

# Long Run Effects of Exposure to Forest Fires in Indonesia

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## Research Question

- What is effect of being exposed to smoke from forest fire in early life on later life health and education. Particularly on
  - Cognition (Fluid intelligence)
  - Lung Capacity
  - Height
  - Primary schooling completion

# Motivation

- Ambient air pollution has several detrimental effect on child health and human capital formation (Chay and Greenstone (2003), Currie and Neidell (2005), Sanders (2012))
- Much of the evidence is from developed countries, though air pollution levels in many developing countries is much higher (Greenstone and Hanna (2014))
- Results from developed countries may not hold in developing countries because a) Levels of pollution are much higher b) Cost and technologies of the avoidance behaviour is different. (Arceo, Hanna and Oliva (2015)).

## Method and Results

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  - Smoke from massive forest fires in 1997 engulfed parts of Indonesia providing spatial variation.
  - This is combined with a temporal variation by comparing individuals who were *in utero* or in their early life with individuals older than five years at the time of the forest fire.

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  - Smoke from massive forest fires in 1997 engulfed parts of Indonesia providing spatial variation.
  - This is combined with a temporal variation by comparing individuals who were *in utero* or in their early life with individuals older than five years at the time of the forest fire.
- Results
  - Exposure to smoke reduces score on Raven's test ten years later for kids who were *in utero* or less than one year, but only for males.
  - There are no effects on lung capacity and height.
  - Exposed kids are also less likely to complete primary school.

# Forest Fires

- Using fires for clearing land for cultivation is common in Indonesia. Industrial farmers burn forest land to replant it with palm and timber trees and small farmers sometime use "slash and burn" technique.
- In 1997 fires spread for several reasons
  - 1997 was particularly a dry year. Rainy season was delayed.
  - Logging by firms increased over years and logging firms often behind wood-debris which made the fire spread fast.

# Forest Fires

**The New York Times**

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September 27, 1997

## Asia's Forest Disaster

The thick smoke spreading throughout Southeast Asia apparently claimed 234 more lives yesterday, when an Indonesian airliner lost its way in the haze a from forest fires on the Indonesian island of Sumatra and the Indonesian part of Borneo, now blankets Singapore, Brunei and parts of Malaysia, the Phil

The fires are accelerated by drought but were set by man. In its headlong rush to cut down its timber and sell it, Asia has saddled itself with the worst defo continent. Environmentalists have long warned of the consequences. Asian leaders have dismissed the critics as subversives inspired by the West to try to economic growth. But while previous fires have not persuaded governments to halt deforestation, Asia's leaders should now realize that growth is fleeting destruction of natural resources.

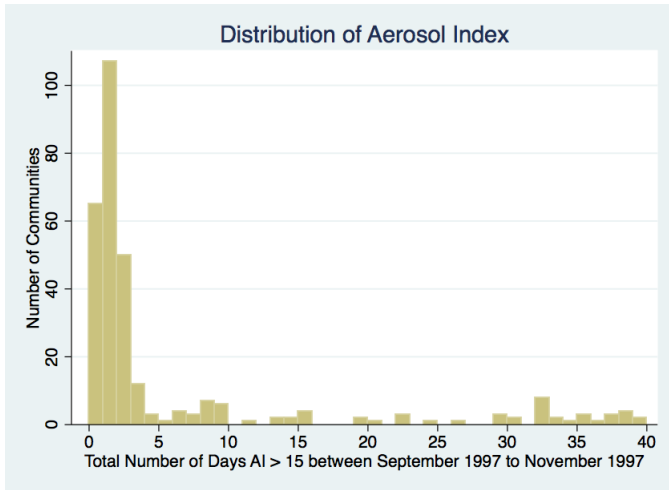
The Indonesian Government has attributed previous fires to farmers clearing their land for crops. This time, because the fires have been burning for mon made public, the Government has been forced to acknowledge that the fires coincide mainly with areas of commercial logging on Borneo and Sumatra.

## Earth Probe

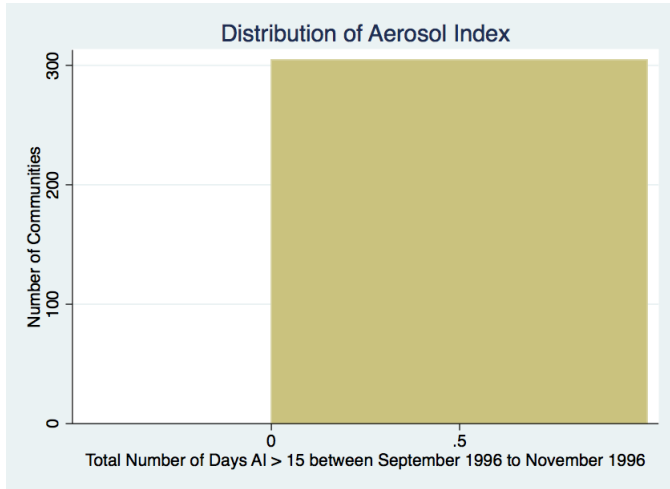
- Uses Aerosol Index from TOMS Earth Probe of NASA.
- It tracks air borne smoke and is calculated by amount of light microscopic particles absorb or reflect.
- It is available at 1X1.25 latitude longitude grid from July 1996.
- Daily mean value of Aerosol Index is calculated for each community by taking an average of Aerosol Index for all grid points lying within 100 km radius of IFLS communities, weighted by the inverse distance.



# Aerosol Index from September to November 1997



# Aerosol Index from September to November 1996



## IFLS and Census Data

- Uses Indonesia Family Life Survey (IFLS 4) conducted in 2007. Contains information on
  - Raven's test 7 – 24 olds.
  - Lung capacity
  - Height.
  - Location of the household in 1997.
- Population Census of 2010, conducted by Central Bureau of Statistics, obtained from IPUMS. Contains information on
  - Primary schooling sompletion
  - District and Year of Birth.

# Empirical Strategy

$$Y_{ihy} = \alpha + \beta_1(\text{First Year})_{ihy} * (\text{Total Number of Days AI} > 15)_{hc} + \beta_2(\text{Five Year})_{ihy} * (\text{Total Number of Days AI} > 15)_{hc} + \gamma X_{ihyc} + \delta_y + \theta_c + \epsilon_{ihyc}$$

- $Y_{ihyc}$  is the Raven's test score of individual  $i$  living in household  $h$ , born in year  $y$ .
- $(\text{First Year})_{ihy}$  takes the value one, if the individual is born between September 1996 and August 1998.
- $(\text{Total Number of Days AI} > 15)_{hc}$  is number of days Aerosol Index (AI) exceeded the value 15 in community  $c$  in which household  $h$  was located in 1997 between September to November of 1997.
- $(\text{Five Year})_{ihy}$  takes the value one if the individual  $i$ , living in household  $h$ , born in year  $y$  was of age between one and five between September to November of 1997.
- $X_{ihyc}$  includes several individual, household and community level controls.
- $\delta_y$  is the year of birth fixed effects and  $\theta_c$  is the community fixed effects.
- Omitted category is the cohort born between January 1983 and August 1992.

## Results-Cognition

### Effect on Cognition

	(1) Male	(2) Female
(First Year Forest Fire)* (Total number of Days AI 15)	-0.00175** (.00073)	-0.00076 (.00085)
(Five Year Forest Fire)* (Total number of Days AI 15)	-0.00017 (.00058)	-0.00049 (.00062)
N	4302	4605

The Dependent variable is percentage of questions answered correctly in Raven's test. Robust Standard Errors clustered at the community level.

## Results-Cognition Robustness Check

### Effect on Cognition (Robustness)

	(1) Male	(2) Female
(First Year Forest Fire)* (Total number of Days AI 15)	-0.00171** (.00074)	-0.00087 (.00079)
(Five Year Forest Fire)* (Total number of Days AI 15)	-0.00024 (.00053)	-0.00050 (.00054)
(Unconceived Forest Fire)* (Total number of Days AI 15)	-0.00057 (.00075)	.00035 (.00097)
N	4936	5179

The Dependent variable is percentage of questions answered correctly in Raven's test. Robust Standard Errors clustered at the community level.

## Results-Lung Capacity

### Effect on Lung Capacity

	(1) Male	(2) Female
(First Year Forest Fire)* (Total number of Days AI 15)	.02176 (.25981)	.07459 (.25618)
(Five Year Forest Fire)* (Total number of Days AI 15)	-.03164 (.25758)	.11873 (.16636)
N	4742	5168

The Dependent variable is average lung capacity. Robust Standard Errors clustered at the community level.

## Results-Height.

### Effect on Height

	(1) Male	(2) Female
(First Year Forest Fire)* (Total number of Days AI 15)	.02083 (.03661)	-.01891 (.04616)
(Five Year Forest Fire)* (Total number of Days AI 15)	.01792 (.03616)	-.00214 (.03887)
N	4758	5181

The Dependent variable is height.. Robust Standard Errors clustered at the community level.



# Primary School Completion

## Primary School Completion

	(1) Male	(2) Female
(One Year Forest Fire)* (Total number of Days AI 15)	-0.00038 (0.00030)	-0.00046* (0.00027)
(Five Year Forest Fire)* (Total number of Days AI 15)	-0.00015*** (0.00006)	-0.00016*** (0.00005)
N	86637	86586

The Dependent variable is proportion completed primary schooling. Robust Standard Errors clustered at the district level and regressions are weighted by cell size.

# Conclusion

- Smoke in early life has effects on cognition for men. There are no effects on women.
- There are no effects on lung capacity and height.
- Primary schooling completion also affected by exposure to smoke in early life, perhaps through other channels than cognition.

# Schooling and Forest Fire

$$\begin{aligned}
 O_{dym} = & \\
 & \alpha + \beta_1 (First\ Year\ Forest\ Fire)_{my} * (Total\ number\ of\ Days\ AI\ 15)_d \\
 & + \beta_2 (Five\ Year\ Forest\ Fire)_{my} * (Total\ number\ of\ Days\ AI\ 15)_d \\
 & + \mu X_{dym} + \delta_d + \gamma_y + \eta_m + \pi d * t + \epsilon_{idq}
 \end{aligned}$$

where

- $O_{dym}$  indicates the proportion of the cohort born in district "d", year "y" and month "m" that completed primary schooling (or worked during previous week as another outcome) It is calculated as (Total number of people completed primary school)/Cohort size. I calculated this separately for Males and Females.
- $(First\ Year\ Forest\ Fire)_{my}$  takes the value one if the cohort born in month "m" and year "y" were between the age of 0 – 12 months at the time of the forest fires.
- $(Five\ Year\ Forest\ Fire)_{my}$  takes the value one if the cohort born in month "m" and year "y" were between the age of 1 – 5 years at the time of the forest fires.
- $(Total\ number\ of\ Days\ AI\ 15)_d$  is the number of days the Aerosol Index exceeded the value 15 between September to November 1997 in district "d".
- $\delta_d$  is the district of birth by month of birth fixed effect,  $\eta_m$  is the month of fixed effects,  $\gamma_y$  is the year of birth fixed effect.  $d * t$  controls for district specific linear trend.

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