# Health Implications of Air Pollution: Evidence from the Brick Sector

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12th South Asia Economic Policy Network Conference on Green Growth in South Asia

October 30, 2023

**Brick kiln operating in India**
Source: DownToEarth, March 11, 2019

# Introduction

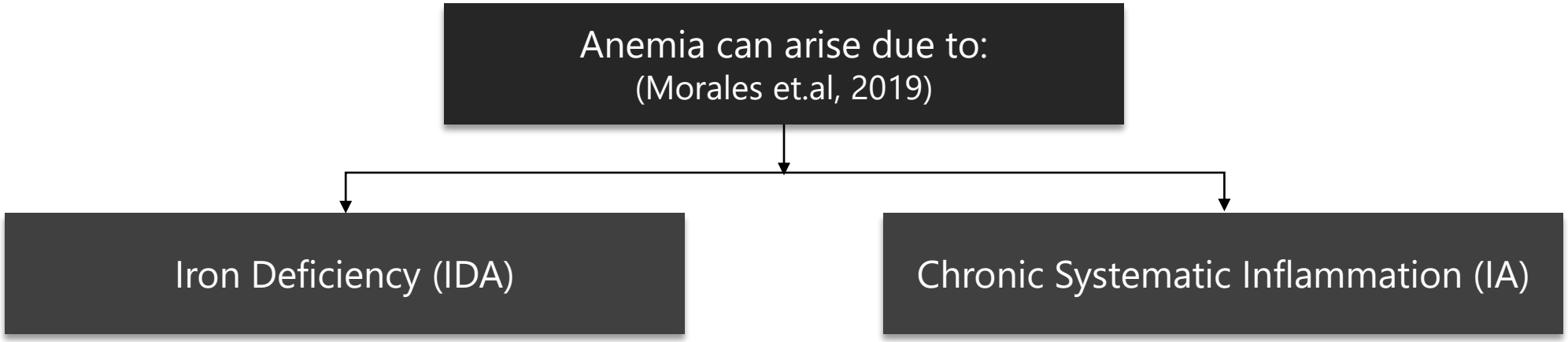
- Air Pollution and Brick Kilns
- Third-largest consumer of coal in the country.
- 70 percent of the brick kilns are operating on obsolete technologies.
- Blatant violation of the norms and orders set by the state and central government.
- Brick Kilns and Health Impacts
- Health impacts associated with brick production remain under-researched in epidemiological and economics literature.
- In India, around 13.6 million cases of respiratory infection among children were attributed to PM10 emissions by the brick sector (Eil et.al,2020)
- Increased risk of musculoskeletal disorders, cancer, anemia, and COPD among the kiln workers (Kamal et al., 2014b; Skinder et al., 2014).

# Focus of the Paper

- We **examined the association** between residential proximity to the brick kilns and the prevalence of anemia.
- A **distinguishing feature of this paper** is the unique data that is assembled by combining the spatial locations of the brick kilns and individual level information on the anemic status of men and women from NFHS-4.
- We leveraged the household cluster locations and geo coordinates of the brick kilns to determine the **impact of residential proximity to these kilns on the likelihood of anemia** while simultaneously controlling for other confounding covariates causing anemia.
- We assessed this association for the population residing in **38 districts across the Bihar state** using the econometric framework of Probit and Ordered Probit models.

# Anemia and Air Pollution

- Anemia is characterized by **low hemoglobin concentration in blood** which results in reduced oxygen-carrying capacity of the blood (Nielssen, 2007).




- Anemia associated with chronic inflammation or inflammatory anemia occurs due to **sustained exposure to fine particulate matters** such as PM2.5 or PM10, sulphur dioxide, oxides of carbon and other gaseous pollutants (Barany, 2018).

# Related Literature

- Strong association between **environmental pollutants and anemia** (Honda et al, 2017; Schraufnagel et al, 2019; Barany, 2001; Sørensen et al, 2003; Stanković et al, 2006; Morales et al., 2019; Ha et al, 2015; Mehta et.al, 2021;Datt et.al,2021 ).

- Earlier studies by Seaton et al. (1999) investigated the impact of the exposure to particulate matter on hemoglobin levels of the individual's aged 60+ in two United Kingdom cities. They estimated the relationship between exposure to particulate matter and hemoglobin using the covariance analysis and found that the exposure to the increased levels of air pollution leads to **decrease in hemoglobin**, after adjusting for confounding variables.

- Ha et al, 2015 have shown higher prevalence rates of anemia among the elderly **population living in polluted cities** compared to those living in less-polluted regions.

- In India, only Mehta et.al, 2021, have observed strong association between increased prevalence of anemia among children and **exposure to particulate matter (PM)**.

# Brick Industry in Bihar State

- Bihar is the **second largest producer of bricks in the country** after Uttar Pradesh, which provides us an opportunity to investigate the association between emissions from kiln and adverse health outcomes.

- The State of Bihar in India currently has **6,800 operational brick kilns** in the region that produce about 19 to 20 billion clay bricks annually.

- Being an agrarian state, there are very few heavy or large-scale polluting industries such as thermal power plants, cement, fertilizer plant operating in Bihar that could confound our results (MOSPI, 2016). This offers us **ideal conditions to estimate the impact of brick industry on the health indicators** of the population residing in the close vicinity to these kilns.

# Data Source

**Anemia Prevalence Estimates:**

- The data has been obtained from NFHS-4, 2015-16.
- Data for the state of Bihar were collected between the periods March 2015 –June 2015.
- For our analysis, we have used information on men and women in the age-group of 15-49 years.
- We have used altitude adjusted hemoglobin concentration (HBA) in g/dl to measure the anemic status.

# Data Source

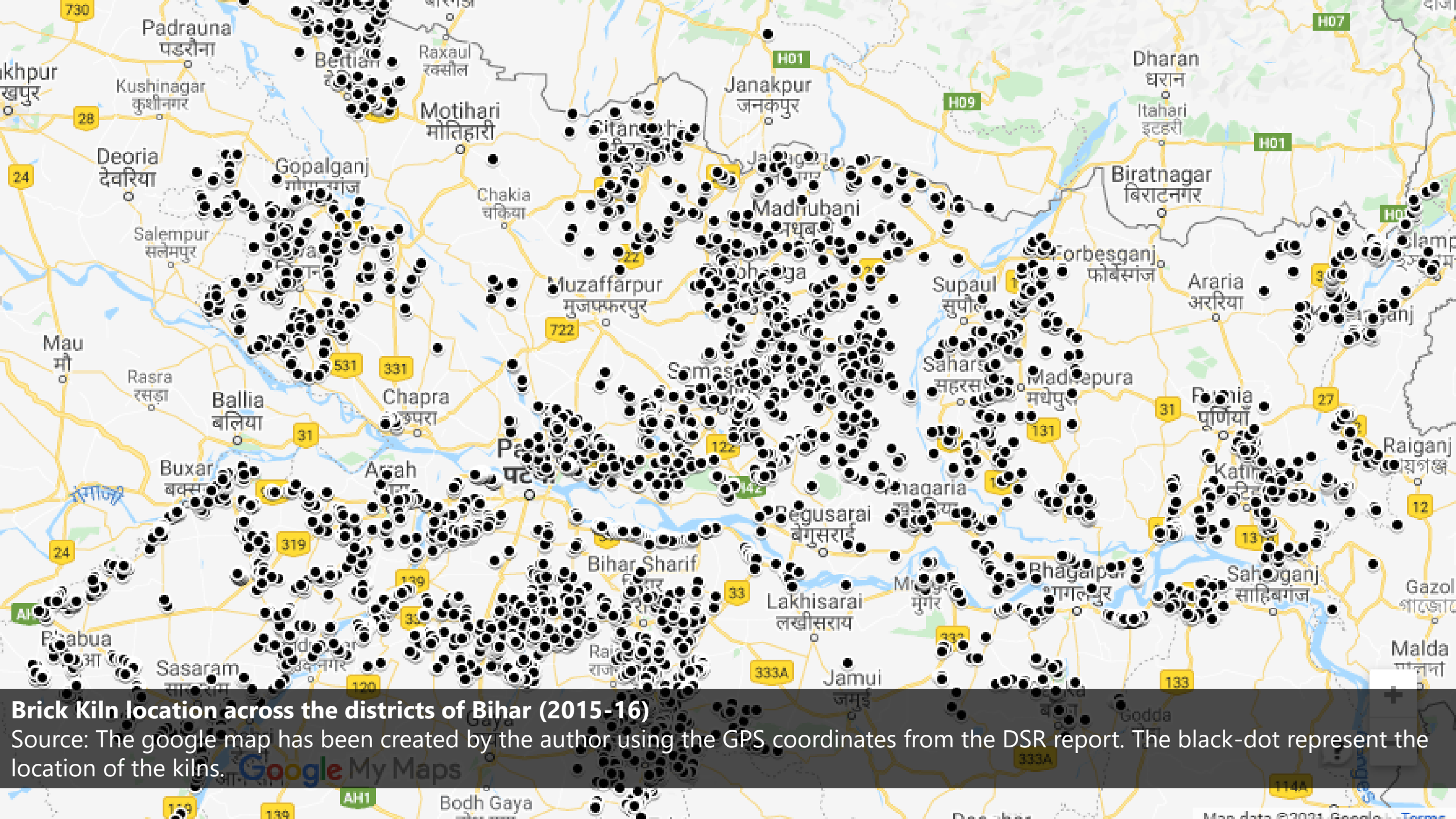
**Confounding Variables:**

- Variables that could potentially affect the likelihood of being anemic were obtained from household questionnaire of the NFHS.
- Variables include- age in years, gender (female/ male), educational attainment of the individual, type of residence (location in rural or urban), source of water, type of toilet facility in the household, consumption of tobacco, and method of cooking.
- Dietary consumption of the individuals has been taken into account as a proxy for iron deficiency (Dietary diversity score)..
- The Body mass index (BMI) was included in the analysis as body weight of the person is considered to important factor (Ghosh et.al, 2019) .
- Socio-economic status (Kim et.al, 2014; Thankachan et.al, 2007).
- Medical history of chronic diseases (Weiss et.al, 2019).

# Data Source

**Brick Kiln Locations:**

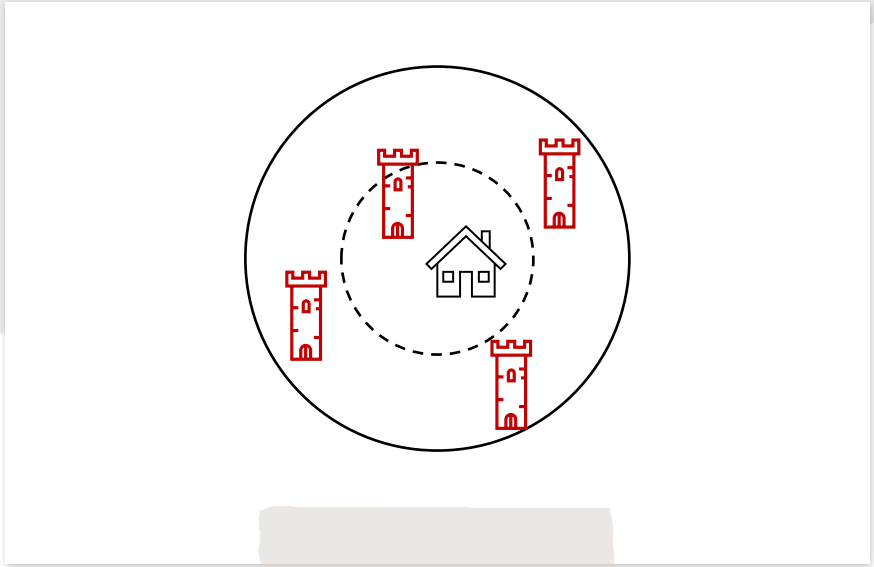
- District survey report published by Bihar Mines and Geology Department for the year 2015-16.
- The report provides the geo-coordinates of the kilns that were manually mapped.
- There are around 6000 bricks operating in various districts of Bihar.
- Given the huge variation in the concentration of brick kilns across the districts, we categorized our data into two regions: heavily concentrated and less concentrated districts.




**Brick Kiln location across the districts of Bihar (2015-16)**

Source: The google map has been created by the author using the GPS coordinates from the DSR report. The black-dot represent the location of the kilns.

# Mapping of Household Location and Kilns



- In the survey, villages in the rural areas and blocks in urban areas correspond to the Primary Sampling Units (PSUs).
- The sample consists of 1,648 clusters and the GPS coordinates are available for all these clusters.
- Respondent confidentiality issues.
- To determine the residential proximity to the kilns, we utilized the GIS information of the clusters and calculated the number of kilns for different radii .
- We have created a buffer around the cluster/ village to locate if there is presence of brick kiln within a specified radius (5, 7, 10, 12 and 15 km).

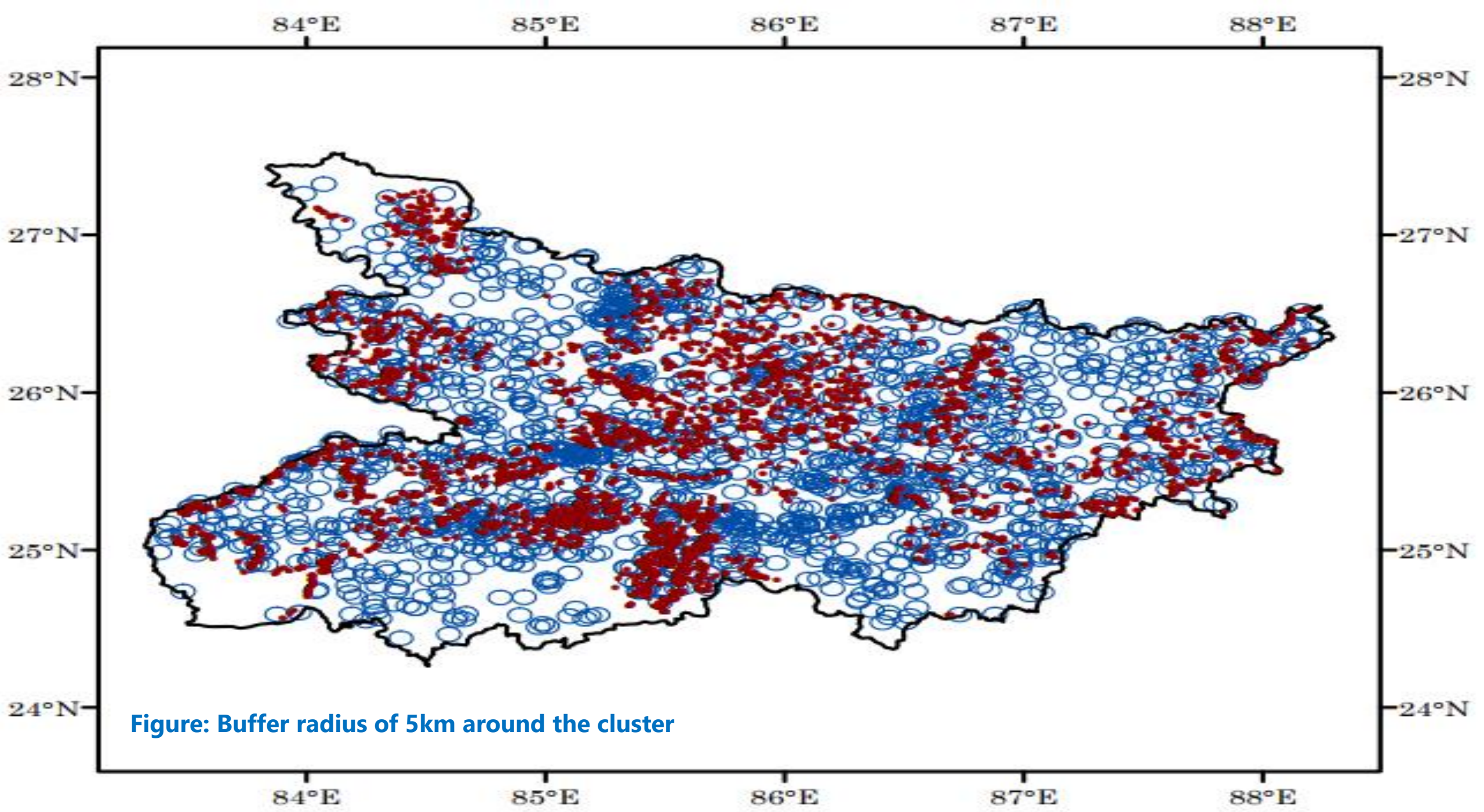
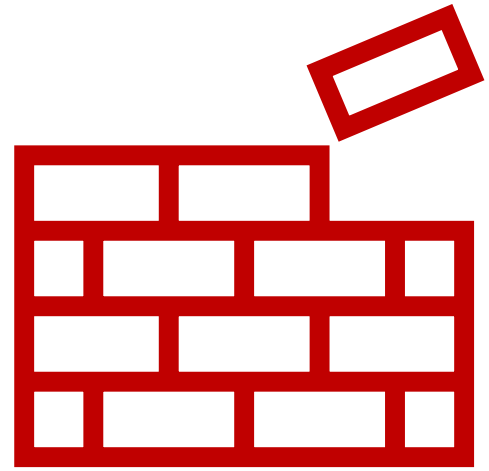



**Figure: Buffer radius of 5km around the cluster**

# Estimation Framework

- In our estimation framework, we focus on emissions from brick kilns and its impact on health outcomes of men and women in the age-group 15-49 years.
- We used **Probit** and **Ordered Probit model** to examine the association between proximity to a brick kiln and prevalence of anemia among men and women.



# Residential Proximity & Anemic Status: Probit Model

- We analyze the anemic status of the individual by using a dichotomous value as “1” if individual has anemia and “0” otherwise.
- For the anemic status of the respondent as binary variable, we estimated the following equation using the Probit model:

$$\boldsymbol{Y_i^* = \beta' \, X_i + u_i}$$

where,

$$Y_i = \begin{cases} 1 \; if \; respondent \; is \; anemic \\ 0 \; \; if \; respondent \; is \; not \; anemic \end{cases}$$

i = 1, 2, . . .., n, represents $i^{th}$ individual

- We created a categorical variable for residential proximity with a value “0” if there is no brick kiln in that buffer and “1”if it is present for the analysis.
- The final results were reported in terms of the average marginal effects of the residential proximity of the household near kilns on the likelihood of becoming anemic.

# Residential Proximity & Anemic Status: Ordered Probit Model

- We used the similar strategy with the outcome variable as $H_i^*$:

$$\boldsymbol{H_i^* = \gamma' X_i + \varepsilon_i}$$

$$\boldsymbol{H_i} = \begin{cases} \boldsymbol{0\ if\ H_i^* \leq \alpha_0} \\ \boldsymbol{1\ if\ \alpha_0 < H_i^* \leq \alpha_1} \\ \boldsymbol{2\ if\ \alpha_1 < H_i^* \leq \alpha_2} \\ \boldsymbol{3\ if \alpha_2 < H_i^*} \end{cases}$$

with $H_i = j\ if\ \alpha_{j-1} < H_i^* \leq \alpha_j$ ; j=0, 1, 2 & 3.

- From the blood test reports of the individual, we have the following categories of anemia for both men and women:
  - Non-anemic: If HBA levels are above 12 g/dl for women and 13 g/dl for men.
  - Mildly anemic- If HBA levels are in the range of 10-11.9 g/dl for women and 12.0-12.9 g/dl in the case of men.
  - Moderately anemic- If HBA levels is between 7.0-9.9 g/dl for women and 9.0-11.9 g/dl for men.
  - Severely anemic- If HBA levels is lower than 7.0 g/dl and 8.9 g/dl for women and men respectively.

# Caveats in the Estimation Framework

- We assume that each brick kiln operating in different distance bins has a homogenous effect, which might not be true.
- We assumed that there is no diffusion or spillovers of the smoke emitted from brick kiln across different distance bins.
- The residential addresses of the individual were geocoded to determine the proximity to kilns. This method assumes that men and women are staying and working within a specified distance bins in our analysis.

# Results

# Table: Summary Statistics

| Sample Variable | Overall Sample | | Non-Anemic | | Anemic | | Diff. in Means |
|---|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | (t-stats) |
| Column | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *Individual Specific* | | | | | | | |
| HBA levels (g/dL) | 11.72 | 1.63 | 13.12 | 0.0074 | 10.67 | 0.0069 | 2.44***(237.48) |
| Age in years | 29.56 | 10.11 | 29.64 | 0.071 | 29.24 | 0.062 | 0.396*** ( 4.168) |
| Body Mass Index (in kg/m2) | 20.86 | 5.21 | 21.15 | 0.037 | 20.6 | 0.032 | 0.550***(11.16) |
| Smoking status (1= Yes, 0= No) | 0.043 | 0.204 | 0.121 | 0.0017 | 0.062 | 0.0010 | 0.059***(22.38) |
| Gender (1= Female, 0= Male) | 0.87 | 0.32 | 0.81 | 0.0027 | 0.929 | 0.0015 | -0.119***(-39.49) |
| Chronic Diseases (1= Yes, 0= No) | 0.036 | 0.187 | 0.023 | 0.0013 | 0.026 | 0.0011 | -0.002 (.001) |
| *Household Characteristics:* | | | | | | | |
| Religion (1= Hindu, 0= Muslim) | 0.84 | 0.36 | 1.15 | 0.0026 | 1.14 | 0.0021 | 0.014**(4.42) |
| Residence (rural/urban) (1= Rural, 0= Urban) | 0.857 | 0.35 | 0.846 | 0.0025 | 0.865 | 0.002 | -0.019***( -5.87) |
| Open defecation (1= Yes, 0= No) | 0.62 | 0.48 | 0.604 | 0.0034 | 0.641 | 0.0029 | -0.0375***(-8.27) |
| Traditional solid fuel in cooking (1= Yes, 0= No) | 0.79 | 0.4 | 0.78 | 0.003 | 0.81 | 0.002 | -0.029***(-7.75) |
| *Dietary Indicators:* | | | | | | | |
| Milk | 0.67 | 0.47 | 0.69 | 0.003 | 0.66 | 0.002 | 0.022***(5.03) |
| Pulses | 0.94 | 0.24 | 0.94 | 0.0016 | 0.94 | 0.0014 | 0.001 (-0.67) |
| Green Leafy Vegetables | 0.86 | 0.34 | 0.85 | 0.0024 | 0.87 | 0.0020 | -0.016**(5.05) |
| Fruits | 0.27 | 0.44 | 0.28 | 0.003 | 0.26 | 0.002 | 0.02***(4.01) |
| Eggs | 0.27 | 0.45 | 0.29 | 0.0031 | 0.26 | 0.0027 | 0.022***(5.45) |
| Meat | 0.24 | 0.43 | 0.24 | 0.003 | 0.23 | 0.0026 | 0.012***(3.01) |

Notes: *** and ** indicates significance at 1% and 5% significance level. The overall sample size is 46,161 with 20,037 observations for non-anemic individuals and 26,124 for anemic individuals.
# Difference = mean (Non-Anemic)—mean (Anemic). The t-statistic is obtained from two-sample mean-comparison test with equal variances.

# Probit Estimates

## Average Marginal Effect of the residential proximity to kiln on anemic status

| Marginal Effects | Heavily Concentrated | Less Concentrated |
|---|---|---|
| Residential Proximity to kilns | | |
| Within 5 km radius | 0.024 (0.009)** | |
| Within 7 km radius | 0.035 (0.011)** | |
| Within 10 km radius | 0.014 (0.013)* | 0.033 (0.012)** |
| Within 12 km radius | | 0.036 (0.013)*** |
| Within 15 km radius | | 0.030 (0.017)* |
| Controls | Yes | Yes |
| District FE | Yes | Yes |

Notes: *** represents significance at 1% significance level and ** at 5% level. Delta-Method standard errors are reported in parentheses. Controls include individual and household covariates. The district fixed effects are for 38 districts across the state of Bihar.

# Heavy Concentrated Regions

| Distance bins | Within 5 km | | | Within 7 km radius | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | | | |
| *Buffer Radius* | 0.043*** (0.007) | 0.050*** (0.007) | 0.024** (0.009) | 0.054*** (0.007) | 0.051*** (0.007) | 0.0363*** (0.011) |
| *Individual covariates* | | | | | | |
| *Body Mass Index: (under-weight as base category)* | | | | | | |
| Healthy | -0.042*** (0.007) | | -0.039*** (0.008) | -0.041*** (0.008) | | -0.039*** (0.0080) |
| Obese | -0.168*** (0.011) | | -0.157*** (0.011) | -0.163*** (0.011) | | -0.156*** (0.012) |
| Age | 0.0007* (0.0003) | | 0.0007* (0.0003) | 0.0008** (0.0003) | | 0.001* (0.000) |
| Currently smokes (Yes=1 & No=0) | -0.015 (0.020) | | -0.013 (0.020) | -0.014 (0.020) | | -0.013 (0.020) |
| Chronic Disease | 0.019 (0.017) | | 0.017 (0.017) | 0.018 (0.017) | | |
| *Dietary Consumption* | | | | | | |
| Green leafy vegetables | -0.007 (0.010) | | -0.007 (0.010) | -0.005 (0.010) | | 0.009 (0.011) |
| Meat | -0.002 (0.008) | | -0.010 (0.008) | -0.0001 (0.008) | | -0.010 (0.008) |

# Heavy Concentrated Regions

| Distance bins | Within 5 km | | | Within 7 km radius | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | | | |
| Wealth Quintile: (Poorest as base category) | | | | | | |
| Poorer | -0.0006 (0.008) | | -0.003 (0.009) | -0.0006 (0.008) | | -0.004 (0.010) |
| Middle | -0.034*** (0.010) | | -0.043** (0.014) | -0.034*** (0.010) | | -0.045*** (0.014) |
| Richer | -0.016 (0.012) | | -0.027 (0.018) | -0.016 (0.012) | | -0.029 (0.018) |
| Richest | -0.013 (0.018) | | -0.029 (0.023) | -0.013 (0.018) | | -0.031 (0.024) |
| *Household Characteristics* | | | | | | |
| Open Defecation | | 0.017** (0.008) | -0.016 (0.010) | | 0.017** (0.008) | -0.017 (0.011) |
| Uses traditional fuel for cooking | | 0.019* (0.010) | -0.007 (0.011) | | 0.019* (0.010) | 0.008 (0.012) |
| Consumes clean water | | -0.057* (0.034) | -0.053 (0.033) | | -0.059 * (0.034) | -0.054 (0.034) |
| Religion: Hindu | | 0.064*** (0.010) | 0.070*** (0.010) | | 0.060*** (0.010) | 0.068*** (0.010) |
| Place of residence (Urban=0 & Rural=1) | | 0.023** (0.011) | 0.020** (0.012) | | 0.025** (0.011) | 0.020** (0.012) |
| Individual Controls | *yes* | *no* | *yes* | *yes* | *no* | *yes* |
| Household Controls | *no* | *yes* | *yes* | *no* | *yes* | *yes* |
| District Fixed Effects | *no* | *no* | *yes* | *no* | *no* | *yes* |

Delta-Method standard errors are reported in parentheses. The total number of observations is 20,158.

# Less Concentrated Regions

| Distance bins | Within 10 km | | | Within 12 km radius | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Buffer Radius* | 0.015 (0.008) | 0.018 (0.008) | 0.034*** (0.013) | 0.0012 (0.009) | 0.003 (0.010) | 0.038*** (0.014) |
| *Individual covariates* | | | | | | |
| *Body Mass Index:* | | | | | | |
| *(under-weight as base category)* | | | | | | |
| Healthy | -0.051*** (0.006) | | -0.049*** (0.007) | -0.051*** (0.006) | | -0.049*** (0.007) |
| Obese | -0.095*** (0.011) | | -0.087*** (0.011) | -0.096*** (0.011) | | -0.087*** (0.011) |
| Age | -0.00004 (0.0003) | | -0.000 (0.000) | -0.00004 (0.0003) | | -0.000 (0.000) |
| Currently smokes (Yes=1 & No=0) | -0.002 (0.015) | | -0.007 (0.016) | -0.002 (0.015) | | -0.007 (0.016) |
| Chronic Disease | -0.017 (0.016) | | -0.019 (0.017) | -0.017 (0.016) | | -0.018 (0.017) |
| *Dietary Consumption* | | | | | | |
| Green leafy vegetables | -0.022* (0.008) | | -0.007 (0.010) | -0.024* (0.008) | | -0.007 (0.010) |
| Meat | -0.005 (0.007) | | -0.002 (0.007) | -0.005 (0.007) | | -0.002 (0.007) |

# Less Concentrated Regions

| Distance bins | Within 10 km | | | Within 12 km radius | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Wealth Quintile: (Poorest as base category) | | | | | | |
| Poorer | -0.013* (0.007) | | -0.007 (0.008) | -0.013* (0.007) | | -0.007 (0.008) |
| Middle | -0.008 (0.009) | | 0.004 (0.012) | -0.009 (0.009) | | 0.004 (0.012) |
| Richer | 0.012 (0.011) | | 0.020 (0.016) | 0.011 (0.011) | | 0.020 (0.016) |
| Richest | -0.017 (0.019) | | -0.008 (0.024) | -0.018 (0.019) | | -0.008 (0.024) |
| *Household Characteristics* | | | | | | |
| Open Defecation | | 0.028*** (0.007) | 0.010 (0.009) | | 0.028*** (0.007) | 0.010 (0.009) |
| Uses traditional fuel for cooking | | 0.015 (0.009) | 0.001 (0.012) | | 0.016* (0.009) | 0.001 (0.012) |
| Consumes clean water | | -0.004 (0.020) | -0.011 (0.020) | | -0.008 (0.020) | -0.010 (0.020) |
| Religion: Hindu | | 0.014* (0.008) | 0.056*** (0.009) | | 0.014* (0.008) | 0.056*** (0.009) |
| Place of residence (Urban=0 & Rural=1) | | -0.005 (0.010) | -0.011 (0.010) | | -0.006 (0.010) | -0.013 (0.010) |
| Individual Controls | *yes* | *no* | *yes* | *yes* | *no* | *yes* |
| Household Controls | *no* | *yes* | *yes* | *no* | *yes* | *yes* |
| District Fixed Effects | *no* | *no* | *yes* | *no* | *no* | *yes* |

# Ordered Probit Estimates

## Heavily Concentrated Region

| | Severe Anemia# | Moderate Anemia# | Mild Anemia# | Non-anemic# |
|---|---|---|---|---|
| Within 5 km radius | 0.0014<br>(0.0003)** | 0.0108<br>(0.004)** | 0.0112<br>(0.004)** | -0.0231<br>(0.0085)** |
| Within 7 km radius | 0.0015<br>(0.0004)** | 0.0159<br>(0.005)** | 0.0164<br>(0.005)** | -0.0340<br>(0.0102)** |
| Within 10 km radius | 0.0004<br>(0.0005) | 0.0051<br>(0.006) | 0.0053<br>(0.006) | -0.0110<br>(0.0122) |
| Controls | Yes | Yes | Yes | Yes |
| District FE | Yes | Yes | Yes | Yes |

# Ordered Probit Estimates

## Less Concentrated Region

| | Severe Anemia# | Moderate Anemia# | Mild Anemia# | Non-anemic# |
|---|---|---|---|---|
| Within 10 km radius | 0.0009<br>(0.0003)* | 0.0131<br>(0.0054)* | 0.0124<br>(0.0050)* | -0.0264<br>(0.0108)* |
| Within 12 km radius | 0.0017<br>(0.0004)*** | 0.0253<br>(0.0058)*** | 0.0239<br>(0.005)*** | -0.0509<br>(0.0117)*** |
| Within 15 km radius | 0.0009<br>(0.0005) | 0.0142<br>(0.0076) | 0.0134<br>(0.007) | -0.0286<br>(0.0154) |
| Controls | Yes | Yes | YES | Yes |
| District FE | Yes | Yes | YES | Yes |

# Severe anemic- If HBA levels is lower than 7.0 g/dL and 8.9 g/dL for women and men respectively.

Mildly anemic- If HBA levels are in the range of 10-11.9 g/dL for women and 12.0-12.9 g/dL in the case of men.

Moderately anemic- If HBA levels is between 7.0-9.9 g/dL for women and 9.0-11.9 g/dL for men.

Non-anemic: If HBA levels are above 12 g/dL for women and 13 g/dL for men.

# Robustness Checks

# Spatial Clustering of Brick Kilns

- The distance from a kiln might not serve as a good measure of exposure owing to the spatial clustering of brick kilns in a particular location.
- We estimated a Probit and an Ordered Probit regression using the number of kiln in lieu of the residential proximity as measure of exposure assessment.
- We constructed a 15km buffer around each household and determined the number of kilns within that buffer.
- We constructed a categorical variable for these kilns taking value ‘0’ for no kiln, ‘1’ for number of kilns between 1 to 100 and value of ‘2’for more than 100 kilns in the buffer.

# Spatial Clustering

## Average Marginal Effect of the number of kilns on the prevalence of anemia

| | Whether person is anemic or not (1) | Ordered Probit Regression | | | |
|---|---|---|---|---|---|
| | | Severe Anemia (2) | Mild Anemia (3) | Moderate Anemia (4) | Non-anemic (5) |
| *Number of Kilns* | | | | | |
| *0* | Reference | Reference | Reference | Reference | Reference |
| Between 1 to 100 | 0.059** (.023) | 0.0017**(.0006) | 0.022**(.008) | 0.027**(.012) | -0.051** (.021) |
| >100 | 0.068**( .024) | 0.0024***(.0006) | 0.030**(.008) | 0.034**( .012) | -0.067 **(.022) |
| Controls | Yes | Yes | Yes | Yes | Yes |

*** represents significance at 1% significance level and ** at 5% level. Delta-Method standard errors are reported in parentheses. Controls include individual and household covariates. The district fixed effects are for 38 districts across the state of Bihar. The total observations is 46,616.

# Dietary Intake

- Anemia due to iron deficiency should be taken into consideration while determining its association with smoke from kilns.
- We computed the Dietary Diversity Score (DDS) as a proxy measure for nutrient deficiency based on the index created by Smith et.al, 1987.
- The NFHS data provides information on the frequency of consumption of various food items.

# Dietary Diversity Score

- These categories were further sub-classified into six food groups such as Vitamin A foods (dark green leafy vegetables), legumes/pulses, meat/fish or chicken, milk or curd, eggs and fruits.
- Respondents were assigned a value 1 for every food group consumed and 0 otherwise.
- Using the dietary classification method from Arimond et al (2009) and Wiesmann et.al (2009) the information on the given food groups were summed to derive at DDS for an individual.
- The DDS take values between 0 to 6 with “0” being no consumption and “6” indicating highest dietary consumption.

# Dietary Diversity Score

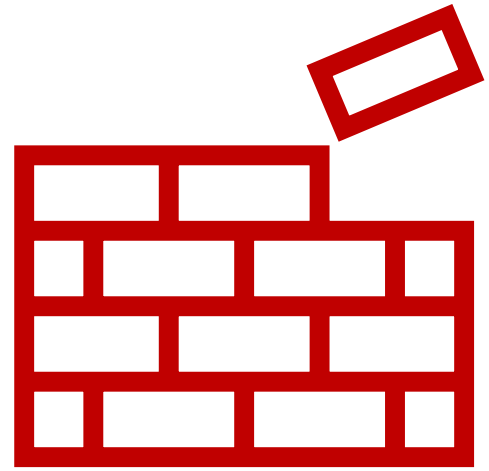
## Average marginal effects of DDS on the prevalence of anemia

| | | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| Distance bins | | | | | | | |
| Within 5 km | | 0.023**(0.009) | | | | | |
| Within 7 km | | | 0.034**(0.011) | | | | |
| Within 10 km | | | | 0.014 (0.013) | 0.032**(0.012) | | |
| Within 12 km | | | | | | 0.035***(0.036) | |
| Within 15 km | | | | | | | 0.030*(0.017) |
| DDS Score | | | | | | | |
| | 1 | -0.0345(0.028) | -0.0343 (0.028) | -0.0349 (0.028) | -0.0012 (0.027) | -0.0020 (0.073) | -0.0016 (0.027) |
| | 2 | -0.0278 (0.026) | -0.0272 (0.026) | -0.0277 (0.026) | -0.0089 (0.025) | -0.0222 (0.067) | -0.0097 (0.025) |
| | 3 | -0.020 (0.025) | -0.0193 (0.025) | -0.0197 (0.025) | -0.0043 (0.024) | -0.0107 (0.066) | -0.0052 (0.024) |
| | 4 | -0.0261 (0.026) | -0.0254 (0.026) | -0.0260 (0.026) | -0.0008 (0.025) | -0.0012 (0.067) | -0.0012 (0.025) |
| | 5 | -0.0162 (0.027) | -0.0150 (0.027) | -0.0156 (0.027) | -0.0057 (0.026) | -0.0137 (0.070) | -0.0064 (0.026) |
| | 6 | -0.0034 (0.027) | -0.0028 (0.027) | -0.0022 (0.027) | -0.0225 (0.026) | -0.0585 (0.070) | -0.0235 (0.026) |
| Controls | | Yes | Yes | Yes | Yes | Yes | Yes |

The district fixed effects are for 38 districts across the state of Bihar. The total observations is 46,616. The DDS takes the value in the range of 0 to 6. Columns (1) to (3) depicts heavily concentrated districts, while (4) to (6) depicts less concentrated districts.

# Concluding Remarks

- We tried to address the relevant policy question: **What are the negative health externalities associated with brick kilns.**
- Bihar is the second largest producer of bricks in India, and analyzing the negative health points associated with operation of the kilns becomes further important owing to poor health indicators among men and women in the state.
- The present study underlines the need for a **shift towards more advanced technology** for manufacturing of the bricks and a **greater role of the government** in regulating the establishment of these kilns near the residential areas.



# Limitations

- **Operational season** of the brick industry is not taken into consideration.
- Issue of the **buffer size**.

# Thank you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12th South Asia Economic Policy Network Conference on Green Growth in South Asia

October 30, 2023