CHILDREN IN THE CHULHA TRAP

ELIMINATING TOXIC EXPOSURE IN ANGANWADIS OF BIHAR

A Centre for Science and Environment assessment report

Writers: Anumita Roychowdhury and Polash Mukerjee

Air quality monitoring: Polash Mukerjee

Editor: Arif Ayaz Parrey

Cover: Ritika Bohra

Design: Ajit Bajaj

Production: Rakesh Shrivastava and Gundhar Das

We are grateful to Shakti Sustainable Energy Foundation for its support. The Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support energy efficiency, renewable energy and the adoption of sustainable urban transport solutions. The views expressed and analysis presented in this document do not necessarily represent those of the Foundation and it accepts no liability for the content of this document, or for the consequences of any actions taken on the basis of the information provided.

We are thankful to the officials of the Department of Social Welfare, Government of Bihar, sevikas and sahiyakas of anganwadis centres in district Gaya, and Bihar chapter of the Indian Academy of Pediatrics, for facilitating air quality monitoring and field investigation for this study.

© 2016 Centre for Science and Environment

This publication is not for sale. Material from this publication can be used, but with acknowledgement.

Citation: Anumita Roychowdhury and Polash Mukerjee, 2016, *Children in the Chulha Trap: Eliminating Toxic Exposure in Anganwadis of Bihar*, Centre for Science and Environment, New Delhi

Maps in this report are indicative and not to scale.

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: cse@cseindia.org
Website: www.cseindia.org

Contents

1. Why this study? 5

2. Health imperatives of this study 7

3. Bihar government's programme on clean fuel for midday meals to protect child health 11

4. Approach to this study 12

5. The results 17

Annexures 23

References 27

1. Why this study?

This quick assessment has been carried out by Centre for Science and Environment to ascertain how switching from biomass-based solid fuels to cleaner liquefied petroleum gas (LPG) for cooking of midday meals in anganwadis (day care centres that facilitate informal learning under supervision) in Bihar can help reduce exposure of children to toxic air. This has been done to support the joint initiative of the Bihar government and Bihar chapter of the Indian Academy of Paediatrics along with UNICEF, under which a pilot scheme to replace biomass-based stoves with LPG for cooking midday meals for children has been started.

Based on the results of this pilot, the Bihar government is expected to expand the programme across the entire state. The rapid indoor air quality monitoring during cooking of midday meals on biomass-based cooking stoves has helped create a baseline of exposures. Children in rural India are already exposed to high levels of cooking stove pollution due to widespread dependence on biomass-based fuels. The few hours that they spend daily in anganwadis and

Stunning outdoors, smoke-filled indoors—the conundrum of anganwadi centres

Knowledge, not smoke, is what children should be filled with at the anganwadi centres

schools that serve midday meals should not add to that exposure. Replacement of these stoves with LPG can help eliminate such exposure levels. Letting this evidence and understanding to directly inform public policy can be instrumental in creating the necessary confidence for stronger action not only in Bihar but in other states as well. The government programmes designed for improving nutritional status of children cannot perpetuate toxic risk for children.

This initiative is consistent with the recommendations of the Union Ministry of Health and Family Welfare's steering committee report on air pollution and health. The report states that proximity and duration, and not general air conditions (subject to climate and weather), are the key factors in assessing the effect of air pollution. How much pollution is breathed in by individuals is heavily influenced by nearby sources such as stoves. Eliminating such exposure will reduce the risk to public health considerably.

2. Health imperatives of this study

According to the 2010 Global Burden of Disease (GBD) estimates, household or indoor air pollution is already the second largest killer in India (after high blood pressure). Household air pollution caused by solid fuel burning is responsible for 1.04 million premature deaths and 31.4 million lost life years annually. This is much higher than the 627,000 premature deaths and 17.8 million lost life years due to outdoor air pollution. Fine particles, or $PM_{2.5}$, are primarily responsible for the disease burden. The GBD has also shown that household air pollution contributes at least 25 per cent to the outdoor air pollution as well. If the disease burden from outdoor ambient pollution is added to these figures, then the two together are the top killers among the 67 risk factors that have been examined in the GBD 2010 exercise. Globally, exposure to indoor smoke from solid fuels is responsible for over half of the 1.8 million annual child deaths from acute lower respiratory infections, making it the largest environmental factor causing ill health and death among children.

According to the GBD estimates, the average annual household air pollution exposures are highest for women and children because of widespread use of solid fuels for cooking at home. Based on measurements and modelling results from India, the GBD has estimated daily average $PM_{2.5}$ exposures of 285 microgram per cubic metre (µg/m^3), 337 µg/m^3 and 204 µg/m^3 for children, women and men respectively. But maximum exposures during cooking can be several times higher than these levels. Studies carried out by Kalpana Balakrishnan, an indoor air pollution expert from Sri Ramachandra Medical College in Chennai, along with other scientists, have shown that the mean 24-hour average exposure concentrations can be as high as 570 µg/m^3 in households using solid fuels. The concentrations are about 80 µg/m^3 in households using gas. Scientists have further cautioned that even for households that cook outdoors, the 24-hour concentrations and exposures could be well above the average outdoor air pollution levels.

There is now substantial data available in India (and globally) on the insidious link between solid fuel use in households and serious health consequences for women and children. Increased incidence of chronic bronchitis in women and acute respiratory infections in children are two clear effects. Household solid fuel is responsible for higher infant and child mortality rates. Children exposed to indoor air pollution from solid fuel use have two to three times greater risk of developing respiratory infections compared to unexposed children. The exposure levels of female children in the age group 6–15 and involved in cooking in households, were much higher than other children.

There is also mounting evidence on strong linkages between indoor air pollution and low birth weight, asthma, tuberculosis, cataracts and cancer of the upper respiratory tract. Balakrishnan (and other scientists) point out that household air pollution punishes children twice—by making them ill and making their mothers ill, which reduces the mother's ability to take care of children. Kirk Smith, an expert on household air pollution from the University of California, Berkeley, who has worked extensively on household pollution in India, points out that the risk from solid fuel use is particularly strong because of the high daily concentrations of pollutants in household settings and the large amount of time children spend with their mothers doing household cooking. Infants and children are particularly susceptible because of the immaturity of their respiratory defence mechanisms and the geometry of their airways. The time spent near the cooking stoves is also a serious contributor. It is, therefore, critical to map out the activity pattern of the children under the age of five years to minimise personal exposures. This must help to identify the most effective intervention strategies.

This will have to be addressed with utmost urgency as India has had one of the highest infant mortality rates in the world historically. The national infant mortality rate has decreased, as shown by the latest National Family Health Survey (NFHS-4) conducted in 2015–16. However, the country's goal to achieve a rate of less than 100 deaths per 1,000 live-births and reducing infant mortality rate to less than 60 per 1,000 live-births by the year 2000 could not be achieved despite improved interventions and an increase in overall resource allocation. Despite the decline, one out of every 14 children born during the five years before NFHS-3 died before reaching the age of five. The most common causes of death in children less than five years of age continue to be pneumonia and respiratory illnesses.

In Bihar, the rate of incidence of acute respiratory infection is 6.8 per cent, as per NFHS-3, which is higher than the national average of 5.8 per cent, and much higher than states such as Himachal Pradesh (1.3 per cent) and Karnataka (1.7 per cent). Though provisional figures for NFHS-4 indicate an improvement in this number for Bihar, these are not yet out for all states.

Children are physically more active than adults, and this increases their vulnerability to air pollution. They have significantly higher oxygen demands so their respiration rates are higher and they inhale more air per unit of body weight than adults. Their smaller stature results in a lower breathing zone, so they inhale air loaded with more particles. The diameters of their airways are smaller and, therefore, more likely to be affected by inflammation produced by air pollution. Their lungs are still developing and, hence, are more vulnerable to airborne pollutants. The efficiency of the detoxification system of the body develops in time-dependent patterns. This in part accounts for increased susceptibility of children at critical points of time. Their immune system is immature and, consequently, less active against inhaled pathogens.

Most of the combustion emissions tested by scientists are highly correlated with the mutagenicity of the emissions. Scientists at Anderson Cancer Centre of the University of Texas have found that prolonged exposure to household pollutants leads to a higher probability of developing long-term health effects. For children below the age of five, higher levels of exposure to mutagens present in emissions could possibly lead to lasting effects on mental growth with lifelong consequences.

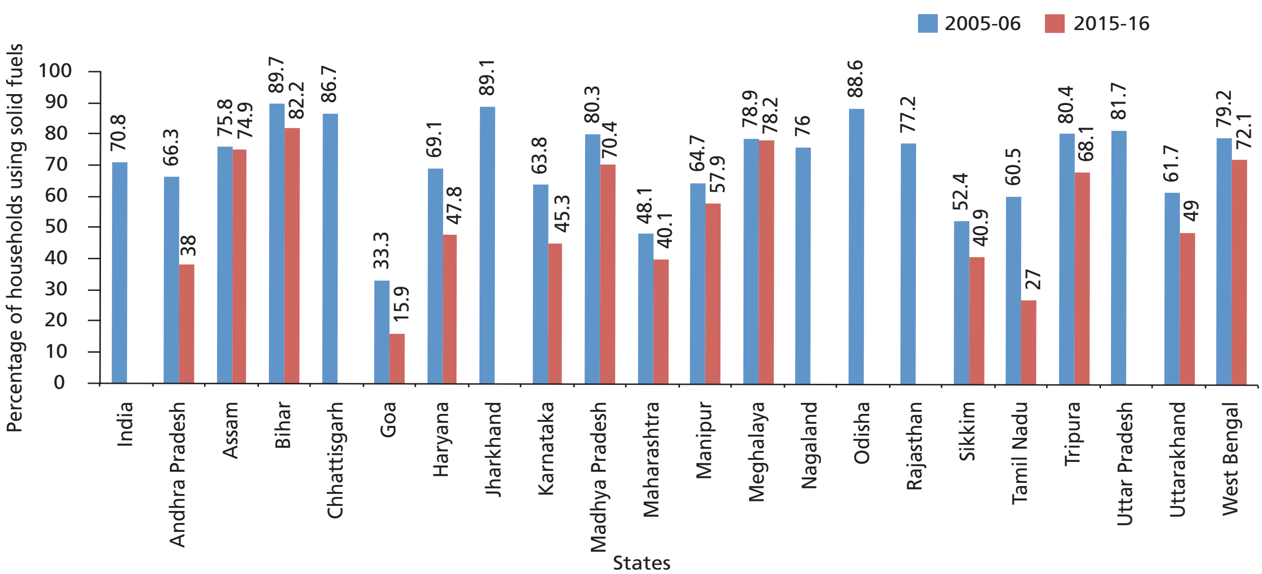
Children's health will continue to be compromised if the use of solid fuel for cooking remains as extensive as it is today. (See *Graph 1: Trends in use of solid fuels in households*). Even though the overall use of solid fuels has declined over time, it still remains substantial in several states, including Bihar. Despite the decline in overall use of solid fuels, Census reports bring out an overall increase in number of households that are still using solid fuels in the country. For instance, according to the 2001 census, the total number of households using firewood was 100.84 million. But a decade later, the census shows that the total number of households using firewood is 120.87 million. This is what Kirk Smith has termed as the **chulha trap**.

The only way to save lives from toxic fumes is to change the fuel and make clean fuel available to all. The recently released report of the expert committee on air pollution and health under the aegis of the Union Ministry of Health and Family Welfare has clearly recommended that LPG be made affordable and accessible to the poor, and that subsidies be restructured for clean fuel to target the poor better. There should be a mission on smokeless villages.

In the meantime, Government of India has launched three major national initiatives (since 2014)—PAHAL, Give it Up, and Ujjwala—to expand use of LPG in households. Under the Give It Up campaign, households that earn more than Rs 10 lakh per annum surrender their LPG subsidy to transfer it to poorer households. This programme aims to cover 1.5 crore households that live below poverty line (BPL) in 2016–17 and five crore more BPL households in the next two years. To achieve universal coverage of cooking gas, about 75 lakh households have given up LPG subsidies. According to Kirk Smith, this amounts to nearly doubling the natural LPG growth rate of 5–6 per cent, which was only keeping up with population, to a rate that can bring India first to the UN goal of clean household fuels for all before 2030.

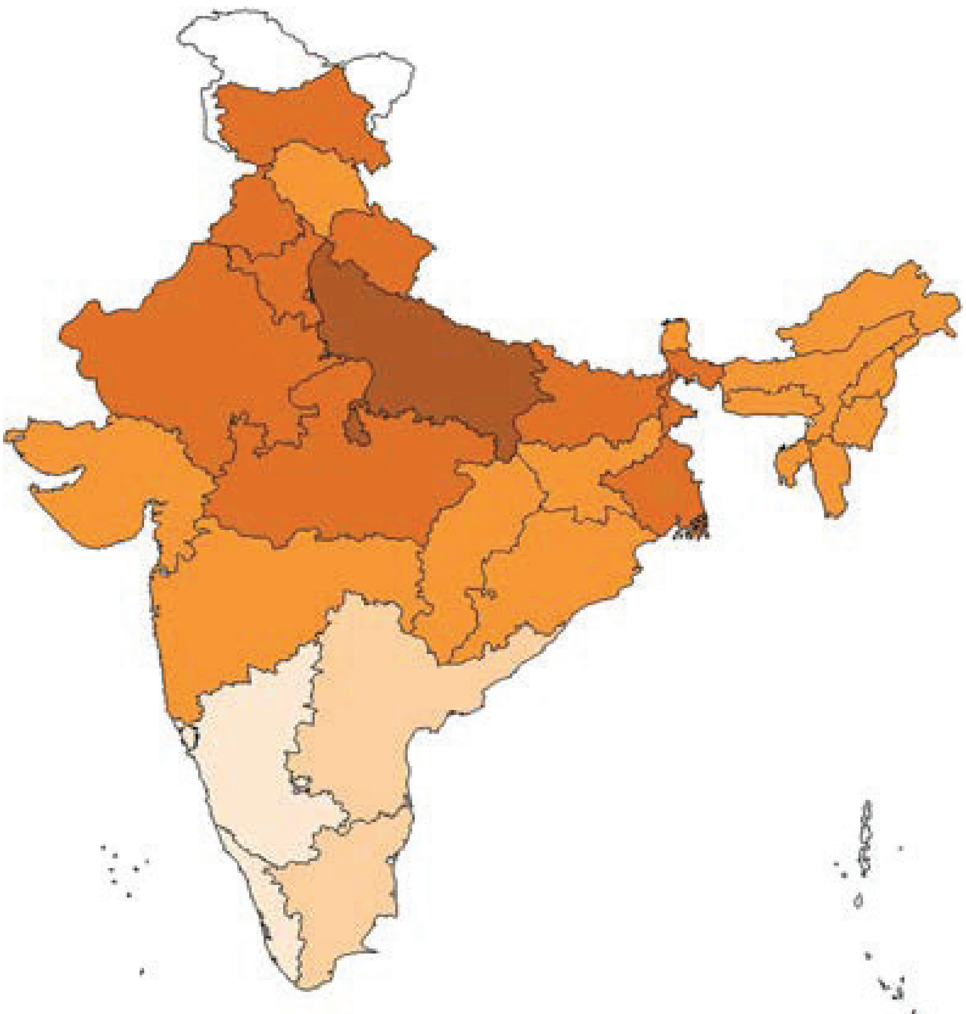
The national level action will have to be backed by even stronger local action in states for real transformation on the ground. The Bihar government's programme to replace biomass-based cook stoves with LPG in its anganwadis is one such initiative.

Graph 1: Trends in use of solid fuels in households

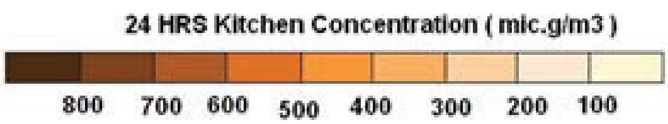


Source: National Family Health Survey-4, 2015–16 and National Family Health Survey-3, 2005-06.

Figure 1: Round the clock particulate concentration in kitchen across India



Source: (Balakrishna, et al., 2013)

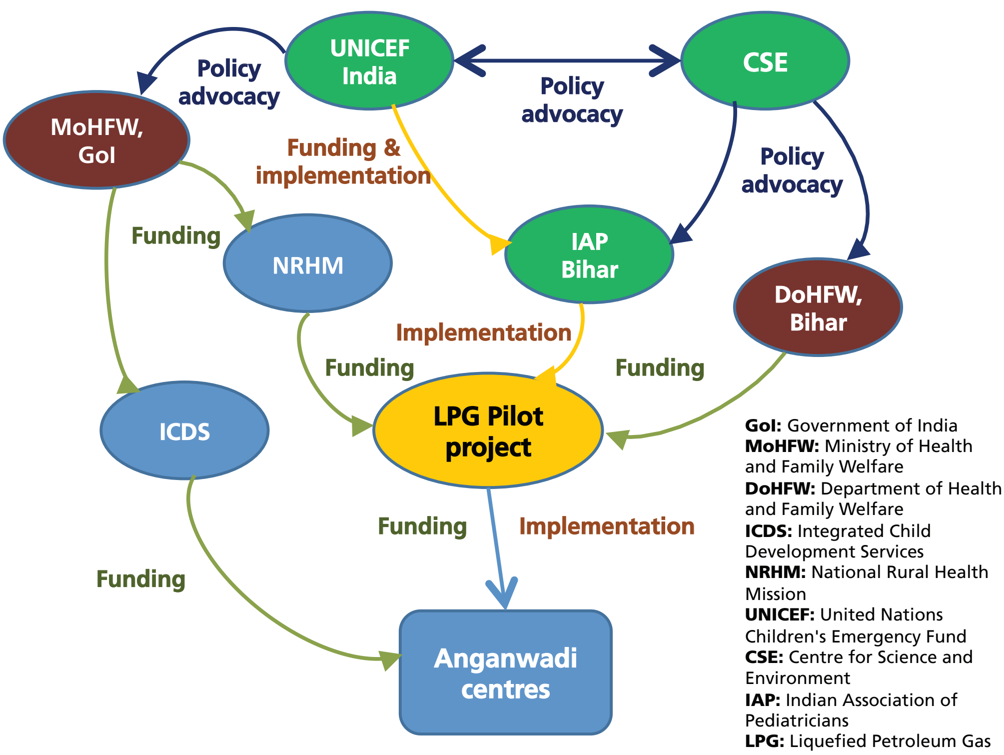


3. Bihar government's programme on clean fuel for midday meals to protect child health

The Bihar government has taken the lead in replacing solid fuel-based stoves with LPG stoves for cooking midday meals in government primary schools to reduce pollution exposure. This pilot initiative has been launched with support from the Bihar chapter of the Indian Academy of Paediatrics and the UNICEF. After the successful completion of the pilot, the state government is expected to implement this programme state-wide (see *Figure 2: Flow chart on the operational plan for the pilot programme in Dobhi Block, Gaya, Bihar*).

The programme targets anganwadis. These schools draw infants and children aged between six months to six years. This is a highly vulnerable age group, whose exposure to toxic levels of indoor pollution should be totally eliminated. The state employs the "sevika" and the "sahayika" (caretaker and helper, respectively) who are remunerated for their services. All these centres get fixed allowance for provision of nutrition through midday meals for children. The state supports the cost of the fuel, cooking utensils and infrastructure for hot meals based on a pre-determined weekly menu. As of 1 January 2015, there are 1.34 million operational anganwadi centres across India, of which about 92,000 are in Bihar.

Figure 2: Flow chart on the operational plan for the pilot programme in Dobhi Block, Gaya, Bihar



4. Approach to this study

CSE team visited Gaya in February 2016 to carry out the monitoring at the anganwadis just before the introduction of LPG for cooking of midday meals in the anganwadis that are part of the pilot project in the Dobhi block of Gaya district, Bihar. This block is predominantly rural, with the nearest city and district headquarters being Gaya. There are 118 anganwadis in Dobhi block that have been progressively provided LPG cylinders and gas stoves for cooking purposes. As per NFHS-4 data (2015–16) use of solid fuels for energy requirements in Bihar is 82.2 per cent. In Gaya, it is 84.4 per cent. Nearly all rural households use solid fuels. The challenge remains in terms of regular supply of LPG to these anganwadi centres.

The monitoring equipment used was a state-of-the-art instrument, TSI DustTrak DRX Aerosol Monitor 8533. Battery operated, it is a light-scattering laser photometer that gives real-time aerosol mass readings. It simultaneously measures all size-segregated mass fraction concentrations corresponding to PM_1, $PM_{2.5}$, and PM_{10}. It uses a sheath air system that isolates the aerosol in the optics chamber to keep the optics clean for improved reliability and low maintenance. It has a heated inlet sample conditioner to reduce the effects of humidity. The monitor is portable and can be carried in a padded backpack designed to limit instrument tilt and vibration. A tube is clipped near the breathing zone. The other end of this tube is attached to the inlet of the instrument. The instrument's zero point was calibrated every time before monitoring using an external zero filter.

Each monitoring was done to capture hourly averages. The monitoring was done in two points—close to the stove or chulha, to capture direct exposure concentrations, and at some distance from the stove near the children, to mimic real exposure of children.

To create the baseline information on air quality, a sample size of 30 anganwadi centres was chosen across the block. These were selected based on the structure and design of the buildings, practice of indoor and outdoor cooking, and the type of biomass fuel used.

The physical structure and layout of the anganwadis determines ventilation and the level of exposure to the smoke and particulates. Broadly, there are three types of buildings: i) Structures developed under Integrated Child Development Services (ICDS) of the Union Ministry of Women and Child Development, ii) New ICDS structures and, iii) temporary structures with ad hoc arrangements for cooking.

Typical old ICDS structures

The anganwadi consists of a raised, square brick building roughly about 20 ft in length. The roof is covered with tiles supported by wooden cross-cutting beams. At one corner of the building, there are 3–5 stairs leading up to a small 6×6 ft porch. The porch opens up to two rooms. The larger of the two rooms has dimensions of roughly 14×20 ft, with two windows. This is the classroom. The other room is the store/kitchen, roughly 6×14 ft. This is where the stove is usually located, but not always. In some cases, stoves are placed on the porch

Cooking inside a new ICDS type building

or even inside the classroom with the children sitting in the same room. This is a worrying trend.

There is usually an open ground next to the anganwadi building with a hand-pump. There are no usable toilets. In some cases, sevikas have also mentioned that there was no hand-pump and that they had to fetch water from far away for cooking purposes. Sometimes they took help of the female children.

Typical new ICDS building structure

The anganwadi consists of a raised and square concrete building roughly about 30 ft in length. The roof is made of concrete. The entry is through the classroom, which is about 20×30 ft large. There is a door on the wall opposite the entry, which leads to an open-to-air courtyard about 10×15 ft in size. The courtyard contains a hand-pump and is surrounded by a seven ft-high concrete wall. But in some anganwadis hand pumps are missing. There are two other doors leading to a kitchen, 15×6 ft and a toilet, 10×4 ft.

The kitchen has a window on the opposite wall and a concrete platform runs along the wall. Across the entire sample, not a single working toilet was seen. Ironically, in several cases the toilets have become stores for firewood and dung cakes for midday meals. Most "toilets" are used as stores or they are vacant. There usually is an open ground near the anganwadi building. However, the sevikas said that the new structures do not provide for such space and in most cases it is private or common land.

A new ICDS anganwadi building with a courtyard

A new ICDS-type anganwadi classroom—spacious and well-lit

Ad hoc arrangements

In some cases, the anganwadis are temporary structures organised in an ad hoc manner. They are temporary, meant only to be used until the district administration builds a new building to house the anganwadi centre. These anganwadis are situated in old, non-permanent structures made of wood, dung and mud. They are of varying sizes. The roof is either thatched or made of tiles supported by wooden beams. These structures are often poorly lit with inadequate ventilation. The children sit in rows, bunched close to each other, and the food is often cooked on stoves placed within the structure. Some structures have a shaded space outside, where the children are seated during winters. Only in one case was an ad hoc anganwadi centre operational in one of the rooms of a concrete structure, which also was the residence of the sevika.

The stoves

Stoves in most anganwadis are manually-built brick and mud structures reinforced with clay. They have an opening on two sides, one for adding solid fuel and the other for letting the smoke escape. These can be categorised as natural draft fire stoves. They are usually built by the sahayika who consult the sevika about the placement of the stove. A single stove can last about 6–8 months.

Anganwadi centre running in an ad hoc structure

Improperly ventilated rooms are quickly filled with smoke which remains trapped with the children for at least two hours

The placement of the stove and the direction in which the door opens make a significant difference in the levels of exposure. In at least 16 per cent of the sample cases, especially in the new ICDS building structures, the stove has been found placed in the open courtyard. This allows free ventilation and, depending on the direction of the wind, the smoke either blows away from the *anganwadi*, or blows into the classroom. Similarly, in some of the ad hoc anganwadis, stoves are kept in the same room as the children. Where the rooms are not properly ventilated, smoke fills them up quickly and remains trapped with the children for at least two hours.

In a few cases, the doors of the classroom and the kitchen/courtyard open in the same direction. The doors are such that at least one of the doors remains shut at all times. This has an immediate effect on the levels of particulate matter, reducing exposure of children to the air pollution from the kitchen.

5. The results

Very high pollution exposure

The average hourly $PM_{2.5}$ concentration across the sample units was 2,524 µg per cubic metre; for just PM_{10}, it was 2,600 µg per cubic metre. Within the sample, individual anganwadis showed tremendous variations, ranging from 84 to 13,700 µg per cubic metre for $PM_{2.5}$ (time weighted average of measurements close to the stove and close to the children), and from 95 to 13,800 µg per cubic metre for PM_{10}. All values are time weighted average of measurements close to the stove and close to the children.

The National Ambient Air Quality Standards for 24 hours average concentration of $PM_{2.5}$ and PM_{10} are 60 and 100 µg per cubic metre respectively. But these standards are not directly comparable with indoor concentrations. It must be noted that as per CSE measurements, indoor concentration levels were found to be several times higher than the ambient standards.

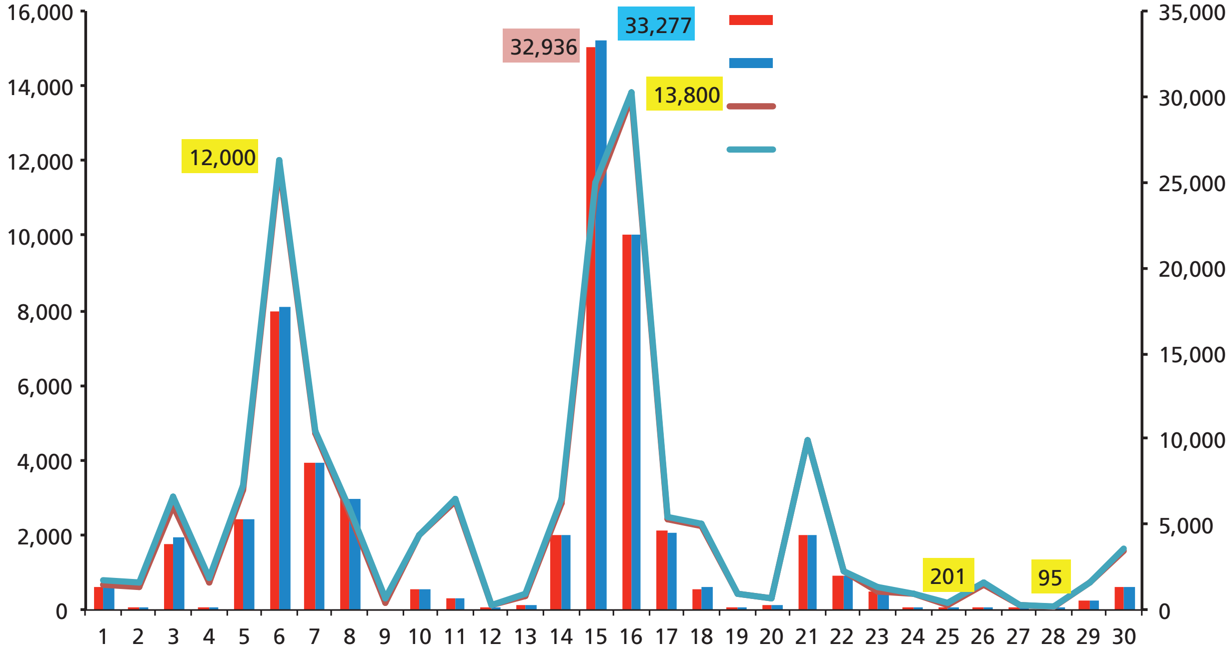
This study has not separately surveyed incidence of diseases and status of child health in the anganwadis. However, during the rapid baseline monitoring, the sevikas reported prolonged absenteeism among children due to ill-health. According to one sahayika, midday meal in the anganwadis is a big incentive to ensure attendance; In fact, sometime sick children are brought to the anganwadi centres around lunchtime to ensure they get a meal. A few sevikas observed that children show greater irritability (excessive crying, restlessness) when chulhas are operational. They have noted respiratory illness to be common among these children.

Particulate levels close to the stoves

The average difference between particulate concentrations at source was significant. Some of the larger differences can be explained by extreme lack of ventilation, as seen in the case of a few anganwadis where the stove is kept in the kitchen with the doors and windows shut. In such a closed environment, the level of PM is extremely high.

Factors such as distance, physical structure and wind are key determinants. In a few cases, the stove is kept next to the children. In some cases, it is kept next to an open window, and depending on the direction of the wind, the smoke either blows into the classroom, exposing the children, or it blows out. Similarly, in case of one particular ad hoc anganwadi, the stove was kept not more than three feet away from the children. In some structures, children are seated outside the classroom in winters and inside during summers and monsoons, right next to where cooking is carried out. There is variation in particulate concentrations ($PM_{2.5}$ and PM_{10}) between direct stove exposure and exposure for children in the classroom (see *Graph 2: Average direct stove exposure and real exposure for children*).

Graph 2: Average direct stove exposure and real exposure for children



Variation in factors such as wind speed and direction, ventilation conditions and structure of the building, amongst others, can reduce or increase exposure levels drastically (see *Table in Annex 3*). On an average, the concentration of $PM_{2.5}$ is found to be 573 per cent higher for direct stove exposure, than the real exposure for children. Across the sample, the average $PM_{2.5}$ concentration for direct stove exposure was found to be as high as 4,906 µg per cubic metre (see *Table 1: Particulate matter concentration for direct stove and real exposure of children*). In comparison, the average $PM_{2.5}$ concentration for real exposure of children across the sample was found to be seven times lower, at 729 µg per cubic metre. It must be noted, however that this lower figure is still significantly higher than the ambient concentration.

Table 1: Particulate matter concentration for direct stove and real exposure of children

$PM_{2.5}$			PM_{10}			Difference between stove area and children area (in per cent)	
Overall average	Direct stove exposure (one hour average)	Real exposure of children (one hour average)	Overall average	Direct stove exposure (one hour average)	Real exposure of children (one hour average)	$PM_{2.5}$	PM_{10}
2,524	4,906	729	2,600	5,008	797	573	528

Source: Centre for Science and Environment, 2016

Pollution level according to building structure

Old ICDS structure buildings have the highest average particulate concentrations. The older ICDS structures have a common open platform at the entrance of the building, which leads to the classroom and the kitchen. This common opening also allows smoke to freely enter the classroom. For instance, at the anganwadi centre in the Kesapi village, the stove was kept inside the kitchen, and a combination of wood and dung-cake was used as fuel. A small amount of dung-cake was heaped into the kitchen, and the sahayika brought out a bundle of firewood with her. Although the kitchen has a large window, which was opened during cooking, much of the smoke blew freely into the classroom through the open doorway. The $PM_{2.5}$ concentration for direct stove exposure was observed to be as high as 19,081 µg per cubic metre, and the real exposure of children 1,588 µg per cubic metre.

New ICDS structures show several notable improvements over the older structure, most notably the open courtyard. The new structures also allow more flexibility. For example, the platform in the kitchen allows for a raised cooking surface, and storage underneath. Similarly, the new structure also has dedicated space and provisions for sanitation. Most sahayikas said that they preferred to place the stove in the courtyard, since it helped in diverting the smoke away from their face and eyes. While outdoor cooking may help reduce the stress of cooking, scientists are of the opinion that even with this type of cooking the overall exposure remains high.

During rains, the stoves are brought inside the kitchen (see *Graph 3: Particulate concentration according to building type*). In village Nawadi, the anganwadi centre made use of dung-cakes as fuel, which caused a lot of dense white smoke in the initial stages of kindling. Once it caught fire, the smoke was reduced a little. The stove was kept in the open courtyard behind the classroom. Strong crosswinds blew some of the smoke back into the classroom. Dung-cakes were stored in the toilet; the latrine facilities were, therefore, blocked by the heaped dung-cake.

Many of the ad hoc spaces have completely variable usage patterns, depending

Graph 3: Particulate concentrations in different building type

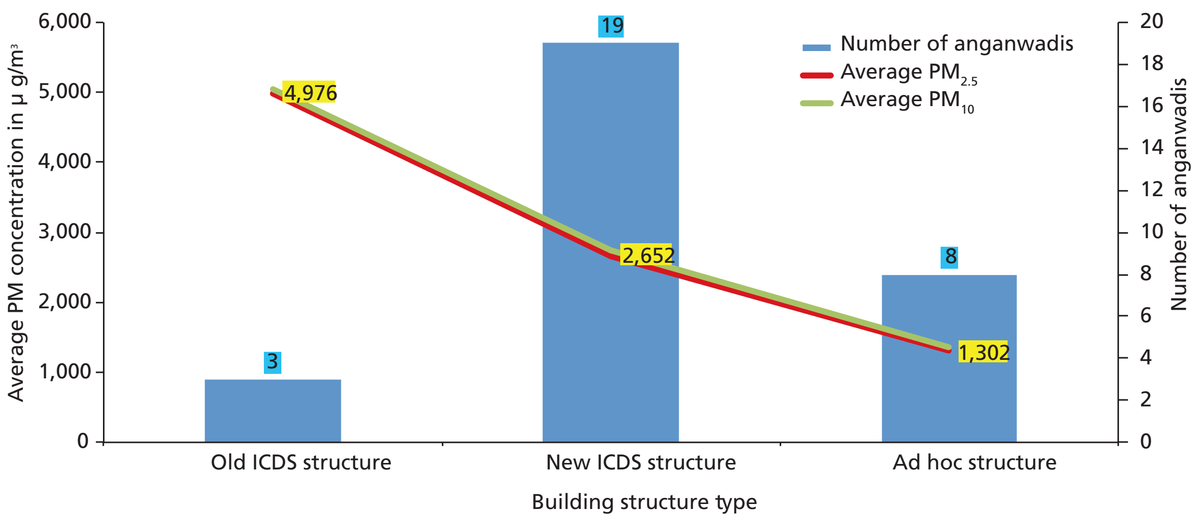


Table 2: Particulate emissions according to the type of fuel

No. of anganwadis	Fuel type	$PM_{2.5}$ hourly average	PM_{10} hourly average
8	Dung-cake	4,228	4,323
5	Wood	2,430	2,510
11	Dung-cake+wood	2,283	2,357
1	Arhar tree stalks	763	835
2	Palm, banana leaves	236	301
1	Bamboo	1,020	1,040
2	Plastic, paper	1,195	1,124

on the season, temperature and circumstances. In some anganwadis, the stove was also kept outside in the open during monitoring, which may or may not have reflected the regular usage pattern. For instance, in Chakla Jayarampur, the Anganwadi centre was located in a single room concrete structure with windows on two sides and a door on one side. There were large covered verandas outside. The sevika informed that the children sometimes sit outside on the verandas. But during the air quality monitoring, the children were sitting inside the room where the cooking was taking place.

Pollution according to fuel type

The particulate concentrations of stoves that exclusively use wood are comparatively lower than those using dung-cakes. Dung-cakes are more widely available, more accessible and easier to transport. In comparison, firewood use is not usually uniform across anganwadis. Some use loose sticks and small branches, while others use commercially available chopped firewood (see *Table 2: Particulate emissions according to the type of fuel*). There is also a large difference in prices between dung-cakes and the various types of firewood.

The type of fuel most commonly used is a combination of the two. Usually, dung-cakes are used to stoke the fire, as they are easily flammable. The anganwadis receive funding from the district education office for purchasing firewood.

In the village of Dharampur Shrichak, the anganwadi centre used only wood as fuel for cooking. The cooking stove was kept in the open courtyard, behind the classroom. Firewood was stockpiled in a small heap in the kitchen. The classroom had a window, but it remained shut. Its opening would allow a cross-breeze through the classroom.

Dry coconut palm leaves and husk are also used a fuel at some places. Bamboo was readily available in one anganwadi centre situated close to a water body, so dry bamboo was used in place of firewood.

It is worrying to note that in many centres, cardboard, newspaper and even polythene bags are used as cooking fuel. At the anganwadi centre in village Dak Bangla, the children share the room with a chulha which uses plastic and other rubbish as ignition fuel, and old newspapers to keep the flames alive. The $PM_{2.5}$ for direct stove exposure was 2,424 µg per cubic metre and the real exposure of the children was 1,176 µg per cubic metre. The variation within a single room was because of five windows and an open door which helped in ventilation. Despite this, the levels of exposure were alarmingly high.

The highest average particulate concentrations are seen in anganwadis that operate cooking stoves using dung-cake as fuel. Alternate solid fuels, such as bamboo or palm leaves, have varying effects on particulate concentrations, but in every case the average particulate concentration is at least three times higher than the maximum permissible ambient levels.

Now that the roll-out of LPG cylinders to these anganwadis has started, the sevikas and sahayaks are getting familiar with the use and operation of the LPG-based cooking stoves. This is important to address some safety concerns that were expressed by the sevikas during the baseline assessment regarding the use of LPG cylinders. These safety concerns have been cited as a sociological barrier to the wider use of LPG as a domestic fuel in the Gaya district.

Wherever LPG has already been introduced, all sevikas have noted visible improvement and have expressed satisfaction. While this has improved ease and comfort of cooking, it has also reduced exposure to harmful pollutants. It may be noted that accessibility to LPG always does not ensure use and the conditions for a community-wide transition will need to be facilitated in the long-term.

Learning from the assessment

Children enrolled in the anganwadis spent a significant part of their day in them. Even though these centres take care of their nutritional requirements, exposing children to unacceptable levels of toxic fumes can have very serious health consequences. These children are already highly exposed in their homes, where solid fuel is the norm. It is important to ensure that it becomes public policy that state support for child nutrition must be provided based on clean fuels. The harmful effects on the children's physiological and mental growth are completely preventable and must be avoided.

The rapid monitoring has shown extremely high levels of exposure for both sevikas and children. Across the sample population, the average hourly $PM_{2.5}$ concentration has been found to be around 2,524 µg per cubic metre. For PM_{10}, the average hourly concentration is 2,600 µg per cubic metre. Both these levels are unacceptably high. They are significantly higher than the outdoor ambient levels.

What further aggravates the problem is the design of the buildings of the anganwadi centres. There are different building typologies that influence the ventilation and inflow and outflow of pollution and, therefore, the concentration. In anganwadis where cooking is carried out in the same room where children are, highest levels of exposure have been observed. Such practices will have to be stopped immediately across states. In other anganwadis, the levels in the area children sit in are comparatively lower than those in close proximity to the stoves, but even that is unacceptably high. Placing of stoves is crucial to moderate the direction of flow of the smoke. In some of the cleaner anganwadis, the mouth of the stove has been placed in such a manner that the smoke blows away from the classroom. But that is still contributing to pollution in the vicinity. There is often a general impression that cooking outside is better. But from children's health perspective, the levels that have been noted in the vicinity of the anganwadis are very high and harmful.

The Steering Committee on Air Pollution and Health Related Issues set up by the Union Ministry of Health has noted that many of the technologies used in the earlier or more recent models of ‘improved’ biomass cooking stoves do not reduce emissions significantly enough to truly offer a healthy alternative. Dropping exposures from 350 to 175 μg per cubic metre, for example, is not likely to produce much risk reduction, particularly compared to reaching the Indian standards of 60 μg per cubic metre or even lower. Kalpana Balakrishna put the issue in perspective thus, “The problem lies not just in the stoves but also in solid fuels themselves, that burn very inefficiently. Our technological know-how does not allow us to build a stove that burns fuel efficiently enough to match WHO standards in the Rs 2,000–3,000 range. In trying for greater efficiency, the costs often shoot up. The need of the hour is to move to cleaner fuels like LPG and electricity.”

In India, the focus of resolving children’s health issues has for long been on curative measures, such as nutrition schemes, improved access to healthcare, immunisation and inoculation. It is time that we put our resources and focus on the preventive element of children’s health. Unless there is a community-wide movement towards cleaner fuels, any strategic intervention will need constant monitoring and external micro-management to show the intended effects.

Central Board of Pollution Control’s 2008 study on children’s health recommended that since children’s health is most acutely affected by exposure to air pollution, potential adverse effects of air pollution on the foetus, infant and child should be the main consideration while establishing standards for an air pollutant as well as during revision of existing standards, and there should be a sufficient margin of safety. This is especially important considering that we have no standards for indoor air pollutant concentrations.

The way forward

This assessment has demonstrated the merit of switching to clean fuels for cooking to protect child health. The midday meal schemes can be a win–win formula where strategies for improvement in nutritional status of children can be combined with clean fuel transition to reduce toxic risk and protect health.

It should be stated without any ambiguity that only access to clean fuels including LPG and electricity can help to cut down health risk of children and women. Based on the pilot project, the Bihar government will be well-advised to quicken state-wide implementation of the LPG programme in all anganwadis and schools that provide midday meals.

In the meantime, step should be taken to improve building design of anganwadis to improve ventilation, separate the cooking area from the classroom, take smoke out of the classrooms, and eliminate use of plastics and trash for stoking fire.

Schools and anganwadis should be places where children come to inhale knowledge, not toxic fumes.

Annexure 1: Average PM concentration for sample population (in µg/m³)

Name of anganwadi centre	Building structure type	Hourly average $PM_{2.5}$ concentration	Hourly average PM_{10} concentration	Fuel type
Pandari	New ICDS	672	816	Dungcake
Dharampur Shrichak	New ICDS	608	712	Wood
Ghungwa	New ICDS	2,790	3,050	Dungcake
Bishunpur	New ICDS	763	835	Arhar tree stalks
Nawadi II	New ICDS	3,210	3,320	Dungcake
Kesapi I	Old ICDS	11,900	12,000	Dungcake + wood
Kesapi II	New ICDS	4,730	4,760	Dungcake
Kesapi III	Old ICDS	2,620	2,697	Dungcake
Mahkar	New ICDS	179	295	Dungcake + wood
Dak Bangla	Ad hoc	1,980	2,010	Plastic, paper
Chakla Jayarampur	Ad hoc	2,900	2,960	Dungcake + wood
Mungesharpur	New ICDS	126	150	Palm + banana leaves
Ghirsindi	Ad hoc	346	452	Palm + banana leaves
Musehna II	Ad hoc	2,850	2,960	Dungcake + wood
Musehna I	New ICDS	11,200	11,400	Wood
Sundarkumhari	New ICDS	13,700	13,800	Dungcake
Kurumava II	New ICDS	2,396	2,468	Dungcake + wood
Kurumava II	New ICDS	2,250	2,330	Dungcake + wood
Trilokpura	Old ICDS	409	445	Plastic, paper
Bundabigha	New ICDS	290	331	Dungcake + wood
Nigri Manipar	New ICDS	4,510	4,530	Dungcake
Surajmandal	Ad hoc	1,020	1,040	Bamboo
Musehni	Ad hoc	504	612	Dungcake + wood
Chanda	New ICDS	413	463	Dungcake + wood
Kalyanpur	New ICDS	142	201	Wood
Patti	New ICDS	702	761	Dungcake + wood
Bhelwa	New ICDS	116	141	Wood
Karpurinagar	Ad hoc	84	95	Wood
Aganada	Ad hoc	728	747	Dungcake + wood
Bhalua	New ICDS	1,590	1,610	Dungcake
Average		2,524	2,600	

Annexure 2: Average PM concentration across spatial variations (proximity) (in μg/m³)

Name of anganwadi centre	$PM_{2.5}$ hourly average			PM_{10} hourly average			Difference in hourly average near stove vs near children (as per cent of near children)	
	Overall average	Directly near stove	Near children	Overall average	Directly near stove	Near children	$PM_{2.5}$	PM_{10}
Pandari	672	1,462	146	816	1,585	302	901	425
Dharampur Shrichak	608	641	542	712	737	667	18	10
Ghungwa	2,790	4,777	942	3,050	5,231	1,047	407	400
Bishunpur	763	840	663	835	914	731	27	25
Nawadi II	3,210	6,137	870	3,320	6,283	956	605	557
Kesapi I	11,900	19,081	1,588	12,000	19,352	1,664	1,102	1,063
Kesapi II	4,730	8,773	112	4,760	8,804	149	7,733	5,809
Kesapi III	2,620	6,638	179	2,697	6,707	272	3,608	2,366
Mahkar	179	NA	179	295	NA	295	NA[1]	NA
Dak Bangla	1,980	2,424	1,176	2,010	2,444	1,234	106	98
Chakla Jayarampur	2,900	3,286	2,586	2,960	3,321	2,663	27	25
Mungesharpur	126	149	115	150	170	141	30	21
Ghirsindi	346	543	241	452	651	346	125	88
Musehna II	2,850	5,198	870	2,960	5,301	977	497	443
Musehna I	11,200	33,385	449	11,400	33,845	568	7,335	5,859
Sundarkumhari	13,700	24,855	2,946	13,800	24,976	3,035	744	723
Kurumava II	2,396	4,880	224	2,468	4,911	361	2,079	1,260
Kurumava II	2,250	3,025	1,798	2,330	3,136	1,853	68	69
Trilokpura	409	540	344	445	566	384	57	47
Bundabigha	290	447	212	331	527	234	111	125
Nigri Manipar	4,510	6,763	2,435	4,530	6,872	2,457	178	180
Surajmandal	1,020	2,312	305	1,040	2,328	323	658	621
Musehni	504	1,185	163	612	1,346	244	627	452
Chanda	413	438	394	463	480	449	11	7
Kalyanpur	142	226	100	201	296	153	126	93
Patti	702	746	670	761	825	712	11	16
Bhelwa	116	163	92	141	211	107	77	97
Karpurinagar	84	87	83	95	99	93	5	6
Aganada	728	1,074	556	747	1,093	574	93	90
Bhalua	1,590	2,193	903	1,610	2,220	924	143	140
Average	2,524	4,906	729	2,600	5,008	797	573	528

1 For this particular anganwadi, the stove is kept in immediate vicinity (within 5 ft) of the children in a small room. In other cases, measurement was taken at the distance where the furthest child from the stove was.

Annexure 3: Average PM concentration across fuel type (in µg/m³)

Number of anganwadis	Fuel legend	$PM_{2.5}$ hourly average			PM_{10} hourly average		
		Overall average	Directly near stove	Near children	Overall average	Directly near stove	Near children
8	Dungcake	4,228	7,700	1,067	4,323	7,835	1,143
5	Wood	2,430	6,900	253	2,510	7,038	318
11	Dungcake+wood	2,283	3,936	840	2,357	4,029	912
1	Arhar tree stalks	763	840	663	835	914	731
2	Palm+banana leaves	236	346	178	301	411	244
1	Bamboo	1,020	2,312	305	1,040	2,328	323
2	Plastic, paper	1,195	1,482	760	1,124	1,505	809

Annexure 4: Average PM concentration across building structure type

Number of anganwadis	Anganwadi building structure type	$PM_{2.5}$ hourly average			PM_{10} hourly average		
		Overall average	Directly near stove	Near children	Overall average	Directly near stove	Near children
3	Old ICDS structure	4,976	8,753	704	5,047	8,875	773
19	New ICDS structure	2,652	5,550	726	2,735	5,668	797
8	Ad hoc structure	1,302	2,014	748	1,360	2,073	807

References

Anon. 2005. *Burden of Disease in India.* National Commission of Macroeconomics and Health, Ministry of Health and Family Welfare, New Delhi.

Anon. 2016. “Cut bad air or face the music”, Delhi City News, TNN, New Delhi. Available at http://timesofindia.indiatimes.com/city/delhi/Cut-bad-air-or-face-the-music/articleshow/53440664.cms as accessed on August 1, 2016.

Anon, 2016. *Clean and Efficient Bioenergy Cookstoves: WBA Factsheet* . World Bioenergy Association, Stockholm.

Anon. 2007. *Indoor Air Pollution: Global Burden of Diseases Estimates.*World Health Organisation, Geneva.

Anon, 2007. *National Family Health Survey (NFHS-3), 2005–06: India: Volume I.* International Institute for Population Sciences (IIPS) and Macro International, Mumbai.

Anon. 2015. *Report of the Steering Committee on Health related issues on Air Pollution and Health Related Issues.* Ministry of Health and Family Welfare, New Delhi.

Anon, 2008. *Study on Ambient Air Quality, Respiratory Symptoms and Lung Function of Children in Delhi.* Central Pollution Control Board, Ministry of Environment and Forests, New Delhi.

Anon. 2016. *What’s health got to do with it? Testing marketing messages for clean cookstoves in Cambodia and Kenya.* Stockholm Environment Institute, Stockholm.

Balakrishna, K., Ghosh, S., Ganguli, B., Sambandam, S., Bruce, N. G., Barnes, D. F., et al. 2013. “State and national household concentrations of PM2.5 from solid cookfuel use: results from measurements and modeling in India for estimation of the global burden of disease”*, Environmental health : a global access science source* , 77.

Bassani, D. G., Jha, P., Dhingra, N., & Kumar, R. 2010. “Child mortality from solid-fuel use in India: a nationally-representative case-control study”. *Biomedical Central* .

Bassani, D. G., Kumar, R., Awasthi, S., Morris, S. K., Paul, V. K., Shet, A., et al. 2010. “Causes of neonatal and child mortality in India: nationally representative mortality survey”. *Maryland: Lancet.*

Gilliland, F. D., McConnell, R., Peters, J., & Gong, H. J. 1999. “A theoretical basis for investigating ambient air pollution and children’s respiratory health”. *Environmental Health Perspectives* , 403-407.

Mutlu, E., Warren, S. H., Ebersviller, S. M., Kooter, I. M., Schmid, J. M., Dye, J. A., et al. 2016. “Mutagenicity and Pollutant Emission Factors of Solid-Fuel Cookstoves: Comparison with Other Combustion Sources”. *Environmental Health Perspectives* , 974-982.

Pratap Pandey, Sunita Narain. 2015. *Anil Agarwal Reader: The Poor in Climate Change.* Anil Agarwal Dialogue 2015, Centre for Science and Environment, New Delhi.

Putti, V. R., Tsan, M., Mehta, S., & Kammila, S. 2015. *The State of Global Clean and Improved Cooking Sector.* World Bank.

Centre for Science and Environment
41, Tughlakabad Institutional Area,
New Delhi 110 062 Phones: 91-11-40616000
Fax: 91-11-29955879 E-mail: cse@cseindia.org
Website: www.cseindia.org