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Long-Run Health Consequences of Air Pollution: Evidence from Indonesia's Forest Fires of 1997

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Abstract

While many studies in the medical literature documented causal relationships between air pollution and negative health outcomes immediately following exposure, much less is known about the long run health consequences of pollution exposure. Using the 1997 Indonesian forest fires as a natural experiment, we estimate the long term effects of air pollution on health outcomes. We take advantage of the longitudinal nature of the Indonesia Family Life Survey (IFLS), which collects detailed individual data on a multitude of health outcomes, in both 1997 and 2007. We find significant negative effects of pollution, which persist in the long run. Men and the elderly are impacted the most, while children seem to recover almost completely from these early shocks.

Keywords: Air Pollution; Health; Indonesia.

JEL Classification Numbers: I1, Q53.

1 Introduction

There is evidence in the medical literature that air pollution, especially smoke pollution, is damaging to health. Smoke from burning vegetation contains particulate matter that is inhaled and transported into the lungs, causing respiratory problems that can lead to other health issues. This pollution negatively affects especially children and older adults. See Pope (2000) for a review of this medical literature. Exposed children can develop acute respiratory infection, which is a leading cause of infant death (Romieu et al. 2002, Chauhan and Johnston 2003), while prenatal exposure leads to an increased risk of infant mortality and a series of other health problems for the survivors such as respiratory issues, low birth weight, blood pressure, and even mental health and cognition issues (Lacasana et al. 2005, van Rossem et al. 2015, Peterson et al. 2015). There is ample empirical evidence that better air quality reduces infant mortality (See Chay and Greenstone 2003a, 2003b, Currie and Neidell 2005, Bobak and Leon 1992, or Loomis et al. 1999), and also that prenatal exposure, especially during the third trimester, leads to poor fetal growth (See Berkowitz et al. 2003, Dejmek et al. 1999, or Wang et al. 1997). Although not as seriously affected, adults are not immune however. Pollution can cause respiratory problems (Emmanuel 2000), difficulties in performing certain physical tasks (Frankenberg et al. 2004), and even higher mortality in older or otherwise unwell adults (Sastry 2002, Pope et al. 1992). There is, however, much less information on the long-term health consequences of pollution. Most of the studies that establish correlations or causal links between air pollution and health rely on short-run, cross-sectional data. This paper takes advantage of a longitudinal data set from Indonesia that allows us to track individuals 10 years after being exposed to a pollution shock. We are able to quantify the degree of pollution exposure and estimate the impact of pollution on current health, while controlling for the initial health stock and other socio-economic determinants of health.

Observational studies do not permit causal inference; however, the Indonesian case presents us with a "natural experiment" that allows for such attribution. From August to November of 1997, large parts of Indonesia were engulfed in forest fires. Slash-and-burn practices are common in Indonesia as a cheap way of clearing land. Because of the especially dry and windy season caused by El Niño that year, fires started by small farmers and large commercial plantations quickly spread, going out of control until the rainy season started in November. The fires destroyed over 12 million acres of land and covered much of the country in thick smoke for weeks. The smoke even reached parts of Malaysia and Singapore, with the most extreme level of pollutants reached in September/October.

Beyond the economic and environmental negative effects of these fires, there were clear negative health consequences on the Indonesian population. Jayachandran (2009) estimates 15,600 "missing children" that were never born or died in infancy due to in utero pollution exposure during the Indonesian fires. The adults were not spared these pollution related negative health shocks. Kunii et al. (2002) reports elevated levels of respiratory problems symptoms during the fires, with about 13% of the respondents reporting severe discomfort. Heil (2000) finds an increase of acute health issues caused by the fires even in neighboring countries like Singapore, with the elderly and children being the most susceptible to adverse health outcomes caused by the smog.

There are also important effects of pollution on economic outcomes. If pollution affects childhood health and childhood health affects human capital accumulation, then exposure to pollution creates life-long socio-economic handicaps. Currie et al. (2014) review the two strands of literature dealing with establishing causality between pollution and early-childhood health, and then between early-childhood health and human capital outcomes later in life. However, most of the literature focuses on the short-run effects of pollution on children and not much was done on the long run consequences for adults.

This paper uses the 1997 Indonesian forest fires as an exogenous shock of pollution, and studies its long term consequences on the health of survivors, both children and adults, ten years after the event. We focus on both subjective and objective health measures, and differentiate between sexes and age groups. Overall, we find significant negative effects of pollution in all our health measures. The impact of pollution is higher for men and the elderly population. Somewhat surprisingly, children seem to be less affected than the elderly, which shows that in spite of the higher short-term impact on young children, they manage to recover the best from early health issues caused by pollution.

2 Data and Methodology

Our primary data source is the Indonesian Family Life Survey (IFLS), which is a longitudinal socio-economic survey that tracks and surveys a sample of households representative for over 80% of the Indonesian Population. There are currently four waves of IFLS, fielded in 1993, 1997, 2000, and 2007. The survey collects demographic and socio-economic data on individual households' family members and also community level indicators such as local infrastructure. The IFLS does a particularly good job in tracking households from one wave to another. Since our main goal is to measure the long run consequences of air pollution caused by the 1997 fires, it is crucial to have the same households monitored in both 1997 and ten years later in 2007.

We collect subjective and objective health measures for more than fifteen thousand respondents in the IFLS that we could track between 1997 and 2007. Depending on the health measure studied, the sample sizes differ, since some health measures are only collected after a certain age. The health measures we focus on are the respondent's lung capacity, hemoglobin level, general health status (GHS) and the number of difficulties with activities of daily living (ADL). To control for initial health stock, we collected these health measures in both 1997 and 2007. The 2007 health measure represents the dependent variable, while the 1997 health measure is used as a control for individual health stock. With respect to the age cutoffs for each individual health measure, lung capacity is only collected for individuals that are at least 9 years old, hemoglobin is measured for everyone older than 1, GHS is collected from respondents that are at least 15 years old, and ADL is only collected for individuals over 40.

Our first two health measures are objective outcomes: lung capacity and hemoglobin. Lung capacity points to impairments of the respiratory system, which is immediately affected by air pollution. While some studies have shown long-term damage to lungs stemming from extended exposure to pollution (e.g. Hwang et al. 2015) we know of no studies that look at the long-term impact of a single pollution event. Hemoglobin reflects the sufficiency of blood (or iron in the blood) through the body. The ingestion of particulate matter inflicts numerous tiny wounds on the lungs, and blood coagulates there to protect and heal them. With extra blood in the lungs, less is available to do the work of blood throughout the body, a condition apparent as reduced hemoglobin (Seaton et al. 1999). While Kargarfard et al. (2015) find no link between pollution and hemoglobin, several other studies have documented a short-term link between exposure to air pollution and decreased hemoglobin (Das and Chatterjee 2015; Nikolic et al. 2008, Poursafa et al. 2011, Seaton et al. 1999). However, we are aware of no work that examines the pollution-hemoglobin relationship in the long term, and the most recent article we found, Das and Chatterjee (2015) calls for more longitudinal work on the subject. Longer term damage is plausible, as even carefully managed injury such as blood donation may be associated with lasting effects: a recent study of blood donation finds that 95% of donors not taking iron supplements are below their pre-donation hemoglobin level after 170 days (Kiss et al. 2015).

Our other two health measures are subjective. GHS and ADL are self-reported measures that aggregate the overall level of health of the individual and thus proxy for a larger variety of health issues. In spite of being self-reported and thus possibly suffering from subjective biases, these measures have been found to be good predictors of future health. For instance GHS is found to be a good predictor for subsequent mortality by Idler and Benyamini (1997), Burstrom and Fredlund (2001), and van Doorslaer and Gerdtham (2003). ADLs show how well a person functions in daily life, or how well people relate to and participate in their environment (Krapp 2002).

We also collect a number of socio-economic factors at the individual and household level that we use as control explanatory variables. These are respondent's age and age squared (to allow for non-linearities with respect to age), years of formal education , household per capita expenditures (PCE[1]), and whether the household kitchen and water source are inside the house or outside.

Our explanatory variable of interest is the pollution level that respondents were exposed to during the 1997 fires. We estimate the amount of pollution in each community by interpolating the Total Ozone Mapping Spectrometer (TOMS) data described in Jayachandran (2009) as provided by Dr. Jayachandran. Using Global Positioning System (GPS) coordinates for each community provided by IFLS, we link each to the nearest TOMS grid points. Using only grid points within 100 km of the community, we weight all relevant data points inversely with their distance from the community. This results in linking from one to six (and an average of four) data points to each community. We then computed the monthly pollution as the median of the daily values, and averaged over the September, October, and November months of 1997 (the months most affected by the fires) to construct the pollution variable used as a health determinant in all our regressions.

Since the exposure to pollution was due to a wholly exogenous phenomenon, rather than to anything that could be correlated with individual or household specific socio-economic factors, we treat it as a natural experiment and simply estimate the effect of the pollution level on the respondents' health as

[1]PCE is used as a proxy for household income. Bound and Krueger (1991) showed that household income is prone to systematic measurement errors, and household PCE has been used since then as a proxy.

measured ten years after the exposure, while controlling for initial health stock and for some socio-economic factors as explained above. Formally, the reduced form models can be written as follows:

$$Health_{ij}^{2007} = \alpha Health_{ij}^{1997} + \beta Pollution_{j}^{1997} + \gamma X_i + \varepsilon_{ij}$$

where i denotes the respondent, j denotes the community, X is the vector of individual and household level control variables mentioned above, and ε_{ij} is the error term representing unobservables uncorrelated with the regressors. The health measures used are lung capacity, hemoglobin, GHS, and ADL. We estimate these equations with Ordinary Least Squares (OLS) with robust standard errors. As a robustness check, we also perform probit estimations when the dependent variable is binary.

Another important issue to consider is whether the pollution affects different demographics differently. For instance, men spend arguably more time outside of the household than women do. This is especially true in developing countries such as Indonesia. It is hence expected that pollution could impact men and women differently. Similarly, the long run impact of pollution could be different for different age groups. While children suffering setbacks can catch up with their counterparts under the right circumstances, pollution is expected to have a higher long term impact for older respondents. We hence disaggregate the sample by sex and age groups in order to study these differential effects.

3 Results

Summary statistics for all the health measures considered in the paper are provided in Table 1, both at the full sample level and disaggregated by gender. We provide summary statistics for both 1997 and 2007. The clear differences in magnitudes between the two waves are not only the result of pollution, but mostly that of aging. The sample sizes vary between different health measures, because not all health measures are collected for all respondents. For instance, lung capacity is only collected for those older than 9 and ADL is only collected for those older than 40. The summary statistics table also includes average pollution levels from September to November of both 1997 and, for comparison, 1996. The average pollution exposure was calculated using the lung capacity sample of 15497 respondents. The 1997 spike in pollution is obvious.

[Table I about here.]

3.1 Lung Capacity

Lung capacity is measured in IFLS for all respondents over 9 years old, using the Personal Best Peak Flow Meter. Lung capacity was measured three times for each respondent and the average of these measurements is used in the analysis. The full-sample effects of pollution on the lung capacity of respondents, as measured ten years post-exposure, are presented in Table 2.

[Table II about here.]

All variables, except for having a kitchen outside of the main household, are highly significant. The forest fires pollution shock causes a large and significant negative effect on lung capacity. There is also a negative effect (although smaller in magnitude) from having the main water source outside of the household. This could be due to increased exposure to pollution, or it could simply be a proxy for low SES. As expected, other socio-economic variables improve health. Respondents with higher levels of education and higher levels of per-capita expenditures have higher lung capacity.

We further disaggregate the sample by sex and age groups, to study how pollution affects different demographics. Men and women could be affected by pollution in different ways, both because of physiological differences and also because of possibly different levels of pollution exposure. Men have generally higher levels of physical activity which results in higher volume of air inhaled and hence more particulate matter reaching their lungs. At the same time, many women in Indonesia use wood burning stoves to cook and are already exposed to indoor air pollution. This might reduce the observed effects of the outdoor air pollution. The same kind of effect can arguably be in play when disaggregating by age groups. Physiologically, children and young adults are stronger and they are more likely to recover from early health shocks. Younger children might also be highly susceptible, but this outcome is unavailable for children under 9. Hence we expect older cohorts to suffer more from pollution, relative to the younger cohorts. The results of these disaggregations are presented in Table 3.

[Table III about here.]

It is clear from the table that the intuitive effects hold. Comparing men and women, regardless of age, we see that the impact of pollution on men is almost four times as high as for women. The coefficient for men is -8.156, while that for women is only -2.125. Both coefficients are statistically significant. With respect to age, we see that for both women and men there are no significant effects on the younger cohort. Respondents who are between 9 and 21 years old in 1997 do not suffer a loss of lung capacity in the long run, not because they are immune to pollution, but presumably because their physiology allows them to fully recover in the long run. For the older cohorts however, the negative long-term effects are significant, especially for men. It is worth noting here that previous research has shown that Indonesian women intake significant amounts of indoor air pollution (Arcenas et al. 2010). Therefore, the marginal effect of the pollution due to the 1997 fires on women might be smaller due to this previous exposure to indoor pollution.

3.2 Hemoglobin

Blood hemoglobin is a health measure for anemia, but hemoglobin counts can also be affected by infections. Hemoglobin counts were measured in the IFLS using the Hemocue meter, which uses a small drop of blood obtained from pricking the respondents' finger. Because hemoglobin levels are measured for all respondents over 1 year old, as opposed to all respondents over 9 years old as was the case with lung capacity, the sample size is some three thousand observations larger for these estimation. The full-sample effects of pollution on the hemoglobin levels of respondents, as measured ten years post-exposure, are presented in Table 4.

[Table IV about here.]

The full sample results show that there is no long-term effect of pollution at the aggregate population level. It seems that people do manage to fully recover from any short-run low hemoglobin levels that pollution might have created. This is consistent with the medical literature that considers low hemoglobin counts and anemia transitory issues that can be corrected with proper nutrition or nutritional supplements. We however investigate further by disaggregating by sex and age groups. Table 5 shows the results of these sub-sample estimations.

[Table V about here.]

The lack of statistical significance persists for most of the demographic groups. Women seem unaffected by pollution in the long run, regardless of age, and so do young men. There are however small negative effects on older men. While the point estimates are small in magnitude and only significant at the 7% (for respondents over 41), and 8% (for respondents between 21 and 41) levels, we cannot confidently reject the null and claim total recovery for all sexes and age groups. Overall however, in the case of hemoglobin, it does seem that respondents recover quite well in the long run.

3.3 Poor General Health Status

The general health status (GHS) is a subjective measure of overall health that IFLS respondents can score as very healthy, somewhat healthy, somewhat unhealthy, or unhealthy. For the purpose of this paper, we code a dummy variable that takes value 1 if respondents report their health status as unhealthy or somewhat unhealthy, and 0 otherwise. The full-sample effects of pollution on respondents' general health are presented in Table 6. The estimates presented are from a linear probability model (LPM), but for robustness purposes we also estimated Probit models and found similar results.

[Table VI about here.]

There is a highly significant negative effect of pollution on general health, where exposure to an extra unit of pollution leads to an approximately 4.9% increase in the probability of being unhealthy, ten years past exposure. As before, we disaggregate again by sex and age groups. These results are presented in Table 7.

[Table VII about here.]

Disaggregating by age groups results in the same patterns observed with the other health measures. Generally speaking, older cohorts are impacted more by exposure to pollution. Contrasting the previous results however, are the differential effects by sexes. In the case of poor GHS, women seem to be more affected by pollution than men. Not only are all the magnitudes larger for women, but all women, regardless of age group, seem to be affected by exposure to pollution. In contrast, the young cohort of men fully recovers in the long run in terms of their general health.

3.4 Difficulties with Activities of Daily Living

The final health measure used in this paper captures physical functioning. Activities of daily living are routine activities such as eating, bathing, dressing, etc. Having any difficulties with ADLs is commonly used in the literature as a measure of disability.[2] For the purpose of this paper, we coded each answer with 1 if the respondents report they can perform these activities only with some assistance or are not able to perform them at all. The sum of all these difficulties with ADLs is used as an outcome variable in our regressions. This health measure is only collected for individuals over 40 years old. The full sample regression results are presented in Table 8.

[Table VIII about here.]

As it is clear from the table, exposure to pollution has a significant negative effect on the long-run health of older respondents in terms of their physical functioning. Since this health measure is only collected for adults over 40 years of age, we do not disaggregate the sample further by age groups. We do however disaggregate by sexes and present these results in Table 9.

[Table IX about here.]

The effects for men and women are very similar in the case of ADLs, with a slightly higher magnitude for women. Comparing between different health measures, the general pattern is that men are affected more by pollution when it comes to objective health measures, while women seem to be more affected when it comes to subjective health measures. It is hard to explain this inconsistency and pinpoint its source. Possible explanations can be formulated based on both physiological and psychological differences.

4 Conclusions

In this paper, we study the long-run health consequences of air pollution using the Indonesian forest fires of 1997 as an exogenous shock of pollution. We analyze a number of health measures, both objective and subjective, and find significant negative effects that persist over long periods of time. We find that pollution causes serious health impairments in terms of respondents' lung capacity, general health status, and difficulties with routine activities at older ages. Although in the long-run

[2]See for instance Schoeni et al. (2005).

most respondents seem to recover from anemia and low hemoglobin counts that pollution causes in the short-run, we cannot fully reject some small causal effect for the older men demographic.

We also find that pollution negatively affects older cohorts to a greater extent than it affects younger cohorts. This result is very surprising, given the existent evidence on pollution having larger effects on infants and young children in the short run. A possible and probable explanation is that younger cohorts recover more easily from early negative health shocks. So although they suffer more greatly from pollution initially, in the long-run they manage to fully recover. Also, it should be noted that only one of our measures applies to young children.

We also find differences in the way pollution affects men and women. Interestingly, men seem to be more affected by pollution when objective health measures are analyzed, while women are more affected when subjective health measures are considered. We believe these inconsistencies require further investigation in future research. There might be psychological differences between men and women that translate into different measures of self-reported health or there might be other physiological channels through which pollution affects sexes differently. In that regard, we believe more health measures should be looked at and analyzed in future research.

Another important issue that we believe is worth investigating, is the direct long-run effects of pollution on human capital accumulation and other socio-economic indicators. Severe episodes of pollution such as the Indonesian one might not only increase infant mortality but also cause retardation and delays in the normal development of surviving children. Such episodes might also affect working adults if the short-run adverse effects are large enough to affect their careers. For instance, working adults might experience severe respiratory problems that will temporarily affect their job-related performance, which might result in them losing their jobs and severely jeopardizing their lifetime economic well-being.

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List of Tables

Table 1: Summary Statistics

Health Measure		Full Sample	Men	Women
Lung Capacity	Mean (2007)	312.60	383.52	255.44
	Std. Dev. (2007)	109.73	107.83	71.11
	Mean (1997)	292.163	345.289	249.345
	Std. Dev. (1997)	99.770	107.928	66.941
	N	15497	6916	8581
Hemoglobin	Mean (2007)	13.44	14.46	12.59
	Std. Dev. (2007)	1.99	1.96	1.59
	Mean (1997)	12.658	13.229	12.180
	Std. Dev. (1997)	1.851	1.987	1.577
	N	18602	8476	10126
Poor General Health Status	Mean (2007)	0.167	0.148	0.183
	Std. Dev. (2007)	0.373	0.355	0.386
	Mean (1997)	0.099	0.085	0.112
	Std. Dev. (1997)	0.299	0.279	0.315
	N	16821	7776	9045
Difficulties with ADL	Mean (2007)	1.073	0.774	1.319
	Std. Dev. (2007)	1.837	1.668	1.932
	Mean (1997)	0.576	0.280	0.819
	Std. Dev. (1997)	1.229	0.915	1.392
	N	9176	4140	5036
Average Pollution	Mean (1996)	0.0907		
	Mean (1997)	0.6865		
	N	15497		

Table 2: Lung Capacity Regression Results - Full Sample Analysis
Dependent Variable: Lung Capacity (as measured in 2007)

Explanatory Variables	**Coefficient**	**Robust Standard Error**
Pollution	-5.370***	1.052
Age	-4.646***	0.234
Age Squared	0.0215***	0.00238
Education	1.904***	0.183
Log PCE	3.099***	1.075
Outside Kitchen	1.424	1.389
Outside Water	-3.029*	1.640
Lung Capacity 97	0.577***	0.0075
Const.	245.1***	14.26

sample size: 15497

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

Table 3: Lung Capacity Regression Results - Sub-sample Analysis
Dependent Variable: Lung Capacity (as measured in 2007)

Explanatory Variables	**Full Sample**	**0-21 yrs.old**	**21-41 yrs.old**	**>41 yrs.old**
(MEN)				
Pollution	-8.156***	-3.913	-11.14***	-13.27***
	(1.654)	(2.760)	(2.589)	(3.051)
Age	-2.459***	29.37***	13.08***	-8.277***
	(0.391)	(5.172)	(4.905)	(2.980)
Age Squared	-0.0102**	-0.692***	-0.182***	0.0330
	(0.00410)	(0.105)	(0.0594)	(0.0223)
Education	2.351***	2.611***	2.358***	1.991***
	(0.286)	(0.511)	(0.436)	(0.549)
Log PCE	7.041***	6.116**	5.351*	6.452**
	(1.597)	(2.454)	(2.823)	(3.159)
Outside Kitchen	3.514*	3.786	-3.971	9.802**
	(2.084)	(3.308)	(3.545)	(3.942)
Outside Water	-6.671***	-8.731**	-9.774**	-0.695
	(2.427)	(3.946)	(4.023)	(4.591)
Lung Capacity 97	0.352***	0.290***	0.421***	0.438***
	(0.0119)	(0.0246)	(0.0207)	(0.0246)
Const.	283.1***	-52.97	-56.68	451.7***
	(21.37)	(68.14)	(107.0)	(107.2)
Sample Size	6916	2564	2440	1912
(WOMEN)				
Pollution	-2.125**	-0.666	-2.648	-2.998*
	(1.018)	(1.700)	(1.789)	(1.745)
Age	0.870***	2.698	5.664*	-8.112***
	(0.229)	(4.004)	(2.912)	(1.508)
Age Squared	-0.0296***	-0.0682	-0.0863**	0.0419***
	(0.0024)	(0.0807)	(0.0352)	(0.0110)
Education	1.225***	0.914***	1.268***	1.680***
	(0.177)	(0.350)	(0.257)	(0.347)
Log PCE	2.815***	2.843	1.474	5.155***
	(1.006)	(1.744)	(1.622)	(1.923)
Outside Kitchen	-0.0591	1.170	1.172	-3.787
	(1.326)	(2.272)	(2.150)	(2.482)
Outside Water	-2.081	4.861*	-4.687*	-6.227**
	(1.543)	(2.675)	(2.462)	(2.888)
Lung Capacity 97	0.248***	0.204***	0.263***	0.234***
	(0.0114)	(0.0225)	(0.0183)	(0.0215)
Const.	174.6***	157.3***	94.21	423.8***
	(13.20)	(50.72)	(63.31)	(57.08)
Sample Size	8581	2824	3476	2281

robust standard errors in parentheses

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

Table 4: Hemoglobin Regression Results - Full Sample Analysis
Dependent Variable: Hemoglobin Level (as measured in 2007)

Explanatory Variables	**Coefficient**	**Robust Standard Error**
Pollution	-0.0336	0.0216
Age	-0.0234***	0.00328
Age Squared	0.0000292	0.0000375
Education	0.0117***	0.00387
Log PCE	0.0538***	0.0204
Outside Kitchen	-0.00787	0.0280
Outside Water	-0.00793	0.0343
Hemoglobin 97	0.383***	0.00883
Const.	8.672***	0.268

sample size: 18602

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

Table 5: Hemoglobin Regression Results - Sub-Sample Analysis
Dependent Variable: Hemoglobin (as measured in 2007)

Explanatory Variables	**Full Sample**	**0-21 yrs.old**	**21-41 yrs.old**	**>41 yrs.old**
(MEN)				
Pollution	-0.0333	0.0435	-0.100*	-0.132*
	(0.0295)	(0.0366)	(0.0557)	(0.0722)
Age	0.0183***	0.623***	0.0546	-0.0818
	(0.00553)	(0.0343)	(0.0963)	(0.0747)
Age Squared	-0.00051***	-0.0138***	-0.000974	0.000286
	(0.000063)	(0.000805)	(0.00120)	(0.00054)
Education	0.0305***	0.0185**	0.00564	-0.000722
	(0.00651)	(0.00858)	(0.00735)	(0.0187)
Log PCE	0.0946***	0.0311	0.178***	0.138*
	(0.0293)	(0.0372)	(0.0588)	(0.0718)
Outside Kitchen	-0.0439	-0.0215	-0.105	-0.0448
	(0.0422)	(0.0494)	(0.0839)	(0.101)
Outside Water	-0.0237	-0.00615	-0.0307	-0.166
	(0.0556)	(0.0564)	(0.0803)	(0.179)
Hemoglobin 97	0.252***	0.180***	0.282***	0.283***
	(0.0129)	(0.0171)	(0.0271)	(0.0298)
Const.	9.917***	5.338***	7.864***	12.34***
	(0.373)	(0.591)	(2.038)	(2.811)
Sample Size	8476	4083	2418	1975
(WOMEN)				
Pollution	-0.0138	-0.0214	-0.0479	-0.0240
	(0.0254)	(0.0315)	(0.0504)	(0.0573)
Age	-0.00135	-0.190***	-0.0817	-0.0157
	(0.00372)	(0.0300)	(0.0818)	(0.0503)
Age Squared	-0.00012***	-0.00398***	0.000901	-0.000056
	(0.0000434)	(0.000710)	(0.000985)	(0.000377)
Education	-0.0182***	-0.0112	-0.0159**	0.0143
	(0.00425)	(0.00685)	(0.00638)	(0.0124)
Log PCE	0.0663***	0.0292	0.0706	0.0681
	(0.0229)	(0.0324)	(0.0451)	(0.0468)
Outside Kitchen	0.0313	-0.0255	0.0824	0.0408
	(0.0308)	(0.0424)	(0.0531)	(0.0696)
Outside Water	-0.0334	0.0235	-0.0349	-0.0570
	(0.0341)	(0.0468)	(0.0608)	(0.0779)
Hemoglobin 97	0.225***	0.195***	0.248***	0.280***
	(0.0109)	(0.0165)	(0.0171)	(0.0264)
Const.	9.403***	12.16***	10.62***	9.281***
	(0.311)	(0.507)	(1.769)	(1.807)
Sample Size	10126	4213	3437	2476

robust standard errors in parentheses

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

Table 6: GHS Regression Results - Full Sample Analysis
Dependent Variable: Poor GHS (as measured in 2007)

Explanatory Variables	**Coefficient**	**Robust Standard Error**
Pollution	0.0486***	0.0050
Age	-0.0000722	0.0000617
Age Squared	0.0000473***	0.00000778
Education	-0.00324***	0.000712
Log PCE	0.00632	0.00450
Outside Kitchen	-0.00236	0.00576
Outside Water	-0.0173**	0.00679
Poor GHS 97	0.127***	0.0113
Const.	-0.0230	0.0577

sample size: 16821

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

Table 7: GHS Regression Results - Sub-Sample Analysis
Dependent Variable: Poor General Health Status (GHS) in 2007

Explanatory Variables	**Full Sample**	**0-21 yrs.old**	**21-41 yrs.old**	**>41 yrs.old**
(MEN)				
Pollution	0.0433***	0.0113	0.0446***	0.0733***
	(0.00686)	(0.0087)	(0.0111)	(0.0155)
Age	-0.00154*	0.0252***	0.0125	0.0180
	(0.000876)	(0.00880)	(0.0164)	(0.0125)
Age Squared	0.000064***	-0.000535***	-0.000133	-0.0000745
	(0.0000112)	(0.000213)	(0.000199)	(0.0000935)
Education	-0.00358***	-0.00588***	-0.00431***	-0.00535**
	(0.00101)	(0.00217)	(0.00139)	(0.00218)
Log PCE	-0.0039	0.00615	0.00504	-0.0171
	(0.00626)	(0.00868)	(0.00998)	(0.0143)
Outside Kitchen	-0.00498	-0.00141	0.0143*	-0.0315*
	(0.00812)	(0.0117)	(0.0125)	(0.0177)
Outside Water	-0.0160*	-0.0208	0.00144	-0.0415*
	(0.00947)	(0.0141)	(0.0140)	(0.0212)
Poor GHS 97	0.141***	0.0345	0.105***	0.223***
	(0.0175)	(0.0242)	(0.0312)	(0.0299)
Const.	0.1271	-0.203	-0.243	-0.365
	(0.0807)	(0.139)	(0.358)	(0.449)
Sample Size	7776	2495	2968	2313
(WOMEN)				
Pollution	0.0532***	0.0383***	0.0527***	0.0673***
	(0.0071)	(0.0112)	(0.0114)	(0.0147)
Age	0.00104	0.0113	-0.0199	0.0178
	(0.00086)	(0.00936)	(0.0167)	(0.0109)
Age Squared	0.0000361***	-0.000190	0.000304	-0.0000881
	(0.0000108)	(0.000229)	(0.000203)	(0.0000809)
Education	-0.00202**	-0.00518**	-0.00208	-0.000287
	(0.00103)	(0.00212)	(0.00145)	(0.00247)
Log PCE	0.0132**	0.0186**	0.0129	0.0103
	(0.00642)	(0.00921)	(0.00988)	(0.0139)
Outside Kitchen	-0.000641	-0.0196	-0.00112	0.0171
	(0.00812)	(0.0119)	(0.0123)	(0.0176)
Outside Water	-0.0176*	-0.0203	-0.0112	-0.0225
	(0.0096)	(0.0148)	(0.0144)	(0.0210)
Poor GHS 97	0.113***	0.0389	0.121***	0.143***
	(0.0148)	(0.0240)	(0.0256)	(0.0242)
Const.	-0.1341	-0.247*	0.260	-0.672*
	(0.0817)	(0.141)	(0.357)	(0.405)
Sample Size	9045	2581	3691	2773

robust standard errors in parentheses

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

Table 8: ADLs Regression Results - Full Sample Analysis
Dependent Variable: Number of Difficulties with ADLs (as measured in 2007)

Explanatory Variables	**Coefficient**	**Robust Standard Error**
Pollution	0.255***	0.0283
Age	-0.0994***	0.0158
Age Squared	0.0013***	0.0001
Education	-0.0175***	0.0038
Log PCE	0.0370	0.0268
Outside Kitchen	-0.0416	0.0336
Outside Water	-0.0624	0.0382
Difficulties ADLs 97	0.328***	0.0233
Const.	1.621***	0.537

sample size: 9176

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

Table 9: ADLs Regression Results - Sub-Sample Analysis
Dependent Variable: Number of Difficulties with ADLs (as measured in 2007)

Explanatory Variables	**Coefficient**	**Robust Standard Error**
(MEN)		
Pollution	0.223***	0.0379
Age	-0.144***	0.0249
Age Squared	0.00166***	0.00022
Education	-0.0134***	0.00494
Log PCE	0.00708	0.0379
Outside Kitchen	-0.0647	0.0466
Outside Water	-0.0991*	0.0540
Difficulties ADLs 97	0.324***	0.0468
Const.	3.267***	0.798
(WOMEN)		
Pollution	0.291***	0.0410
Age	-0.0604***	0.0204
Age Squared	0.00108***	0.000179
Education	-0.00135	0.00588
Log PCE	0.00837	0.0374
Outside Kitchen	-0.0131	0.0470
Outside Water	-0.0256	0.0529
Difficulties ADLs 97	0.274***	0.0278
Const.	0.691	0.720

sample size: 4140 men, 5036 women

*-significant at 10% level **-significant at 5% level ***-significant at 1% level