes in the region were at higher risk of death than non-tribes in their first year of life as there was statistically significant difference between the survival distributions of tribal and non-tribal populations (Table 2).

Table 1. Percentage distribution of births during five years prior to the survey by selected background characteristics of Central and Eastern India, DLHS-III, 2007–2008

Covariates	Overall sample Central and Eastern India[a]	Tribes[a]	Non-Tribes[a]
Household/community variables			
State of residence			
Jharkhand	26.8	29.6	25.5
Odisha	17.8	16.2	18.5
Chhattisgarh	15.4	19.6	13.4
Madhya Pradesh	40.0	34.6	42.6
Place of residence			
Urban	14.4	4.0	19.2
Rural	85.6	96.0	80.8
Religion			
Hindu	87.0	79.0	90.9
Muslim	5.7	0.1	8.2
Christian	2.5	7.2	0.3
Others	4.8	13.7	0.6
Household wealth index			
Poor	64.0	88.0	52.6
Middle	16.0	7.7	20.0
Rich	20.0	4.3	27.4
Caste			
SC	16.6	—	—
ST	32.0	—	—
Others	51.4	—	—
Mother-specific variables			
Age			
15–24	42.8	40.6	43.8
25–34	48.6	48.7	48.5
35+	8.6	10.7	7.7
Feeding with colostrum			
No	84.1	83.6	84.4
Yes	15.9	16.4	15.6
Mother's education			
Illiterate	53.4	71.0	45.1
Primary	16.7	13.4	18.3
Secondary	23.7	13.7	28.5
Higher	6.2	1.9	8.1
Infant-specific variables			
Birth order			
1 to 2 children	58.5	52.1	61.5
3 or more children	36.3	43.9	32.7
Sex of the infant			
Male	49.9	49.6	50.1
Female	46.0	47.5	45.2
Place of pregnancy registered[c]			
Not registered	47.4	50.2	46.1
Registered in government facility	9.7	3.8	12.5
Registered in private facility	39.1	43.5	37.1
No. of mothers[b]	**119,534**	**34,698**	**84,532**
No. of births[b]	**54,584**	**17,515**	**36,945**

Note: (1) a. Weighted percentages in the table were based on births during last five years prior to survey; b. denotes unweighted frequency; c. Information was collected for live birth/still birth of last pregnancy. (2) Missing cases of each variable were not reported; thus, the sum of percentage of some variables did not add up to 100%. (3) SC: Scheduled caste; ST: Scheduled tribes; Others: other classes.

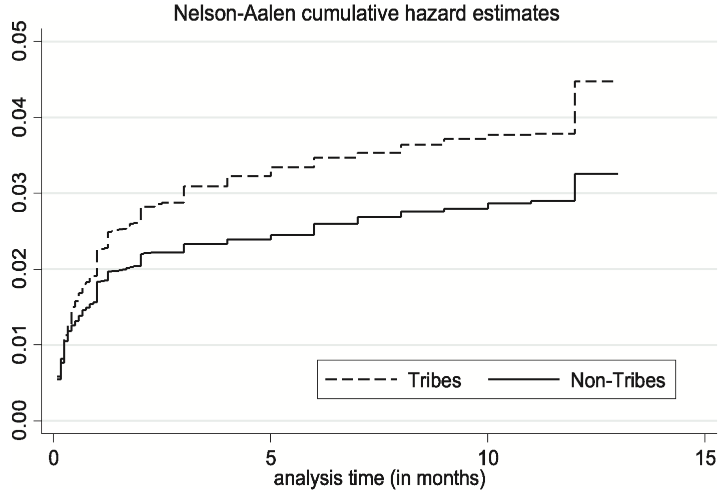

Figure 1. Cumulative hazard functions of the tribal and non-tribal groups in Central and Eastern Indian region, DLHS-III, 2007–2008
Note: Non-tribes includes scheduled caste (SC), other backward classes (OBC), and others

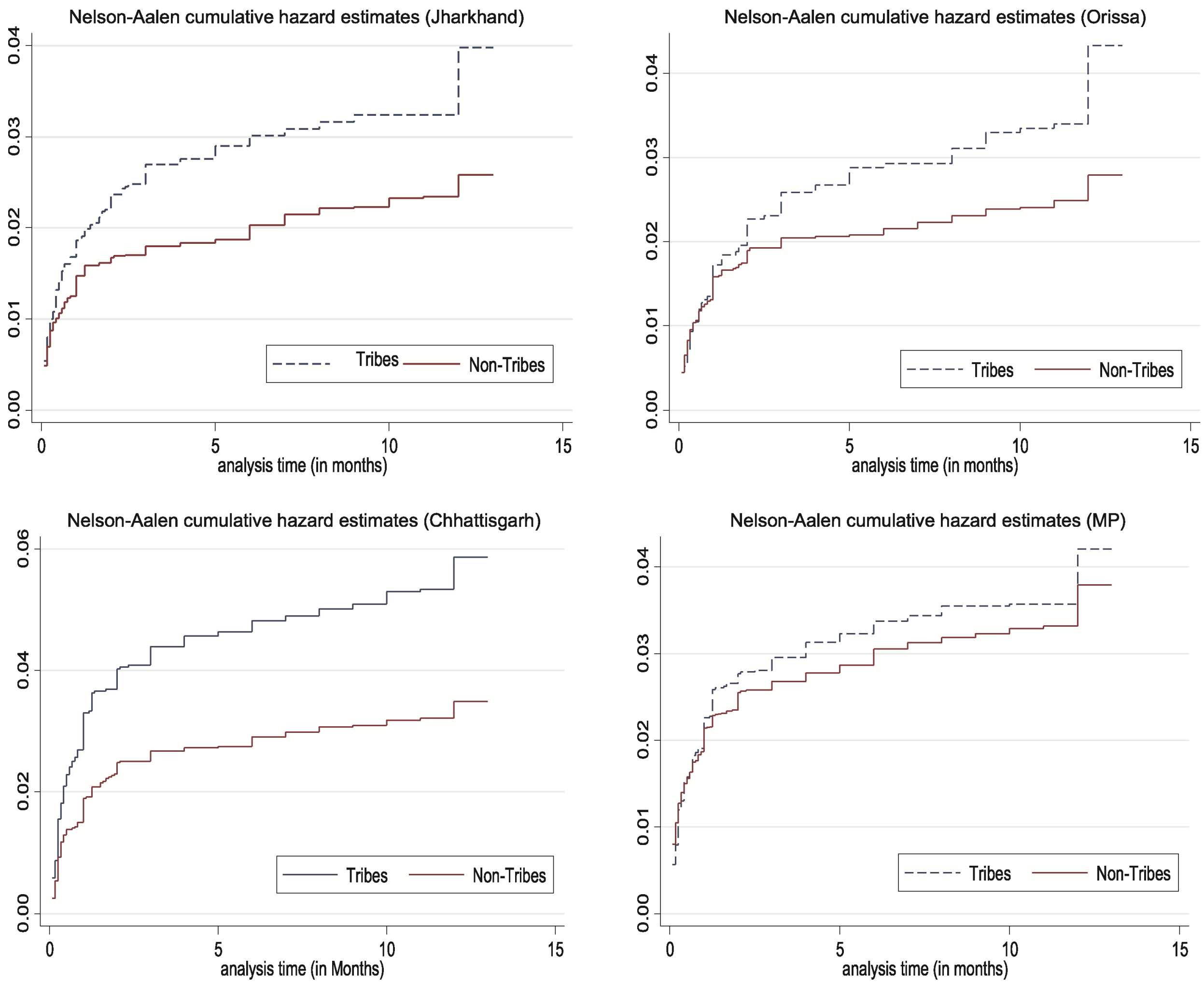

Figure 2. Cumulative hazard functions for tribal and non-tribal populations in Jharkhand, Orissa, Chhattisgarh, and Madhya Pradesh, DLHS-III, 2007–2008
Note: Non-tribes includes scheduled caste (SC), other backward classes (OBC), and others

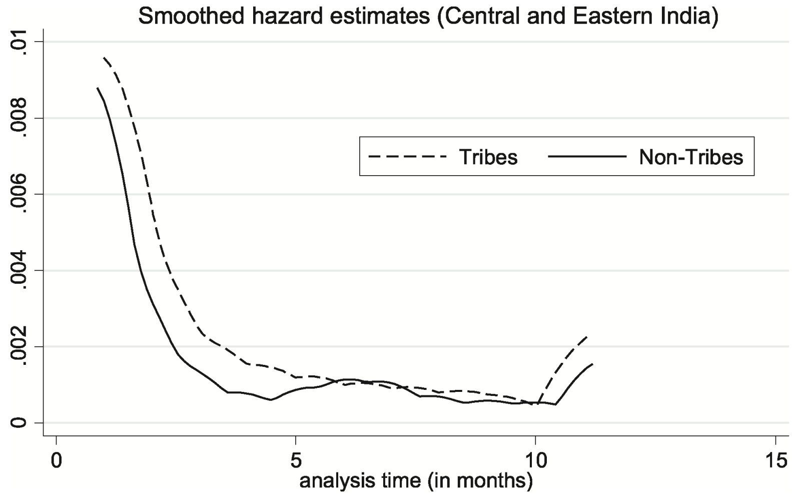

Figure 3. Smoothed relative hazards curves for tribal and non-tribal populations in Central and Eastern Indian region, DLHS-III, 2007–2008
Note: Non-tribes includes scheduled caste (SC), other backward classes (OBC), and others

Table 2. Log-rank test for equality of survivor functions for tribal and non-tribal populations in Central and Eastern India, DLHS-III, 2007–2008

Caste	Events observed	Events expected
Tribes	369	284.49
Non-tribes	512	596.51
Total	**881**	**881**

Note: χ^2 (1) = 37.20; $p < 0.0001$

3.3 Cox Hazards Regression Models

The results of Cox regression models for both tribal and non-tribal populations are presented in Table 3. Comparisons between tribal and non-tribal populations revealed clear patterns of both similarity and dissimilarity. Sex of infants, whether the infant was fed with colostrum, and age of mother at birth had a similar relationship with infant mortality risk in both tribes and non-tribes. The risk of death for a female infant was 15% ($p < 0.05$) lower in tribes and 16% ($p < 0.05$) lower in non-tribes compared to a male infant. Infants fed with colostrum had 21% ($p < 0.05$) lower risk of death in tribes and 40% ($p < 0.001$) lower risk of death in non-tribes. Infants born to mothers aged 25–34 had 40% ($p < 0.001$) lower risk of death in tribes and 35% ($p < 0.001$) lower risk of death in non-tribes compared to those born to mothers aged 15–24. Infants born to mothers ages 35 or older had a marginally significant 23% ($p < 0.1$) lower risk of death in tribes compared to those born to mothers aged 15–24. In non-tribes, infants born to mothers aged 35 or older had 39% ($p < 0.01$) lower risk of death compared to infants born to mothers aged 15–24.

However, state of residence, wealth of household, religion, rural or urban residence, mother's education, and birth order of the infant did not have a similar association with infant mortality in tribes and non-tribes. For tribes, among the household/community factors, we found that infants born in Chhattisgarh had 78% higher risk of mortality ($p < 0.001$) in comparison to those born in Jharkhand. Infants born in Christian families had 85% higher risk of death than those born in Hindu families ($p < 0.001$).

Infants born to women with an educational attainment of primary school and secondary school had 26% ($p < 0.05$) and 44% ($p < 0.001$) lower risk of death compared to those born to women without any schooling, respectively. Although infants born to women with an educational attainment of high school or above had 43% lower risk of death than those born to illiterate women, this mortality risk reduction was not significant, possibly due to the small sample size of higher educated

Table 3. Relative infant mortality risk and 95% confidence interval (CI) for tribal and non-tribal populations by selected covariates, Central and Eastern India, DLHS-III, 2007–2008

Covariates	Tribes	Non-Tribes
Household/community variables		
State of residence		
Odisha (Jharkhand)	1.25 (0.92, 1.71)	1.13 (0.88, 1.44)
Chhattisgarh (Jharkhand)	1.78 (1.32, 2.39) ***	1.44 (1.13, 1.85) **
Madhya Pradesh (Jharkhand)	1.13 (0.85, 1.52)	1.44 (1.19, 1.73) ***
Place of residence		
Rural (urban)	1.32 (0.76, 2.30)	1.29 (1.02, 1.63) *
Religion		
Christian (Hindu)	1.85 (1.34, 2.55) ***	N.A.
Muslims (Hindu)	N.A.	1.04 (0.78, 1.37)
Others (Hindu)	1.35 (0.97, 1.88)	1.88 (1.04, 3.42) *
Household wealth index		
Middle (poor)	0.69 (0.47, 1.02)	0.86 (0.72, 1.04)
Rich (poor)	1.10 (0.65, 1.88)	0.68 (0.54, 0.86) **
Mother-specific variables		
Age		
25–34 (15–24)	0.60 (0.49, 0.73) ***	0.65 (0.56, 0.77) ***
35+ (15–24)	0.77 (0.56, 1.06)	0.61 (0.45, 0.83) **
Feeding with colostrum		
Yes (no)	0.79 (0.65, 0.98) *	0.60 (0.51, 0.71) ***
Mother's education		
Primary school (illiterate)	0.74 (0.57, 0.97) *	1.01 (0.84, 1.22)
Secondary school (illiterate)	0.56 (0.41, 0.75) ***	0.86 (0.71, 1.05)
High school or above (illiterate)	0.57 (0.25, 1.30)	0.76 (0.51, 1.13)
Infant-specific variables		
Birth order		
3 or more children (1 or 2)	0.67 (0.55, 0.83) ***	0.99 (0.84, 1.18)
Sex		
Female (male)	0.85(0.72, 1.00) *	0.84 (0.73, 0.96) *
Program variables		
Place of pregnancy registered		
Govt. facility (not registered)	0.98 (0.82, 1.18)	0.96 (0.82, 1.12)
Private facility (not registered)	0.81 (0.48, 1.36)	0.88 (0.68, 1.14)

Note: (1) Non-tribes includes scheduled caste (SC), other backward classes (OBC), and others. (2) The category of a given variable in the parentheses is the reference group of that variable. N.A.: not applicable. (3) *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

women among tribes (less than 2% of women in tribal populations received high school level or higher). Among infant-specific factors, the birth order and the sex of the infant were found to be significantly associated with the risk of infant death among tribes. Infants whose birth order was 3 or higher had 33% lower risk of death ($p < 0.001$) in comparison to infants who were first or second births. Being a female infant in tribes was associated with 15% reduced risk of death in comparison to being a male infant ($p < 0.05$).

For non-tribes, we found that infants born in the state of Chhattisgarh had 44% ($p < 0.01$) higher mortality risk in comparison to those born in Jharkhand. This was also true for infants born in the state of Madhya Pradesh in comparison to those born in Jharkhand. Infants born to rural women had 29% ($p < 0.05$) higher risk of death compared to infants born to urban women. Infants born to rich families had 30% ($p < 0.01$) lower risk of death in comparison to those born in poor families.

No significant association between place of pregnancy registration and infant mortality was found in either tribal populations or non-tribal populations.

4. Discussion

In most states in India, tribal populations are isolated, concentrated in certain regions, and live in hilly and forested areas that make communication and access to services difficult even in normal circumstances. These tribal populations have higher infant mortality than non-tribal populations. However, systematic examinations of factors associated with infant mortality between these two populations are rare. By using the dataset of the DLHS-III in 2007–2008, the present study examined the infant mortality gap between tribal and non-tribal populations and factors associated with infant mortality for both tribal and non-tribal populations that include characteristics of households/communities, mothers, and infants. We found that the difference in infant mortality between tribal and non-tribal populations was substantial in the early months after birth, it narrowed between the fourth and eighth months, and then enlarged mildly afterwards. Our results were contradictory to one previous study focusing on nationwide data which found that STs and non-STs' probabilities of survival did not differ significantly during the first year, but during the second year the gap between the *adivasi* and non-*adivasi* children's chances of dying widens and becomes statistically significant (Das, Kapoor and Nikitin, 2010). The different mortality in the first year of life in the present study is possibly due to inaccessibility or unavailability of postnatal care services because these states have low levels of socioeconomic development. We welcome more research to shed light on the theme.

Our Cox regression models show that while some factors are associated with infant mortality similarly among tribes and non-tribes, distinctive associations between tribal and non-tribal populations were striking. Sex of infants, breastfeeding with colostrum, and age of mother at birth acted similarly between tribes and non-tribes, yet factors such as state of residence, wealth of household, religion, place of residence, mother's education, and birth order of the infant behaved differently. No significant association between place of pregnancy registration and infant mortality was found in either tribes or non-tribes.

Female genes are found to be comparatively biologically stronger than male genes. Hence, female infants face a lower risk of death after birth in comparison to male infants for both groups. In comparison with the women younger than 25 years, increase in the age of mother till 34 years of age decreases the risk of infant death both for tribes as well as non-tribes. Some previous studies also reached a similar conclusion regarding the association between mother's age at birth and mortality risk of infants (Gunasekaran, 2008; Singh, Kumar, and Kumar, 2013).

A significant linkage between breastfeeding with colostrum and infant survival for both tribal and non-tribal populations was observed in our study. Breastfeeding is a behavioral as well as biological factor, and a mother usually practices it irrespective of caste, race, or culture. The behavioral practice of exclusive breastfeeding exists in almost every culture, but may vary in degree which may affect a child's survival. Many previous studies in India and South Asian countries have indicated that women commonly wait several days after birth to initiate breastfeeding to avoid giving colostrum (Baqui, Williams, Darmstadt *et al.*, 2007; Engle, 2002; Huffman, Zehner, Victora *et al.*, 2001; Macro and IIPS, 2000; Rahi, Taneja, Misra *et al.*, 2006). Most tribal women do not initiate breastfeeding within the first hour of birth and few of them squeeze out the first milk before initiation of breastfeeding. Some tribe-specific studies have also reported that most babies do not receive mothers' milk in the first two or three days (Baqui, Williams, Darmstadt *et al.*, 2007; Engle, 2002; Huffman, Zehner, and Victora, 2001).

Factors acting differently for tribal and non-tribal populations were state of residence, wealth, religion, place of residence, mother's education, and birth order. Even after adjusting for characteristics of the infant and the mother and program related factors, regional variation in risk of infant death for both groups exists. For tribes, we found higher risk of infant death in Chhattisgarh in comparison to Jharkhand; for non-tribes, residing in Chhattisgarh and Madhya Pradesh raised the risk of experiencing infant death by almost 44% in comparison to Jharkhand. These spatial or geographic differentials in infant mortality may be due to the differences in their socio-economic development and/or cultural factors. These findings are in accordance with previous studies (Dhar, 2013; Marwar and Jain, 1997; NSSO, NSO, and MOSPI, 2011; Pandey, 1988; Pandey and Tiwari, 2001; Sahu, Nair, Singh *et al.*, 2015; Sharma, 2010; van Dillen, 2006).

Tribes following Christianity in the Central and Eastern region had a higher relative risk of infant death in comparison to Hindus. The possible reason could be that most of the tribes in this region have adopted Christianity and because of their own religious customs they may not be able to utilize modern healthcare facilities, which resulted in high risk of disease, infections, or even death among newborn children (Pandey, Choe, Luther *et al.*, 1998). The different infant feeding practices between the two religious groups may also contribute to higher risk of infant mortality among Christian tribes. In Christian tribes, children are usually fed cow's milk and, because of their religious and traditional rituals they usually wait several days after birth to initiate breastfeeding (Baqui, Williams, Darmstadt *et al.*, 2007; Huffman, Zehner, Victora, 2001); children in Hindu tribes are normally fed with breast milk right after birth.

For non-tribes, no difference was found between two major religious groups: Hindus and Muslims. The similarity between these two religions may be responsible for this non-significant difference. Furthermore, the homogeneity in socio-cultural environment, availability of health infrastructure, similarity in attitudes, behaviors, and access to public health services in the areas where members of these two religions are located may also explain the similarity of infant mortality between these two religious groups (Guillot and Allendorf, 2010; Bhalotra, Valente, and van Soest, 2010; Mistry, 2005).

The risk of infant death among the rich families in non-tribes was significantly lower. Families with good economic condition normally have great resources to afford timely and high quality medical treatments when family members are in need (Cutler, Deaton, and Lleras-Muney, 2006; Bhalotra, 2007; Das Gupta, 1990), and have good living environments both at home and in the neighborhood that prevents their members, especially children, from experiencing health deterioration due to poor living environments (Das Gupta, 1990; Sastry, 1997). Mothers from economically well-off households are more likely to have the ability to provide better health care for their children in terms of adequate nutrients, proper clothing, clean tap water, clean sanitary conditions, and other amenities which affect health (Aber, Bennett, Conley *et al.*, 1997; Barrett and Browne, 1996; Defo, 1997). However, for tribes, no difference exists in the risk of infant death among the three wealth classes. We speculate that it might be due to high poverty among tribal populations (Dhar, 2013; NSSO, NSO, and MOSPI, 2011), and the fact that very few families in the tribal populations were classified as rich families and most of them have similar socio-economic status.

In non-tribes, infants born in rural areas had a higher risk of death than those born in urban areas. Rural areas normally have limited maternal and antenatal/postnatal care facilities, and thus infants born in rural areas cannot get timely and adequate care services, which increase mortality risk. Our finding on this rural-urban difference in infant mortality is in line with previous studies (Pandey, 1998). However, for tribes, the rural-urban difference in risk of infant death was not significant. This may be due to the fact that more than 95% of tribal populations reside in rural areas and they have homogeneously low access to and utilization of maternal and antenatal/postnatal care services (Singh and Ram, 2006).

After controlling for other factors (household, child, and program factors), mother's education was found to have a significant influence on infant survival among tribes. Education of mother is known to have a strong and positive impact on children's health and her ability to access as well as use of health care services such as ante-natal care (Sastry, 1997b; Ramalingaswami, Jonsson, and Rohde, 1996; Measham, Rao, Jamison *et. al.* 1999; Gragnolati, Shekar, Das Gupta *et al.* 2005; Nair, 2007; Virmani, 2007; Sharma, Sarangi, Kanungo *et al.*, 2009; Gaiha, Kulkarni, Pandey *et al.*, 2011; Sahu, Nair, Singh *et al.*, 2015). Educated women are not only likely to earn more — thus, improving living conditions for the children at home — but also likely to assert more control over household resources and spend for their children (Caldwell, 1993). Educated mothers are also more likely to take their children to health centers when ill and regulate their own reproductive behavior (Cleland and Van Ginneken, 1988; Das Gupta, 1990; Martin and Juarez, 1995). All these advantages could make a difference in infant mortality. Due to its very small proportion within tribes, infants born to women with high school level education or above did not experience a significant protection in survival compared to those born to illiterate women. However, among non-tribes, education of the mother did not play a significant role in affecting the survival of infants. This result is unexpected, and is possibly because of the following reasons. Firstly, the quality of education in the central and eastern Indian region is very poor, which leads to poor educational outcomes even among educated women; also, women still remain superstitious and follow home-based child care rather than scientific-based care. Secondly, due to homogeneity in the socio-economic environment, the attitude and behavior of both educated and uneducated women in child rearing are hardly different. Thirdly, women who approach healthcare centers for their children are driven mostly by the experience of older women of the household instead of education.

We found relatively higher infant survival for higher order births among tribes. One possible reason could be that for initial births, tribal women strictly followed their own traditional customs, rituals, and norms; but later on, for higher order births they utilized their own experience gained in previous child care and even relaxed some of their traditional beliefs, which led to better child survival prospects (Das Gupta, 1990). On the other side, for non-tribes there is no significant influence of higher order births on infant survival. Few earlier studies highlighted that after controlling for factors such as mother's age and child's birth weight, the child's birth order does not affect its mortality for the first six months of life (DaVanzo, Butz, and Habicht, 1983). This could be because women's behavior towards postnatal child care and utilization of modern health care facilities does not change for higher order births (Miller, Trussell, Pebley *et al.*, 1992; Bhalotra and van Soest, 2008).

The strength of the present paper is the comparison of factors associated with infant mortality between tribal and non-tribal populations in Central and Eastern India. The theme on differentials in infant mortality between tribal and non-tribal populations is understudied in the existing literature. By using a recent survey dataset with a relatively large sample size and inclusion of major characteristics of the household/community, the mother, and the infant, we examined factors that contribute to the difference in infant mortality among these tribes and non-tribes. Because of these unique features, we argue that our results are robust. However, as we did not perform separate analysis for SCs from other classes of non-tribes, some associations may be mixed. Research on separation analysis will likely provide new insights on this issue.

Our findings could have important implications. The present study tries to raise a few issues affecting the infant mortality among both tribes and non-tribes. Overall, our study implies that the differentials in the situation faced by mothers and infants/children of the tribal and non-tribal populations need quick actions by both the government and the health industry sector so that the differentials in child mortality risk could be reduced. Our research further emphasizes the need to ensure accessibility and affordability in health services utilization for all the people. There should be a separate plan for tribal and non-tribal areas, and all plans or programs should be region-specific, not based on the overall conditions of the district. Our findings for tribal populations also imply that the health infrastructure should be strengthened in the areas where there are larger numbers of tribes. Many of the maternal and newborn health problems can be prevented by increasing the awareness and utilization of ante-natal care, institutional deliveries, and postnatal visits among tribes. There is an urgent need to educate tribal mothers and health personnel, especially in early newborn care. Appropriate behavior change communication (BCC) strategies should be developed for tribal women and their family members. Some mission-based programs such as Janani Suraksha Yojana (JSY) should be promoted in the remotest corner of the country. Successful programs such as an intervention program by Society for Education, Action and Research in Community Health (SEARCH) in the remote tribal areas of Gadchiroli (Maharashtra) should be replicated extensively in other tribal areas (Goswami, 2003).

As the millennium development goals (MDGs) have been upgraded to the era of sustainable development goals (SDGs) agenda (UNDP, 2016), the Government of India needs to re-frame policies and pool more efforts to reduce the infant mortality rates in tribes and regional inequity across the country to avoid the delayed achievement of SDGs.

5. Conclusions

Although much literature has analyzed the predictors of child survival among the tribal population and non-tribal population, it is less frequent to simultaneously look into factors associated with infant mortality in both tribal and non-tribal populations. Based on the data of the District Level Household Survey-III in 2007–2008, the present paper examined differentials in factors associated with infant mortality risks between tribes and non-tribes. We found that sex of infants, breastfeeding with colostrum, and age of mother at birth were significant factors associated with infant mortality in both tribal and non-tribal populations. However, state of residence, wealth, religion, place of residence, mother’s education, and birth order seemed to have different associations with infant mortality between tribal and non-tribal population. Such differential associations likely resulted from the differences in cultural traditions, socioeconomic development, and availability of health care services between these two populations. These results could have implications for intervention programs that aim to reduce the infant mortality rate in India.

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No conflict of interest is reported by all authors.

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Author Contributions

Laxmi Kant Dwivedi and Mukesh Ranjan conceived and designed the research paper; Mukesh Ranjan, Laxmi Kant Dwivedi and Brajesh analysed the data; Mukesh Ranjan, Laxmi Kant Dwivedi and Brajesh contributed agents/materials/analysis tools; Mukesh Ranjan, Rahul Mishra, Laxmi Kant Dwivedi wrote the manuscript. Rahul Mishra, Laxmi Kant Dwivedi and Brajesh refined the manuscript.

Ethics Statement

The analysis done in this paper was performed using secondary data obtained from publicly available sources as outlined in the Data and Methods section.

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