

**IMPACT OF HOUSEHOLD AIR POLLUTION EXPOSURE
ON BLOOD PRESSURE AND FASTING BLOOD SUGAR
IN ADULTS**

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DECLARATION

I hereby declare that this dissertation titled “**Impact of household air pollution exposure on blood pressure and fasting blood sugar in adults**” is a bonafide record of my original research. It has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published and unpublished work of others has been duly acknowledged in the text.

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June 2024

CERTIFICATE

Certified that the dissertation titled - **“Impact of household air pollution exposure on blood pressure and fasting blood sugar in adults”** is a record of the research work undertaken by Dr. G Vaishnavi, in partial fulfilment of the requirements for the award of the degree of Master of Public Health under my guidance and supervision.

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GLOSSARY OF ABBREVIATIONS

APL	Above Poverty Line
ACCESS	Access to Clean Cooking Energy and Electricity – Survey of States
BPL	Below Poverty Line
BMI	Body Mass Index
CO	Carbon Monoxide
CVD	Cardiovascular Disease
CEBs	Census Enumeration Blocks
COPD	Chronic Obstructive Pulmonary Disease
CDB	Community Development Blocks
DHS	Demographic and Health Survey
DM	Diabetes Mellitus
DBP	Diastolic Blood Pressure
DALYs	Disability-Adjusted Life Years
FBS	Fasting Blood Sugar
HAP	Household Air Pollution
IEC	Institutional Ethics Committee
LPG	Liquefied Petroleum Gas
LMICs	Low- and Middle-Income Countries
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MoHFW	Ministry of Health and Family Welfare
NFHS-5	National Family Health Survey-5
PM	Particulate Matter
PSUs	Primary Sampling Units
PI	Principal Investigator
PPS	Probability Proportional to Size
SD	Standard Deviation
SBP	Systolic Blood Pressure
WHO	World Health Organization

ABSTRACT

Background: Household air pollution from solid fuels is a global public health concern and a risk factor for cardiometabolic diseases. However, the impact of household air pollution on blood pressure and fasting blood sugar shows mixed results, highlighting the need for further studies to clarify its effects.

Methods: A cross-sectional study was conducted among 226 participants aged 18–69 years from 162 households in Pathanamthitta district, Kerala. A structured interview schedule was administered. Blood pressure, fasting blood sugar, and household air pollutants (PM_{2.5} and PM₁₀) were measured. The NFHS-5 data (2019–2020) from 1,646,097 individuals with primary cooking fuel type as a proxy for household air pollution exposure were also analyzed. Multivariable regression models were employed to explore the independent association between the type of cooking fuel (a proxy for household air pollution) and blood pressure/ fasting blood sugar.

Results: The study population's mean age (SD) was 51.3 ± 11.9 years. The mean PM_{2.5} concentration was substantially lower ($75.15 \mu\text{g}/\text{m}^3$) in clean fuel users compared to solid fuel users ($85.83 \mu\text{g}/\text{m}^3$). Participants exposed to PM_{2.5} $>75 \mu\text{g}/\text{m}^3$ had 2.35 mmHg higher mean systolic blood pressure (95% CI: -1.98, 7.04) and 1.66 mmHg higher mean diastolic blood pressure (95% CI: -0.86, 4.33) compared to those exposed to PM_{2.5} $\leq 75 \mu\text{g}/\text{m}^3$, after adjusting for potential confounders. Mean fasting blood glucose levels did not vary according to household air pollution exposure. In the NFHS-5 study, individuals exposed to solid fuels had higher mean systolic blood pressure (1.50 mmHg, 95% CI: 1.37, 1.62) and diastolic blood pressure (0.401 mmHg, 95% CI: 0.31, 0.48) compared to those using only clean fuels, after adjusting for potential confounders.

Conclusion: Our findings suggest that solid fuel use is associated with increased household air pollution and higher mean systolic and diastolic blood pressure. Comprehensive strategies focused on transitioning households from solid fuel to clean fuel usage to improve indoor air quality will result in substantial exposure reductions and health benefits for the population. A moderate decrease in mean systolic blood pressure (~ 2 mmHg) at the population level will yield substantial public health savings in terms of up to 10% reduction in cardiovascular mortality and morbidity.

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Background

Household air pollution resulting from the combustion of solid fuels, including biomass (such as wood and crop residues), coal, and kerosene, for heating or cooking using open fires or cookstoves with limited ventilation is a global public health concern (State of Global Air, 2020). Unlike ambient air pollution, which may disperse over larger areas, pollutants within households tend to concentrate in their enclosed spaces and can considerably adversely impact health. Globally, it is estimated that household air pollution accounts for approximately 12 to 30 percent of ambient air pollution (Chowdhury et al., 2023).

In recent decades, there has been a decline in the use of solid fuels in low- and middle-income countries, reflecting an increase in access to clean fuel and technologies (such as biogas, natural gas, liquefied petroleum gas (LPG), electricity, and clean cookstoves). Although approximately 2.4 billion people worldwide still rely on solid fuels for cooking and heating (State of Global Air, 2020; Chowdhury et al., 2023).

Every year, around 3.2 million people die prematurely as a result of illnesses caused by household air pollution. Exposure to household air pollution contributes to a range of health outcomes, such as lower respiratory infection, chronic obstructive pulmonary disease (COPD), cardiovascular disease, diabetes, lung cancer, ophthalmic complications, and skin diseases (WHO, 2023). The burning of solid fuels produces a complex of pollutants such as particulate matter (PM_{2.5} and PM₁₀), carbon monoxide (CO), and black carbon (Turner et al., 2020). Among the various pollutants, fine particulate matter (PM_{2.5}) has been

identified as having the most substantial adverse effects. It can reach the systemic circulation and cause autonomic imbalance, chronic inflammation, oxidative stress, endothelial dysfunction, and impaired glucose metabolism, all of which can lead to the development of cardiometabolic risk factors such as high blood pressure and high fasting blood sugar (Rajagopalan et al., 2018). Consequently, prolonged exposure to high mean PM_{2.5} concentrations over several years has been a reliable predictor of mortality from cardiovascular, respiratory, and other disorders (State of Global Air, 2020).

Ensuring universal access to clean fuels and technologies for cooking by 2030 is a crucial target under Sustainable Development Goal 7. However, ‘Fuel stacking’ or the simultaneous use of both clean and solid fuels by households is the norm in many developing countries. A study conducted as part of the Access to Clean Cooking Energy and Electricity Survey of States (ACCESS Survey) in 2014–15 reported that only four percent of LPG-owning households used the fuel exclusively, whereas the rest of the majority of Indian households used a combination of LPG and solid fuels for cooking purposes (Gould and Urpelainen, 2018). This often leads to exposures that exceed the recommended values of the World Health Organization’s indoor air quality guidelines for a 24-hour mean PM_{2.5} concentration of 15 µg/m³ and an interim target-1 guideline of 75 µg/m³ (WHO Global Air Quality Guidelines, 2021).

While growing epidemiological evidence indicates that household air pollution substantially contributes to the rising global burden of cardiovascular diseases and overall mortality, few studies have investigated the association between household air pollution and fasting blood sugar (Zheng et al., 2021). Similarly, the studies suggesting the association between household air pollution and blood pressure are also limited and report inconsistent findings (Baumgartner et al., 2018; Young et al., 2019). This variability in findings is influenced by factors such as fuel type, exposure patterns, exposure time, and

‘sources of household air pollution, which differ across countries and regions (Arku et al., 2020; Tawiah et al., 2022). Moreover, most studies focus on self-reported solid fuel usage as a proxy for household air pollution exposure rather than direct quantitative measurements of air pollutants, indicating a need for further investigation in this area.

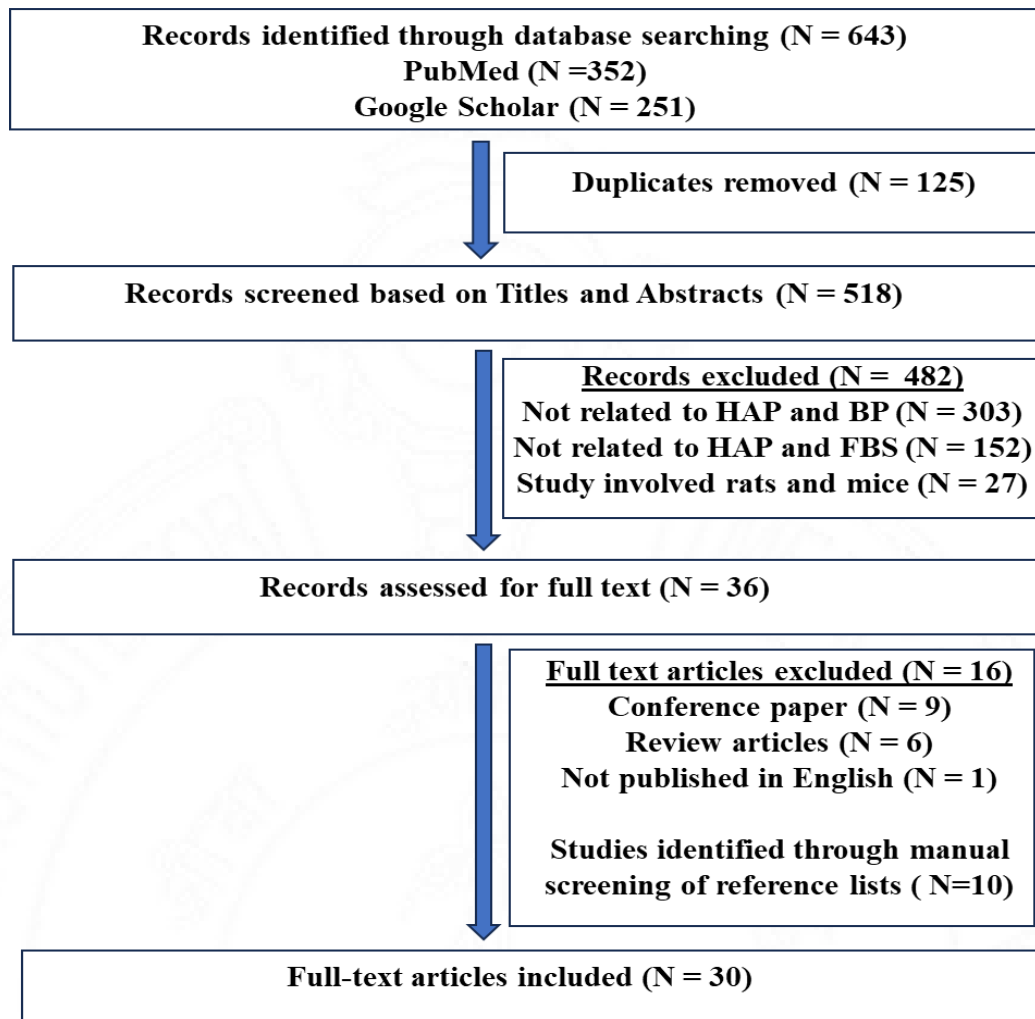
This study aims to explore the association between quantitative exposure measurement of PM_{2.5} levels from different cooking fuel types and their influence on blood pressure and fasting blood sugar among adults. The study also aims to assess the impact of solid fuel-induced household air pollution on blood pressure and fasting blood sugar at the national level using the National Family Health Survey-5 data set.

1.2 Literature Review Process

The literature review aims to identify relevant publications showing the association between cooking fuel use and household air pollution exposure with blood pressure and fasting blood sugar, which are risk factors for cardiometabolic diseases. It will also identify literature gaps and suggest future research directions.

A literature review was conducted by searching academic databases such as PubMed and Google Scholar for relevant articles published between 2005 and 2023. Keywords used in the search engine included “Household air pollution,” “Indoor air pollution,” “Solid fuel,” “Biomass fuel,” “Particulate matter,” “Household PM_{2.5}”, for exposure variable, and “Blood pressure,” “Hypertension,” “Fasting blood sugar,” “Fasting blood glucose,” “Diabetes,” “Glycemic markers,” “Glucose metabolism,” for the outcome variable. In addition, the bibliography section of each article was looked at to recognize studies that might have been left out during the database search.

Figure 1.1: Flowchart of the literature review process



*HAP–Household air pollution, BP–Blood pressure, FBS–Fasting blood sugar

1.3 Household Air Pollution

Household air pollution is now ranked ninth globally among the modifiable risk factors associated with the burden of cardiovascular diseases (Global Burden of Disease, 2019). It contributes to 6.67 million deaths, accounting for almost 12 percent of the total global population. Four percent of these deaths are attributable to household air pollution alone (State of Global Air, 2020). In India, 1.67 million deaths in 2019 were attributed to air pollution, representing 17.8 percent of the country's total deaths. Additionally, of these deaths, 0.6 million were explicitly linked to household air pollution (Pandey et al., 2021).

1.3.1 Household Air Pollution and Different Cooking Fuels

Achieving universal access to clean cooking, as stated in the 2030 Agenda for Sustainable Development, is prioritised, acknowledging the substantial burden caused by household air pollution (United Nations, 2021). According to the World Health Organisation, clean fuels and technologies for cooking include stoves/cookers using electricity, liquefied petroleum gas (LPG)/natural gas/biogas, solar, and alcohol/ethanol. Polluting fuels include unprocessed biomass (wood, crop residues, and dung), charcoal, coal, and kerosene. At the same time, polluting technologies refer to those stoves with emission rates higher than the recommended annual average air quality guideline level for PM_{2.5} of 5 µg/m³.

The household mean PM_{2.5} concentration levels vary greatly with different types of fuels used for cooking and heating purposes within households (Chen et al., 2020). Solid fuel is the largest source of household air pollution in low- and middle-income countries. Solid fuels include coal/lignite, charcoal, wood, straw/shrub/grass, processed biomass (pellets) or woodchips, garbage/plastic, crops, animal dung/waste, and sawdust (DHS Program, 2022). The incomplete combustion of these solid fuels leads to exposure to PM_{2.5} and other pollutants. The level of household air pollutants such as CO, PM_{2.5}, and PM₁₀ were found

to be significantly higher in kitchen and living areas of biomass or solid fuel users in comparison to LPG or other alternative fuel users (Hu et al., 2014; Chakraborty and Mondal, 2018; Mitra et al., 2023). Studies showing variations in mean PM_{2.5} concentration by fuel type are shown in Table 1.1. In Indian households, household air pollution from solid fuel use contributed to a mean PM_{2.5} concentration of 82.5 µg/m³ (Pandey et al., 2021).

The configuration of the kitchen, whether solid fuels are used indoors, outdoors, or in combination, also plays a crucial role in determining the spatial distribution and intensity of indoor air pollution exposures (Balakrishnan et al., 2013). Kitchen ventilation also plays a crucial role in determining pollution levels in the kitchen area (Mitra et al., 2023). While comparing the average indoor concentrations of PM_{2.5} and PM₁₀, rural areas had a higher concentration than urban areas due to biomass burning in rural areas (Shukla and Dutta, 2022).

Table 1.1: Studies on variations in mean PM_{2.5} concentration by fuel type

Authors	Study Setting	Study Design	Sample Size	Findings
Balakrishnan et al. (Balakrishnan et al., 2013)	Four states (Madhya Pradesh, Tamil Nadu, Uttaranchal, West Bengal), India	Cross-Sectional study	617 rural households	The mean 24-hour PM _{2.5} concentration in households using solid fuel ranged from 163 µg/m ³ (95% CI: 143,183) in the living area to 609 µg/m ³ (95% CI: 547,671) in the kitchen area.

Authors	Study Setting	Study Design	Sample Size	Findings
Hu et al. (Hu et al., 2014)	Xuanwei and Fuyuan, China	Observational study	163 women	Burning wood/ plant materials resulted in higher personnel PM _{2.5} concentration of 225 µg/m ³ compared to smokeless coal of 115 µg/m ³ .
Chakraborty and Mondal (Chakraborty and Mondal, 2018)	West Bengal, India	Cross-Sectional study	90 women (60 biomass and 30 LPG users)	The exposure assessment index of a median value of 2.13 was reported among biomass users, which was higher than 0.54 among LPG users.
Shukla and Dutta (Shukla and Dutta, 2022)	Lucknow, India	Cross-Sectional study	60 households	The rural households had a higher average PM _{2.5} concentration of 337 µg/m ³ than urban areas with an average PM _{2.5} concentration of 115.4 µg/m ³ .

Authors	Study Setting	Study Design	Sample Size	Findings
Mitra et al. (Mitra et al., 2023)	West Bengal, India	Cross- Sectional study	123 women (83 biomass and 40 clean fuel users)	The mean kitchen concentrations of CO, PM _{2.5} , and PM ₁₀ were significantly higher in biomass users than clean fuel users ($p < 0.001$).
CI: Confidence interval; CO: Carbon monoxide				

In developing countries, even with access to clean fuels and financial assistance, adopting and sustained use of cleaner fuel alternatives remains a challenge. The level of exposure to toxic emissions from biomass fuel also depends on improper ventilation and the lack of chimneys. A higher concentration of kitchen and personnel PM_{2.5} was measured in households using unvented stoves, indicating that proper chimneys and vented stoves effectively reduce household air pollution exposures (Hu et al., 2014; Aung et al., 2018). As an interim solution to this problem, an improved cookstove was introduced as a better alternative to traditional cookstoves. The improved cookstove has an added chimney feature, improved combustion, and more advanced combustion methods (Kshirsagar and Kalamkar, 2014).

Interventional studies were conducted to study the effectiveness of these improved cookstoves (Table 1.2). Different types of improved cookstoves were introduced according to the other study settings, such as 'Plancha stove', 'Rocket stove', and 'Justa stove' (McCracken et al., 2007; Aung et al., 2018; Benka-Coker et al., 2021).

Table 1.2: Interventional studies for reduction of household air pollution exposure

Authors	Study Setting	Sample Size	Exposure Variable	Findings
McCracken et al. (McCracken et al., 2007)	Guatemala, Central America	120 rural women (intervention group-49 women and control group-71 women)	Personnel average PM _{2.5} measurement	The average daily PM _{2.5} exposure in the control group was 264 µg/m ³ , while in the intervention group, it was 102 µg/m ³ .
Aung et al. (Aung et al., 2018)	Karnataka, India	187 women (intervention group-96 women and control group-91 women)	PM _{2.5} measurements	A higher 24-hour mean PM _{2.5} concentration of 139 µg/m ³ (95% CI: 61, 229) was reported in the control group, compared to 73 µg/m ³ (95% CI: -6, 156) in the intervention group.
Benka-Coker et al. (Benka-Coker et al., 2021)	Honduras, Central America	230 women (intervention group-115 women and control group-115 women)	Kitchen and personnel PM _{2.5} concentration	The median 24-hour PM _{2.5} exposure for the control group was 81 µg/m ³ (95% CI: 50, 141), while for the intervention group, it was 43 µg/m ³ (95% CI: 27, 73).
CI: Confidence interval				

1.3.2 Household Air Pollution and Blood Pressure

High blood pressure, or hypertension, is a global risk factor for cardiovascular disease and a significant cause of morbidity and mortality worldwide. Emerging evidence suggests that household air pollution increases the risk of developing cardiovascular diseases, including hypertension and other heart diseases, especially in low- and middle-income countries (LMICs) (Mohapatra et al., 2018). Cardiovascular disease (CVD) accounts for an estimated 0.3 million deaths and 9.5 million disability-adjusted life years (DALYs) caused by household air pollution globally (Lee et al., 2020).

In resource-constrained settings, where direct measurements of household air pollutants are often lacking, the self-reported primary cooking fuel type is commonly used as a proxy indicator for exposure to household air pollution. This approach is based on the premise that the use of solid fuels is associated with higher household air pollution levels than the use of clean fuels.

Several studies have examined the relationship between the type of cooking fuel used and blood pressure, as summarized in Table 1.3. A study that utilized nationally representative population-based data from Bangladesh found women living in households with access to solid cooking fuel were associated with elevated blood pressure and increased risk of having hypertension (Khan et al., 2021). Similarly, a multi-country study by Arku et al. (2018) reported a 16 percent increased risk of hypertension among individuals using solid fuel for cooking (Arku et al., 2018). The duration of exposure to different cooking fuels is also an essential factor when exploring the potential association between household air pollution exposure and blood pressure. A study in China found that long-term exposure to solid fuels was associated with a higher risk of cardiovascular events, indicating chronic toxicity related to solid fuel use (Lee et al., 2012).

Table 1.3: Studies associated with self-reported primary cooking fuel type and blood pressure

Authors	Study Setting	Study Design	Sample Size	Findings
Lee et al. (Lee et al., 2012)	Shanghai, China	Cross-Sectional study	14,068 adults	The odds of developing hypertension were 1.7 times higher (95% CI: 1.40, 0.7) among solid fuel users compared to non-solid fuel users.
Burroughs Peña et al. (Burroughs Peña et al., 2015)	Peru, South America	Cross-Sectional study	1004 participants	Biomass fuel users had a 7.0 mmHg higher systolic BP (95% CI: 4.4–9.6) and a 5.9 mmHg higher Diastolic BP (95% CI: 4.2–7.6) compared to non-biomass users.
Arku et al. (Arku et al., 2018)	10 LMICs	Cross-Sectional study	77,605 women	The primary use of solid fuel was associated with 0.58 mmHg higher systolic BP (95% CI: 0.23, 0.93) than the primary use of clean fuel.

Authors	Study Setting	Study Design	Sample Size	Findings
Mohapatra et al. (Mohapatra et al., 2018)	Odisha, India	Cross-Sectional study	193 women	Exposure to biomass fuel smoke is significantly associated with the prevalence of symptoms of hypertension.
Khan et al. (Khan et al., 2021)	Bangladesh	Cross-Sectional study	6543 women	Solid fuel users had significantly 3.76 mmHg higher systolic BP (95% CI: 2.00, 5.51) and 1.17 mmHg higher diastolic BP (95% CI: 0.17, 2.18) compared to clean fuel users.
BP: blood pressure, LMICs: low- and middle-income countries, CI: Confidence interval				

Although self-reported primary fuel type is commonly taken as a proxy for household air pollution exposure, it is limited as it fails to capture the nuances of actual pollutant concentrations experienced by individuals. Therefore, studies that directly measure PM_{2.5} concentration provide a more robust and quantifiable assessment of the dose-response relationship between household air pollution exposure and blood pressure. For a single 24-hour sample, the 24-hour kitchen PM_{2.5} may provide a more accurate picture of long-term exposure to solid fuel combustion than 24-hour personal PM_{2.5} exposures. Studies that have

directly measured mean PM_{2.5} concentrations and their association with blood pressure outcomes are presented in Table 1.4.

Emerging evidence suggests that age is a potential modifier of the relationship between household air pollution exposure and blood pressure. The association between household air pollution exposure and blood pressure levels was stronger among older women than among younger populations (Baumgartner et al., 2011; Young et al., 2019).

Table 1.4: Studies associated with mean PM_{2.5} concentrations and blood pressure

Authors	Study Setting	Study Design	Sample Size	Findings
Baumgartner et al. (Baumgartner et al., 2011)	Rural China	Cross-Sectional study	280 women	1 log µg/m ³ increase in PM _{2.5} exposure was associated with 2.2 mmHg higher systolic BP (95% CI: 0.8 to 3.7) and 0.5 mmHg higher diastolic BP (95% CI: -0.4 to 1.3) among all women.
Dutta et al. (Dutta et al., 2011)	West Bengal, India	Cross-Sectional study	480 women (244 biomass fuel users and 236 LPG users)	For every unit increase in PM _{2.5} exposure, the odds of developing hypertension increased 41% in biomass fuel users compared to LPG users.

Authors	Study Setting	Study Design	Sample Size	Findings
Young et al. (Young et al., 2019)	Honduras, Central America	Cross- Sectional study	147 women	For every unit increase in natural log-transformed kitchen PM _{2.5} concentration, adjusted mean systolic BP increased by 2.5 mmHg (95% CI, 0.7 to 4.3).
BP: blood pressure, CI: Confidence interval				

While an increasing number of studies have explored the association between solid fuel use and blood pressure or hypertension, there has been a lack of consistency in these previous studies, which has led to a variety of conflicting findings as the strength of the association varies across countries and regions depending upon the fuel type, exposure patterns, exposure time, and household air pollution sources. Some studies have reported inverse or no association between solid fuel use and blood pressure, as summarized in Table 1.5.

Table 1.5: Studies reporting inverse or no association between household air pollution and blood pressure

Authors	Study Setting	Study Design	Sample Size	Findings
Fatmi et al. (Fatmi et al., 2019)	Sindh, Pakistan	Cross- Sectional study	876 women (438 biomass fuel users and 438 non- biomass fuel users)	The odds of developing hypertension were the same between biomass and non-biomass fuel users. (OR: 1.0, 95% CI: 0.8, 1.4).

Authors	Study Setting	Study Design	Sample Size	Findings
Arku et al. (Arku et al., 2020)	10 Low, middle, and high-income Countries	Cross-Sectional study	43,313 participants	Individuals who used solid fuels for cooking had a lower systolic BP of 0.51 mmHg (95% CI: -0.99, -0.03) and a lower diastolic BP of 0.46 mmHg (95% CI: -0.75, -0.18) as compared to clean fuel users.
Tawiah et al. (Tawiah et al., 2022)	Ghana, West Africa	Cross-Sectional study	350 cooks	A decrease in 2.42 mmHg of systolic BP (95% CI: -8.65, 3.80) and 0.32 mmHg of diastolic BP (95% CI: -5.09, 4.45) was observed in solid fuel users compared to LPG users.
BP: Blood pressure, CI: Confidence interval, OR: Odds ratio				

Research suggests that even modest improvements in air quality can confer long-term health benefits (Chen et al., 2020). Lowering systolic blood pressure by as little as two mmHg could result in a 10 percent decrease in stroke mortality and a seven percent decrease in death from ischemic heart disease or other vascular causes (Young et al., 2019). Globally, there are initiatives to mitigate exposure to household air pollution by transitioning from traditional cookstoves to cleaner technologies, that either replace biomass fuel use with liquefied petroleum gas or electricity or effectively vent the smoke from biomass fuel

combustion out of the home. Studies have shown that using improved cookstoves over traditional cookstoves resulted in a decrease in blood pressure.

The substitution of solid fuels with clean energies would reduce personal PM_{2.5} exposure and systolic blood pressure by over 21 percent and 3.7 percent respectively. This highlights the need for effective intervention programs to mitigate household air pollution and safeguard the health of those living in high-risk environments. The findings from interventional studies on the impact of improved cookstoves on household air pollution and blood pressure reduction are summarized in Table 1.6.

Table 1.6: Interventional studies for household air pollution and blood pressure reduction

Authors	Study Setting	Sample Size	Exposure Variable	Findings
McCracken et al. (McCracken et al., 2007)	Guatemala, Central America	120 rural women (intervention group-49 women and control group-71 women)	Personnel average PM _{2.5} measurement	The improved cookstove was associated with a 3.7 mmHg lower systolic BP (95% CI: -8.1, 0.6) & 3.0 mmHg lower diastolic BP (95% CI: -8.7, 0.4) compared to controls.
Alexander et al. (Alexander et al., 2015)	Bolivia, South America	28 women	Kitchen mean PM _{2.5} measurement	The improved cookstove intervention was significantly associated with a decrease in mean

Authors	Study Setting	Sample Size	Exposure Variable	Findings
				systolic blood pressure from 114.5 mmHg (13.0) to 109.0 mmHg (10.4).
Aung et al. (Aung et al., 2018)	Karnataka, India	222 women (control group-111 women and intervention group-111 women)	24-hour mean kitchen PM _{2.5} measurements	A lower systolic BP of 2 mmHg (95% CI: -4.5, 0.5) and diastolic BP of 1.1 mmHg (95% CI: -2.9, 0.6) was observed among exclusive users of intervention stoves compared to the control group.
BP: blood pressure, CI: Confidence interval				

1.3.3 Household Air Pollution and Fasting Blood Sugar

Diabetes mellitus (DM) is a chronic metabolic disease characterized by elevated fasting blood sugar levels for an extended period. This chronic condition is a significant risk factor for cardiometabolic diseases. The high burden of prediabetes and diabetes is closely linked to high fasting blood sugar levels. In addition to traditional risk factors like obesity and unhealthy lifestyles for Type 2 Diabetes mellitus, there is increasing evidence indicating that exposure to air pollution is positively associated with impaired glucose metabolism and Type 2 Diabetes mellitus.

There has been extensive research on the association between fasting blood sugar levels and ambient air pollution exposure. Still, relatively less studies have been conducted to assess the association between fasting blood sugar and household air pollution. Only two of the available studies directly examined the exposure to quantitative indicators of household air pollution (Rajkumar et al., 2018; Mitra et al., 2023). All the other studies have evaluated the self-reported use of solid fuels (yes or no) as a proxy for exposure to household air pollution. Studies showing the association between household air pollution and blood sugar levels are presented in Table 1.7. Among solid fuel users, being overweight or obese increases the chance of developing high fasting blood sugar levels by two times (Zheng et al., 2021).

Table 1.7: Studies showing the association between household air pollution and blood sugar level

Authors	Study Setting	Sample Size	Exposure Variable	Findings
Lee et al. (Lee et al., 2012)	Shanghai, China	14,068 adults	Self-reported solid fuel use	Solid fuel users had two times higher odds of developing diabetes than clean fuel users.
Qu et al. (Qu et al., 2015)	Shanxi, China	14100 participants	Self-reported solid fuel use	The odds of developing diabetes were 1.97 times higher in solid fuel users compared to clean fuel users.

Authors	Study Setting	Sample Size	Exposure Variable	Findings
Rajkumar et al. (Rajkumar et al., 2018)	Honduran, Central America	142 women (72 traditional fuel users and 70 clean fuel users)	24-hour mean personnel and kitchen PM _{2.5} measurements	For every 84 µg/m ³ increase in PM _{2.5} exposure, the prevalence of prediabetes and diabetes increased by 1.49 times (95% CI: 1.11, 2.01) compared to normal HbA1c.
Mishra et al. (Mishra et al., 2020)	India (National Household Survey)	9502 women	Self-reported cooking fuel type	Women over 45 years old who used solid fuels had a 59% higher risk of developing diabetes compared to those who did not use solid fuels.
Zheng et al. (Zheng et al., 2021)	Guangdong, China	1664 women	Self-reported cooking fuel type	The exposure to biomass fuel was significantly associated with a 0.19 mmol/L (95% CI: 0.01,0.37) increase in fasting blood glucose levels compared to non-exposed fuel users.

Authors	Study Setting	Sample Size	Exposure Variable	Findings
Zheng et al. (Zheng et al., 2022)	Guangdong, South urban, China	3414 participants	Self-reported cooking fuel type	Exposure to polluting cooking fuels resulted in a mean increase in fasting blood sugar of 0.30mmol/L (95% CI: 0.22, 0.38) compared to non- exposed users.
CI: Confidence interval				

In contrast to the studies mentioned above that found a positive association between household air pollution and elevated blood sugar levels or diabetes risk, a few studies have reported an inverse relationship, as summarized in Table 1.8. These studies have shown that exposure to household air pollution is associated with reduced blood sugar and insulin levels in solid fuel users compared to clean fuel users.

Table 1.8: Studies reporting an inverse association between household air pollution and blood sugar level

Authors	Study Setting	Sample Size	Exposure Variable	Findings
Kang et al. (Kang et al., 2022)	Henan, China	20900 women	Self-reported cooking fuel type	Women who cooked with solid fuel had 0.35 μ U/ml lower insulin levels (95% CI: 0.17, 0.53) than those who cooked with clean fuel.

Authors	Study Setting	Sample Size	Exposure Variable	Findings
Mitra et al. (Mitra et al., 2023)	West Bengal, India	123 women (83 biomass and 40 clean fuel users)	24-hour mean kitchen PM _{2.5} measurements	A higher mean blood glucose level of 100.38 mg/dl (± 34.13) was recorded in LPG users compared to biomass users, who had a mean blood glucose level of 94.31 mg/dl (± 18.72).
CI: Confidence interval				

1.4 Rationale for the study

Household air pollution is a global public health burden affecting billions globally, particularly in low- and middle-income countries. According to Global Health Statistics, high blood pressure and high fasting blood sugar are critical risk factors for the development of cardiometabolic diseases (Vaduganathan et al., 2022).

About 41% of Indians primarily rely on traditional cooking practices involving the use of solid fuels (IIPS and ICF, 2021). In Kerala, most households follow a multiple-fuel strategy, but there is still a lack of research on exposure to household air pollution and its health effects in this part of the state.

Therefore, this study is undertaken to estimate the quantitative exposure measurement of mean PM_{2.5} concentration with different cooking fuel types and to explore the association between mean PM_{2.5} exposure levels and blood pressure as well as fasting blood sugar in the rural areas of Pathanamthitta, Kerala. Furthermore, by leveraging the National Family

Health Survey-5 (NFHS-5) dataset, this study aims to estimate the broader impact of solid fuel-induced household air pollution on blood pressure and fasting blood sugar.

1.5 Objectives

1. To estimate household air pollution levels with different cooking fuel types used within households in Pathanamthitta district, Kerala.
2. To explore the association between household air pollution levels and blood pressure and fasting blood sugar among adults in rural areas of Pathanamthitta district, Kerala.
3. To estimate the potential national-level impact of solid fuel-induced household air pollution on blood pressure and fasting blood sugar using the National Family Health Survey-5 data set.

CHAPTER 2

METHODOLOGY

The methodology of the study comprises two distinct components:

- **Section 2A (Objectives one and two):** A primary research conducted in the rural areas of Pathanamthitta district, Kerala.
- **Section 2B (Objective three):** A secondary analysis using the National Family Health Survey-5 (NFHS-5) data set.

SECTION 2A

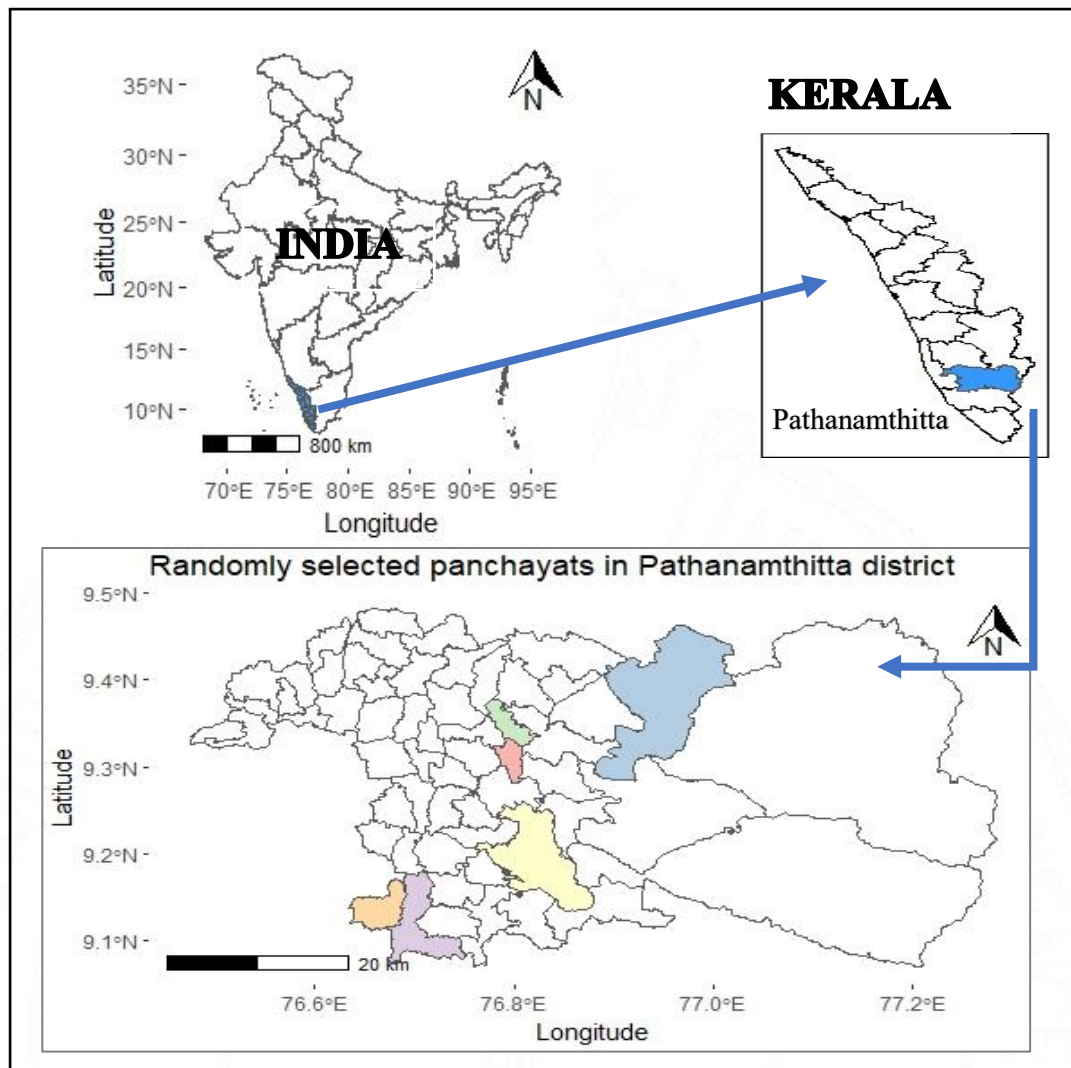
2A.1 Study Design

A cross-sectional survey explored the association between household air pollution and different cooking fuels and its influence on blood pressure and fasting blood sugar in adults residing in rural areas of Pathanamthitta district, Kerala.

2A.2 Study Setting

The study was conducted in rural Pathanamthitta district, Kerala (Figure 2.1). Pathanamthitta, a southern district of Kerala, is characterized by three natural geographical regions: the highland, the midland, and the lowland. Pathanamthitta district has an area of 2637 km² and a tropical monsoon climate. Approximately 50 percent of the total district area is covered by reserve forests. Eighty-nine percent of the total population in Pathanamthitta lives in rural areas, and only 11 percent lives in urban.

Figure 2.1: Study areas of Pathanamthitta District, Kerala, India



2A.3 Study Participants

The study included participants aged 18-69 years residing within the same household for at least five days a week in rural areas of Pathanamthitta district, Kerala.

Exclusion Criteria

- Pregnant women
- Those who were currently taking medications for hypertension and diabetes

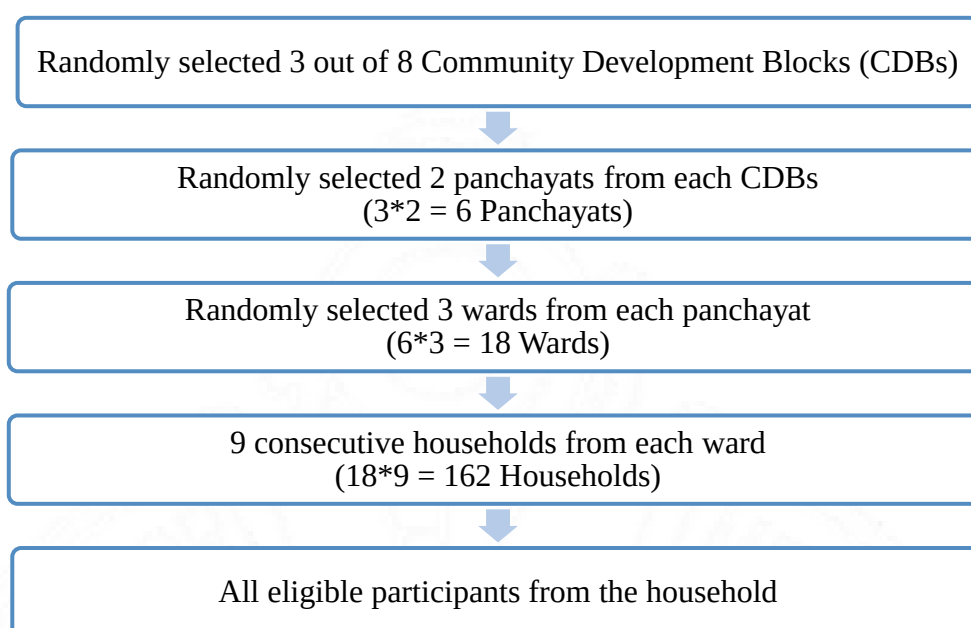
2A.4 Sample Size

The sample size was computed using G*Power version 3.1 software. Anticipating an R^2 value of 0.12, five predictor variables in a linear regression model, a power of 80 percent, a design effect of 1.4, and a non-response rate of 10 percent, the estimated sample size was 155, rounded off to 160 households.

2A.5 Sampling Procedure

In this study, a multi-stage cluster sampling method was employed. Pathanamthitta district consisted of eight community development blocks (CDBs). Out of these eight CDBs, three blocks were randomly selected by simple random sampling using Computer-generated random numbers. In the second stage, two panchayats were randomly chosen from each block. Three wards from each panchayat were randomly selected from the selected six panchayats. Additionally, nine consecutive households were selected in each ward. Ward members assisted in identifying the wards. With the help of ward members, the central location and the main junction of each ward were located. After identifying each ward's central location, the first household was identified using a Random Direction Generator. Subsequently, the following nine consecutive households on the right-hand side of the road were visited. In case the selected house was empty or locked, the next household was visited. An interview schedule was administered to all eligible participants in the selected households.

Figure 2.2: Sampling strategy



2A.6 Data Collection Process

The study was carried out from January 11th, 2024, to February 27th, 2024, after obtaining approval from the Institutional Ethics Committee (IEC).

Initially, the ward members of the respective wards were contacted. The ward members accompanied the principal investigator (PI) during household visits. The investigator explained the purpose of the visit and the study objectives to the participants. The investigator explained that in all participating households, a real-time particulate matter monitor would be placed in the kitchen, living area, and outdoor spaces for a maximum duration of 12 ± 2 hours. The participants were also provided with an information sheet with specific details regarding the study. This information sheet was provided in Malayalam, the local language, to ensure clarity and understanding among the participants. After clarifying the concerns and queries of the participants, the household was selected based on whether they accepted the placement of the particulate matter monitoring in their respective household, or else the next household was approached. From the selected

households, participants who met the eligibility criteria and agreed to undergo the baseline clinical examination and interview were asked to either sign the consent form or provide a thumb impression as a form of consent. A total of 178 households were visited. Sixteen households refused to participate in the study. The reasons for non-participation were fear of placing some unknown monitor inside their household for such a prolonged duration.

2A.7 Data Collection Tool

2A.7.1 Structured Interview Schedule

A structured interview schedule was administered, which was developed in English and then translated to Malayalam for data collection. The interview was conducted in Malayalam. Data collection from the field was done using ODK Collect, an open-source app used for survey-based data collection. The interview schedule broadly consisted of four sections as follows:

Section 1: Sociodemographic details

This section covered the details regarding age in years, sex, years of education, occupation, and years of stay in the household.

Section 2: Household characteristics

This section included the type of house, number of household members, number of rooms, and color of ration card.

Section 3: Household kitchen and fuel details

This section focused on the type of kitchen, type of primary and secondary stove and fuel, cooking exposure time, reasons for using that respective fuel, and kitchen and living area characteristics

Section 4: Habits and general health characteristics

This section covered the presence or absence of certain health conditions, drinking and smoking habits, exercise and diet patterns, and sleeping habits.

2A.7.2 Kitchen and Living Area Measurements

Before making observations and taking measurements in the kitchen and living area, consent was obtained from the study participants. The principal investigator visually observed the number of windows and type of ventilation in the kitchen and living area. The investigator also noted the parallel placement of the kitchen window and door to assess cross-ventilation. The kitchen and living area dimensions were then measured using a standard measuring tape.

2A.7.3 Exposure to Household Air Pollution

Exposure to household air pollution was measured by 12-hour mean concentrations of fine particulate matter (PM_{2.5}) and coarse particulate matter (PM₁₀) using an Airveda particulate matter monitor (Model: PM2510) (Figure 2.3). Initially, a pilot study was conducted to assess the potential difference in exposure measurements of PM_{2.5} concentration between 24-hour and 12-hour sampling periods. The variation in measurements was found within $\pm 6 \mu\text{g}/\text{m}^3$, which did not significantly affect the relative validity of the exposure assessment. Therefore, a 12-hour sampling was chosen for the study, considering the logistical feasibility and participant convenience.

The household air pollutant levels (PM_{2.5} and PM₁₀) from the kitchen, living area, and outdoor spaces were measured. The monitor was fully charged before the sampling period. The monitor was placed approximately 1-1.5 m away from the stove and 1.5-2 m above ground level at the breathing zone, in a location that would not interfere with cooking for a maximum sampling period of 12 ± 2 hours (Figure 2A.3). Sampling was mainly done in

the evening time, with the monitor kept in the kitchen for a period of 12 ± 2 hours from evening to morning, as most of the households used to cook in the early morning. However, daytime sampling was also taken for those who used to cook their food during the daytime, keeping the monitor from morning to evening.

Figure 2.3: Airveda particulate matter monitor and its placement in different kitchen environments



2A.7.4 Anthropometric and Clinical Measurements

2A.7.4.1 Waist Circumference

The procedure was explained to the participant before taking the measurements. The participant was advised to wear light clothing, and adequate privacy was ensured. The participant was asked to breathe out, and the measurement was taken at the end of the breath using a constant tension tape (SECA 201). The tape was bound around the participant's body, positioned at the midpoint of the top of the hip bone and last palpable rib. The tape

was carefully placed to ensure it was horizontal across the front and back and parallel to the floor.

2A.7.4.2 Blood Pressure Measurements

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a standard digital sphygmomanometer (OMRON HEM-7120 BP Monitor). The blood pressure of each participant was measured twice during the study process. For each measurement, the participant was made to sit comfortably with the machine at the same level as their heart. Three readings were recorded at five-minute intervals on the non-dominant arm. The first set of three blood pressure measurements was taken at the beginning of the study, and the second was taken after the 12-hour sample collection period. The average of these six measurements was used as the participant's final SBP and DBP estimate for analysis.

2A.7.4.3 Fasting Blood Sugar Measurements

Fasting blood sugar was measured using a glucometer (ONETOUCH UltraEasy) using the capillary method. The measurement was conducted in the morning before any meal intake. A lancing device was used to make a small puncture on the finger. A small drop of blood was placed onto the chemically treated disposable testing strip, which was inserted into the electronic device to record the blood glucose level in mg/dL from the display.

2A.8 Data Management

The data entered in ODK Collect was retrieved in tabular format. The hard copy of the consent form signed by the participant was kept safely and accessible only to the principal investigator. The confidentiality of data was strictly maintained. The soft copy of the air sampling data is stored in an encrypted folder and stored securely with the principal

investigator. The soft copies of all the data will be deemed destroyed when no longer needed or after one year of dissertation report submission, whichever comes first.

2A.9 Variables under study

2A.9.1 Dependent variables

- Mean systolic blood pressure measurement
- Mean diastolic blood pressure measurement
- Fasting blood sugar level

2A.9.2 Independent variables

- 12- hour mean kitchen PM_{2.5} concentration (Main exposure variable)
- Outdoor and living area mean PM_{2.5} concentration
- Household and kitchen characteristics: Type of cooking fuel, cooking exposure time, cooking location, placement of fuels in the kitchen, cross ventilation
- Other factors- age, sex, educational status, smoking status, alcohol consumption, waist circumference

2A.10 Operational definition

2A.10.1 Household air pollution

Household air pollution (HAP) arises from the inefficient combustion of solid fuels such as unprocessed biomass (wood, crop residues, dung) for heating or cooking, often using open fires or cookstoves with inadequate ventilation.

2A.10.2 Solid fuel

Solid fuel is combustible materials such as wood, coconut husk and shell, agriculture crops, and straw/shrub/grass.

2A.10.3 Clean fuel

Clean fuel refers to electricity, liquefied petroleum gas (LPG), natural gas, and biogas.

2A.10.4 Mixed fuel

Mixed fuel refers to using clean and solid fuels simultaneously within the same households.

2A.10.5 Cross ventilation

Cross ventilation refers to the parallel placement of doors and windows in the kitchen.

2A.11 Categorization of variables in the study

- Primary fuel: The main fuel which is used in the household. There were initially five categories, but they were later grouped into clean fuel and solid fuel.
- Secondary fuel: The additional fuel used in the household alongside the primary fuel. Initially, there were six categories, but later, they were grouped into four categories: clean fuel, solid fuel, mixed fuel, and none.
- Cooking fuel type: This variable was derived from primary and secondary fuel usage. This was grouped into three categories: clean fuel, solid fuel, and mixed fuel.
- Polluting fuel usage hours: The total number of hours per week, considering both primary and secondary fuel usage, that solid fuels were used for cooking and heating purposes in the household.
- Non-polluting fuel usage hours: The total number of hours per week, considering both primary and secondary fuel usage, that clean fuels were used for cooking purposes in the household.
- Educational qualification: The highest level of education attained by the participant. Initially, it was a continuous variable, later categorized into lower secondary education, higher secondary education, and graduate and above.

- Occupation: The participant's current employment status. During data collection, there were seven categories. They were later grouped into five categories according to the type of employment: government/non-government employee, daily wagers/self-employed, homemakers, unskilled workers, and others. The category 'Unskilled worker' included MNREGA workers and cashew factory workers. The category 'Others' included retirees, students, and the unemployed.
- The type of house and primary lighting source were excluded from the analysis as all the participants reported pucca houses and electricity as the primary lighting source respectively.

2A.12 Data Analysis

Data analysis was performed using R statistical software (v4.3.1; R Core Team 2023). Descriptive statistics were computed, presenting the mean with standard deviation for continuous variables and frequencies and percentages for categorical variables. Continuous variables underwent appropriate transformations when necessary. Specifically, a log transformation was applied to fasting blood sugar values due to its non-normal distribution.

The measured 12-hour mean PM_{2.5} concentration, which directly represents the level of household air pollution exposure, was initially treated as a continuous variable. The t-test and ANOVA were employed to find the association between the 12-hour mean PM_{2.5} concentration and different cooking fuel types.

To explore the association between household air pollution levels and systolic and diastolic blood pressure and fasting blood sugar among adults, the measured 12-hour mean PM_{2.5} concentration was categorized into two groups based on the World Health Organization's (WHO) recommended interim target value of 75 µg/m³ for 24-hour mean PM_{2.5} concentration. The two exposure groups were 'PM_{2.5} ≤ 75 µg/m³' and 'PM_{2.5} > 75 µg/m³'.

Multivariable regression models were employed to investigate the independent association between these two-household air pollution exposure groups (characterized by the measured PM_{2.5} levels) and systolic blood pressure (SBP), diastolic blood pressure (DBP), and fasting blood sugar (FBS), after adjusting for potential covariates. The regression equations were generalized as follows:

$$SBP / DBP / FBS = \beta_0 + \beta_1 HAP + \sum \gamma_i Z_i + \varepsilon \quad (1)$$

where β_0 is the intercept; β_1 is the effect estimate for the household air pollution exposure groups (characterized by the measured PM_{2.5} levels) on mean systolic and diastolic blood pressure as well as fasting blood sugar, holding other covariates constant; Z_i represents each potential covariates, and ε is the model residual. The findings were interpreted and presented using tables, graphs, and charts.

2A.13 Ethical Consideration

The Institutional Ethics Committee of Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, Kerala reviewed the study and gave clearance to conduct the study (SCT/IEC/2160/DECEMBER/2023). Before enrolling participants in the study, written informed consent was obtained from each individual. The participants were informed of their right to refuse participation at the outset or to withdraw their participation at any study stage without any consequences. The participants' identities, personal information, and household particulate matter (PM_{2.5} and PM₁₀) data were kept confidential.

The particulate matter monitor used in the study was non-invasive and did not include other sensors to capture additional data. Separate lancets were used pricking to prick the fingertips to obtain capillary blood samples. Participants with abnormal blood pressure or fasting blood sugar values requiring immediate care were directed to a local health facility.

SECTION 2B

2B.1 Data source

The secondary analysis was conducted using data from the National Family Health Survey (NFHS-5) from 2019 to 2021. The NFHS-5 survey was conducted on a large scale and included a representative sample of households that covered 29 states and seven union territories across India. The NFHS surveys were conducted under the authority of the Ministry of Health and Family Welfare (MoHFW), Government of India. The NFHS-5 survey was carried out in two phases between June 17, 2019, and April 30, 2021, as a result of the COVID-19 outbreak.

2B.2 Sampling Design

The NFHS-5 used a stratified two-stage cluster sample design to ensure national, state/union territory, and district representation. In the first stage, the probability proportional to size (PPS) technique was used to pick primary sampling units (PSUs), which included villages in rural areas and census enumeration blocks (CEBs) in cities. In the second stage, a fixed number of 22 households were systematically selected with equal probability from each selected PSU. The survey gathered data from 636,699 households, 724,115 women, and 101,839 men.

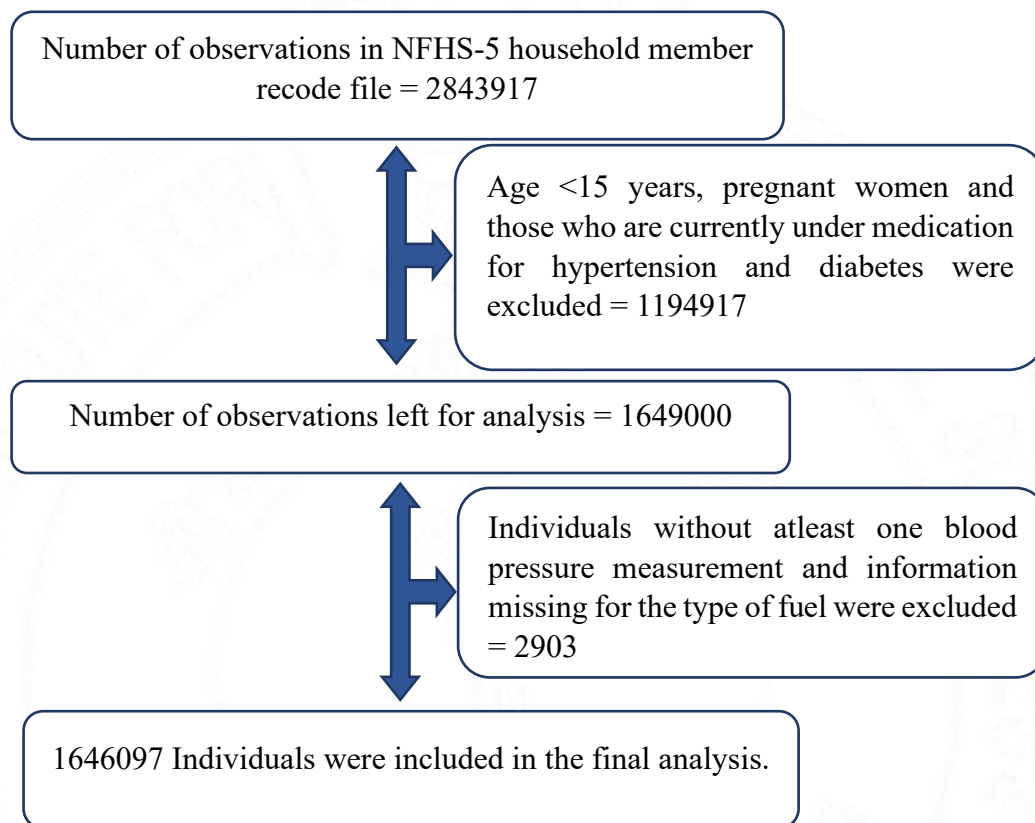
2B.3 Data Access

Before conducting the secondary analysis, a formal request was submitted to the Demographic and Health Survey (DHS) program, and permission was granted to obtain the required NFHS-5 data files. Data from the household member recode file (IAPR7CFL) was extracted and used for the analysis.

2B.4 Study Population and Sample Selection

The sample selection process involved excluding specific subgroups and observations with missing data, as depicted in the flow chart (Figure 2.4). For the final analysis, 1646097 individuals were included.

Figure 2.4: Sample selection process for NFHS-5 analysis



2B.5 Variables of interest

2B.5.1 Dependent variables

The primary outcomes of interest were systolic and diastolic blood pressure measurements and random blood glucose values.

- The average of all three blood pressure measurements per participant was calculated to determine the blood pressure outcome variable.

- The outcome variables were considered continuous for the analysis.

2B.5.2 Independent variables

A. Exposure variable

The primary exposure variables for assessing household air pollution were the primary fuel type, cooking location, and kitchen ventilation.

- The type of cooking fuel was taken as a proxy indicator for assessing household air pollution. NFHS-5 had 12 responses for this variable. For the analysis, the type of cooking fuel was grouped into three categories: solid fuels, clean fuels, and kerosene, since kerosene can neither be categorized into clean nor solid fuel.
- Solid fuels included coal, lignite, charcoal, wood, straw/shrubs/grass, crops, or animal dung, and clean fuels included LPG, electricity, natural gas, or biogas.

B. Potential confounders

The potential confounders were considered according to the following domains:

- Sociodemographic factors: Age, sex, education, place of residence, wealth index, presence of APL/BPL card, type of house
- Anthropometric measurements: Body mass index (BMI) and waist circumference
- Lifestyle factors: smoking status, alcohol consumption
- Body mass index (BMI) was categorized as underweight (BMI < 18.5), regular weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), and obese (BMI ≥ 30.0).

2B.6 Data Analysis

Survey weights were employed to account for differential sampling in certain regions, variation in response rates from one geographic area to the next, and to maximise

representation of the general population. The NFHS authority computed and delivered the weights (IPSS and ORC Macro).

Baseline characteristics of the study population were presented as the mean and standard deviation for continuous variables and as frequencies and percentages for categorical variables. The t-test and ANOVA were conducted to determine the association between the continuous variables. For bivariate analysis, linear regression was employed to find the association between the outcome variables (SBP/DBP/FBS) and the indicators of household air pollution and other covariates.

In multivariate analysis, covariates previously published in studies and for which sufficient data from NFHS-5 were available were included. Multivariable regression models (Equation 1) were employed to explore the independent association between the type of cooking fuel (a proxy for household air pollution) and mean blood pressure/ fasting blood sugar after adjusting for the potential confounders. Data analysis was performed using R statistical software (v4.3.1; R Core Team 2023).

2B.7 Ethical Considerations

The Demographic and Health Survey (DHS) program obtained the necessary ethical clearances from Indian ethics committees before conducting the surveys. Participants were required to provide their informed consent before participating in the survey. De-identified datasets that were made publicly available were used in this study following approval from the DHS Program.

CHAPTER 3

RESULTS

The findings of this study are presented in two sections. Section 3A presents the findings addressing the first two objectives. Section 3B presents the findings addressing the third objective.

SECTION 3A

A total of 178 households were visited. However, only 162 households participated in the study (91% response rate). All eligible participants within the participating household were selected, resulting in a total of 226 participants. Data analysis was performed using R statistical software (v4.3.1; R Core Team 2023).

This section covers socio-demographic and household characteristics, household air pollution levels stratified by fuel type, and the association between household air pollution exposure and blood pressure and fasting blood sugar.

3A.1 Socio-demographic Characteristics

The socio-demographic characteristics of the study population are given in Table 3.1. The study included 226 participants with a mean age of 51.3 years (standard deviation [SD], 11.2; range, 22-69 years). The study participants included more females (76.5 percent) than males. Half the number of participants (50.4 percent) were homemakers.

Table 3.1. Socio-demographic characteristics of the study participants by exposure group

Characteristics	PM _{2.5} ≤ 75 (n=114)	PM _{2.5} > 75 (n=112)	Total (N=226)
Age (years) Mean (SD)	50.7 (12.1)	51.9 (11.7)	51.3 (11.9)
Sex n (%)			
Female	85 (74.6)	88 (78.6)	173 (76.5)
Male	29 (25.4)	24 (21.4)	53 (23.5)
Education n (%)			
Lower secondary education	7 (6.1)	15 (13.4)	22 (9.7)
Higher secondary education	79 (69.3)	82 (73.2)	161 (71.2)
Graduate and above	28 (24.6)	15 (13.4)	43 (19.0)
Ration card color n (%)			
White	64 (56.1)	48 (42.9)	112 (49.6)
Blue	33 (28.9)	46 (41.1)	79 (35.0)
Pink	17 (14.9)	15 (13.4)	32 (14.2)
Yellow	0 (0.0)	3 (2.7)	3 (1.3)
Occupation n (%)			
Govt and non-govt employee	17 (14.9)	19 (17.0)	36 (15.9)
Self-employed	14 (12.3)	10 (8.9)	24 (10.6)
Homemaker	56 (49.1)	58 (51.8)	114 (50.4)
Unskilled worker	8 (7.0)	11 (9.8)	19 (8.4)
Others	19 (16.7)	14 (12.5)	33 (14.6)

*Unskilled worker: MNREGA, cashew factory workers; Others: Retired, student, unemployed; SD: Standard deviation

3A.2 Household Fuel Characteristics

Most participants (86.7 percent) reported using clean fuel as their primary cooking fuel. However, when considering the overall fuel usage patterns, most participants (82.7 percent) used a mixed fuel type. When stratified by exposure groups based on the recommended interim target value of $75 \mu\text{g}/\text{m}^3$ for 24-hour mean $\text{PM}_{2.5}$ concentration, a higher proportion of participants in the $\text{PM}_{2.5} > 75 \mu\text{g}/\text{m}^3$ group (23.2 percent) used solid fuel as their primary cooking fuel compared to the $\text{PM}_{2.5} \leq 75 \mu\text{g}/\text{m}^3$ group (3.5 percent). Out of the 226 participants, 168 (74.3 percent) participants reported using both fuels in the same kitchen. Table 3.2 shows the study participants' household fuel type characteristics.

Table 3.2. Household fuel type characteristics of the study participants by $\text{PM}_{2.5}$ exposure group

Characteristics n (%)	Total (N=226)	$\text{PM}_{2.5} \leq 75$ (n=114)	$\text{PM}_{2.5} > 75$ (n=112)	p-value
Primary fuel				< 0.001
Clean Fuel	196 (86.7)	110 (96.5)	86 (76.8)	
Solid Fuel	30 (13.3)	4 (3.5)	26 (23.2)	
Secondary fuel				0.022
Clean Fuel	55 (24.3)	21 (18.4)	34 (30.4)	
Solid Fuel	146 (64.6)	81 (71.1)	65 (58.0)	
Combination	14 (6.2)	4 (3.5)	10 (8.9)	
None	11 (4.9)	8 (7.0)	3 (2.7)	
Type of fuel				0.012**
Mixed fuel	187 (82.7)	89 (78.1)	98 (87.5)	
Only Clean fuel	36 (15.9)	25 (21.9)	11 (9.8)	
Only Solid fuel	3 (1.3)	0 (0.0)	3 (2.7)	
Both fuels in the same kitchen				0.080
Yes	168 (74.3)	79 (69.3)	89 (79.5)	
No	58 (25.7)	35 (30.7)	23 (20.5)	

*Clean fuel- LPG, electricity. Solid fuel- Wood, coconut husk, and shell.

Mixed fuel- Using both clean fuel and solid fuel.

**Yates continuity correction

3A.3 Kitchen Environment Characteristics

3A.3.1 Kitchen ventilation

Most participants reported opening their windows (87.6 percent) and doors (85.8 percent) while cooking. The presence of cross-ventilation in the kitchen was higher in the $PM_{2.5} \leq 75 \mu g/m^3$ group (19.3 percent) compared to the $PM_{2.5} > 75 \mu g/m^3$ group (5.4 percent). Seventy-seven percent of participants reported they weren't using an exhaust fan. Table 3.3 shows the kitchen ventilation characteristics of the study participants.

Table 3.3. Kitchen ventilation characteristics of the study participants by $PM_{2.5}$ exposure group

Characteristics n (%)	Total (N=226)	$PM_{2.5} \leq 75$ (n=114)	$PM_{2.5} > 75$ (n=112)	p-value
Open window				0.096
Yes	198 (87.6)	104 (91.2)	94 (83.9)	
No	28 (12.4)	10 (8.8)	18 (16.1)	
Open door				0.231
Yes	194 (85.8)	101 (88.6)	93 (83.0)	
No	32 (14.2)	13 (11.4)	19 (17.0)	
Use of exhaust fan				0.002
No	175 (77.4)	77 (67.5)	98 (87.5)	
Yes	17 (7.5)	12 (10.5)	5 (4.5)	
Sometimes	34 (15.0)	25 (21.9)	9 (8.0)	
Cross ventilation				0.001
Yes	28 (12.4)	22 (19.3)	6 (5.4)	
No	198 (87.6)	92 (80.7)	106 (94.6)	

3A.3.2 Kitchen environments

Various kitchen conditions were observed, ranging from well-ventilated to poorly ventilated cooking areas (Figure 3.1).



Figure 3.1 Various kitchen layouts noted among the participants (A: Clean fuel kitchen with exhaust fan, B: Clean fuel kitchen without an exhaust fan, C: Traditional solid fuel kitchenD: Mixed-fuel kitchen)

3A.3.3 Kitchen layout and setup

Table 3.4 shows the kitchen layout and setup of the study participants. Nearly all (99.1 percent) participants reported having a separate kitchen room. The mean kitchen area was 138.7 sq ft (SD: 45.8) and was slightly smaller in the $PM_{2.5} > 75 \mu g/m^3$ group (133.7 sq ft) compared to the $PM_{2.5} \leq 75 \mu g/m^3$ group (143.7 sq ft).

Table 3.4. Kitchen layout and setup details among the study participants

Characteristics	Total (N=226)	$PM_{2.5} \leq 75$ (n=114)	$PM_{2.5} > 75$ (n=112)	p-value
Kitchen layout n (%)				0.152
Separate room	224 (99.1)	114 (100.0)	110 (98.2)	
Same room	2 (0.9)	0 (0.0)	2 (1.8)	
Kitchen area (sq ft)				
Mean (SD)	138.7 (45.8)	143.7 (47.3)	133.7 (43.9)	0.102

3A.4 Air Pollution Exposures

3A.4.1 Household air pollution exposure

The mean weekly cooking hours were similar between the two exposure groups. However, the mean polluting fuel hours were significantly higher in the $PM_{2.5} > 75 \mu g/m^3$ group (22.1 hours), and the mean non-polluting fuel hours were significantly higher in the $PM_{2.5} \leq 75 \mu g/m^3$ group (30.2 hours). Table 3.5 illustrates the mean household air pollution exposure hours among study participants.

Table 3.5 Household air pollution exposure among the study participants

Characteristics	Total (N=226)	$PM_{2.5} \leq 75$ (n=114)	$PM_{2.5} > 75$ (n=112)	p-value
Weekly cooking hours Mean (SD)	36.3 (8.2)	35.9 (8.4)	36.7 (7.9)	0.466
Polluting fuel hours Mean (SD)	19.6 (10.1)	17.3 (10.3)	22.1 (9.3)	< 0.001
Non-polluting fuel hours Mean (SD)	28.6 (9.9)	30.2 (9.6)	27.0 (10.1)	0.017

3A.4.2 Other air pollution exposure sources

Table 3.6 shows the household practices contributing to air pollution. Open burning practices were common, observed by 81 percent of participants. Incense sticks were prevalent with 73.5 percent of participants engaging in this practice.

Table 3.6 Household practices contributing to air pollution among study participants

Characteristics n (%)	Total (N=226)	$PM_{2.5} \leq 75$ (n=114)	$PM_{2.5} > 75$ (n=112)	p-value
Open burning				0.434
Yes	183 (81.0)	90 (78.9)	93 (83.0)	
No	43 (19.0)	24 (21.1)	19 (17.0)	
Use of incense sticks				0.703
Yes	166 (73.5)	85 (74.6)	81 (72.3)	

Characteristic	Total (N=226)	PM _{2.5} ≤ 75 (n=114)	PM _{2.5} > 75 (n=112)	p-value
No	60 (26.5)	29 (25.4)	31 (27.7)	
Use of mosquito coil				0.262
Yes	43 (19.0)	25 (21.9)	18 (16.1)	
No	183 (81.0)	89 (78.1)	94 (83.9)	

3A.5 Lifestyle Risk Factors

Out of 226 participants, six percent and fifteen percent reported tobacco use and alcohol consumption, respectively. Only 30.1 percent of participants reported engagement in physical activity. Table 3.7 shows lifestyle risk factors in the study population.

Table 3.7 Lifestyle risk factors among study participants

Characteristics n (%)	Total (N=226)	PM _{2.5} ≤ 75 (n=114)	PM _{2.5} > 75 (n=112)	p-value
Tobacco use				0.049
Yes	13 (5.8)	10 (8.8)	3 (2.7)	
No	213 (94.2)	104 (91.2)	109 (97.3)	
Smokeless tobacco use				0.495
Yes	25 (11.1)	11 (9.6)	14 (12.5)	
No	201 (88.9)	103 (90.4)	98 (87.5)	
Alcoholic consumption				0.388
Yes	35 (15.5)	20 (17.5)	15 (13.4)	
No	191 (84.5)	94 (82.5)	97 (86.6)	
Physical activity				0.052
Yes	68 (30.1)	41 (36.0)	27 (24.1)	
No	158 (69.9)	73 (64.0)	85 (75.9)	

3A.6 Cardiometabolic Risk Factors

Table 3.8 presents various cardiometabolic risk factors, including waist circumference, mean systolic and diastolic blood pressure, and fasting blood sugar levels, crucial for assessing cardiovascular health.

Table 3.8 Cardiometabolic risk factors among study participants

Characteristics	Total (N=226)	PM _{2.5} ≤ 75 (n=114)	PM _{2.5} > 75 (n=112)	p-value
Waist circumference (cm) Mean (SD)	85.5 (7.1)	85.7 (7.1)	85.2 (7.0)	0.582
Mean systolic BP (mmHg) Mean (SD)	135.0 (17.9)	134.2 (16.9)	135.9 (19.0)	0.502
Mean diastolic BP (mmHg) Mean (SD)	85.5 (9.3)	84.9 (8.8)	86.2 (9.7)	0.303
Fasting blood sugar (mm/dL) Mean (SD)	120.4 (41.5)	121.2 (43.7)	119.7 (39.3)	0.791

3A.7 Relationship between household air pollution level and fuel types

The relationship between household air pollution levels and different cooking fuel types is depicted in Figure 3.2 and Figure 3.3. The mean PM_{2.5} concentration was significantly lower (75.15 µg/m³) in clean fuel users compared to solid fuel users (85.83 µg/m³). After considering the combined use of primary and secondary fuel, participants who used only clean fuel had the lowest mean PM_{2.5} concentration (67.3 µg/m³), followed by those who used mixed fuels (78.1 µg/m³), and the highest concentration was observed for those who used solid fuels (90.2 µg/m³) for cooking.

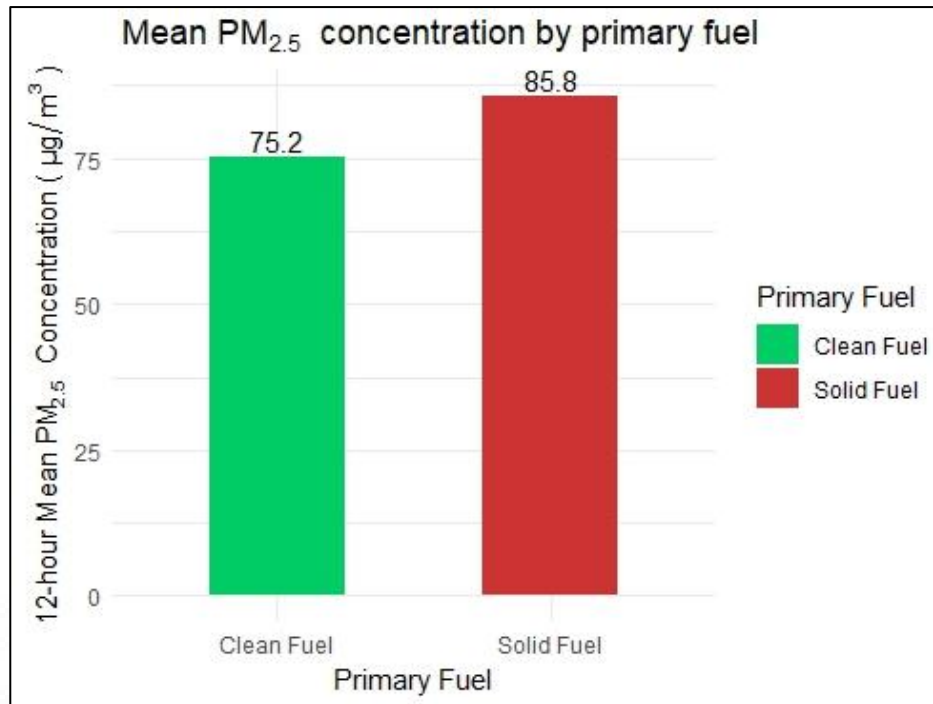


Figure 3.2 Bar graph showing 12-hour mean PM_{2.5} concentration by primary fuel

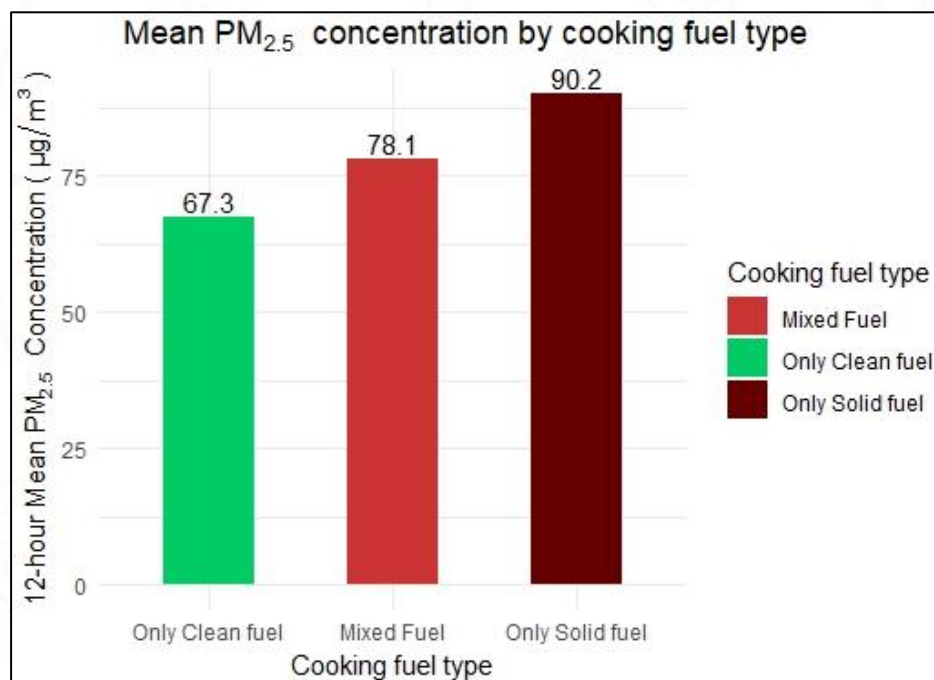


Figure 3.3 Bar graph showing 12-hour mean PM_{2.5} concentration by different cooking fuel

3A.8 Association between PM_{2.5} exposure groups and mean blood pressure and fasting blood sugar

Multivariable linear regression analysis was employed to explore the independent association between household air pollution exposure, characterized by the two PM_{2.5} exposure groups, and the health outcomes of interest: mean systolic blood pressure, mean diastolic blood pressure, and mean fasting blood sugar. The potential covariates included in the study were outdoor mean PM_{2.5} concentration, living area mean PM_{2.5} concentration, age, sex, education, waist circumference, and smoking status.

3A.8.1 Systolic Blood Pressure

Table 3.9 presents the association between PM_{2.5} exposure groups and the mean systolic blood pressure. Participants exposed to PM_{2.5} >75µg/m³ had 2.35 mmHg higher mean systolic blood pressure (95% CI: -1.98, 7.04) compared to those exposed to PM_{2.5} ≤75µg/m³ after adjusting for potential covariates. However, the confidence intervals were wide enough and included a null value.

Other factors, such as age and waist circumference, were significantly associated with systolic blood pressure. For every one-year increase in age, there was a 0.681 mmHg increase in mean systolic blood pressure (95% CI: 0.495, 0.868). Additionally, waist circumference was associated with higher systolic blood pressure, with a 0.492 mmHg increase in mean systolic blood pressure per unit increase in waist circumference (95% CI: 0.156, 0.829). However, outdoor and living area mean PM_{2.5} concentrations, sex, education level, and smoking status did not significantly correlate with systolic blood pressure.

Table 3.9 Association between household air pollution exposure and mean systolic blood pressure

Characteristic	Estimate (β)	95% CI	p-value
(Intercept)	68.1	37.3, 98.9	<0.001
Exposure Groups			0.300
PM _{2.5} ≤ 75 µg/m ³	—	—	
PM _{2.5} > 75 µg/m ³	2.35	-2.11, 6.81	0.300
Outdoor mean PM _{2.5} concentration	-0.083	-0.303, 0.138	0.460
Living area mean PM _{2.5} concentration	-0.027	-0.248, 0.194	0.810
Sex			0.353
Female	—	—	
Male	-2.80	-8.72, 3.12	0.353
Age	0.681	0.495, 0.868	<0.001
Education			0.283
Lower secondary education	—	—	
Higher secondary education	-3.18	-10.4, 4.07	0.388
Graduate and above	0.686	-7.95, 9.32	0.876
Waist circumference	0.492	0.156, 0.829	0.004
Smoking status			0.150
No	—	—	
Yes	7.30	-2.66, 17.3	0.150

* Adjusted for outdoor PM_{2.5} concentration, living area PM_{2.5} concentration, age, sex, education, waist circumference, and smoking status. CI- Confidence interval

3A.8.2 Diastolic Blood Pressure

The association between PM_{2.5} exposure groups and mean diastolic blood pressure is presented in Table 3.10. After adjusting for potential covariates, participants in the group

with exposure to $\text{PM}_{2.5} > 75 \mu\text{g}/\text{m}^3$ had 1.66 mmHg higher mean diastolic blood pressure (95% CI: -0.860, 4.19) compared to those with exposure to $\text{PM}_{2.5} \leq 75 \mu\text{g}/\text{m}^3$. However, the association was not statistically significant.

Other factors, such as age and waist circumference, were significantly associated with diastolic blood pressure ($p < 0.001$). Additionally, current smokers had a 6.40 mmHg higher mean diastolic blood pressure compared to non-smokers (95% CI: 0.764, 12.0). Outdoor and living area $\text{PM}_{2.5}$ concentrations, sex, and education level did not significantly correlate with diastolic blood pressure.

Table 3.10 Association between household air pollution exposure and mean diastolic blood pressure

Characteristic	Estimate (β)	95% CI	p-value
(Intercept)	56.8	39.4, 74.2	<0.001
Exposure Groups			0.195
$\text{PM}_{2.5} \leq 75 \mu\text{g}/\text{m}^3$	—	—	
$\text{PM}_{2.5} > 75 \mu\text{g}/\text{m}^3$	1.66	-0.860, 4.19	0.195
Outdoor mean $\text{PM}_{2.5}$ concentration	-0.077	-0.202, 0.048	0.224
Living area mean $\text{PM}_{2.5}$ concentration	0.032	-0.093, 0.157	0.612
Sex			0.103
Female	—	—	
Male	-2.78	-6.13, 0.569	0.103
Age	0.134	0.028, 0.240	0.013
Education			0.173
Lower secondary education	—	—	
Higher secondary education	-3.17	-7.27, 0.923	0.128
Graduate and above	-1.27	-6.16, 3.61	0.608
Waist circumference	0.321	0.131, 0.512	0.001

Characteristic	Estimate (β)	95% CI	p-value
Smoking status			0.026
No	—	—	
Yes	6.40	0.764, 12.0	0.026

* Adjusted for outdoor PM_{2.5} concentration, living area PM_{2.5} concentration, age, sex, education, waist circumference, and smoking status. CI- Confidence interval

3A.8.3 Fasting Blood Sugar

The association between household air pollution exposure and mean fasting blood sugar levels was evaluated and presented in Table 3.11. Due to the non-normal distribution of fasting blood sugar, a log transformation was applied for the analysis. No significant association between PM_{2.5} exposure groups and mean fasting blood sugar was found. After adjusting for potential covariates, participants in the PM_{2.5} > 75 $\mu\text{g}/\text{m}^3$ exposure group had one percent lower fasting blood sugar levels compared to those exposed to PM_{2.5} $\leq 75 \mu\text{g}/\text{m}^3$, with a point estimate of -0.01 (95%CI: -0.08, 0.07).

Table 3.11 Association between household air pollution exposure and mean fasting blood sugar levels

Characteristic	Estimate (β)	95% CI	p-value
(Intercept)	4.00	3.46, 4.55	<0.001
Exposure Groups			0.861
PM _{2.5} $\leq 75 \mu\text{g}/\text{m}^3$	—	—	
PM _{2.5} > 75 $\mu\text{g}/\text{m}^3$	-0.01	-0.08, 0.07	0.861
Outdoor mean PM _{2.5} concentration	0.00	-0.004, 0.004	0.890
Living area mean PM _{2.5} concentration	0.00	-0.005, 0.003	0.643

Characteristics	Estimate (β)	95% CI	p-value
Female	—	—	
Male	0.031	-0.073, 0.136	0.554
Age	0.005	0.001, 0.008	0.006
Education			0.175
Lower secondary education	—	—	
Higher secondary education	0.036	-0.091, 0.163	0.578
Graduate and above	-0.052	-0.204, 0.100	0.498
Waist circumference	0.007	0.001, 0.013	0.024
Smoking status			0.330
No	—	—	
Yes	-0.087	-0.262, 0.088	0.330

* Adjusted for outdoor PM_{2.5} concentration, living area PM_{2.5} concentration, age, sex, education, waist circumference, and smoking status. CI- Confidence interval

SECTION 3B

The study included 1,646,097 individuals from a dataset of 2,843,917 individuals for the final analysis. Sample weights were used for the analysis, and the analysis was done on the weighted population (n = 1605612). This section covers the socio-demographic and household characteristics of the NFHS-5 study population and the association between the type of cooking fuel (a proxy for household air pollution) and mean blood pressure/ fasting blood sugar.

3B.1 Socio-demographic Characteristics

The study population consisted of 1,605,612 individuals, with 52.5 percent being females and 47.5 percent males. The mean age of the total population was 38.2 years (SD = 16.6

years). Three-fourths (69.3 percent) of the individuals lived in rural areas, and 46.5 percent of the population had a Below poverty line (BPL) card. Educational attainment differed across urban and rural areas, with a higher proportion of urban residents (21.7 percent women, 26.5 percent men) having higher education than rural residents (7.8 percent women, 12.1 percent men). The wealth index showed a clear urban-rural divide, with most urban residents classified as rich (73.4 percent women, 73.3 percent men), while most rural residents were classified as poor (53.2 percent women, 51.9 percent men). The socio-demographic characteristics of the study participants are summarized in Table 3.12.

Table 3.12 Socio-demographic characteristics of the study participants (NFHS 5)

Variables	RURAL		URBAN		TOTAL
	Women (n= 587933)	Men (n= 525370)	Women (n=255148)	Men (n=237161)	(N= 1605612)
Age(years)	37.9	38.9 (17.2)	37.5	37.7	38.2
Mean (SD)	(16.6)		(15.6)	(16.1)	(16.6)
Education attained n(%)					
No education, preschool	226,372 (38.5)	101,668 (19.4)	48,489 (19.0)	20,765 (8.8)	397,294 (24.8)
Primary	82,476 (14.0)	82,538 (15.7)	28,793 (11.3)	25,010 (10.6)	218,817 (13.6)
Secondary	232,837 (39.6)	277,141 (52.8)	122,322 (48.0)	128,405 (54.2)	760,704 (47.4)
Higher	46,040 (7.8)	63,614 (12.1)	55,459 (21.7)	62,825 (26.5)	227,938 (14.2)
BPL card n(%)					
No	278,937 (47.5)	249,564 (47.6)	170,101 (66.8)	159,196 (67.3)	857,797 (53.5)
Yes	307,996 (52.5)	274,940 (52.4)	84,534 (33.2)	77,514 (32.7)	744,984 (46.5)

	RURAL		URBAN		TOTAL
Variables	Women (n= 587933)	Men (n= 525370)	Women (n=255148)	Men (n=237161)	(N= 1605612)
Wealth Index n(%)					
Poor	312,657 (53.2)	272,496 (51.9)	26,971 (10.6)	24,824 (10.5)	636,948 (39.7)
Middle	132,957 (22.6)	122,454 (23.3)	40,913 (16.0)	38,538 (16.2)	334,863 (20.9)
Rich	142,319 (24.2)	130,419 (24.8)	187,264 (73.4)	173,799 (73.3)	633,807 (39.5)

3B.2 Household and Fuel Characteristics

Sixty percent of the individuals lived in pucca houses. Clean fuel was the primary cooking fuel used by 56.3 percent of the individuals, with a predominant use of clean fuel in urban areas and solid fuel in rural areas. Most individuals (80.1 percent) cooked inside the house, with three-fourths of the individuals (71.1 percent) having a separate room serving as the kitchen.

Table 3.13 Household and fuel characteristics of the study participants (NFHS 5)

	RURAL		URBAN		TOTAL
Variables	Women (n= 587933)	Men (n= 525370)	Women (n=255148)	Men (n=237161)	(N= 1605612)
House type n (%)					
Kachha	34,803 (6.0)	31,015 (6.0)	2,254 (0.9)	2,050 (0.9)	70,123 (4.4)
Semi-pucca	2,62,016 (45.1)	2,31,002 (44.5)	35,910 (14.2)	32,870 (14.0)	5,61,798 (35.4)
Pucca	2,83,510 (48.9)	2,56,551 (49.5)	2,14,063 (84.9)	1,99,419 (85.1)	9,53,543 (60.1)

Variables n (%)	RURAL		URBAN		TOTAL
	Women (n= 587933)	Men (n= 525370)	Women (n=255148)	Men (n=237161)	(N= 1605612)
Type of Fuel					
Clean fuel	2,44,114 (41.5)	2,21,618 (42.2)	2,26,334 (88.7)	2,11,482 (89.2)	9,03,548 (56.3)
Kerosene	2,115 (0.4)	2,139 (0.4)	950 (0.4)	1,005 (0.4)	6,209 (0.4)
Solid fuel	3,41,704 (58.1)	3,01,612 (57.4)	27,864 (10.9)	24,674 (10.4)	6,95,855 (43.3)
Place of cooking					
In the house	4,46,369 (75.9)	3,99,210 (76.0)	2,27,941 (89.3)	2,12,151 (89.5)	12,85,671 (80.1)
In separate building	82,998 (14.1)	74,936 (14.3)	20,046 (7.9)	18,637 (7.9)	1,96,617 (12.2)
Outdoors	58,144 (9.9)	50,843 (9.7)	7,107 (2.8)	6,330 (2.7)	1,22,424 (7.7)
Separate room as kitchen					
Yes	2,93,439 (65.7)	2,65,428 (66.5)	1,84,532 (81.0)	1,70,719 (80.5)	9,14,118 (71.1)
No	1,52,930 (34.2)	1,33,782 (33.5)	43,409 (19)	41,431 (19.5)	3,71,552 (28.9)
Ventilation in kitchen					
Yes	3,80,636 (85.3)	3,40,158 (85.2)	2,07,948 (91.2)	1,93,256 (91.1)	11,21,998 (87.3)
No	65,732 (14.7)	59,052 (14.8)	19,993 (8.8)	18,894 (8.9)	1,63,672 (12.7)

3B.3 Lifestyle characteristics

Half of the participants (58.7 percent) had an average BMI ranging from 18.5 - 24.9. The prevalence of underweight (BMI < 18.5) was higher among rural women (21.5 percent) compared to urban women (13.7 percent). Overweight and obesity were more prevalent among urban residents. Alcohol consumption and tobacco use were reported by 9.9 percent and 23.4 percent of the individuals, respectively.

Table 3.14 Lifestyle characteristics of the study participants (NFHS 5)

	RURAL		URBAN		TOTAL
Variables n (%)	Women (n= 587933)	Men (n= 525370)	Women (n=255148)	Men (n=237161)	(N= 1605612)
BMI (weight/height²)					
Underweight (<18.5)	94,035 (21.5)	10,704 (17.4)	27,110 (13.7)	3,563 (12.6)	1,35,412 (18.7)
Regular weight (18.5-24.9)	2,61,817 (59.8)	39,367 (64.0)	1,08,360 (54.9)	16,447 (57.9)	4,25,990 (58.7)
Overweight (25-29.9)	63,909 (14.6)	9,713 (15.8)	43,377 (22.0)	6,768 (23.8)	1,23,766 (17.1)
Obese (≥30)	18,423 (4.2)	1,767 (2.9)	18,607 (9.4)	1,612 (5.7)	40,409 (5.6)
Alcohol Consumption					
Yes	9,669 (1.7)	1,06,373 (20.4)	1,462 (0.6)	39,489 (16.8)	1,56,993 (9.9)
No	5,78,191 (98.3)	4,18,111 (79.6)	2,53,653 (99.4)	1,97,326 (83.2)	14,47,282 (90.1)
	RURAL		URBAN		TOTAL

Variables n (%)	Women (n= 587933)	Men (n= 525370)	Women (n=255148)	Men (n=237161)	(N= 1605612)
Smoking Status					
Yes	61,497 (10.5)	2,28,815 (43.6)	13,900 (5.4)	71,387 (30.1)	3,75,599 (23.4)
No	5,26,350 (89.5)	2,95,784 (56.4)	2,41,220 (94.6)	1,65,396 (69.9)	12,28,750 (76.6)

3B.4 BIVARIATE ANALYSIS

The bivariate analysis is employed between the three health outcomes of interest (mean systolic blood pressure, mean diastolic blood pressure, and mean fasting blood sugar) and the independent variables.

3B.4.1 Sociodemographic variables

Age was positively associated with mean systolic blood pressure, diastolic blood pressure, and fasting blood sugar ($p < 0.001$). Females had significantly lower mean levels of systolic blood pressure (-5.02 mmHg), diastolic blood pressure (-2.01 mmHg), and fasting blood sugar (-1.71 mmol/L) compared to males ($p < 0.001$). Rural residents had lower mean diastolic blood pressure (-0.38 mmHg) and mean fasting blood sugar (-1.59 mmol/L) than urban residents ($p < 0.001$), with no significant difference in mean systolic blood pressure between urban and rural areas. Individuals with lower educational attainment had higher mean systolic blood pressure, mean diastolic blood pressure, and mean fasting blood sugar than those with higher education ($p < 0.001$). Individuals with Below Poverty Line (BPL) status had lower mean systolic blood pressure (-0.42 mmHg), mean diastolic blood pressure (-0.22 mmHg), and mean fasting blood sugar (-0.62 mmol/L) compared to those with Above Poverty Line (APL) status ($p < 0.001$). Additionally, wealthier households had higher mean systolic blood pressure, mean diastolic blood pressure, and mean fasting blood sugar than those from poorer households ($p < 0.001$).

The association between sociodemographic variables with the outcome variables, mean systolic and diastolic blood pressure, and mean fasting blood sugar are shown in Table 3.15.

Table 3.15 Association between sociodemographic variables and outcome variables

Variables		SBP	DBP	FBS
		β (95% CI)	β (95% CI)	β (95% CI)
Age		0.37 (0.36, 0.37)	0.16 (0.16, 0.17)	0.47 (0.46, 0.47)
	p-value	< 0.001	< 0.001	< 0.001
Sex				
	Male	Reference	Reference	Reference
	Female	-5.02 (-5.09, -4.96)	-2.01 (-2.06, -1.97)	-1.71 (-1.85, -1.58)
	p-value	< 0.001	< 0.001	< 0.001
Place of residence				
	Urban	Reference	Reference	Reference
	Rural	-0.03 (-0.17, 0.09)	-0.38 (-0.47, -0.30)	-1.59 (-1.82, -1.36)
	p-value	0.57	< 0.001	< 0.001
Education attained				
	Higher	Reference	Reference	Reference
	No education/preschool	5.87 (5.73, 6.02)	2.14 (2.06, 2.23)	6.39 (6.12, 6.66)
	Primary	3.86 (3.71, 4.02)	1.79 (1.69, 1.88)	5.55 (5.24, 5.85)
	Secondary	0.12 (0.01, 0.24)	-0.31 (-0.38, -0.24)	0.57 (0.34, 0.80)
	p-value	< 0.001	< 0.001	< 0.001
BPL/APL cardholder				
	APL	Reference	Reference	Reference
	BPL	-0.42 (-0.51, -0.34)	-0.22 (-0.28, -0.17)	-0.62 (-0.79, -0.46)
	p-value	< 0.001	< 0.001	< 0.001
Wealth index				
	Poor	Reference	Reference	Reference
	Middle	-0.01 (0.12, 0.09)	0.53 (0.47, 0.60)	0.86 (0.66, 1.07)
	Rich	0.76 (0.65, 0.87)	0.97 (0.90, 1.05)	2.03 (1.83, 2.03)
	p-value	< 0.001	< 0.001	< 0.001

CI- Confidence interval; SBP- Systolic blood pressure; DBP-Diastolic blood pressure; FBS- Fasting blood sugar

3B.4.2 Fuel and Household Characteristics

Individuals using solid fuel exhibited a negative association with mean systolic blood pressure (-0.22 mmHg), mean diastolic blood pressure (-0.71 mmHg), and mean fasting blood sugar (-1.84 mmol/L) compared to those using clean fuel ($p < 0.001$). Cooking outdoors or in a separate building was associated with lower mean systolic blood pressure, diastolic blood pressure, and fasting blood sugar compared to cooking inside the house. These differences are statistically significant ($p < 0.001$). Furthermore, individuals without a separate room for the kitchen demonstrated higher mean levels of systolic blood pressure (0.57 mmHg), diastolic blood pressure (0.54 mmHg), and fasting blood sugar (1.64 mmol/L) compared to those with a separate kitchen ($p < 0.001$). The association of the Fuel and Household characteristics with the outcome variables, mean systolic and diastolic blood pressure, and mean fasting blood sugar are shown in Table 3.16

Table 3.16 Association between Fuel and Household characteristics and outcome variables

Variables		SBP β (95% CI)	DBP β (95% CI)	FBS β (95% CI)
Type of cooking fuel				
	Clean fuel	Reference	Reference	Reference
	Kerosene	0.42 (-0.21, 1.05)	0.12 (-0.33, 0.57)	-0.30 (-1.53, 0.91)
	Solid fuel	-0.22 (-0.32, -0.13)	-0.71 (-0.77, -0.65)	-1.84 (-2.01, -1.67)
	p-value	< 0.001	< 0.001	< 0.001
Ventilation in kitchen				
	No	Reference	Reference	Reference
	Yes	0.11 (-0.01, 0.24)	0.19 (0.11, 0.28)	1.82 (1.57, 2.06)
	p-value	< 0.001	< 0.001	< 0.001
Place of cooking				
	In the house	Reference	Reference	Reference
	In a separate building	-0.17 (-0.31, -0.04)	-0.26 (0.35, -0.17)	1.14 (0.89, 1.38)
	Outdoors	-0.49 (-0.66, -0.32)	-0.50 (-0.61, -0.39)	-0.45 (-0.77, -0.14)
	p-value	< 0.001	< 0.001	< 0.001

Variables	SBP	DBP	FBS
	β (95% CI)	β (95% CI)	β (95% CI)
Separate room as a kitchen			
Yes	Reference	Reference	Reference
No	0.57 (0.47, 0.68)	0.54 (0.51, 0.65)	1.64 (1.44, 1.83)
p-value	< 0.001	< 0.001	< 0.001

CI- Confidence interval; SBP- Systolic blood pressure; DBP-Diastolic blood pressure; FBS- Fasting blood sugar

3B.4.3 Lifestyle Characteristics

Individuals with higher BMI, alcohol consumption, and tobacco use exhibited significantly elevated mean systolic blood pressure and mean diastolic blood pressure, as well as increased mean fasting blood sugar levels, compared to their counterparts with regular BMI and non-consumers/non-users, with all differences being statistically significant ($p < 0.001$). Table 3.17 shows the association between Lifestyle characteristics and outcome variables.

Table 3.17 Association between Lifestyle characteristics and outcome variables

Variables	SBP	DBP	FBS
	β (95% CI)	β (95% CI)	β (95% CI)
BMI (weight/height²)			
Underweight (<18.5)	Reference	Reference	Reference
Regular (18.5-24.9)	5.27 (5.15, 5.39)	3.19 (3.11, 3.27)	4.13 (3.95, 4.31)
Overweight (25-29.9)	9.24 (9.08, 9.39)	6.85 (6.75, 6.96)	10.4 (10.1, 10.8)
Obese (≥ 30)	9.73 (9.49, 9.97)	8.54 (8.39, 8.69)	15.0 (14.5, 15.6)
p-value	< 0.001	< 0.001	< 0.001
Alcohol Consumption			
No	Reference	Reference	Reference
Yes	5.30 (5.19, 5.41)	3.61 (3.54, 3.69)	3.68 (3.43, 3.94)
p-value	< 0.001	< 0.001	< 0.001

Variables	SBP	DBP	FBS
	β (95% CI)	β (95% CI)	β (95% CI)
Smokes/ uses tobacco			
No	Reference	Reference	Reference
Yes	4.98 (4.90, 5.07)	2.64 (2.58, 2.69)	4.60 (4.42, 4.78)
p-value	< 0.001	< 0.001	< 0.001

CI- Confidence interval; SBP- Systolic blood pressure; DBP-Diastolic blood pressure; FBS- Fasting blood sugar

3B.5 Association between type of cooking fuel and mean blood pressure and mean fasting blood sugar

Multivariable linear regression analysis was employed to explore the independent association between household air pollution exposure, using type of cooking fuel as a proxy indicator, and the health outcomes of interest: mean systolic blood pressure, mean diastolic blood pressure, and mean fasting blood sugar. The potential covariates included in the study were ventilation in the kitchen, place of residence, age, sex, BPL/APL card holder, w, and smoking status.

3B.5.1 Systolic Blood Pressure

Participants using solid fuel had a 1.50 mmHg higher mean systolic blood pressure compared to those using clean fuel (95% CI: 1.37, 1.62) after adjusting for potential covariates ($p < 0.001$). However, there was no significant difference in mean systolic blood pressure between kerosene and clean fuel users. Lack of ventilation in the kitchen was associated with a 0.30 mmHg higher mean systolic blood pressure ($p < 0.001$). Additionally, for every one-year increase in age, mean systolic blood pressure increased by 0.39 mmHg (95% CI: 0.38, 0.40). Overweight and obese individuals had a 2.35 mmHg

(95% CI: 2.21, 2.49) and a 3.15 mmHg (95% CI: 2.91, 3.39) higher mean systolic blood pressure than those with regular weight. Individuals residing in rural areas were significantly associated with higher mean systolic blood pressure than those in urban areas ($p < 0.001$). Table 3.18 presents the association between PM_{2.5} exposure groups and the mean systolic blood pressure.

Table 3.18 Association between type of cooking fuel and mean systolic blood pressure

Characteristic	Estimate (β)	95% CI	p-value
(Intercept)	104	104, 104	<0.001
Type of cooking fuel			<0.001
Clean Fuel	—	—	
Kerosene	0.43	-0.55, 1.42	0.392
Solid Fuel	1.50	1.37, 1.62	<0.001
Ventilation in kitchen			<0.001
Yes	—	—	
No	0.30	0.14, 0.45	<0.001
Place of residence			<0.001
Rural	—	—	
Urban	-0.34	-0.51, -0.18	<0.001
Smoking Status			0.043
No	—	—	
yes	-0.19	-0.37, -0.01	0.043
Sex			<0.001
Female	—	—	
Male	6.64	6.47, 6.82	<0.001
Age (years)	0.39	0.38, 0.40	<0.001

Characteristic	Estimate (β)	95% CI	p-value
BMI category			<0.001
Regular weight	—	—	
Underweight	-3.31	-3.44, -3.19	<0.001
Obesity	3.15	2.91, 3.39	<0.001
Overweight	2.35	2.21, 2.49	<0.001
BPL card Holder			<0.001
No	—	—	
Yes	-0.45	-0.56, -0.33	<0.001

* Adjusted for ventilation, age, sex, BMI category, place of residence, BPL/APL card, and smoking status. CI- Confidence interval

3B.5.2 Diastolic Blood Pressure

Solid fuel users had a 0.40 mmHg higher mean diastolic blood pressure compared to clean fuel users (95% CI: 0.32, 0.48) after adjusting for covariates ($p < 0.001$). However, there was no significant difference between kerosene and clean fuel users. Lack of ventilation in the kitchen was significantly associated with a 0.21 mmHg higher mean diastolic blood pressure ($p < 0.001$). Being overweight and obese were significantly associated with higher diastolic blood pressure, with overweight individuals having a 2.53 mmHg higher mean (95% CI: 2.44, 2.62) and obese individuals having a 4.32 mmHg higher mean (95% CI: 4.17, 4.47) compared to those with regular weight. Other factors, such as age and residing in rural areas, were also significantly associated ($p < 0.001$). Table 3.19 presents the association between PM_{2.5} exposure groups and the mean diastolic blood pressure.

Table 3.19 Association between type of cooking fuel and mean diastolic blood pressure

Characteristic	Estimate (β)	95% CI	p-value
(Intercept)	69.4	69.3, 69.6	<0.001
Type of cooking fuel			<0.001
Clean Fuel	—	—	
Kerosene	0.19	-0.33, 0.71	0.468
Solid Fuel	0.40	0.32, 0.48	<0.001
Ventilation in kitchen			<0.001
Yes	—	—	
No	0.21	0.11, 0.31	<0.001
Place of residence			<0.001
Rural	—	—	
Urban	-0.21	-0.32, -0.11	<0.001
Smoking Status			<0.001
No	—	—	
yes	0.47	0.35, 0.60	<0.001
Sex			<0.001
Female	—	—	
Male	2.40	2.24, 2.51	<0.001
Age	0.26	0.25, 0.26	<0.001
BMI category			<0.001
Regular weight	—	—	
Underweight	-1.89	-1.98, -1.80	<0.001
Obesity	4.32	4.17, 4.47	<0.001
Overweight	2.53	2.44, 2.62	<0.001

Characteristic	Estimate (β)	95% CI	p-value
BPL card Holder			0.012
No	—	—	
Yes	-0.10	-0.17, -0.02	0.012

* Adjusted for ventilation, age, sex, BMI category, place of residence, BPL/APL card, and smoking status. CI- Confidence interval

3B.5.3 Fasting Blood Sugar

The type of cooking fuel was not significantly associated with mean fasting blood sugar levels. Being overweight and obese showed a significant association with fasting blood sugar ($p < 0.001$). The other findings are presented in Table 3.20, which show the association between PM_{2.5} exposure groups and the mean fasting blood sugar.

Table 3.20 Association between type of cooking fuel and mean fasting blood sugar

Characteristic	Estimate (β)	95% CI	p-value
(Intercept)	95.1	94.8, 95.4	<0.001
Fuel Type Category			0.188
Clean Fuel	—	—	
Kerosene	0.72	-0.53, 1.97	0.260
Solid Fuel	0.17	-0.04, 0.39	0.118
Type of House			<0.001
Pucca	—	—	
Kachha	-0.01	-0.41, 0.40	0.986
semi-pucca	-0.50	-0.71, -0.29	<0.001
Place of cooking			<0.001
In the house	—	—	
In a separate building	1.72	1.44, 2.01	<0.001
Outdoors	0.63	0.27, 0.99	<0.001

Characteristic	Estimate (β)	95% CI	p-value
Place of residence			0.550
Rural	—	—	
Urban	0.08	-0.19, 0.36	0.550
Sex			<0.001
Female	—	—	
Male	2.77	2.43, 3.11	<0.001
Age	0.49	0.48, 0.51	<0.001
BMI category			<0.001
Regular weight	—	—	
Underweight	-1.58	-1.76, -1.40	<0.001
Obesity	8.58	8.00, 9.15	<0.001
Overweight	4.06	3.76, 4.35	<0.001
Smoking Status			0.014
No	—	—	
Yes	-0.45	-0.82, -0.09	0.014

* Adjusted for place of cooking, age, sex, BMI category, place of residence, BPL/APL card, and smoking status. CI- Confidence interval

CHAPTER 4

DISCUSSION AND CONCLUSION

This study aimed to estimate the household air pollution levels with different cooking fuels and to explore the association between household air pollution levels and blood pressure as well as fasting blood sugar among 226 participants aged 18–69 years from 162 households in rural areas of Pathanamthitta district, Kerala. A pilot study compared 24-hour and 12-hour mean PM_{2.5} concentration sampling, showing variations within $\pm 6 \mu\text{g}/\text{m}^3$, which did not significantly affect the relative validity of the exposure assessment. Hence, 12-hour mean PM_{2.5} concentration sampling was chosen for the study.

The primary study highlights the differences between 12-hour mean PM_{2.5} concentration and different cooking fuels. Therefore, the type of cooking fuel was taken as a proxy for household air pollution. Consequently, to obtain a broader picture of the impact of solid fuel-induced household air pollution on mean blood pressure and fasting blood sugar at the national level, the National Family Health Survey-5 (NFHS-5) dataset was analyzed.

The 12-hour mean PM_{2.5} concentration of participants relying on solid fuels was nearly $10 \mu\text{g}/\text{m}^3$ higher than those using clean fuels. Although no significant association was found between PM_{2.5} exposure groups and mean blood pressure or fasting blood sugar, a positive association was observed between PM_{2.5} exposure groups and mean blood pressure. To study the impact at the national level, the NFHS-5 data was analyzed. In the NFHS-5 data, individuals exposed to solid fuels had higher mean blood pressure than those using only clean fuels. In both studies, mean fasting blood glucose levels did not vary according to household air pollution exposure.

4.1 Household Air Pollution and Cooking Fuels

This study highlights that a significant proportion (86.7 percent) of participants used clean fuel as their primary cooking source. However, the practice of "fuel stacking," which involves simultaneously using clean and solid fuels for cooking, was widespread, with 82.7 percent of participants engaging in this behavior. Similar fuel stacking practices have also been observed in studies conducted in other southern parts of India, such as Karnataka and Odisha (James et al., 2020; Mohapatra et al., 2018). This widespread solid fuel use, even as a secondary fuel source, contributed to higher PM_{2.5} concentrations. Other studies also found that solid fuel users experience higher levels of PM_{2.5} exposure compared to clean fuel users (Chakraborty and Mondal, 2018; Mitra et al., 2023).

In this study, the 12-hour mean PM_{2.5} concentration was significantly higher among individuals using solid fuels (85.83 µg/m³) than those using clean fuels (75.15 µg/m³). This finding aligns with the observation that household air pollution resulting from the use of solid fuels contributed to a 24-hour mean PM_{2.5} concentration of 82.5 µg/m³ in Indian households (Pandey et al., 2021). Notably, comparatively higher mean PM_{2.5} levels observed among clean fuel users remain a concern, which might be attributed to the smaller study population size, fuel stacking practices, and other environmental sources of PM_{2.5}, such as open burning and the use of incense sticks, contributing to increased exposure levels even among individuals primarily using clean fuels.

The study further suggests that lack of cross-ventilation was more prevalent among individuals in the PM_{2.5} > 75 µg/m³ group (94.6 percent) compared to the PM_{2.5} ≤ 75 µg/m³ group (80.7 percent). This observation could be explained by the accumulation of household air pollution due to inadequate ventilation. This result is supported by previous

studies that demonstrated the role of kitchen configuration and ventilation in determining the intensity of indoor air pollution exposures (Balakrishnan et al., 2013; Mitra et al., 2023).

Furthermore, this study underscores a significant disparity in solid fuel use between urban (~ 4 percent) and rural areas (~ 40 percent) in India. This trend aligns with the WHO's report, which indicates that while only 14 percent of individuals in urban areas rely on polluting fuels and technologies globally, this percentage rises to 49 percent among the rural population (WHO, 2022).

4.2 Household Air Pollution and Mean Blood Pressure

The study findings showed an association between higher levels of PM_{2.5} exposure and elevated mean blood pressure, although the results were not statistically significant. Participants exposed to PM_{2.5} >75µg/m³ had 2.35 mmHg higher mean systolic blood pressure (95% CI: -1.98, 7.04) and 1.66 mmHg higher mean diastolic blood pressure (95% CI: -0.86, 4.33) compared to those exposed to PM_{2.5} ≤75µg/m³, after adjusting for potential confounders. These results were consistent with an interventional study conducted in Karnataka, India, where participants using an improved stove had two mmHg lower mean systolic blood pressure (95% CI: -4.5, 0.5) and 1.1 mmHg lower mean diastolic blood pressure (95% CI: -2.9, 0.6) compared to the control group using a traditional stove (Aung et al., 2018). Other studies have reported stronger associations between higher mean PM_{2.5} exposure levels and elevated systolic and diastolic blood pressure (McCracken et al., 2007; Young et al., 2019). This variation in association could be attributed to differences in the type of solid fuels being used, cooking practices, age, exposure patterns, population demographics, and geographical regions analyzed.

The NFHS-5 analysis, which used cooking fuel type as a proxy for exposure, showed that individuals using solid fuels had a 1.50 mmHg higher mean systolic blood pressure and a

0.40 mmHg higher mean diastolic blood pressure than those using clean fuels. This finding aligns with previous studies that have reported an increased risk of hypertension or elevated blood pressure associated with self-reported solid fuel use (Lee et al., 2012; Arku et al., 2018; Khan et al., 2021).

In addition, the study findings observed that other factors, such as age and body mass index (BMI), were significantly associated with an increase in mean systolic and mean diastolic blood pressure. These results were consistent with previous studies reporting a stronger association between PM_{2.5} exposure and blood pressure among women aged 40 years or older (Baumgartner et al., 2011; Young et al., 2019). Similarly, increased BMI was linked to elevated blood pressure, aligning with the findings of this study and other studies (Khan et al., 2021).

4.3 Household Air Pollution and Mean Fasting Blood Sugar

This study could not find any association between household air pollution or type of cooking fuel and mean fasting blood sugar. Participants in the PM_{2.5} >75 µg/m³ exposure group had one percent lower fasting blood sugar levels than those exposed to PM_{2.5} ≤75 µg/m³, with a point estimate of -0.01 (95% CI: -0.08, 0.07). Similar to this study, a cross-sectional study conducted in West Bengal, India, which used direct PM_{2.5} exposure measurement, recorded a higher blood glucose level of 100.38 ± 34.13 mg/dL among LPG users and 94.31 ± 18.72 mg/dL among biomass users (p < 0.30) (Mitra et al., 2023). Another study by Kang et al. (2022) also found comparable results when using self-reported cooking fuel type as a proxy for household air pollution exposure (Kang et al., 2022).

However, many other studies have shown an association between household air pollution and fasting blood sugar (Lee et al., 2012; Rajkumar et al., 2018; Mishra et al., 2020; Zheng et al., 2021). These discrepancies in findings may arise from variations in methodologies,

such as assessing the exposure variable as self-reported cooking fuel type or the outcome variable as self-reported diabetes, rather than utilizing actual measurements, as undertaken in this study.

Furthermore, being overweight and obese showed a significant association with fasting blood sugar ($p < 0.001$) in this study. A similar result was seen in a study by Zheng (2021), where among participants exposed to biomass fuel, being overweight or obese increased the risk of acquiring high levels of fasting blood glucose (OR: 2.10, 95% CI: 1.46, 3.02) (Zheng et al., 2021).

4.4 Strengths of the study

Quantitative exposure measurements of PM_{2.5} concentrations in the kitchen, living area, and outdoor environment strengthens the study's assessment of household air pollution exposure compared to relying solely on self-reported fuel use as a proxy. Additionally, the inclusion of clinical measurements for blood pressure and fasting blood sugar levels enhances the study's credibility by avoiding potential biases associated with self-reported health data. Moreover, the analysis of the NFHS-5 dataset, which comprises a large, nationally representative sample, further validates the primary study findings and enables the estimation of the broader impact of household air pollution on mean blood pressure and mean fasting blood.

4.5 Limitations of the study

The cross-sectional study design limits the establishment of causality, and the temporal relationship between exposure and outcome could not be assessed. The single-day measurement of PM_{2.5} may not accurately capture the day-to-day variability and seasonal variations in household air pollution exposure. Additionally, the study focused solely on PM_{2.5} and PM₁₀, excluding other pollutants from solid fuel combustion.

Furthermore, the NFHS-5 survey data used for validation considers only primary fuel usage, potentially underestimating solid fuel use in households with multiple fuel types. Its sampling weights may also not represent the entire population across all age groups.

The major bias in this study arises from the presence of air pollution monitors in households, which could have led to a Hawthorne effect. Individuals may have altered their cooking patterns or behavior, introducing a potential source of bias in the measured household air pollution levels.

4.6 Significance

Studies have shown that even small reductions in air pollutant levels can lead to substantial decreases in mortality rates at the population level. Zhang et al. (2017) reported that a 10 $\mu\text{g}/\text{m}^3$ reduction in $\text{PM}_{2.5}$ and PM_{10} decreased the daily mortality rate by 1.11% and 0.71%, respectively (Zhang et al., 2017). Studies suggest that a moderate decrease of even two mmHg in mean systolic blood pressure across populations can result in significant public health savings by reducing cardiovascular mortality and morbidity (Young et al., 2019). The minimal changes in blood pressure observed due to household air pollution exposure may not have significant clinical relevance for individuals. However, considering the widespread exposure to household air pollution, these minor effects can result in substantial global health burdens.

4.7 Conclusion and Recommendations

This cross-sectional study indicates a higher mean $\text{PM}_{2.5}$ concentration level in solid fuel users than clean fuel users. Furthermore, it highlights that exposure to solid fuel was positively associated with higher mean systolic and diastolic blood pressure than clean fuel exposure.

These findings underscore the urgent need to address household air pollution to mitigate its adverse effects on public health. Promoting the transition from solid fuels to clean fuel usage should be a priority, as this transition could improve indoor air quality, reduce exposures, and yield substantial health benefits for the population. Public health policies that provide financial support or subsidies for purchasing and sustaining cleaner fuels could facilitate this transition. Interventions to improve kitchen ventilation could also reduce exposure to household air pollution and associated health risks.

Furthermore, longitudinal studies and interventional trials would be valuable in establishing causal relationships between exposure to household air pollution and health outcomes and evaluating the effectiveness of interventions in reducing household air pollution exposure and its associated health impacts.

BIBLIOGRAPHY

- Alexander D, Larson T, Bolton S, et al. (2015) Systolic blood pressure changes in indigenous Bolivian women associated with an improved cookstove intervention. *Air Quality, Atmosphere & Health* 8(1): 47–53. DOI: 10.1007/s11869-014-0267-6
- Arku RE, Ezzati M, Baumgartner J, et al. (2018) Elevated blood pressure and household solid fuel use in premenopausal women: Analysis of 12 Demographic and Health Surveys (DHS) from 10 countries. *Environmental Research* 160: 499–505. DOI: 10.1016/j.envres.2017.10.026
- Arku RE, Brauer M, Ahmed SH, et al. (2020) Long-term Exposure to Outdoor and Household Air Pollution and Blood Pressure in the Prospective Urban and Rural Epidemiological (PURE) Study. *Environmental pollution (Barking, Essex: 1987)* 262: 114197. DOI: 10.1016/j.envpol.2020.114197
- Aung TW, Baumgartner J, Jain G, et al. (2018) Effect on blood pressure and eye health symptoms in a climate-financed randomized cookstove intervention study in rural India. *Environmental Research* 166: 658–667. DOI: 10.1016/j.envres.2018.06.044
- Balakrishnan K, Ghosh S, Ganguli B, et al. (2013) State and national household concentrations of PM_{2.5} from solid cookfuel use: Results from measurements and modeling in India for estimation of the global burden of disease. *Environmental Health* 12(1): 77. DOI: 10.1186/1476-069X-12-77
- Baumgartner J, Schauer JJ, Ezzati M, et al. (2011) Indoor Air Pollution and Blood Pressure in Adult Women Living in Rural China. *Environmental Health Perspectives* 119(10): 1390–1395. DOI: 10.1289/ehp.1003371
- Baumgartner J, Carter E, Schauer JJ, et al. (2018) Household air pollution and measures of blood pressure, arterial stiffness and central haemodynamics. *Heart (British Cardiac Society)* 104(18): 1515–1521. DOI: 10.1136/heartjnl-2017-312595
- Benka-Coker ML, Young BN, Keller JP, et al. (2021) Impact of the wood-burning *Justa* cookstove on fine particulate matter exposure: A stepped-wedge randomized trial in rural Honduras. *Science of The Total Environment* 767: 144369. DOI: 10.1016/j.scitotenv.2020.144369
- Burroughs Peña M, Romero KM, Velazquez EJ, et al. (2015) Relationship between daily exposure to biomass fuel smoke and blood pressure in high-altitude Peru. *Hypertension (Dallas, Tex.: 1979)* 65(5): 1134–1140. DOI: 10.1161/HYPERTENSIONAHA.114.04840
- Chakraborty D and Mondal NK (2018) Hypertensive and toxicological health risk among women exposed to biomass smoke: A rural Indian scenario. *Ecotoxicology and Environmental Safety* 161: 706–714. DOI: 10.1016/j.ecoenv.2018.06.024
- Chen Y, Fei J, Sun Z, et al. (2020) Household air pollution from cooking and heating and its impacts on blood pressure in residents living in rural cave dwellings in Loess Plateau of

China. *Environmental Science and Pollution Research International* 27(29). 29: 36677–36687. DOI: 10.1007/s11356-020-09677-1

Chowdhury S, Pillarisetti A, Oberholzer A, et al. (2023) A global review of the state of the evidence of household air pollution's contribution to ambient fine particulate matter and their related health impacts. *Environment International* 173: 107835. DOI: 10.1016/j.envint.2023.107835

DHS Program (2022) Cooking Fuels and Technologies, Guide to DHS Statistics DHS-8. Available at: https://www.dhsprogram.com/data/Guide-to-DHS-Statistics/Cooking_Fuels_and_Technologies.htm (Accessed: 25 December 2023).

Dutta A, Mukherjee B, Das D, et al. (2011) Hypertension with elevated levels of oxidized low-density lipoprotein and anticardiolipin antibody in the circulation of premenopausal Indian women chronically exposed to biomass smoke during cooking. *Indoor Air* 21(2). 2: 165–176. DOI: 10.1111/j.1600-0668.2010.00694.x

Fatmi Z, Ntani G and Coggon D (2019) Coronary heart disease, hypertension and use of biomass fuel among women: comparative cross-sectional study. *BMJ open* 9(8). 8. British Medical Journal Publishing Group: e030881. DOI: 10.1136/bmjopen-2019-030881

Global Burden of Disease (GBD) (2019). Available at: <https://www.healthdata.org/research-analysis/gbd> (accessed 29 October 2023).

Gould CF and Urpelainen J (2018) LPG as a clean cooking fuel: Adoption, use, and impact in rural India. *Energy Policy* 122: 395–408. DOI: 10.1016/j.enpol.2018.07.042

Hu W, Downward GS, Reiss B, et al. (2014) Personal and indoor PM_{2.5} exposure from burning solid fuels in vented and unvented stoves in a rural region of China with a high incidence of lung cancer. *Environmental Science & Technology* 48(15): 8456–8464. DOI: 10.1021/es502201s

IIPS and ICF (2021) National Family Health Survey (NFHS-5) 2019-21 India Factsheet. Available at: http://rchiips.org/nfhs/NFHS-5_FCTS/India.pdf (Accessed: 28 October 2023).

James BS, Shetty RS, Kamath A, et al. (2020) Household cooking fuel use and its health effects among rural women in southern India—A cross-sectional study. *PLOS ONE* Dunea D (ed.) 15(4): e0231757. DOI: 10.1371/journal.pone.0231757

Kang N, Song X, Zhang C, et al. (2022) Association of household air pollution with glucose homeostasis markers in Chinese rural women: Effect modification of socioeconomic status. *Ecotoxicology and Environmental Safety* 248: 114283. DOI: 10.1016/j.ecoenv.2022.114283

Khan JR, Hossain MdB and Gupta RD (2021) Household cooking fuels associated with elevated blood pressure among adult women: a national-wide assessment in Bangladesh. *Environmental Science and Pollution Research* 28(47): 67814–67821. DOI: 10.1007/s11356-021-15344-w

Kshirsagar MP and Kalamkar VR (2014) A comprehensive review on biomass cookstoves and a systematic approach for modern cookstove design. *Renewable and Sustainable Energy Reviews* 30: 580–603. DOI: 10.1016/j.rser.2013.10.039

Lee KK, Bing R, Kiang J, et al. (2020) Adverse health effects associated with household air pollution: a systematic review, meta-analysis, and burden estimation study. *The Lancet Global Health* 8(11): e1427–e1434. DOI: 10.1016/S2214-109X(20)30343-0

Lee M-S, Hang J, Zhang F, et al. (2012) In-home solid fuel use and cardiovascular disease: a cross-sectional analysis of the Shanghai Putuo study. *Environmental Health* 11: 18. DOI: 10.1186/1476-069X-11-18

McCracken JP, Smith KR, Díaz A, et al. (2007) Chimney stove intervention to reduce long-term wood smoke exposure lowers blood pressure among Guatemalan women. *Environmental Health Perspectives* 115(7): 996–1001. DOI: 10.1289/ehp.9888

Mishra S, McClure LA, Golla V, et al. (2020) Relationship between diabetes mellitus and indoor air pollution: An exploratory analysis. *International Journal of Noncommunicable Diseases* 5(4): 165. DOI: 10.4103/jncd.jncd_38_20

Mitra P, Chakraborty D, Nayek S, et al. (2023) Biomass using tribal women exhibited respiratory symptoms, hypertensive risks and abnormal pulmonary function. *Chemosphere* 311(Pt 1): Pt 1: 136995. DOI: 10.1016/j.chemosphere.2022.136995

Mohapatra I, Das S and Samantaray S (2018) Health impact on women using solid cooking fuels in rural area of Cuttack district, Odisha. *Journal of Family Medicine and Primary Care* 7(1): 11. DOI: 10.4103/jfmpe.jfmpe_21_17

Pandey A, Brauer M, Cropper ML, et al. (2021) Health and economic impact of air pollution in the states of India: the Global Burden of Disease Study 2019. *The Lancet Planetary Health* 5(1): e25–e38. DOI: 10.1016/S2542-5196(20)30298-9

Qu W, Yan Z, Qu G, et al. (2015) Household Solid Fuel Use and Cardiovascular Disease in Rural Areas in Shanxi, China. *Iranian Journal of Public Health* 44(5): 625–638.

Rajagopalan S, Al-Kindi SG and Brook RD (2018) Air Pollution and Cardiovascular Disease. *Journal of the American College of Cardiology* 72(17): 2054–2070. DOI: 10.1016/j.jacc.2018.07.099

Rajkumar S, Clark ML, Young BN, et al. (2018) Exposure to Household Air Pollution from Biomass-Burning Cookstoves and HbA1c and Diabetic Status among Honduran Women. *Indoor air*: 10.1111/ina.12484. DOI: 10.1111/ina.12484

Shukla D and Dutta V (2022) Indoor Air Quality Monitoring of Urban and Rural Households of a North Indian City During Cooking Hours. *Aerosol Science and Engineering* 6(1): 86–98. DOI: 10.1007/s41810-021-00126-1

State of Global Air (2020) Available at: <https://www.stateofglobalair.org/resources/report/state-global-air-report-2020> (accessed 28 November 2023).

Tawiah T, Shupler M, Gyaase S, et al. (2022) The Association between Household Air Pollution and Blood Pressure in Obuasi Municipality, Ghana. *Atmosphere* 13(12). 12. Multidisciplinary Digital Publishing Institute: 2033. DOI: 10.3390/atmos13122033

Turner MC, Andersen ZJ, Baccarelli A, et al. (2020) Outdoor air pollution and cancer: An overview of the current evidence and public health recommendations. *CA: A Cancer Journal for Clinicians* 70(6): 460–479. DOI: 10.3322/caac.21632

United Nations (2021) Transforming our world: the 2030 Agenda for Sustainable Development. Available at: <https://sdgs.un.org/2030agenda> (accessed 8 April 2024).

Vaduganathan M, Mensah GA, Turco JV, et al. (2022) The Global Burden of Cardiovascular Diseases and Risk. *Journal of the American College of Cardiology* 80(25). American College of Cardiology Foundation: 2361–2371. DOI: 10.1016/j.jacc.2022.11.005

WHO (2023) Household air pollution. Available at: <https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health> (accessed 29 October 2023).

WHO Global Air Quality Guidelines: particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide (2021). Available at: <https://www.who.int/publications-detail-redirect/9789240034228> (accessed 23 March 2024).

Young BN, Clark ML, Rajkumar S, et al. (2019) Exposure to household air pollution from biomass cookstoves and blood pressure among women in rural Honduras: A cross-sectional study. *Indoor Air* 29(1). 1: 130–142. DOI: 10.1111/ina.12507

Zhang J, Liu Y, Cui L, et al. (2017) Ambient air pollution, smog episodes and mortality in Jinan, China. *Scientific Reports* 7: 11209. DOI: 10.1038/s41598-017-11338-2

Zheng X, Tang S, Guan W, et al. (2021) Exposure to biomass fuel is associated with high blood pressure and fasting blood glucose impairment in females in southern rural China. *Environmental Research* 199: 111072. DOI: 10.1016/j.envres.2021.111072

Zheng X, Ma S, Guan W, et al. (2022) Impact of polluting fuels for cooking on diabetes mellitus and glucose metabolism in south urban China. *Indoor Air* 32(1): e12960. DOI: 10.1111/ina.12960

ANNEXURE I

Achutha Menon Centre for Health Science Studies (AMCHSS) Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST) Trivandrum- 11

Participant Information Sheet

I am Dr. G Vaishnavi, currently pursuing Master of Public Health (MPH) at Achutha Menon Centre for Health Science Studies (AMCHSS), Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala. I am doing a study on “**Impact Of Household Air Pollution Exposure On Blood Pressure And Fasting Blood Sugar In Adults**” as a part of my course work, under the guidance of Dr. Jeemon P, Additional Professor of Epidemiology at AMCHSS.

You are being invited to participate in this research study. Before you decide whether or not to participate in this study, it is important that you understand why the research is being done and what it will involve. Please read / listen the information sheet and the consent form carefully and feel free to ask for clarifications you may have.

Purpose of the study

The purpose of this study is to explore the association between exposure to household air pollution arising from the use of various cooking fuels and its influence on blood pressure and fasting blood sugar levels of adults within rural households.

Procedure

If you are willing to participate in the study, you will be asked to complete an interview schedule which will include questions focussing on demographic information, household characteristics, and general lifestyle habits. The interview will take approximately 20-25 minutes of your valuable time. Additionally, we will measure the level of PM_{2.5} in the kitchen, living area, and outdoor area by placing a particulate matter monitoring instrument in these locations for a maximum duration of 12 hours. Along with this, kitchen and living area dimensions will be taken. Waist circumference, blood pressure measurements and fasting blood sugar readings will be taken as a part of the study.

Potential risks and discomforts

Participating in the study imposes no risk to your health. However, placing an instrument inside your house to monitor PM_{2.5} levels may cause temporary discomfort or inconvenience. Please note that the instrument is non-invasive and designed solely for

particulate matter monitoring. It does not have any other sensors to capture additional data. Some discomfort might be felt while taking the blood sample.

Possible benefits

Your participation in the study will not give any direct benefit to you now other than knowing the PM_{2.5} levels in your households, your blood pressure and fasting blood sugar measurements. However, the results of the study will be helpful for understanding the complex relationship between household air pollution, blood pressure and fasting blood sugar.

Cost and financial benefit

There is no cost for participation in this study. Participation is completely voluntary and no payment will be provided.

Confidentiality

Information obtained in this study will be kept strictly confidential. A participant identification number will be assigned to each participant which will help to maintain the strict confidentiality of the data collected. Your name will not be used in reporting information in publications or reports.

Withdrawal from the study

Your participation in the study will be completely voluntary. You are free and have the right to withdraw at any time during the study. There will be no penalty for withdrawal or not participating in the study.

Contact information

If you have any research-related questions or you would like to verify my credentials, you may contact me or member secretary of our institute's ethics committee at the following address:

Dr. G Vaishnavi
Principal Investigator
MPH 2022, AMCHSS, SCTIMST
Contact Number: 7012674503
Email: vaishnavi.girija96@gmail.com

Dr. Srinivas G
Member Secretary
Institutional Ethics Committee
SCTIMST, TRIVANDRUM- 695011
Office: 04712524689
Email: iec.mem.sec@sctimst.ac.in

ANNEXURE II

Informed Consent Form

I confirm that I have read/ heard and understood the information regarding the study **“Impact of household air pollution exposure on blood pressure and fasting blood sugar in adults”** as provided in the participant information sheet. All of my questions concerning this study have been answered and all the possible harms, discomforts, and benefits (if any) of this study have been explained to me. I also understand that my identity and personal information will be kept confidential. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without consequences. By signing this form, I agree to participate in this study. A copy of this form has been given to me.

Date:

Place:

Name of the participant

Signature/Thumb impression

Principal Investigator

Signature

ANNEXURE III

INTERVIEW SCHEDULE

Exclusion Criteria			
SL.NO		YES	NO
1	Are you currently pregnant?		
2	Are you currently taking medication for hypertension?		
3	Are you currently taking medication for diabetes?		
If the answer to any question is 'YES', then End of the survey			

1. GENERAL INFORMATION

1.1	Household ID	
1.2	Participant ID	
1.3	Date of interview	
1.4	Consent form has been read and signed	Yes/ No

2. DEMOGRAPHIC INFORMATION

SL.NO	QUESTION	RESPONSE
2.1	Age completed in years	
2.2	Sex	☐ 1- Male ☐ 2- Female ☐ 3- Transgender
2.3	How many years of formal schooling have you completed?	
2.4	What is your occupation?	☐ 1- Student ☐ 2- Self-employed ☐ 3- Govt employee ☐ 4- Non-govt employee ☐ 5- Homemaker ☐ 6- Retired ☐ 99- Unemployed
2.5	How long have you been living in this household?	

3. HOUSEHOLD CHARACTERISTICS

SL.NO	QUESTION	RESPONSE
3.1	Type of house	☐ 1- Kutchha ☐ 2- Semipucca ☐ 3- Pucca
3.2	How many members are there in this household (including children)?	
3.3	How many rooms does your household have, excluding bathroom/toilet?	
3.4	What is the main source of lighting in your household?	☐ 1- Electricity ☐ 2- Kerosene lamp ☐ 3- Other; specify_____
3.5	What is the type of ration card you have?	☐ 1- White card ☐ 2- Yellow card ☐ 3 - Pink card ☐ 4 - Blue card ☐ 99 - No ration card

4. HOUSEHOLD KITCHEN AND STOVE TYPES

SL.NO	QUESTION	RESPONSE
4.1	Type of kitchen	☐ 1- In a room used for living or sleeping (with partition) ☐ 2- In a room used for living or sleeping (without partition) ☐ 3- In a separate room used as a kitchen ☐ 4- In a separate building used as a kitchen ☐ 5- Outdoors / Open air kitchen (If '5' is selected, go to 4.1.1)
4.1.1	Is the stove located under any shed roof or canopy?	☐ 1- Yes ☐ 2- No
4.2	What is the primary stove used in your household for daily cooking purposes? (Please select one)	☐ 1- Open fire/ Three stone fire ☐ 2- Traditional mud cook stove ☐ 3- Improved cook stove ☐ 4- LPG cook stove ☐ 5- Kerosene stove ☐ 6- Electric or induction stove ☐ 7- Others; specify_____

4.3	In addition to the primary stove mentioned, do you use any secondary stoves in your household for specific cooking needs such as boiling water or cooking parboiled rice? (Please select all that apply)	☐ 1- Open fire/ Three stone fire ☐ 2- Traditional mud cook stove ☐ 3- Improved cook stove ☐ 4- LPG cook stove ☐ 5- Kerosene stove ☐ 6- Electric or induction stove ☐ 7- Others; specify _____ ☐ 8- None
4.4	Are the primary and secondary stoves in the same kitchen?	☐ 1- Yes ☐ 2- No

5. HOUSEHOLD COOKING FUEL

SL.NO	QUESTION	RESPONSE
5.1	Cooking Exposure time	
5.1.1	How long have/had you been cooking?	_____ years
5.1.2	On an average day, how much time do/did you spend in the kitchen: a) Weekday b) Weekend	_____ hours _____ hours
5.2	Primary Cooking Fuel	
5.2.1	What is the primary cooking fuel used in your household for daily cooking purposes? (Please select one)	☐ 1- Solid fuels (wood/ coconut husk/crop residues/coal/charcoal) ☐ 2- LPG ☐ 3- Electricity ☐ 4- Biogas ☐ 5- Kerosene ☐ 6- Others; specify _____
5.2.2	How long has your household been using this primary cooking fuel?	_____ years
5.2.3	On average, how many hours per day is the primary cooking fuel used?	_____ hours
5.2.4	What are the main reasons for using this primary cooking fuel? (Select all that apply)	☐ 1- Availability ☐ 2- Affordability ☐ 3- Takes less time to cook ☐ 4- Convenience ☐ 5- Fuel produces less smoke ☐ 6- Traditional, cultural, or taste preferences ☐ 7- Others; specify _____

5.3	Secondary Cooking Fuel	
5.3.1	In addition to the primary cooking fuel mentioned, do you use any secondary cooking fuel in your household for specific cooking needs such as boiling water or cooking parboiled rice? (Please select all that apply)	☐ 1- Solid fuels (wood/ coconut husk/crop residues/coal/charcoal) ☐ 2- LPG ☐ 3- Electricity ☐ 4- Biogas ☐ 5- Kerosene ☐ 6- Others; specify _____ ☐ 7- None (If '7' is selected, skip to 5.4)
5.3.2	How long has your household been using this secondary cooking fuel?	_____ years
5.3.3	On average, how many hours per day is the secondary cooking fuel used?	_____ hours
5.3.4	What are the main reasons for using this secondary cooking fuel? (Please select all that apply)	☐ 1- Availability ☐ 2- Affordability ☐ 3- Takes less time to cook ☐ 4- Convenience ☐ 5- Fuel produces less smoke ☐ 6- Traditional, cultural, or taste preferences ☐ 7- Others
5.4	Has your household ever changed its primary fuel usage pattern?	☐ 1- Yes ☐ 2- No (If '2' is selected, skip to 6.1)
5.4.1	Specify the previous and current cooking fuel to which you have changed.	_____ (Previous fuel) _____ (Current fuel)
5.4.2	What were the reasons for changing the fuel usage pattern?	

6. KITCHEN / COOKING AREA CHARACTERISTICS

SL.NO	QUESTION	RESPONSE
6.1	Do you open the windows while cooking?	☐ 1- Yes ☐ 2- No
6.2	Do you open the doors while cooking?	☐ 1- Yes ☐ 2- No
6.3	Do you use an exhaust fan while cooking?	☐ 1- Yes ☐ 2- No ☐ 3- Sometimes

7. LIVING AREA CHARACTERISTICS

SL.NO	QUESTION	RESPONSE
7.1	Does anyone smoke in your household?	☐ 1- Yes ☐ 2- No ☐ 3- Refuse to reply (If '2' or '3' is selected, skip to 7.3)
7.1.1	Where do you and/or other family members (if any) primarily smoke?	☐ 1- Inside the house ☐ 2- Outside the house ☐ 3- Both inside and outside the house ☐ 4- Other ☐ 5- Refuse to reply
7.2	Do you burn incense sticks in your house?	☐ 1- Yes ☐ 2- No (If '2' is selected, skip to 7.4)
7.2.1	How many incense sticks do you burn per day?	
7.3	Do you burn mosquito coils in your house?	☐ 1- Yes ☐ 2- No (If '2' is selected, skip to 8.1)
7.3.1	How many mosquito coils do you burn per day?	
7.4	Do you engage in open burning within a distance of 10 meters from your house at least once a week?	☐ 1- Yes ☐ 2- No

8. QUESTIONS ON RISK FACTORS

SL.NO	QUESTION	RESPONSE
8.1	Have you ever been diagnosed with any of the conditions given?	☐ 1- Diabetes ☐ 2- Hypertension ☐ 3- Any heart diseases ☐ 4- Any respiratory disorders ☐ 5- Any chronic kidney disorders ☐ 6- None ☐ 7- Others, specify
8.2	Do you take regular medication for any of the previously given conditions?	☐ 1- Yes ☐ 2- No
8.3	Have you used any tobacco products in the past 30 days?	☐ 1- Yes ☐ 2- No ☐ 3- Refuse to reply
8.4	Have you used any smokeless tobacco products such as snuff, chewing tobacco, betel, quid)?	☐ 1- Yes ☐ 2- No ☐ 3- Refuse to reply
8.5	Have you consumed any alcoholic beverages in the past 12 months?	☐ 1- Yes ☐ 2- No ☐ 3- Refuse to reply

8.6	Do you perform regular physical activity like walking or jogging, fitness, or recreational (leisure) activities continuously for at least 30 minutes, 5 days a week, or cumulatively 150 mins of PA/ week?	☐ 1- Yes ☐ 2- No
8.7	How much time do you usually spend sitting or reclining (such as watching TV, reading, using electronic gadgets like mobile phones, and laptops) on a typical day?	_____ mins
8.8	In a typical week, how many days do you eat fruit?	_____ days (If '0' is entered, skip to 8.9)
8.8.1	How many servings of fruit do you eat on one of those days?	_____ servings
8.9	In a typical week, how many days do you eat vegetables?	_____ days (If '0' is entered, skip to 8.10)
8.9.1	How many servings of vegetables do you eat on one of those days?	_____ servings
8.10	How often do you add salt or salty sauce to your food right before you eat it or as you are taking it? (Please select one)	☐ 1- Always ☐ 2- Often ☐ 3- Sometimes ☐ 4- Rarely ☐ 5- Never ☐ 6- Don't know
8.11	Do you have trouble sleeping?	☐ 1- Falling asleep ☐ 2- Staying asleep ☐ 3- Both ☐ 4- Sound sleep
8.12	How many hours of sleep do you get every day at night?	_____ hours

OBSERVATIONS AND MEASUREMENTS

SL.NO	QUESTION	RESPONSE
1.1	Number of windows in kitchen	-----
1.2	Kitchen/cooking area dimension (in feet)	☐ 1- Length: _____ ☐ 2- Width: _____ ☐ 3- Height: _____
1.3	Type of ventilation present in the kitchen (Please select all that apply)	☐ 1- Chimney ☐ 2- Exhaust fan ☐ 3- Open windows ☐ 4- Roof vents ☐ 5- No ventilation ☐ 6- Others, specify
1.4	Is there cross ventilation in kitchen?	☐ 1- Yes ☐ 2- No
1.5	Rate the ventilation of the kitchen.	☐ 1- Poor ☐ 2- Moderate ☐ 3- Good
1.6	Living area dimension (in feet)	☐ 1- Length: _____ ☐ 2- Width: _____ ☐ 3- Height: _____
1.7	Number of windows in the living area	_____
1.8	Rate the ventilation of the living area.	☐ 1- Poor ☐ 2- Moderate ☐ 3- Good

ANTHROPOMETRIC AND CLINICAL MEASUREMENTS

SL.NO	MEASUREMENTS	READINGS	
1.1	Waist circumference	_____ cm	
1.2	Fasting plasma glucose	_____ mg/dl	
1.3	Blood pressure (Evening)		
		Systolic (mm Hg)	Diastolic (mm Hg)
	Reading 1		
	Reading 2		
	Reading 3		
1.4	Blood pressure (Morning)		
		Systolic (mm Hg)	Diastolic (mm Hg)
	Reading 1		
	Reading 2		
	Reading 3		

AIR SAMPLING DATASHEET

Date of sample taken (DD/MM/YY)			
Location	Kitchen	Living area	Outdoor
Instrument ID			
Sample start time (hh:min)			
Sample end time (hh:min)			
Total sample time (mins)			
Average PM _{2.5} (ug/m ³)			
Average PM ₁₀ (ug/m ³)			
Average AQI			

ANNEXURE IV

**അച്യുത മേനോൻ സെന്റർ ഫോർ ഹെൽത്ത്
സയൻസ് സ്റ്റഡീസ് (AMCHSS)**

**ശ്രീചിത്ര തിരുനാൾ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഫോർ മെഡിക്കൽ
സയൻസ് ആൻഡ് ടെക്നോളജി (SCTIMST)
തിരുവനന്തപുരം- 11**

വിവര ഷീറ്റ്

ഞാൻ ഡോ. ജി വൈഷ്ണവിയാണ്, നിലവിൽ കേരളത്തിലെ തിരുവനന്തപുരത്തെ ശ്രീചിത്ര തിരുനാൾ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഫോർ മെഡിക്കൽ സയൻസ് ആൻഡ് ടെക്നോളജിയിലെ അച്യുതമേനോൻ സെന്റർ ഫോർ ഹെൽത്ത് സയൻസ് സ്റ്റഡീസിൽ മാസ്റ്റർ ഓഫ് പബ്ലിക് ഹെൽത്ത് (എംപിഎച്ച്) പഠിക്കുന്നു. എഎംസിഎച്ച്എസ്എസിലെ എപ്പിഡെമിയോളജി അഡീഷണൽ പ്രൊഫസർ ഡോ. ജിമോൻ പി യുടെ മാർഗനിർദ്ദേശപ്രകാരം എന്റെ കോഴ്സ് വർക്കിന്റെ ഭാഗമായിട്ടാണ് ഞാൻ ഈ പഠനം നടത്തുന്നത്.

ഈ ഗവേഷണ പഠനത്തിൽ പങ്കെടുക്കാൻ നിങ്ങളെ ക്ഷണിക്കുന്നു. ഈ പഠനത്തിൽ പങ്കെടുക്കണമോ വേണ്ടയോ എന്ന് തീരുമാനിക്കുന്നതിന് മുമ്പ്, എന്തിനാണ് ഗവേഷണം നടത്തുന്നതെന്നും അതിൽ എന്താണ് ഉൾപ്പെടുന്നതെന്നും നിങ്ങൾ മനസ്സിലാക്കേണ്ടത് പ്രധാനമാണ്. ദയവായി വിവര ഷീറ്റും സമ്മത ഫോമും ശ്രദ്ധാപൂർവ്വം വായിക്കുക / കേൾക്കുക. ഈ പഠനവുമായി ബന്ധപ്പെട്ട ഏത് ചോദ്യവും താങ്കൾക്ക് ചോദിക്കാവുന്നതാണ്.

പഠനോദ്ദേശ്യം

ഗാർഹിക വായുമലിനീകരണം മൂലം, പ്രതേകിച്ചു വിവിധ പാചക ഇന്ധനങ്ങളുടെ ഉപയോഗത്തിൽ നിന്ന് ഉയർന്നുവരുന്ന സൂക്ഷ്മ കണികകൾ രക്തസമ്മർദ്ദത്തിലും ഉപവാസ രക്തത്തിലെ പഞ്ചസാരയുടെ അളവിലും ചെലുത്തുന്ന സ്വാധീനത്തെക്കുറിച്ചു മനസ്സിലാക്കുകയെന്നാണ് ഈ പഠനംകൊണ്ടു ഉദ്ദേശിക്കുന്നത്. പത്തനംതിട്ടയിലെ ഗ്രാമീണ കുടുംബാങ്ങൾക്കിടയിലാണ് ഈ പഠനം നടക്കുന്നത്.

നടപടിക്രമം

പഠനത്തിൽ പങ്കെടുക്കാൻ നിങ്ങൾ തയ്യാറാണെങ്കിൽ, ഡെമോഗ്രാഫിക് വിവരങ്ങൾ, ഗാർഹിക സവിശേഷതകൾ, പൊതുവായ ജീവിതശൈലിൾ എന്നിവ ഉൾപ്പെടുന്ന ഒരു അഭിമുഖ ഷെഡ്യൂൾ പൂർത്തിയാക്കാൻ നിങ്ങളോട് ആവശ്യപ്പെടും. അഭിമുഖത്തിന് നിങ്ങളുടെ വിലയേറിയ സമയത്തിന്റെ ഏകദേശം 20-25 മിനിറ്റ് വരെ എടുക്കും. കൂടാതെ, വായുവിന്റെ ഗുണനിലവാരം അളക്കുന്ന ഉപകരണമൊക്കെ അടുക്കള, ലിവിംഗ് ഏരിയ, ഔട്ട്ഡോർ ഏരിയ എന്നിവിടങ്ങളിൽ പരമാവധി 12 മണിക്കൂർ ദൈർഘ്യത്തിൽ ഞങ്ങൾ പിഎം 2.5 ന്റെ അളവ് അളക്കും. ഇതോടൊപ്പം അടുക്കള, ലിവിംഗ് ഏരിയ എന്നിവിടങ്ങളിലേ ചുറ്റളവുകളും എടുക്കുന്നതായിരിക്കും. അരക്കെട്ടിന്റെ ചുറ്റളവ്, രക്ത സമ്മർദ്ദ അളവുകൾ, ഉപവാസ രക്ത ഷുഗർ റീഡിംഗുകൾ എന്നിവ പഠനത്തിന്റെ ഭാഗമായി എടുക്കും.

അപകടസാധ്യതയും അസ്വസ്ഥതകളും

പഠനത്തിൽ പങ്കെടുക്കുന്നത് നിങ്ങളുടെ ആരോഗ്യത്തിന് ഒരു അപകടവും വരുത്തുന്നില്ല. എന്നിരുന്നാലും, പിഎം 2.5 നിരീക്ഷിക്കാൻ നിങ്ങളുടെ വീടിനുള്ളിൽ ഒരു ഉപകരണം സ്ഥാപിക്കുന്നത് താൽക്കാലിക അസ്വസ്ഥതയോ അസൗകര്യമോ ഉണ്ടാക്കിയേക്കാം. ഉപകരണം ആക്രമണാത്മകമല്ലെന്നും വായുവിന്റെ ഗുണനിലവാരം നിരീക്ഷണത്തിനായി മാത്രം രൂപകൽപ്പന ചെയ്തതാണെന്നും ശ്രദ്ധിക്കുക. വായുവിന്റെ ഗുണനിലവാരമല്ലാതെ മറ്റേത് ഡാറ്റ ശേഖരിക്കാൻ കെൽപ്പുള്ള ഒരു സെൻസറും ഈ ഉപകാരണത്തിലില്ല. രക്ത സാമ്പിൾ എടുക്കുമ്പോൾ ചില അസ്വസ്ഥതകൾ അനുഭവപ്പെട്ടേക്കാം.

നേട്ടങ്ങൾ

ഈ പഠനത്തിൽ പങ്കെടുക്കുന്നതുമൂലം ഇപ്പോൾ നിങ്ങൾക്ക് നേരിട്ടുള്ള പ്രയോജനമൊന്നും ലഭിക്കുന്നില്ല, പക്ഷേ നിങ്ങളുടെ വീടിലെ PM2.5 ന്റെ അളവ്, നിങ്ങളുടെ രക്ത സമ്മർദ്ദം, ഉപവാസ രക്തഷുഗറിന്റെ അളവ് എന്നിവ അറിയുവാൻ സാധിക്കും. എന്നിരുന്നാലും, ഗാർഹിക വായു മലിനീകരണം, രക്തസമ്മർദ്ദം, ഉപവാസ രക്തത്തിലെ പഞ്ചസാര എന്നിവ തമ്മിലുള്ള സങ്കീർണ്ണമായ ബന്ധം മനസ്സിലാക്കാൻ ഈ പഠനമൂലം സാധിക്കും.

ചെലവും സാമ്പത്തിക നേട്ടവും

ഈ പഠനത്തിൽ പങ്കെടുക്കുന്നതിന് യാതൊരു ചെലവും ഇല്ല. പങ്കാളിത്തം പൂർണ്ണമായും സ്വമേധയാ ഉള്ളതാണ്, യാതൊരു സാമ്പത്തികനേട്ടവും ഇതിലൂടെ ലഭിക്കുന്നില്ല.

രഹസ്യാത്മകത

ഈ പഠനത്തിൽ നിന്നും ലഭിക്കുന്ന വിവരങ്ങൾ രഹസ്യമായി സൂക്ഷിക്കും. ഓരോ പങ്കാളിക്കും ഒരു തിരിച്ചറിയൽ നമ്പർ നൽകും, ഇത് ശേഖരിക്കുന്ന ഡാറ്റയുടെ രഹസ്യാത്മകത നിലനിർത്താൻ സഹായിക്കും. നിങ്ങളുടെ പേര് ഈ പഠനവുമായി ബന്ധപ്പെട്ട പ്രസിദ്ധീകരണങ്ങളിൽ ഉപയോഗിക്കില്ല.

പഠനത്തിൽ നിന്ന് പിൻവാങ്ങൽ

പഠനത്തിലെ നിങ്ങളുടെ പങ്കാളിത്തം പൂർണ്ണമായും സ്വമേധയാ ആയിരിക്കും. പഠന വേളയിൽ ഏത് സമയത്തും പിൻവാങ്ങാനുള്ള സ്വാതന്ത്ര്യവും അവകാശവും നിങ്ങൾക്കുണ്ട്. പഠനത്തിൽ നിന്ന് പിൻവാങ്ങുന്നതിനോ പങ്കെടുക്കാതിരിക്കുന്നതിനോ പിഴയൊന്നും ഉണ്ടായിരിക്കുന്നതല്ല.

ബന്ധപ്പെടാനുള്ള വിവരങ്ങൾ

നിങ്ങൾക്ക് ഗവേഷണവുമായി ബന്ധപ്പെട്ട എന്തെങ്കിലും ചോദ്യങ്ങൾ ഉണ്ടെങ്കിൽ അല്ലെങ്കിൽ എന്റെ ക്രെഡൻഷ്യലുകൾ പരിശോധിക്കാൻ നിങ്ങൾ ആഗ്രഹിക്കുന്നുവെങ്കിൽ, ഇനിപ്പറയുന്ന വിലാസത്തിൽ നിങ്ങൾക്ക് എന്നെയോ ഞങ്ങളുടെ ഇൻസ്റ്റിറ്റ്യൂട്ടിന്റെ എത്തിക്സ് സമിതിയുടെ മെമ്പർ സെക്രട്ടറിയെയോ ബന്ധപ്പെടാം:

ഡോ. ജി വൈഷ്ണവി
പ്രധാന അന്വേഷകൻ
എം പി എച്ച്, എ എം സി എച്ച്
എസ് എസ്,
എസ് സി റ്റി ഐ എം എസ് റ്റി
ബന്ധപ്പെടേണ്ട നമ്പർ:
7012674503
ഇമെയിൽ:
vaishnavi.girija96@gmail.com

ഡോ. ശ്രീനിവാസ് ജി
മെമ്പർ സെക്രട്ടറി
ഇൻസ്റ്റിറ്റ്യൂഷണൽ എത്തിക്സ്
കമ്മിറ്റി
എസ് സി റ്റി ഐ എം എസ് റ്റി
തിരുവനന്തപുരം-695011
ഓഫീസ്: 04712524689
ഇമെയിൽ:
iec.mem.sec@sctimst.ac.in

ANNEXURE V

സമ്മത പത്രം

വിവര ഷീറ്റിൽ നൽകിയിരിക്കുന്ന പഠനവുമായി ബന്ധപ്പെട്ട വിവരങ്ങൾ ഞാൻ വായിച്ചുവെന്നും/ കേട്ടുവെന്നും മനസ്സിലാക്കിയെന്നും ഞാൻ സ്ഥിരീകരിക്കുന്നു. ഈ പഠനവുമായി ബന്ധപ്പെട്ട എന്റെ എല്ലാ ചോദ്യങ്ങൾക്കും ഉത്തരം ലഭിച്ചിട്ടുണ്ട്, കൂടാതെ ഈ പഠനത്തിന്റെ സാധ്യമായ എല്ലാ ദോഷങ്ങളും അസ്വാഭാവികതകളും നേട്ടങ്ങളും (എന്തെങ്കിലും ഉണ്ടെങ്കിൽ) എനിക്ക് വിശദീകരിച്ചു തന്നിട്ടുണ്ട്. എന്റെ ഐഡൻറിറ്റിയും വ്യക്തിഗത വിവരങ്ങളും രഹസ്യമായി സൂക്ഷിക്കുമെന്നും ഞാൻ മനസ്സിലാക്കുന്നു. എന്റെ പങ്കാളിത്തം സ്വമേധയാ ഉള്ളതാണെന്നും, കാരണം പറയാതെയും അനന്തരഫലങ്ങളില്ലാതെയും എപ്പോൾ വേണമെങ്കിലും പിൻവലിക്കാൻ എനിക്ക് സ്വാതന്ത്ര്യമുണ്ടെന്നും ഞാൻ മനസ്സിലാക്കുന്നു.

ഈ ഫോമിൽ ഒപ്പിടുന്നതിലൂടെ, ഈ പഠനത്തിൽ പങ്കെടുക്കാൻ ഞാൻ സമ്മതിക്കുന്നു. ഈ ഫോമിന്റെ ഒരു പകർപ്പ് എനിക്ക് തന്നിട്ടുണ്ട്.

തീയതി:

സ്ഥലം:

പങ്കെടുക്കുന്നയാളുടെ പേര് ഒപ്പ്/തമ്പ് ഇംപ്രഷൻ

പ്രധാന അന്വേഷകന്റെ ഒപ്പ്

ANNEXURE VI

ഇൻറർവ്യൂ ഷെഡ്യൂൾ

ഒഴിവാക്കൽ മാനദണ്ഡം			
ക്രമ നമ്പർ		അതെ	ഇല്ല
1	നിങ്ങൾ ഇപ്പോൾ ഗർഭിണിയാണോ?		
2	നിങ്ങൾ നിലവിൽ ഹൈപ്പർടെൻഷൻ മരുന്ന് കഴിക്കുന്നുണ്ടോ?		
3	നിങ്ങൾ നിലവിൽ പ്രമേഹത്തിന് മരുന്ന് കഴിക്കുന്നുണ്ടോ?		
ഏതെങ്കിലും ചോദ്യത്തിനുള്ള ഉത്തരം 'അതെ' ആണെങ്കിൽ, സർവ്വേയുടെ അവസാനം			

1. പൊതുവിവരം

1.1	ഗാർഹിക ഐഡി	
1.2	പങ്കെടുക്കുന്ന വ്യക്തിയുടെ ഐഡി	
1.3	ഇൻറർവ്യൂ തീയതി	
1.4	സമ്മതപത്രം വായിച്ചു ഒപ്പിട്ടു	അതെ / അല്ല

2. ഡെമോഗ്രാഫിക് വിവരങ്ങൾ

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
2.1	നിങ്ങളുടെ മുഴുവൻ വയസ്സ് എത്രയാണ്? (വർഷത്തിൽ)	☐ ☐
2.2	നിങ്ങളുടെ ലിംഗം?	☐ 1- പുരുഷൻ ☐ 2- സ്ത്രീ ☐ 3- ട്രാൻസ്ജെൻഡർ
2.3	നിങ്ങൾ എത്ര വർഷത്തെ ഔപചാരിക സ്കൂൾ വിദ്യാഭ്യാസം പൂർത്തിയാക്കി?	☐ ☐
2.4	നിങ്ങളുടെ തൊഴിൽ എന്താണ്?	☐ 1- വിദ്യാർത്ഥി ☐ 2- സ്വയം തൊഴിൽ ചെയ്യുന്നവർ ☐ 3- സർക്കാർ ജീവനക്കാരൻ ☐ 4- സർക്കാർ ഇതര ജീവനക്കാരൻ

		☐ 5- വീടുമ്മ ☐ 6- വിരമിച്ചു ☐ 99- തൊഴിൽരഹിതർ
2.5	എത്ര കാലമായി ഈ വീട്ടിൽ താമസിക്കുന്നു?	

3. ഗാർഹിക വിവരങ്ങൾ

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
3.1	വീടിന്റെ തരം	☐ 1- മൺവീട് ☐ 2- ഓലമമഞ്ഞ വീട് ☐ 3- ഉറപ്പുള്ള വീട്
3.2	ഈ വീട്ടിൽ (കുട്ടികൾ ഉൾപ്പെടെ) എത്ര അംഗങ്ങളുണ്ട്?	
3.3	ബാത്ത്റൂം/ടോയ്ലെറ്റ് ഒഴികെ നിങ്ങളുടെ വീട്ടിൽ എത്ര മുറികളുണ്ട്?	
3.4	നിങ്ങളുടെ വീട്ടിലെ വെളിച്ചത്തിന്റെ പ്രധാന ഉറവിടം എന്താണ്?	☐ 1- വൈദ്യുതി ☐ 2- മണ്ണെണ്ണ വിളക്ക് ☐ 3- മറ്റുള്ളവ; വ്യക്തമാക്കുക _____
3.5	നിങ്ങളുടെ പക്കലുള്ള റേഷൻ കാർഡ് എന്താണ്?	☐ 1- വെള്ള കാർഡ് ☐ 2- മഞ്ഞ കാർഡ് ☐ 3 - പിങ്ക് കാർഡ് ☐ 4 - നീല കാർഡ് ☐ 99 - റേഷൻ കാർഡ് ഇല്ല

4. വീട്ടിലെ അടുക്കളയും അടുപ്പിന്റെ തരങ്ങളും

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
4.1	അടുക്കളയുടെ തരം	☐ 1- താമസിക്കാനും ഉറങ്ങാനും ഉപയോഗിക്കുന്ന മുറിയിൽ (വിഭജനത്തോടെ) ☐ 2- താമസിക്കാനും ഉറങ്ങാനും ഉപയോഗിക്കുന്ന മുറിയിൽ (വിഭജനം ഇല്ലാതെ) ☐ 3- അടുക്കളയായി ഉപയോഗിക്കുന്ന പ്രത്യേക മുറിയിൽ

		☐ 4- അടുക്കളയായി ഉപയോഗിക്കുന്ന പ്രത്യേക കെട്ടിടത്തിൽ ☐ 5- ഔട്ട്ഡോർ / ഓപ്പൺ എയർ അടുക്കള ('5' തിരഞ്ഞെടുത്തിട്ടുണ്ടെങ്കിൽ, 4.1.1-ലേക്ക് പോകുക)
4.1.1	ഏതെങ്കിലും ഷെഡ് മേൽക്കൂരയുടെയോ മേലാപ്പിന്റേയോ താഴെയോ സ്റ്റൗപ് സ്ഥിതി ചെയ്യുന്നത്?	☐ 1- അതെ ☐ 2- നമ്പർ
4.2	ദൈനംദിന പാചക ആവശ്യങ്ങൾക്കായി നിങ്ങളുടെ വീട്ടിൽ ഉപയോഗിക്കുന്ന പ്രാഥമിക അടുപ്പ് ഏതാണ്? (ദയവായി ഒന്ന് തിരഞ്ഞെടുക്കുക)	☐ 1- വീടിന്റെ പുറത്തുള്ള പുക അടുപ്പ് ☐ 1- പുക അടുപ്പ് ☐ 3- ആലുവ അടുപ്പ് ☐ 4- എൽപിജി കൂക്ക് സ്റ്റൗ ☐ 5- മണ്ണെണ്ണ അടുപ്പ് ☐ 6- ഇലക്ട്രിക് അല്ലെങ്കിൽ ഇൻഡക്ഷൻ സ്റ്റൗ ☐ 7- മറ്റുള്ളവ; വ്യക്തമാക്കുക _____
4.3	സൂചിപ്പിച്ച പ്രൈമറി സ്റ്റൗവിന് പുറമേ, തിളയ്ക്കുന്ന വെള്ളമോ പാകം ചെയ്ത അരി പാകം ചെയ്യുന്നതോ പോലുള്ള പ്രത്യേക പാചക ആവശ്യങ്ങൾക്കായി നിങ്ങൾ ഏതെങ്കിലും ദ്വിതീയ സ്റ്റൗവുകൾ നിങ്ങളുടെ വീട്ടിൽ ഉപയോഗിക്കാറുണ്ടോ? (ദയവായി ബാധകമായതെല്ലാം തിരഞ്ഞെടുക്കുക)	☐ 1- വീടിന്റെ പുറത്തുള്ള പുക അടുപ്പ് ☐ 1- പുക അടുപ്പ് ☐ 3- ആലുവ അടുപ്പ് ☐ 4- എൽപിജി കൂക്ക് സ്റ്റൗ ☐ 5- മണ്ണെണ്ണ അടുപ്പ് ☐ 6- ഇലക്ട്രിക് അല്ലെങ്കിൽ ഇൻഡക്ഷൻ സ്റ്റൗ ☐ 7- മറ്റുള്ളവ; വ്യക്തമാക്കുക _____ ☐ 8- ഒന്നുമില്ല
4.4	പ്രാഥമികവും ദ്വിതീയവുമായ അടുപ്പുകൾ ഒരേ അടുക്കളയിലാണോ?	☐ 1- അതെ ☐ 2- നമ്പർ

5. ഗാർഹിക പാചക ഇന്ധനം

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
5.1	പാചകം എക്സ്പോഷർ സമയം	
5.1.1	നിങ്ങൾ എത്ര കാലമായി പാചകം ചെയ്യുന്നു/ചെയ്തു?	_____ വർഷം
5.1.2	ഒരു ശരാശരി ദിവസം, നിങ്ങൾ അടുക്കളയിൽ എത്ര സമയം ചെലവഴിച്ചു/ചെലവഴിച്ചു: c) പ്രവൃത്തിദിനം d) വാരാന്ത്യം	_____ മണിക്കൂറുകൾ _____ മണിക്കൂറുകൾ
5.2	പ്രാഥമിക പാചക ഇന്ധനം	
5.2.1	ദൈനംദിന പാചക ആവശ്യങ്ങൾക്കായി നിങ്ങളുടെ വീട്ടിൽ ഉപയോഗിക്കുന്ന പ്രാഥമിക പാചക ഇന്ധനം ഏതാണ്? (ദയവായി ഒന്ന് തിരഞ്ഞെടുക്കുക)	☐ 1- ഖര ഇന്ധനങ്ങൾ (മരം/ തെങ്ങിൻ തൊണ്ട്/വിള അവശിഷ്ടങ്ങൾ/കൽക്കരി/കരി) ☐ 2- എൽ.പി.ജി ☐ 3- വൈദ്യുതി ☐ 4- ബയോഗ്യാസ് ☐ 5- മണ്ണെണ്ണ ☐ 6- മറ്റുള്ളവ; വ്യക്തമാക്കുക _____
5.2.2	നിങ്ങളുടെ വീട്ടുകാർ ഈ പ്രാഥമിക പാചക ഇന്ധനം എത്ര കാലമായി ഉപയോഗിക്കുന്നു?	_____ വർഷം
5.2.3	പ്രാഥമിക പാചക ഇന്ധനം പ്രതിദിനം ശരാശരി എത്ര മണിക്കൂർ ഉപയോഗിക്കുന്നു?	_____ മണിക്കൂറുകൾ
5.2.4	ഈ പ്രാഥമിക പാചക ഇന്ധനം ഉപയോഗിക്കുന്നതിനുള്ള പ്രധാന കാരണങ്ങൾ എന്തൊക്കെയാണ്? (ബാധകമായതെല്ലാം തിരഞ്ഞെടുക്കുക)	☐ 1- ലഭ്യത ☐ 2- താങ്ങാനാവുന്നത ☐ 3- പാചകം ചെയ്യാൻ കുറച്ച് സമയമെടുക്കും ☐ 4- സൗകര്യം ☐ 5- ഇന്ധനം കുറച്ച് പുക ഉൽപാദിപ്പിക്കുന്നു ☐ 6- പരമ്പരാഗത, സാംസ്കാരിക, അല്ലെങ്കിൽ രൂചി മുൻഗണനകൾ ☐ 7- മറ്റുള്ളവ; വ്യക്തമാക്കുക _____

		☐ 7- മറ്റുള്ളവ; വ്യക്തമാക്കുക _____
5.3	ദിതീയ പാചക ഇന്ധനം	
5.3.1	സൂചിപ്പിച്ച പ്രാഥമിക പാചക ഇന്ധനത്തിന് പുറമേ, തിളയ്ക്കുന്ന വെള്ളമോ വേവിച്ച അരി പാകം ചെയ്യുന്നതോ പോലുള്ള പ്രത്യേക പാചക ആവശ്യങ്ങൾക്കായി നിങ്ങൾ ഏതെങ്കിലും ദിതീയ പാചക ഇന്ധനം നിങ്ങളുടെ വീട്ടിൽ ഉപയോഗിക്കുന്നുണ്ടോ? (ദയവായി ബാധകമായതെല്ലാം തിരഞ്ഞെടുക്കുക)	☐ 1- ഖര ഇന്ധനങ്ങൾ (മരം/ തെങ്ങിൻ തൊണ്ട്/വിള അവാശിഷ്ടങ്ങൾ/കൽക്കരി/കരി) ☐ 2- എൽ.പി.ജി ☐ 3- വൈദ്യുതി ☐ 4- ബയോഗ്യാസ് ☐ 5- മണ്ണെണ്ണ ☐ 6- മറ്റുള്ളവ; വ്യക്തമാക്കുക _____ ☐ 7- ഒന്നുമില്ല ('7' തിരഞ്ഞെടുത്തിട്ടുണ്ടെങ്കിൽ, 5.4 ലേക്ക് പോകുക)
5.3.2	നിങ്ങളുടെ വീട്ടിൽ എത്ര കാലമായി ഈ ദിതീയ പാചക ഇന്ധനം ഉപയോഗിക്കുന്നു?	_____ വർഷം
5.3.3	ദിതീയ പാചക ഇന്ധനം പ്രതിദിനം ശരാശരി എത്ര മണിക്കൂർ ഉപയോഗിക്കുന്നു?	_____ മണിക്കൂറുകൾ
5.3.4	ഈ ദിതീയ പാചക ഇന്ധനം ഉപയോഗിക്കുന്നതിനുള്ള പ്രധാന കാരണങ്ങൾ എന്തൊക്കെയാണ്? (ദയവായി ബാധകമായതെല്ലാം തിരഞ്ഞെടുക്കുക)	☐ 1- ലഭ്യത ☐ 2- താങ്ങാനാവുന്നത ☐ 3- പാചകം ചെയ്യാൻ കുറച്ച് സമയമെടുക്കും ☐ 4- സൗകര്യം ☐ 5- ഇന്ധനം കുറച്ച് പുക ഉൽപാദിപ്പിക്കുന്നു ☐ 6- പരമ്പരാഗത, സാംസ്കാരിക, അല്ലെങ്കിൽ രൂചി മുൻഗണനകൾ ☐ 7- മറ്റുള്ളവ
5.4	നിങ്ങളുടെ വീട്ടിലെ പ്രാഥമിക ഇന്ധന ഉപയോഗ രീതി എപ്പോഴെങ്കിലും മാറ്റിയിട്ടുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല ('2' തിരഞ്ഞെടുത്തിട്ടുണ്ടെങ്കിൽ, 6.1 ലേക്ക് പോകുക)

5.4.1	നിങ്ങൾ മാറ്റിയ മുമ്പത്തേതും നിലവിലുള്ളതുമായ പാചക ഇന്ധനം വ്യക്തമാക്കുക.	_____ (മുമ്പത്തെ ഇന്ധനം) _____ (നിലവിലെ ഇന്ധനം)
5.4.2	ഇന്ധന ഉപയോഗ രീതി മാറ്റാനുള്ള കാരണങ്ങൾ എന്തായിരുന്നു?	

6. അടുക്കള / പാചക മേഖലയുടെ സവിശേഷതകൾ

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
6.1	പാചകം ചെയ്യുമ്പോൾ നിങ്ങൾ ജനാലകൾ തുറക്കാറുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല
6.2	പാചകം ചെയ്യുമ്പോൾ നിങ്ങൾ വാതിൽ തുറക്കാറുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല
6.3	പാചകം ചെയ്യുമ്പോൾ നിങ്ങൾ എക്സ്‌ഹോസ്റ്റ് ഫാൻ ഉപയോഗിക്കാറുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല ☐ 3- ചിലപ്പോൾ

7. ലിവിംഗ് ഏരിയയുടെ സവിശേഷതകൾ

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
7.1	നിങ്ങളുടെ വീട്ടിൽ ആരെങ്കിലും പുകവലിക്കുന്നുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല ☐ 3- മറുപടി നൽകാൻ വിസമ്മതിക്കുക ('2' അല്ലെങ്കിൽ '3' തിരഞ്ഞെടുത്തിട്ടുണ്ടെങ്കിൽ, 7.3 ലേക്ക് പോകുക)
7.1.1	നിങ്ങൾ കൂടാതെ/അല്ലെങ്കിൽ മറ്റ് കുടുംബാംഗങ്ങൾ (എന്തെങ്കിലും ഉണ്ടെങ്കിൽ) പ്രാഥമികമായി പുകവലിക്കുന്നത് എവിടെയാണ്?	☐ 1- വീടിനുള്ളിൽ ☐ 2- വീടിന് പുറത്ത് ☐ 3- വീടിനകത്തും പുറത്തും ☐ 4- മറ്റുള്ളവ ☐ 5- മറുപടി നൽകാൻ വിസമ്മതിക്കുക
7.2	നിങ്ങളുടെ വീട്ടിൽ ധൂപവർഗ്ഗം കത്തിക്കുന്നുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല ('2' തിരഞ്ഞെടുത്തിട്ടുണ്ടെങ്കിൽ, 7.4 ലേക്ക് പോകുക)
7.2.1	നിങ്ങൾ പ്രതിദിനം എത്ര ധൂപവർഗ്ഗങ്ങൾ കത്തിക്കുന്നു?	

7.3	നിങ്ങളുടെ വീട്ടിൽ കൊതുക് ചുരുളുകൾ കത്തിക്കുന്നുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല (2' തിരഞ്ഞെടുത്തിട്ടുണ്ടെങ്കിൽ, 8.1 ലേക്ക് പോകുക)
7.3.1	നിങ്ങൾ ഒരു ദിവസം എത്ര കൊതുക് ചുരുളുകൾ കത്തിക്കുന്നു?	
7.4	ആഴ്ചയിൽ ഒരിക്കലെങ്കിലും നിങ്ങളുടെ വീട്ടിൽ നിന്ന് 10 മീറ്റർ അകലെ തുറന്ന് കത്തിക്കുന്നതിൽ നിങ്ങൾ ഏർപ്പെടാറുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല

8. അപകട ഘടകങ്ങളെക്കുറിച്ചുള്ള ചോദ്യങ്ങൾ

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
8.1	നിങ്ങൾക്ക് എപ്പോഴെങ്കിലും നൽകിയിരിക്കുന്ന ഏതെങ്കിലും വ്യവസ്ഥകൾ രോഗനിർണ്ണയം നടത്തിയിട്ടുണ്ടോ?	☐ 1- പ്രമേഹം ☐ 2- ഹൈപ്പർടെൻഷൻ ☐ 3- ഏതെങ്കിലും ഹൃദയ രോഗങ്ങൾ ☐ 4- ഏതെങ്കിലും ശ്വാസകോശ സംബന്ധമായ തകരാറുകൾ ☐ 5- ഏതെങ്കിലും വിട്ടുമാറാത്ത വൃക്ക തകരാറുകൾ ☐ 6- ഒന്നുമില്ല ☐ 7- മറ്റുള്ളവ, വ്യക്തമാക്കുക
8.2	മുമ്പ് നൽകിയ ഏതെങ്കിലും അവസ്ഥകൾക്ക് നിങ്ങൾ പതിവായി മരുന്ന് കഴിക്കാറുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല
8.3	കഴിഞ്ഞ 30 ദിവസങ്ങളിൽ നിങ്ങൾ ഏതെങ്കിലും പുകയില ഉൽപ്പന്നങ്ങൾ ഉപയോഗിച്ചിട്ടുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല ☐ 3- മറുപടി നൽകാൻ വിസമ്മതിക്കുക
8.4	സ്നഫ്, ച്യൂയിംഗ് പുകയില, വെറ്റില, ക്വിഡ് പോലുള്ള പുകയില്ലാത്ത പുകയില ഉൽപ്പന്നങ്ങൾ നിങ്ങൾ ഉപയോഗിച്ചിട്ടുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല ☐ 3- മറുപടി നൽകാൻ വിസമ്മതിക്കുക

8.5	കഴിഞ്ഞ 12 മാസത്തിനിടെ നിങ്ങൾ ഏതെങ്കിലും ലഹരിപാനീയങ്ങൾ കഴിച്ചിട്ടുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല ☐ 3- മറുപടി നൽകാൻ വിസമ്മതിക്കുക
8.6	നടത്തം അല്ലെങ്കിൽ ജോഗിംഗ്, ഫിറ്റ്നസ് അല്ലെങ്കിൽ വിനോദ (വിശ്രമം) പ്രവർത്തനങ്ങൾ പോലുള്ള പതിവ് ശാരീരിക പ്രവർത്തനങ്ങൾ നിങ്ങൾ തുടർച്ചയായി കുറഞ്ഞത് 30 മിനിറ്റോ ആഴ്ചയിൽ 5 ദിവസമോ അല്ലെങ്കിൽ 150 മിനിറ്റ് പിഎ/ആഴ്ചയിൽ തുടർച്ചയായി ചെയ്യുന്നുണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല
8.7	ഒരു സാധാരണ ദിവസത്തിൽ നിങ്ങൾ സാധാരണയായി എത്ര സമയം ഇരിക്കുന്നതിനോ ചാരിയിരിക്കുന്നതിനോ (ടിവി കാണൽ, വായന, മൊബൈൽ ഫോണുകൾ, ലാപ്ടോപ്പുകൾ പോലുള്ള ഇലക്ട്രോണിക് ഗാഡ്ജറ്റുകൾ ഉപയോഗിക്കുന്നത് പോലുള്ളവ) ചെലവഴിക്കുന്നു?	_____ മിനിറ്റ്
8.8	ഒരു സാധാരണ ആഴ്ചയിൽ, നിങ്ങൾ എത്ര ദിവസം പഴങ്ങൾ കഴിക്കും?	_____ ദിവസങ്ങളിൽ ('0' നൽകിയാൽ, 8.9 ലേക്ക് പോകുക)
8.8.1	ആ ദിവസങ്ങളിലൊന്നിൽ നിങ്ങൾ എത്ര പഴം കഴിക്കും?	_____ സെർവിംഗ്സ്
8.9	ഒരു സാധാരണ ആഴ്ചയിൽ, എത്ര ദിവസം നിങ്ങൾ പച്ചക്കറികൾ കഴിക്കും?	_____ ദിവസങ്ങളിൽ ('0' നൽകിയാൽ, 8.10 ലേക്ക് പോകുക)
8.9.1	ആ ദിവസങ്ങളിലൊന്നിൽ നിങ്ങൾ എത്ര പച്ചക്കറികൾ കഴിക്കും?	_____ സെർവിംഗ്സ്
8.10	നിങ്ങൾ ഭക്ഷണം കഴിക്കുന്നതിന് മുമ്പോ കഴിക്കുമ്പോഴോ എത്ര തവണ ഉപ്പ് അല്ലെങ്കിൽ ഉപ്പിട്ട സോസ് ചേർക്കുന്നു? (ദയവായി ഒന്ന് തിരഞ്ഞെടുക്കുക)	☐ 1- എപ്പോഴും ☐ 2- പലപ്പോഴും ☐ 3- ചിലപ്പോൾ ☐ 4- അപൂർവ്വമായി ☐ 5- ഒരിക്കലുമില്ല ☐ 6- അറിയില്ല
8.11	നിങ്ങൾക്ക് ഉറങ്ങാൻ ബുദ്ധിമുട്ടുണ്ടോ?	☐ 1- ഉറങ്ങുന്നു ☐ 2- ഉറങ്ങുന്നത്

		☐ 3- രണ്ടും ☐ 4- നല്ല ഉറക്കം
8.12	രാത്രിയിൽ നിങ്ങൾ ദിവസവും എത്ര മണിക്കൂർ ഉറങ്ങുന്നു?	_____ മണിക്കൂറുകൾ



നിരീക്ഷണങ്ങളും അളവുകളും

ക്രമ നമ്പർ	ചോദ്യം	പ്രതികരണം
1.1	അടുക്കളയിലെ ജനാലകളുടെ എണ്ണം	-----
1.2	അടുക്കള/പാചക സ്ഥലത്തിന്റെ അളവ് (അടിയിൽ)	☐ 1- നീളം: _____ ☐ 2- വീതി: _____
1.3	അടുക്കളയിൽ നിലവിലുള്ള വെന്റിലേഷൻ തരം (ദയവായി ബാധകമായതെല്ലാം തിരഞ്ഞെടുക്കുക)	☐ 1- ചിമ്മിനി ☐ 2- എക്സ്ഹോസ്റ്റ് ഫാൻ ☐ 3- വിൻഡോകൾ തുറക്കുക ☐ 4- മേൽക്കൂര വെന്റുകൾ ☐ 5- വെന്റിലേഷൻ ഇല്ല ☐ 6- മറ്റുള്ളവ, വ്യക്തമാക്കുക
1.4	അടുക്കളയിൽ ക്രോസ് വെന്റിലേഷൻ ഉണ്ടോ?	☐ 1- ഉണ്ട് ☐ 2- ഇല്ല
1.5	അടുക്കളയുടെ വെന്റിലേഷൻ റേറ്റുചെയ്യുക.	☒ 1- മോശം ☐ 2- മിതമായ ☐ 3- നല്ലത്
1.6	താമസിക്കുന്ന പ്രദേശത്തിന്റെ അളവ് (കാലുകളിൽ)	☐ 1- നീളം: _____ ☐ 2- വീതി: _____
1.7	ലിവിംഗ് ഏരിയയിലെ ജാലകങ്ങളുടെ എണ്ണം	_____
1.8	താമസിക്കുന്ന സ്ഥലത്തിന്റെ വെന്റിലേഷൻ റേറ്റുചെയ്യുക.	☐ 1- മോശം ☐ 2- മിതമായ ☐ 3- നല്ലത്

ആന്ത്രോപോമെട്രിക്, ക്ലിനിക്കൽ അളവുകൾ

ക്രമ നമ്പർ	അളവുകൾ	വായനകൾ	
1.1	അരയ്ക്കുള്ള ചുറ്റളവ്	_____ സെമി	
1.2	ഉപവാസ പ്ലാസ്മ ഗ്ലൂക്കോസ്	_____ mg/dl	
1.3	രക്തസമ്മർദ്ദം (സായാഹ്നം)		
		സിസ്റ്റോളിക് (mm Hg)	ഡയസ്റ്റോളിക് (mm Hg)
	റീഡിങ് 1		
	റീഡിങ് 2		
	റീഡിങ് 3		
1.4	രക്തസമ്മർദ്ദം (രാവിലെ)		
		സിസ്റ്റോളിക് (mm Hg)	ഡയസ്റ്റോളിക് (mm Hg)
	റീഡിങ് 1		
	റീഡിങ് 2		
	റീഡിങ് 3		

ഏയർ സാമ്പിൾ ഡാറ്റാഷീറ്റ്

സാമ്പിൾ എടുത്ത തീയതി (DD/MM/YY)			
സ്ഥാനം	അടുക്കള	ലിവിങ് ഏരിയ	ഔട്ട്ഡോർ
ഉപകരണ ഐഡി			
സാമ്പിൾ ആരംഭ സമയം (hh:min)			
സാമ്പിൾ അവസാനിക്കുന്ന സമയം (hh:min)			
മൊത്തം സാമ്പിൾ സമയം (മിനിറ്റ്)			
ശരാശരി PM _{2.5} ($\mu\text{g}/\text{m}^3$)			
ശരാശരി PM ₁₀ ($\mu\text{g}/\text{m}^3$)			
ശരാശരി AQI			

ANNEXURE VII



श्री चित्रा तिरुनाल आयुर्विज्ञान और प्रौद्योगिकी संस्थान, त्रिवेन्द्रम
तिरुवनन्तपुरम - ६९५०११, केरल, इंडिया
SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM
Thiruvananthapuram - 695 011, Kerala, India
(An Institute of National Importance under Govt. of India)

Grams : Chitramet, Phone : +91-471-2443152, Fax : +91-471-2550728 / 2446433, E-mail : sct@sctimst.ac.in, Website : www.sctimst.ac.in

Institutional Ethics Committee

CDSCO Registration No: ECR/189/Inst/KL/2013/RR-21
DHR Registration No: EC/NEW/INST/2022/2775

SCT/IEC/2160/DECEMBER/2023

11 01 2024

Dr. G. Vaishnavi
MPH Student, AMCHSS
SCTIMST, Thiruvananthapuram

Dear Dr. Vaishnavi,

The Institutional Ethics Committee held on 30th December, 2023, reviewed and discussed your application to conduct the study titled "IMPACT OF HOUSEHOLD AIR POLLUTION EXPOSURE ON , BLOOD PRESSURE AND FASTING BLOOD SUGAR IN ADULTS (IEC /2160)"

Principal Investigator	Dr. G Vaishnavi, MPH Student, AMCHSS, SCTIMST
Co-Principal Investigator(s)	Dr. Jeemon P., Additional Professor, AMCHSS, SCTIMST
Duration of the study	6 months

The following members of the Ethics Committee were present at the meeting held on 30th December, 2023

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Smt. Sathi Nair	MA (English Literature)	Female	Lay Person	No
2.	Dr. Kala Kesavan P	MBBS, MD	Female	Basic Medical Scientist	No
3.	Adv. Priya Kaimal	LLM, MBL	Female	Legal Expert	No
4.	Dr. P. Manickam	BSMS, MSc (Epid), PhD	Male	Health Science Expert/ Social Scientist	No
5.	Dr. Christina George	MD Psychiatry	Female	Clinician	No
6.	Dr. Narayanan Namboodiri. K K	MBBS, MD, DM	Male	Clinician	Yes
7.	Dr. Biju Soman	MBBS, MD, DPH, MSc, DLSHTM	Male	Basic Medical Scientist	Yes

The following documents were reviewed:Original submission

1. Checklist Form
2. Covering letter addressed to the Chairman, IEC, SCTIMST dated 30.11.2023
3. Responses /amendments made based on the Reviewer's comments
4. IEC Application Form
5. Declaration Form
6. Research Proposal
7. Participant Information Sheet in English and Malayalam
8. Informed Consent Form in English and Malayalam
9. Interview Schedule in English and Malayalam
10. CV of Principal Investigator and Co-PI
11. SRC Recommendation Letter

Revised submission

1. Checklist Form
2. Covering letter addressed to the Chairman, IEC, SCTIMST dated 10.01.2024
3. Copy of IEC Recommendation letter dated 09.01.2024
4. Responses /amendments made based on the Reviewer's comments
5. IEC Application Form
6. Declaration Form
7. Research Proposal
8. Participant Information Sheet in English and Malayalam
9. Informed Consent Form in English and Malayalam
10. Interview Schedule in English and Malayalam
11. CV of Principal Investigator and Co-PI

IEC Decision

The IEC approved the conduct of the study in the present form.

Remarks:

The Institutional Ethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and asks to be provided a copy of the final report.

There was no member of the study team / Guide who participated in voting / decision making process. The ethics committee is organized and operated according to the requirements of Good Clinical Practice and the requirements of the Indian Council of Medical Research (ICMR).

Sincerely,



Dr. G. Srinivas
Member Secretary, IEC

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE (IEC)
SCTIMST, THIRUVANANTHAPURAM

