Environmental and Socio-demographic Determinants of Under-5 Mortality in India: A Survival Analysis on Indian DHS Data

1. INTRODUCTION

With the end of the Millennium Development Goals (MDGs) era, the international community agreed on a new framework of Sustainable Development Goals (SDGs) which targets to end preventable deaths of new-borns and children under five years by 2030. Despite the substantial progress in the reduction of child mortality, child survival remains an urgent concern. It is admissible that 15,000 children die every day, mostly from treatable diseases and preventable causes, even though the knowledge and technologies for life-saving interventions are available. Around 12.6 million deaths worldwide in 2012 were attributable to the environment-related exposures, including 26% of these deaths among children under five. Global environmental challenges are increasing, including rapid urbanization, climate change and increased resistance to drugs. In recent years, environmental epidemiology has expanded its purview from investigating specific agents in air, water, drought, agriculture and industry to investigate how the physical environments affect health and risk factors for chronic diseases across the globe.

Environmental threats to child health are widespread and are multiplying as nations undergo industrial development and countries pass through the epidemiologic transition. Environmental risk factors interact with socio-demographic factors that contribute to specific effects on child health outcomes. Poverty and associated risk factors, including un-improved drinking water, inadequate sanitation facilities and indoor air pollution from solid fuels, account for a large proportion of under-five deaths parents' education socioeconomic status and geography are significant predictors of child survival. While many of the previous studies in the Indian context have investigated the role of child, maternal, and household-level risk factors of infant and child survival, these studies have largely ignored the potential effect of environment and geographic space in explaining child survival. Further, little has been done on studying how in under-five mortality are associated with socio-demographic and environmental aspects that have been found to affect child survival.

1.1 Need for the study

Identifying these hazards prevalent in various settings for children's lives is an essential foundation for setting-based interventions. Also, understanding the role of each element and its contribution to specific adverse health outcomes would be very useful in identifying courses of protective action. Even though many studies have investigated the relationship between human health and environmental exposures, but still, there exist critical and unanswered questions that need to be addressed. A crucial issue in this context is the knowledge on the extent to which environment adversely affect child survival and under-five mortality. To best of our knowledge, there has been virtually no study that has attempted to study the associations between under-five and the environmental exposures such as air pollution, water pollution, drought and other socio-demographic determinants in the Indian context.

1.2 Objective

Our study aimed to investigate whether environmental exposures affect under-five mortality in India. We are also interested in focusing on regional differences in child survival.

2. METHODOLOGY

2.1 Data source

The data used in this study has been taken from the National Family Health Survey (NFHS) -4. The NFHS is the Indian version of the Demographic and Health Surveys conducted in a representative sample of households throughout India. The data on air pollution used in the study is obtained from The Air Quality Life Index initiative by the Energy Policy Institute at the University of Chicago (EPIC).

The AQLI uses satellite-derived PM2.5 raw data from the Atmospheric Composition Analysis Group at Dalhousie University, which covers the globe at a high resolution of 10km x 10km. The data on groundwater quality for the year 2015-2016 is obtained from the Central Ground Water Board (CGWB), Ministry of Water Resources RD & GR, Government of India. The chemical quality of shallow groundwater is being monitored by CGWB through a network of 14377 observation wells located all over the country. The data on drought-prone areas for the year 2015 was obtained from the Ministry of Agriculture and Farmers Welfare, Government of India and the Mahalanobis National Crop Forecast Centre (MNCFC) at New-Delhi. MNCFC has been established under the Ministry of Agriculture and Farmers Welfare, Government of India for applications of space and geospatial technology in various domains of agriculture.

2.2 Statistical Analysis

To explore the association between environmental and socio-demographic factors with under-five mortality in India, we used Kaplan-Meier survival plots, log-rank test (Mantel test) and Cox proportional hazard model. The death rates were calculated using the synthetic cohort component approach. The Kaplan–Meier estimator is a non-parametric statistic used to estimate the survival function from lifetime data. It is the simplest way of computing survival over time despite all these difficulties associated with subjects or situations. For each time interval, survival probability is calculated as the number of subjects surviving divided by the number of patients at risk. Kaplan-Meier survival plots are used for graphical comparison of the potential differences. To test the null hypothesis, the survival distribution is the same in two or more groups log-rank test is used. The main idea behind the log-rank test is to compare the number of observed events to the number of expected events (based on Kaplan-Meier curves) at all points where the events are observed. The numerical value of the test statistic is compared to the chi-square distribution with degrees of freedom that are equal to the number of groups being compared minus one. We used Cox proportional hazard regression to estimate the hazard ratios (HRs) with their 95% confidence intervals (CIs) for under-five mortality. Adjusted hazard ratios for under-five death were calculated for the total sample, adjusting for each of the independent variables.

3. RESULTS

The association between environmental and socio-demographic factors with under-five mortality in India is depicted in Table-1. The mortality rates, results of log-rank test and hazard ratio confirm the influence of environmental predicators on under-five mortality and child survival in India. The under-five mortality rates in air polluted areas are 59.09 deaths per thousand live births while in non-air polluted areas is 38.27 deaths per thousand live births. The gap in mortality rates is around 20.82 deaths per 1000 live births. The under-five mortality rates in water polluted areas are 53.90 deaths per thousand live births while in non-water polluted areas is 42.30 deaths per thousand live births. The gap in mortality rates is around 11.6 deaths per thousand live births. The under-five mortality rates in drought-prone are 53.87deaths per thousand live births while that in non-drought prone areas is 46.63 deaths per thousand live births. The gap in mortality rates is around 7.2 deaths per thousand live births. At the same time, the under-five mortality rate at the national level is 49.75 deaths per thousand live births. The log-rank test statistic value is respectively 344.27, 38.28, and 83.54 for air pollution, water pollution and drought is compared to a chi-square distribution results in the p-value less than .001 for all the environmental factors. Therefore we would reject the hypothesis that the survival experience is the same for all the groups. The hazard ratio shows that the children living in the air polluted areas are 1.09 times at higher risk of under-five death compared to those children living in the non-air polluted regions. The children living in water polluted have 1.071 times higher risk of under-five death compared to those children residing in non-water polluted areas. The children living in drought-prone

areas have 1.055 times more risk of under-five death compared to those children residing in non-drought prone areas. The Kaplan-Meier survival plots comparing child survival across three environmental exposures is given in Figure-1.

4. CONCLUSION

Environmental health risks can be significantly mitigated or prevented through a variety of activities in different sectors, mainly in infrastructure, energy, transport and agriculture. The most sustainable way is to go hand in hand with creating a healthier and more sustainable environment with an enhanced focus on prevention through action on the root causes the exposures. This can be achieved by using efficient energy solutions, regulating emissions from industry, developing healthy and efficient transport options, reducing agricultural waste incineration, forest fires and certain agroforestry. This unique study comprehensively examines whether environmental exposures affect under-five mortality in India health by using advanced statistical analyses and nationally representative data.

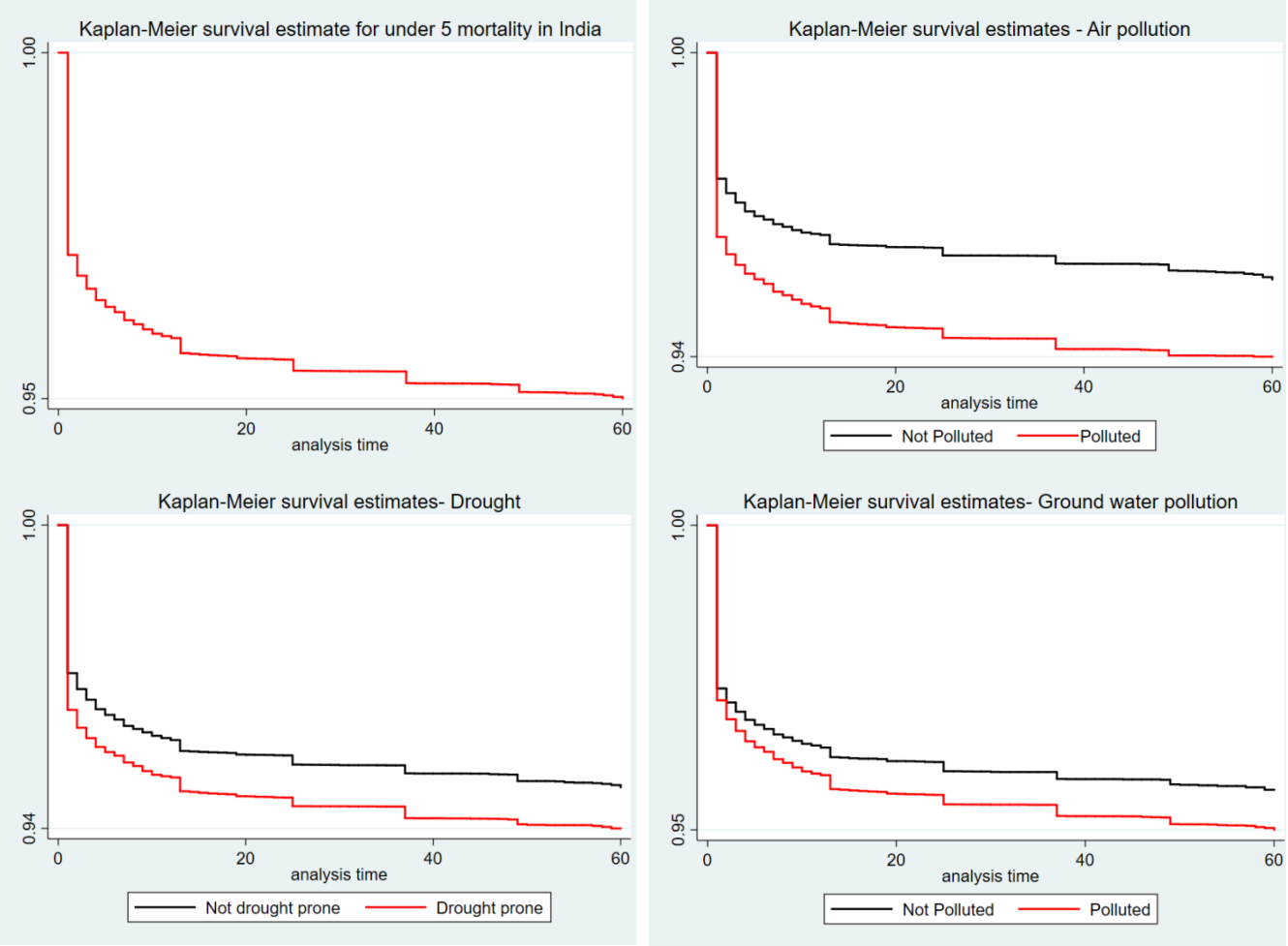

Figure-1: *Kaplan-Meier survival plots comparing child survial in India, 2015-16*

Table-1: *Association of under-five deaths with environmental predicators and other background characteristics India, 2015*-16

Background characteristics	Total (N)	Weighted Percentage	Percentage of under five deaths	Under-five mortality rate *5q0* (95% CI)	Log-Rank test statistic	P-value	Adjusted HR (95% CI)	P-value
Air pollution								
Not polluted	112368	44.95	3.41	38.27 [36.58-39.96]	344.27	<0.001	1.00	
Polluted	137599	55.05	5.22	59.09 [57.43-60.75]			1.095 [1.0414 1.1523]	<0.001
Water Pollution								
Not polluted	31575	35.98	3.76	42.30 [40.40-44.21]	38.28	<0.001	1.00	
Polluted	95406	64.02	4.77	53.90 [52.55-55.26]			1.071 [1.0213 1.1238]	0.005
Drought								
Not drought prone	142305	24.87	4.18	46.63 [45.16-48.09]	83.54	<0.001	1.00	
Drought prone	107662	75.13	4.72	53.87 [52.26-55.49]			1.055 [1.0084 1.1029]	0.020
Sex of child								
Male	130572	52.24	4.66	51.47 [49.78-53.16]	34.35	<0.001	1.121 [1.0813 1.1623]	<0.001
Female	119395	47.76	4.14	47.85 [46.47-49.23]			1.00	
Residence								
Urban	70118	28.05	3.08	34.40 [32.16-36.65]	210.86	<0.001	0.970 [0.9203 1.0229]	0.263
Rural	179849	71.95	4.93	55.76 [54.27-57.25]			1.00	
Mothers age								
15-24	87491	35.00	4.63	52.59 [50.49-54.69]			1.073 [0.9990 1.1516]	0.053
25-34	141171	56.48	4.04	44.92 [43.46-46.37]	187.14	<0.001	0.871 [0.8194 0.9253]	<0.001
35-49	21305	8.52	5.99	63.46 [59.63-67.29]			1.00	
Mothers education								
No education	75140	30.06	5.99	67.44 [65.29-69.58]			1.218 [1.1600 1.2783]	<0.001
Primary	35120	14.05	5.36	59.56 [56.29-62.83]	734.74	<0.001	1.204 [1.1399 1.2713]	<0.001
Secondary or more	139707	55.89	3.32	36.47 [35.09-37.84]			1.00	
Birth order								
One	96475	38.59	4.37	47.82 [45.81-49.83]			0.872 [0.8202 0.9274]	<0.001
Two-Three	117983	47.20	3.77	42.87 [41.64-44.11]	446.81	<0.001	0.744 [0.7050 0.7845]	<0.001
Four and above	35510	14.21	6.63	75.62 [72.75-78.50]			1.00	
Religion								
Hindu	196629	78.66	4.49	50.52 [49.43-51.62]			1.178 [1.0496 1.3213]	0.005
Muslim	41379	16.55	4.39	49.94 [47.42-52.46]	103.92	<0.001	1.218 [1.0765 1.3781]	0.002
Christian	5111	2.04	2.77	32.21 [26.29-38.13]			1.085 [0.9439 1.2464]	0.252
Others	6848	2.74	3.37	38.97 [33.78-44.16]			1.00	
Caste/Tribe								
Scheduled caste	53851	21.54	4.91	55.86 [53.72-57.99]			1.120 [1.0516 1.1926]	<0.001
Scheduled tribe	26350	10.54	4.93	57.24 [53.71-60.77]	130.55	<0.001	1.056 [0.9848 1.1314]	0.127
Other backward class	110399	44.17	4.54	50.78 [49.22-52.34]			1.043 [0.9878 1.1013]	0.129
Others	59366	23.75	3.48	38.97 [36.77-41.16]			1.00	
Wealth quintile								
Poorest	63394	25.36	6.27	71.70 [69.45-73.96]			1.944 [1.7732 2.1310]	<0.001
Poorer	54939	21.98	5.07	57.33 [54.82-59.84]			1.786 [1.6368 1.9489]	<0.001
Middle	49577	19.83	4.20	46.16 [42.99-49.32]	958.53	<0.001	1.603 [1.4717 1.7460]	<0.001
Richer	45305	18.12	3.11	34.90 [32.35-37.45]			1.381 [1.2663 1.5057]	<0.001
Richest	36752	14.70	2.08	22.57 [20.89-24.26]			1.00	
Region								
North	32928	13.17	3.97	44.43 [42.43-46.42]			1.354 [1.2339 1.4856]	<0.001
Central	67799	27.12	6.41	73.50 [71.66-75.35]			1.857 [1.6864 2.0444]	<0.001
East	63638	25.46	4.46	49.55 [47.44-51.67]			1.263 [1.1446 1.3942]	<0.001
Northeast	8839	3.54	4.45	50.09 [46.52-53.66]	903.55	<0.001	1.258 [1.1292 1.4014]	<0.001
West	31836	12.74	2.93	33.58 [29.95-37.21]			1.107 [0.9889 1.2388]	0.077
South	44927	17.97	2.69	29.42 [26.86-31.97]			1.00	
India	**249967**	**100.00**	**4.41**	**49.74 [48.60-50.88]**			-	-