

Linkages between exposure to greenness and COVID-19 mortality: An area-level analysis in India.

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Research Background

The outbreak of novel coronavirus disease-2019 (COVID-19) has spread rapidly across the world since December 2019. It has been declared as a Public Health Emergency of International Concern by the Director of the World Health Organization on January 30, 2020 (World Health Organization, 2020). India has experienced a colossal death toll due to novel coronavirus disease-2019 (COVID-19). Scientific discussion is emerging that environmental factors may affect the COVID-19 susceptibility and mortality. Exposure to greenness is associated with improved immunity, enhanced respiratory functions and better mental health. However, evidence specifically related to novel coronavirus disease (COVID-19) is equivocal due to data and methodological restrictions. Our objective was to check if better district-level greenness exposure is associated with a lower risk of COVID-19 mortality.

Data and methods

This exploratory research attempts to study the associations between exposure to greenness with COVID-19 mortality by integrating remotely sensed environmental data and population health data as described below.

- *COVID-19 mortality*: Cumulative death counts of deaths due to COVID-19 up to May 1, 2021 (which was considered as the peak of the second wave in India) were derived for 640 districts of India from the covid19india.org open data platform.

- *Greenness*: Greenness exposure was estimated for 640 Indian districts using Normalized Difference Vegetation Index (NDVI) derived from Oceansat-2 Ocean Color Monitor (OCM2) Global Area Coverage (GAC) sensor from January to March 2019 (Figure 1a). This data of NDVI with 1*1km spatial grids were rescaled to administrative boundaries of the districts and categorized into quantiles.

- *Particulate Matter 2.5 (PM2.5)*: Average annual concentrations of surface PM2.5 of 2018 (latest available data) were derived from the Atmospheric Composition Analysis Group with 0.01*0.01 degree spatial grids and rescaled to district boundaries (Figure 1b).
- *Temperature*: Average annual temperature was estimated by adding month-wise minimum and maximum temperature data available from the WorldClim platform for 2018 (Figure 1c).
- *Demographic variables*: District-level total population, population density and proportion of elderly (50+ years) were estimated from gridded spatial data provided by POPGRID for the year 2020 (Figure 1d, 1e).

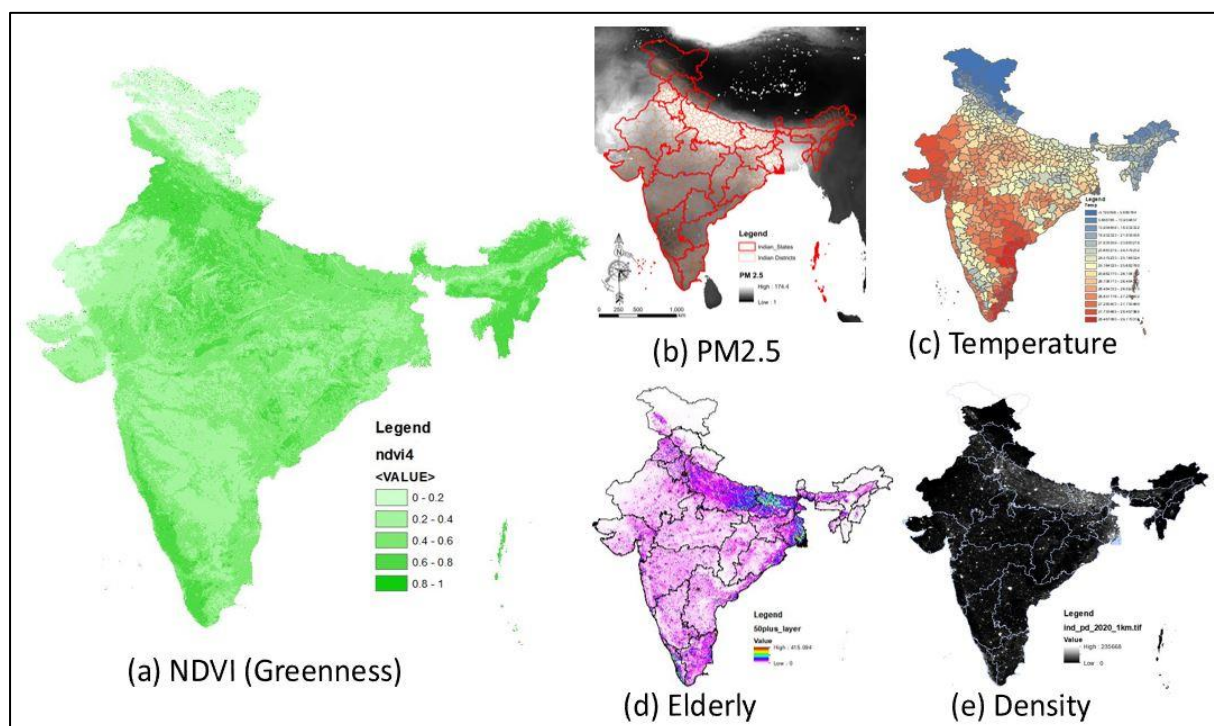


Figure 1 Graphical presentation of spatial variables used in the study.

- *Other covariates*: Education (at least 10 years), media exposure (availability of mobile/TV), and overcrowding (more than 3 persons per room) were derived from the latest round (2015-16) of the National Family Health Survey (NFHS-4).

We used negative binomial regression using the generalized linear mixed model (GLMM) ‘glmmTMB’ package (Brooks et al., 2017) in R version 4.0.2 (R Core Team, 2019) to evaluate the association between NDVI quantiles and COVID-19 mortality. To account for the state measures to suppress COVID-19 incidents and deaths, we included state as a random effect in

the analysis. The model used district population as an offset thus modeling COVID-19 rates on a log scale.

Preliminary findings

The results of generalized negative binomial regression suggest a significant association between increasing NDVI quantiles and reduced COVID-19 mortality rate (Table 1). The model made adjustments for particulate matter (pm25), temperature (temp_3), population density (density), proportion of elderly population (elderly), proportion of population with at least 10 years of education (edu) and proportion of households having TV and mobile phone (media). In comparison to the coefficient between the lowest NDVI quantile 1 (where NDVI values are below 0.2 and showing absence of any greenness) and COVID-19 deaths, districts within NDVI quantiles 2-5 have significantly reducing coefficients. It means the districts with better levels of greenness have lower have experienced lower levels of deaths due to COVID-19 and vice versa.

Table 1 Results of the generalized negative binomial regression model for the association between COVID-19 deaths and greenness (NDVI quantiles).

Generalized negative binomial regression		Number of obs	=	640		
		LR chi2(10)	=	457.44		
		Prob > chi2	=	0.0000		
Log likelihood = -3865.0501		Pseudo R2	=	0.0559		
deceased	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
deceased						
ndvi_5						
2	-.2724287	.1351947	-2.02	0.044	-.5374054	-.007452
3	-.4003807	.136904	-2.92	0.003	-.6687075	-.1320538
4	-.6694538	.1386078	-4.83	0.000	-.9411201	-.3977875
5	-.881085	.1392622	-6.33	0.000	-1.154034	-.608136
pm25	.0011135	.0017106	0.65	0.515	-.0022392	.0044661
temp_3	.0423698	.0077717	5.45	0.000	.0271376	.0576021
density	.0000835	.0000195	4.28	0.000	.0000453	.0001217
edu	.0629713	.0050552	12.46	0.000	.0530632	.0728793
media	.0186981	.0086554	2.16	0.031	.0017339	.0356623
elderly	.0376545	.0129429	2.91	0.004	.0122868	.0630222
_cons	-7.37718	.694536	-10.62	0.000	-8.738446	-6.015915
logpop	1	(offset)				
lnalpha						
_cons	.0364604	.0526637	0.69	0.489	-.0667586	.1396794

References

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