Air pollution exposure differences and health: evidence from Nepal

Niraj Khatiwada[1*] and Alok K. Bohara[2]

[1]Department of Economics, Texas A&M University, College Station, TX, USA and

[2]Department of Economics, The University of New Mexico, Albuquerque, NM, USA

[*]Corresponding author: Niraj Khatiwada; Email: nkhatiwada@tamu.edu

ONLINE APPENDIX

Table A1. Descriptive statistics for variables

Variables	Descriptions	Mean	S.D.	Min	Max
Dependent Variable					
(FEV_1/FVC) Ratio	The ratio of forced expiratory volume in 1 second (FEV_1) to forced vital capacity (FVC)	0.760	0.136	0.375	1
Explanatory Variables					
Laborer-Farmer	1 = Respondent is either laborer or farmer 0 = Otherwise	0.144	0.351	0	1
Brick Kiln	1 = HHs live in wards containing brick kilns 0 = Otherwise	0.195	0.396	0	1
Distance to Road	HH's distance to the nearest major road (in kilometers)	0.086	0.110	0.0004	0.575
Composite Avoidance Measures	Composite index of exposure avoidance measures (facemasks, clean cooking stoves, and air filters) used to reduce air pollution exposure	0.892	0.733	0	2
	0 = No measure used	0.328			
	1 = One measure used	0.452			
	2 = Two or more measures used	0.220			
Residence Duration	How long the HH has lived in the community	3.871	1.532	1	5
	1 = less than 5 years	0.145			
	2 = 5 to 10 years	0.100			
	3 = 10 to 15 years	0.081			
	4 = 15 to 20 years	0.091			
	5 = More than 20 years	0.584			
Smoke	1 = Respondent smokes 0 = Does not smoke	0.061	0.239	0	1
Wealth Index	Division of sample into 5 quintiles based on the amount of assets owned by the HH	2.98	1.423	1	5
Education	HH head's education level	2.317	0.901	1	4
	1 = No formal education	0.210			
	2 = Grade 1 to 8	0.348			
	3 = Grade 9 to 12	0.355			
	4 = Bachelor's degree and beyond	0.086			
Age	Respondent's age	38.926	14.689	18	82
Male	1 = If respondent is a male 0 = If respondent is female	0.593	0.492	0	1
Identifying Variables					
Good Air Quality Perception	1 = Perceive air quality to be good 0 = Perceive air quality to be poor	0.503	0.500	0	1
Awareness	1 = Aware that air pollution causes illnesses 0 = Otherwise	0.811	0.391	0	1

Data source: Nepal Study Center, UNM, 2019.

Table A2. Ordinary least squares (OLS) estimates of the FEV_1/FVC ratio

	Model 1	Model 2
Exposure Avoidance		
Composite Avoidance Measures	0.035	
	(0.012)	
Facemask		0.032
		(0.019)
Clean Cooking Stove		0.038
		(0.022)
Occupational Exposure		
Laborer-Farmer	-0.059	-0.060
	(0.027)	(0.028)
Environmental Exposure		
Brick Kiln	-0.056	-0.057
	(0.023)	(0.023)
Distance to Road	-0.045	-0.034
	(0.229)	(0.231)
Distance to Road Square	-0.271	-0.290
	(0.580)	(0.583)
Constant	0.864	0.864
	(0.045)	(0.045)
Socioeconomic Controls	Yes	Yes
N	274	274
R-squared	0.155	0.154
AIC	-334.360	-331.828
BIC	-292.198	-286.257

Notes: Socioeconomic (and other) controls include variables for years lived in the community, smoking, age, sex, education level, and household wealth. Standard errors in parentheses.

Table A3a. Regression estimates of the FEV_1/FVC ratio with endogeneity

	Ratio (continuous) Model 1	Ratio (continuous) Model 2	Ratio (continuous) Model 3
Exposure Avoidance			
Composite Avoidance Measures	0.071	0.073	0.114
	(0.031)	(0.042)	(0.049)
Occupational Exposure			
Laborer-Farmer		-0.040	-0.039
		(0.026)	(0.027)
Environmental Exposure			
Brick Kiln		-0.050	-0.046
		(0.029)	(0.030)
Distance to Road		-0.066	0.040
		(0.234)	(0.244)
Distance to Road Square		-0.161	-0.553
		(0.661)	(0.719)
Constant	0.696	0.715	0.702
	(0.029)	(0.044)	(0.074)
Socioeconomic Controls	No	No	Yes
N	305	291	274
AIC-corrected	869.530	810.179	753.003
BIC	904.585	879.080	863.354

Notes: Estimates of only health outcome equation are shown for presentational simplicity. Socioeconomic (and other) controls include variables for smoking, age, sex, education level, and household wealth. Years lived in the community variable omitted in Model 3 due to convergence issue. Robust standard errors in parentheses.

Table A3b. Regression estimates of composite avoidance measures (full model)

	Composite avoidance measures (ordered)
Identifying Variables	
Good Air Quality Perception	-0.259
	(0.101)
Awareness	0.458
	(0.152)
Controls	
Laborer-Farmer	-0.297
	(0.152)
Brick Kiln	-0.475
	(0.141)
Distance to Road	0.094
	(1.225)
Distance to Road Square	0.857
	(2.738)
Smoke	-0.370
	(0.168)
Age	-0.013
	(0.003)
Male	0.254
	(0.107)
Education	0.133
	(0.058)
Wealth Index	0.251
	(0.059)
N	274
ρ_{12}	-0.491
Joint significance test of IVs (Chi-square value)	22.52

Note: Robust standard errors in parentheses

Table A4. Moran's I test for spatial autocorrelation (univariate)

	Moran's I Statistics	Z(I)	p-value
FEV_1/FVC Ratio	0.020	0.571	0.569
Composite Avoidance Measures	0.215	5.160	0.000
Facemask	0.125	3.045	0.002
Clean Cooking Stove	0.220	5.271	0.000
Laborer-Farmer	0.153	3.738	0.000
Brick Kiln	0.784	18.644	0.000
Distance to Road	0.682	16.498	0.000

Null hypothesis: Spatial randomization.

Table A5. Moran's test for spatial autocorrelation (regression)

FEV_1/FVC Ratio	Chi-squared value	p-value
Regression with Composite Avoidance Measures and other controls	2.63	0.104
Regression with Facemask, Clean Cooking Stove, and other controls	2.60	0.106

Null hypothesis: Error is i.i.d.

Table A6. Estimates of the FEV_1/FVC ratio across different models

	OLS	Simultaneous (mixed process)	Spatial error model	Spatial-IV
Exposure Avoidance				
Composite Avoidance Measures	0.035	0.114	0.037	0.052
	(0.013)	(0.049)	(0.012)	(0.022)
Occupational Exposure				
Laborer-Farmer	-0.057	-0.039	-0.058	-0.051
	(0.028)	(0.027)	(0.027)	(0.028)
Environmental Exposure				
Brick Kiln	-0.056	-0.046	-0.056	-0.051
	(0.029)	(0.030)	(0.021)	(0.021)
Distance to Road	-0.076	0.040	-0.019	0.007
	(0.247)	(0.244)	(0.216)	(0.219)
Distance to Road Square	-0.200	-0.553	-0.384	-0.443
	(0.721)	(0.719)	(0.512)	(0.522)
Constant	0.865	0.702	0.842	0.827
	(0.062)	(0.074)	(0.045)	(0.053)
Spatial lag (Error)			-0.617	-0.885
			(0.292)	(0.540)
Socioeconomic Controls	Yes	Yes	Yes	Yes
N	274	274	264	264
R-Squared	0.154	—	0.161	0.156
AIC-corrected	-331.850	753.003	-318.874	—
BIC	-289.692	863.354	-268.811	—

Notes: Estimates of only health outcome equation are shown for presentational simplicity. Socioeconomic (and other) controls include variables for years lived in the community, smoking, age, sex, education level, and household wealth. Robust standard errors in parentheses.

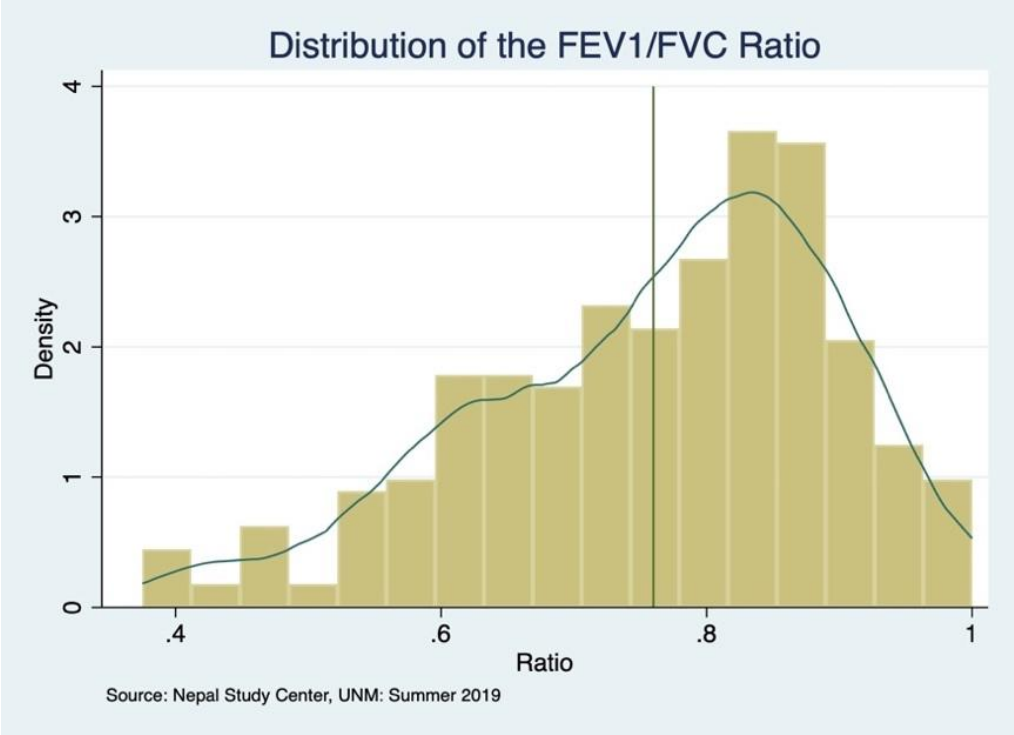


Figure A1. Distribution of the FEV_1/FVC ratio.
Note: The vertical line on 0.76 indicates the mean.

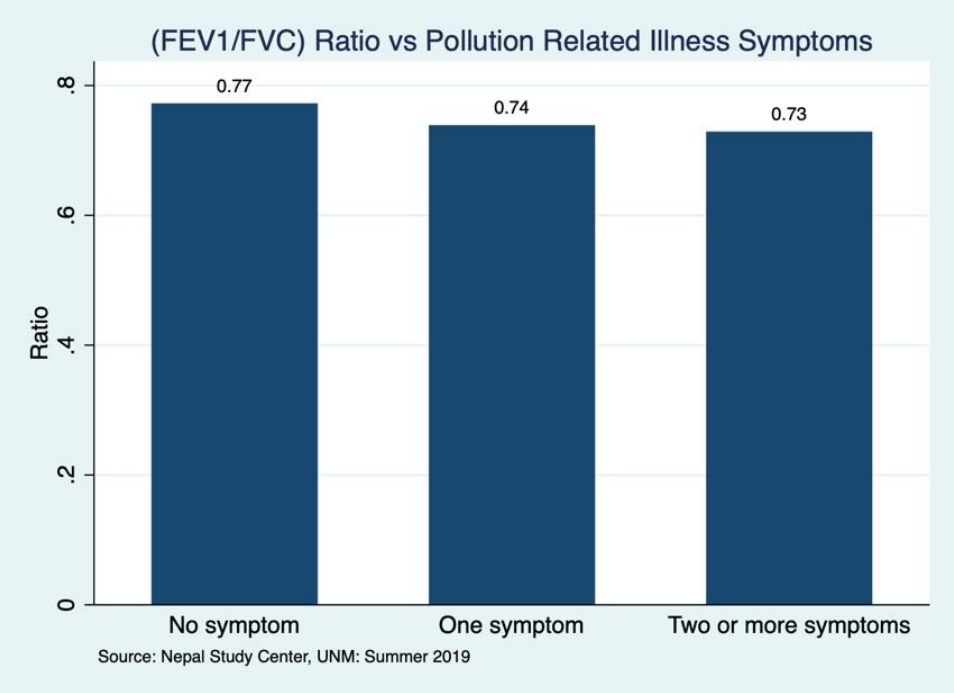


Figure A2. FEV_1/FVC measurement vs self-reported health status.

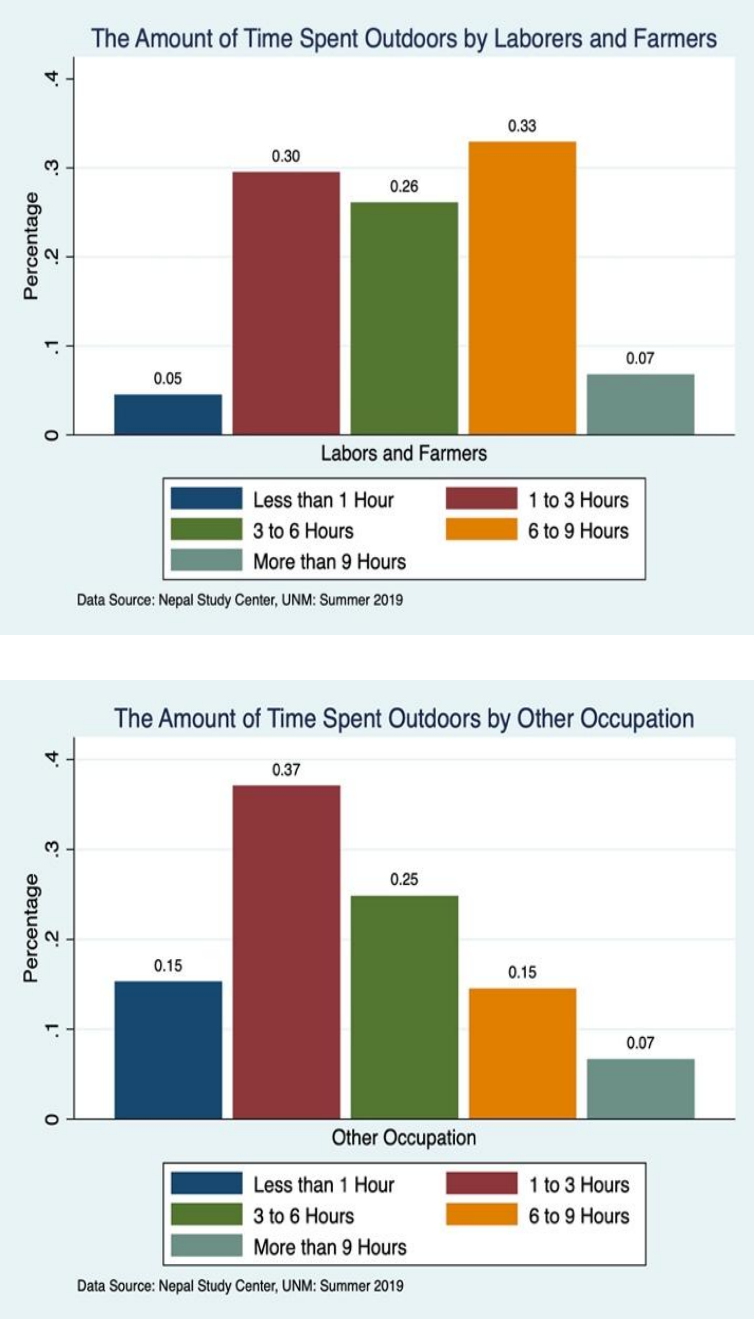
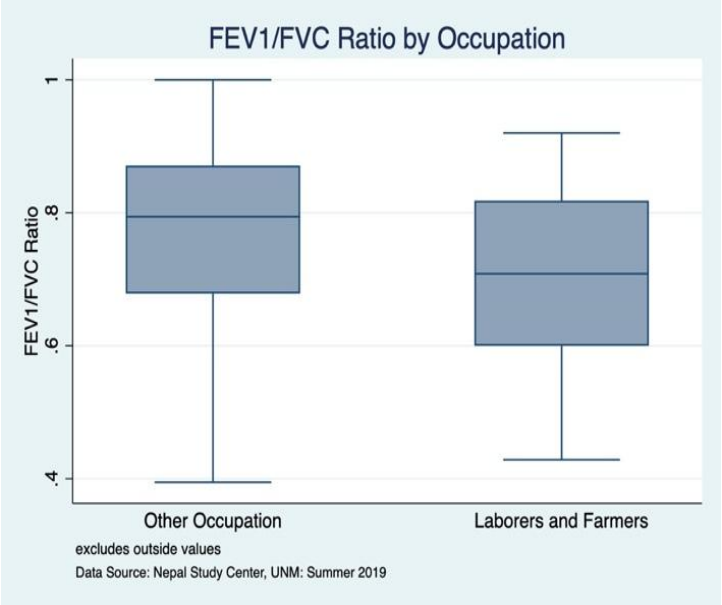


Figure A3. The amount of time spent outdoors by laborers and farmers and other occupations.



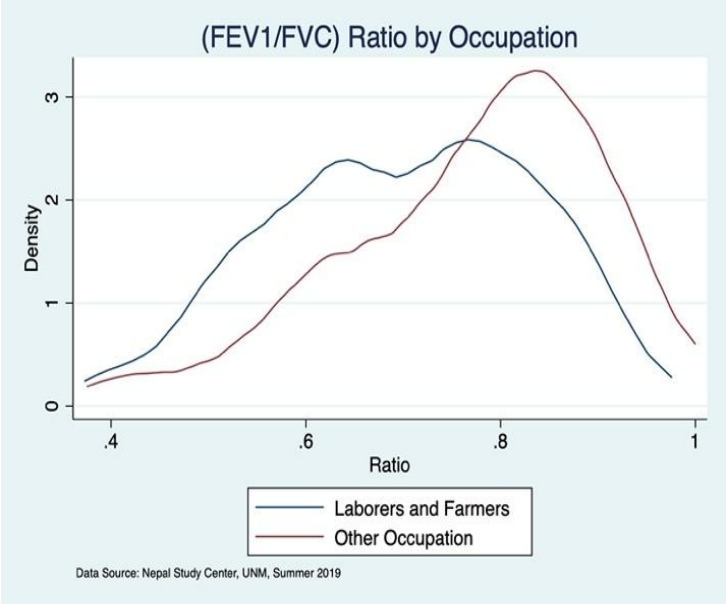
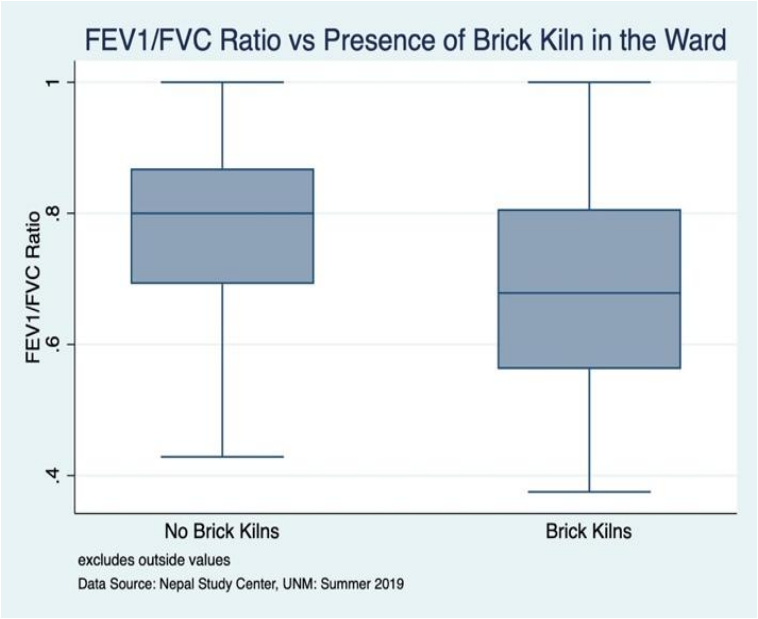
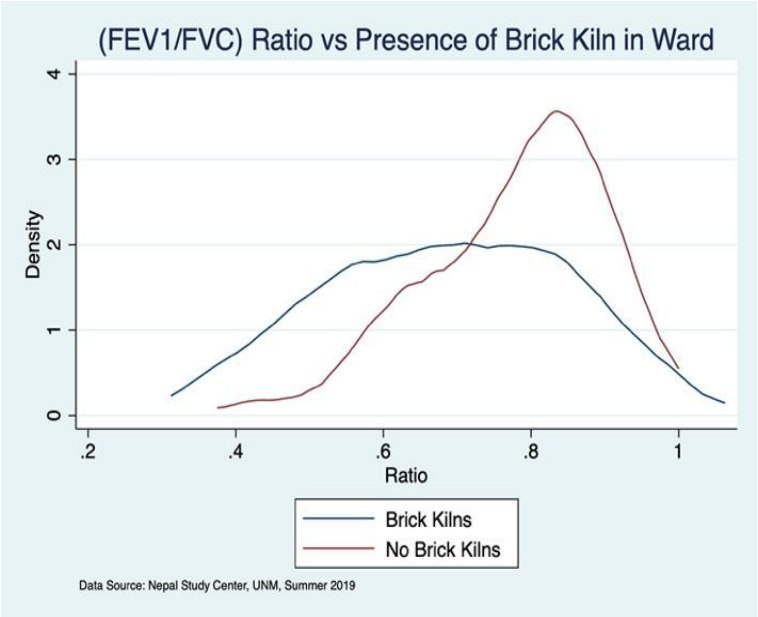
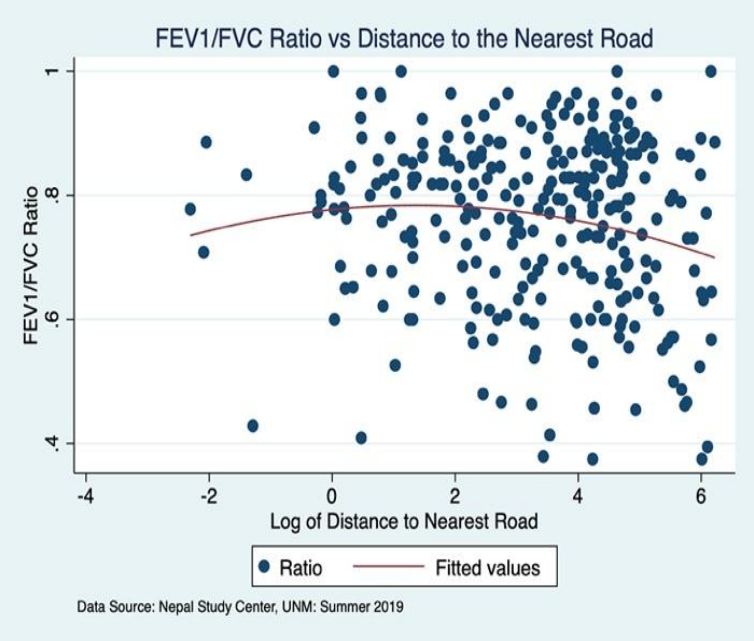


Figure A4. FEV_1/FVC ratio distribution by occupation.


FEV1/FVC Ratio vs Presence of Brick Kiln in the Ward
FEV1/FVC Ratio
.4
.6
.8
1
No Brick Kilns
Brick Kilns
excludes outside values
Data Source: Nepal Study Center, UNM: Summer 2019


(FEV1/FVC) Ratio vs Presence of Brick Kiln in Ward
Density
0
1
2
3
4
.2
.4
.6
.8
1
Ratio
Brick Kilns
No Brick Kilns
Data Source: Nepal Study Center, UNM, Summer 2019



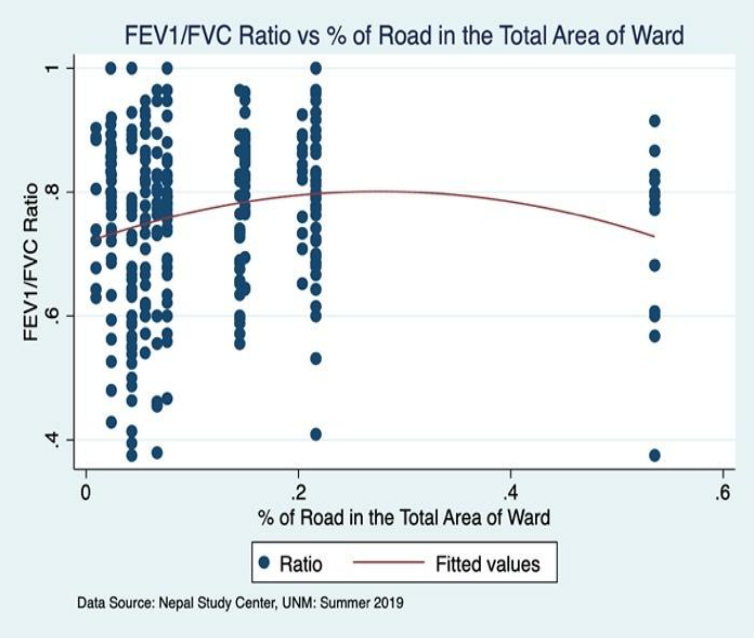
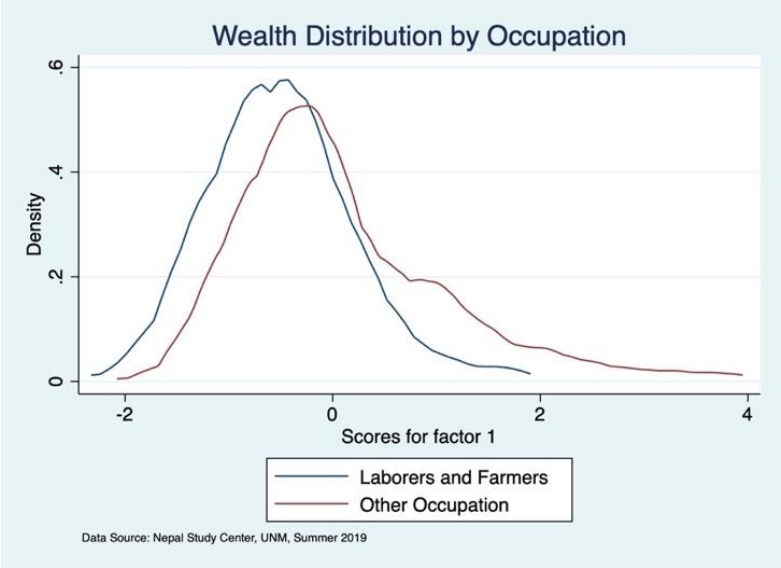


Figure A5. FEV_1/FVC ratio vs distance to road and density of road.



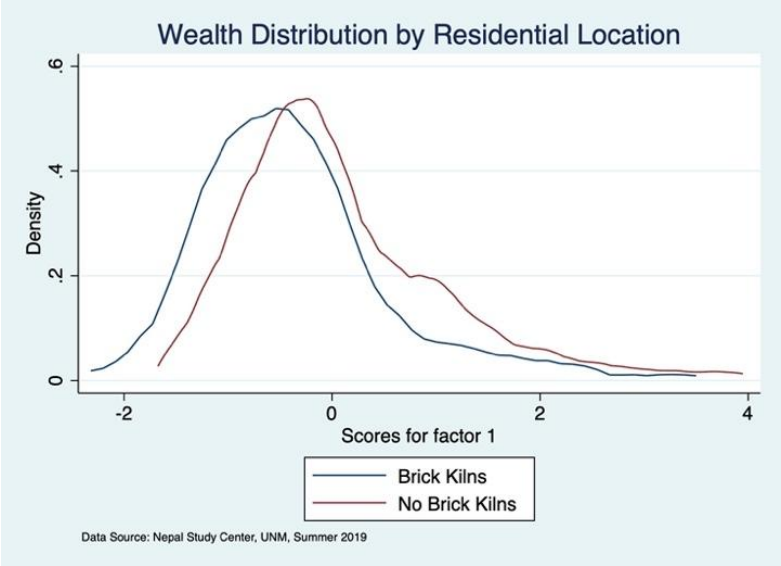


Figure A6. Wealth distribution by occupation and residential location.

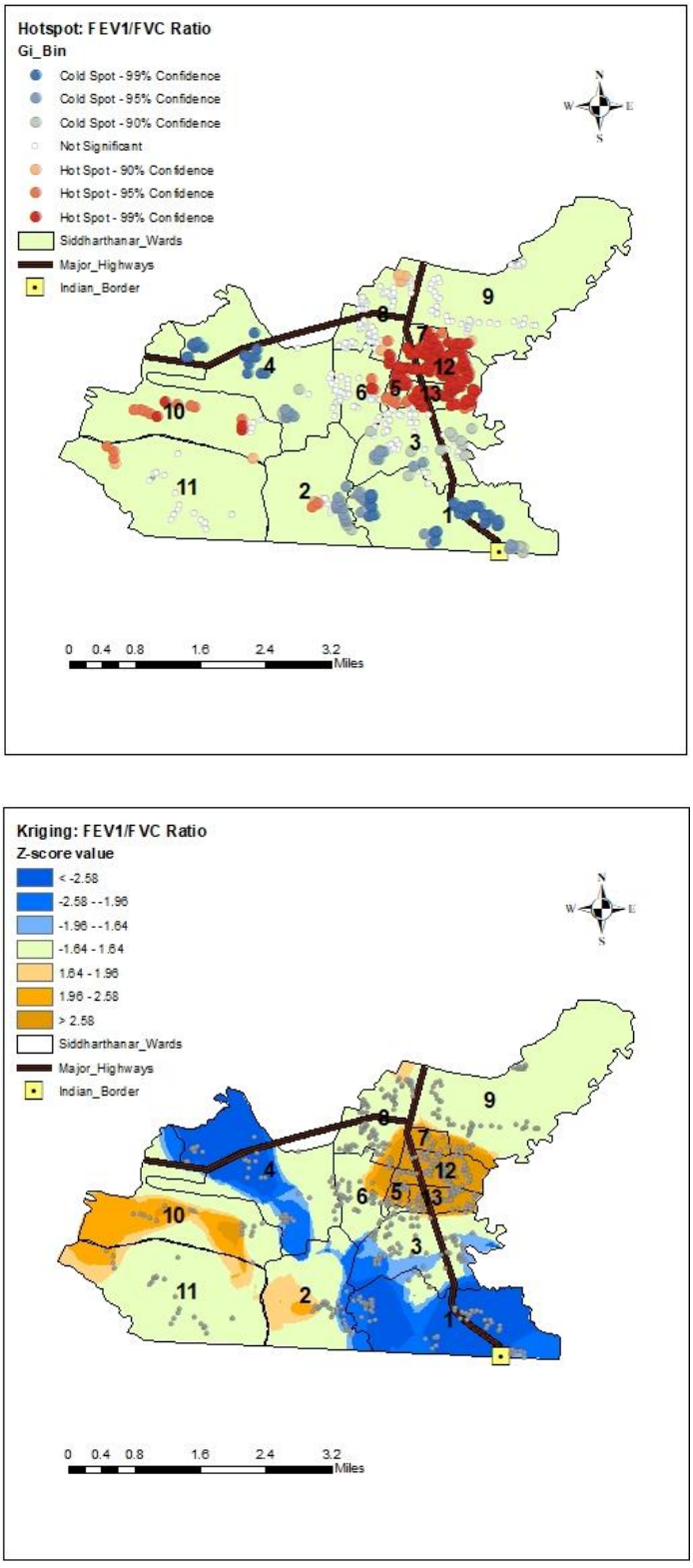
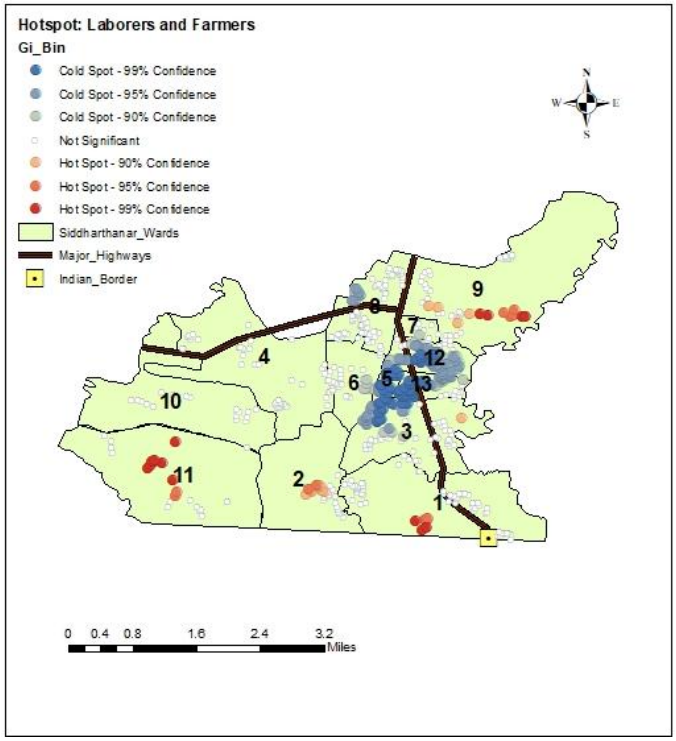


Figure A7. Hot spot and Kriging interpolation analysis of the FEV_1/FVC ratio.

Notes: In the Hot Spot and Kriging Interpolation figures above, red colored dots and red regions represent hot spot areas for (higher) lung capacity respectively, and blue colored dots and blue regions represent cold spot areas for (lower) lung capacity respectively. Therefore, blue regions in this case represent areas that are affected the most.



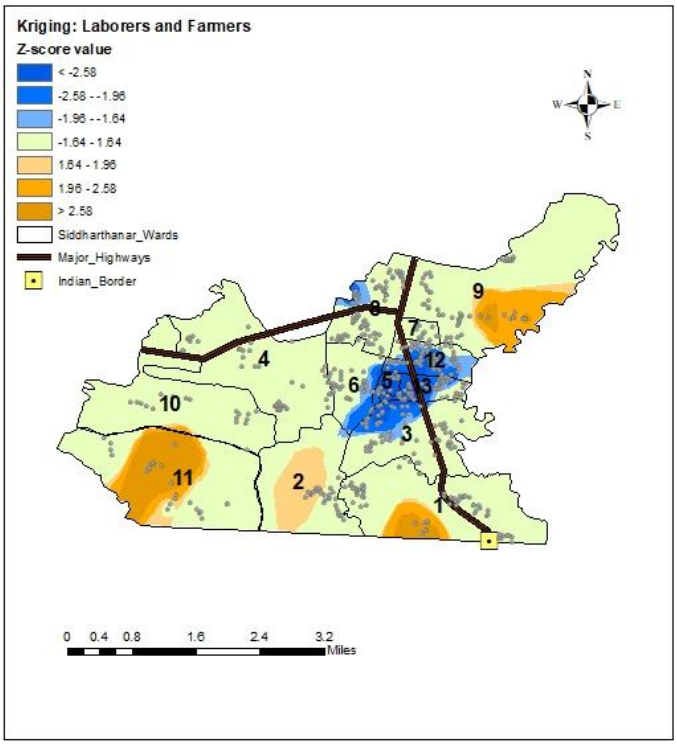
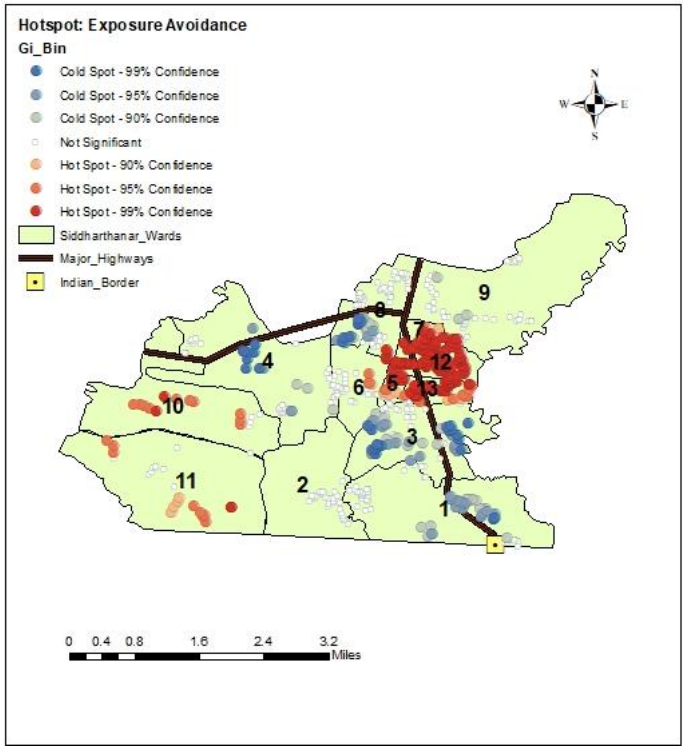


Figure A8. Hot spot and Kriging interpolation analysis of the location of laborers and farmers.

Note: In the Hot Spot and Kriging Interpolation figures above, red colored dots and red regions represent hot spot areas of the location of laborers and farmers respectively, and blue colored dots and blue regions represent cold spot areas of the location of laborers and farmers respectively.



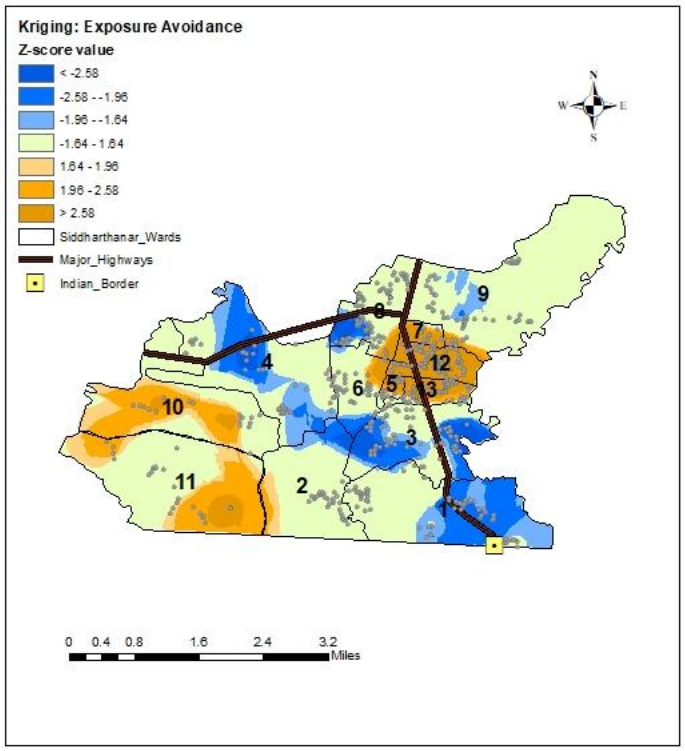


Figure A9. Hot Spot and Kriging interpolation analysis of air pollution exposure avoidance.

Notes: In the Hot Spot and Kriging Interpolation figures above, red colored dots and red regions represent hot spot areas of air pollution exposure avoidance respectively, and blue colored dots and blue regions represent cold spot areas of air pollution exposure avoidance respectively.