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Indoor air pollution, health and economic well-being

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Abstract. Indoor air pollution (IAP) caused by solid fuel use and/or traditional cooking stoves is a global health threat, particularly for women and young children. The WHO World Health Report 2002 estimates that IAP is responsible for 2.7% of the loss of disability adjusted life years (DALYs) worldwide and 3.7% in high-mortality developing countries. Despite the magnitude of this problem, social scientists have only recently begun to pay closer attention to this issue and to test strategies for reducing IAP. In this paper, we provide a survey of the current literature on the relationship between indoor air pollution, respiratory health and economic well-being. We then discuss the available evidence on the effectiveness of popular policy prescriptions to reduce IAP within the household.

Keywords. Indoor air pollution (IAP), global health, economic development, randomized evaluation, future studies

Table of Contents

1. Introduction
2. Fuel types, traditional cooking stoves, and air pollution
3. Evidence on the effect of air pollution on health
4. Evidence on the relationship between respiratory health and productivity
5. Policy interventions to reduce IAP
6. Conclusions

1 Introduction

Indoor air pollution (IAP) remains a potentially large global health threat. One half of the world population, and up to 95% in poor countries, continues to rely on solid fuels, including biomass fuels (wood, dung, agricultural residues) and coal, to meet their energy needs. Cooking and heating with solid fuels on open fires or on traditional stoves generates high levels of health-damaging pollutants, such as particulates and carbon monoxide. As women are primarily responsible for cooking, and as children often spend time with their mothers while they are engaged in cooking activities, women and young children are disproportionately affected. For example, the World Health Report (2002) estimates that acute respiratory infection (ARI) is one of the leading causes of child mortality in the world, accounting for up to 20% of fatalities among children under five, almost all of them in developing countries (IAP is thought to cause about one-third of ARI cases). This makes solid fuels the second most important environmental cause of disease after contaminated waterborne diseases (Bruce et al., 2006) and the fourth most important cause of overall excess mortality in developing countries after malnutrition, unsafe sex, and waterborne diseases (Bruce et al., 2006). In addition to impacts on mortality, IAP may have long lasting effects on general health and well-being: early exposure to IAP during childhood may stifle lung development, suggesting that the cost of this pollution may continue later in life. In fact, a growing literature indicates that environmental insults at early ages can have long lasting influences on human health and productivity (e.g., Almond, 2006).

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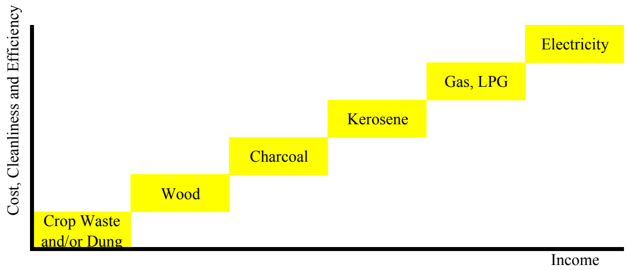

Figure 1. The energy ladder.

(a) Traditional Cooking Stove (b) Improved Cooking Stove

Figure 2. Cooking stoves in India. Source: Author photographs.

Despite the importance of this issue, social scientists have only recently become interested in IAP. Pitt, Rosenzweig and Hasan (2006) observe that the most comprehensive review on economic studies of health in the developing world (Strauss and Thomas, 1998) does not contain any reference to this problem. Furthermore, much of the existing evidence on the consequences of IAP presents serious shortcomings, as it is largely based on observational studies and may confuse the causal effect of IAP with the effects of the determinants to its exposure. Also troubling is the fact we have very little evidence on the impact of IAP exposure on economic outcomes, such as child school attendance and adult labor market productivity.

This article will provide an overview of the literature on the relationships between indoor air pollution, traditional cooking stoves, health and economic well-being. We first discuss the impact of fuel type on air pollution levels within the household. Next, we discuss the available evidence on the relationship between air pollution and health, and between respiratory health and productivity. We conclude with a discussion on what is known regarding the effectiveness of popular strategies to combat indoor air pollution in developing countries.

2 Fuel types, traditional cooking stoves and air pollution levels

Figure 1 illustrates the classic "energy ladder," which describes transitions in fuel use at different levels of economic development (Holdren and Smith, 2000). Households at lower levels of income and development tend to be at the bottom of the energy ladder, using fuel that is cheap and locally available but not very clean nor efficient. According to the World Health Organization, over three billion people worldwide are at these lower rungs, depending on biomass fuels – crop waste, dung, wood, leaves, etc. – and coal to meet their energy needs. A disproportionate number of these individuals reside in Asia and Africa: 95% of the population in Afghanistan uses these fuels, 95% in Chad, 87% in Ghana, 82% in India, 80% in China, and so forth. Coal is seen as a higher quality fuel due to its efficiency and storage, and thus is higher on the energy ladder, but as Holdren and Smith (2000) describe, coal can in fact be dirtier than wood. As incomes rise, we would expect that households would substitute to higher quality fuel choices. However, this process has been quite slow. In fact, the World Bank reports that the use of biomass for *all* energy sources had remained constant at about 25% since 1975. For empirical tests of the energy ladder, see, for example, Hosier and Dowd (1987) and Chaudhuri and Pfaff (2003).

For those on the lower rungs, cooking with traditional solid fuels on open flames or traditional cooking stoves (see Fig. 2a) may result in exposure to extremely damaging toxic pollutants, resulting, in some contexts, in ambient concentrations of more than 10 times the permitted EPA level over a 24 h period. For example, PM_{10} refers to particulate matter with a diameter of less than or equal to 10 μm; these particles are widely believed to pose the greatest health problems. The United States Environmental Protection Agency (EPA) standard for an acceptable annual 24-h average of PM_{10} is 150 $\mu g/m^3$, and they state that this level should not be exceeded more than once per year. In fact, 50 $\mu g/m^3$ is the accepted norm for PM_{10} (EPA, 2006). In contrast, Smith (2000) reports that mean 24-h PM_{10} concentration in solid-fuel-using households in India sometimes exceeds 2000 $\mu g/m^3$. Dasgupta et al. (2004) find an average of 600 $\mu g/m^3$ in Bangladesh, far outside the EPA guidelines. Similarly, a study of about 400 households in the provinces of Shaanxi, Hubei, and Zhejiang, China, were monitored for PM_4, and it was found that most households exceed China's Indoor Air Quality Standards (Zhang and Smith, 2007).

These ambient concentration readings alone could mask individuals' true exposure, as exposure may also vary with an individual's proximity to the stove during periods when the stove is in use. Ezzati, Saleh, and Kammen (2000) and Ezzati and Kammen (2001b) used personal monitors with real-time monitoring in rural Kenya over a two-year period. These studies recorded peak concentrations greater than 50 000 $\mu g/m^3$ in the immediate vicinity of the cooking fire, suggesting that women and children who congregate near cooking stoves are exposed to pollution levels unheard of in the developed world. Menon (1988) and Saksena, Prasad, Pal, Joshi (1992) have found similar results in India, with reported levels of 20 000 $\mu g/m^3$ or more near the cooking location and with much lower concentrations of these toxins in the rest of the kitchen/other rooms in the household. The global health community has recognized the deficit of information on exposure levels: for example, the 1999 Air Quality Guidelines of the World Health Organization states that "although work on simple exposure indicators urgently needs to be encouraged, realistically it is likely to be some years before sufficient environmental monitoring can be undertaken in most developing countries." However, continued innovations in the field are allowing for more accurate and reliable data that will allow for more informed policy decisions regarding IAP.

Overall, while there is general agreement that traditional fuels release a high level of toxin pollutants, the recent literature has been focused on trying to understand the magnitude of the exposure levels. The next main challenge, then, is to translate these exposure levels to health impacts. Therefore, we now turn to a discussion of the current state of the literature regarding the effects of air pollution on health.

3 Evidence on the effect of air pollution on health

Most of what we know about the relationship between air pollution and health comes from studies that look at the impacts of ambient air pollution levels in the developed world. In fact, there is a substantial literature indicating that these ambient air pollution levels substantially affect human health, especially the health of infants and young children. Dockery, et al. (1993) and Pope, et al. (1995) find a positive relationship between adjusted mortality rates and concentrations of particulate pollution. In a pair of natural experiment designs, Chay and Greenstone (2003a and b) find that higher concentrations of total suspended particulates (TSPs) are strongly associated with higher rates of infant mortality; they found that a 1% increase in ambient TSPs results in a 0.35% decrease in the fraction of infants surviving to 1 year of age. However, the combination of relatively low ambient air pollution concentrations in developed countries and the possibility of a nonlinear relationship between health and pollution mean that these studies may not be informative about the impacts of IAP on health in the developing world.

In developing countries, recent natural experiments have provided opportunities to measure the health impacts of higher concentrations of ambient air pollution that appear closer to the levels of air pollutants that rise from traditional stoves. For example, the 1997 massive forest fires in Indonesia resulted in pollution levels that in some parts of Indonesia were comparable to IAP concentrations associated with wood burning stoves. A series of studies have found that the unusually high levels of pollution caused by the fires had significant negative impacts on health. Frankenberg, McKee and Thomas (2005) compare adults in high and low smoke areas, both before and after the fires, and find that pollution impacted individuals' abilities to perform strenuous activities and other health outcomes. Jayachandran (2006) found that the smoke caused by the fires led to an increase in infant mortality rates. In fact, she estimates that the pollution that was induced by the fire led to approximately 16 400 fewer surviving infants in Indonesia. Emmanuel (2000) found an increase in respiratory related hospitalizations in nearby Singapore.

While the evidence from fluctuations in outdoor air pollution is *suggestive* of potentially large impacts of IAP, it is limited in its interpretation for at least two reasons. First, the most basic economic models predict that individuals could limit their exposure to temporarily high outdoor ambient pollution concentrations by changing their activities or purchasing protective devices (e.g., masks). Second, the health impacts from the relatively brief elevated concentrations may differ from daily exposure to IAP. Indeed, Jayachandran (2006) found that the effect of the fires was stronger for households that used traditional stoves, perhaps suggesting that chronic exposure to smoke lowers resistance to further smoke exposure.

Because of this growing consensus that the impacts of indoor air quality in the developing world cannot be derived solely from studies on outdoor air pollution, there has been a rise in research specifically on IAP and health. Numerous studies have found associations between IAP and acute lower respiratory infection (Smith et al., 2000; Ezzati and Kammen, 2001a, b), chronic obstructive pulmonary disease (Bruce et al., 2000; WHO, 2002) and lung cancer in the case of coal smoke (Mumford, 1987; Smith, 1993). There is emerging evidence that IAP increases the risk of other child and adult health problems, including low birth-weight, perinatal mortality, asthma, otitis media (or middle ear infection), tuberculosis, nasopharyngeal cancer, cataracts, blindness, and cardiovascular disease (WHO, 2002). In fact, the World Health Organization estimates that IAP is responsible for 2.7% of the loss of disability adjusted life years (DALYs) worldwide and 3.7% in high-mortality developing countries. More recently, Zhang and Smith (2007) undertook a very through meta-analysis of 200 publications regarding IAP in China. They showed that most of the studies find a strong correlation between IAP and negative health outcomes: lung function reductions, immune system impairment, lung cancer, etc.

However, much of the evidence on the link between health and IAP is based on observational studies (Bruce et al., 2000). The shortcoming of observational studies is that individuals who have taken measures to improve their indoor air quality may do so because they are wealthier, are better informed, or just have greater cause for concern about their health. In this case, a simple comparison of households that do and do not own stoves will confound the effect of the stoves with these other factors. For example, Bruce et al. (1998) examined the association between the use of wood stoves and other housing improvements that may affect health in Guatemala. They found that 82% of open wood fire users had dirt floors, while just 18% had cement or tile floors. The statistics were nearly reversed among users of stoves with chimneys: only 16% had dirt floors, while the rest had cement or tile floors. They concluded that confounding factors are likely to lead to substantial biases in observational studies of the link between IAP and health. Thus, they argue that randomized interventions are necessary to learn whether there actually is a causal relationship between IAP and health.

A second important aspect that most previous studies have failed to take into account is the optimizing behavior of the household. In Bangladesh, Pitt, Rosenzweig and Hassan (2006) find that, within the household, women who cook exhibit greater symptoms of respiratory illness, as do the young children whom they supervise. They also find that the women who cook tend to be the women with the worst health endowments. They conclude that the household "shares" the burden of disease in an optimal way. This suggests that any health gain associated with the availability of a new stove will be mediated by the household's behavioral response (for example, how and by whom they are used). It also suggests that there may be other welfare gains to the families associated with the new stoves. Collecting good measures of individual time use and individual exposure to pollution for all household members before and after the introduction of a new technology is, therefore, essential to a full understanding of its effects.

The most comprehensive study on the impact of IAP on health to date is the RESPIRE study in Guatemala that is described in Smith-Sivertsen et al. (2004) and Diaz et al. (2007). The RESPIRE study, begun in October 2002, was the first randomized experiment of the provision of improved stoves. The stoves used in the study, called *planchas*, are indigenously designed stoves constructed out of steel. They include a metal chimney that expels the smoke out of the house. The study randomly selected women who either had a child less than four months old or were pregnant at the time the study began. Each household was followed for three years, until the infants reached 18 months of age. The original study aimed to examine at the impacts on children under age 18 months. The researchers then added on a study to examine the impacts of IAP on women's health using lung functioning tests and semi-annual health assessments. To measure exposure to smoke from the stoves, they tested individuals using CO breath analyzers and gave individuals 48-h CO personal monitoring tubes. Follow-up health assessments were conducted every 6 months, covering respiratory symptoms, eye irritation, headaches and backaches. In addition, the survey team assessed respiratory function using spirometery tests. The study found that CO levels and the reported health symptoms were reduced among women who received *planchas*. After about 16 months, a little over half (52.3%) of women in the treatment group stated that their health had improved, compared with a quarter (23.5%) of the control group. Women in the treatment group had reductions of sore eyes, of headaches, and of sore throats as compared to the control. Children in the treatment group experienced reductions in crying and of sore eyes.

4 Evidence on the relationship between health and productivity

In measuring the costs of indoor air pollution, it is important to look further than just the main effects on health. Imagine that an individual is in poor health. As such, he may not be able to conduct strenuous or sustained work. This limits his labor market opportunities and provides him with lower wages (if employed). Because the household exists in poverty, he cannot afford to pay for goods that could improve his health – better fuel, more nutritious foods, doctor's visits – and would therefore improve his work ability. Thus, it becomes a vicious cycle, where because members of the household are both financially disadvantaged and in poor health, the household remains both in poverty and in poor health. In the economics literature, this is called a poverty trap (Dasgupta and Ray, 1986, 1987, 1990; Ray and Streufert, 1993; Ray, 1993).

Several papers have tried to study whether air pollution contributes to the poverty trap. Smith (2000) uses morbidity/mortality relationships for the diseases attributable to indoor air pollution to estimate that, in terms of sick days, the annual health burden for India from indoor air pollution is 1.6–2.0 billion days of work lost. Likewise, Frankenberg et al. (2005) estimate that haze from the fires in Indonesia caused older adults in areas covered by the haze to be more than 5% more likely to report having difficulty carrying a heavy load than older adults in non-haze areas.

However, other than these studies, there is very little evidence on the direct impact of air pollution on economic productivity. In fact, Bruce et al. (2000) explicitly state that much *more* evidence is needed on this point. On the other hand, there is a large medical literature linking iron supplements, which also improve respiratory functioning, to productivity (for example, see Davies et al., 1984; Hass and Brownlie, 2001; Zhu and Haas, 1998; Woodson et al., 1978). Iron-deficiency anemia (IDA, which combines iron deficiency with low hemoglobin levels) affects the body through two pathways. First, low hemoglobin levels limit aerobic capacity, or the ability of the body to use oxygen. Second, low iron levels limit the amount of oxygen that can be carried to the muscles, reducing endurance and requiring harder work from the circulatory system (Thomas and Frankenberg, 2002). Thus, we would expect that if the iron supplements have a large effect in practice, removing indoor air pollution should also have a large productivity effect.

The available evidence suggests that iron supplements have a large effect. For example, Basta et al. (1979), found an increase in work output among anemic latex workers in Indonesia who were given iron supplementation. Note, however, that while the study by Basta et al was a randomized controlled trial, it was marked by problems of attrition, and so their estimate of a 20% increase in output may be biased upwards. Similarly, Thomas et al. (2003) used randomized evaluation techniques to measure the impact of iron supplementation on adult productivity in Indonesia. After six months, hourly earnings among self-employed males rose substantially, indicating an increase in productivity. In addition to the study by Thomas, one other randomized evaluation (Li et al., 1994) carried out with female factory workers in China supports the link between productivity and iron supplementation. Workers who received treatment (iron supplementation) increased their energy efficiency, experienced reduced heart rates, and increased production efficiency, allowing treated women to complete the same amount of work at a lower energy cost. There was no increase in output, however, potentially because the workers were based on a conveyor belt and constrained by their co-workers.

In addition to reducing adult productivity, there is considerable evidence that health also affects the school attendance and productivity of children. For example, previous studies (Duflo and Hanna, 2005) have found a very large absence rate from school in rural India (on the order of 60%). This high level of absence is in part due to poor health. Two recent randomized evaluations have quantified the impact of improving health on attendance. First, Bobonis, Miguel, and Sharma (2004) report results from an evaluation of the impact of a combined iron supplementation and deworming program on preschoolers in Delhi. They find that participation in treatment preschools increased *substantially* in response to the iron supplementation and deworming program. Second, Miguel and Kremer (2004) also find a substantial effect of a school health intervention (deworming) on schooling in Kenya. The program they evaluated led to a 7.5 percentage point gain in attendance, reducing student absenteeism by nearly a quarter. One might, therefore, expect that an intervention reducing indoor air pollution could have significant impacts on schooling outcomes.

Pitt et al. (2006) provide indirect evidence on the effect of indoor air pollution on productivity by constructing a model where households allocate female labor between cooking, agricultural labor, and child care, in order to maximize overall productivity. Their model suggests that when exposure to smoke reduces health and consequently reduces labor productivity, it is efficient for households to allocate one member to specialize in cooking, and that when health status within the household is heterogeneous, women with poor health will be allocated to this role, so that the other members' health is protected. Indeed, they find that this is exactly what households do, and that the allocation of household members to the cooking task is endogenous to prior health endowments, with the weakest female household members more likely to specialize in cooking. This evidence indirectly suggests that there are productivity effects of IAP and that households try to shield themselves against these effects, at the cost of exacerbating the already poor health status of some of their members.

In sum, indoor air pollution has the potential to not only impact health, but also impact the general economic well-being of the household. While evidence from the literature on iron supplements suggests that this may be a large effect, further research is needed to understand the magnitude of the effect of indoor air pollution on well-being.

5 Policy interventions to reduce IAP

Due to the potentially large impacts of IAP on health and mortality, many governments, non-governmental organizations, and international organizations have begun to devise strategies for reducing indoor air pollution for individuals at the bottom rungs of the energy ladder. One method has been to subsidize cleaner fuel technologies. For example, to encourage the use of kerosene rather than traditional biomass fuels, countries such as Indonesia and Ecuador had policies to subsidize kerosene for cooking for the poor (Barnes and Helpern, 2000). However, this strategy is often not entirely feasible, and can be very costly. In addition, electric stoves are not practical in areas with low electricity levels, and the access of the poor to electricity varies greatly across countries, with 1.3% in Tanzania of the rural poor having access to electricity versus 99% in Mexico (Duflo and Banerjee, 2007). Even with subsidies, Kerosene and LPG/Gas are often too expensive for poor households, and they may have the additional difficulty of being difficult to transfer to rural areas that often lack roads. Additionally, these subsidy programs tend to be quite expensive, in an age when governments are trying to trim already overstretched budgets. For example, in Indonesia's program, although many low income households did switch to kerosene, the large inclusion error in targeting led to high program costs.

A second strategy has been the development, promotion and subsidization of "improved cooking stoves". Improved cooking stoves attempt to use traditional fuels in a more efficient manner and, therefore, do not impose a large cost on poor households. Often including a chimney, they are designed to remove harmful pollutants from the kitchen. Figure 2b provides an example of an improved cooking stove with a chimney in India (taken by the authors). Unlike the traditional cooking stove shown in Fig. 2a, one can see that there is less soot on the walls surrounding the improved cooking stove, indicating that fewer visible pollutants are being emitted in the air.

The improved cooking stove has become a particularly popular policy prescription. While China is reported to lead in the number of improved stoves installed (at over 35 million), India likely ranks second – distributing over 12 million improved stoves in the first seven years of a national program to develop and subsidize improved stoves that has now been ongoing for more than 20 years. Through joint government, donor, and NGO effort, Kenya distributed around 1.5 million jiko stoves (over twenty years), and Ethiopia distributed a similar number of lakech charcoal stoves (over ten years). However, only recently has there been research on whether or not distributing the improved cooking stoves actually is a cost-effective method to both reduce IAP and improve health.

Much of the research has centered on whether the stoves reduce IAP. For example, McCracken and Smith (1998), Ezzati and Kammen (2002), Ezzati, Saleh, and Kammen (2000), Ezzati, Mbinda, and Kammen (2000), and Albalak et al. (2001) have all found that various types of improved cooking stoves have resulted in reductions of toxic pollutants. However, even if they reduce smoke in the households, the effects could, in theory, be mitigated by behavioral responses. First, the stove's ability to reduce smoke relies on its proper use and maintenance. Second, while the improved cooking stove only reduces IAP, it does not remove the smoke from the kitchen entirely. If there is less smoke near the stove, individuals may choose to spend more time around the stove then they previously did. If smoke is indeed greater in the vicinity of the stove than elsewhere in the kitchen, it is then not necessarily clear that an individual who spends more time near the improved cooking stove would suffer from significantly less smoke exposure. Thus, we actually have very little understanding of the impact of stoves on health and even less understanding of whether or not the money spent on the stoves could be spent on other, more cost effective health interventions, including alternative interventions to reduce indoor air pollution.

The most complete study to date on the impact of IAP on health is the RESPIRE study in Guatemala (described in Sect. 3). The RESPIRE study found significantly large impacts of the stoves on health. This study (Smith-Sivertsen et al., 2004 and Diaz et al., 2007) evaluated *planchas*, stoves that are large and cost about \$64 to \$110 (Alvarez et al., 2004). The *planchas* are very sturdy, but they require substantial training time. More work is needed to understand whether cheaper stoves – for example, mud stoves that are less sturdy, but significantly cheaper – can also produce the same results at a lower cost. See Box 1 for an example of an ongoing study that is investigating this issue.

According to the 2001 Indian Census, 72.3% of households in India – and 90% of the population in poorer, rural regions – use traditional fuels. In response to perceived health threats from the traditional fuels, both the Indian government and many non-governmental organizations (NGOs) have implemented clean stove programs. During the 1980s and 1990s, the government of India alone subsidized and distributed 32 million improved stoves. However, there is little evidence on whether the stoves improve health, and if effective, how the stoves compare with other possible health interventions.

To this end, Gram Vikas, a rural development organization that works with marginalized communities in rural Orissa, India, began an investigation into the efficacy of its stove program. At the start of the study, Gram Vikas had planned to subsidize improved stoves ("chulhas" in Hindi and Oriya) to roughly 15 000 households over the next three to five years. As the stoves are primarily made of locally available mud, the stoves can be easily constructed in remote, rural areas. These stoves enclose the cooking flame, which in laboratory settings leads to increased efficiency and lower biofuel requirements. Importantly, they also include a chimney that directs the smoke out of the room. Gram Vikas subsidizes the stove cost by contributing stove materials (chimney) and design, but households are responsible for providing mud for the stove base, labor and a payment of Rs. 30 which is used to pay the person who assists in building and maintaining the stoves.

To evaluate the stove program, a randomized evaluation has been implemented. Since installing such a large number of stoves takes considerable time and resources, Gram Vikas will phase in the stove construction over the next few years. In about 40 villages (about 2500 households), the order according to which households will receive the stove was determined randomly. In each of these villages, a lottery was conducted to randomly divide the village households into three groups. Based on the lottery results, the first group was given a chance to get the stove immediately. A year and a half into the project, the second group will be given an opportunity to get a stove. The third group will be given the opportunity at the end of three years. It is important to note that because the assignment into groups was conducted at the household level, rather than the village level, we can be sure that differences in outcomes between households that were and were not offered a stove are attributable to the stove, and not to other characteristics common to households in a particular village.

In collaboration with Gram Vikas, the Center for Micro-Finance (CMF) at the Institute for Financial Research and Management, a research institute based in Chennai, India, has undertaken a considerable data collection effort to better understand the impacts of the program. Specifically, in 2006, CMF conducted a detailed baseline in the 40 villages. CMF is currently conducting follow-up surveys to understand the impacts of the improved stoves on cooking practices, fuel usage, CO exposure, health status and health expenditures, and labor supply.

This study will further our understanding of the impacts of a clean stove program in the field. First, this is the largest randomized evaluation of a stove program to date. Second, this study will use data from a program wholly run and operated by an NGO, which has the added advantage of more accurately evaluating the likely impact of a program in the real world. Moreover, this study evaluates a fairly cheap stove design, where stoves are constructed using locally available material. Previous studies evaluated *planchas*, stoves that are large and costly.

The stoves we evaluate, while more likely to break, are potentially more cost-effective and practical for remote areas where there are high transport costs. Next, CMF is collecting a rich series of productivity measures, including child school attendance. This study, thus, takes into account the welfare consequences of poor health due to both illness *and* reduced productivity. Finally, the study is based on richer data that allows for an examination of households' behavioral responses upon receiving the option to buy a stove (take up, use, changes in who cooks and when they cook, change in other health behaviors) and on economic consequences of better health.

Box 1: Improved Chulhas Project in India

A third type of strategy has been to convince households to increase ventilation within the household. Several studies have stated that the kitchen location, ventilation, and permeability of roofs and walls significantly affect smoke exposure (Dasgupta et al., 2004a, 4b). For example, this is one of the recommended policy interventions of the Disease Control Priorities Project, of the World Bank Group. However, if smoke exposure is the greatest threat in the immediate vicinity of the stove, it is unclear whether improving ventilation in the kitchen as a whole will reduce the smoke exposure for the primary cook in the household. Indeed, other recent studies (Pitt et al., 2006) find no correlation between ventilation and smoke exposure.

6 Conclusions

Indoor air pollution (IAP) may have potentially large impacts on the health and well-being of poor families. The literature indicates ambient IAP levels and personal exposure levels from cooking with traditional fuels are dramatically high. Although the literature is growing, there is currently a deficit of information on the impacts of IAP on health, and even less on the impacts on the economic well-being of the family, with much of the evidence – except from the RESPIRE study – resulting from observational studies. In the observational studies, we cannot rule out the possibility that observed respiratory illnesses are not due to other factors that also contribute to a households' decision to use a traditional stove, including poverty and health preferences. Thus, our understanding of the causal impact of IAP is weak.

However, the evidence from the RESPIRE study and randomized evaluations of iron supplements (that also affect respiratory health) suggests that the gains from reducing air pollution within the household can, in fact, be quite large. First, the reduction of air pollution within the household has the potential to have a direct effect on respiratory – and even general – health. Second, if household tend be in better health due to the stoves, they can save much in medical expenditures, which tends to be a large portion of expenditures among the very poor. Third, if household members are in better health, there is a potential for the household to be more productive, with household adults missing fewer days of work and children missing fewer days of school. Much work, therefore, is needed to better understand the welfare effects of reducing IAP within households and to better understand the most cost effective way to reduce it.

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