

**Measuring the health effects of a pilot indoor air
pollution intervention in Bangladesh**

Draft protocol

7 May 2008

ICDDR,B study team:

**Emily Gurley
Md. Shohel Shomik
Abdullah Brooks
Steve Luby**

Table of contents

1. Brief summary of the study	3
2. Study objectives	3
3. Background	4
4. Methods	10
5. References	19
6. Timeline	23
Annexes	
Annex A: Table of reviewed literature	24
Annex B: Case control study questionnaire	29
Annex C: Cohort household baseline questionnaire	48
Annex D: Cohort baseline/endline questionnaire for children <5	56
Annex E: Cohort baseline questionnaire for cooks	64
Annex F: Cohort monthly surveillance questionnaire for children <5	67
Annex G: Cohort monthly surveillance questionnaire for cooks	72
Annex H: Community participation data collection tool	75
Annex I: Verbal autopsy for neonatal deaths	76
Annex J: Verbal autopsy for childhood deaths	77
Annex K: Consent for case control study	78
Annex L: Household head consent for cohort study	80
Annex M: Cook consent for cohort study	82
Annex N: Parental consent for cohort study	84

1. Brief summary of the study

Acute respiratory infections are the leading cause of death in children worldwide and in Bangladesh. Indoor air pollution has been repeatedly shown to contribute to poor health outcomes in children and adults, including acute respiratory infections. In rural homes across Bangladesh biomass and other polluting fuels (e.g. kerosene) are routinely burned for cooking, heating, and lighting purposes creating indoor air pollution levels higher than recommended healthy levels for ambient air by the US Environmental Protection Agency and Bangladesh Ambient Air Quality Standards. Considering the burden of respiratory infections and the contribution of indoor air pollution to poor health outcomes, it may be possible to decrease morbidity and mortality from respiratory disease by decreasing indoor air pollution levels. Indeed, decreasing this burden is crucial to improving the lives of Bangladeshi children in order to reach the Millennium Development Goals. However, the best way to reduce indoor air pollution in Bangladeshi households and what, if any, health improvement to expect from interventions to improve indoor air pollution are not currently known. An intervention to introduce improved cookstoves into rural Bangladeshi homes is being planned, based on the total sanitation model. These cookstoves are believed to improve fuel efficiency and decrease the amount of particulate matter and toxic gases released in the home from burning biomass fuels which would suggest a health benefit for the household inhabitants. There is evidence from Guatemala that improved cookstoves can improve child health. A randomized-controlled trial of improved cookstoves in Guatemala showed significantly lower rates of non-RSV pneumonia¹ in children <5 years of age in households using the improved stoves. The proposed study will measure the health impact of a 'real-world' intervention using improved cookstoves; that is, it will measure the impact of the intervention itself without actively managing and fully subsidizing the uptake and use of improved stoves. Given the findings from Guatemala the study will focus on pneumonia in children as a primary outcome. It will also measure other health outcomes and intermediate health indicators in children and cooks and compare outcomes between households with and without improved cookstoves. The data we collected will help to describe the seasonality of indoor air pollution in Bangladesh, for which little evidence is currently available. The study will also assess whether data collected by community members on childhood episodes of respiratory disease is comparable to data collected through more rigorous study procedures in an effort to determine whether the community participation model of evaluation might be useful in measuring the impact of such interventions in the future. As a part of the current activity, the methods outlined in this protocol will be tested in the field to refine and improve the proposed study design and tools.

2. Study objectives:

¹ Non- RSV pneumonia refers to an acute lower respiratory infection which is not caused by respiratory syncytial virus (RSV). There are many causes of lower respiratory infections including viruses, bacteria, and fungi. Previous studies suggested that indoor air pollution was not associated with increased incidence of RSV so children suffering from this infection were excluded from the analysis in the Guatemala study.

This study is an evaluation of the health effects of a pilot indoor air pollution intervention in rural and peri-urban Bangladesh. The specific objectives are to:

1. Measure whether or not children <5 years of age who develop pneumonia and other respiratory symptoms during the study period are more or less likely than other children <5 years of age without pneumonia to use an improved cookstove at home.
2. Compare health indicators in children <5 years of age and adults who cook between households that use cookstoves and those that do not.
3. Describe differences in particulate matter and CO levels between households using improved cookstoves and those not, including differences in seasonality.
4. Determine whether health outcome data on respiratory illness in children <5 years of age collected by community volunteers is comparable to data collected through rigorous scientific methods.

3. Background

3.1 The health impacts of indoor air pollution

Extensive scientific research has consistently documented the ill health effects of breathing smoke from biomass fuels commonly burned in the developing world for cooking and heating ¹. Some diseases directly result from breathing specific toxins produced from burning biomass, while breathing fine particulate matter (PM) can compromise the respiratory tract making those exposed more vulnerable to viral and bacterial infections. Respiratory disease has been strongly associated with indoor air pollution (IAP). Acute respiratory infections are significantly higher in children exposed to IAP, especially those < 5 years old. One study in Kenya ² showed a dose response relationship between ARI and IAP exposure and numerous studies have shown that children exposed to IAP have 2-3 times greater likelihood of experiencing a serious episode of ARI, compared to those not exposed, even after controlling for socio-economic conditions ³. Older persons exposed to IAP from biomass are also much more likely to suffer from chronic obstructive pulmonary disorder (COPD) ^{1,3,4}. Tuberculosis, a leading cause of death in the developing world ⁵, is also closely associated with IAP exposure ^{6,7}. The evidence for the association of IAP with low birth weight and poor pregnancy outcomes has also become quite convincing ^{8,9}. Even low amounts of CO have been linked with preterm birth ¹⁰.

There is some evidence that asthma ^{11,12}, stunting, and anemia ¹³ may also be associated with IAP exposure but available data are insufficient to make specific recommendations. Additional studies are recommended to better understand the relationship between IAP and these health outcomes. Burns and scalds from burning biomass in open fires in homes receive less attention but are additional adverse health outcome associated with burning biomass ¹⁴. In addition to episodes of acute respiratory illness, respiratory symptoms such as cough and burning throat have been significantly associated with IAP exposure, including one small study in Bangladesh ¹⁵.

3.2 The scale of the problem

The ill effects of polluted air are concerning because so many people have daily exposures to high levels of pollution in their homes. WHO estimates that 2.4 billion people worldwide (approximately 30% of all people) rely on burning biomass fuels for cooking and heating their homes¹⁶. People in the developing world are disproportionately exposed to polluted air from using biomass fuels for cooking and heating. According to Demographic Health Survey data, 74% percent of people in South Asia are exposed to biomass in their homes, including 88% of people in Bangladesh¹⁶. Women and children are thought to be the most affected because of their domestic roles in meal preparation. Studies from South Asia showed that women and children < 5 years of age spent more time in proximity to fires in the home and hypothesized that this increased proximity to fires was related to higher levels of IAP exposure^{17,18}. However, another study from Bangladesh suggests that pollution from fires rapidly spreads throughout all rooms of a house exposing all individuals in the house to high levels of IAP, not just the cook¹⁸.

Not only are poor populations in the developing world exposed to IAP more frequently, the levels of biomass smoke they are exposed to are many times higher than acceptable standards for indoor air published by the United States Environmental Protection Agency¹⁹ (PM₁₀ of 50 µg/m³ are acceptable) and the ambient air standards outlined by the Government of Bangladesh. One study in Bangladesh found that household levels frequently reached 300 µg/m³, although spikes of up to 4864 µg/m³ were observed, and that regional levels varied²⁰.

Given the ill health effects of breathing polluted air and the constant, prolonged exposures to extremely high levels of IAP experienced by people in the developing world, estimates of burden of disease attributable to indoor air pollution are significant. Numerous modeling exercises have estimated the global burden of disease attributable to indoor air pollution. A World Health Organization (WHO) report from 2005 estimates that exposure to IAP is responsible for 2.7% of the global burden of disease and is responsible for 1.6 million deaths, concluding that the ill effects of IAP are more than 5 times those of outdoor air pollution²¹. Another modeling exercise estimates that IAP was responsible for about 1.2 million premature deaths globally in the early 1990s²². Indoor air pollution has also been linked with child mortality in a trend analysis²³.

Globally and in Bangladesh, pneumonia is the leading cause of death in all age groups combined as well as in children < 5 years of age^{1,24,25}. Bangladesh has some of the highest rates of tuberculosis in the world^{26,27}. As Bangladesh struggles to meet the Millennium Development Goals (MDGs), reducing exposure to IAP could increase the chances of reaching MDGs 4 and 5 which call for reduction in maternal and child mortality¹⁶. By reducing the amount of biomass used for cooking and heating Bangladeshi homes, contributions could also be made to reaching MDG 7, ensuring environmental sustainability¹⁶. One WHO report estimates that in 2002 there were 32,330 deaths from acute lower respiratory infections in children <5 years old and 13,620 deaths in adults from COPD attributable to solid fuel burning in homes, constituting 3.6% of the total national burden of disease²⁸.

If breathing polluted indoor air causes ill health, common sense suggests that reducing levels of indoor air pollution is a good idea. Various interventions have been used to decrease the exposure to polluted air in homes including substituting cleaner burning fuels in homes, improving the efficiency of stoves, adding chimneys to stoves, improving ventilation around cooking areas, and asking people to cook outdoors to reduce the amount of smoke in the home. Both India and China have decades of experience with large scale IAP interventions. The interventions in India introduced improved cook stoves which require less biomass to operate, due to increased efficiency, and usually had some kind of chimney to direct smoke out of living areas. Evaluations of the program in India are rare which limits understanding of the lessons learned from that project. In China a large national program in the 1980's to bring improved cook stoves to rural homes received large government support. Recent assessments of the effectiveness of these cook stoves show that they have reduced IAP levels in households, but not to nationally acceptable levels²⁹. The intervention has achieved some success but would be difficult to replicate in other areas because political will and funding is not available in all countries at the same level provided by the Chinese government.

Successful smaller-scale interventions using improved cook stoves also exist. In Guatemala, the use of improved stoves called *planchas* improved IAP levels and showed significant health benefits^{30,31}. This was the first study to show that use of improved cookstoves resulted in a decreased incidence of pneumonia in children <5. These findings, however, are limited in their applicability to other improved cookstove interventions because of the study design used and the context of IAP in Guatemala. First, the indoor air in homes using traditional stoves in Guatemala is among the most polluted in the world. Therefore, by using an improved stove, there is more likely to be an improvement in IAP than if by using improved stoves in a setting where indoor air was not as polluted. Second, this was a randomized-controlled trial where households were randomly selected to receive an improved cookstove and the cookstove was purchased and maintained by the study. This represents a best-case scenario for improvements in health to be observed. Real-world interventions, which do not provide stoves or constant support and maintenance for consumers, are less likely to have an observable effect on health.

Other countries, including Bangladesh, have experimented with improved cook stoves as well as behavior change around cooking location and increased ventilation in households. One study from Bangladesh suggests that improving ventilation in cooking areas can significantly decrease exposure to IAP, regardless of the fuel or stove used²⁰.

3.3 Unanswered questions

Certain critical questions about the relationship between indoor air pollution and health remain unanswered^{4,14}. First, despite decades of intervention attempts, we know very little about the improvements in air quality that IAP interventions produce in practical use^{32,33}. The few studies which have actually examined the use of improved cook stoves have shown mixed results. In some cases, levels of IAP were reduced³⁴ while in other studies, interventions actually increased the levels of IAP³⁵. In one study from

Guatemala, improved stoves did reduce levels of PM_{2.5} and CO but the improvements over open fires were not dramatic and tended to fade over time³⁶. In order for any IAP intervention in Bangladesh to be successful, we must show that the intervention is effective at reducing the levels of IAP in the household, and thereby reducing exposures of household inhabitants. In laboratory tests and observational studies, increased ventilation has shown promising results in dramatically reducing IAP levels^{20,37}. However there have been no evaluations of improved ventilation interventions to date. Evidence of improved air quality is essential for any IAP intervention.

Second, despite vast evidence about the poor health outcomes associated with breathing biomass smoke in the home, very little is known about the best way to prevent these outcomes³². Even if interventions reduce the amount of IAP, the level of reduction required to show health benefits is unknown. In addition, relative effectiveness of interventions to reduce IAP have not been studied, and the solution is likely to be regional, rather than global¹⁴. Only a few studies have examined the relationship between indoor air pollution interventions and health outcomes. Preliminary data from an evaluation of improved cook stoves in Guatemala look promising; however, for reasons previously mentioned, these outcomes are only somewhat applicable to other improved cookstove interventions (Smith, et al, unpublished data). Women using the improved stoves in the Guatemala study experienced reduced blood pressure and were less likely to report eye soreness and headache^{30,31}. The evidence that the use of these stoves improved health outcomes in Guatemala is encouraging; however, successful IAP interventions must be able to provide evidence of decreased IAP and improved health.

Third, there is currently little data available on the seasonality of indoor air pollution; most studies have focused on IAP levels through a 24-hour period rather than throughout the year. Seasonal differences in ambient air have been observed (Zmirou et al. 1998) and intuitively it would seem that increased heating needs during colder months might increase the amount of biomass burned in households or that during the monsoon, people might be less likely to cook outside in Bangladesh. Households with substantial ventilation during the summer might, by design, have very little ventilation in the winter time. One study examined IAP levels during the winter in Bangladesh, but measurements from other seasons would be useful in determining the seasonality of IAP²⁰. There are some data to suggest that incidence of pneumonia in children in Bangladesh might also vary by season and peak in September through November^{38,39}. The proposed study will attempt to document the variation of IAP throughout the year, highlighting seasons of highest risk which might provide opportunity for a targeted intervention, and describe any association between seasonal differences in IAP and pneumonia in children <5.

3.4 Current IAP monitoring activities in Bangladesh

Currently, there are no IAP evaluation activities which attempt to measure health impact. There are however two small studies planned to measure improvements in IAP levels from improved cookstoves.

BRAC, in collaboration with Stanford University and the University of Colorado in the USA, recently began an evaluation of traditional and improved cookstoves with two primary goals: 1) determine which cookstove design would produce the least amount of smoke, require the least amount of fuel, and be socially and culturally acceptable to households and 2) determine what factors most influence the decision to purchase and continue using an improved cookstove in the home. The study began by testing various cookstove designs in a test kitchen and currently the study team is deciding which stove would be most appropriate for inclusion in their study. In order to address the second goal, 3000 households will be surveyed and various incentives to purchase an improved stove will be offered to participants. There will be five study groups and one each will receive: education and awareness building about IAP and its negative health consequences; the same messages plus a 50% subsidy for stove purchase; same messages and the option to have a stove purchased for them or receive the cash equivalent where the decision will be made by the head female of the household; same messages and the option to have a stove purchased for them or receive the cash equivalent where the decision will be made by the head male of the household; and two groups where community leaders only are targeted for messages and one group will be provided stoves and the other will not. The initial phase will take about 3 months to complete and after 6 months experience with the stoves the study will document if families are still using the stoves and conduct IAP monitoring activities.

VERC, a pioneer in the development and marketing of improved cookstoves, has been working on ICS since 1987. They have a program titled National Network on Improved Cook stoves Program in Bangladesh which involves 83 NGOs working across 28 districts in the country. Their program titled 'Reduction of Exposure to Indoor Air pollution through Household Energy and Behavior Improvement Project' in Saidpur and Parbatipur has been largely successful in promoting use of improved cookstoves in these areas. They also work on technology innovation, training, enterprise development, and social marketing. In the near future they plan to integrate small-scale IAP monitoring activities into their projects.

3.5 Overview of proposed pilot evaluation

Currently, an IAP intervention to encourage use of improved cookstoves is being planned in Bangladesh (M. Sohel Shomik, field report, 27 September 2007). The proposed study will compare health outcomes between households which adopt the improved cookstoves and those which do not. Specifically, comparisons will be made between levels of indoor air pollution, indirect measures of health, and health outcomes. The study will primarily focus on health outcomes in women and children since numerous studies have shown that they are more frequently exposed to IAP and suffer disproportionately from its ill health effects. Measurements will include acute episodes of illness, especially acute respiratory illnesses and pneumonia in children <5 years old. Some examples of intermediate health indicators of interest are oxygen saturation in children, maternal blood pressure, and amount of CO in breath. Although these intermediate indicators do not measure direct health outcomes, they are meaningful as reasonable short-term indicators of future health benefits⁴⁰. Measurements of respiratory symptoms, such as coughing and eye irritation, have also been linked with

IAP and also provide reasonable estimates of decreased exposure to IAP⁴¹. Finally, toxins and pollutants in the air which have been linked with poor health outcomes will also be measured, such as particulate matter and CO. These indicators of air quality are important because they will provide evidence as to whether or not interventions are actually producing lower levels of IAP. In addition, the study may provide insight into the level of pollution reduction required to produce improved health outcomes, which is currently unknown. Low-cost smoke detectors to measure particulate matter have been developed by Kirk Smith and colleagues and will be used in this evaluation study.

Community involvement in interventions to reduce indoor air pollution is essential for adoption of interventions, especially as most interventions include a behavior change component. Interventions such as the Total Sanitation Campaign in Bangladesh have successfully involved community members in the evaluation of the interventions, as well as the intervention design and implementation. Involvement of community members in evaluation can have the added effect of sensitizing and raising awareness in the community around the issue. In the spirit of community involvement, the proposed study will also involve community members in data collection for evaluating IAP interventions in Bangladesh.

In summary, the proposed study will use standard scientific methods to measure the health effects of IAP interventions in order to document the relative effectiveness and potential of such interventions to reduce IAP and disease. The findings from this study will not only directly benefit program implementers in Bangladesh and the Bangladeshi people who may ultimately benefit from these interventions, but will also contribute to the global knowledge gaps around IAP interventions and their potential contribution to improved health outcomes in the developing world. This evaluation is a novel exercise; there is currently no published account of such an IAP intervention evaluation.

4. Methods

4.1 Methodology overview

The proposed study will use both a case-control and cohort study designs to measure outcomes described in the study objectives. A prospective case control study design will be used to find cases of pneumonia in children < 5 years of age presenting to licensed health care providers in the intervention areas and risk exposures will be measured to determine if children living in households with improved cook stoves are less likely to develop pneumonia. A prospective cohort study will be conducted in two villages where the intervention is ongoing and one village where no intervention is taking place to look for differences at the household level in health indicators in children and cooks and particulate matter and CO levels. A subset of children in the cohort study will also have data collected by village level volunteers on ARI episodes to compare with data collected through the formal cohort study methodology. The methods which will be used to meet each of the study objectives are described below.

4.2 Methodology rationale

There are practical and scientific reasons for choosing to conduct both a case-control and cohort study to answer the study questions. Each study design offers real benefits in the type of data collected and power to answer important study questions. When designing this study, the focus has been on collecting sufficient data to make scientifically based conclusions about the effectiveness of the intervention in the most efficient manner possible.

A case-control study design is best used when the outcome of interest is relatively rare and the objective of the study is to determine what exposures are associated with developing the disease of interest. This study design can provide statistical power to evaluate these associations with less time and resources than if a cohort design were used; it is more efficient than a cohort design because rather than follow a group of people over time to observe exposures and outcomes, focus is on finding cases and then collecting data on past exposures. This study design was chosen to evaluate risk factors for developing pneumonia in the intervention area because pneumonia is a rare outcome and we will be able to determine if there is any association with this outcome and the use of an improved cookstove with a minimal amount of resources. The limitation of this design is that often exposures of interest may not be easily recalled by persons with the disease. However, it is not anticipated that this will be a problem during this study as all children's mothers are expected to be able to recall the type of stove used for cooking and heating in their homes.

Conducting a cohort study is generally more resource intensive than a case-control study. This is because the design entails following a defined population over a period of time to measure exposures of interest and document outcomes. However, this is a function of the relative frequency of the outcome of interest. The advantages of this study design are that data are collected prospectively so that recall bias is minimized. In addition, cohort studies can generate incidence rates of disease (i.e., number of new episodes of disease over a specific time period) which are generally more informative than prevalence rates. Another advantage is that data are collected longitudinally, that is, numerous observations may be made over a period of time. This allows for an analysis of trends over the study period. This study design could be used to look for cases of pneumonia; indeed, data on respiratory

illness generally and health care visits and hospitalizations due to respiratory disease will be collected. However, as previously discussed, since these outcomes are relatively rare, and in order to have confidence that the study will be able to compare differences in outcomes between groups (i.e. those using improved cookstoves and those not) a much larger cohort population or much longer study period would be required, which would mean a more expensive study. This study design will be very useful for observing other, more common, health outcomes and intermediate health indicators. For example, the study is powered to evaluate more common health outcomes such as respiratory symptoms in children or eye soreness in cooks. In addition, multiple observations over time in CO in breath of cooks, PM and CO concentrations in the kitchen, and fuel and stove use will allow for a more complete description of the context of IAP in these homes and differences in more common health outcomes between households using improved cookstoves and those not.

4.3 Defining the study area

These studies will be conducted in the intervention area. This area will be selected by the partners who are designing and implementing the intervention. The design of the intervention will be such that households will be encouraged through various economic, health, and environmental arguments to begin using improved cookstoves in their homes; uptake is not expected to reach 100%. Therefore, although households enrolled in the cohort study or children in the case control study may reside in 'intervention villages' this does not mean that they have an improved cookstove in their homes. Rather, it simply denotes that they live in a village where the intervention is ongoing.

4.4 Objective 1:

Measure whether or not children <5 years of age who develop pneumonia and other respiratory symptoms during the study period are more or less likely than other children <5 years of age without pneumonia to use an improved cookstove at home.

4.4.1 Case-control study

A case-control study to investigate the association between exposure to IAP in developing pneumonia will be conducted; i.e. children in the intervention area who develop pneumonia will be identified and the proportion of these children with improved cookstoves in their home will be compared to the proportion without improve stoves.

First, qualified health care providers serving the intervention area will be identified. This would include private and public practitioners and government and NGO clinics in the intervention area. A health care utilization survey will be conducted in conjunction with the cohort study (described below) to ask households where they would seek care for a child with serious respiratory illness; the providers identified by the community will be used to choose providers for participation in this study. The health care providers most frequently mentioned will be listed and those most frequently mentioned will be targeted for case control selection sites. An attempt will be made to include enough providers mentioned in the survey so that at least 75% of potential pneumonia cases in the cohort study areas will be expected to be included in the case control study.

Care providers at each of the health facilities mentioned by cohort study participants will be identified and recruited for the study. They will receive training on the study case definition for pneumonia and will be asked to call the medical officer assigned to the study when a case is identified; for every case identified they will receive a small finder's fee. The medical officer will be a licensed physician stationed in the intervention evaluation area. Upon receiving the call, the medical officer will visit the facility and enroll the child in the case control study. The medical officer will assess the children and determine whether or not they meet the WHO clinical case definition of pneumonia. The medical officer will complete a clinical, health, and socio-demographic questionnaire for each case and control which will include information about residence and whether or not their household is using an improved cook stove. (Annex A) Two controls will be selected from the next two children <5 years of age who seek care from the provider or facility for any complaint which does not involve respiratory symptoms and the same questionnaires completed. We will assess whether cases of pneumonia are more likely than other children seeking care for non-respiratory illnesses to have used an improved cookstove in their households in the previous month.

4.4.2 Case definitions

Pneumonia will be defined based on the WHO clinical case definition and distinctions will be made for severe and non-severe pneumonia based on this case definition. WHO has developed purely clinical criteria which allow for standardization of definitions across countries and studies without additional laboratory or other diagnostic testing. This definition is very sensitive but not as specific as others which include diagnostic criteria. Children presenting with severe pneumonia will be referred to the nearest facility with the ability to treat such cases; the study will bear the cost of transporting the child, when required.

WHO case definition:

Pneumonia:

Symptoms: Cough or difficult breathing AND

Signs: Breathing >50/minute for infants aged 2 months to <1 year
Breathing >40/minute for child aged 1 to 5 years AND
No chest indrawing, stridor or danger signs

Severe pneumonia:

Symptoms: cough or difficult breathing AND any general danger sign OR chest indrawing or stridor in a calm child

General danger signs: For children aged 2 months to 5 years, unable to drink or breast feed, vomits everything, convulsions, lethargic or unconscious, central cyanosis

4.5 Objective 2:

Measure differences in health indicators, illness rates, and risk of illness between children <5 years of age and cooks in households which use improved cook stoves and those which do not.

4.5.1 Cohort study

We will enroll 2 villages in the intervention area and 1 village outside the intervention area into a prospective cohort study to measure health outcomes in individuals with and without improved cookstoves in the household. We will focus on outcomes in children <5 years of age and cooks because they are expected to have the greatest exposure to pollution created by stoves.

4.5.2 Study population

The population under study will be determined by the areas chosen for the indoor air pollution intervention activities. Currently, the implementing partners are planning to introduce improved cookstoves into 3-4 unions in 3-4 different districts throughout Bangladesh. The purpose of the study is to evaluate the effect of the intervention, not the success of intervention uptake; therefore, the district and unions where the intervention activities are believed will be the most successful will be chosen. Households in intervention areas as well as non-intervention areas will be enrolled in the study.

4.5.3 Household selection

Two hundred households (roughly 2 villages) in intervention areas and 100 households (approximately 1 village) in a non-intervention area with children <5 years of age will be chosen for the cohort study. Children expected to celebrate their 5th birthday within two months from study enrollment will not be included as they will only provide one month of data to the study. Although households will be enrolled based on the community where they are located, the analysis of health outcomes will be conducted at the household level. This is because even though a house might be located in the intervention area does not mean that they will necessarily be using an improved cookstove. Rates of illness will be compared between intervention and non-intervention households, including analysis pre and post intervention in households which begin using the improved stoves during the study period.

The villages chosen for the study will be chosen randomly from the upazilla where the intervention is expected to be the most successful. In the intervention areas a union which is expected to be high performing will be chosen and each village in that union assigned a random number. Villages will be sorted by random number and every household with children <5 years of age from the first village listed will be enrolled until 200 total households are enrolled. Based on other studies in rural Bangladesh (data from SHEWA-B), 40% of all households in the village are expected to have a child <5 years of age. Therefore, 500 households will be approached before enrolling the total sample size from the intervention area, or approximately 2-3 villages.

A list of villages in a nearby union, which is similar to the intervention union in terms of demographics and social indicators, will also be made. Random numbers will be assigned to each village and the villages sorted by random number. One hundred households will be enrolled starting with the first village and continuing until the sample size is met.

Although villages will be randomly selected, households will not. Once a village is selected, all households in that village with children <5 years of age will be eligible for the study. A house to house survey will be conducted in each of the three villages selected and

households with at least one child <5 years old will be asked to participate. Households with a pregnant member will have the due date recorded and will be revisited to enroll the newborn. A field research assistant will describe the study, including the objectives and methods. The household will be visited when both household head and cook(s) or parents of children in the house are present. Household heads, cook(s), and parents of children <5 years of age will be asked to provide written consent to participate until the study ends, or until the child reaches their 5th birthday, whichever occurs first. They will be asked to sign or provide their thumbprint to the consent form and will receive a copy of their consent form.

Once per quarter throughout the study, a house to house survey will be conducted to identify pregnant women in households without children <5, as well as to document migration of any households out of, or (rarely) into, the study area. Estimated dates of delivery will be recorded for pregnant women and the field team will visit the household after the delivery of the child to enroll the household in the study. All newborns in households currently in the cohort will be included in the study during the first visit to the home after the birth. The study will observe all outcomes in children <5 years of age throughout the study period; therefore, it is important to include all newborns in the cohort area in the study. In addition, these children are at highest risk for death due to respiratory illness and could benefit most from improvements in indoor air quality. Including them will also provide more data on the association between birth weight and IAP, although this is not a major outcome of this study.

Cohort data collectors will be highly experienced field workers with training in health evaluation studies, anthropometric measurements, taking blood pressure and other medical measurements, installation of particulate matter and CO sensors, and verbal autopsy techniques.

4.5.4 Baseline data collection from participating households

Baseline data will be collected from participating households, which will include a health assessment for kids and cooks, a health care utilization survey, and indoor air quality assessment. This will include socio-demographic data at the household level including house and kitchen construction, stove type and type of fuel used, amount of fuel used in the past week, education levels, the number and frequency of persons smoking in the house, deaths in the house in the past year, which will include probing about pregnancies and their outcomes, and monthly income. (Annex B) Individual questionnaires will be completed for each child <5 years of age (Annex C) and for each cook (defined as any person responsible for cooking a family meal at least once per day) (Annex D). These individual assessments will include the amount of time spent cooking or indoors while cooking in the past week, anthropometric measurements for kids, hospitalizations or physician visits for respiratory illness in the past two months, including where care was sought, respiratory symptoms in the past 7 days, experience of eye soreness in past 7 days, pulse oxygen in kids, CO and blood pressure in cooks, and experience of burns or injury from stove/fire in the past month. Any deaths in children <5 years of age which occurred in the household will be documented and investigated during a follow-up visit with a verbal autopsy.

4.5.5 Routine surveillance for health indicators

Each household will be visited once per month to inquire about the health experiences of the cook and children < 5 years of age. These monthly assessments will include information on hospitalizations and visits to a physician for respiratory symptoms in the past month, report of any respiratory symptoms in the past 7 days, burns or stove/fire related injury in the past month for kids. Once per quarter (every third visit) pulse oxygen for children and CO in breath and blood pressure of cooks will also be measured. Respiratory rate and chest indrawing will be recorded for any child experiencing fever with cough at the time of the visit. Any child experiencing chest indrawing, high respiratory rate, or signs of severe illness will be referred to a local clinic/hospital. These monthly visits will also document any changes to cooking and heating practices in the past month, such as location of cooking, type of stove used, and hours of heating.

Children who have completed their 5th birthday within the past month will be excluded from data collection and, unless there are other children in the house <5 years of age living the home to keep the household eligible for the cohort study, an endline data collection will take place. Any deaths in children or cooks enrolled in the study will be investigated using a verbal autopsy.

4.5.6 Endline data collection from households

Upon completion of the study, either 2 years after study enrollment or when there are no longer children < 5 years of age in the household, whichever ever happens first, all of the data collected at baseline will be collected again during an endline assessment of households.

4.6 Objective 3:

Describe differences in particulate matter and CO levels between households using improved cookstoves and those not, including differences in seasonality.

A particulate matter (PM) sensor (manufactured by Berkeley Air group which monitors PM_{2.5}) and CO monitor (HOBO logger) will be placed in each household enrolled during the baseline data collection phase for 24 hours to collect information on the indoor air quality. In addition, once per quarter, 24 hours of data on particulate matter and CO levels will be collected from each house from the room where cooking takes place (or the nearest room to cooking location if cooking takes place outside). This will allow us to measure differences in PM_{2.5} and CO levels between houses using improved cookstoves and those using traditional cookstoves; to estimate the percent of PM_{2.5} and CO reduced, if any, by using an improved cookstove; and will allow for a seasonal description of indoor air pollution in the homes under study.

4.7 Objective 4:

Determine whether health outcome data on respiratory illness in children <5 years of age collected by community volunteers is comparable to data collected through rigorous scientific methods.

One village volunteer will be chosen from every 10 households enrolled in the cohort study to participate in data collection (there will be about 30 volunteers total). Women will be chosen as volunteers since we expect that they will be more easily accepted than men as data

collectors by other mothers and children in the community. Women will be eligible to be volunteers if they are interested in participating and are able to read and write Bangla. These women will undergo a day-long training, conducted locally, where they learn about indoor air pollution and objectives of the study and will be trained to administer a simple data collection tool. They will be asked to visit the 10 households in their area once per month to inquire about respiratory symptoms in children <5 years old. Information collected will include fever, cough/cold, and difficulty breathing in the child in the 7 days prior to the survey (Annex G).

Community volunteers will receive a small monthly stipend for their work (Tk 100 suggested) and will serve as dissemination points for information about study activities and will be an invaluable source of informal information for the study team. Study staff will meet with community volunteers once per quarter to follow-up on data collection and encourage continued participation.

4.8 Sample size calculation

EpilInfo 2000 was used to calculate sample size for an unmatched case-control study with WHO defined pneumonia as an outcome. With 95% confidence and 80% power, assuming that 85% of those with pneumonia are not using an improved cookstove and 75% of those with pneumonia are from households using an improved cookstove, we will need to observe 206 episodes of pneumonia and 412 control episodes. Based on the assumptions below, there will be enough pneumonia episodes in the cohort study to see a difference between intervention and non-intervention groups after 2 years of data collection. However, more children will be able to be enrolled in the case-control study and include clinically confirmed pneumonia with this study design. This time frame would also be sufficient to observe differences between other health indicators measured in the cohort study.

In calculating the sample size and data collection period the following assumptions are made:

- 40% of all households will have at least one child < 5 years of age (from SHEWA-B experience)
- Each household with at least one child <5 years of age will have on average 1.2 children <5 years of age (from SHEWA-B experience)
- Therefore, we will enroll 200 households in intervention areas with 240 total children <5 years of age and 100 households in non-intervention areas for a total of 120 children <5 years of age in the cohort study
- Approximately 20% of households in intervention areas will actually adopt an intervention (this is just a guess- current projects in the field report about 10% uptake)
- Therefore, there will be 48 households who adopt an intervention in the cohort and 298 who do not; this is 114 child years of observation in 2 years for the intervention cohort and 714 child years for non-intervention cohort.
- Children without an intervention will experience ARI at a rate of 5.5 episodes per child year (based on Zaman et al study in Matlab), so we expect to see 3927 (714×5.5) in the year of the study
- Children without an intervention will experience ALRI or pneumonia at a rate of 0.23 episodes per child year (based on Zaman et al study in Matlab), so we expect to see 164 (714×0.23) in the 2 years of the cohort study

- Children with an intervention will experience ARI at a rate of 4 episodes per child year (this is about a 25% reduction- didn't have data on what % of ARI is attributable to IAP, but in some studies about 50% of ALRI is attributable, but this is a small % of the total ARI), so we expect 656 (4×164) episodes in two years
- Children with an intervention will experience pneumonia at a rate of 0.18 episodes per child year (this is a 20% reduction, a conservative estimate since studies in Zimbabwe found a 50% reduction), so we expect about 30 (164×0.18) episodes in two years.

4.9 Outcome measures

The outcome measures of interest from the case-control study will be:

1. Risk factors for developing pneumonia and severe pneumonia, according to WHO clinical case definitions, during the study period, specifically if there is decreased risk in children living in households which use improved cook stoves will be assessed through calculating odds ratios with 95% confidence intervals.

The outcome measures of interest from the cohort study will be:

1. Differences between intervention and non-intervention households and pre and post intervention (measured as relative risk ratios with 95% confidence intervals) within intervention households in:
 - Incidence of ARI and pneumonia in children <5 years of age
 - Rates of hospitalization in children <5 years for any respiratory illness
 - Prevalence of eye soreness and headache in person(s) cooking
 - Pulse oximetry data in children <5 years of age
 - CO in breath of person(s) cooking
 - Incidence of burns or other injuries from fire or stove in children <5 years of age and person(s) cooking
 - Deaths in children <5 years of age (we will measure this although we will not be powered to find significant differences between the two groups)
 - Mean PM_{2.5} levels
 - Mean CO levels
2. Description of variation of PM_{2.5} and CO concentrations by season
3. Comparison of rates of respiratory illness in children using data collected from professional field workers and community volunteers

4.10 Mitigating potential study threats

There are two main threats to the success of this study. First, if the intervention is unable to reach meaningful levels of participation in the community it will be unlikely that any differences between incidence of disease between intervention and non-intervention areas will be found. This threat is mitigated by using a case-control study design in order to maximize the number of pneumonia cases detected. The case-control study will be the most likely way in which to show a difference between those using improved cookstoves and those not in developing pneumonia, but the lower the participation rate, the more pneumonia cases must be enrolled to observe differences between the two groups.

The second potential threat is that households which use improved cookstoves are likely to be different than those who choose not to use the stoves. Based on past experience, only well-off households use these cookstoves. This makes a comparison between outcomes in the two groups more difficult because households from high socio-economic groups might also have very different risks for pneumonia. Household socio-economic status will be controlled for during data analysis; i.e. outcomes will be compared between households of similar status. This is a challenge because if only households from higher socio-economic status use the improved stoves, only comparisons to other households with similar characteristics will be valid which limits the study population and therefore power to detect differences. This threat is mitigated by enrolling all households in a non-intervention village so that even if only wealthier households use improved stoves in the intervention villages, wealthier households from a non-intervention village will be enrolled for comparison.

4.11 Testing the study methods and tools in the field

Prior to finalization of this protocol, the methods and data collection instruments will be tested in the field. This field test will be carried out in 2 locations, one rural and one peri-urban community where improved cookstove interventions are already ongoing.

Skilled and experienced data collectors will be used for the cohort study field test; these persons already work for other ICDDR,B field studies and have years of experience with similar data collection procedures and activities. They will be able to quickly learn to administer the cohort questionnaires and because of their considerable previous experience will be able to comment on the structure and flow of the questionnaire and the potential of study questions to illicit valid responses from participants. The baseline data collection forms will be used for this field test since they are the most extensive questionnaires proposed and include data on anthropometrics, which might be challenging to obtain.

The case-control study methods will be piloted by the physician currently working with the study team. A community clinic will be chosen and he will spend a day there screening children for pneumonia and completing the exams and questionnaires for at least three children with respiratory symptoms.

A fifth field worker will be trained on the community participation questionnaire. They will spend a one day orientation to the project in Dhaka and will then spend two days in each of the field test sites. On the first day in the site they will randomly select two households with children <5 and ask their mothers to participate in the field test of the tool. Mothers must be able to read and write Bangla in order to participate. The field worker will spend a few hours with the mother on the first day explaining the purpose of our study and training her on how to collect data on this form. Then, on the second day in each site, she will ask the mother to collect data from the 5 households nearest to her own with children <5 years of age. She will then discuss the process with the mother and document the mother's suggestion for improving the data collection process and her perceptions about willingness of other mothers in the area to participate in such volunteer work.

The total field test will take approximately 5 working days. The first 2 days will be spent with the two field teams (consisting of 2 field workers each) training them on obtaining consent

and administering the baseline questionnaires for the household, child, and cook. They will also be trained to count respiratory rate, identify chest indrawing, take blood pressure and anthropometric measurements (if not already trained to do so). Then each team will spend two days in the field collecting data; one team will test the methods in a rural area and another in a peri-urban area. They will administer the baseline questionnaires in at least 6 households each. They will be asked to make a note of each of the difficulties they face with each interview to share with the group. On the 5th day, the team will meet together as a group and all the study procedures and questionnaires will be reviewed in detail to obtain feedback and suggestions for improvement from the team.

Important outcomes from this field test will include: the time needed to complete the questionnaires; identification of questions which respondents find difficult to answer; identification of any measurements which are not feasible to take in the field; and suggestions from field team on how to make data collection methods or tools more efficient. The goal of the field test is to understand how our methods are going to perform during the study and to improve their performance. Therefore, the field test will be successful if we are able to test all of our questions and instruments and if the field team is able to suggest ways in which to improve our proposed study design.

4.12 Potential contributions of this pilot evaluation

The potential contributions of this pilot evaluation are substantial and will be useful and of interest not only for the local IAP and health community but also to global experts on IAP and health. Findings from this study will provide one of the most detailed accounts IAP intervention and health outcomes available. We envision publishing at least 4 manuscripts in international, peer-reviewed journals from findings from this study including, but not limited, to: 1) Association between use of improved cookstoves and developing pneumonia in children <5 years of age, 2) Association between use of improved cookstoves and health outcomes in cooks, 3) Seasonality of indoor air pollution in Bangladesh, and 4) Describing stove and fuel use for cooking and heating in Bangladeshi homes.

5. References

1. Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: a major environmental and public health challenge. *Bull World Health Organ* 2000;78(9):1078-1092.
2. Ezzati M, Kammen DM. Quantifying the effects of exposure to indoor air pollution from biomass combustion on acute respiratory infections in developing countries. *Environ Health Perspect* 2001;109(5):481-488.
3. Smith KR. Inaugural article: national burden of disease in India from indoor air pollution. *Proc Natl Acad Sci U S A* 2000;97(24):13286-13293.
4. Smith KR, Samet JM, Romieu I, Bruce N. Indoor air pollution in developing countries and acute lower respiratory infections in children. *Thorax* 2000;55(6):518-532.
5. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* 2006;367(9524):1747-1757.

6. Lin HH, Ezzati M, Murray M. Tobacco smoke, indoor air pollution and tuberculosis: a systematic review and meta-analysis. *PLoS Med* 2007;4(1):e20.
7. Baris E, Ezzati M. Should interventions to reduce respirable pollutants be linked to tuberculosis control programmes? *Bmj* 2004;329(7474):1090-1093.
8. Boy E, Bruce N, Delgado H. Birth weight and exposure to kitchen wood smoke during pregnancy in rural Guatemala. *Environ Health Perspect* 2002;110(1):109-114.
9. Siddiqui AR, Peerson J, Brown KH, Gold EB, lee K, Bhuta ZA. Indoor Air Pollution From Solid Fuel Use and Low Birth Weight (Lbw) in Pakistan. *Epidemiology* 2005;Volume 16(5)September 2005p S86(September, 2005).
10. Ritz B, Yu F, Chapa G, Fruin S. Effect of Air Pollution on Preterm Birth Among Children Born in Southern California Between 1989 and 1993. *Epidemiology* 2000;Vol. 11 No. 5.
11. Mohamed N, Ng'ang'a L, Odhiambo J, Nyamwaya J, Menzies R. Home environment and asthma in Kenyan schoolchildren: a case-control study. *Thorax* 1995;50(1):74-78.
12. Azizi BH, Zulkifli HI, Kasim S. Indoor air pollution and asthma in hospitalized children in a tropical environment. *J Asthma* 1995;32(6):413-418.
13. Mishra V, Retherford RD. Does biofuel smoke contribute to anaemia and stunting in early childhood? *Int J Epidemiol* 2007;36(1):117-129.
14. Rouse JR. Indoor Air Pollution: Issues for Bangladesh. International Symposium on Environmental Management, Bangladesh University of Engineering & Technology., 2004.
15. Khalequzzaman M, Kamijima M, Sakai K, Chowdhury NA, Hamajima N, Nakajima T. Indoor air pollution and its impact on children under five years old in Bangladesh. *Indoor Air* 2007;17(4):297-304.
16. Rehfuess E, Mehta S, Pruss-Ustun A. Assessing household solid fuel use: Multiple implications for the Millennium development goals. 2006.
17. Balakrishnan K, Sambandam S, Ramaswamy P, Mehta S, Smith KR. Exposure assessment for respirable particulates associated with household fuel use in rural districts of Andhra Pradesh, India. *J Expo Anal Environ Epidemiol* 2004;14 Suppl 1:S14-25.
18. Dasgupta S, Huq M, Khaliquzzaman M, Pandey K, Wheeler D. Who suffers from indoor air pollution? Evidence from Bangladesh. *Health Policy Plan* 2006;21(6):444-458.
19. Air Quality for Particulate Matter. Vol. 1, 1996.
20. Dasgupta S, Huq M, Khaliquzzaman M, Pandey K, Wheeler D. Indoor air quality for poor families: new evidence from Bangladesh. *Indoor Air* 2006;16(6):426-444.
21. World Health Organization. Indoor air pollution and health
Scope of the problem. WHO Fact sheet N°292, 2005.
22. Smith KR, Mehta S. The burden of disease from indoor air pollution in developing countries: comparison of estimates. *Int J Hyg Environ Health* 2003;206(4-5):279-289.
23. Rinne ST, Rodas EJ, Rinne ML, Simpson JM, Glickman LT. Use of biomass fuel is associated with infant mortality and child health in trend analysis. *Am J Trop Med Hyg* 2007;76(3):585-591.
24. Baqui AH, Sabir AA, Begum N, Arifeen SE, Mitra SN, Black RE. Causes of childhood deaths in Bangladesh: an update. *Acta Paediatr* 2001;90(6):682-690.

25. Bryce J, Victora CG. Child survival: countdown to 2015. *Lancet* 2005;365(9478):2153-2154.
26. Zaman K, Yunus M, Arifeen SE, Baqui AH, Sack DA, Hossain S, Rahim Z, Ali M, Banu S, Islam MA, Begum N, Begum V, Breiman RF, Black RE. Prevalence of sputum smear-positive tuberculosis in a rural area in Bangladesh. *Epidemiol Infect* 2006;134(5):1052-1059.
27. Begum V, van der Werf MJ, Becx-Bleumink M, Borgdorff MW. Viewpoint: do we have enough data to estimate the current burden of tuberculosis? The example of Bangladesh. *Trop Med Int Health* 2007;12(3):317-322.
28. Indoor Air Pollution: National Burden of Disease Estimates. World Health Organization, 2007.
29. Edwards RD, Liu Y, He G, Yin Z, Sinton J, Peabody J, Smith KR. Household CO and PM measured as part of a review of China's National Improved Stove Program. *Indoor Air* 2007;17(3):189-203.
30. Diaz E, Smith-Sivertsen T, Pope D, Lie RT, Diaz A, McCracken J, Arana B, Smith KR, Bruce N. Eye discomfort, headache and back pain among Mayan Guatemalan women taking part in a randomised stove intervention trial. *J Epidemiol Community Health* 2007;61(1):74-79.
31. McCracken JP, Smith KR, Diaz A, Mittleman MA, Schwartz J. Chimney stove intervention to reduce long-term wood smoke exposure lowers blood pressure among Guatemalan women. *Environ Health Perspect* 2007;115(7):996-1001.
32. Ezzati M, Kammen DM. The health impacts of exposure to indoor air pollution from solid fuels in developing countries: knowledge, gaps, and data needs. *Environ Health Perspect* 2002;110(11):1057-1068.
33. Smith KR, Dutta K, Chengappa C, Gusain P, Masera O, Berrueta V, Edwards RD, Bailis R, Shields KN. Monitoring and evaluation of improved biomass cookstove programs for indoor air quality and stove performance: conclusions from the Household Energy and Health Project. *Energy for Sustainable Development* 2007;XI(2):5-17.
34. Albalak R, Bruce N, McCracken JP, Smith KR, De Gallardo T. Indoor respirable particulate matter concentrations from an open fire, improved cookstove, and LPG/open fire combination in a rural Guatemalan community. *Environ Sci Technol* 2001;35(13):2650-2655.
35. Smith KR. Indoor air pollution in developing countries: recommendations for research. *Indoor Air* 2002;12(3):198-207.
36. Naehler LP, Leaderer BP, Smith KR. Particulate matter and carbon monoxide in highland Guatemala: indoor and outdoor levels from traditional and improved wood stoves and gas stoves. *Indoor Air* 2000;10(3):200-205.
37. Still D, MacCarty N. The effect of ventilation on carbon monoxide and particulate levels in a test kitchen. *Boiling Point*. Vol. 52, 2006;24-26.
38. Brooks WA, Breiman RF, Goswami D, Hossain A, Alam K, Saha SK, Nahar K, Nasrin D, Ahmed N, El Arifeen S, Naheed A, Sack DA, Luby S. Invasive pneumococcal disease burden and implications for vaccine policy in urban Bangladesh. *Am J Trop Med Hyg* 2007;77(5):795-801.

39. Zaman K, Baqui AH, Yunus M, Sack RB, Bateman OM, Chowdhury HR, Black RE. Acute respiratory infections in children: a community-based longitudinal study in rural Bangladesh. *J Trop Pediatr* 1997;43(3):133-137.
40. Gauderman WJ, McConnell R, Gilliland F, London S, Thomas D, Avol E, Vora H, Berhane K, Rappaport EB, Lurmann F, Margolis HG, Peters J. Association between Air Pollution and Lung Function Growth in Southern California Children. *Am J Respir Crit Care Med* 2000;Vol 162.
41. Zemp E, Elsasser S, Schindler C, Kunzli N, Perruchoud AP, Domenighetti G, Medici T, Ackermann-Lieblich U, Leuenberger P, Monn C, Bolognini G, Bongard JP, Brandli O, Karrer W, Keller R, Schoni MH, Tschopp JM, Villiger B, Zellweger JP. Long-term ambient air pollution and respiratory symptoms in adults (SAPALDIA study). The SAPALDIA Team. *Am J Respir Crit Care Med* 1999;159(4 Pt 1):1257-1266.

DRAFT

Timeline

	Year 1												Year 2												Year 3					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Study villages chosen	■																													
Baseline data collection	■	■																												
Health care utilization surveys	■	■																												
Medical officers placed at health facilities			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Routine data collection in cohort study		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Case-control study ongoing			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Data cleaning and analysis				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

DRAFT

Annex A
Summary of literature reviewed

SL No	Author	Yr	Journal	Title	Result
1	Bruce, N. Perez-Padilla, R. Albalak, R.	2000	Bulletin of the World Health Organization	Indoor air pollution in developing countries: a major environmental and public health challenge	<ul style="list-style-type: none"> • There is consistent evidence that indoor air pollution increases the risk of chronic obstructive pulmonary disease and of acute respiratory infections in childhood, the most important cause of death among children under 5 years of age in developing countries. • Evidence also exists of associations with low birth weight, increased infant and perinatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer, cataract, and, specifically in respect of the use of coal, with lung cancer. • Conflicting evidence exists with regard to asthma. • Indoor air pollution is a major global public health threat requiring greatly increased efforts in the areas of research and policy-making. Research on its health effects should be strengthened, particularly in relation to tuberculosis and acute lower respiratory infections.
2	Ezzati, M. Kammen, D. M.	2001	Environmental Health Perspectives	Quantifying the effects of exposure to indoor air pollution from biomass combustion on acute respiratory infections in developing countries	<ul style="list-style-type: none"> • Acute respiratory infections (ARI) are the leading cause of burden of disease worldwide and have been causally linked with exposure to pollutants from domestic biomass fuels in developing countries • Acute respiratory infections and acute lower respiratory infections are concave, increasing functions of average daily exposure to PM₁₀, with the rate of increase declining for exposures above approximately 1,000-2,000 microgm/m
3	Smith, K. R.	2000	Proceedings of the National Academy of Sciences (PNAS)	Inaugural article: National burden of disease in India from indoor air pollution	<ul style="list-style-type: none"> • Sufficient evidence is available to estimate risks most confidently for acute respiratory infections (ARI), chronic obstructive pulmonary disease (COPD), and lung cancer • Insufficient quantitative evidence is currently available to estimate the impact of adverse pregnancy outcomes (e.g., low birth weight and stillbirth)

					<ul style="list-style-type: none"> • Using a disability-adjusted lost life-year approach, the total is 4-6% of the Indian national burden of disease, placing indoor air pollution as a major risk factor in the country.
4	Smith, K. R. Samet, J. M Romieu, I. Bruce, N.	2000	Thorax	Indoor air pollution in developing countries and acute lower respiratory infections in children	<ul style="list-style-type: none"> • The studies of indoor air pollution from household biomass fuels are reasonably consistent and, as a group, show a strong significant increase in risk for exposed young children compared with those living in households using cleaner fuels or being otherwise less exposed • ARI is the chief cause of death in children in less developed countries, and exacts a larger burden of disease than any other disease category for the world population, even small additional risks due to such a ubiquitous exposure as air pollution have important public health implications
5	Lopez, A. D. Mathers, C. D. Ezzati, M. Jamison, D. T. Murray, C. J.	2006	Lancet	Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data	<ul style="list-style-type: none"> • About 56 million people died in 2001. Of these, 10.6 million were children, 99% of whom lived in low-and-middle-income countries. More than half of child deaths in 2001 were attributable to acute respiratory infections, measles, diarrhea, malaria, and HIV/AIDS. The ten leading diseases for global disease burden were perinatal conditions, lower respiratory infections, ischemic heart disease, cerebrovascular disease, HIV/AIDS, diarrheal diseases, unipolar major depression, malaria, chronic obstructive pulmonary disease, and tuberculosis. There was a 20% reduction in global disease burden per head due to communicable, maternal, perinatal, and nutritional conditions between 1990 and 2001. • Almost half the disease burden in low-and-middle-income countries is now from non-communicable diseases. • Under nutrition remains the leading risk factor for health loss. An estimated 45% of global mortality and 36% of global disease burden are attributable to the joint hazardous effects of the 19 risk factors studied. Uncertainty in all-cause mortality estimates ranged from around 1% in high-income countries to 15-20% in Sub-Saharan Africa. Uncertainty was larger for mortality from specific diseases, and for incidence and prevalence of non-fatal

					<p>outcomes.</p> <ul style="list-style-type: none"> • The findings suggested that substantial gains in health have been achieved in most populations, countered by the HIV/AIDS epidemic in Sub-Saharan Africa and setbacks in adult mortality in countries of the former Soviet Union. Our results on major disease, injury, and risk factor causes of loss of health, together with information on the cost-effectiveness of interventions, can assist in accelerating progress towards better health and reducing the persistent differentials in health between poor and rich countries.
6	Lin, H. H. Ezzati, M. Murray, M.	2007	Public Library of Science (PLoS) Medicine	Tobacco smoke, indoor air pollution and tuberculosis: a systematic review and meta-analysis	<ul style="list-style-type: none"> • Evidence showed that tobacco smoking is positively associated with TB, regardless of the specific TB outcomes • It is also evidenced that passive smoking and indoor air pollution increased the risk of TB disease, these associations are less strongly supported by the available evidence
7	Baris, E. Ezzati, M.	2004	British Medical Journal	Should interventions to reduce respirable pollutants be linked to tuberculosis control programmes?	<ul style="list-style-type: none"> • Risk of tuberculosis disease or mortality is increased among smokers and those exposed to indoor air pollution from solid fuels • The social and potential etiological links between respirable pollutants and tuberculosis could provide an opportunity for integrated intervention • Before attempting integrated programs three important research and surveillance issues must be tackled • Scientific research must establish whether respirable pollutants increase susceptibility to new infections, facilitate progress to active tuberculosis, or increase tuberculosis mortality risk • Tuberculosis surveillance should incorporate data on smoking and fuel use to quantify the correlation between tuberculosis and these risk factors • Effectiveness of joint interventions needs to be assessed to avoid compromising existing tuberculosis programs and to select the most effective combination of interventions
8	Boy, H Bruce, N.	2002	Environmental Health	Birth weight and exposure to kitchen wood smoke during	<ul style="list-style-type: none"> • Study on association with reduced birth weight, independent of key maternal, social, and economic confounding factors

	Delgado, H		Perspectives	pregnancy in rural Guatemala	<ul style="list-style-type: none"> • Children born to mothers habitually cooking on open fires had the lowest mean birth weight of 2,819 gm; those using a chimney stove had an intermediate mean of 2,863 gm; and those using the cleanest fuels (electricity or gas) had the highest mean of 2,948 gm. • The percentage of low birth weights (< 500 g) in these three groups was 19.9% (open fire), 16.8% (chimney stove), and 16% (electricity/gas) • Confounding factors were strongly associated with fuel type, but after adjustment wood users still had a birth weight 63 gm lower.
9	Siddiqui, A R Peerson, J Brown, K H Gold, E B Lee, K Bhuta, Z A	2005	Epidemiology	Indoor air pollution from solid fuel use and low birth weight (LBW) in Pakistan	<ul style="list-style-type: none"> • To identify the contribution of indoor air pollution from biomass fuel use to LBW in a population in Pakistan. • Data were available for 941 pregnant women interviewed for a maternal health program in Pakistan. LBW defined as a birth weight (measured within 48 hours of birth) of < 2500 g, was 31%. To adjust for socio-economic confounding factors, a composite socio-economic status (SES) variable was created using, water supply, lighting source, toilet facilities, house ownership, construction, and density (occupants/room). • Multiple logistic regression model showed that use of wood fuel, adjusted for SES, body mass index, serum Vitamin A levels, age, gravid status, and not receiving a tetanus toxoid injection in pregnancy, was independently associated with LBW. • Mean levels for 24 hours for CO were 24 ppm for wood use compared to 5 ppm in natural gas using kitchens with cooking time levels reaching above 150 ppm in wood-burning houses. Mean levels for PM 2.5 were 12 mg/ m³ in wood and 0.25 mg/m³ in houses using natural gas. In wood using houses daytime average levels for PM 2.5 were from 2.2 to 30 mg/m³, and during cooking, they were as high as 300 mg/m³. • The increased air concentrations of CO and PM 2.5 correlated well with each other and varied by an order of magnitude by the type of fuel used.

					<ul style="list-style-type: none"> • The findings of this study suggested an independent effect of indoor air pollution on birth weight, in line with findings from the few other studies available to date. This analysis also suggested the importance of assessing LBW in populations where pregnant women are exposed to high levels of indoor air pollution from solid fuels.
10	Ritz, B Yu, F Chapa, G Fruin, S	2000	Epidemiology	Effect of air pollution on preterm birth among children born in southern California between 1989 and 1993	<ul style="list-style-type: none"> • Evaluation of the effect of air pollution exposure during pregnancy on the occurrence of preterm birth in a cohort of 97,518 neonates born in Southern California. • measurements of carbon monoxide (CO), nitrogen dioxide, ozone, and particulate matter less than 10 [μ]m (PM₁₀) collected at 17 air-quality-monitoring stations to create average exposure estimates for periods of pregnancy. • It was observed a 20% increase in preterm birth per 50-μg increase in ambient PM₁₀ levels averaged over 6 weeks before birth and a 16% increase when averaging over the first month of pregnancy. • PM₁₀ effects showed no regional pattern. • CO exposure 6 weeks before birth consistently exhibited an effect only for the inland regions and during the first month of pregnancy, the effect was weak for all stations. • Exposure to increased levels of ambient PM₁₀ and possibly CO during pregnancy may contribute to the occurrence of preterm births in Southern California.
11	Mohamed, N. Ng'ang'a, L. Odhiambo, J. Nyamwaya, J. Menzies, R.	1995	Thorax	Home environment and asthma in Kenyan schoolchildren: a case-control study	<ul style="list-style-type: none"> • Study on the relationship between home environmental factors and asthma in school children • In multivariate analysis the following factors were associated with asthma, damage caused by dampness in the child's sleeping area (adjusted odds ratio (OR) 4.9; 95% confidence interval (CI) 2.0 to 11.7), air pollution in the home (OR 2.5; 95% CI 2.0 to 6.4), presence of rugs or carpets in child's bedroom (OR 3.6; 95% CI 1.5 to 8.5) • Home environmental factors appear to be strongly associated with

					asthma in schoolchildren in a developing nation
12	Azizi, B. H. Zulkifli, H. I. Kasim, S.	1995	Journal of Asthma	Indoor air pollution and asthma in hospitalized children in a tropical environment	<ul style="list-style-type: none"> • Univariate analysis identified two indoor pollution variables as significant factors, sharing a bedroom with a adult smoker and exposure to mosquito coil smoke at least three nights in a week were both associated with increased risk for asthma. • No association between asthma and exposure to kerosene stove, wood stove, aerosol mosquito repellent, type of housing, of crowding.
13	Mishra, V. Retherford, R. D.	2007	International Journal of Epidemiology	Does biofuel smoke contribute to anaemia and stunting in early childhood?	<ul style="list-style-type: none"> • The study examined the association between household use of bio fuels (wood, dung, and crop residues) for cooking and heating and prevalence of anemia and stunting in children. • Multinomial logistic regression is used to estimate the effects of bio fuel use on prevalence of anemia and stunting, controlling for exposure to tobacco smoke, recent episodes of illness, maternal education and nutrition, and other potentially confounding factors. • Analysis showed that prevalence of moderate-to-severe anemia was significantly higher among children in households using bio fuels than among children in households using cleaner fuels. • Prevalence of severe stunting was also significantly higher among children in bio fuel using households. • Thirty-one per cent of moderate-to-severe anemia and 37% of severe stunting among children aged 6-35 months in India may be attributable to exposure to bio fuel smoke. • Effects on mild anemia and moderate stunting were smaller, but positive and statistically significant. • The study provided an evidence of the strong association between bio fuel use and risks of anemia and stunting in children, suggesting that exposure to bio fuel smoke may contribute to chronic nutritional deficiencies in young children.
14	Rouse, J R		Boiling Point	Indoor air pollution: Issues for Bangladesh	<ul style="list-style-type: none"> • The most important driving force behind IAP reduction interventions is health improvement as the evidence-base grows.

					<ul style="list-style-type: none"> • Other reason for using clean household energy as deforestation, air pollution, saving people money, labor and time saving, making people's use of energy safer and more convenient. • Many interventions failed due 'top-down' nature of their implementation. • Certain major gaps persist, such as the exact relationship between exposure to IAP and ARI, and the extent by which different interventions reduce exposure to IAP
15	Khalequzzaman, M. Kamijima, M. Sakai, K. Chowdhury, N. A. Hamajima, N. Nakajima, T.	2007	Indoor Air	Indoor air pollution and its impact on children under five years old in Bangladesh	<ul style="list-style-type: none"> • Indoor air concentrations of volatile organic compounds (VOCs), carbon monoxide (CO), carbon dioxide (CO₂), nitrogen dioxide (NO₂), and dust particles were measured for 49 biomass and 46 fossil fuel users in urban slums of Dhaka, Bangladesh • Mean concentrations of CO were found to be significantly higher in biomass fuel users, while geometric mean concentrations of benzene, xylene, toluene, hexane, total VOCs, and NO₂ were significantly higher in the fossil fuel users. • Symptoms such as redness of eyes, itching of skin, nasal discharge, cough, shortness of breath, chest tightness, wheezing, or whistling chest were found to be associated with the choice of biomass fuel, with the odds ratio ranging from 4.0 to 6.3 • No significant association of use of biomass fuel with respiratory diseases, eczema, diarrhea, or viral fever was observed after adjustment for potential confounders • Study suggested suggest a significant association between the biomass fuel-using population and respiratory symptoms
16	Rehfuess, E Mehta, S. Pruss-Ustun, A	2006	Environmental Health Perspectives	Assessing household solid fuel use: Multiple implications for the Millennium development goals	<ul style="list-style-type: none"> • The article discussed the results of a comprehensive assessment of solid fuel use, conducted in 2005, and discussed the implications of our findings in the context of achieving the MDGs. • According to the assessment, 52% of the world's population uses solid fuels. This percentage varies widely between countries and regions, ranging from 77%, 74%, and 74% in Sub-Saharan Africa, Southeast Asia, and the Western Pacific Region, respectively, to 36% in the Eastern Mediterranean Region, 16% in Latin America

					and the Caribbean and in Central and Eastern Europe. In most industrialized countries, solid fuel use falls to the < 5% mark. <ul style="list-style-type: none"> • Although the “percentage of population using solid fuels” is classified as an indicator to measure progress towards MDG 7, reliance on traditional household energy practices has distinct implications for most of the MDGs, notably MDGs 4 and 5.
17	Balakrishnan, K Sambandam, S RamaSwamy, P Mehta, S. Smith, K. R.	2004	Journal of Exposure Analysis and Environmental Epidemiology	Exposure assessment for respirable particulates associated with household fuel use in rural districts of Andhra Pradesh, India	<ul style="list-style-type: none"> • The mean 24 hours average concentration ranged from 73 to 732 microgram/m³. Concentrations were significantly correlated with fuel type, kitchen type, and fuel quantity. • Among women exposures were highest in the age group of 15-40 years, while in men age group 65-80 years.
18	Dasgupta, S. Huq, M. Khaliquzzaman, M. Pandey, K. Wheeler, D.	2006	Health Policy and Planning	Who suffers from indoor air pollution? Evidence from Bangladesh	<ul style="list-style-type: none"> • Investigated individuals’ exposure to indoor air pollution • High level of exposure for children and adolescents of both sexes, both particularly serious exposure for children under 5 years. • Among prime-age adults men have half the exposure of women • Elderly men had significant lower exposure than women
19	Anon.	1996	Environmental Protection Agency	Air quality for particulate matter	<ul style="list-style-type: none"> • Particulate matter is composed of small solid and liquid particles suspended in the ambient air, and research studies have associated exposure to elevated levels of these particles in the air with damaging health effects.
20	Dasgupta, S. Huq, M. Khaliquzzaman, M. Pandey, K. Wheeler, D.	2006	Indoor Air	Indoor air quality for poor families: new evidence from Bangladesh	<ul style="list-style-type: none"> • A stratified sample in Dhaka and Narayanganj showed that 24 hours PM₁₀ concentrations were 300 microgm/m³ or greater common, implying widespread health hazard. • There are relationship between PM₁₀ concentration and fuel choices, household cooking, ventilation practices, structure characteristic were present • Exposure to dangerous pollution level was not confined to cooking areas.
21	World Health Organization	2005	Fact sheet N°292	Indoor air pollution and health: Scope of the problem	<ul style="list-style-type: none"> • Tackling indoor air pollution in the context of household energy is linked to achieving the Millennium Development Goals, in

					particular to reducing child mortality (Goal 4), to promoting gender equality and empowering women (Goal 3), to opening up opportunities for income generation and eradicating extreme poverty (Goal 1), and to ensuring environmental sustainability (Goal 7)
22	Smith, K. R. Mehta, S.	2003	International Journal of Hygiene and Environmental Health	The burden of disease from indoor air pollution in developing countries: comparison of estimates	<ul style="list-style-type: none"> • 4-5 percent of the global LDC totals for both deaths and DALYs from acute respiratory infections, chronic obstructive pulmonary disease, tuberculosis, asthma, lung cancer, ischemic heart disease, and blindness can be attributed to solid fuel use in developing countries • Acute respiratory infections in children under five years of age are the largest single category of deaths (64%) and DALYs (81%) from indoor air pollution, apparently being responsible globally for about 1.2 million premature deaths annually in the early 1990s
23	Rinne, S T Rodas, E J Rinne, M L Simpson, J M Glickman, L T	2007	American Journal of Tropical Medicine and Hygiene	Use of biomass fuel is associated with infant mortality and child health in trend analysis	<ul style="list-style-type: none"> • The aim of the study was to explore the relationship between biomass fuel, infant mortality, and children's respiratory symptoms. • Eighty households in a rural community in Ecuador were selected based on their use of biomass fuel and questioned regarding a history of infant mortality and children's respiratory symptoms. • Carbon monoxide (CO) and particulate matter (PM) were measured in a subset of these homes to confirm the relationship between biomass fuel use and IAP. • Results showed a significant trend for higher infant mortality among households that cooked with a greater proportion of biomass fuel. Similar trends were noted for history of cough and earache among children living in these households.
24	Baqui, A. H. Sabir, A. A. Begum, N. Arifeen, S. E. Mitra, S. N. Black, R. E.	2001	Acta Paediatrica	Causes of childhood deaths in Bangladesh: an update	<ul style="list-style-type: none"> • To determine cause structure death verbal autopsy interviews were conducted in BDHS • Cause specific mortality revealed that deaths due to almost all causes declined although significantly only for ARI, Diarrhea and drowning. • Despite impressive decline in deaths due to ARI, this condition

					remains the most important known cause of death in Bangladeshi children
25	Bryce, J. Victora, C. G.	2005	Lancet	Child survival: countdown to 2015	<ul style="list-style-type: none"> • Recent trends in mortality and nutrition and in coverage levels for child survival interventions. • Evaluation of innovative delivery channels for scaling-up population coverage with child survival interventions. • Assessment of impact of child survival interventions on equity. • Health policy and systems issues relevant to child survival. • Community participation and ownership of child survival projects. • Resource flows in child survival programs and research. • Financial protection mechanisms and their impact on access and coverage of child survival. Interventions.
26	Zaman, K. Yunus, M. Arifeen, S. E. Baqui, A. H. Sack, D. A. Hossain, S. Rahim, Z. Ali, M. Banu, S. Islam, M. A. Begum, N. Begum, V. Breiman, R. F. Black, R. E.	2006	Epidemiology and Infection	Prevalence of sputum smear-positive tuberculosis in a rural area in Bangladesh	<ul style="list-style-type: none"> • objective of the study was to determine the prevalence of smear-positive tuberculosis (TB) in a rural area in Bangladesh • The prevalence of chronic cough and sputum positive were significantly higher among males compared to females • The population-based prevalence rate of smear-positive TB cases was 95/100,000 among persons aged > or = 15 years. Cases of TB clustered geographically.
27	Begum, V. van der Werf, M. J. Becx-Bleumink, M. Borgdorff, M. W.	2007	Tropical Medicine and International Health	Viewpoint: do we have enough data to estimate the current burden of tuberculosis? The example of Bangladesh	<ul style="list-style-type: none"> • Interpretation and extrapolation of existing epidemiological data of Bangladesh to estimate the current burden of TB is difficult • To enable the evaluation of progress towards the MDGs and to be able to assess the global burden of TB, epidemiological surveys are needed

28	Anon.	2007	World Health Organization	Indoor air pollution: National burden of disease estimates	<ul style="list-style-type: none"> • Summary of burden of disease attributable to breathing polluted indoor air
29	Edwards, R D Y, Liu	2007	Indoor Air	Household CO and PM measured as part of a review of China's National Improved Stove Program	<ul style="list-style-type: none"> • The results of the indoor air quality component indicate that for nearly all household stove or fuel groupings, PM₄ levels were higher than - and sometimes more than twice as high as - the national PM₁₀ standard for indoor air (150 microg PM₁₀/m³) • Improved stoves resulted in reduced PM₄ from biomass fuel combinations, but still not at levels that meet standards, and little improvement was observed in indoor pollution levels when other unimproved stoves were present in the same kitchen • Many households change fuels according to daily and seasonal factors, resulting in different seasonal concentrations in living rooms and kitchens, assessing health implications from fuel use requires longitudinal evaluation of fuel use and IAQ levels, combined with accurate time-activity information
30	Diaz, E Sivertsen, T S Pope, D Lie, R T Diaz, A McCracken, J Byron, A Smith, K. R. Bruce, N.	2007	Journal of Epidemiology and Community Health	Eye discomfort, headache and back pain among Mayan Guatemalan women taking part in a randomized stove intervention trial	<ul style="list-style-type: none"> • In Guatemala, the first randomized controlled trial ever performed on health effects from solid fuel use had the goal to assess the effect of improved stoves (planchas) on exposure and health outcomes in a rural population reliant on wood fuel • A high prevalence of eye discomfort, headache and backache was found. The odds of having sore eyes and headache were substantially reduced in the plancha group relative to the group using open fires for the follow-up period (odds ratio (OR) 0.18, 95% confidence interval (CI) 0.11 to 0.29 and (OR) 0.63, 95% CI 0.42 to 0.94, respectively). Median CO in breath among women in the intervention trial was significantly lower than controls • Continuous improvements in symptoms experienced by a substantial proportion of women may help to gain acceptance and wider use of planchas.
31	McCracken, J. P. Smith, K. R. Diaz, A.	2007	Environmental Health Perspectives	Chimney stove intervention to reduce long-term wood smoke exposure lowers blood	<ul style="list-style-type: none"> • The two group comparisons study showed, particularly for Diastolic Blood pressure, that the chimney stove reduces blood pressure. The before-and-after comparisons were consistent with

	Mittleman, M. A. Schwartz, J.			pressure among Guatemalan women	this evidence.
32	Ezzati, M. Kammen, D. M.	2002	Environmental Health Perspectives	The health impacts of exposure to indoor air pollution from solid fuels in developing countries: knowledge, gaps, and data needs	<ul style="list-style-type: none"> • The current knowledge on the relationship between IAP exposure and disease and on interventions for reducing exposure and disease • Knowledge gaps and detailed research questions that are essential in successful design and dissemination of preventive measures and policies
33	Smith, K. R. Dutta, K Chengappa, C Gusain, P Masera, O Berrueta, V Edwards, R Bailis, R Sheilds, K	2007	Energy for Sustainable Development	Monitoring and evaluation of improved biomass cook stove programs for indoor air quality and stove performance: conclusions from the Household Energy and Health Project	<ul style="list-style-type: none"> • Monitoring and evaluation of changes in indoor air quality and stove fuel performance were developed and deployed in programs to disseminate improve cook stoves in India and Mexico • The result showed major and mostly statistically significant improvements in 48 hours indoor air pollution concentrations in those households using the stoves one year after introduction. Kitchen levels of carbon monoxide reduced 30-70% and concentrations small particles reduced 25-65%.
34	Albalak, R. Bruce, N. McCracken, J P Smith, K. R. De Gallardo, T.	2001	Environmental Science Technology	Indoor respirable particulate matter concentrations from an open fire improved cook stove, and LPG/open fire combination in a rural Guatemalan community	<ul style="list-style-type: none"> • Improved biomass cook stove potentially reduce pollution and reduce pollution exposure who cook daily with biomass fuel • A generalized estimation equation showed that 45% in PM_{3,5} concentrations for the LPG/open fire combination as compared to open fire alone • Season did not effect pollutant concentrations • Plancha appears to offer best prospects among the interventions
35	Smith, K. R.	2002	Indoor Air	Indoor air pollution in developing countries: recommendations for research	<ul style="list-style-type: none"> • Research suggested: <ol style="list-style-type: none"> 1. epidemiology: case-control studies for tuberculosis (TB) and cardiovascular disease in women and randomized intervention trials for childhood acute respiratory diseases and adverse pregnancy outcomes 2. exposure assessment: techniques and equipment for inexpensive exposure assessment at large scale, including national level surveys

					3. interventions: engineering and dissemination approaches for improved stoves, fuels, ventilation, and behavior that reliably and economically reduce exposure
36	Naeher, L. P. Leaderer, B. P. Smith, K. R.	2000	Indoor Air	Particulate matter and carbon monoxide in highland Guatemala: indoor and outdoor levels from traditional and improved wood stoves and gas stoves	<ul style="list-style-type: none"> • Comparisons with other studies in the area indicate that the reductions in indoor concentrations achieved by improved wood-burning stoves deteriorate with stove age • Mother and child personal CO and PM_{2.5} measurements for each stove condition demonstrate the same trend as area measurements, but with less differentiation
37	Still, D. MacCarty, N.	2006	Boiling Point	The effect of ventilation on carbon monoxide and particulate levels in a test kitchen	<ul style="list-style-type: none"> • Concentrations of carbon monoxide (CO) and particulate matter were monitored in a test kitchen when differing levels of ventilation were introduced to the building. These included: all windows and doors closed; door open; a small hole cut in the roof; cross-ventilation to the hole in the roof provided by a small window. Each configuration was tested three times with a constant pollution source. Increasing amounts of ventilation significantly reduced the levels of carbon monoxide and particulate matter.
38	Brooks, W. A. Breiman, R. F. Goswami, D. Hossain, A. Alam, K. Saha, S. K. Nahar, K. Nasrin, D. Ahmed, N. El Arifeen, S. Naheed, A. Sack, D. A. Luby, S.	2007	American Journal of Tropical Medicine and Hygiene	Invasive pneumococcal disease burden and implications for vaccine policy in urban Bangladesh	<ul style="list-style-type: none"> • Streptococcus pneumoniae was isolated from 34 pneumococcal patients; invasive pneumococcal disease was clinically associated with pneumonia (24%), upper respiratory infection (62%), and febrile syndromes (14%). Overall, IPD and 13-valent serotype-related invasive pneumococcal disease incidences were 447 and 276 episodes/100,000 child-years, respectively. Peak invasive pneumococcal disease incidence occurred during the cool dry seasons. Penicillin, cotrimoxazole, chloramphenicol, and ciprofloxacin resistances were 2.9%, 82.4%, 14.7%, and 24.1%, respectively. Current conjugate vaccines should substantially reduce invasive pneumococcal disease, childhood pneumonia, and antimicrobial resistance in Bangladesh.

39	Zaman, K. Baqui, A. H. Yunus, M. Sack, R. B. Bateman, O. M. Chowdhury, H. R. Black, R. E.	1997	Journal of Tropical Pediatrics	Acute respiratory infections in children: a community-based longitudinal study in rural Bangladesh	<ul style="list-style-type: none"> • A community-based longitudinal study conducted in Matlab, a rural area in Bangladesh, investigated acute respiratory infections (ARI) among children. • A cohort of 696 children under 5 years of age was followed for 1 year yielding 183,865 child-days of observation. Trained field workers visited the study children every fourth day. Data on symptoms suggesting ARI, such as fever, cough, and nasal discharge, were collected for the preceding 3 days by recall. • To determine the type and severity of ARI, the field workers conducted physical examinations of children reporting cough and fever. The overall incidence of ARI was 5.5 episodes per child-year observed; the prevalence was 35.4 per hundred days observed. Most of the episodes (96 per cent) were upper respiratory infections. The incidence of acute lower respiratory infections was 0.23 per child per year. The incidence of URI was highest in 18-23-month-old children, followed by infants 6-11 months old. The highest incidence of ALRI was observed in 0-5-month-old infants followed by 12-17-month-old children. Among 559 children who were followed for 6 months or longer, about 9 per cent did not suffer any URI episode and about 16 per cent suffered one or more ALRI episodes. About 46 per cent of URI and 65 per cent of ALRI episodes lasted 15 days or more. • The incidence rates of URI were higher during the monsoon and pre-winter periods, and that of ALRI at the end of the monsoon and during the pre-winter periods. Socio demographic variables were not associated with the incidence of URI or ALRI. The study documents ARI to be a major cause of morbidity among rural Bangladeshi children.
40	Gauderman, W J McConnell, R Gilliland, F London, S	2000	American Journal of Respiratory Critical Care	Association between air pollution and lung function growth in southern California children	<ul style="list-style-type: none"> • Significant deficiencies in growth of lung function were found in association with exposure to PM₁₀, PM_{2.5}, NO₂ and inorganic acid vapor

	Thomas, D Avol, E Vora, H Berhane, K Rapport, E B Lurmann, F margolis, H G Peters, J		and Medicine		
41	Zemp, E. Elsasser, S. Schindler, C. Kunzli, N. Perruchoud, A. P. Domenighetti, G. Medici, T. Ackermann- Liebrich, U. Leuenberger, P. Monn, C. Bolognini, G. Bongard, J. P. Brandli, O. Karrer, W. Keller, R. Schoni, M. H. Tschopp, J. M. Villiger, B. Zellweger, J. P.	1999	American Journal of Respiratory Critical Care and Medicine	Long-term ambient air pollution and respiratory symptoms in adults (SAPALDIA study). The SAPALDIA Team	<ul style="list-style-type: none"> • The association between long-term exposure to ambient air pollution and respiratory symptoms was investigated in a cross-sectional study in random population samples of adults • The impact of annual mean concentrations of air pollutants was analyzed separately for never-, former, and current smokers • positive associations between annual mean concentrations of NO₂, total suspended particulates, and PM₁₀ and reported prevalence of chronic phlegm production, chronic cough or phlegm production, breathlessness at rest during the day, breathlessness during the day or at night, and dyspnea on exertion • no associations with wheezing without cold, current asthma, chest tightness, or chronic cough • The observed associations remained stable when further control was applied for environmental tobacco smoke exposure, past and current occupational exposures, atopy, and early childhood respiratory infections when restricting the analysis to long-term residents and to non- alpine areas, and when excluding subjects with physician-diagnosed asthma • This study provided further evidence that long-term exposure to air pollution of rather low levels is associated with higher prevalence of respiratory symptoms in adults

**Annex B
CASE CONTROL QUESTIONNAIRE**

Patient ID

Name of the child:

Age: (In months)

Birthday:
m m d d y y

Address:

Para: Village:

Union: Thana:

Name of household head: _____

Name of father (if different from household head):

Name of mother: _____

Date of interview:

Name of clinic/provider where child seen: _____

Respondent name: _____

Relationship to child:

Mother=1, Father=2, Grandparent=3, Aunt=4, Other primary care giver=5

Is the child currently enrolled in the cohort study? (check list of enrolled children)

Yes=1, No=2, DK=9

If yes, please provide household and child ID numbers from list:

Household ID:

ID:

CLINICAL PRESENTATION

1. Does child meet case definition for pneumonia?

Yes=1, No=2

WHO case definition:

Pneumonia:

Symptoms: Cough or difficult breathing AND

Signs: breathing >50/minute for infants aged 2 months to <1 year
Breathing >40/minute for child aged 1 to 5 years WITH or

WITHOUT

chest indrawing, stridor or danger signs

2. Temperature (°F):

<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
----------------------	----------------------	----------------------	----------------------

3. Pulse: Rate/min.

<input type="text"/>	<input type="text"/>	<input type="text"/>
----------------------	----------------------	----------------------

4. Respiration: Rate/min

<input type="text"/>	<input type="text"/>	<input type="text"/>
----------------------	----------------------	----------------------

5. Blood pressure: Systolic (put 000 if non recordable)

<input type="text"/>	<input type="text"/>	<input type="text"/>
----------------------	----------------------	----------------------

Diastolic (Put 000 if non recordable)

<input type="text"/>	<input type="text"/>	<input type="text"/>
----------------------	----------------------	----------------------

6. Findings from chest auscultation:

7. Was chest x-ray performed?

Yes=1, No=2

8. Was chest x-ray ordered?

Yes=1, No=2

9. Chest x-ray findings, if any:

10. Is child being referred to another facility?

Yes=1, No=2

If yes, give name of facility:

HISTORY OF PRESENT ILLNESS :	How many days ago did it start? (if started today. code = 00, NA = 88, unsure = 99)
Fever:	
Nausea:	
Vomiting:	
Diarrhea:	
Cough/cold:	
Difficult breathing:	
Chest indrawing:	
Vomits everything:	
Unable to drink or breastfeed:	
Severe weakness/lethargy:	
Convulsions:	
Altered consciousness:	
Loss of consciousness:	
Central cyanosis	

If child not enrolled in cohort study, continue with the following questions:

CHILD HEALTH HISTORY

1. If child is >2 years old, was the child vaccinated according to EPI schedule?
(Check the schedule card, if available)

Yes=1, 2=No, 3=DK, 4=Child <2 years old

3. Height of the child (in cm)

4. Weight of the child (in kg)

5. Upper arm circumference (in cm)

6. Is your child breast-fed?

Yes=1, No=2, DK=9

If answer to 6 is No, skip to section on household socio-economic status.

7. If 6 is yes, was the child breast fed last week?

Yes=1, No=2, DK=9

If answer of 7 is No, skip to section on household socio-economic status.

8. If 7 is Yes, was the child exclusively breast fed last week?
Yes=1, No=2, DK=9

HOUSEHOLD SOCIO-ECONOMIC STATUS

1. Number of rooms in the HH (including kitchen):

2. Monthly Expenditure (by all the HH members)

1. <2,000 Tk
2. 2,000-5000
3. 5000-10000
4. >10000
5. Don't know

3. Which of the following does your family own [*make sure whether its working or not, if anything non-working do not record*]

1. Mobile phone
2. Television (B/W)
3. Television (Color)
4. Electric fan
5. Refrigerator
6. Sewing machine
7. Bicycle
8. Motor cycle

4. Number of years of education completed by the mother of the child:

5. Number of years of education completed by the father of the child:

6. What is the main drinking source of water of the house hold?

1. Pond/river/lake
2. Well
3. Tube well
4. Deep tube well
5. Tap/pipe supply water
6. Other (specify) _____

7. What is the ownership type of the drinking water source?

1. Public

- 2. Someone else
- 3. Shared with others
- 4. Only for the house hold

8. What type of latrine do household members primarily use?

[Improved sanitation facilities]

- 1. Piped sewer system
- 2. Septic tank
- 3. Flush to pit latrine
- 4. Pit latrine with slab and water seal
- 5. Pit latrine with slab and no water seal but with a lid
- 6. Composting toilet (this toilet ensures separation of urine, water and excreta)

[Unimproved sanitation facilities]

- 7. Flush of pour flush toilet connected to somewhere else (Canal, ditch, river etc.)
- 8. Pit latrine without slab/open pit
- 9. Pit latrine with slab and no water seal/broken water seal and no lid.
- 10. Hanging toilet/latrine

[Open defecation]

- 11. No toilet facility/bush/field
- 12. Others (specify) _____

HOUSEHOLD CONSTRUCTION

1. What is the main material of the roof of the principal dwelling?

- 1. bamboo/thatch/straw
- 2. Tin
- 3. Tiled
- 4. Pacca/concrete
- 5. Others (specify) _____

2. What is the main material of the wall of the principal dwelling?

- 1. Bamboo/ straw
- 2. Mud
- 3. Wood
- 4. Tin
- 5. Semi pacca (pacca + tin)
- 6. Pacca/concrete
- 7. Other (specify) _____

3. What is the main material of the floor of the principal dwelling?

- 1. Mud

- 2. Bamboo/ wood
- 3. Pacca/concrete
- 4. Others (specify) _____

4. Type of the kitchen:

- 1. Placed in an open space
- 2. No wall, only roof top
- 3. Roof with partial wall
- 4. Roof with full wall
- 5. Others (specify): _____

5. What is the main material of the roof of the kitchen?

- 1. bamboo/thatch/straw
- 2. Tin
- 3. Tiled
- 4. Pacca/concrete
- 5. Others (specify) _____

6. What is the main material of the wall of the kitchen?

- 1. Bamboo/ straw
- 2. Mud
- 3. Wood
- 4. Tin
- 5. Semi pacca (pacca + tin)
- 6. Pacca/concrete
- 7. Other (specify) _____

7. What is the main material of the floor of the kitchen?

- 1. Mud
- 2. Bamboo/ wood
- 3. Pacca/concrete
- 4. Others (specify) _____

8. How many windows are there in the house?

Crowding

1. How many people <5 years of age share the same sleeping room with the child?
(Including the child)

2. How many people share the same bed/mat/area at night?
(Including the child)

3. How many windows and doors are there in the room has where the child sleeps at night?

Smoking

1. Does the mother of the child (or primary care giver) smoke?

Yes=1 No=2

(If Yes) Specify the types of smoke used

- 1. Cigarettes
- 2. Biri
- 3. Hookkah
- 4. Others (Specify) _____

2. Does anybody else living in the household with the child smoke?

Yes=1 No=2

(If yes then write the name of the person and relation with the child. Also write type of smoke he/she uses)

1. Name: Relation:Type

2. Name: Relation:Type

Types:

- 1. Cigarettes
- 2. Biri
- 3. Hookkah
- 4. Others (Specify) _____

STOVES AND FUEL USE

1. Where is the child usually when cooking occurs?

- 1. with the cook, in the kitchen
- 2. within the eye site of the cook
- 3. out of the eye site of the cook
- 4. Other _____

2. What type of stove did your household use for cooking in the past month? [include all kinds of stoves used, in order of frequency of usage]

Stove Type Stove type2 Stove type3

- 1. Ancient type cooking stove build with mud
- 2. ICS without chimney

3. ICS with Chimney [one way]
4. ICS with Chimney [two ways]
5. Kerosene stove
6. Bio gas stove
7. LPG stove
8. Supply gas stove
9. Electric stove
10. Others (specify) _____

3. What type of fuel did you household use for cooking in the past month? [*list all types of fuel used in order of frequency of use*]

Fuel type1 Fuel Type2 Fuel Type3 Fuel Type4

1. Dung cakes
2. Crop residue/ grass
3. Dried leaves
4. Wood stick/bamboo stick
5. Wood
6. coal/charcoal
7. Kerosene
8. Bio gas
9. LPG
10. Supply gas
11. Electricity
12. Others (specify)

4. What type of stove (if any) did your household use in the past month for heating? [*include all kinds of stoves used, in order of frequency of usage*]

Stove Type Stove type2 Stove type3

1. Ancient type cooking stove build with mud
2. ICS without chimney
3. ICS with Chimney [one way]
4. ICS with Chimney [two ways]
5. Kerosene stove
6. Bio gas stove
7. LPG stove
8. Supply gas stove
9. Electric stove
10. Others (specify) _____

5. What type of fuel did your household use in the past month for heating? *[list all types of fuel used in order of frequency of use]*

Fuel type1 Fuel Type2 Fuel Type3 Fuel Type4

1. Dung cakes
2. Crop residue/ grass
3. Dried leaves
4. Wood stick/bamboo stick
5. Wood
6. coal/charcoal
7. Kerosene
8. Bio gas
9. LPG
10. Supply gas
11. Electricity
12. Others (specify)

DRAFT

List the names, ages, birthday, and mother of all children in the household under 5 years of age.

[If the child is adopted then write the name of primary care giver] [ID number = HHID01-05]

ID Number	Name of child	Name of mother	Age (in months)	Birthday	Relationship to HH

HOUSEHOLD SOCIO-ECONOMIC STATUS

1. Number of rooms in the HH (including kitchen):

2. Monthly Expenditure (by all the HH members)

- 6. <2,000 Tk
- 7. 2,000-5000
- 8. 5000-10000
- 9. >10000
- 10. Don't know

5. Which of the following does your family own [make sure whether its working or not, if anything non-working do not record]

- 1. Mobile phone
- 2. Television (B/W)
- 3. Television (Color)
- 4. Electric fan
- 5. Refrigerator
- 6. Sewing machine
- 7. Bicycle
- 8. Motor cycle

6. Number of years of education completed by the mother of the youngest child

5. Number of years of education completed by the father of the youngest child:

6. What is the main drinking source of water of the house hold?

1. Pond/river/lake
2. Well
3. Tube well
4. Deep tube well
5. Tap/pipe supply water
6. Other (specify) _____

7. What is the ownership type of the drinking water source?

1. Public
2. Someone else
3. Shared with others
4. Only for the house hold

HOUSEHOLD OBSERVATIONS:

8. What is the main material of the roof of principal dwelling?

1. bamboo/thatch/straw
2. Tin
3. Tiled
4. Pacca/concrete
5. Others (specify) _____

9. What is the main material of the wall of principal dwelling?

1. Bamboo/ straw
2. Mud
3. Wood
4. Tin
5. Semi pacca (pacca + tin)
6. Pacca/concrete
7. Other (specify) _____

10. What is the main material of the floor of principal dwelling?

1. Mud
2. Bamboo/ wood
3. Pacca/concrete
4. Others (specify) _____

11. Type of the kitchen:

1. Placed in an open space

2. No wall, only roof top
3. Roof with partial wall
4. Roof with full wall
5. Others (specify): _____

12. (If the kitchen has roof with full wall, observe the followings) ventilation of the kitchen:

1. Well ventilated with windows and door in 4 directions
2. windows/doors placed opposite direction with north/south ventilation
3. windows/doors are present but not with north/south ventilation
4. Only one window and a door
5. Only door
6. Others (specify) _____

13. What is the main material of the roof of the kitchen?

1. bamboo/thatch/straw]
2. Tin
3. Tiled
4. Pacca/concrete
5. Others (specify) _____

14. What is the main material of the wall of the kitchen?

1. Bamboo/ straw
2. Mud
3. Wood
4. Tin
5. Semi pacca (pacca + tin)
6. Pacca/concrete
7. Other (specify) _____

15. What is the main material of the floor of the kitchen?

1. Mud
2. Bamboo/ wood
3. Pacca/concrete
4. Others (specify) _____

16. Distance of the kitchen with the living room (in feet)
[calculate the distance from door to door]

17. How many windows are there in the house?

18. What type of latrine do household members primarily use?



[Improved sanitation facilities]

1. Piped sewer system
2. Septic tank
3. Flush to pit latrine
4. Pit latrine with slab and water seal
5. Pit latrine with slab and no water seal but with a lid
6. Composting toilet (this toilet ensures separation of urine, water and excreta)

[Unimproved sanitation facilities]

7. Flush or pour flush toilet connected to somewhere else (Canal, ditch, river etc.)
8. Pit latrine without slab/open pit
9. Pit latrine with slab and no water seal/broken water seal and no lid.
10. Hanging toilet/latrine

[Open defecation]

11. No toilet facility/bush/field
12. Others (specify) _____

SKETCH HOUSEHOLD

Be sure to show windows, doors, other ventilation holes (such as space between roof and walls) cooking areas, and locations of stoves.

DRAFT

STOVES AND FUEL USE

18. What type of stove did your household use in the past month for cooking? [*include all kinds of stoves used, in order of frequency of usage*]

Stove Type Stove type2 Stove type3

1. Ancient type cooking stove build with mud
2. ICS without chimney
3. ICS with Chimney [one way]
4. ICS with Chimney [two ways]
5. Kerosene stove
6. Bio gas stove
7. LPG stove
8. Supply gas stove
9. Electric stove
10. Others (specify) _____

19. What type of fuel did your household use in the past month for cooking? [*list all types of fuel used in order of frequency of use*]

Fuel type1 Fuel Type2 Fuel Type3 Fuel Type4 Fuel Type 5

1. Dung cakes
2. Crop residue/ grass
3. Dried leaves
4. Wood stick/bamboo stick
5. Wood
6. coal/charcoal
7. Kerosene
8. Bio gas
9. LPG
10. Supply gas
11. Electricity
12. Others (specify)

21. What type of fuel did your household burn in the past month for heating? [*list all types of fuel used in order of frequency of use*]

Fuel type1 Fuel Type2 Fuel Type3 Fuel Type4 Fuel Type 5

1. Dung cakes
2. Crop residue/ grass

3. Dried leaves
4. Wood stick/bamboo stick
5. Wood
6. coal/charcoal
7. Kerosene
8. Bio gas
9. LPG
10. Supply gas
11. Electricity
12. Others (specify)

22. Did your house hold burn any of the following things for lighting in the past month?
 (Write according to the use)

Type1 Type2 Type3 Type 4

1. Dung cakes
2. Crop residue/ grass
3. Dried leaves
4. Wood stick/bamboo stick
5. Wood
6. coal/charcoal
7. Kerosene
8. Bio gas
9. LPG
10. Supply gas
11. Electricity
12. Paper
13. Plastic
14. Garbage
15. Coconut shell
16. Akaar Bati
17. Dhoop
18. Candle
19. Others (specify) _____

QUESTIONS ABOUT COOK

25. Who is primarily responsible for cooking food in the family?

Name:

Age (in Years)

ID6:

Relationship with the youngest child of the house:
1= mother, 2=grandmother, 3=sister, 4=aunt, 5=other

Deaths

1. Within the past year, have there been any deaths in the household or pregnancies where the child is not currently alive?

If yes, list the name and age of the deceased for follow-up with a verbal autopsy.

1. Name _____ Age: _____

2. Name _____ Age: _____

2. If your child were sick with a severe respiratory illness where would you take him/her for care?

DRAFT

**Annex D
BASELINE QUESTIONNAIRE FOR CHILDREN <5**

Household ID

Name of the child:

Age: (In months)

Birthday:

ID:

Date of interview:

Interviewer: _____

Respondent name: _____

Relationship to child:
 Mother=1, Father=2, Grandmother=3, Aunt=4, Other primary care giver=5

Child Health Observation

1. If child is >2 years old, was the child vaccinated according to EPI schedule?
 (Check the schedule card)
 Yes=1, 2=No, 3=DK, 4=Child <2 years old

3. Height of the child (in cm)

4. Weight of the child (in kg)

5. Upper arm circumference (in cm)

6. Record child oxygen saturation (%)

Illness history in past 7 days

7. In the last 7 days, has the child had episodes of repeated coughing?
 Yes=1, No=2, DK=9

8. In the last 7 days, has the child had difficulty breathing?
 Yes=1, No=2, DK=9

9. In the last 7 days, has the child had nasal congestion or a runny nose?
 Yes=1, No=2, DK=9

10. In the last 7 days has the child had fever?
Yes=1, No=2, DK=9

11. In the last 7 days did the child (if >2 months of age) have any signs of severe illness?
(Multiple answers possible)

- 1. Child > 2 months of age but no signs
- 2. Child < 2 months of age
- 3. unable to drink or breast feed
- 4. vomits everything
- 5. convulsions
- 6. lethargic
- 7. unconscious
- 8. central cyanosis

12. Is the child still experiencing respiratory symptoms today?
Yes=1, No=2, DK=9

If yes, check respiratory rate and note here.

If child >2 months and <1 year experiencing >50 respirations per minute or >1 year experiencing >40 or child experiencing any danger sign during visit immediately refer to health care facility.

13. Is your child breast-fed?
Yes=1, No=2, DK=9

If answer to 10 is No, skip to Question 17.

14. If 14 is yes, was the child breast fed last week?
Yes=1, No=2, DK=9

If answer of 15 is No, skip to Question 17.

15. If 15 is Yes, was the child exclusively breast fed last week?
Yes=1, No=2, DK=9

Health care seeking in past 2 months

16. Within the last 2 months did this child have an illness with cough, difficulty breathing or fever that prompted you to bring the child to someone to treat?
Yes=1, No=2, DK=9

If answer of 16 is No or Don't know, skip to 29.

17. Within the last 2 months how many episodes of an illness with cough, difficulty breathing or fever did this child have that prompted you to you to bring the child to someone to treat?

If answer to Question 14 is > 1, then address all of the following questions on the most recent episode of illness.

18. What was the primary symptom the child had that prompted you to bring the child to a health care practitioner?
1) Cough
2) Difficulty breathing
3) Fever
4) Decreased level of consciousness
8) Other _____

19. During this illness did the child have fever?
Yes=1, No=2, DK=9

20. During this illness did the child have a cough?
Yes=1, No=2, DK=9

21. During this illness did the child have difficulty breathing?
Yes=1, No=2, DK=9

22. During the illness was the child unable to stay normally awake and alert?
Yes=1, No=2, DK=9

If answer of 22 is Yes, note down the symptoms of the child:

23. During this illness did the child (if >2 months of age) have any signs of severe illness? (Multiple answers possible)

1. Child > 2 months of age but no signs

2. Child < 2 months of age

- 3. unable to drink or breast feed
- 4. vomits everything
- 5. convulsions
- 6. lethargic
- 7. unconscious

24. For how many days did the child appear ill before he/she was brought to a health care provider? (If can't answer, put 99) Days:

25. During the last episode of illness of your child, which health care practitioner did you visit or consult with? Please check all answers. (Multiple responses possible)

- 1 = qualified doctor i.e. MBBS & above
- 2 = unqualified doctor
- 3 = LMAF
- 4 = Paramedics (GoB/NGO)
- 5 = Compounder
- 6 = Drug seller
- 7 = Homeopath
- 8 = traditional care provider
- 9 = spiritual healer
- 10 = Others (write down) _____

26. Was the child seen at a hospital or clinic?
 Yes=1, No=2, DK=9

If the answer to 26 is Yes, please give the name(s) of the clinic(s) or hospital(s).

27. Did the child recover completely?
 Yes=1, No=2, DK=9

If answer to 27 is Yes, ask 28, otherwise skip to 29.

28. If yes, how many days passed before the child recovered (put code=99 if DK)

Days:

Hospitalization in the past year

29. Within the last 12 months did this child have an illness with cough, difficulty breathing or fever that resulted in the child being hospitalized?

Yes=1, No=2, DK=9

If answer to 29 is 2 or 9, move to question 45.

30. Within the last 12 months how many episodes of an illness with cough, difficulty breathing or fever did this child have that resulted in the child being hospitalized?

Episodes:

If > 1 episode, then address all of the following questions on the most recent episode of illness.

31. For the most recent episode of hospitalization, it began how long (month/days) back from today (Survey date)?

Months:

Days:

32. What was the primary symptom the child had that resulted in the child being hospitalized? 1) Cough

2) Difficulty breathing

3) Fever

4) Decreased level of consciousness days

33. During this illness did the child have fever?

Yes=1, No=2, DK=9

34. During this illness did the child have a cough?

Yes=1, No=2, DK=9

35. During this illness did the child have difficulty breathing?

Yes=1, No=2, DK=9

36. During the illness was the child unable to stay normally awake and alert?

Yes=1, No=2, DK=9

37. During the illness did the child (if >2 months of age) have any signs of severe illness? (Multiple answers possible)

1. Child > 2 months of age but no signs

2. Child < 2 months of age

- 3. unable to drink or breast feed
- 4. vomits everything
- 5. convulsions
- 6. lethargic
- 7. unconscious

38. For how many days did the child appear ill before he/she was hospitalized?
 (put code=99 if DK) Days:

39. Was the child seen by a doctor, clinic, or hospital?
 Yes=1, No=2, DK=9

If answer of 39 is 2 or 9, skip to 44.

40. If yes, where was the child seen?

- 1. _____
- 2. _____
- 3. _____

41. Was admission at hospital recommended for the child?
 Yes=1, No=2, DK=9

42. If yes, was the child admitted to hospital?
 Yes=1, No=2, DK=9

If answer of 42 is 2 or 9, skip to 44

43. Where was the child admitted?
 1. _____
 2. _____

44. Did the child recover completely?
 Yes=1, No=2, DK=9

Crowding

45. How many people aged < 5 years share the same sleeping room with the child?
 (Including the child)

46. How many people share the same bed/mat/area at night?
(Including the child)

47. How many windows and doors the room has where the child sleeps at night

Smoking

48. Does the mother of the child (or primary care giver) smoke?
Yes=1 No=2

(If Yes) Specify the types of smoke used

- 1. Cigarettes
- 2. Biri
- 3. Hookkah
- 4. Others (Specify) _____

49. Does anybody else living in the household with the child smoke?
Yes=1 No=2

(If yes then write the name of the person and relation with the child. Also write type of smoke he/she uses)

1. Name: Relation:Type

2. Name: Relation:Type

Types:

- 1. Cigarettes
- 2. Biri
- 3. Hookkah
- 4. Others (Specify) _____

Exposure to burning fuel

50. Where is the child usually when cooking occurs?

- 1. with the cook, in the kitchen
- 2. within the eye site of the cook
- 3. out of the eye site of the cook
- 4. Other _____

51. In the past month did this child experience a burn or other injury from the stove/fire used for cooking or heating?

- 1. Yes, child experienced a burn only
- 2. Yes, child experienced other injury only

3. Yes, child experienced both burn and injury
4. No, no burn or injury
9. Don't know

DRAFT

Annex E
BASELINE QUESTIONNAIRE FOR COOKS

Household ID

Name of the cook:

Age: (in completed years):

ID:

Date of interview:
mm / dd / yy

Interviewer: _____

Cook Health Observation

1. Height of the cook (in cm)

2. Weight of the cook (in kg)

3. Upper arm circumference (in cm)

4. Record results of CO in breath (in $\mu\text{L/L}$)

5. Record blood pressure Systolic:

Diastolic:

Illness history in past 7 days

6. In the last 7 days, did you have episodes of repeated coughing?
Yes=1, No=2, DK=9

7. In the last 7 days, did you have difficulty breathing?
Yes=1, No=2, DK=9

8. In the last 7 days, did you have nasal congestion or a runny nose?
Yes=1, No=2, DK=9

9. In the last 7 days did you have fever?
Yes=1, No=2, DK=9

10. In the last 7 days did you experience a burning sensation in the eyes?
Yes=1, No=2, DK=9

11. In the last 7 days did you experience headache?
Yes=1, No=2, DK=9

12. In the last 7 days did you experience back pain?
Yes=1, No=2, DK=9

Smoking

13. Do you smoke?

Yes=1

No=2

If yes, specify the type of smoking (check all types used)

1. Cigarettes

2. Biri

3. Hookkah

4. Others
(Specify) _____

14. In the past 7 days, how many times did you usually smoke (any type) each day?

1. <1 time

2. 1-5 times

3. 5-10 times

4. > 10 times

Exposure to burning fuel

15. How many times do you cook in a day?

16. How long do you usually spend for cooking per day (*write in hours*)

17. How long it takes to prepare a meal (in hours)

(if she does not cook in any of the meal write '0')

1. Breakfast

2. Lunch

3. Dinner

18. In the past 7 days, how many hours, on average, did cooking take place per day?

19. In the past 7 days, how many hours, on average, was fuel burned for heating the house per day?

--	--

20. In the past month did you experience a burn or other injury from the stove/fire used for cooking or heating?

--

- 5. Yes, experienced a burn only
- 6. Yes, experienced other injury only
- 7. Yes, experienced both burn and injury
- 8. No, no burn or injury
- 10. Don't know

DRAFT

Annex F
MONTHLY QUESTIONNAIRE FOR CHILDREN <5

Household ID

Name of the child:

Age: (In months)

Birthday:

ID:

Date of interview:

Interviewer: _____

Respondent name: _____

Relationship to child:
Mother=1, Father=2, Grandmother=3, Aunt=4, Other primary care giver=5

Vaccination

1. If child became two years of age since the last visit, has the child been vaccinated according to EPI schedule?

(Check the schedule card)

Yes=1, 2=No, 3=DK, 4=Child <2 years old, 5=did not become 2 since last

Illness history in past 7 days

2. In the last 7 days, has the child had episodes of repeated coughing?
Yes=1, No=2, DK=9

3. In the last 7 days, has the child had difficulty breathing?
Yes=1, No=2, DK=9

4. In the last 7 days, has the child had nasal congestion or a runny nose?
Yes=1, No=2, DK=9

5. In the last 7 days has the child had fever?
Yes=1, No=2, DK=9

6. In the last 7 days did the child (if >2 months of age) have any signs of severe illness?
(Multiple answers possible) (If child <2 months of age skip to question 14)

- 1. Child > 2 months of age but no signs
- 2. Child < 2 months of age
- 3. unable to drink or breast feed
- 4. vomits everything
- 5. convulsions
- 6. lethargic
- 7. unconscious

7. Is the child still experiencing respiratory symptoms today?
Yes=1, No=2, DK=9

If yes, check respiratory rate and note here.

If child >2 months and <1 year experiencing >50 respirations per minute or >1 year experiencing >40 or child experiencing any danger sign during visit immediately refer to health care facility.

8. Is your child breast-fed?
Yes=1, No=2, DK=9

If answer to 8 is No, skip to Question 11.

9. If 8 is yes, was the child breast fed last week?
Yes=1, No=2, DK=9

If answer of 9 is No, skip to Question 11.

10. If 9 is Yes, was the child exclusively breast fed last week?
Yes=1, No=2, DK=9

Health care seeking in past month (since the last visit)

11. Within the last month (since the last visit) did this child have an illness with cough, difficulty breathing or fever that prompted you to bring the child to someone to treat?
Yes=1, No=2, DK=9

If answer of 11 is No or Don't know, move to Question 27.

12. Within the last month how many episodes of an illness with cough, difficulty breathing or fever did this child have that prompted you to bring the child to someone to treat?

If answer to Question 12 is > 1, then address all of the following questions on the most recent episode of illness.

13. What was the primary symptom the child had that prompted you to bring the child to a health care practitioner?

- 1) Cough
- 2) Difficulty breathing
- 3) Fever
- 4) Decreased level of consciousness
- 8) Other _____

14. During this illness did the child have fever?
Yes=1, No=2, DK=9

15. During this illness did the child have a cough?
Yes=1, No=2, DK=9

16. During this illness did the child have difficulty breathing?
Yes=1, No=2, DK=9

17. During the illness was the child unable to stay normally awake and alert?
Yes=1, No=2, DK=9

If answer of 17 is Yes, note down the symptoms of the child:

—

18. During this illness did the child (if >2 months of age) have any signs of severe illness? (Multiple answers possible)

- 1. No, child > 2 months of age but no signs
- 2. Child < 2 months of age
- 3. child was unable to drink/breast feed
- 4. vomited everything

5. had convulsions

6. was lethargic

7. was unconscious

19. For how many days did the child appear ill before he/she was brought to a health care provider? (If can't answer, put 99) Days:

20. During the last episode of illness of your child, which health care practitioner did you visit or consult with? Please check all answers. (Multiple responses possible)

1 = qualified doctor i.e. MBBS & above

2 = unqualified doctor

3 = LMAF

4 = Paramedics (GoB/NGO)

5 = Compounder

6 = Drug seller

7 = Homeopath

8 = traditional care provider

9 = spiritual healer

10 = Others

(specify) _____

21. Was the child seen at a hospital or clinic?
Yes=1, No=2, DK=9

If the answer to 21 is Yes, please give the name(s) of the clinic(s) or hospital(s).

22. Was admission at hospital recommended for the child?
Yes=1, No=2, DK=9

23. If yes, was the child admitted to hospital?
Yes=1, No=2, DK=9

If answer of 23 is 2 or 9, skip to 44

24. Where was the child admitted?

1. _____

2. _____

25. Did the child recover completely?

Yes=1, No=2, DK=9

If answer to 25 is Yes, ask 26, otherwise skip to 27.

26. If yes, how many days passed before the child recovered (put code=99 if DK)

Days:

Exposure to smoke

27. In the past 7 days where was the child usually when cooking occurred?

1. with the cook, in the kitchen
2. within the eye site of the cook
3. out of the eye site of the cook
4. Other _____

28. In the past 7 days, where did cooking take place?

1. Inside living area only
2. Outside living area only
3. Inside and outside

29. In the past month did this child experience a burn or other injury from the stove/fire used for cooking or heating?

9. Yes, child experienced a burn only
10. Yes, child experienced other injury only
11. Yes, child experienced both burn and injury
12. No, no burn or injury
11. Don't know

Child observation (every third month)

30. Record child oxygen saturation (%)

Annex G
MONTHLY QUESTIONNAIRE FOR COOKS

Household ID

Name of the cook:

ID:

Date of interview:
mm / dd / yy

Interviewer: _____

Illness history in past 7 days

- 1. In the last 7 days, did you have episodes of repeated coughing?
Yes=1, No=2, DK=9
- 2. In the last 7 days, did you have difficulty breathing?
Yes=1, No=2, DK=9
- 3. In the last 7 days, did you have nasal congestion or a runny nose?
Yes=1, No=2, DK=9
- 4. In the last 7 days did you have fever?
Yes=1, No=2, DK=9
- 5. In the last 7 days did you experience a burning sensation in the eyes?
Yes=1, No=2, DK=9
- 6. In the last 7 days did you experience headache?
Yes=1, No=2, DK=9
- 7. In the last 7 days did you experience back pain?
Yes=1, No=2, DK=9

Smoking

- 8. In the past 7 days, how many times did you usually smoke (any type) each day?
 - 1. <1 time
 - 2. 1-5 times
 - 3. 5-10 times
 - 4. > 10 times

Exposure to burning fuel

9. In the past 7 days, where did cooking take place?

1. Inside living area only
2. Outside living area only
3. Inside and outside

10. In the past month was there any change in the type of stove used for cooking?
Yes=1, No=2

11. If yes, what stoves were used in the household in the past 7 days?

Stove Type Stove type2 Stove type3

1. Ancient type cooking stove build with mud
2. ICS without chimney
3. ICS with Chimney [one way]
4. ICS with Chimney [two ways]
5. Kerosene stove
6. Bio gas stove
7. LPG stove
8. Supply gas stove
9. Electric stove
10. Others (specify) _____

12. In the past month was there any change in the type of stove used for heating?
Yes=1, No=2

13. If yes, please select the types of stoves used for heating in the past 7 days.

Stove Type Stove type2 Stove type3

1. Ancient type cooking stove build with mud
2. ICS without chimney
3. ICS with Chimney [one way]
4. ICS with Chimney [two ways]
5. Kerosene stove
6. Bio gas stove
7. LPG stove
8. Supply gas stove
9. Electric stove
10. Others (specify) _____

14. In the past 7 days, how many hours, on average, was fuel burned for heating the house per day?

15. In the past 7 days, how many hours, on average, was fuel burned for cooking per day?

18. In the past month did you experience a burn or other injury from the stove/fire used for cooking or heating?

- 13. Yes, experienced a burn only
- 14. Yes, experienced other injury only
- 15. Yes, experienced both burn and injury
- 16. No, no burn or injury
- 12. Don't know

Cook Health Observation (every third visit)

19. Record results of CO in breath (in $\mu\text{L/L}$)

20. Record blood pressure Systolic:

Diastolic:

DRABEF

Annex I
Verbal autopsy for neonates (infants <29 days old)

DRAFT

Annex J

Verbal Autopsy for children >28 days and < 5 years old

DRAFT

Annex K
Case-control study consent form

International Centre for Diarrhoeal Disease Research, Bangladesh
Voluntary Consent Form

Title of the Research Project: Measuring the Health Effect of Indoor Air Pollution Interventions

Principal Investigator: Emily Gurley

We will require informed, written, voluntary consent for participation in case-control study and collection of health measurements from children. The language to be used for each group is included below. These consent forms will be translated into Bangla and a copy will be given to each study participant.

Consent form for participant's parent (case control)

Assalamualakum/adaab. My name is _____, I'm am from ICDDR,B, also known as the Cholera Hospital. Our office is here to do research on Indoor Air Pollution and its relationship with diseases. We would like to get some information from you regarding this topic.

Purpose of the study: The purpose of this study is to better understand the relationship between air pollution in the home with disease and its consequences. We would like to better understand the relationship between the type of stove and fuel used in your home for cooking and heating with air pollution levels and illnesses in people using those stoves and children in your home.

Procedure: If you agree to participate we will talk with you for about an hour. We will ask you questions regarding your child's health, history of illness, past illness, the construction of your house, and the kinds of stoves and fuel you use for cooking and heating. In addition, we would like to take some health measurements of your child, including height, weight, and the oxygen saturation level in their blood.

Risks: There is minimal risk involved in your participation in this study. The measurements we collect from your child your responses will be used only for the purposes of our study and your name will not be linked with your responses.

Benefits: Through your participation in this study, you can help us to understand the relationship of indoor air pollution and diseases and how we might prevent ill health from indoor air pollution. There will be no direct benefit to you in participating and we will not provide you with any payment for participating in this study. However, your participation may help us to better plan how to improve the health of people in your community.

Confidentiality: All the information obtained from you will be used only for the purpose of the study. No one will have access to the information other than study staff. All data will be secured in a locked cabinet. Your name or other identifiers will not be reported in any publication.

Voluntary participation: Your participation is completely voluntary. If you agree to participate you may choose to end the interview at any time or refuse to answer any question if you wish. If you do not want to participate in the study, you will still receive the same care from this physician or institution.

Rights of the participant: You may ask me any questions you may have about the study. If you have additional questions about the study you may contact Dr. Sohel Shomik at ICDDR,B at 0171-413-2715 at any time. If you have additional questions about your participation in this study you may contact M A Salam at ICDDR,B at 9882252 (Ext: 3206) at office hours only.

Do you agree to participate in our study today? Yes No
(please circle)

Signature of study representative

Signature of participant

(Date)

(Date)

Annex L
Consent form for cohort study household heads

International Center for Diarrhoeal Disease Research, Bangladesh
Voluntary Consent Form

Title of the Research Project: Measuring the Health Effect of Indoor Air Pollution Interventions

Principal Investigator: Emily Gurley

We will require informed, written, voluntary consent for participation in the cohort study and taking indoor air pollution measurements. The language to be used for each group is included below. These consent forms will be translated into Bangla and a copy will be given to each study participant.

Consent form for participant (Household Head)

Assalamualakum/adaab. My name is _____, I'm am from ICDDR,B, also known as the Cholera Hospital. We are here to do research on Indoor Air Pollution and its relationship with diseases. We would like to get some information from you regarding this topic.

Purpose of the study: The purpose of this study is to better understand the relationship between air pollution in the home with disease and its consequences. We would like to better understand the relationship between the type of stove and fuel used in your home for cooking and heating with air pollution levels and illnesses in people using those stoves and children in your home.

Procedure: If you agree to participate we will talk with you for about 30 minutes today. We will ask you questions regarding your household income, your education, your household members, your house construction, and the stoves and fuel used for cooking. In addition we would install some air pollution monitors in your house for 24 hours. We would install those monitors now and return to your house tomorrow to retrieve them.

Our study will continue for 2 years or until the youngest child in your house is 5 years old. During that time, we would like to visit your house once every three months to monitor the amount of pollution in the air in your house.

Risks: There is minimal risk involved in your participation in this study. We will use your responses only for the purposes of our study and your name will not be linked with your responses.

Benefits: Through your participation in this study, you can help us to understand the relationship of indoor air pollution and diseases and how we might prevent ill health from indoor air pollution. There will be no direct benefit to you in participating and we will not provide you with any payment for participating in this study. However, your

participation may help us to better plan how to improve the health of people in your community.

Confidentiality: All the information obtained from you will be used only for the purpose of the study. No one will have access to the information other than study staff. All data will be secured in a locked cabinet. Your name or other identifiers will not be reported in any publication.

Voluntary participation: Your participation is completely voluntary. If you agree to participate you may choose to end the interview at any time or refuse to answer any question if you wish. You may also choose to end your participation at any time during the 2 years of the study. There is no penalty for choosing not to participate and it will not affect any services you may currently receive.

Rights of the participant: You may ask me any questions you may have about the study. If you have additional questions about the study you may contact Dr. Sohel Shomik at ICDDR,B at 0171-413-2715 at any time. If you have additional questions about your participation in this study you may contact M A Salam at ICDDR,B at 9882252 (Ext: 3206) at office hours only.

Do you agree to participate in our study today?

Yes No *(please circle)*

Signature of study representative

Signature of participant

(Date)

(Date)

Annex M

Consent form for cohort study children's guardians

International Centre for Diarrhoeal Disease Research, Bangladesh Voluntary Consent Form

Title of the Research Project: Measuring the Health Effect of Indoor Air Pollution Interventions

Principal Investigator: Emily Gurley

We will require informed, written, voluntary consent from guardians for participation in the cohort study and taking of health measurements of children. The language to be used for each group is included below. These consent forms will be translated into Bangla and a copy will be given to each study participant.

Consent form for participant's parent (for cohort)

Assalamualakum/adaab. My name is _____, I'm am from ICDDR,B, also known as the Cholera Hospital. Our office is here to do research on Indoor Air Pollution and its relationship with diseases. We would like to get some information from you regarding this topic.

Purpose of the study: The purpose of this study is to better understand the relationship between air pollution in the home with disease and its consequences. We would like to better understand the relationship between the type of stove and fuel used in your home for cooking and heating with air pollution levels and illnesses in people using those stoves and children in your home.

Procedure: If you agree to participate we will talk with you about your child/children for about 30 minutes today. We will ask you questions regarding your child's health, behavior, exposure to smoke, past illness, and hospitalization. We will also weight, height, and oxygen saturation. This study will continue for two years and our trained assistant will visit the child for once in a month in that period to ask about any illnesses they had in the previous month.

Risks: There is minimal risk involved in your participation in this study. We will use your responses only for the purposes of our study and your name will not be linked with your responses.

Benefits: Through your participation in this study, you can help us to understand the relationship of indoor air pollution and diseases and how we might prevent ill health from indoor air pollution. There will be no direct benefit to you in participating and we will not provide you with any payment for participating in this study. However, your participation may help us to better plan how to improve the health of people in your community

Confidentiality: All the information obtained from you will be used only for the purpose of the study. No one will have access to the information other than study staff. All data will be secured in a locked cabinet. Your name or other identifiers will not be reported in any publication.

Voluntary participation: Your participation is completely voluntary. If you agree to participate you may choose to end the interview at any time or refuse to answer any question if you wish. You may also choose to end your participation at any time during the 2 years of the study. There is no penalty for choosing not to participate and it will not affect any services you may currently receive.

Rights of the participant: You may ask me any questions you may have about the study. If you have additional questions about the study you may contact Dr. Sohel Shomik at ICDDR,B at 0171-413-2715 at any time. If you have additional questions about your participation in this study you may contact M A Salam at ICDDR,B at 9882252 (Ext: 3206) at office hours only.

Do you agree to participate in our study today? Yes No *(please circle)*

Signature of study representative

Signature of participant

(Date)

(Date)

Annex N
Consent form for cohort study cooks

International Center for Diarrhoeal Disease Research, Bangladesh
Voluntary Consent Form

Title of the Research Project: Measuring the Health Effect of Indoor Air Pollution Interventions

Principal Investigator: Emily Gurley

We will require informed, written, voluntary consent for participation in the cohort study and monthly visits and health measurements. The language to be used for each group is included below. These consent forms will be translated into Bangla and a copy will be given to each study participant.

Consent form for participant (for cook)

Assalamualakum/adaab. My name is _____, I'm am from ICDDR,B, also known as the Cholera Hospital. Our office is here to do research on Indoor Air Pollution and its relationship with diseases. We would like to get some information from you regarding this topic.

Purpose of the study: The purpose of this study is to better understand the relationship between air pollution in the home with disease and its consequences. We would like to better understand the relationship between the type of stove and fuel used in your home for cooking and heating with air pollution levels and illnesses in people using those stoves and children in your home.

Procedure: If you agree to participate we will talk with you for about 15 minutes today. We will ask you questions about the amount of time you spend cooking, the kind of stove and fuel you use, and your health. We will also measure your blood pressure, your weight, height, and the amount of carbon monoxide in your breath. We will continue this study for two years or until the youngest child in your house is 5 years old. We will visit you each month and ask about your recent cooking and heating practices and your health.

Risks: There is minimal risk involved in your participation in this study. We will use your responses only for the purposes of our study and your name will not be linked with your responses.

Benefits: Through your participation in this study, you can help us to understand the relationship of indoor air pollution and diseases and how we might prevent ill health from indoor air pollution. There will be no direct benefit to you in participating and we will not provide you with any payment for participating in this study. However, your

participation may help us to better plan how to improve the health of people in your community.

Confidentiality: All the information obtained from you will be used only for the purpose of the study. No one will have access to the information other than study staff. All data will be secured in a locked cabinet. Your name or other identifiers will not be reported in any publication.

Voluntary participation: Your participation is completely voluntary. If you agree to participate you may choose to end the interview at any time or refuse to answer any question if you wish. You may also choose to end your participation at any time during the 2 years of the study. There is no penalty for choosing not to participate and it will not affect any services you may currently receive.

Rights of the participant: You may ask me any questions you may have about the study. If you have additional questions about the study you may contact Dr. Sohel Shomik at ICDDR,B at 0171-413-2715 at any time. If you have additional questions about your participation in this study you may contact M A Salam at ICDDR,B at 9882252 (Ext: 3206) at office hours only.

Do you agree to participate in our study today?

Yes No *(please circle)*

Signature of study representative

Signature of participant

(Date)

(Date)