Evaluation of Pradhan Mantri Ujjwala Yojana (PMUY) in Six States of India

Indian Institute of Technology, Kanpur

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Evaluation of Pradhan Mantri Ujjwala Yojana (PMUY) in Six States of India

Study by

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Executive Summary

The project titled, "Evaluation of Pradhan Mantri Ujjwala Yojana (PMUY) in 6 states of India" was executed by IIT Kanpur with the help of Respirer Living Sciences Pvt. Ltd. The project was sponsored by Ministry of Health and Family Welfare, Government of India with the support of National Health Systems Resource Centre (NHSRC). The key objectives of this project were to assess the health status of PMUY beneficiaries with regards to their respiratory health and out of pocket expenditure on care seeking, air quality levels inside and near the homes of PMUY beneficiaries and any improvement in quality of life among the beneficiaries of PMUY.

A multi-language large-scale survey was undertaken in 6 States viz., Rajasthan, Bihar, Jharkhand, Uttar Pradesh, Madhya Pradesh, and West Bengal. A total of 2366 households have been surveyed, as follows, Rajasthan 401 households, Bihar 409 households, Jharkhand 399 households, Uttar Pradesh 405 households, Madhya Pradesh 395 households and West Bengal 357 households. Apart from the survey, PM2.5 data was also collected from the villages with 16 Low-Cost Sensor based Air Quality devices installed in each State. This low-cost sensor data has provided additional support to the survey objectives. Three months' data was collected for analysis. The aggregated data from all six states was analysed for measuring overall health improvement and change in the quality of life of the PMUY beneficiaries. The households were classified based on the primary fuel used for cooking. From all the survey responders, the households using the LPG (Liquified Petroleum Gas) as a primary fuel for cooking were identified based on the responses received to the survey questions linked to the cooking fuel used, accessibility of LPG, and ability to refill LPG cylinder at present and in the last six months. Out of 2366 surveyed households, more than 72 %, i.e., 1716 households were found to be using LPG as a primary fuel for cooking. More than 40% of the LPG users have reported significant ($p<0.05$) improvement in the general health of the primary cooking person. Moreover, 55% of the surveyed LPG users have reported a lesser number of episodes for the occurrence of the respiratory illnesses in themselves and their family members post-LPG (PMUY) connections. Around 44% of LPG users have reported a significant ($p<0.05$) decrease in respiratory illnesses among the villagers using LPG under the PMUY scheme.

The infiltration of clean fuel, i.e., LPG through PMUY, have increased the LPG users in the villages. Thus, in order to analyse the health benefits on the community and surrounding, two villages, i.e., one having the highest and one having the lowest number of LPG connections under PMUY in each studied state, were also analysed separately based on the number of the PMUY connections and the fuel type. To analyse the state-wise results, we have divided the households surveyed into four categories based on type

of primary cooking fuel being used and number of PMUY roll-out in the area. For e.g.: Rajasthan High LPG Primary means group of households using LPG as primary fuel for cooking in a village which had the highest number of beneficiaries of PMUY in that state (thereby having the highest density of PMUY beneficiaries in the state) roll- out in Rajasthan. The categories are:

- High LPG Primary Village: Households from the high LPG connection village who use LPG as primary fuel.
- High LPG Secondary Village: Households from the high LPG connection village who use a combination of LPG and other cooking fuel.
- Low LPG Village: Households from the low LPG connection village who use LPG as their primary fuel.
- Low Chulha Village: Households from the low LPG connection village who use chulha and solid fuel.

The idea behind selecting a "High LPG" and "Low LPG" village from each of the 6 states is that clean air is a shared 'common' resource and air pollution from one household affects others in the immediate vicinity. Hence, in a "Low LPG" village, even though a household may have moved to using LPG as its primary cooking fuel, the health impact of clean air on members of that household will be fully realised only when other neighbouring households also start using LPG. The "High LPG" villages were selected to capture this collective effect of clean air at the village level.

The survey questionnaire consisted of 69 questions and was translated into native language of the respective states. The survey responses from Rajasthan, Bihar and Uttar Pradesh provides a strong evidence for improvement in the overall health of people in households using LPG from PMUY, while the three States of Jharkhand, Madhya Pradesh and West Bengal show mild improvement. Rajasthan Low Chulha category reported no noticeable improvement while all other categories show significant improvement in terms of general health of primary cooking person post LPG adoption from PMUY. More than 8% of respondents in Rajasthan High LPG Primary have shown improvement with respect to the general health of other people in the home post LPG. Occurrence of respiratory illnesses among the villagers since using LPG under PMUY has decreased significantly ($p<0.05$) for Rajasthan High LPG Primary and Secondary categories. General health of the primary cooking person post LPG has improved significantly for Bihar High LPG Primary & Secondary and Bihar Low LPG. UP Low Chulha shows significantly higher percent of respiratory related health problem in the family. General health of the primary cooking person has improved significantly for Jharkhand Low LPG and Jharkhand Low LPG Chulha. General health of other people in the home has improved significantly for Jharkhand Low LPG and Jharkhand Low LPG Chulha. More than 60% of responses for all the categories except Jharkhand Low Chulha share that they have decreased

number of visits to doctors since the use of LPG. More than 11% of respondents in both Madhya Pradesh (MP) Low Chulha and MP Low LPG have respiratory related health problem in the family. 10% of respondents in West Bengal Low LPG indicate having respiratory related health problem which is significantly higher as compared to others.

After further analysis we have found that in three states (Rajasthan, Uttar Pradesh and Bihar), for the PMUY high village (high number of PMUY connection) when people are using LPG as primary source of cooking, their general health has improved by almost 50% more than in comparison with low PMUY village. Regarding direct effect like reported respiratory problem, we have observed an average of 2 to 5 times more reported respiratory problems in villages where PMUY connection is low compared with high PMUY villages for the above mentioned three states. For example, in Rajasthan, reported respiratory illness for PMUY high villages is only 1.2%, whereas for low connection villages it is 19.2%. For the States of Jharkhand and Madhya Pradesh, we have observed an improvement of 10%. The study results were evaluated for different income groups as a socio-economic confounder. The health benefits from PMUY were found consistent for all the income groups surveyed which signified that benefits of PMUY on the health were not constrained based on income categories. Industrial emissions, crop/residue burning and smoking may substitute as confounder for sources of air pollution on general health of the respondents but the tracking of these confounders was beyond the scope of this project.

The survey also quantified some of the challenges encountered in LPG refills with respondents indicating they had to travel outside the village to get their LPG refills done. The survey data showed that around 29% of the LPG users still get their LPG cylinder refill from outside the village. More than 38% of the LPG users had refilled their LPG cylinders only 0-2 times in the last six months. Around 47% of the LPG users have reported refilling cost as a limiting factor for LPG cylinder refilling. Also, the number of refills undertaken by Low LPG households was substantially less as compared to those in High LPG villages.

In terms of exposure of PM2.5 particles to the primary cooking person, the low-cost sensor analysis data shows high PMUY connection villages indoor environment have 10 to 20 percent less average exposure than the low connection village. This value becomes highly significant considering long-time exposure.

The results of the project clearly show that PMUY was effective in positively impacting the health of its beneficiaries in the Indian villages. The health survey analysis and the air quality data collected in such a project can be communicated to the PMUY beneficiaries to encourage more continued use of LPG cylinders by existing PMUY beneficiaries.

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Introduction

Background

Household air pollution (HAP) has now become a global threat for human health, as more than 3.8 million annual deaths were reported globally (World Health Organisation, 2018). As per the global burden of disease (GBD), 2019 estimates, the HAP is 9th leading cause of global deaths. Around 2.31 million deaths were reported from long-term exposure to HAP caused due to solid fuel burning in kitchens. However, In India the age-standardized rates of deaths attributable to HAP was lowest (i.e., 60/100,000) as compared to other South-Asian countries (Health Effects Institute and Institute for Health Metrics and Evaluation´s Global Burden of Disease project, 2020). In India alone around 1.67 million deaths were reported to air pollution in 2019, out of which around 0.61 million deaths were reported from HAP (Pandey et al., 2021). HAP is primarily caused due to incomplete combustion of unclean fuels, such as agricultural residue, cow dung cakes, and wood burning in kitchens. HAP is predominant in rural parts of the country, where biomass burning is commonly used fuel for cooking due to its easy access and unaffordability of the cleaner fuel such as LPG. Around 49% of the global population (3.8 billion people) are still using biomass, coal and kerosene for cooking their food on daily basis. In the rural parts of the low and middle-income Asian countries around 1.5 billion people, i.e. around 68% of the global population, are still depends on unclean fuel for cooking (Health Effects Institute, State of Global Air 2018). Moreover, the World Health Organisation (WHO) 2018 report highlighted that around 59% population still rely on unclean fuel for their daily cooking in traditional cook stoves (WHO, 2018). India is home to more than 24 Crore households out of which about 10 Crore households are still deprived of clean cooking fuel such as LPG and have to rely on firewood, coal, dung – cakes etc. as primary source of cooking fuels. The smoke from burning such fuels causes alarming household pollution and adversely affects the health of women & children causing several respiratory diseases/ disorders. As per a WHO report, smoke inhaled by women from unclean fuel is equivalent to burning 400 cigarettes in an hour. In addition, women and children must go through the drudgery of collecting fire wood (Umapathy and Sreeramulu, 2019). The Pradhan Mantri Ujjwala Yojana (PMUY) aims to safeguard the health of women & children by providing them with a clean cooking fuel – LPG, so that they don't have to compromise their health in smoky kitchens or wander in unsafe areas for collecting firewood. PMUY was launched by Hon'ble Prime Minister Shri Narendra Modi on May 1st, 2016 in Ballia, Uttar Pradesh.

The exposure to HAP also depends on factors such as characteristics of the houses, geographic location, exposure time, socioeconomic condition of the households, ventilation, and design of the kitchen, along with the fuel type used. Several studies have found that the exposure to HAP severely affected the human health, spatially the cooking person (Parikh et al., 2020; Shi et al., 2016; Idavain et al., 2019; Swiston et al., 2008). The smoke emission from incomplete and inefficient combustion of unclean fuels generates several hazardous pollutants such as fine particulate matters, volatile organic compounds, CO, CO2, O3, SO2 and NO2 in indoor micro environments, deteriorating the indoor air quality (IAQ) of the houses. The IAQ refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Understanding and controlling common pollutants indoors can help reduce your risk of indoor health concerns. Health effects from indoor air pollutants may be experienced soon after exposure or, possibly, years later.

Immediate Effects

Some health effects may show up shortly after a single exposure or repeated exposures to a pollutant. These include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution if it can be identified. Soon after exposure to some indoor air pollutants, symptoms of some diseases such as asthma may show up, be aggravated, or worsened.

The likelihood of immediate reactions to indoor air pollutants depends on several factors including age and pre-existing medical conditions. In some cases, whether a person reacts to a pollutant depends on individual sensitivity, which varies tremendously from person to person. Some people can become sensitized to biological or chemical pollutants after repeated or high-level exposures.

Certain immediate effects are similar to those from colds or other viral diseases, so it is often difficult to determine if the symptoms are a result of exposure to indoor air pollution. For this reason, it is important to pay attention to the time and place symptoms occur. If the symptoms fade or go away when a person is away from the area, for example, an effort should be made to identify indoor air sources that may be possible causes. Some effects may be made worse by an inadequate supply of outdoor air coming indoors or from the heating, cooling, or humidity conditions prevalent indoors.

Long-Term Effects

Other health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure. These effects, which include some respiratory diseases, heart disease and cancer, can be severely debilitating or fatal. It is prudent to try to improve the indoor air quality in your home even if symptoms are not noticeable.

While pollutants commonly found in indoor air can cause many harmful effects, there is considerable uncertainty about what concentrations or periods of exposure are necessary to produce specific health problems. People also react very differently to exposure to indoor air pollutants. Further research is needed to better understand which health effects occur after exposure to the average pollutant concentrations found in homes and which occurs from the higher concentrations that occur for short periods of time.

Exposure to indoor pollution from solid cooking fuel, mainly as biomass, causes an estimated 925,000 deaths yearly in India today (Smith and Pillarisetti, 2017). The number of people most affected—700 million to 800 million—has not declined in 30 years, despite considerable economic development and the growth of clean fuel use for the middle class. An efficient way of reducing indoor pollution significantly is by using LPG for cooking. This is especially applicable for rural households in India, where the primary reason for using unclean fuel is lack of means to afford clean fuel. Thus, the PMUY scheme had been introduced to combat this problem by issuing LPG cylinders to 'below poverty line' families in India. This policy was expected to affect approximately 5 crore households.

It is well established that the use of clean fuel and improved stoves is a means to lower harmful emissions from solid fuels (Capuno et al., 2018). Children from households using LPG had a 5.0% lower probability of reporting Acute Respiratory Illness (ARI) relative to exclusive users of polluting fuels, with larger effects (10.7%) in rural households. The probability of ARI in households using improved stoves and mixed fuel use was also lower in rural households, by 2.9% and 2.8%, respectively (Lamichhane et al., 2017).

A number of recent studies have reported the reduction in HAP and reducing the health risk while using the clean fuel such as LPG. For example, Deepthi et al., (2019) have estimation of respiratory dosage and indoor PM concentrations for the households in rural areas of Telangana states of India. The study found the high levels of dosage (1181.4 to 5891.7 µg) in households using biomass as compared to LPG households. Furthermore, the indoor kitchens have reported 10.6 times higher concentration than outdoor kitchens in rural settings. Chowdhury et al. (2019) have found that the elimination of household use of kerosene and biomass burning in India may reduce the PM2.5 exposure up to 17.5% in terms of average annual ambient concentrations. Similarly, Parikh et al. (2020) evaluated the prevalence of respiratory illness among women exposed to HAP in rural parts of India. The study found that the exposure to nitric oxide was significantly higher in women exposed to biomass burning as compared to the households using LPG for their energy needs. Recently, the study conducted by Islam et al. (2021) have found that use of clean cooking fuels may significantly reduce HAP and decrease

the prevalence of stunting in children up to 4 percent. There is also evidence that vulnerability also increases at lower incomes due to poorer nutrition, adaptive ability and other immune deficiencies. The studies have found significant correlation between usage of unclean cooking fuel and adverse health effects related to HAP (Chattopadhyay et al., 2021). The study conducted by Balakrishnan et al. (2013) have monitored fine particulates with respect to indoor air pollution in kitchen of Madhya Pradesh and West Bengal; it was and found that PM2.5 concentrations varied from 179µg/ m3 to 590µg/ m3 caused due to burning of different solid fuels. Similarly, Gautam et al. (2013) examined 55 families in three villages in Haryana and found that the various fuels used were in the following order: PNG, LPG, kerosene, shrub/farm waste, and cow dung.

Indian Status on Cooking Fuel

In India, the reliance on solid fuels and the estimated related burden of disease are pronounced. An estimated 770 million individuals—approximately 70 percent of the total population (Smith and Pillarisetti, 2017)—living in 160 million households continue to use solid fuels as a primary energy source for cooking (Chengappa et al., 2007). Among all risk factors contributing to ill health in India, exposure to HAP from cooking ranks second for mortality, with approximately 0.925 million premature deaths yearly; it ranks third for disability-adjusted life years (DALYs), amounting to approximately 25 million lost DALYs per year (Rumchev et al., 2017). An estimated 4 percent of the deaths occur in children under age five years because of pneumonia, which overall accounts for 12 percent of total child deaths in India.

The Government of India has under-taken several policy initiatives to address HAP through improved biomass combustion, beginning in the 1980s with a failed National Programme on Improved Chulhas (Kulshreshtha et al., 2008) and continuing in 2010 with a National Biomass Cookstoves Initiative. More recently, two innovative programs—the Give It Up (GIU) and Smokeless Village (SV) campaigns—are seeking to bring clean cooking via LPG to the rural poor (Smith and Pillarisetti, 2017). GIU, encourages better-off Indian households to voluntarily give up their LPG subsidies and redirects those subsidies one-for-one to below- poverty-line (BPL) families, and SV, connects every household in a village to LPG, in close collaboration with India's three national oil companies. In mid-2016, Prime Minister Narendra Modi introduced Pradhan Mantri Ujjwala Yojana (PMUY), a program to extend the GIU and SV campaigns by making free LPG connections available to all BPL households. These programs have the potential to substantially reduce the mortality and morbidity associated with the use of solid fuels for cooking, if one assumes near-complete transitions to clean fuels (Smith and Pillarisetti, 2017). The mitigation measures by Government of India and the aggressive campaigns has encouraged the people to use clean and resulted the

reductions in the percentage of populations exposed to HAP from 73% to 61% over the last decade, i.e., from 2010 to 2019 (Health Effects Institute and Institute for Health Metrics and Evaluation´s Global Burden of Desease project, 2020).

The PMUY is a flagship scheme of Ministry of Petroleum and Natural Gas (MoPNG), Government of India, which intended to provide 80 million liquefied petroleum gas (LPG) connections to the rural and deprived households of India by March 2020. The successful implementation of the PMUY has helped in increasing the LPG coverage about 99% as on 1st April 2021 in India from as compared to 62% on 1st May 2016. This scheme has benefitted approximately 92.7 million households till January 2022 by providing the access to clean fuels (PMUY, 2022).

Thus, this project was undertaken to quantify the health impact of PMUY in six States of India. This project was executed by IIT Kanpur with the help of Respirer Living Sciences Pvt. Ltd. The project was sponsored by Ministry of Health and Family Welfare, GoI with the financial support of National Health Systems Resource Centre (NHSRC).

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Objective

The key objective of this project is to assess the following points:

- Health status of PMUY beneficiaries with regards to their respiratory health and out of pocket expenditure on care seeking.
- Quality of life among the beneficiaries of the PMUY in terms of amount of time saved in cooking and collecting firewood.
- Experiences of beneficiaries in accessing and using the LPG.

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Design and Methodology

A combination of digital survey-based tools and real-time Particulate Matter low-cost sensor- based air quality monitoring devices were used to evaluate the key objectives of PMUY. The digital survey tool was developed using open-source community led mobile survey technologies.

The survey was conducted on basic Android phones and the digital questionnaire was translated into the native language of the state where the survey was conducted. The approval has been taken by the ethics committee of IIT Kanpur. The consent was filled by the respondents with their digital signature, and it was kept as the part of the questionnaire also. The respondents were randomly selected based on their availability and the willingness to take part in the survey. The ethics were ensured by keeping the responses secure and confidential; and keeping the recruitment of respondents voluntary, as mentioned in the consent form given to them, prior to the survey.

The six states selected for this study had the largest scale of PMUY roll-out (Table 1). The selection was supported by PMUY data made available to us at village level by the Ministry of Petroleum and Natural Gas. Another factor considered is that the villages with highest and lowest number of PMUY connections fall in easily accessible areas, not prone to violence or political unrest, as these factors would add bias to the survey. Based on the combination of these criteria and the data provided by Ministry of PNG, the six States were chosen for this study, i.e., Bihar, Jharkhand, Madhya Pradesh, Rajasthan, Uttar Pradesh, and West Bengal.

Table 1: List of selected high and low PMUY connection villages

State	Highest PMUY Connection Village (district)	Lowest PMUY Connections Village (district)
Uttar Pradesh	Hardatt Nagar Giant (Shrawasti)	Ronija (Gautam Buddha Nagar)
Bihar	Basmatiya (Araria)	Gaiaspur (Patna)
Rajasthan	Kasarwari (Banswara)	Ramsingh pura (Jaipur)
Jharkhand	Kachanpur (Garhwa)	Lupung (Ranchi)
Madhya Pradesh	Sidhi (Hanumangarh),	Nolana (Indore)
West Bengal	Birghai (Uttar Dinajpur),	Rajarhat (North 24 Parganas)

Following the selection of States, an exhaustive questionnaire was prepared for the survey, in consultation with a Technical Advisory Group (TAG), consisting of the following

members: Dr. Rajani Ved, NHSRC; Dr. N. Yuvraj, Joint Secretary, NHM, MoHFW; Dr Neha Dumka (KMD NHSRC), Dr. Poornima Prabhakaran, Head-Environmental Health & Additional Professor, Public Health Foundation of India; Dr. Bratati Banerjee, Professor, Maulana Azad Medical College; Dr. Sanjay Rai, Centre for Community Medicine, AIIMS; Dr. Debajit Palit, Rural Energy & Livelihoods Division, TERI. The questionnaire approved through the Institute Ethics Committee of IIT Kanpur was pre-tested in 60 households in Kanpur, Uttar Pradesh before conducting the actual survey. Based on the feedback obtained from the pretesting, the questionnaire was modified, and provisions were made to facilitate support from local government in the survey areas.

A large-scale survey was completed for 6 States included in this project, viz., Rajasthan, Bihar, Jharkhand, Uttar Pradesh, Madhya Pradesh, and West Bengal. A total of 2366 households have been surveyed, as follows, Rajasthan 401 households, Bihar 409 households, Jharkhand 399 households, Uttar Pradesh 405 households, Madhya Pradesh 395 households and West Bengal 357 households, the households were selected randomly for the survey. Further, we have identified in these six States which villages have high PMUY connection and which villages have low number of PMUY connections. Then we performed the survey on these target villages over a 2-month period to quantify the clear impact of PMUY connection on these villages. It must be noted that the seasonal occurrence of acute disease in the studied households was eliminated by clearly mentioning in the questionnaire to exclude the seasonal occurrences and only asked about persistent respiratory symptoms.

PMUY Digital Survey Infrastructure was built by Respirer Living Sciences. The survey was conducted in local languages in all the six States, with the data and analysis available in real-time as well as in online and offline scenarios. The technology for the digital survey infrastructure was built using the Open Source framework from KoBoToolbox. The survey data collection platform was set up on a cloud machine of Respirer Living Sciences. Data is saved in Postgre SQL and automatic, periodic backups of was enabled.

The methodology used to analyse the survey responses includes the following steps:

- Classify State Responses into villages with highest and lowest number of PMUY connections
- Handling Multiple Choice Question Options as per priority
- Summarizing Survey Responses
- Identifying Applicable Health Questions
- Summarizing Survey Responses for classifications
- Summary of Inferences drawn for the State

The out pocket expenditure for care seeking was analysed by the number of visits to

the doctor since use of the LPG. While the quality of life of the households was analysed by assessing their responses for time spent on cooking, cleaning utensils, use of warm water usage and their ease of cooking. Apart from the survey, $PM_{2.5}$ data had also been collected from the villages with 16 devices installed in each State. This low-cost sensor data provided additional support to the survey objectives. Three months' data was collected for analysis. The new low-cost sensors (Atmos device, Figure 1) were installed in this study to collect the PM concentrations in the studied households. These sensors work on laser-scattering principle to measure real-time PM mass concentrations. The sensors measure the PM in range of 0–1000 µg/ m^3, with ±1 µg/ m^3 resolution and 1–10 s response time. These sensors have shown a significant reliability in accuracy based on the validation performed with the US EPA-approved Federal Reference Methods based monitoring instruments. The quality of assurance of these sensors also been tested in the previous studies (Ballamajalu et al., 2018; Jha et al., 2021; Sahu et al., 2020). Previous studies have also reported the field performance and calibrations of low-cost sensors using simultaneous

Gaussian process regression and simple linear regression (Zheng et al., 2019, 2018). For quality control the study performed the colocation for the EBAM data Vs Atmos data (i.e., Low cost sensors used). The colocation results are attached in APPENDIX C

Figure 1: Atmos - Low cost sensors for air quality monitoring

Statistical Analysis

The descriptive statistical analysis was carried using 95% confidence interval formula as mentioned

$$[\hat{p} - z_{\frac{\alpha}{2}}\sqrt{\frac{\hat{p}\,(1-\hat{p}\,)}{n}}, \quad \hat{p} + z_{\frac{\alpha}{2}}\sqrt{\frac{\hat{p}\,(1-\hat{p}\,)}{n}}]$$

Where p̂ is the population proportion.

One Sample T-test was performed to examine the statistical significance of the responses, assuming the null hypothesis: there is no change in occurrence of respiratory illness among the villagers since using LPG under PMUY. The results were reported statistically significant only when the test statistics P-value was found <0.05. All the statistical tests were performed using IBM SPSS Statistic 20.

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Results and Discussion

Overall Health Assessment and Change in the Quality of Life

A large-scale survey was carried out for six states of India: Rajasthan, Bihar, Jharkhand, Uttar Pradesh, Madhya Pradesh, and West Bengal. A total of 2366 households have been surveyed, including Rajasthan 401 households, Bihar 409 households, Jharkhand 399 households, Uttar Pradesh 405 households, Madhya Pradesh 395 households and West Bengal 357 households. The assessment for overall health improvement and change in the quality of life of the PMUY beneficiaries was carried out using the pooled data from the studied states. The respondents were classified based on the primary fuel used for cooking. From all the survey responders, the households using the LPG as a primary fuel for cooking were identified based on the responses received for the survey questions linked to the cooking fuel used, accessibility of LPG, and ability to refill LPG cylinder at present and in the last six months. Of 2366 surveyed households, more than 72 %, i.e., 1716 households, were found to be using LPG as a primary fuel for cooking.

The health assessment of PMUY beneficiaries was carried out based on the responses received for the health-related questions, i.e., (a) How has the general health of the primary cooking person been affected post-LPG (PMUY)? (b) How has the general health of other people in the home been affected post-LPG (PMUY)? (c) Have you noticed any change in the occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (d) Have the number of visits to doctors changed since the use of LPG? and (e) How do you find the occurrence of respiratory illnesses in you or your family members, compared to that of other fuel like kerosene, fuelwood, coconuts, cow dung cakes etc.? While filling out the questionnaire, the respondents were asked to exclude seasonal occurrences and only report persistent problems. More than 40% of the LPG users have reported significant ($p<0.05$) improvement in the general health of the primary cooking person. About 33% of LPG users have also reported improvement in the general health of other family members post-LPG (PMUY) connections.

The respondents' perceptions of respiratory health illnesses were analysed based on the responses to the respiratory health questions. It was found that only 8% of the studied LPG users have reported positively for having any respiratory-related health problem in their family. However, more than 14% of LPG users have reported not being aware of such health-related illnesses in the family. Moreover, 55% of the surveyed LPG users have reported a lesser number of episodes for the occurrence of the respiratory illnesses in themselves and their family members post-LPG (PMUY) connections. Among the studied LPG users, around 40% have also reported a decrease in the number of

visits to doctors since using LPG as primary cooking fuel. The occurrence of respiratory illnesses among the villagers was assessed based on the individual response from the surveyed households. Around 44% of LPG users have reported a significant ($p<0.05$) decrease in respiratory illnesses among the villagers since using LPG under the PMUY scheme.

The assessment for change in PMUY beneficiaries' quality of life was carried out based on the responses received for the questions a) How much time do you have to spend for cooking using LPG in comparison to other fuels like kerosene, fuelwood, coconuts, cow dung cakes etc.? b) Is there any difference in cleaning of utensils since using LPG? c) Has warm water usage changed since the LPG connection (PMUY)? Around 99% of the LPG users have reported less time spent in cooking using LPG compared to other fuels. Similarly, 97% of the LPG users have reported ease of utensils cleaning after using PMUY LPG connection for cooking. However, only 14 % of LPG users have reported an increase in warm water usage since using LPG, indicating usage of warm water has not changed suggestively post-LPG. The health and quality of the life-related questions, along with the percentage responses from LPG users, are shown in Table 2.

Table 2: The responses received from LPG users for the health and quality of life-related questions.

S.NO.	QUESTION	RESPONSES	% OF TOTAL RESPONSES
1	How has the general health of the primary cooking person been affected post-LPG (PMUY)?	Deteriorated Improved Same No response	0.3 40.4 57.3 1.9
2	How has the general health of other people in the home been affected post-LPG (PMUY)?	Deteriorated Improved Same No response	0.2 33.1 64.3 2.4
3	How do you find the occurrence of respiratory illnesses in you or your family members in comparison to that of other fuel?	Lesser number of episodes More number of episodes Same No response	54.5 0.2 27.0 18.2
4	Have the number of visits to doctors changed since the use of LPG?	Decreased Increased No change No response	39.7 0.9 36.1 23.3
5	Have you noticed any change in the occurrence of respiratory illnesses among the villagers since using LPG under PMUY?	Decreased Increased No change No response	43.9 0.2 44.6 11.4

6	How much time do you have to spend for cooking using LPG in comparison to other fuels?	Less time More time Same time No response	99.1 0.1 0.5 0.4
7	Is there any difference in cleaning of utensils since using LPG?	Easier to clean Harder to clean No difference No response	97.3 0.1 1.9 0.8
8	Has the usage of warm water changed since LPG connection (PMUY)?	Decreased Increased Same No response	8.2 12.2 12.2 56.9

The state-wise assessment was also carried out for the health improvement of surveyed LPG users. The highest percentage of positive responses for the improvement in the general health of the primary cooking person was reported from the West-Bengal villages, i.e., 96% of the surveyed LPG users of West-Bengal, followed by Madhya Pradesh, i.e., 48% of the surveyed LPG users from Madhya Pradesh villages. The state-wise percentage responses for the general health of the primary cooking person are shown in Figure 2.

The state-wise responses for the status of respiratory-related health problems in the family showed that around 15% of the surveyed LPG users from Bihar have positively reported respiratory-related health in their family. Similarly, 11% of LPG users from Jharkhand and 7% of LPG users from Uttar Pradesh have also reported positively to respiratory-related illnesses in the family. While only 6%, 5% and 2% of respondents from Madhya Pradesh, Rajasthan and West Bengal, respectively, responded positively to respiratory-related illness in the family. Moreover, around 99% of the surveyed LPG users from Jharkhand having respiratory illness in the family have reported fewer episodes of respiratory-related illness since using LPG as primary cooking fuel. Similarly, 89%, 68% and 46% of the surveyed LPG users from Rajasthan, Bihar, and Madhya Pradesh, respectively, have also reported a lesser number of episodes of respiratory illnesses in themselves and their family members post LPG connection. The state-wise percentage responses for the occurrence of respiratory illnesses are shown in Figure 3.

The infiltration of clean fuel, i.e., LPG through PMUY, have increased the LPG users in the villages. A significant health improvement has been reported by the individual households who are using LPG as a primary cooking fuel, as previously reported in this report. Furthermore, in order to analyse the health benefits on the community and surrounding, two villages, i.e., one having the highest and one having the lowest number of LPG connections under PMUY in each studied state, were also analysed separately based on the number of the PMUY

Figure 2: State percentage responses for the general health of the primary cooking person -wise

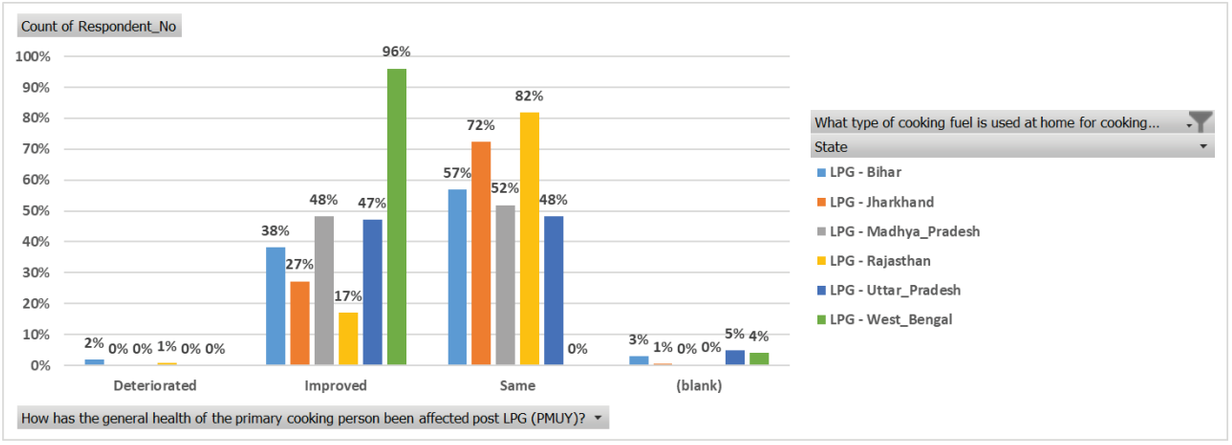
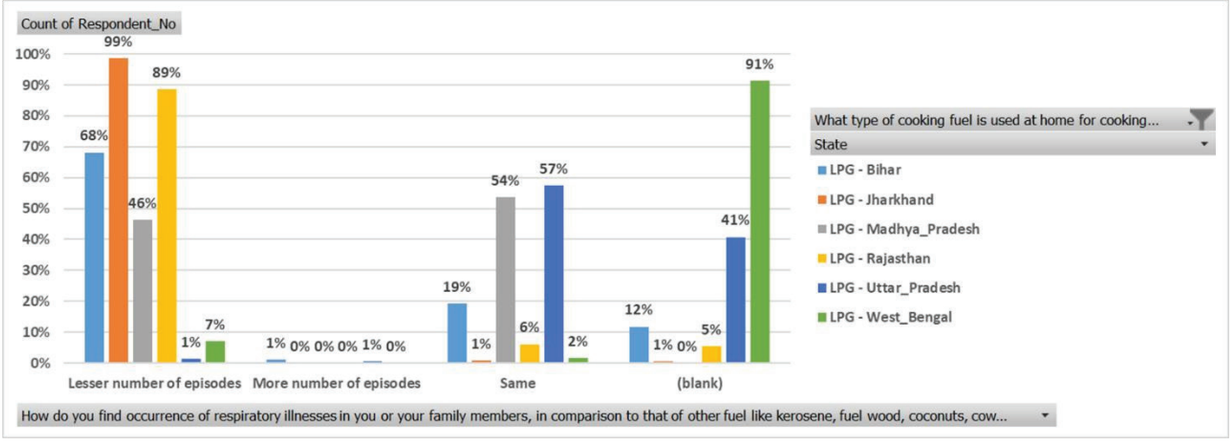


Figure 3: State-wise percentage responses for the occurrence of respiratory illnesses



connections and the fuel type. To analyse the state-wise results, the surveyed households were classified into four categories based on the type of primary cooking fuel being used and the number of PMUY roll- outs in the area. For e.g., Rajasthan High LPG Primary means the group of households using LPG (Liquified Petroleum Gas) as a primary fuel for cooking in a village which had the highest number of beneficiaries of PMUY in that state (thereby having the highest density of PMUY beneficiaries in the state) roll-out in Rajasthan. The categories are:

- High LPG Primary Village: Households from the high LPG connection village who use LPG as a primary fuel.
- High LPG Secondary Village: Households from the high LPG connection village who use a combination of LPG and other cooking fuel.
- Low LPG Village: Households from the low LPG connection village who use LPG as their primary fuel.
- Low Chulha Village: Households from the low LPG connection village who use chulha and solid fuel.

a. Rajasthan

For the State of Rajasthan, a total number of 401 survey responses were obtained. Among these, 50.2% were from the village with high PMUY connections and 49.8% were from the village with low PMUY connectivity. From all the survey responders, 56.9% surveys were taken by the primary Cooking person of the family, of which 98.75% were women of the household. 45% of the households had 4-5 family members and 30% had 6-7 family members. For 94.5% of the families, there was only one bread-earner in the family. Only 4% had two bread-earners. The detailed distributions for these figures are available in appendix A.

Health analysis: The questions considered for health analysis in Rajasthan are given below:

- Does anyone in the family have respiratory related health problem?
- How has the general health of the primary cooking person been affected post LPG (PMUY)?
- How has the general health of other people in the home been affected post LPG (PMUY)?
- Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?
- Have the number of visits to doctors changed since the use of LPG?
- How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems)

Table 3: Classification of the survey responders in Rajasthan (The details of the type of cooking fuel and combinations for the villages is given in the Appendix A)

Category	High LPG Primary Village	High LPG Secondary Village	Low LPG Village	Low Chulha Village
% Responders in this category	33.1	16.96	21.20	28.68

The details for each question and its responses are shown in the figures below.

Question 1: Does anyone in the family have respiratory related health problem?

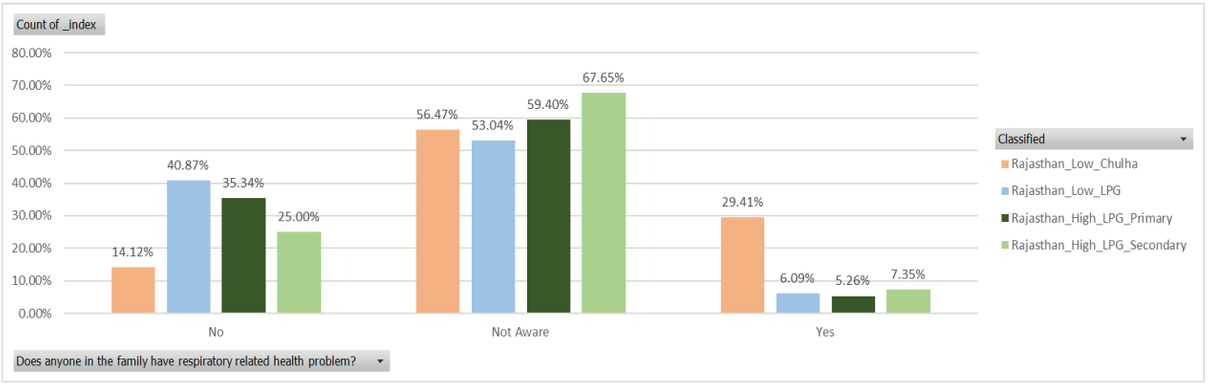


Figure 4: Survey responses for the question 'Does anyone in the family have respiratory related health problems', in the State of Rajasthan for the classified categories.

More than 29% of respondents in Rajasthan Low Chulha category have respiratory health related problem in the family. Over 40% of respondents in Low LPG households have reported no respiratory related health problems, thereby signifying impact of LPG even in low LPG villages.

Question 2: How has the general health of the primary cooking person been affected post LPG (PMUY)?

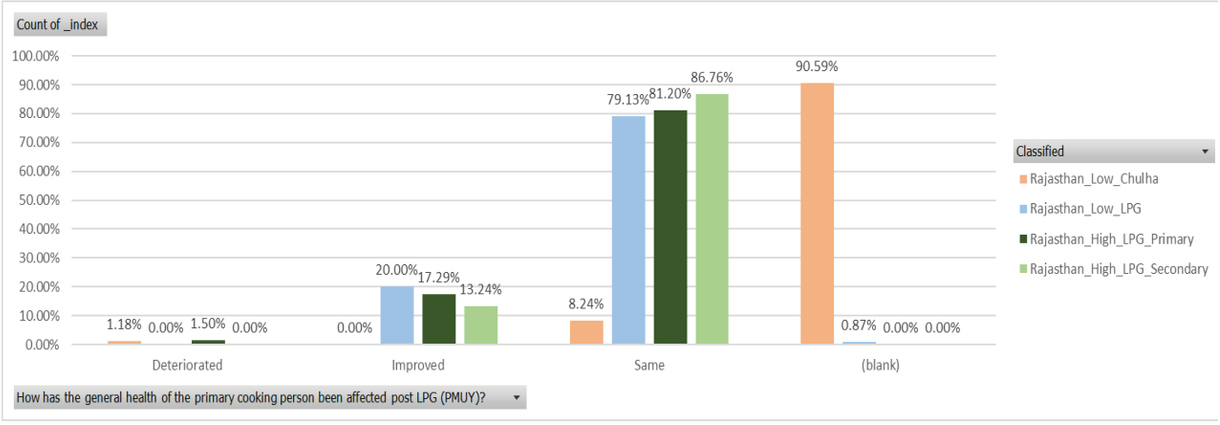


Figure 5: Survey responses for the question 'How has the general health of the primary cooking person been affected post LPG (PMUY)', in the State of Rajasthan for the classified categories.

Rajasthan Low Chulha category shows no improvement while all other show improvement in terms of general health of primary cooking person post LPG

Question 3: How has the general health of other people in the home been affected post LPG (PMUY)?

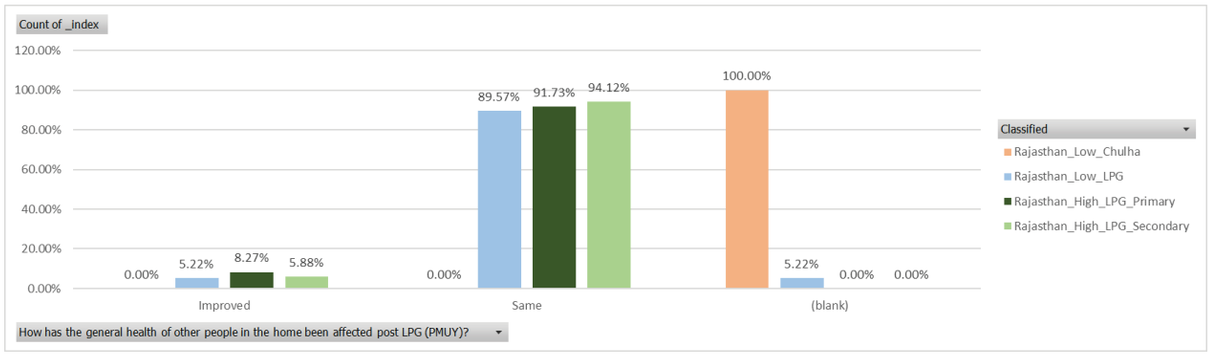


Figure 6: Survey responses for the question 'How has the general health of other people in the home been affected post LPG (PMUY)', in the State of Rajasthan for the classified categories.

More than 8% of respondents in Rajasthan High LPG Primary have shown improvement with respect to the general health of other people in the home post LPG.

Question 4: Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?

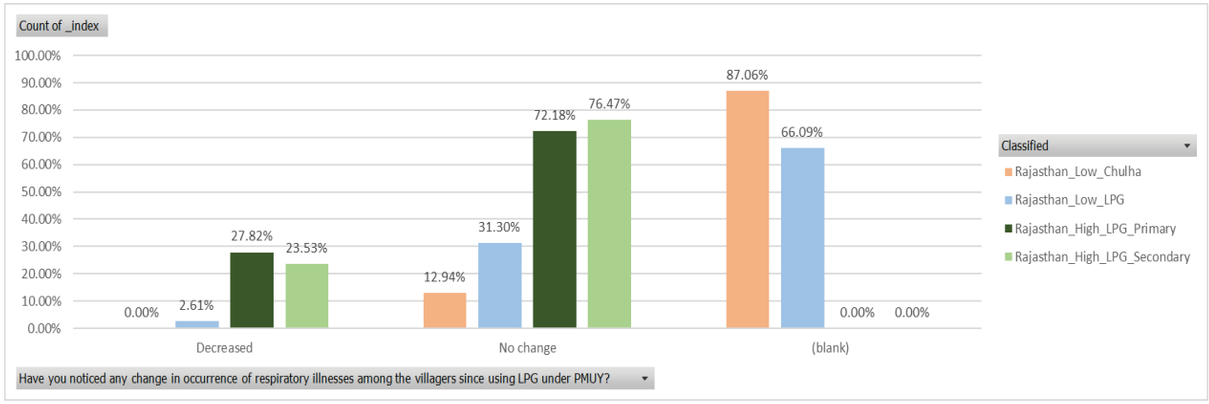


Figure 7: Survey responses for the question 'Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY ', in the State of Rajasthan for the classified categories.

Occurrence of respiratory illnesses among the villagers since using LPG under PMUY has decreased ($p<0.05$) for Rajasthan High LPG Primary and Secondary categories.

Question 5: Have the number of visits to doctors changed since the use of LPG?

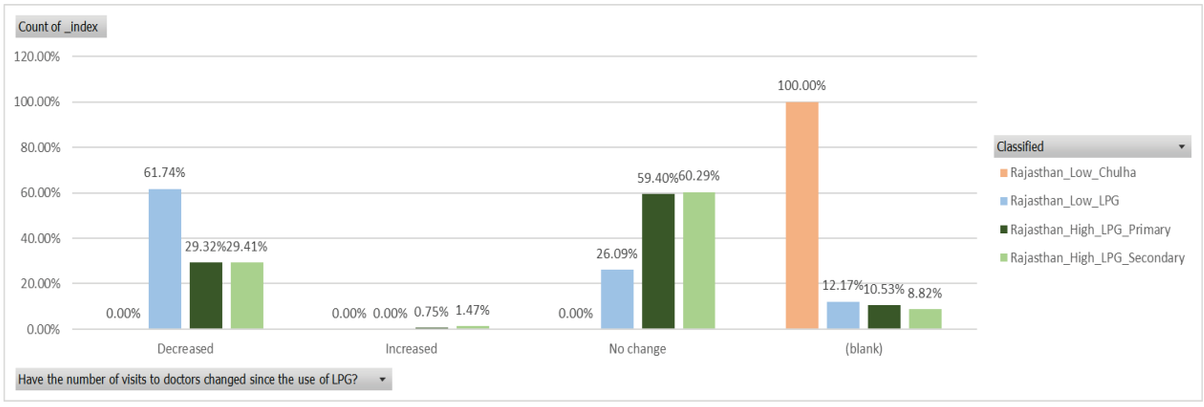


Figure 8: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG', in the State of Rajasthan for the classified categories.

Number of visits to doctors has changed for both categories Low and High involving LPG as fuel since the use of LPG.

Question 6: How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel?

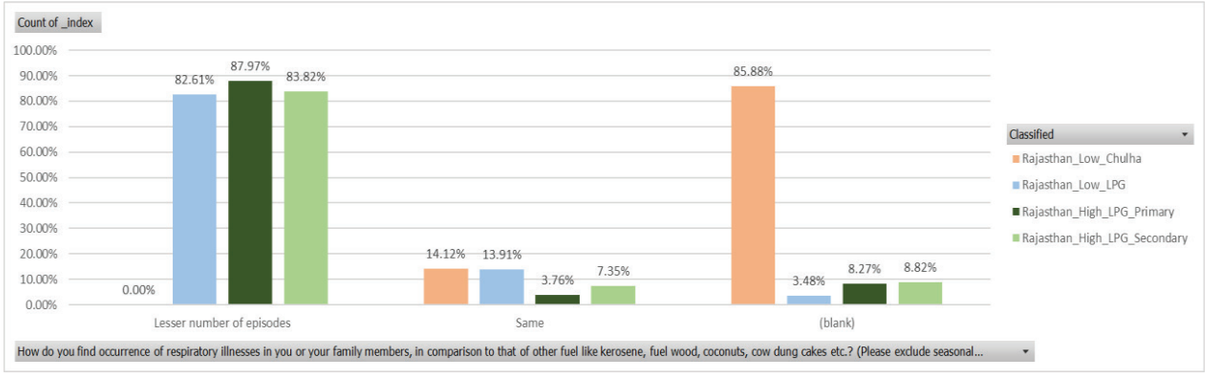


Figure 9: Survey responses for the question 'How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel', in the State of Rajasthan for the classified categories.

Rajasthan Low LPG and Rajasthan High LPG Primary as well as secondary have lesser number of episodes related to occurrence of respiratory illnesses.

Quality of life

Question 7: How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

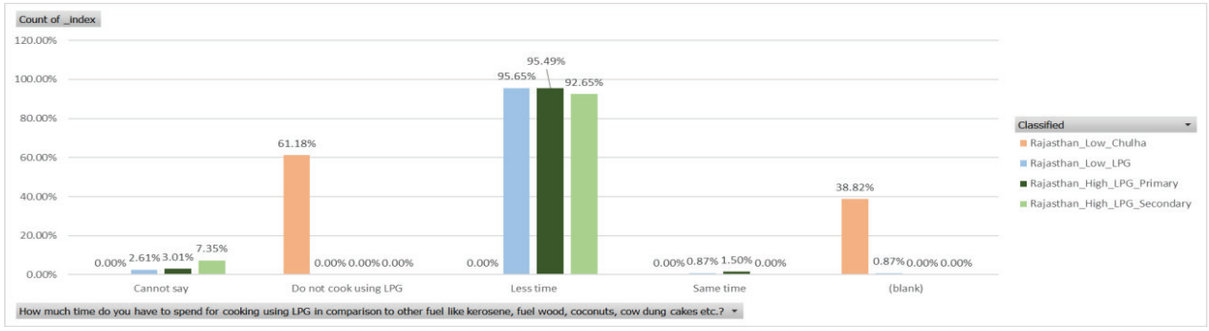


Figure 10: Survey responses for the question 'How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.' in the State of Rajasthan for the classified categories.

The time for the cooking has reduced for Rajasthan Low LPG and High LPG Primary as well as secondary category households.

Question 8: Is there any difference in cleaning of utensils since using LPG?

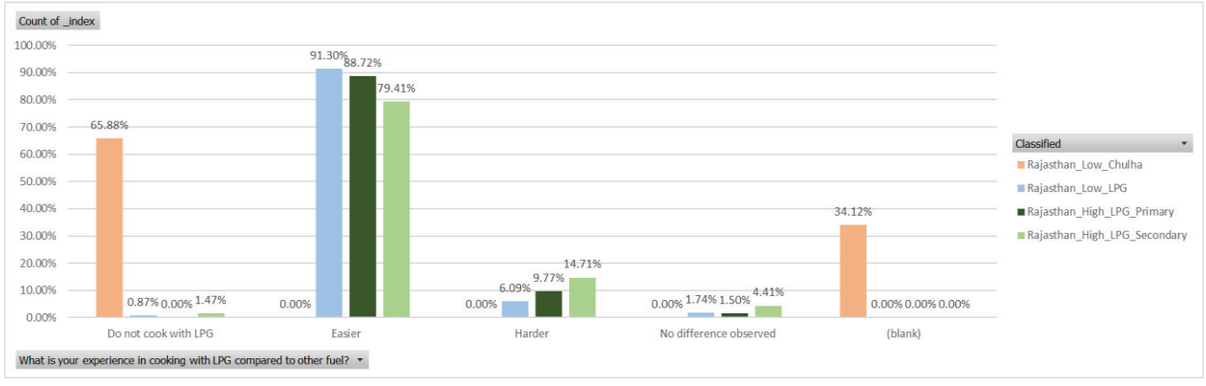


Figure 11: Survey responses for the question 'Is there any difference in cleaning of utensils since using LPG' in the State of Rajasthan for the classified categories.

Rajasthan Low LPG and Rajasthan High LPG Primary as well as secondary have reported ease in cleaning of utensils since using LPG.

Question 9: Has the usage of warm water changed since LPG connection (PMUY)?

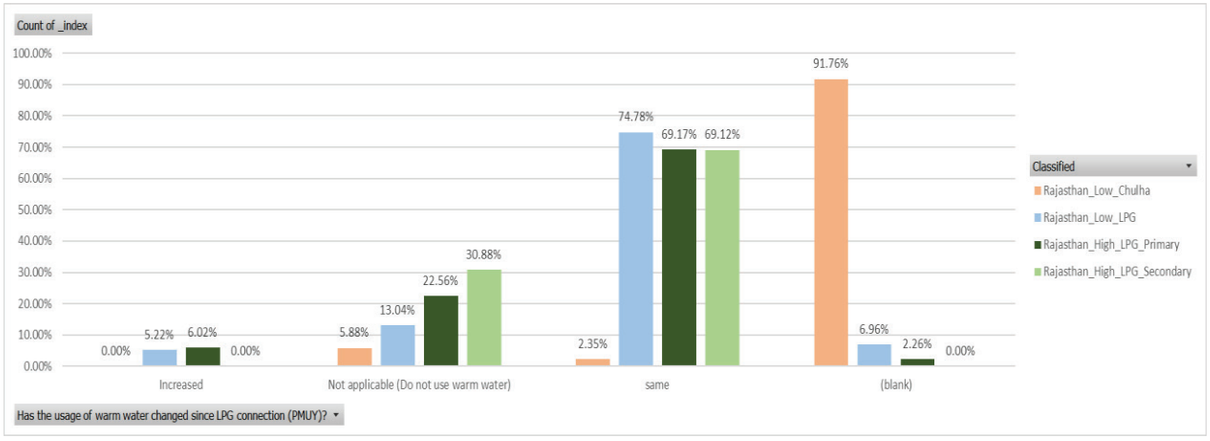


Figure 12: Survey responses for the question 'Has the usage of warm water changed since LPG connection (PMUY)' in the State of Rajasthan for the classified categories.

Only 5 – 6% of respondents from Rajasthan Low LPG and Rajasthan High LPG Primary has reported increase in usage of warm water since using LPG connection (PMUY).

Question 10: What is your experience in cooking with LPG compared to other fuel?

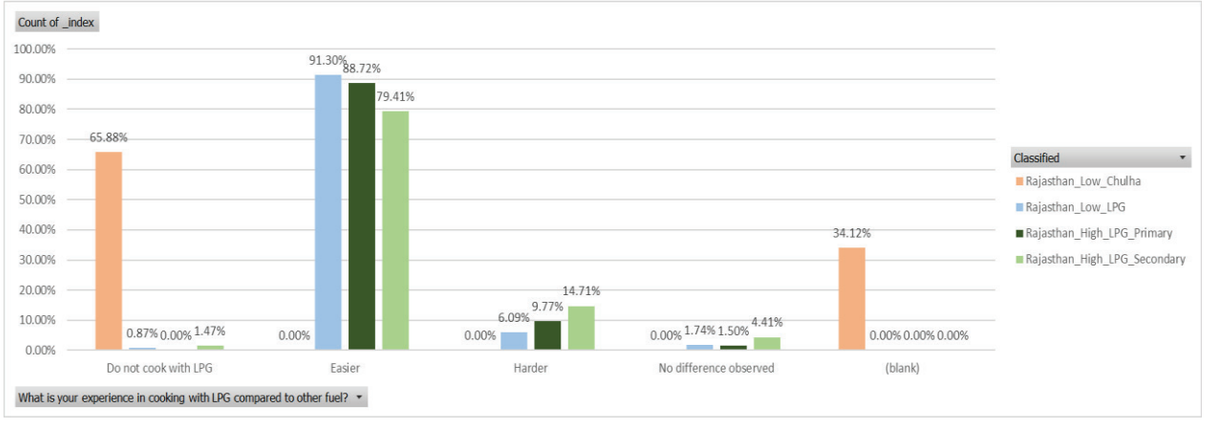


Figure 13: Survey responses for the question 'What is your experience in cooking with LPG compared to other fuel' in the State of Rajasthan for the classified categories.

Around 80% -90% of respondents from Rajasthan Low LPG and Rajasthan High LPG villages have experienced ease in cooking with LPG.

Out of Pocket Expenditure on care seeking

Question 11: Have the number of visits to doctors changed since the use of LPG?

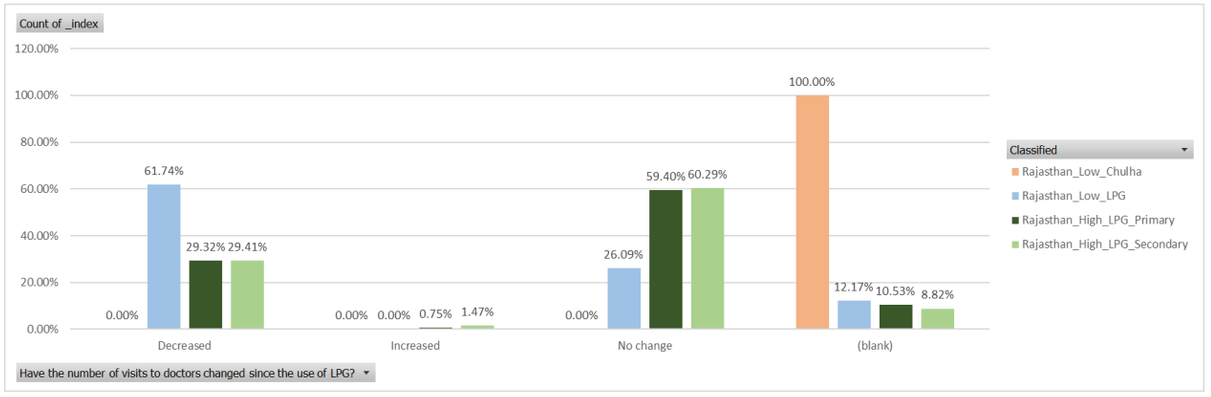


Figure 14: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG?' in the State of Rajasthan for the classified categories.

The out of pocket expenditure on care with respect to number of visits to doctors decreased around 30% to 60% for Rajasthan High LPG and Rajasthan Low LPG, respectively.

Analysis of Particulate Matter from the installed Low-Cost Sensors

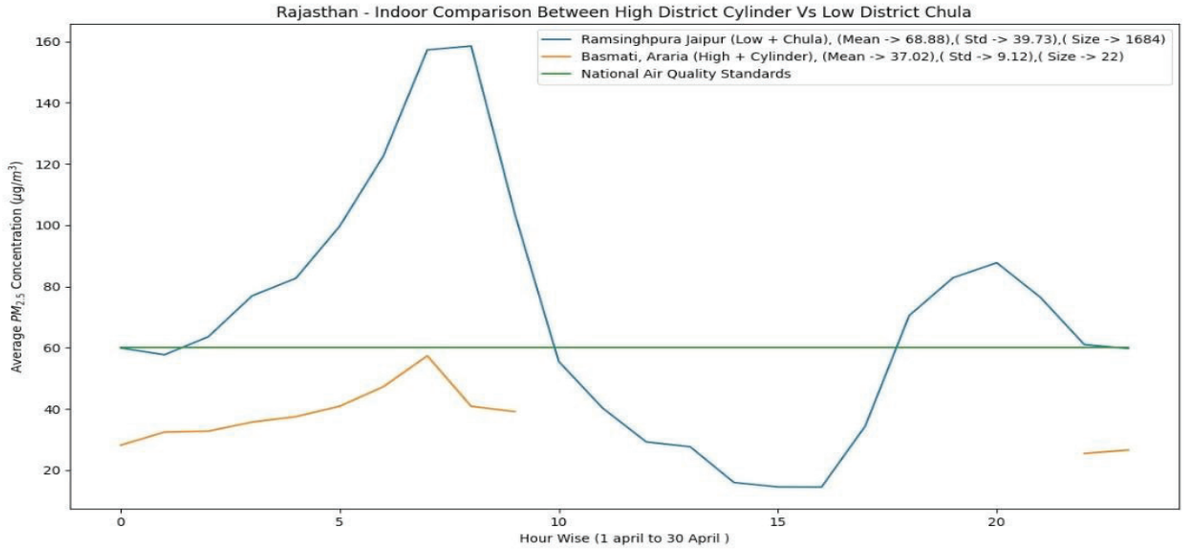


Figure 15: PM analysis from installed low-cost sensors in Rajasthan showing the comparison between High district cylinder vs low district chulha

The average concentrations of $PM_{2.5}$ in the studied high_LPG district was 37.02±9.12 µg/m^3 whereas it was 68.88±39.73 µg/m^3 in low_LPG district houses. It is worthwhile to note that the other factors such as the use of mosquito coils, heating elements, smoking and incense sticks burning in the studied houses has also contributed to the measured indoor PM2.5 concentrations. In Rajasthan, more than 10% of the studied houses in the high LPG primary category were close to the industry (Fig. 16). Moreover, around 80% of the respondents of high LPG primary category has reported the presence of smoking person in the house on daily basis (Fig. 18) and more than 30% households has reported use of incense sticks also (Fig. 17).

Question 12: Is the place of work at or close to any industry (Brick kiln, smelters, forging, foundry, fertilizer plant), power plants or expressways? [If clarification is required, please read out the list of 17 recognized industries given by CPCB].

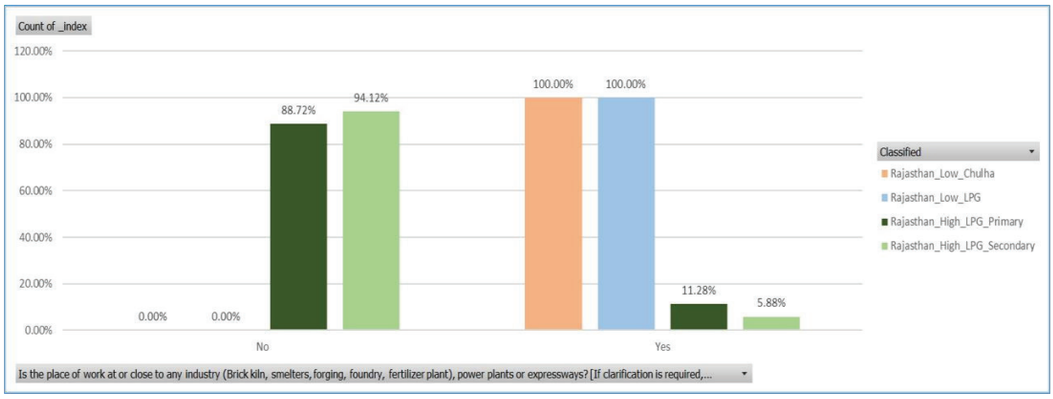


Figure 16: Survey responses for the question 'Is the place of work at or close to any industry (Brick kiln, smelters, forging, foundry, fertilizer plant), power plants or expressways?' in the State of Rajasthan for the classified categories.

Question 13: Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other.

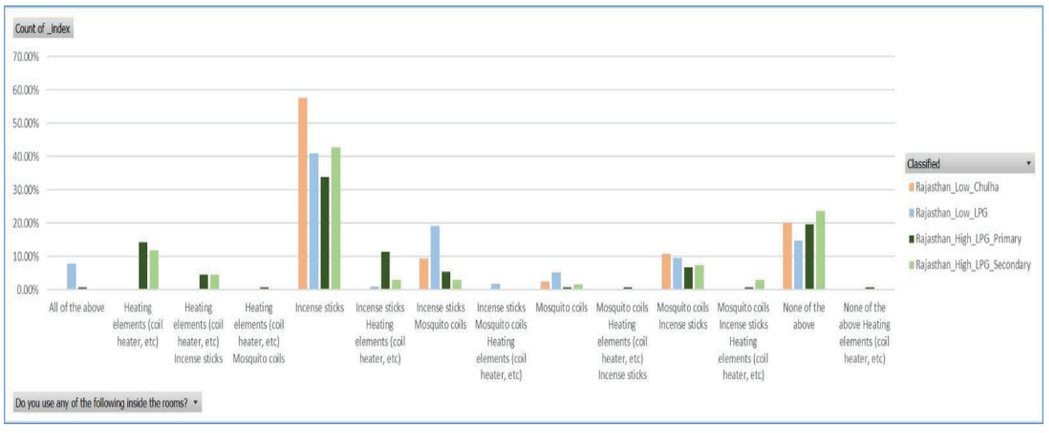


Figure 17: Survey responses for the question 'Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other' in the State of Rajasthan for the classified categories.

Question 14: Are there any smokers in the family (Bidi, cigarette, hookah)?

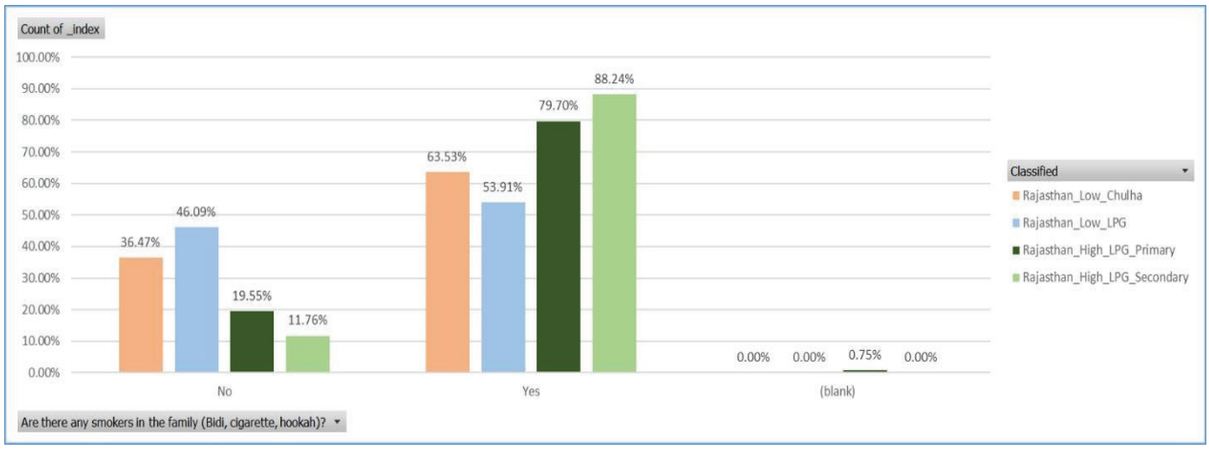


Figure 18: Survey responses for the question 'Are there any smokers in the family (Bidi, cigarette, hookah)?' in the State of Rajasthan for the classified categories.

Question 15: Is waste and crop burning common in the village?

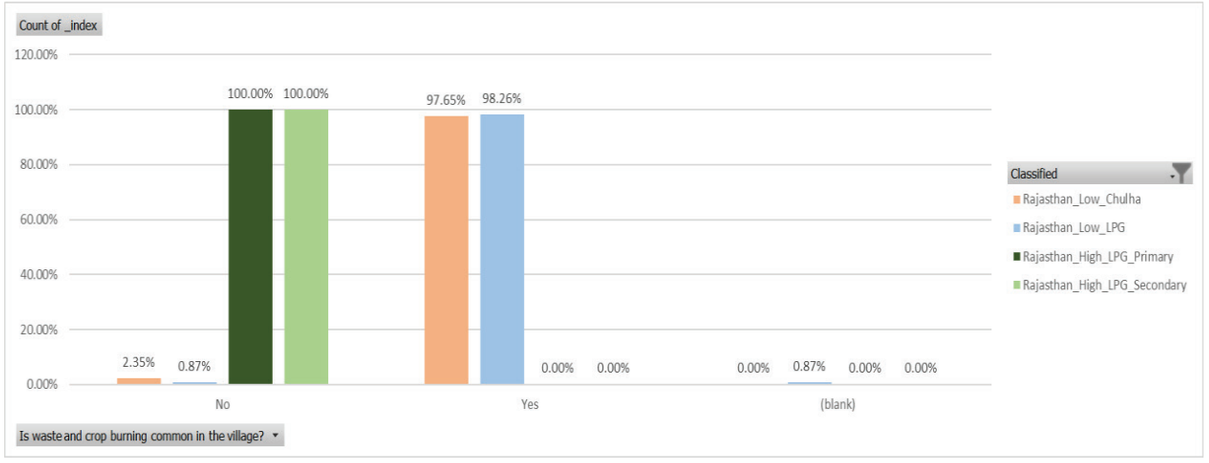


Figure 19: Survey responses for the question 'Is waste and crop burning common in the village?', in the State of Rajasthan for the classified categories.

Rajasthan High LPG primary and secondary were found free from waste and crop burning in the village.

b. Bihar

For the State of Bihar, a total number of 412 survey responses were obtained. Among these, 51% were from the village with high PMUY connections and 49% were from the village with low PMUY connectivity. From all the survey responders, 73.3% surveys were taken by the primary cooking person of the family, of which 98.06% were women of the household. 40% of the households had 4-5 family members and 32% had 6-7 family members. For 85% of the families, there was only one bread-earner in the family. Only 11% had two bread-earners. The detailed distributions for these figures are available in appendix A.

Based on the number of data and responses obtained, the survey households have been divided into four categories:

- High LPG Primary Village: The group of households from the high LPG connection village who use LPG as their primary cooking fuel.
- High LPG Secondary Village: The group of households from the high LPG connection village who use a combination of LPG and other cooking fuel.
- Low LPG Village: The group of households from the low LPG connection village who use LPG as their primary cooking fuel.
- Low Chulha Village: The group of households from the low LPG connection village who use chulha and solid fuel for cooking.

Health analysis: The questions considered for health analysis in Bihar are given below:

- Does anyone in the family have respiratory related health problem?
- How has the general health of the primary cooking person been affected post LPG (PMUY)?
- How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

Table 4: Classification of the survey responders in Bihar (The details of the type of cooking fuel and combinations for the villages is given in Appendix A)

Category	High LPG Primary Village	High LPG Secondary Village	Low LPG Village	Low Chulha Village
% Responders in this category	26.16	3.91	20.29	28.61

The details for each question and its responses are shown in the figures below.

Question 1: Does anyone in the family have respiratory related health problem?

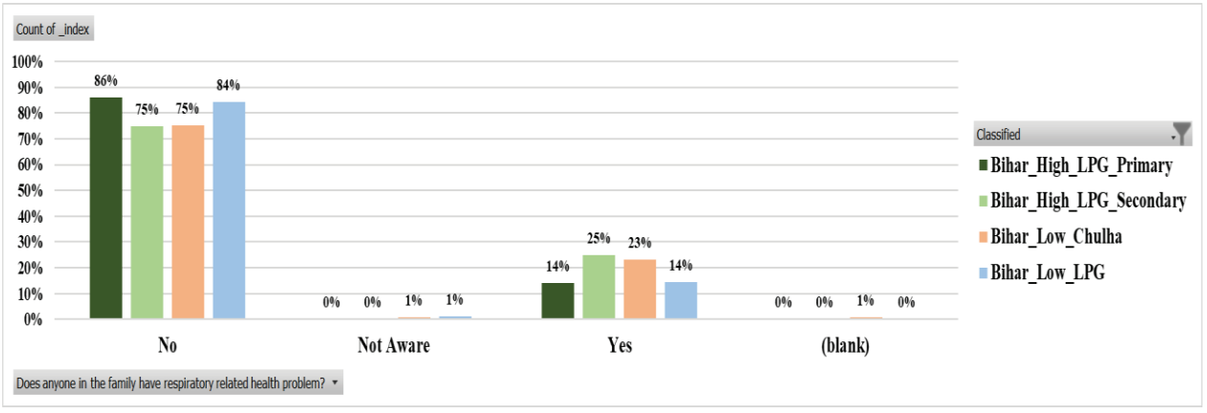


Figure 20: Survey responses for the question 'Does anyone in the family have respiratory related health problem', in the State of Bihar for the classified categories.

Categories Bihar low LPG and Bihar High LPG Primary have relatively less respiratory related health problem in the family.

Question 2: How has the general health of the primary cooking person been affected post LPG (PMUY)?

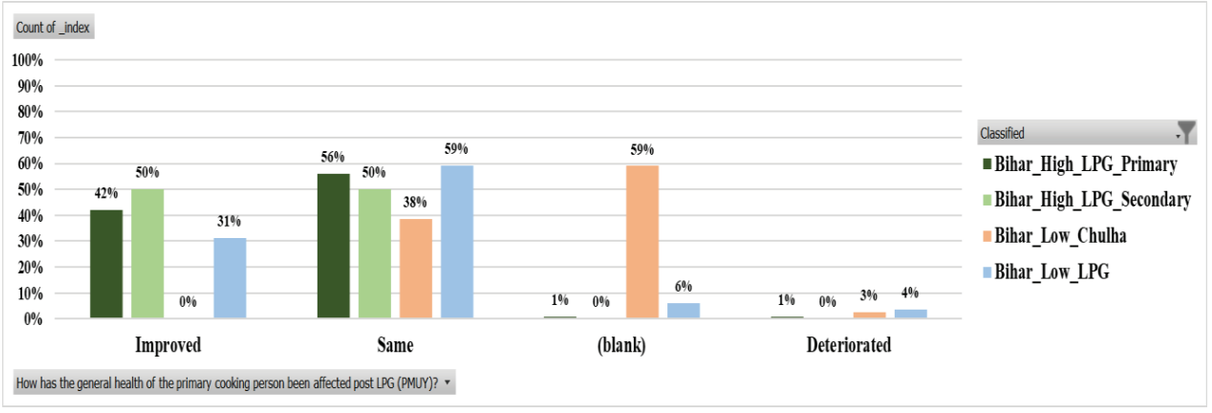


Figure 21: Survey responses for the question 'How has the general health of the primary cooking person been affected post LPG (PMUY)', in the State of Bihar for the classified categories.

General health of the primary cooking person post LPG has improved significantly for Bihar High LPG Primary & Secondary and Bihar Low LPG.

Question 3: How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel?

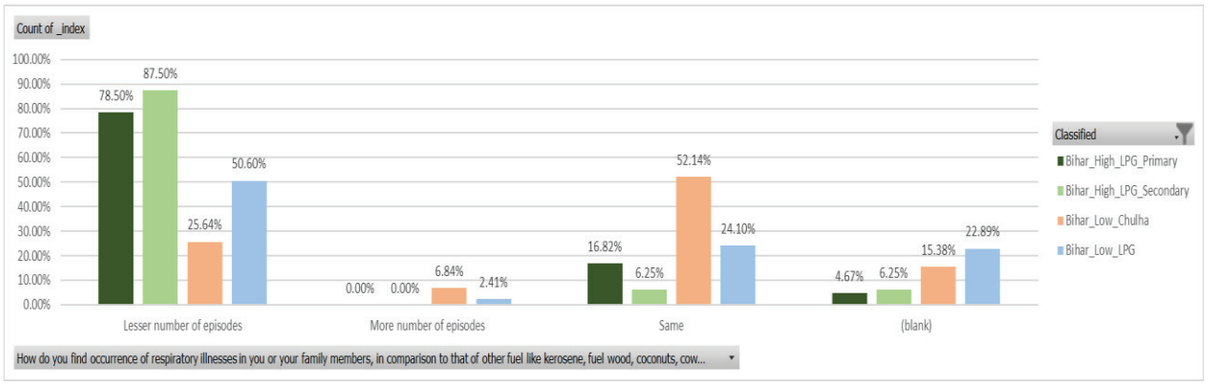


Figure 22: Survey responses for the question 'How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel', in the State of Bihar for the classified categories.

More than 52% of respondents belonging to Bihar Low Chulha category have same occurrence of respiratory illnesses.

Question 4: Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?

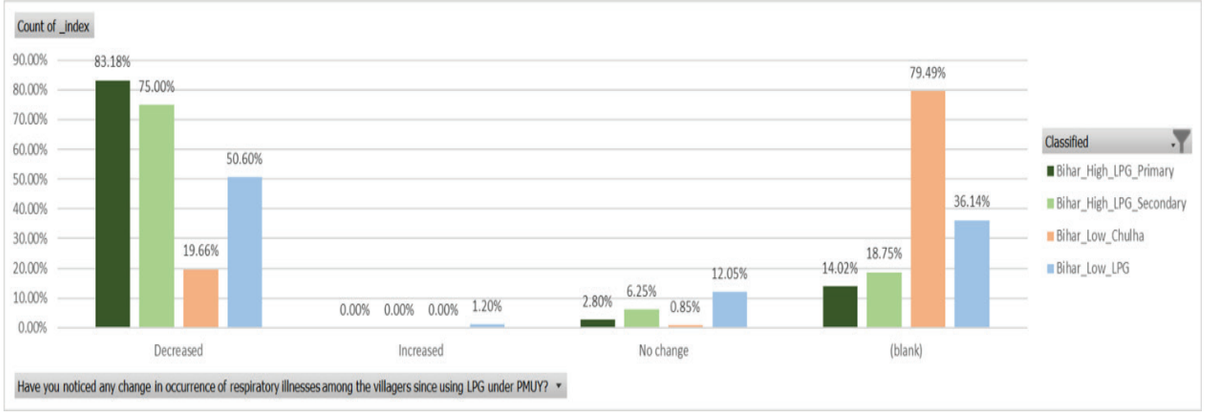


Figure 23: Survey responses for the question 'Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY ', in the State of Bihar for the classified categories.

More than 75% of respondents belonging to Bihar_High_LPG_Primary and Secondary category have shown significant (T-test statistics, $p<0.05$) decrease in occurrence of respiratory illnesses among villagers since using LPG.

Quality of life

Question 5: How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

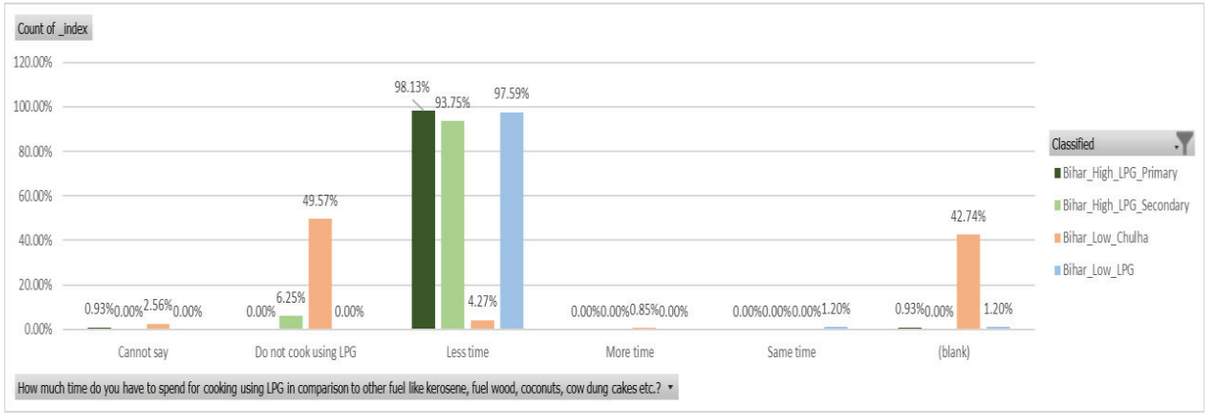


Figure 24: Survey responses for the question 'How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? ', in the State of Bihar for the classified categories.

The time for the cooking has reduced for Bihar Low LPG and Bihar High LPG Primary as well as secondary category households.

Question 6: Is there any difference in cleaning of utensils since using LPG?

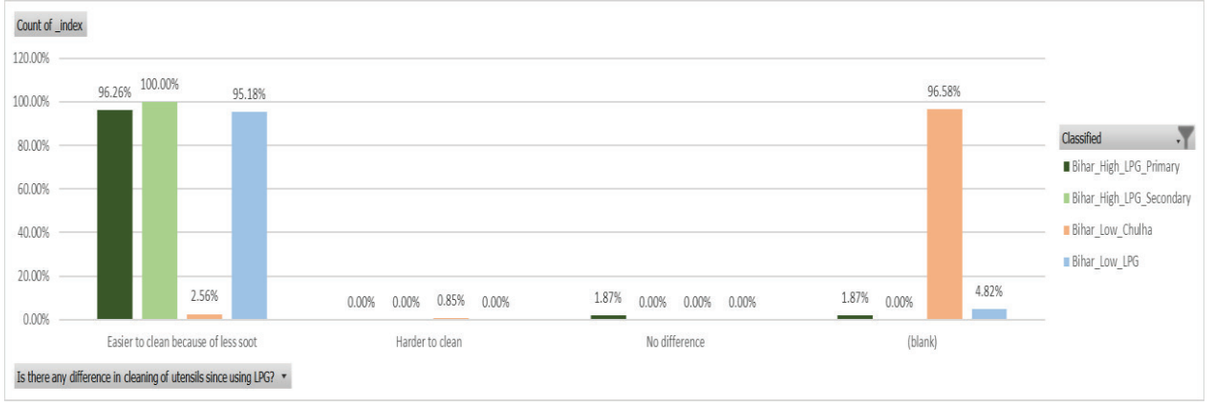


Figure 25: Survey responses for the question 'Is there any difference in cleaning of utensils since using LPG?', in the State of Bihar for the classified categories.

Bihar Low LPG and Bihar High LPG have reported ease in cleaning of utensils since using LPG.

Question 7: Has the usage of warm water changed since LPG connection (PMUY)?

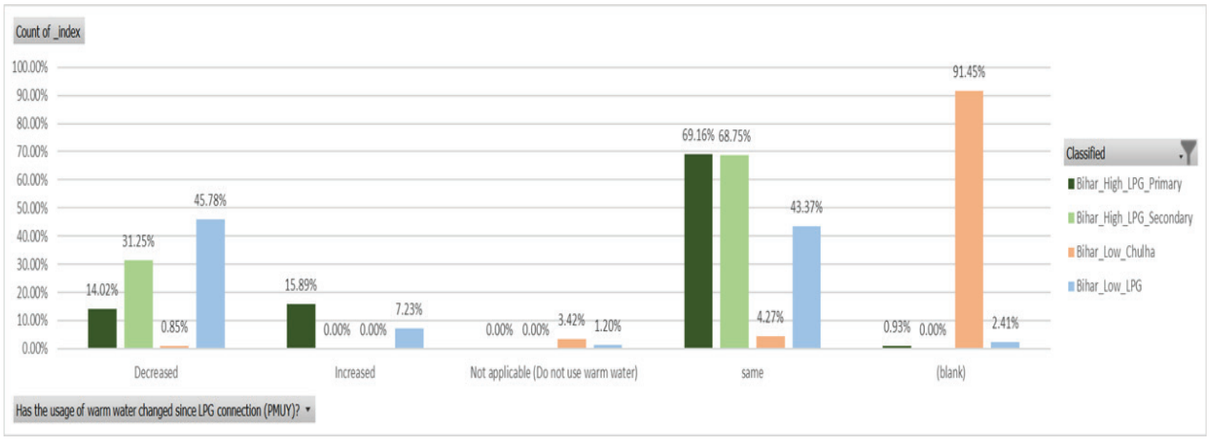


Figure 26: Survey responses for the question 'Has the usage of warm water changed since LPG connection (PMUY)?', in the State of Bihar for the classified categories.

Only 15 – 7% of respondents from Bihar High LPG Primary and Bihar Low LPG has reported increase in usage of warm water since using LPG connection (PMUY).

Question 8: What is your experience in cooking with LPG compared to other fuel?

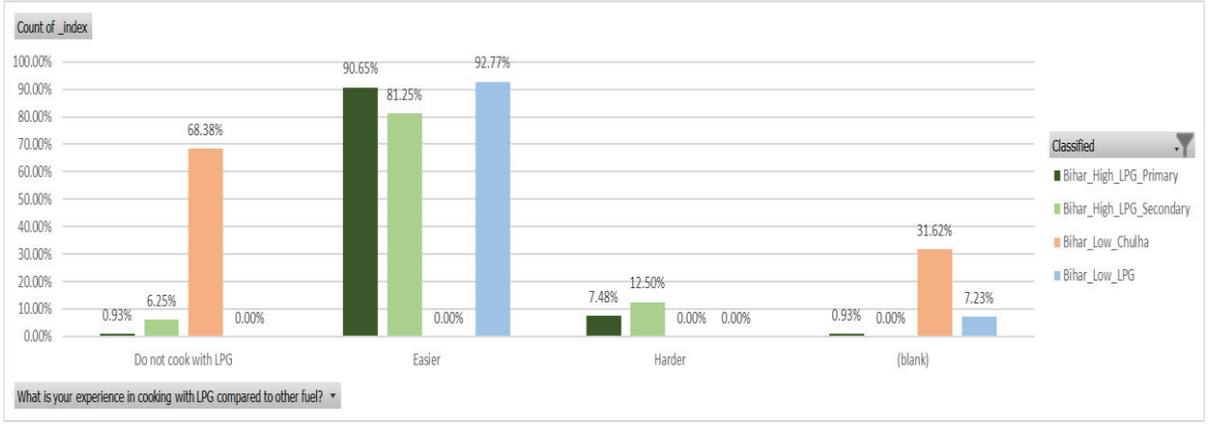


Figure 27: Survey responses for the question 'How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?', in the State of Bihar for the classified categories.

Around 80% -90% of respondents from Bihar High LPG and Bihar Low LPG villages have experienced ease in cooking with LPG.

Out of Pocket Expenditure on care seeking

Question 9: Have the number of visits to doctors changed since the use of LPG?

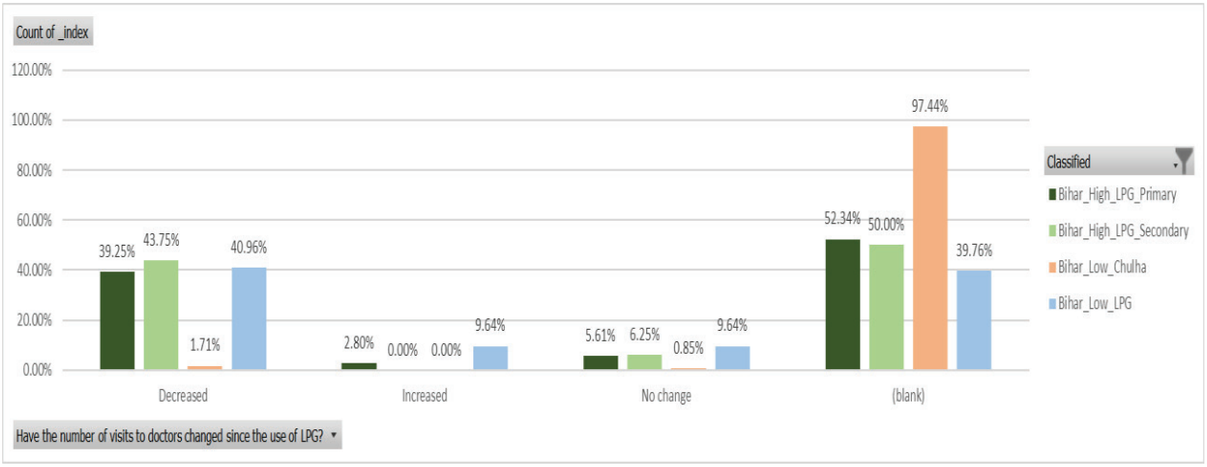


Figure 28: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG?', in the State of Bihar for the classified categories.

The out of pocket expenditure on care with respect to number of visits to doctors decreased around 40% for Bihar High LPG and Bihar Low LPG.

Analysis of Particulate Matter from the installed Low-Cost Sensors

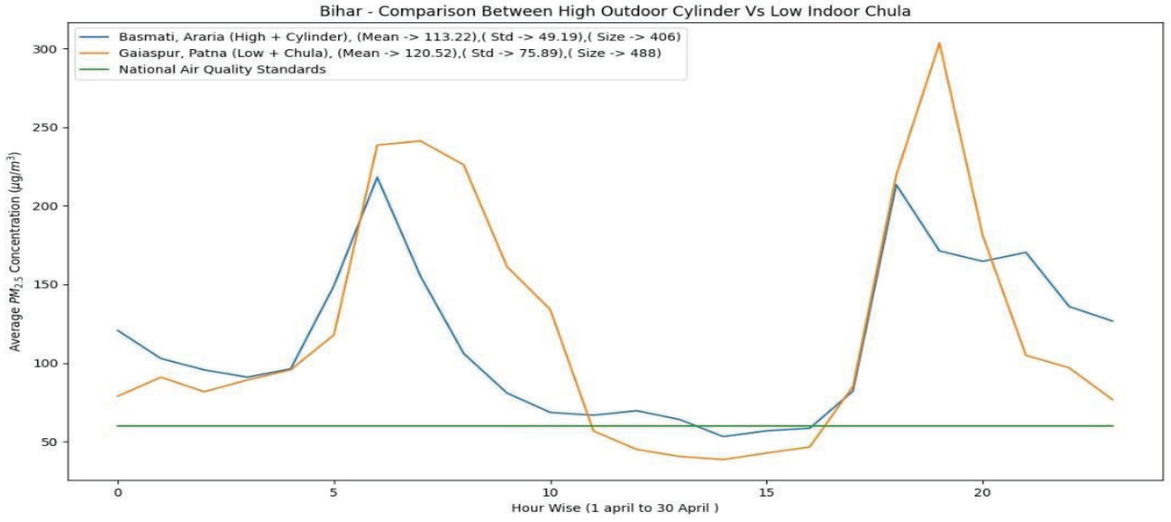


Figure 29: PM analysis from installed low-cost sensors in Bihar showing the comparison between High outdoor cylinder vs low indoor chulha.

The average concentrations of PM2.5 in the studied high_LPG district was 113.22±49.19 µg/ m^3 whereas it was 120.52±75.89 µg/ m^3 in low_LPG district houses. It is worthwhile to note that the other factors such as the use of mosquito coils, heating elements, smoking and incense sticks burning in the studied houses has also contributed to the measured indoor

PM2.5 concentrations. In Bihar, more than 95% of the studied houses in the low LPG category were close to the industry. Moreover, around 17.6% of the respondents of high LPG primary category has reported the presence of smoking person in the house on daily basis and more than 48% households has reported use of incense sticks also (Fig. 31). It was observed that the high _LPG primary and secondary village did not report any waste and residue burning while more than 90% of the respondent of low chulha and low LPG villages have responded positively for waste and residue burning.

Question 10: Is the place of work at or close to any industry (Brick kiln, smelters, forging, foundry, fertilizer plant), power plants or expressways? [If clarification is required, please read out the list of 17 recognized industries given by CPCB].

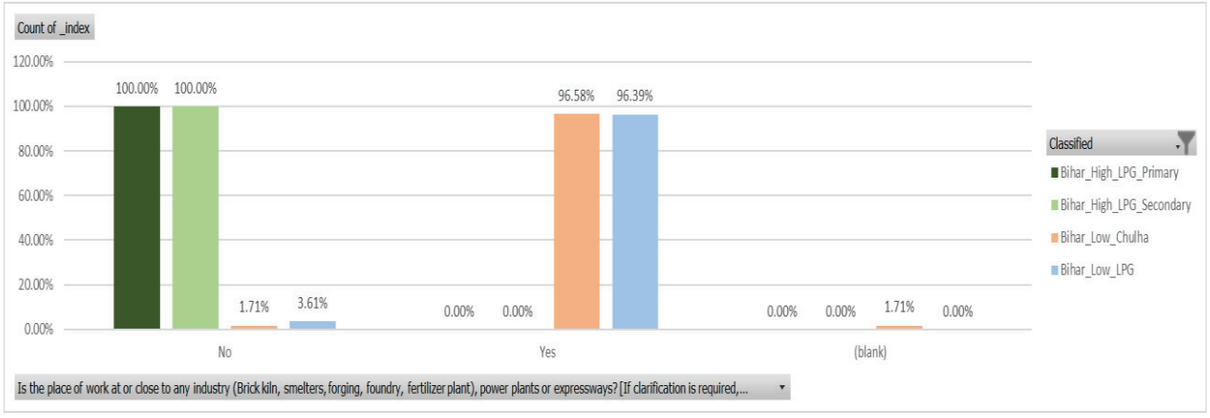


Figure 30: Survey responses for the question 'Is the place of work at or close to any industry (Brick kiln, smelters, forging, foundry, fertilizer plant), power plants or expressways?', in the State of Bihar for the classified categories.

Question 11: Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other.

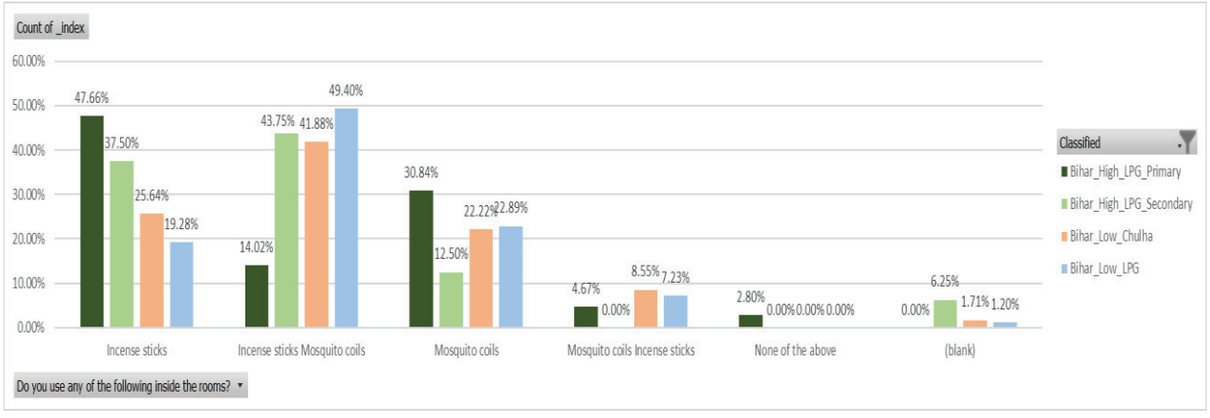


Figure 31: Survey responses for the question 'Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other, in the State of Bihar for the classified categories.

Question 12: Are there any smokers in the family (Bidi, cigarette, hookah)?

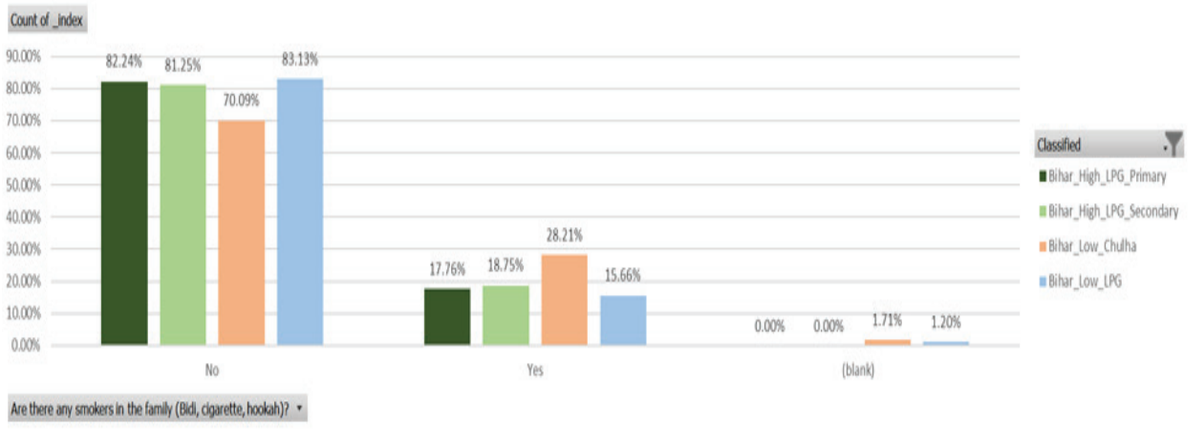


Figure 32: Survey responses for the question 'Are there any smokers in the family (Bidi, cigarette, hookah)?', in the State of Bihar for the classified categories.

Question 13: Is waste and crop burning common in the village?

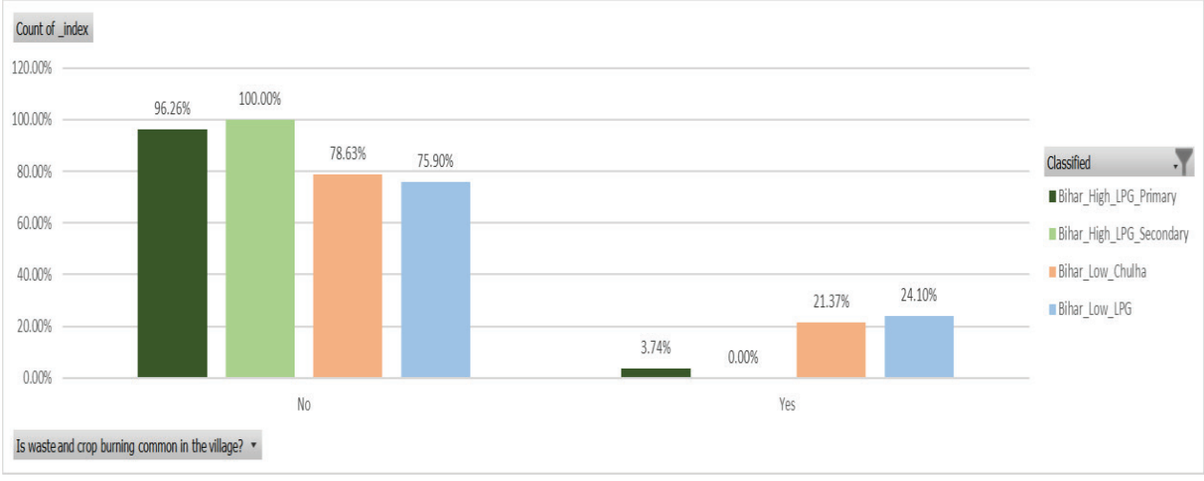


Figure 33: Survey responses for the question 'Is waste and crop burning common in the village?', in the State of Bihar for the classified categories.

Bihar High LPG primary and secondary were found free from waste and crop burning in the village.

c. Uttar Pradesh

For the State of Uttar Pradesh, a total number of 405 survey responses were obtained. Among these, 50.6% were from the village with high PMUY connections and 49.4% were from the village with low PMUY connectivity. From all the survey responders, 47.41% surveys were taken by the primary cooking person of the family, of which 100% were women of the household. 34% of the households had 4-5 family members and 27% had 6-7 family members. For 77% of the families, there was only one bread-earner in the family. Only 20% had two bread-earners. The detailed distributions for these figures are available in appendix A.

Based on the number of data and responses obtained, the survey households have been divided into four categories:

- High LPG Primary Village: The group of households from the high LPG connection village who use LPG as their primary cooking fuel.
- High LPG Secondary Village: The group of households from the high LPG connection village who use a combination of LPG and other cooking fuel.
- Low LPG Chulha Village: The group of households from the low LPG connection village who use combination of LPG and challah as their primary cooking.
- Low Chulha Village: The group of households from the low LPG connection village who use chulha and solid fuel for cooking.

Health analysis: The questions considered for health analysis in Uttar Pradesh are given below:

- Does anyone in the family have respiratory related health problem?
- How has the general health of the primary cooking person been affected post LPG (PMUY)?
- How has the general health of other people in the home been affected post LPG (PMUY)?
- Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?

Table 5: Classification of the survey responders in Uttar Pradesh (The details of the type of cooking fuel and combinations for the villages is given in Appendix A)

Category	High LPG Primary Village	High LPG Secondary Village	Low LPG Village	Low Chulha Village
% Responders in this category	47.16	3.46	42.96	6.42

The details for each question and its responses are shown in the figures below.

Question 1: Does anyone in the family have respiratory related health problem?

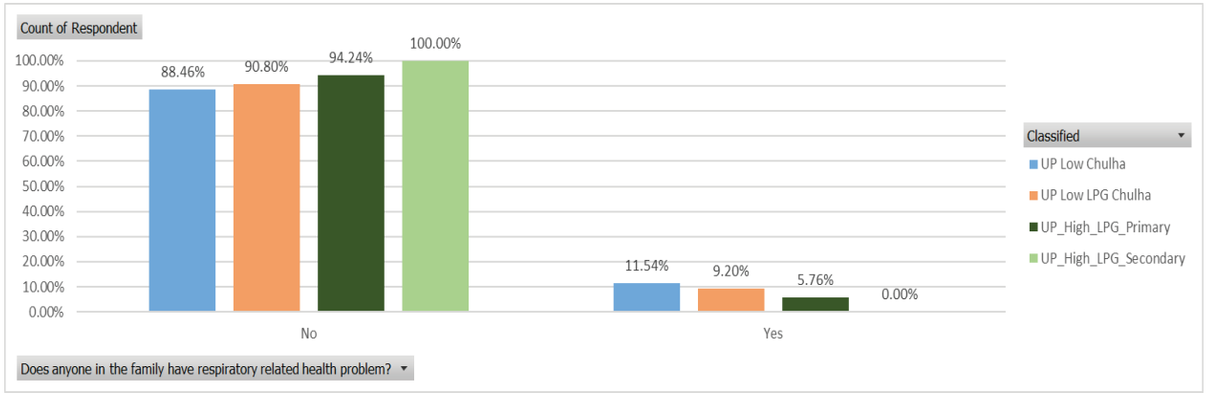


Figure 34: Survey responses for the question 'Does anyone in the family have respiratory related health problem', in the State of Uttar Pradesh for the classified categories.

UP Low Chulha shows higher percent of respiratory related health problem in the family.

Question 2: How has the general health of the primary cooking person been affected post LPG (PMUY)?

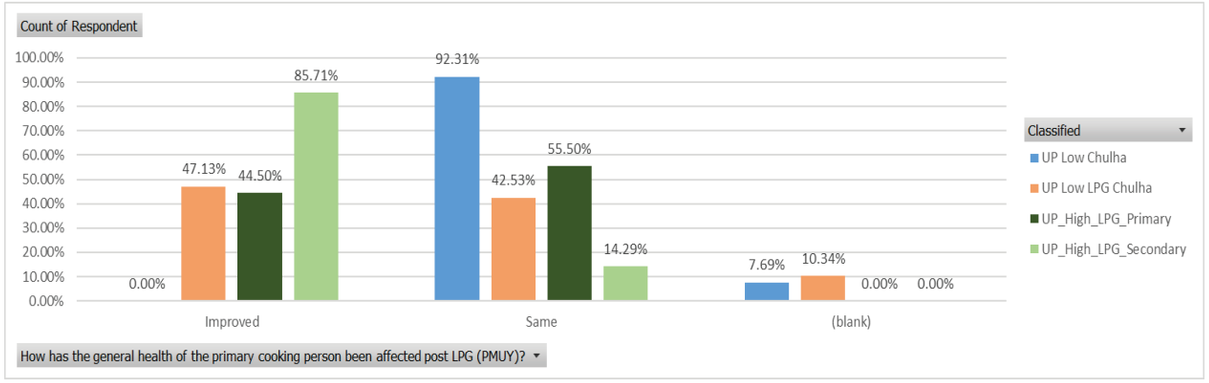


Figure 35: Survey responses for the question 'How has the general health of the primary cooking person been affected post LPG (PMUY)', in the State of Uttar Pradesh for the classified categories.

UP Low Chulha shows no improvement related to general health of the primary cooking person post LPG.

Question 3: How has the general health of other people in the home been affected post LPG (PMUY)?

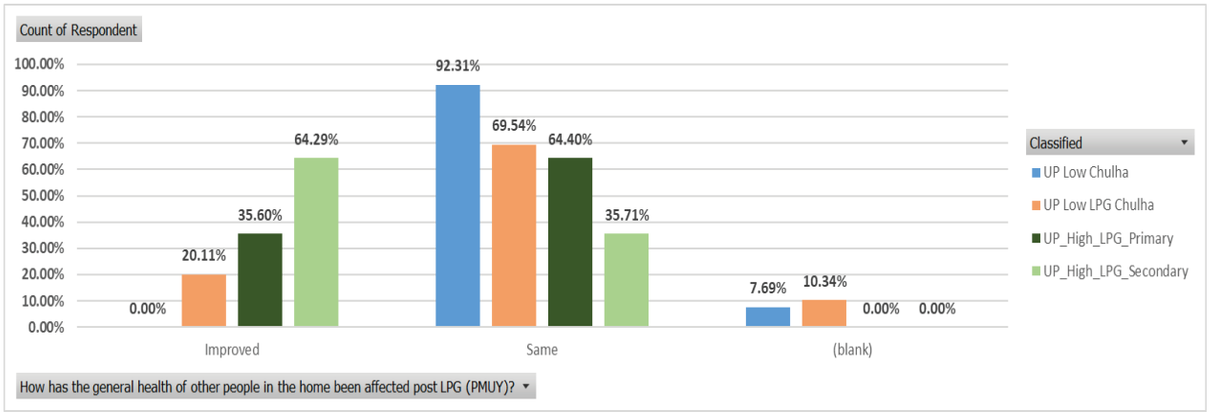


Figure 36: Survey responses for the question 'How has the general health of other people in the home been affected post LPG (PMUY)', in the State of Uttar Pradesh for the classified categories.

UP Low Chulha shows no improvement related to general health of other people in the home post LPG.

Question 4: Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?

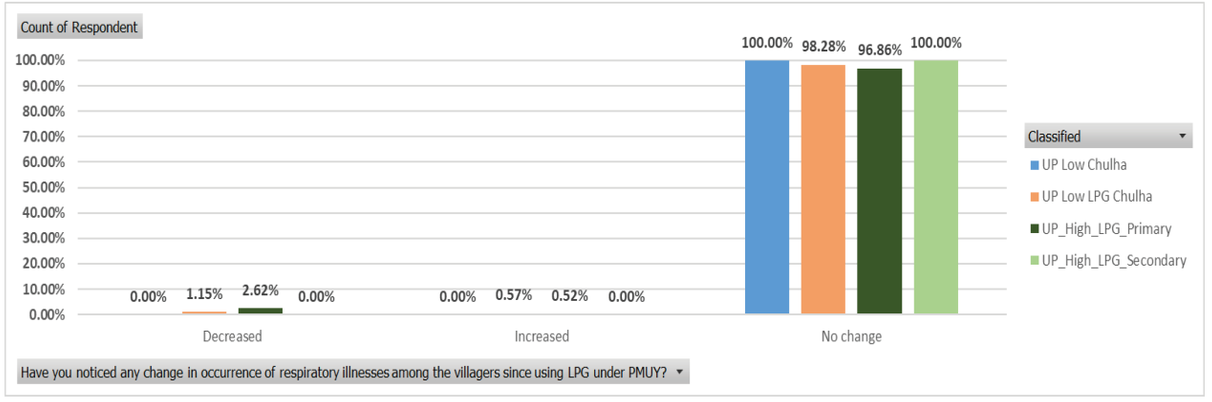


Figure 37: Survey responses for the question 'Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY', in the State of Uttar Pradesh for the classified categories.

All categories of respondents reported no change in the occurrence of respiratory illnesses among the villagers.

Question 5: How do you find occurrences of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems)

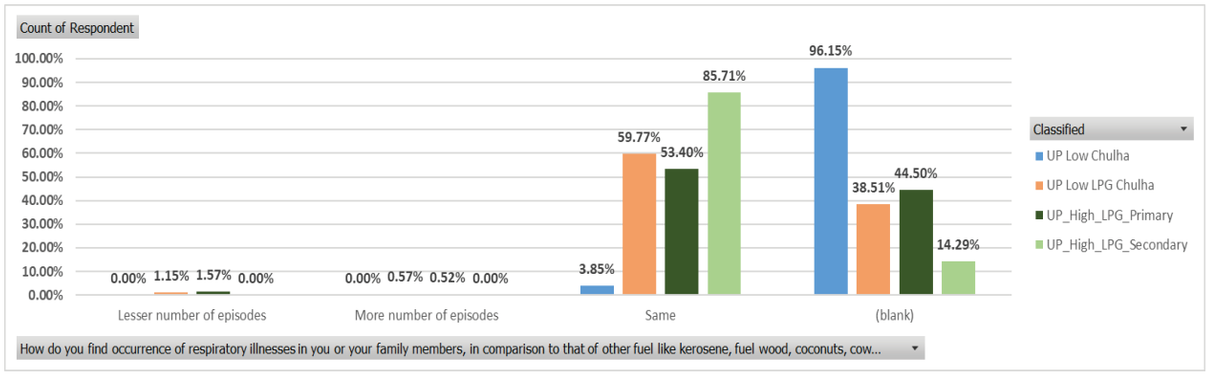


Figure 38: Survey responses for the question 'How do you find occurrences of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?', in the State of Uttar Pradesh for the classified categories.

More than 59% of respondents belonging to UP Low LPG category have same occurrence of respiratory illnesses. While around 1.5% of respondents belonging to UP high LPG primary have shown lesser occurrence of respiratory illness in studied households.

Quality of life

Question 6: How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

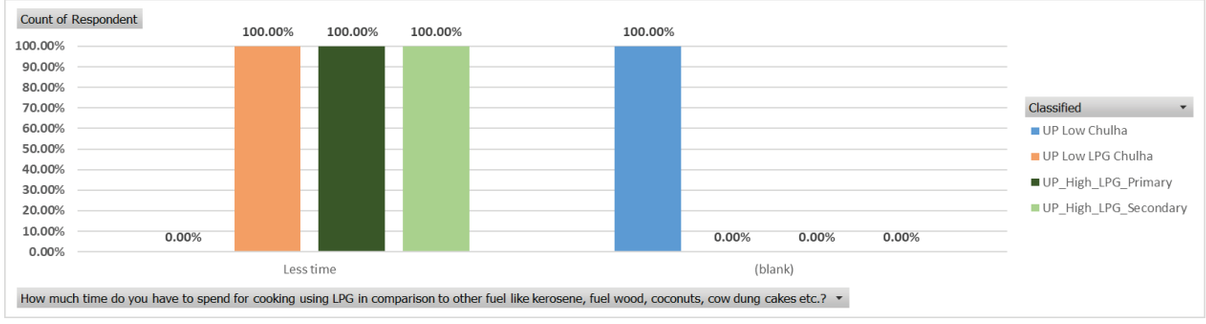


Figure 39: Survey responses for the question 'How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?', in the State of Uttar Pradesh for the classified categories.

The time for the cooking has reduced for Uttar Pradesh Low LPG and High LPG Primary as well as secondary category households.

Question 7: Is there any difference in cleaning of utensils since using LPG?

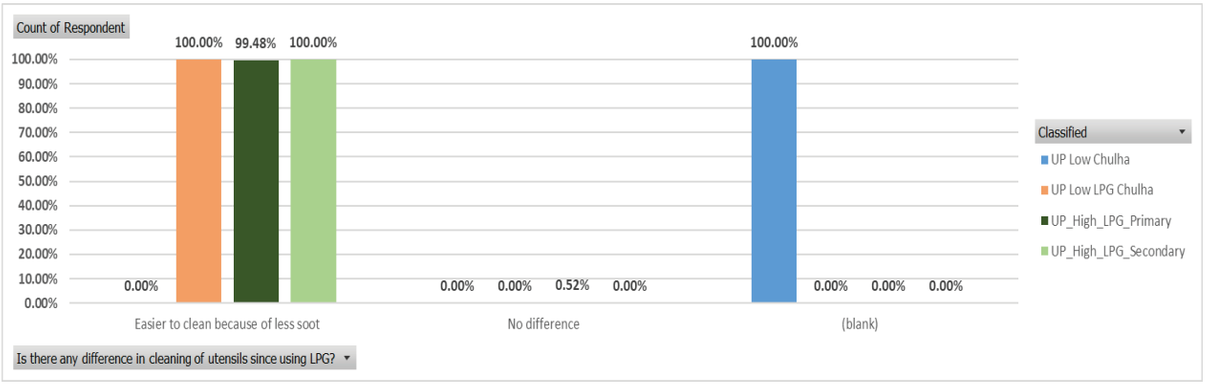


Figure 40: Survey responses for the question 'Is there any difference in cleaning of utensils since using LPG?', in the State of Uttar Pradesh for the classified categories.

Uttar Pradesh Low LPG and High LPG Primary as well as secondary have reported ease in cleaning of utensils since using LPG.

Question 8: Has the usage of warm water changed since LPG connection (PMUY)?

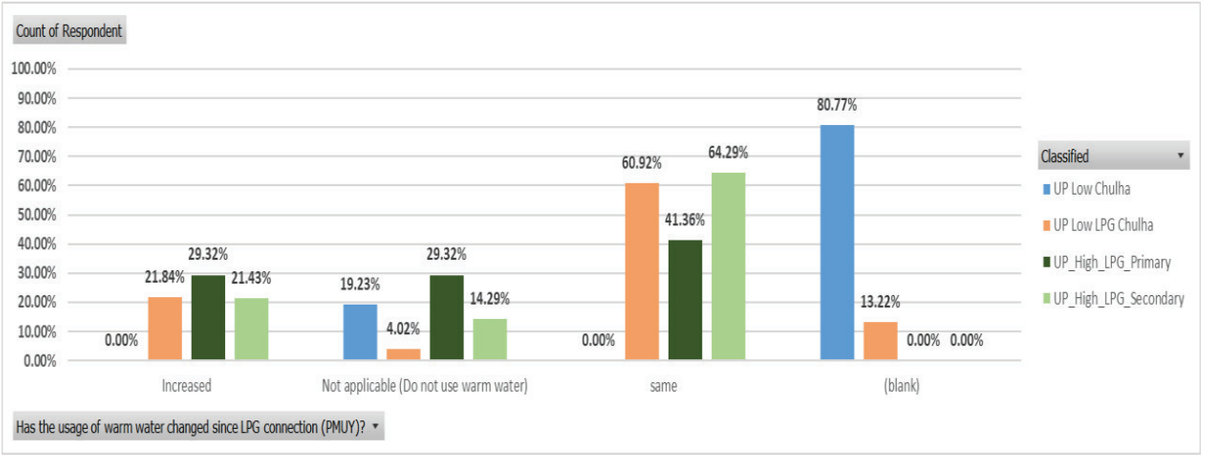


Figure 41: Survey responses for the question 'Has the usage of warm water changed since LPG connection (PMUY)?', in the State of Uttar Pradesh for the classified categories.

More than 20% of respondents from Uttar Pradesh Low LPG and High LPG Primary has reported increase in usage of warm water since using LPG connection (PMUY).

Question 9: What is your experience in cooking with LPG compared to other fuel?

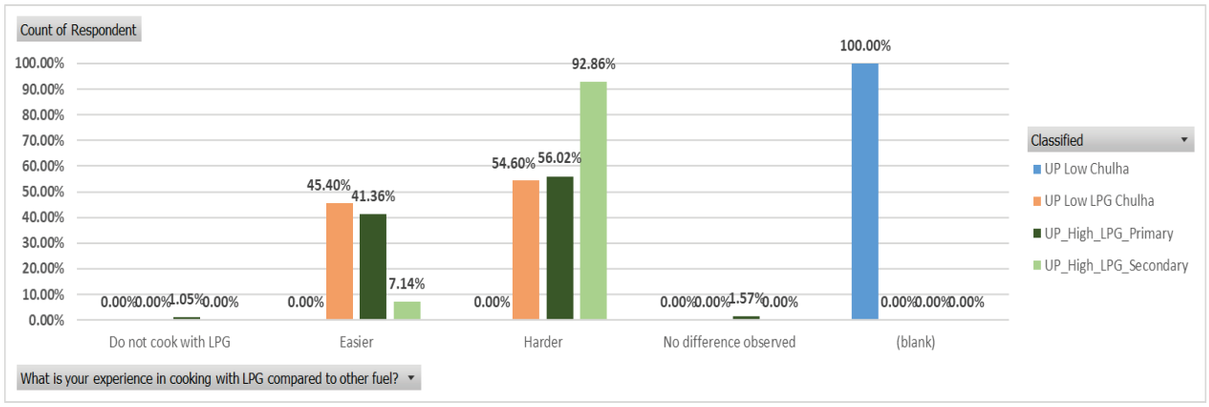


Figure 42: Survey responses for the question 'What is your experience in cooking with LPG compared to other fuel?', in the State of Uttar Pradesh for the classified categories

More than 40% of respondents from Uttar Pradesh Low LPG and High LPG villages have experienced ease in cooking with LPG.

Out of Pocket Expenditure on care seeking

Question 10: Have the number of visits to doctors changed since the use of LPG?

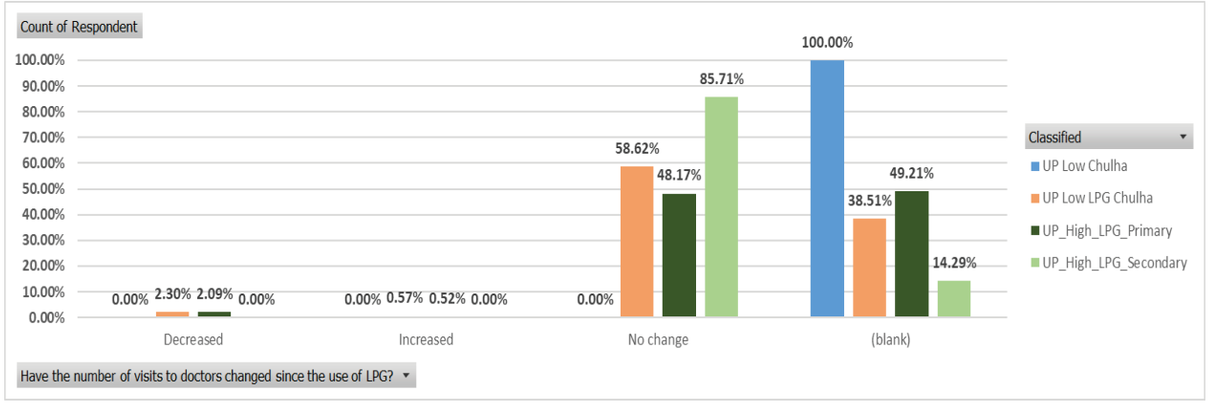


Figure 43: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG?', in the State of Uttar Pradesh for the classified categories.

Around 2% respondents from Uttar Pradesh High LPG and Uttar Pradesh Low LPG villages have reported decrease in out-of-pocket expenditure on care with respect to number of visits to doctors.

Analysis of Particulate Matter from the installed Low Cost Sensors

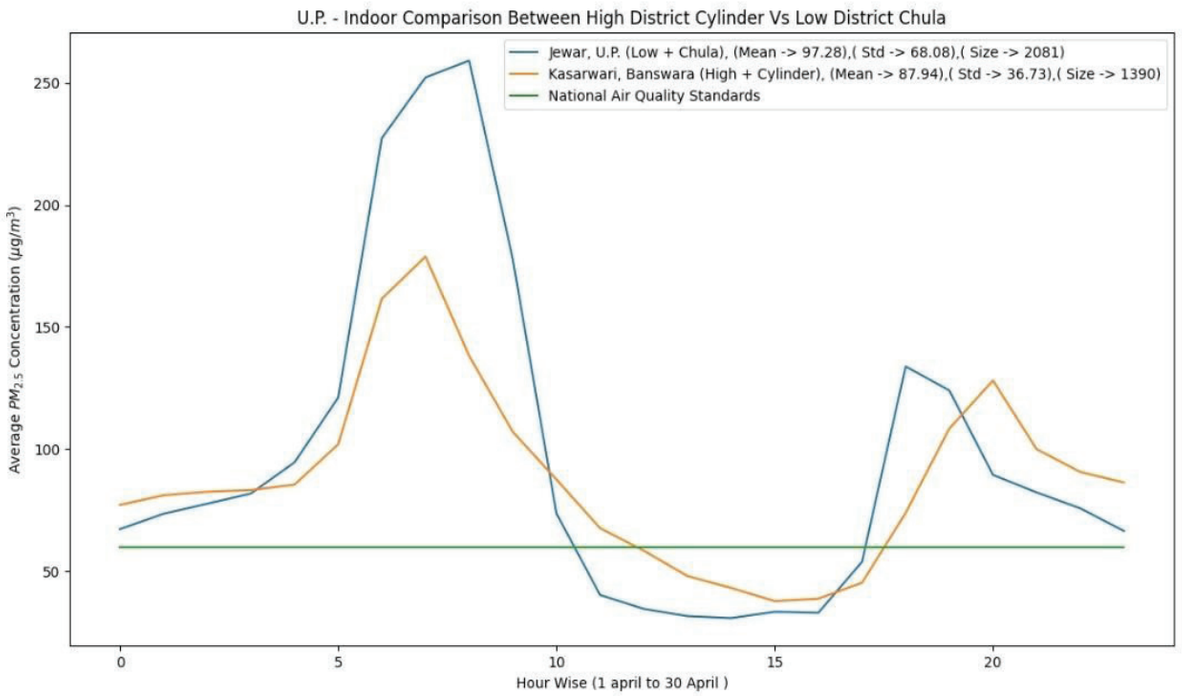


Figure 44: PM analysis from installed low-cost sensors in Uttar Pradesh showing the comparison between High indoor cylinder vs low indoor chulha.

The average concentrations of $PM_{2.5}$ in the studied high_LPG district was 87.94±36.73 µg/ m^3 whereas it was 97.28±68.08 µg/ m^3 in low_LPG district houses. It is worthwhile to note that other factors such as the use of mosquito coils, heating elements, smoking and incense sticks burning in the studied houses has also contributed to the measured indoor PM2.5 concentrations. In Uttar Pradesh, more than 57% of the studied houses in the high LPG secondary category were close to the industry. Moreover, around 23% of the respondents of high LPG primary category has reported the presence of smoker in the house on daily basis and more than 53% households has reported use of incense sticks (Fig. 46).

Question 11: Is the place of work at or close to any industry (Brick kiln, smelters, forging, foundry, fertilizer plant), power plants or expressways?

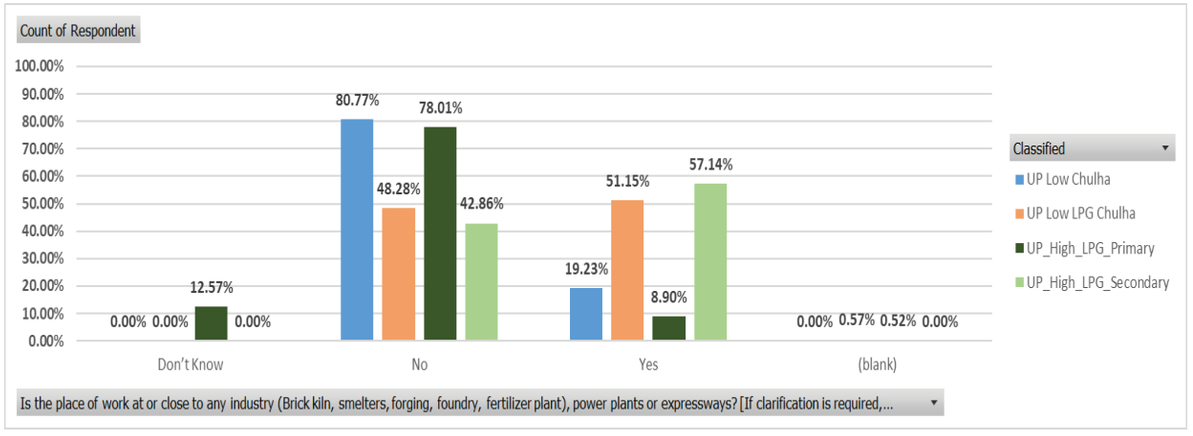


Figure 45: Survey responses for the question 'Is the place of work at or close to any industry (Brick kiln, smelters, forging, foundry, fertilizer plant), power plants or expressways?', in the State of Uttar Pradesh for the classified categories.

Question 12: Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other.

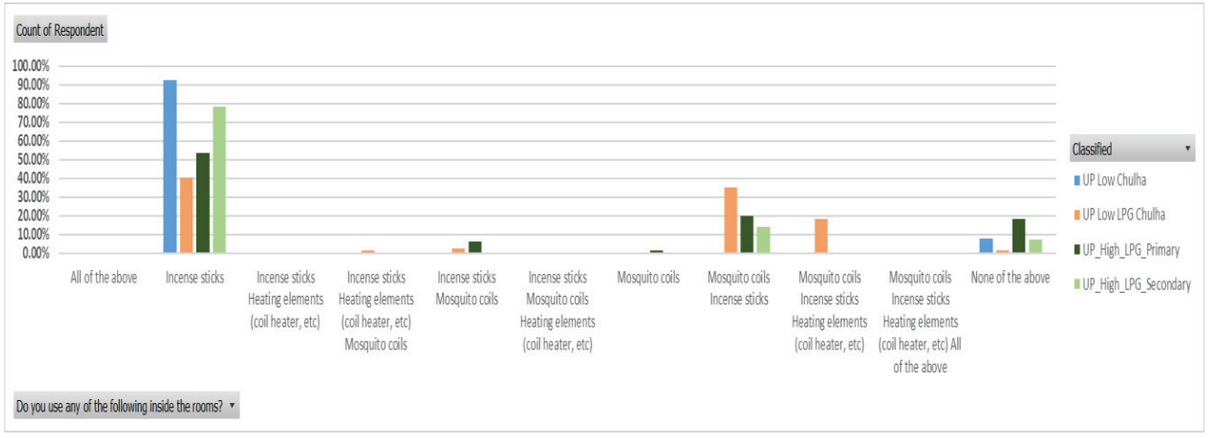


Figure 46: Survey responses for the question 'Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other', in the State of Uttar Pradesh for the classified categories.

Question 13: Are there any smokers in the family (Bidi, cigarette, hookah)?

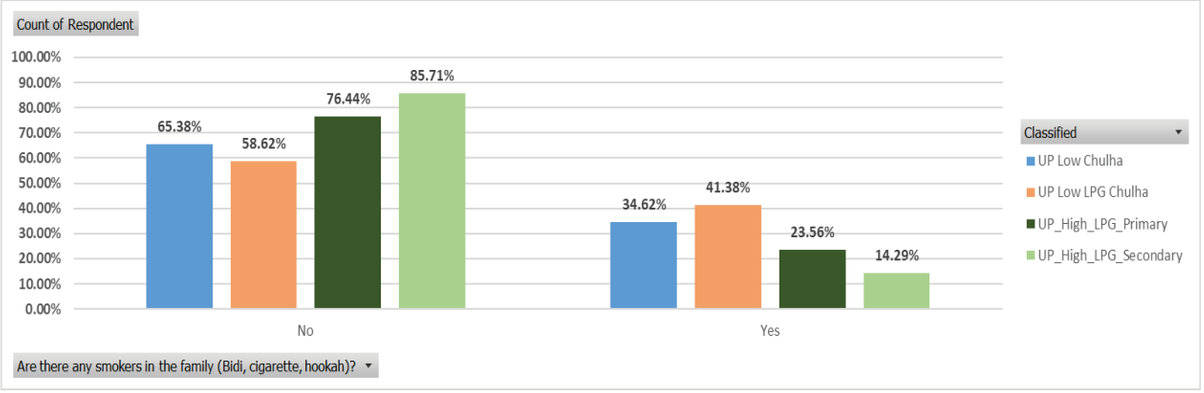


Figure 47: Survey responses for the question 'Are there any smokers in the family (Bidi, cigarette, hookah)?', in the State of Uttar Pradesh for the classified categories.

Question 14: Is waste and crop burning common in the village?

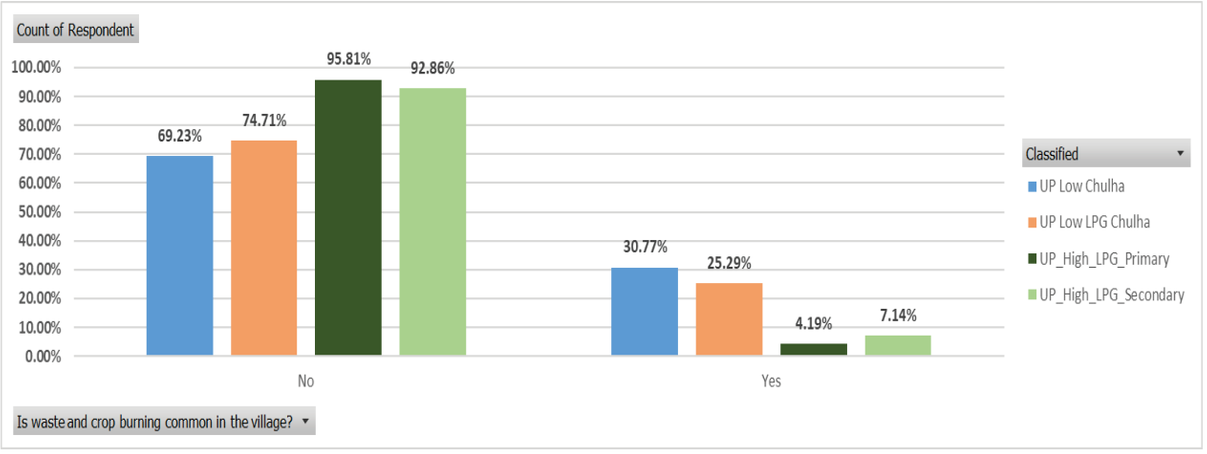


Figure 48: Survey responses for the question 'Is waste and crop burning common in the village?', in the State of Uttar Pradesh for the classified categories.

d. Jharkhand

For the State of Jharkhand, a total number of 402 survey responses were obtained. Among these, 50.2% were from the village with high PMUY connections and 49.8% were from the village with low PMUY connectivity. From all the survey responders, 40.30% surveys were taken by the primary cooking person of the family, of which 99% were women of the household. 43% of the households had 4-5 family members and 27% had 6-7 family members. For 48.23% of the families, there was only one bread-earner in the family. Only 37.81% had two bread-earners. The detailed distributions for these figures are available in appendix A.

Based on the number of data and responses obtained, the survey households have been divided into four categories:

- High LPG Primary Village: The group of households from the high LPG connection village who use LPG as their primary cooking fuel.
- High LPG Secondary Village: The group of households from the high LPG connection village who use a combination of LPG and other cooking fuel.
- Low LPG Village: The group of households from the low LPG connection village who use LPG as their primary cooking fuel.
- Low Chulha Village: The group of households from the low LPG connection village who use chulha and solid fuel for cooking.

Health analysis: The questions considered for health analysis in Jharkhand are given below:

- Does anyone in the family have respiratory related health problem?
- How has the general health of the primary cooking person been affected post LPG (PMUY)?
- How has the general health of other people in the home been affected post LPG (PMUY)?
- Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?
- Have the number of visits to doctors changed since the use of LPG?
- How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months? Please enter number
- How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

Table 6: Classification of the survey responders in Jharkhand (The details of the type of cooking fuel and combinations for the villages are given in Appendix A)

Category	High LPG Primary Village	High LPG Secondary Village	Low LPG Village	Low Chulha Village
% Responders in this category	47.12	1.50	20.29	8.77

The details for each question and its responses are shown in the figures below.

Question 1: Does anyone in the family have respiratory related health problem?

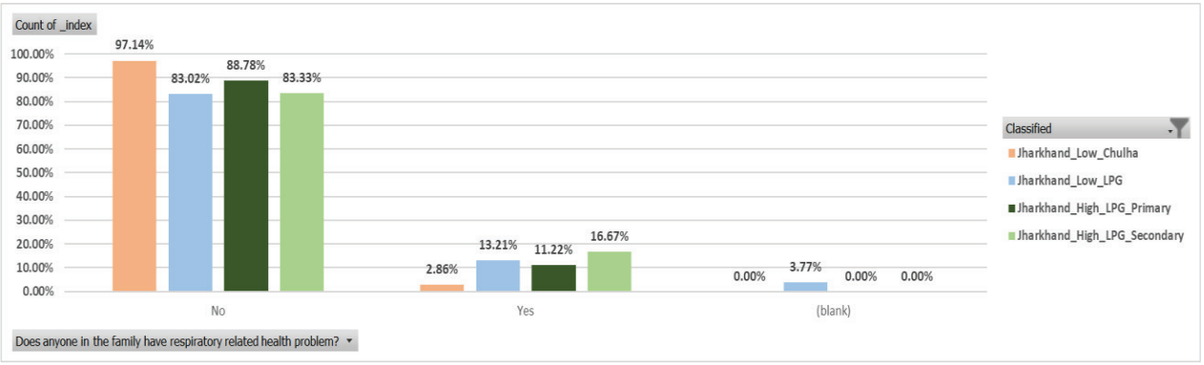


Figure 49: Survey responses for the question 'Does anyone in the family have respiratory related health problem', in the State of Jharkhand for the classified categories.

More than 80% of responses for all the categories show no respiratory health related problem.

Question 2: How has the general health of the primary cooking person been affected post LPG (PMUY)?

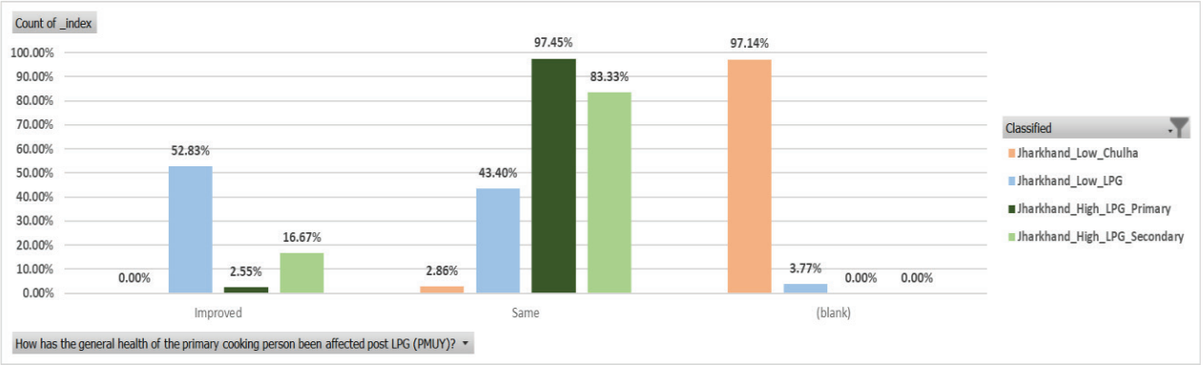


Figure 50: Survey responses for the question 'How has the general health of the primary cooking person been affected post LPG (PMUY)', in the State of Jharkhand for the classified categories.

General health of the primary cooking person has improved for Jharkhand Low LPG and Jharkhand Low LPG Chulha.

Question 3: How has the general health of other people in the home been affected post LPG (PMUY)?

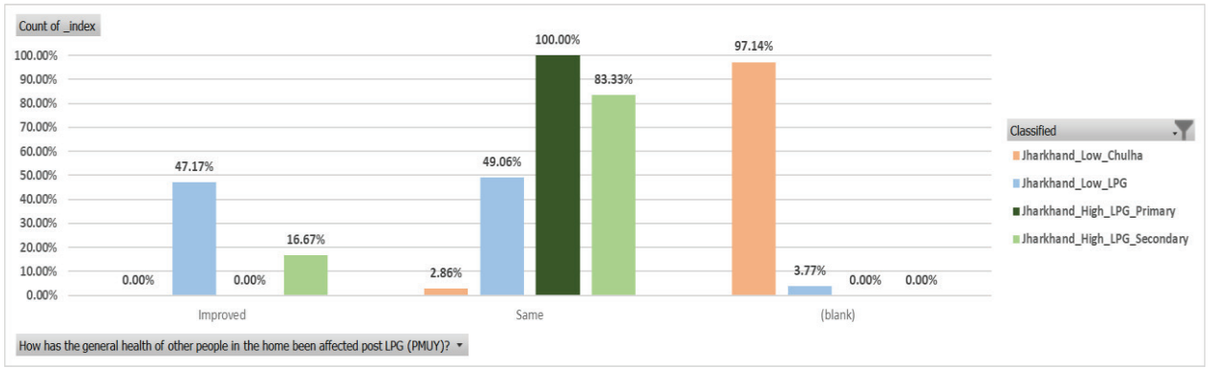


Figure 51: Survey responses for the question 'How has the general health of other people in the home been affected post LPG (PMUY)', in the State of Jharkhand for the classified categories.

General health of other people in the home has improved for Jharkhand Low LPG and Jharkhand Low LPG Chulha.

Question 4: Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?

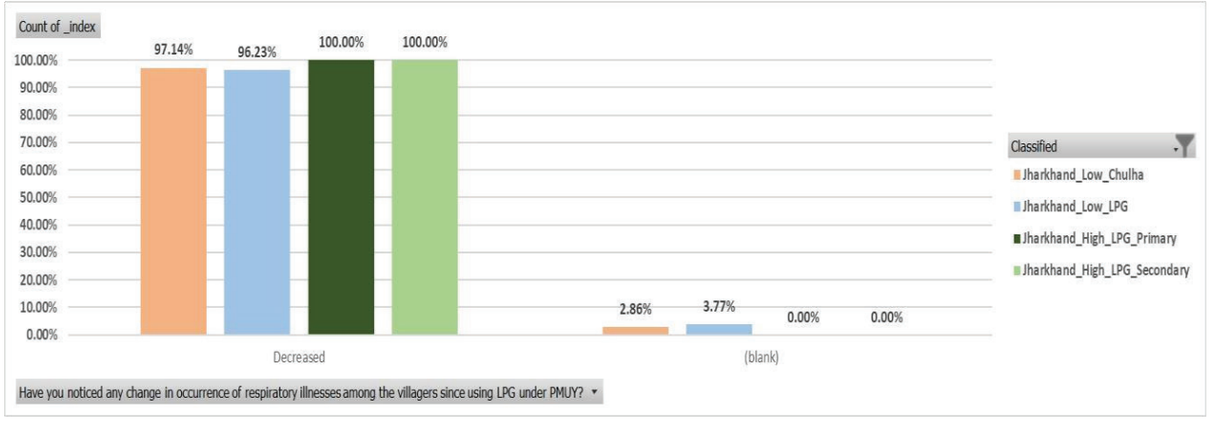


Figure 52: Survey responses for the question 'Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY', in the State of Jharkhand for the classified categories.

Occurrence of respiratory illnesses has decreased by more than 90% for all the categories since using LPG.

Question 5: Have the number of visits to doctors changed since the use of LPG?

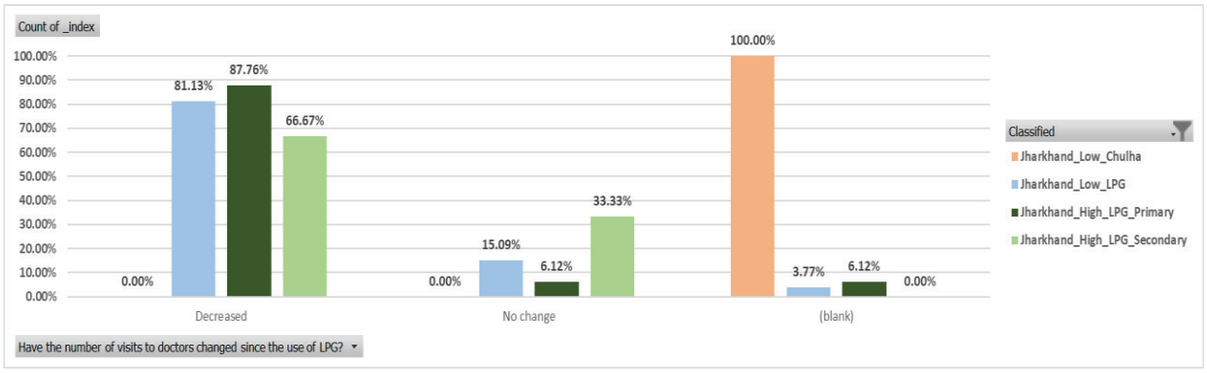


Figure 53: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG', in the State of Jharkhand for the classified categories.

More than 60% of responses for all the categories except Jharkhand Low Chulha share that they have decreased number of visits to doctors since the use of LPG.

Question 6: How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months?

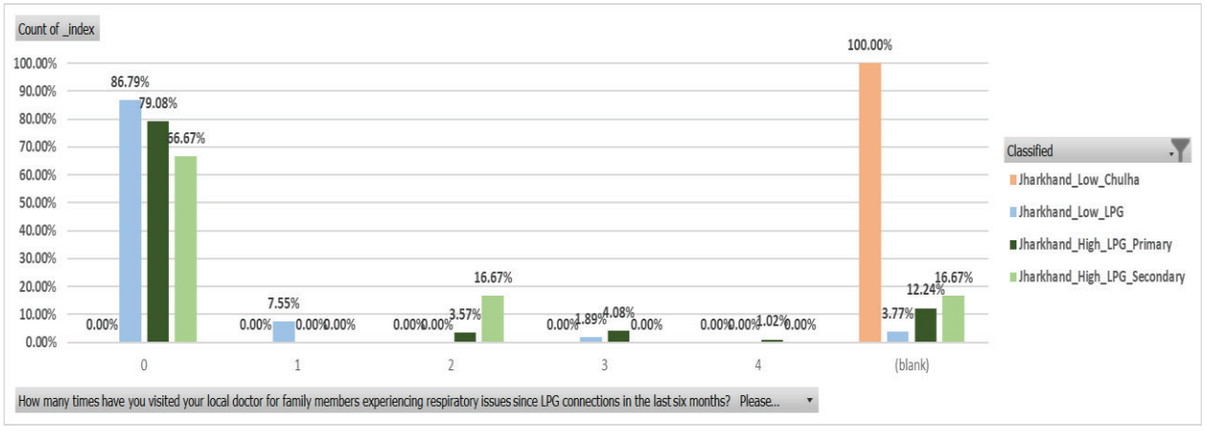


Figure 54: Survey responses for the question 'How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months', in the State of Jharkhand for the classified categories.

More than 16% of respondents in Jharkhand High LPG Secondary have visited local doctor twice for respiratory issues since LPG connections in the last six months.

Question 7: How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel

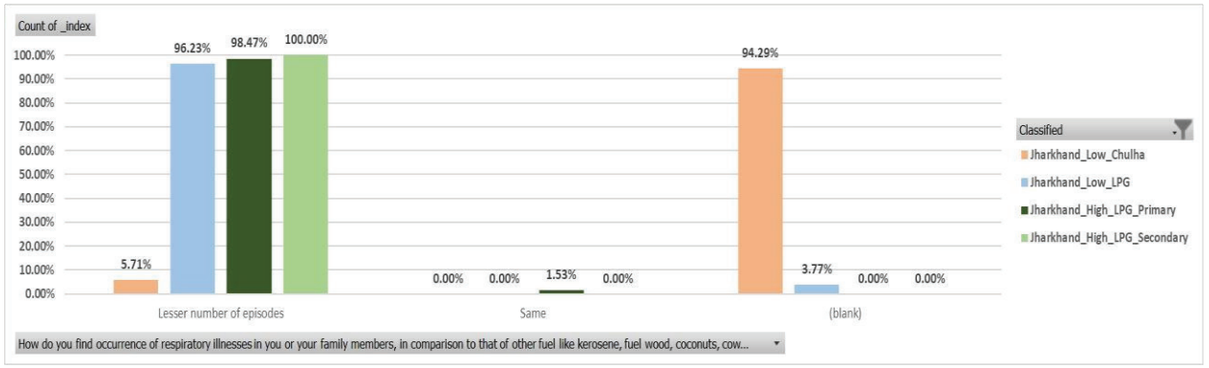


Figure 55: Survey responses for the question 'How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel', in the State of Jharkhand for the classified categories.

All categories except Jharkhand Low Chulha indicate lesser number of episodes for this question.

Analysis of Particulate Matter from the installed Low-Cost Sensors

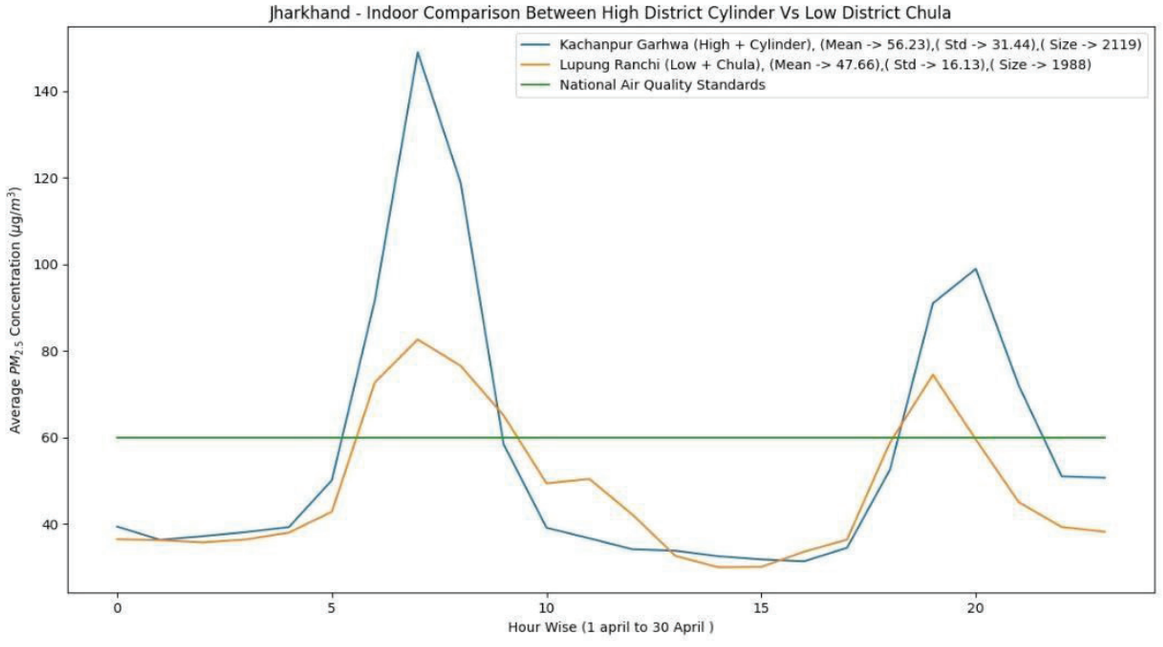


Figure 56: PM analysis from installed low-cost sensors in Jharkhand showing the comparison between High indoor cylinder vs low indoor chulha.

The average concentrations of $PM_{2.5}$ in the studied high_LPG district was 56.23±31.44 µg/m3 whereas it was 47.66±16.13 µg/m3 in low_LPG district houses. It is worthwhile to note that the other factors such as the use of mosquito coils, heating elements, smoking and incense sticks burning in the studied houses has also contributed to the measured indoor $PM_{2.5}$ concentrations. In Jharkhand, all the studied houses in the respective category were close to the industry. Moreover, around 60% of the respondents of high LPG primary category has reported the presence of smoker in the house on daily basis and more than 54% households has reported use of mosquito coils also. Moreover, it was found that the waste and crop burning was a common issue in all categories of village (Fig. 59).

Question 8: Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other.

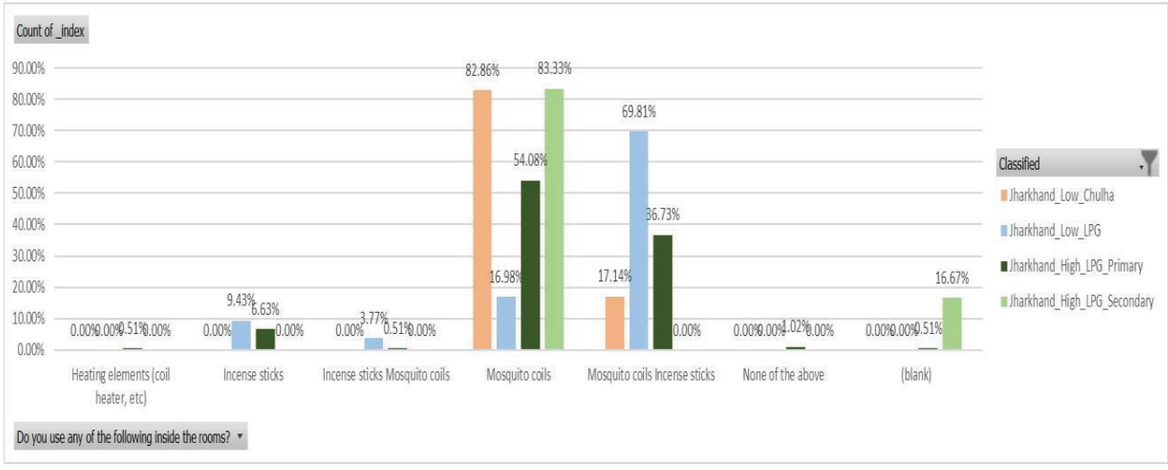


Figure 57: Survey responses for the question 'Do you use any of the following inside the rooms? /Mosquito coils, Incense sticks, heating elements and other.', in the State of Jharkhand for the classified categories.

Question 9: Are there any smokers in the family (Bidi, cigarette, hookah)?

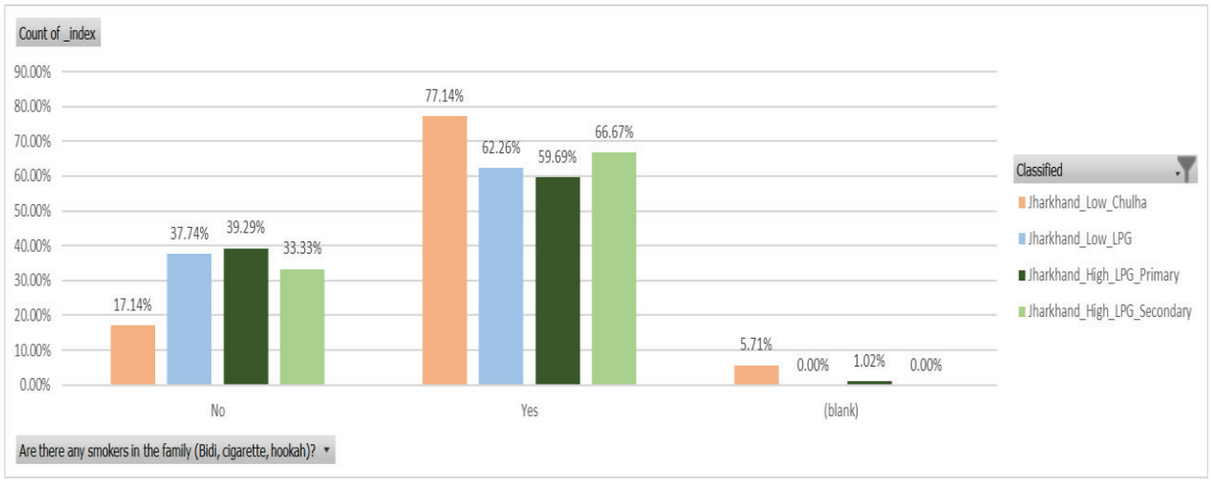


Figure 58: Survey responses for the question 'Are there any smokers in the family (Bidi, cigarette, hookah)?', in the State of Jharkhand for the classified categories.

Question 10: Is waste and crop burning common in the village?

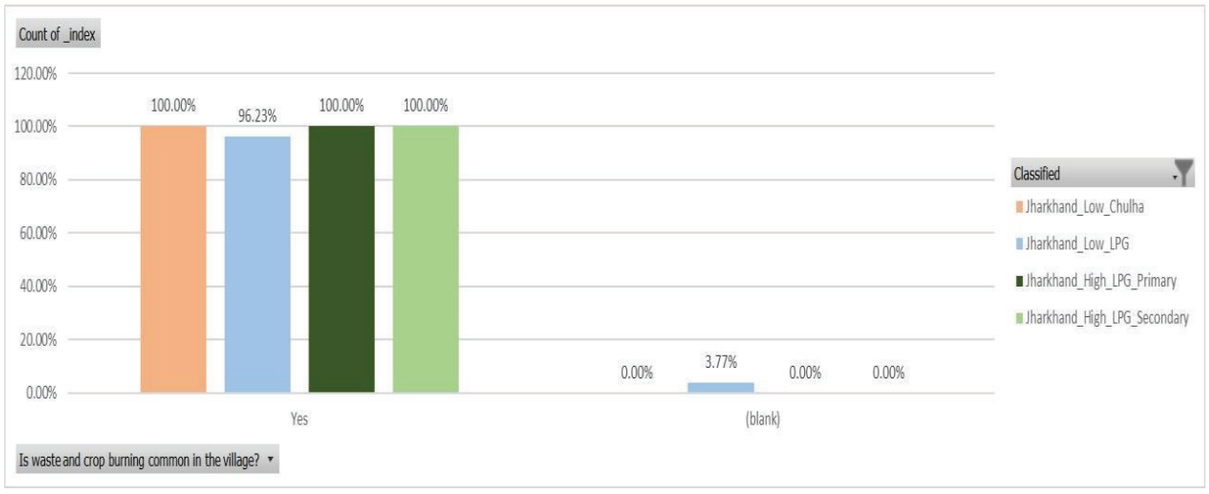


Figure 59: Survey responses for the question 'Is waste and crop burning common in the village?', in the State of Jharkhand for the classified categories.

e. Madhya Pradesh

For the State of Madhya Pradesh, a total number of 395 survey responses were obtained. Among these, 50.6% were from the village with high PMUY connections and 49.4% were from the village with low PMUY connectivity. From all the survey responders, 78% surveys were taken by the primary cooking person of the family, of which 97.47% were women of the household. 40% of the households had 4-5 family members and 21% had 6-7 family members. For 59% of the families, there was only one bread-earner in the family. Only 31% had two bread-earners. The detailed distributions for these figures are available in appendix A.

Based on the number of data and responses obtained, the survey households have been divided into four categories:

- High LPG Primary Village: The group of households from the high LPG connection village who use LPG as their primary cooking fuel.
- High LPG Secondary Village: The group of households from the high LPG connection village who use a combination of LPG and other cooking fuel.
- Low LPG Village: The group of households from the low LPG connection village who use LPG as their primary cooking fuel.
- Low Chulha Village: The group of households from the low LPG connection village who use chulha and solid fuel for cooking.

Health analysis: The questions considered for health analysis in Madhya Pradesh are given below:

- Does anyone in the family have respiratory related health problem?
- How has the general health of the primary cooking person been affected post LPG (PMUY)?
- How has the general health of other people in the home been affected post LPG (PMUY)?
- Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?
- How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months? Please enter number
- Have the number of visits to doctors changed since the use of LPG?
- How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

Table 7: Classification of the survey responders in Madhya Pradesh (The details of the type of cooking fuel and combinations for the villages is given in Appendix A)

Category	High LPG Primary Village	High LPG Secondary Village	Low LPG Village	Low Chulha Village
% Responders in this category	45	5.50	38	12

The details for each question and its responses are shown in the figures below.

Question 1: Does anyone in the family have respiratory related health problem?

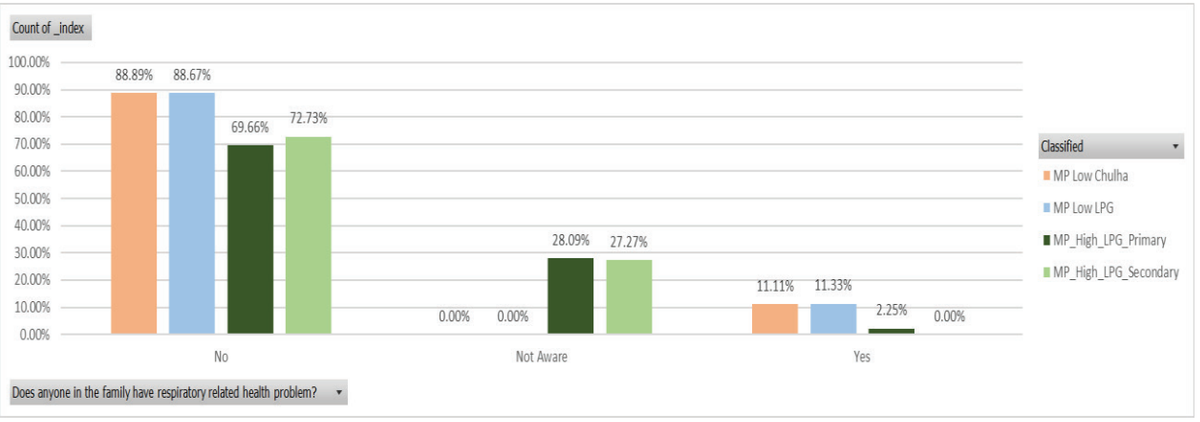


Figure 60: Survey responses for the question 'Does anyone in the family have respiratory related health problem', in the State of Madhya Pradesh for the classified categories.

More than 11% of respondents in both MP Low Chulha and MP Low LPG have reported respiratory related health problem in the family.

Question 2: How has the general health of the primary cooking person been affected post LPG (PMUY)?

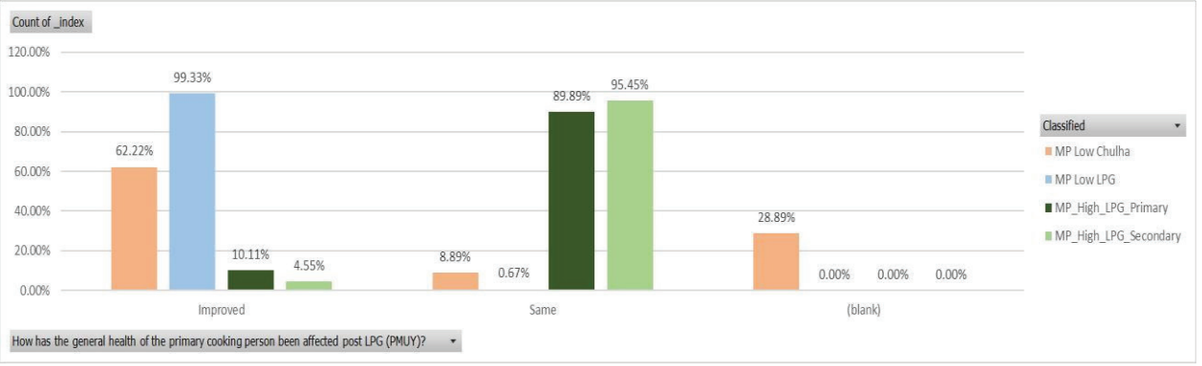


Figure 61: Survey responses for the question 'How has the general health of the primary cooking person been affected post LPG (PMUY)', in the State of Madhya Pradesh for the classified categories.

MP High LPG Primary and Secondary show very high percentage of no change in terms of the general health of the primary cooking person post LPG.

Question 3: How has the general health of other people in the home been affected post LPG (PMUY)?

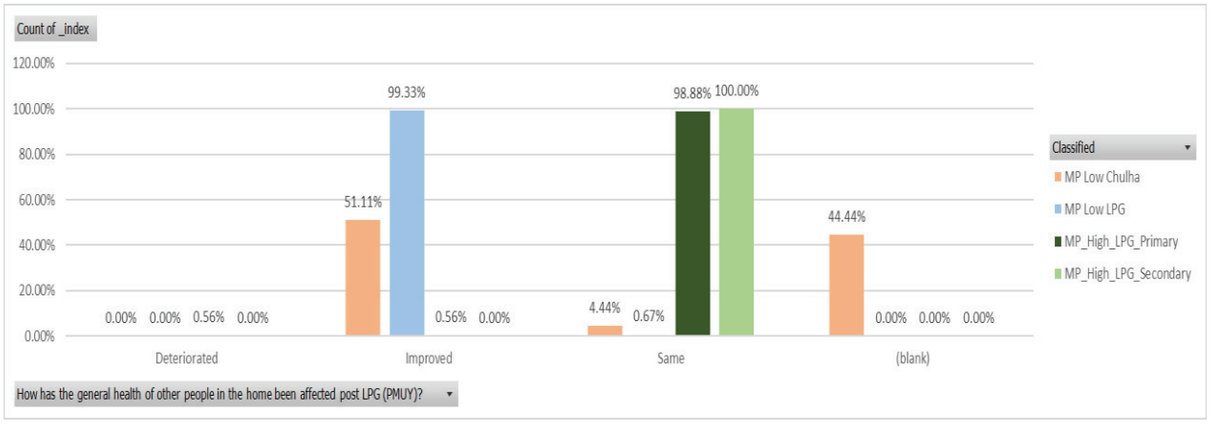


Figure 62: Survey responses for the question 'How has the general health of other people in the home been affected post LPG (PMUY)', in the State of Madhya Pradesh for the classified categories.

MP High LPG Primary and Secondary show very high percentage of no change in terms of the general health of other people in the home post LPG.

Question 4: Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?

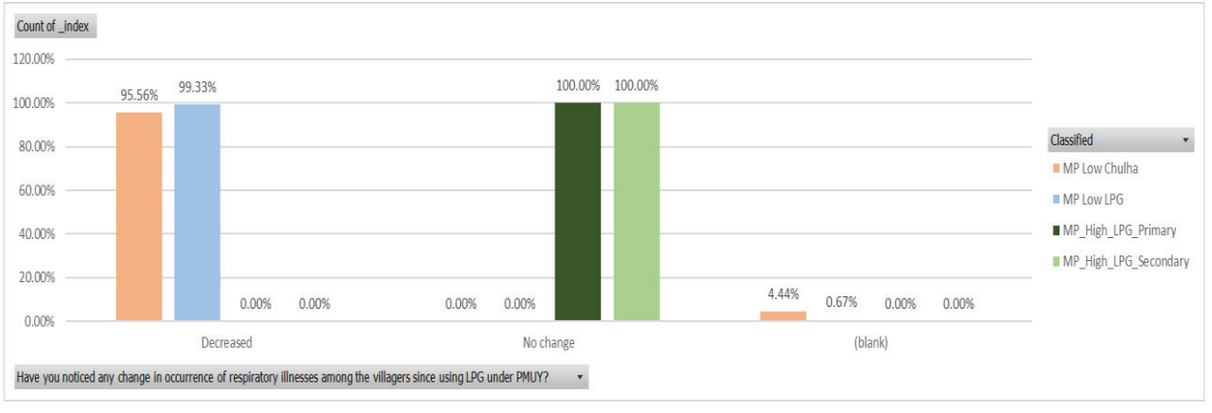


Figure 63: Survey responses for the question 'Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY', in the State of Madhya Pradesh for the classified categories.

MP High LPG Primary and Secondary show very high percentage of no change in terms of change in occurrence of respiratory illnesses since using LPG.

Question 5: How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months?

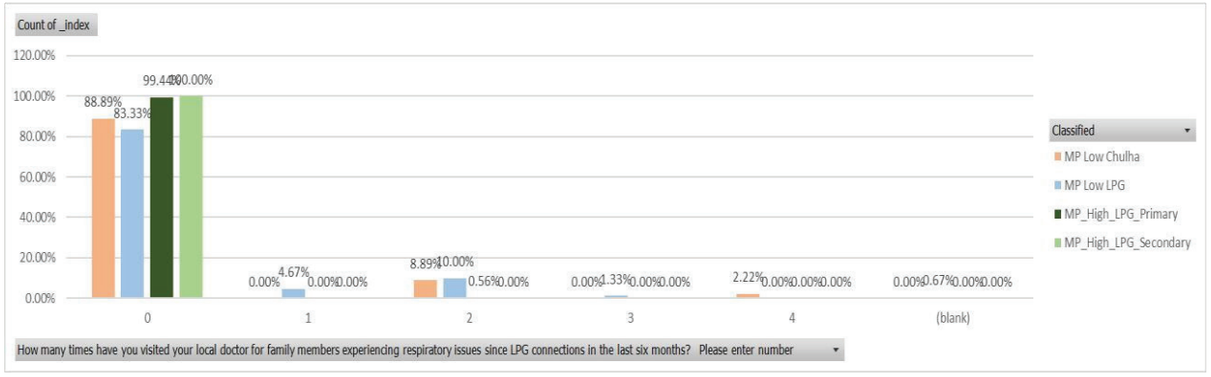


Figure 64: Survey responses for the question 'How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months', in the State of Madhya Pradesh for the classified categories.

Around 9% and 10% of respondents in MP Low Chulha and MP Low LPG respectively have visited their local doctor twice due to respiratory illnesses.

Question 6: Have the number of visits to doctors changed since the use of LPG?

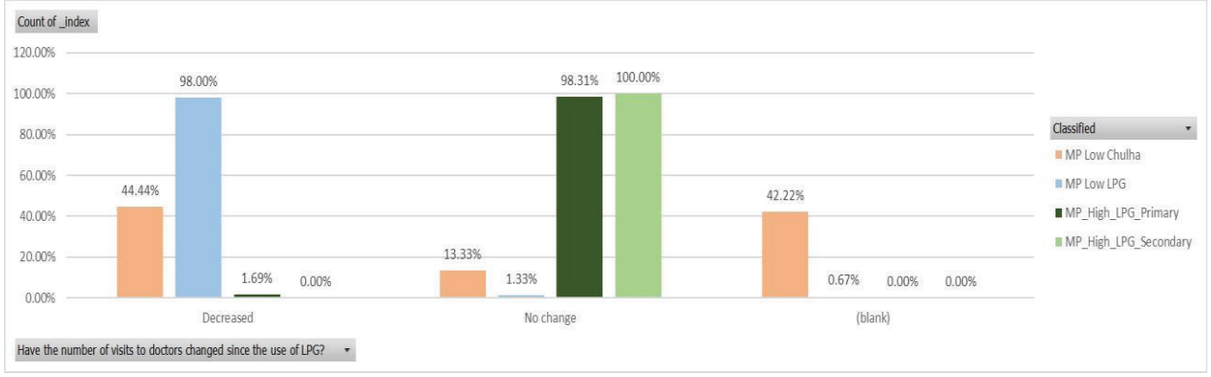


Figure 65: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG', in the State of Madhya Pradesh for the classified categories.

MP High LPG Primary and Secondary show very high percentage of no change in terms of number of visits to doctors since the use of LPG.

Question 7: How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel.

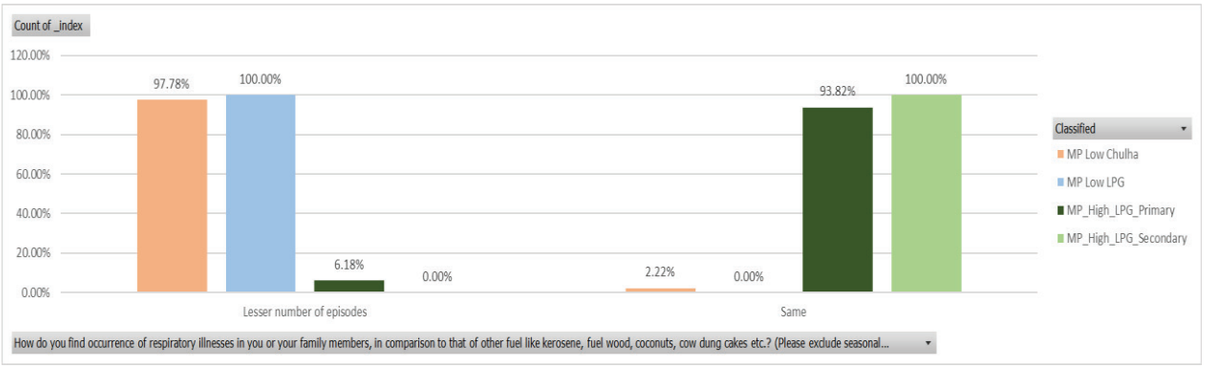


Figure 66: Survey responses for the question 'How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel', in the State of Madhya Pradesh for the classified categories.

MP High LPG Primary and Secondary show very high percentage of no change in terms of occurrence of respiratory illnesses.

Madhya Pradesh Low LPG and Low Chulha category villages had shown higher positive responses for the improvement in general health and respiratory illness post-LPG (PMUY) compared to Madhya Pradesh High LPG primary and secondary villages. This indicated that respondents from the lowest PMUY connection village had found greater improvement in health compared to the highest PMUY connection village of Madhya Pradesh. In order to calibrate and validate these results, a dipstick study was carried out in the studied villages of Madhya Pradesh in May 2022. Fifty responses were collected from both villages again, and the responses were analysed as earlier. It was found that the dipstick results had also shown similar results for the key health questions. The dipstick study results are shown in Appendix D. Based on the field survey and responses received from the studied highest PMUY connection village of Madhya Pradesh, it was found that the biomass fuel was free and easily available to the households. Therefore, the households of the highest PMUY connection village of Madhya Pradesh are using biomass fuel more frequently, which may be resulted in lower positive responses for the improvement in general health and respiratory illness post-LPG (PMUY) connection.

Quality of Life:

Question 8: How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

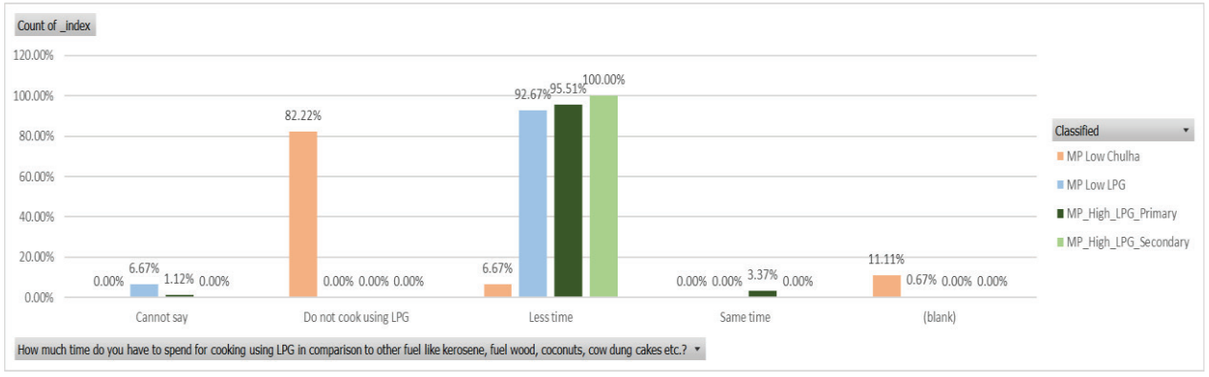


Figure 67: Survey responses for the question 'How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel', in the State of Madhya Pradesh for the classified categories.

The time for the cooking has reduced for MP Low LPG and MP High LPG Primary as well as secondary category households.

Question 9: Is there any difference in cleaning of utensils since using LPG?

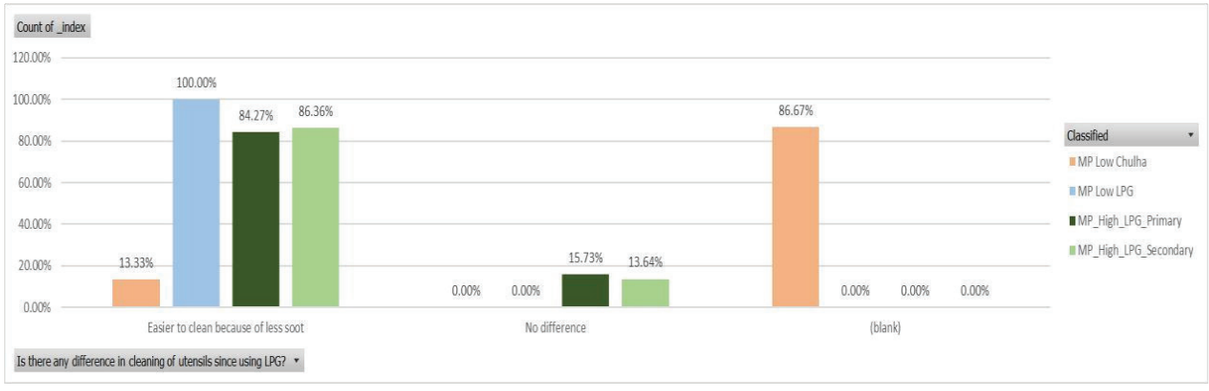


Figure 68: Survey responses for the question 'Is there any difference in cleaning of utensils since using LPG?', in the State of Madhya Pradesh for the classified categories.

MP Low LPG and MP High LPG Primary as well as secondary have reported ease in cleaning of utensils since using LPG.

Question 10: Has the usage of warm water changed since LPG connection (PMUY)?

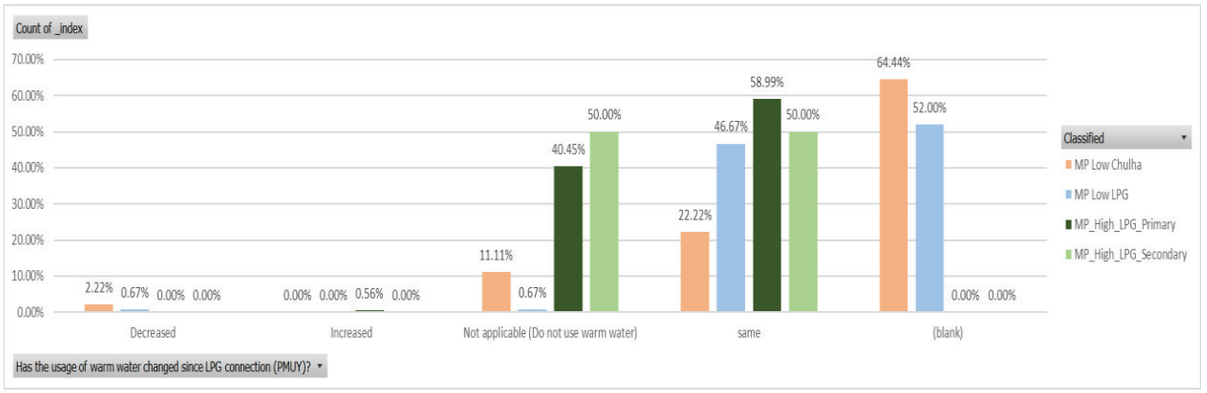


Figure 69: Survey responses for the question 'Has the usage of warm water changed since LPG connection (PMUY)?', in the State of Madhya Pradesh for the classified categories.

Only 2% of respondents from MP Low LPG has reported increase in usage of warm water since using LPG connection (PMUY).

Question 11: What is your experience in cooking with LPG compared to other fuel?

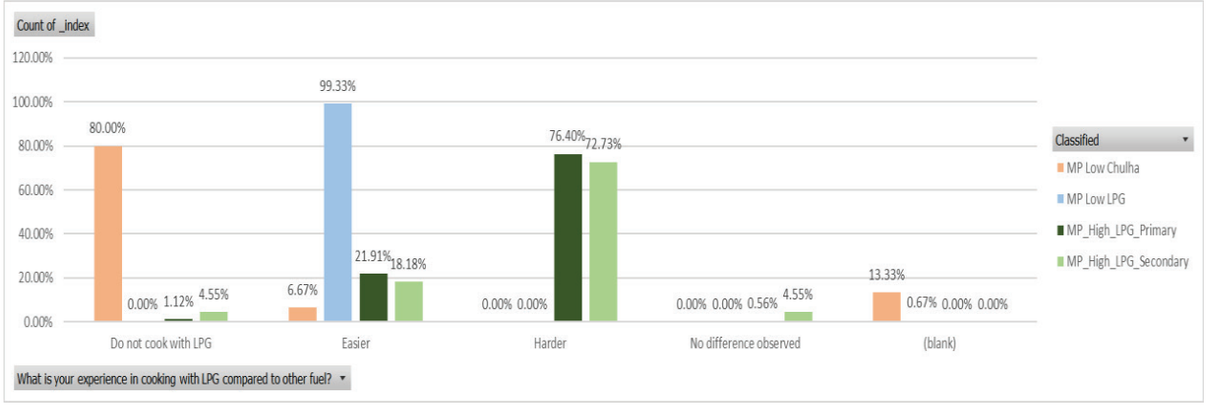


Figure 70: Survey responses for the question 'What is your experience in cooking with LPG compared to other fuel?', in the State of Madhya Pradesh for the classified categories.

Only 18%-21% of respondents from MP High LPG villages have experienced ease in cooking with LPG.

Out of Pocket Expenditure on care seeking

Question 12: Have the number of visits to doctors changed since the use of LPG?

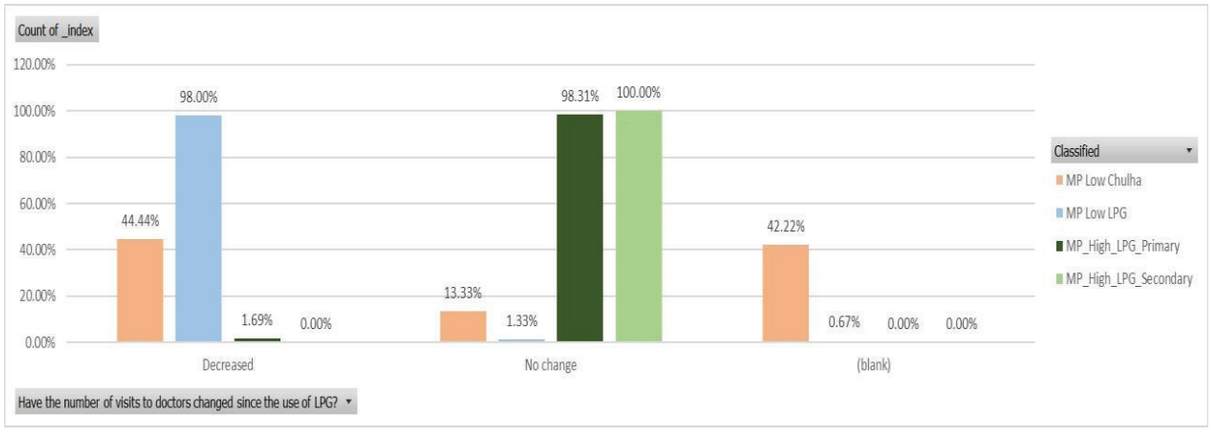


Figure 71: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG?', in the State of Madhya Pradesh for the classified categories.

f. West Bengal

For the State of West Bengal, a total number of 360 survey responses were obtained. Among these, 54% were from the village with high PMUY connections and 46% were from the village with low PMUY connectivity. From all the survey responders, 97% surveys were taken by the primary cooking person of the family, of which 100% were women of the household. 52% of the households had 4-5 family members and 21% had 6-7 family members. For 65% of the families, there was only one bread-earner in the family. Only 31% had two bread-earners. The detailed distributions for these figures are available in appendix A.

Based on the number of data and responses obtained, the survey households have been divided into four categories:

- High LPG Primary Village: The group of households from the high LPG connection village who use LPG as their primary cooking fuel.
- High LPG Secondary Village: The group of households from the high LPG connection village who use a combination of LPG and other cooking fuel.
- Low LPG Village: The group of households from the low LPG connection village who use LPG as their primary cooking fuel.
- Low Chulha Village: The group of households from the low LPG connection village who use chulha and solid fuel for cooking.

Table 8: Classification of the survey responders in West Bengal (The details of the type of cooking fuel and combinations for the villages are given in Appendix A)

Category	High LPG Primary Village	High LPG Secondary Village	Low LPG Village	Low Chulha Village
% Responders in this category	33	0.5	5	40

Health analysis: The questions considered for health analysis in West Bengal are given below:

Question 1: Does anyone in the family have respiratory related health problem?

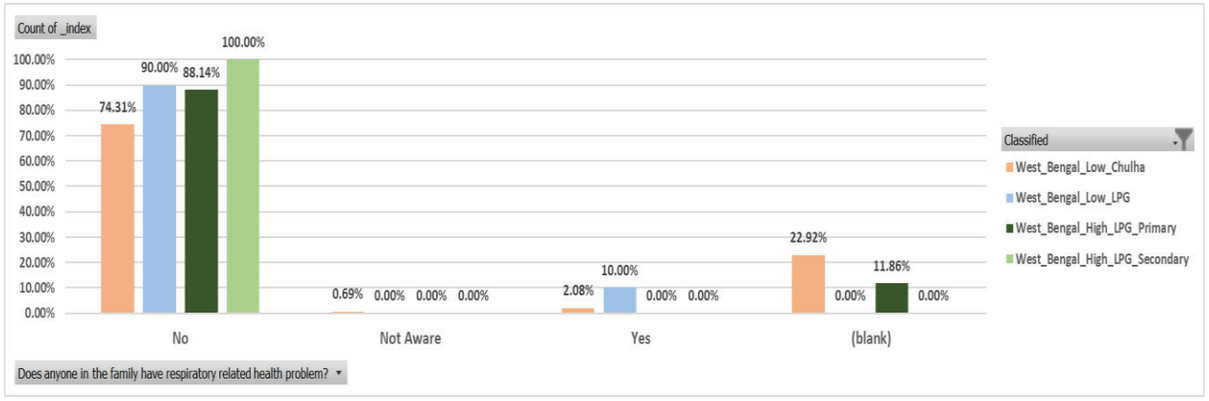


Figure 72: Survey responses for the question 'Does anyone in the family have respiratory related health problem', in the State of West Bengal for the classified categories.

10% of respondents in West Bengal Low LPG indicate having respiratory related health problem which is significantly higher as compared to others.

Question 2: How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?

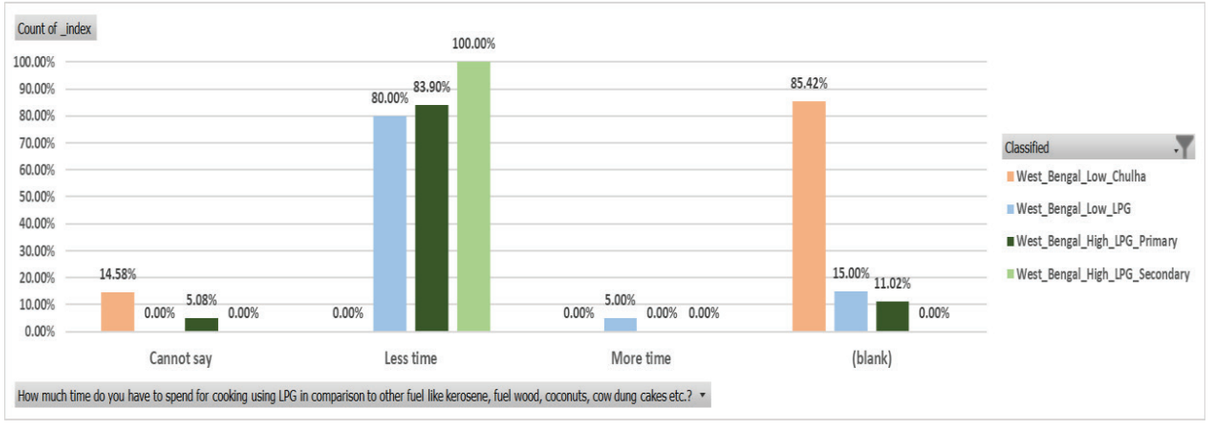


Figure 73: Survey responses for the question 'How much time do you have to spend for cooking using LPG in comparison to other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?', in the State of West Bengal for the classified categories.

The time for the cooking has reduced for West Bengal Low LPG and High LPG Primary as well as secondary category households.

Question 3: Is there any difference in cleaning of utensils since using LPG?

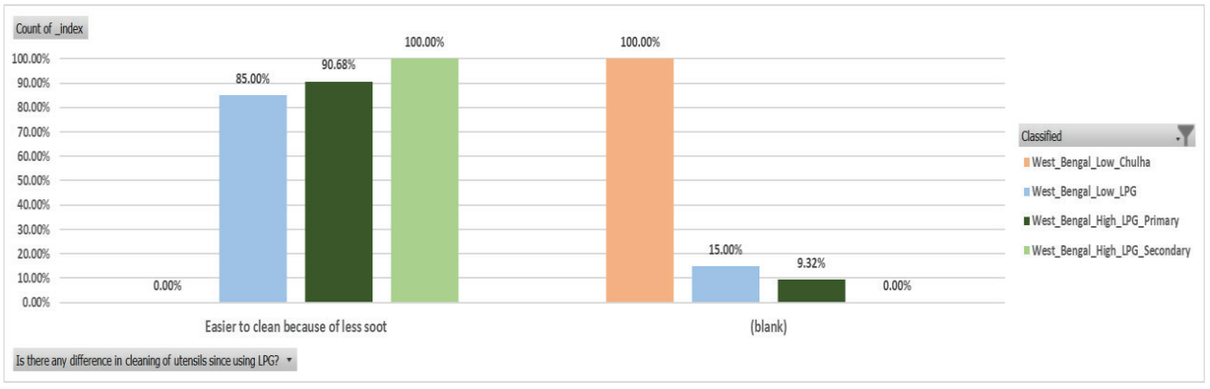


Figure 74: Survey responses for the question 'Is there any difference in cleaning of utensils since using LPG?', in the State of West Bengal for the classified categories.

West Bengal Low LPG and West Bengal High LPG Primary as well as secondary have reported ease in cleaning of utensils since using LPG.

Question 4: Has the usage of warm water changed since LPG connection (PMUY)?

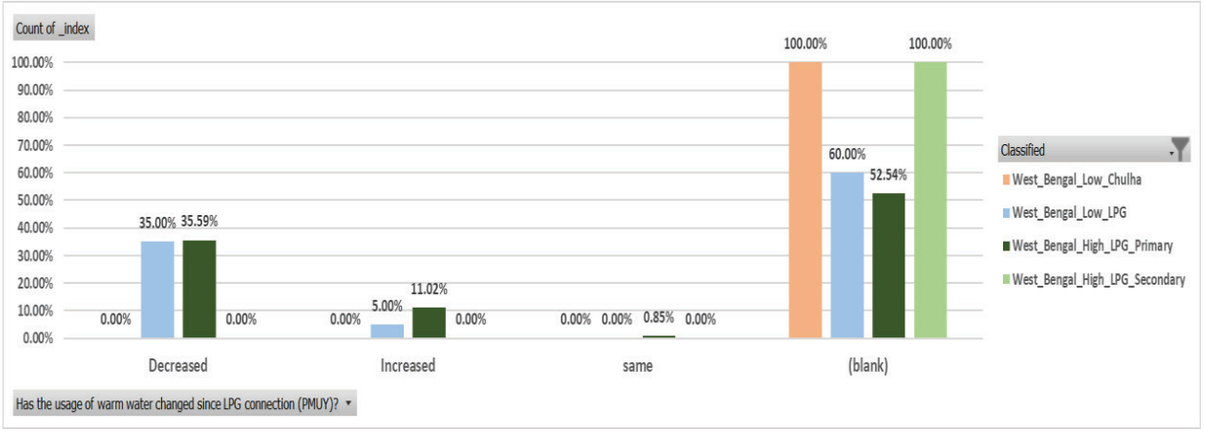


Figure 75: Survey responses for the question 'Has the usage of warm water changed since LPG connection (PMUY)?', in the State of West Bengal for the classified categories.

Around 11% of respondents from West Bengal High LPG Primary has reported increase in usage of warm water since using LPG connection (PMUY).

Question 5: What is your experience in cooking with LPG compared to other fuel?

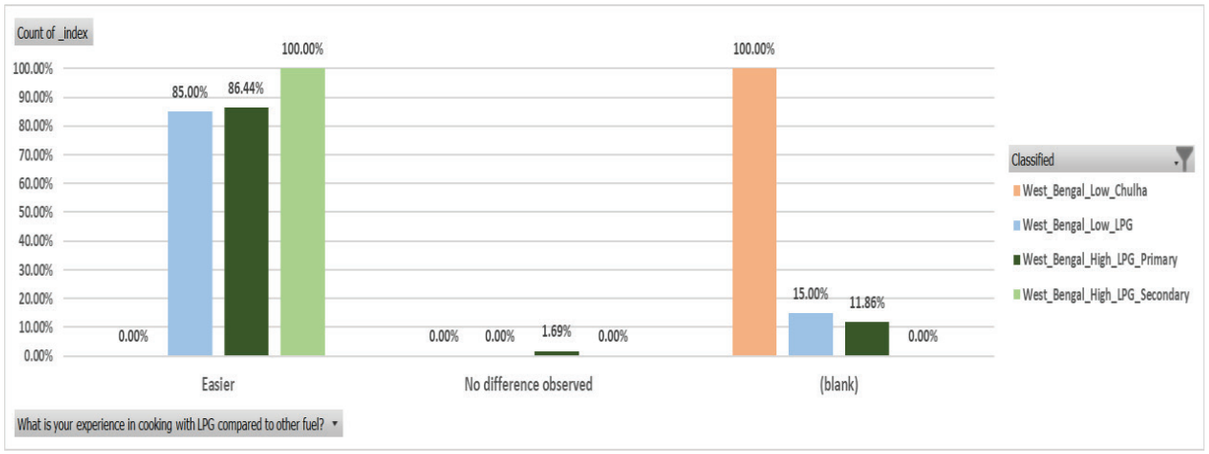


Figure 76: Survey responses for the question 'What is your experience in cooking with LPG compared to other fuel?', in the State of West Bengal for the classified categories.

Around 80% - 90% of respondents from West Bengal Low LPG and High LPG villages have experienced ease in cooking with LPG.

Out of Pocket Expenditure on care seeking

Question 6: Have the number of visits to doctors changed since the use of LPG?

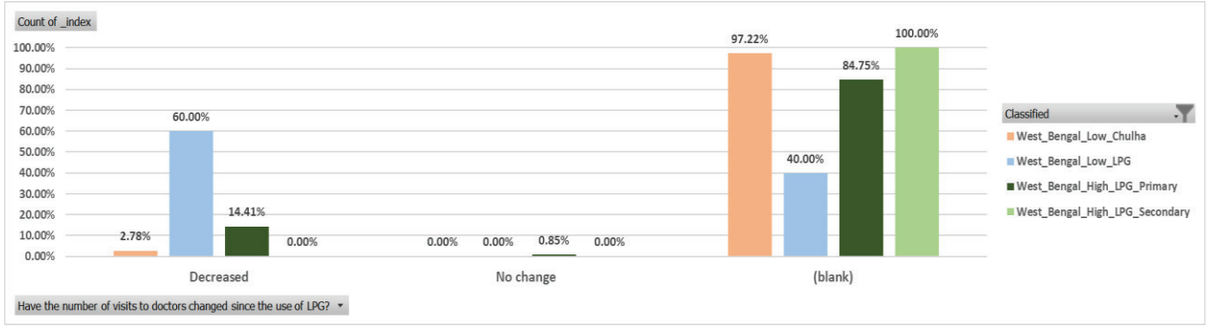


Figure 77: Survey responses for the question 'Have the number of visits to doctors changed since the use of LPG?', in the State of West Bengal for the classified categories.

The out- of - pocket expenditure on care with respect to number of visits to doctors decreased around 14% to 60% for West Bengal High LPG and Low LPG , respectively.

Socioeconomic factor:

The key findings were assessed for the different socioeconomic groups among the studied categories, i.e., High LPG Primary Village, High LPG Secondary Village, Low LPG Village, and Low Chulha Village. The respondents were divided into three categories based on their total monthly income in rupees, i.e., (a) respondent's monthly income < Rs. 5000, (b) respondent's monthly income between Rs.5000-10000, (c) respondent's monthly income between Rs.10000- 20000. It was found that the respondents had shown lesser number of episodes for the occurrence of respiratory illness irrespective of their socioeconomic diversity. Hence the study results were found consistent for different socioeconomic groups and the socioeconomic factor was not found as a major confounder in this study. The socioeconomic effects with respect to the occurrence of respiratory illness are shown in figure for Rajasthan and Bihar, respectively.

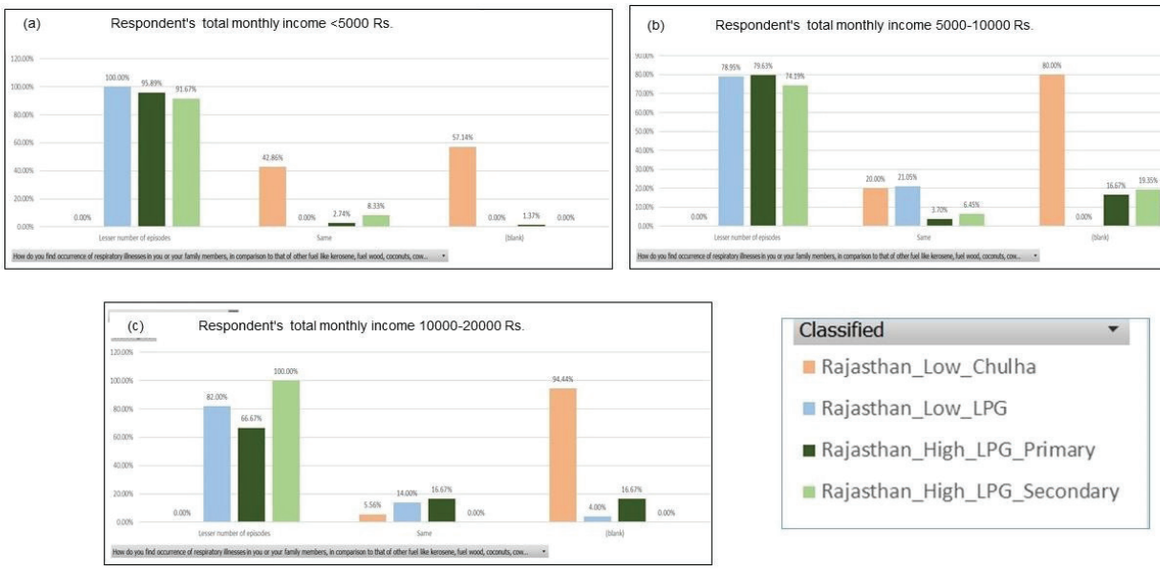


Figure 78: The socioeconomic effects with respect to the occurrence of respiratory illness for Rajasthan for different socioeconomic groups, i.e., Respondent's total monthly income (in Rs.) a) < 5000 Rs; b) 5000-10,000 Rs; c) 10000-20000.

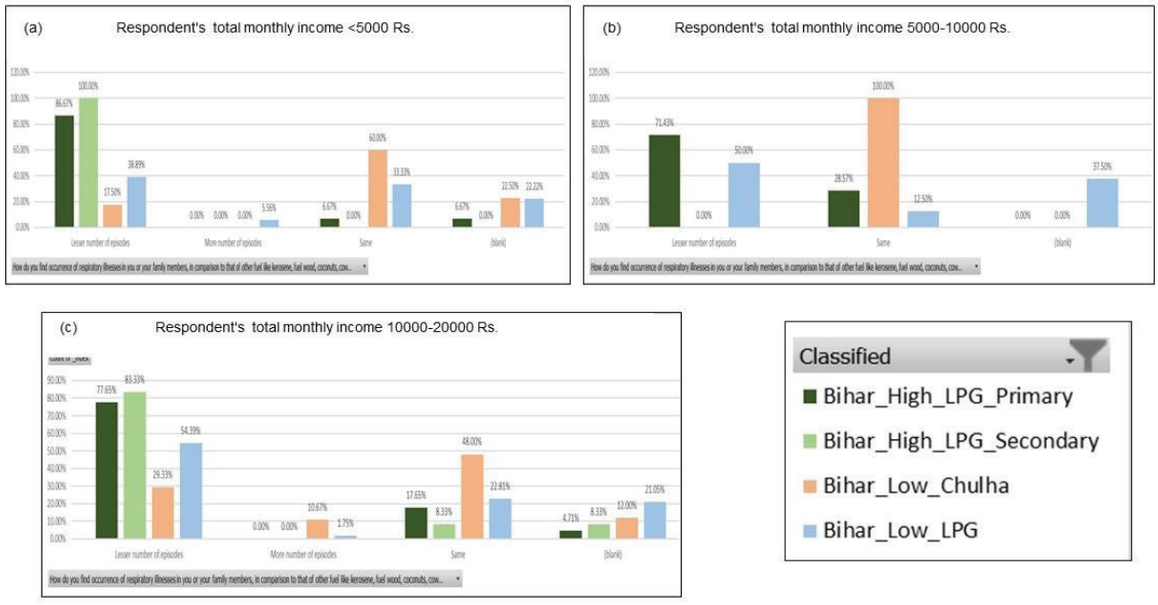


Figure 79: The socioeconomic effects with respect to the occurrence of respiratory illness for Bihar for different socioeconomic groups, i.e., Respondent's total monthly income (in Rs.) a) < 5000 Rs; b) 5000-10,000 Rs; c) 10000-20000.

Access to LPG Cylinders and Re-fills

The continued access to LPG cylinder refills is a big factor in maintaining the health benefits and improved air quality from the PMUY distributed LPG cylinders. The accessibility to LPG cylinders and their refill status were analysed by the responses received to the LPG refill related questions. The responses received for the accessibility of LPG cylinder refill showed that more than 38% of the LPG users get their LPG refill from village distributers, and only 29% of the LPG users get it from outside the village (Figure 80). At the same time, around 33% of the LPG users get their LPG cylinder refills through home delivery. These LPG refill home deliveries were reported as convenient and satisfactory by 76% and 13% of LPG users, respectively and collectively by more than 93% of respondents.

The percentage responses for the PMUY beneficiaries for LPG cylinder refilling in the last six months (from the survey date) are shown in Figure 81. It was found that more than 23% of the LPG users have refilled the cylinder only two times, and 12 % of LPG users have refilled their LPG cylinder only once in the last six months, which indicated that more than 38% of the LPG users had refilled their LPG cylinders only 0-2 times the last six months. The respondents reported the different reasons for the low refilling (0-2 times) of the LPG cylinders in the last six months. Around 6% of the LPG users have reported inconvenience in LPG refilling, 4% have reported availability issues, while 4% of the LPG users have reported that they do not find value in LPG refill. However, more than 47% of the LPG users have reported refilling cost as a limiting factor for LPG cylinder refilling. Around 52% of

the LPG users have reported that the cost of purchasing/refilling has affected their food consumption also. The distance travelled for undertaking the LPG refill and the number of refills undertaken by the PMUY beneficiaries gives an indication to the level of adoption and change in habits that has been established by the PMUY scheme. The results of the survey in the context of the LPG refills provides an insight on some of the challenges that the PMUY scheme may encounter once the initial free cylinders are utilized.

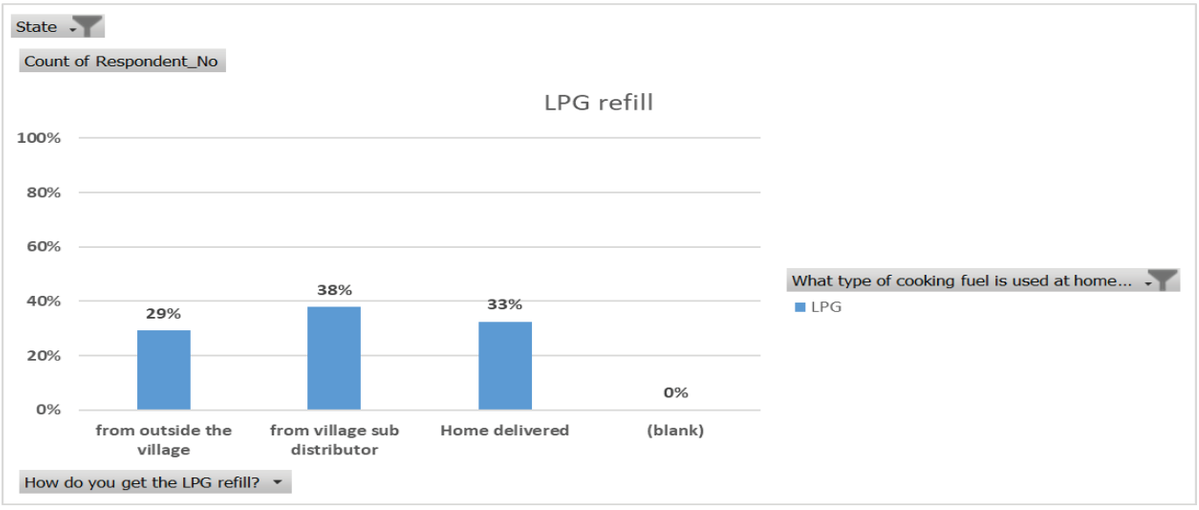


Figure 80: Distance travelled by PMUY beneficiaries for LPG refills.

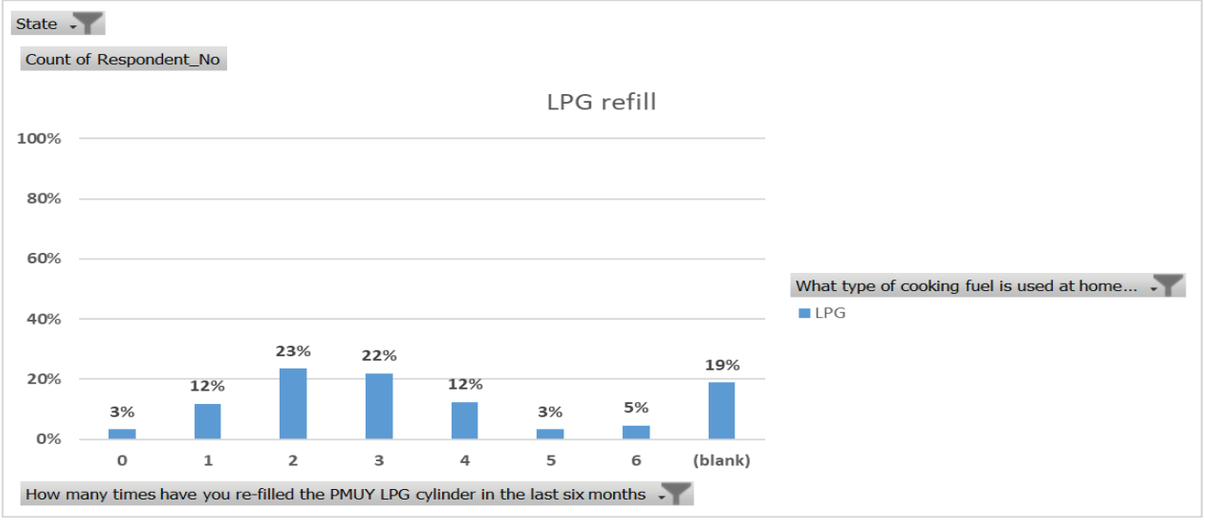


Figure 81: Number of LPG refills undertaken by PMUY beneficiaries in past 6 months.

Statistical Summary

The collected pooled data from all the studied states and states-wise data were statistically analysed to determine the accurate impact of the PMUY connection for the households who uses LPG as primary cooking fuel. The detailed statistical analysis for the pooled data and state-wise data is presented below with a 95% confidence level.

Table 9: One-Sample Test statistical summary for all the surveyed LPG users' responses.

S.No	Questions	Test Value		
		t	df	P-value*
1	How has the general health of the primary cooking person been affected post LPG (PMUY)?	47.518	1774	0.000
2	How has the general health of other people in the home been affected post LPG (PMUY)?	55.330	1710	0.000
3	How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel?	24.266	1564	0.000
4	Have the number of visits to doctors changed since the use of LPG?	28.352	1296	0.000
5	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?	34.978	1041	0.000
6	Is there any difference in cleaning of utensils since using LPG?	2.141	1686	0.032
7	How much time do you have to spend for cooking using LPG in comparison to other fuel?	-13.780	1894	0.000
8	Has the usage of warm water changed since LPG connection (PMUY)?	41.911	1617	0.048

Table 10: Normality test summary for all the surveyed LPG users' responses

Shapiro-Wilk Test				
S.No	**Questions**	**Statistic**	**df**	**P-value**
1	How has the general health of the primary cooking person been affected post LPG (PMUY)?	0.646	1774	0.001
2	How has the general health of other people in the home been affected post LPG (PMUY)?	0.566	1710	0.013
3	How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel?	0.551	1564	0.002
4	Have the number of visits to doctors changed since the use of LPG?	0.641	1296	0.016
5	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?	0.628	1041	0.010
6	How much time do you have to spend for cooking using LPG in comparison to other fuel?	0.117	1686	0.001
7	Is there any difference in cleaning of utensils since using LPG?	0.041	1894	0.003
8	Has the usage of warm water changed since LPG connection (PMUY)?	0.610	1617	0.043

Rajasthan

Table 11: One-Sample Test statistical summary for the state of Rajasthan

	Test Value					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Occurrence of respiratory illnesses among the villagers since using LPG under PMUY	25.128	400	0.000	1.738	1.60	1.87

Bihar

Table 12: One-Sample Test statistical summary for the state of Bihar

	Test Value					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Occurrence of respiratory illnesses among the villagers since using LPG under PMUY	20.625	400	0.000	1.177	1.06	1.29

Uttar Pradesh

Table 13: One-Sample Test statistical summary for the state of Uttar Pradesh

	Test Value					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Occurrence of respiratory illnesses among the villagers since using LPG under PMUY	285.317	404	0.000	1.990	1.98	2.00

Table 14: Statistical analysis of the survey responders in Rajasthan

State	Connection type (Sample Size)	Health Questions	Sample Proportion	95% confidence interval
Rajasthan	High LPG Primary Village (133)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	0.278	[0.201, 0.354]
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	0.082	[0.035, 0.128]
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.172	[0.107, 0.236]
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	0.293	[0.215, 0.370]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	0.879	[0.823, 0.934]
		Does anyone in the family have respiratory related health problem? (Yes)	0.052	[0.0142, 0.089]
	High LPG Secondary Village (68)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	0.235	[0.134, 0.335]
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	0.058	[0.002, 0.113]
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.132	[0.051, 0.212]
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	0.294	[0.185, 0.402]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	0.838	[0.750, 0.925]

		Does anyone in the family have respiratory related health problem? (Yes)	0.073	[0.011, 0.134]
	Low LPG Village (115)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	0.026	[0.0152, 0.100]
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	0.052	[0.011, 0.092]
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.200	[0.126, 0.273]
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	0.617	[0.528, 0.705]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	0.826	[0.756, 0.895]
		Does anyone in the family have respiratory related health problem? (Yes)	0.060	[0.016, 0.103]
	Low Chulha Village (85)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	No change	No change
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	No change	No change
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	NA	NA
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	NA	NA
		Does anyone in the family have respiratory related health problem? (Yes)	0.29	[0.193, 0.386]

Table 15: Statistical analysis of the survey responders in Bihar

State	Connection type (Sample Size)	Health questions	Sample Proportion	95% confidence interval
Bihar	High LPG Primary Village (107)	How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.420	[0.326, 0.513]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	0.780	[0.701, 0.858]
		Does anyone in the family have respiratory related health problem? (Yes)	0.140	[0.074, 0.205]
	High LPG Secondary Village (16)	How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.50	[0.235, 0.765]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	0.875	[0.699, 1.00]
		Does anyone in the family have respiratory related health problem? (Yes)	0.250	[0.020, 0.479]
	High Chulha Village (86)	How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.016	[0, 0.042]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	0.510	[0.404, 0.615]
		Does anyone in the family have respiratory related health problem? (Yes)	0.279	[0.184, 0.373]
	Low LPG Village (83)	How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.310	[0.210, 0.409]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.?	0.506	[0.398, 0.613]

		(Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)		
		Does anyone in the family have respiratory related health problem? (Yes)	0.140	[0.065, 0.214]
	Low Chulha Village (117)	How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	No change	NA
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	0.256	[0.176, 0.335]
		Does anyone in the family have respiratory related health problem? (Yes)	0.230	[0.153, 0.306]

Table 16: Statistical analysis of the survey responders in Uttar Pradesh

State	Connection type (Sample Size)	Health Questions	Sample Proportion	95% confidence interval
Uttar Pradesh	High LPG Primary Village (191)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	0.356	[0.288, 0.423]
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.445	[0.374, 0.515]
		Does anyone in the family have respiratory related health problem? (Yes)	0.0560	[0.023, 0.088]
	High LPG Secondary Village (14)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	0.640	[0.364, 0.915]
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.857	[0.656, 1.00]
		Does anyone in the family have respiratory related health problem? (Yes)	0	0
	Low LPG Chulha Village (174)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	0.203	[0.143, 0.262]
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.473	[0.398, 0.547]
		Does anyone in the family have respiratory related health problem? (Yes)	0.0920	[0.049, 0.134]
	Low Chulha Village (26)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	No change	No change
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	No change	No change
		Does anyone in the family have respiratory-related health problem? (Yes)	0.112	[0,0.238]

Table 17: Statistical analysis of the survey responders in Jharkhand

State	Connection type (Sample Size)	Health Questions	Sample Proportion	95% confidence interval
Jharkhand	High LPG Primary Village (196)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	NA	NA
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.0255	[0.003, 0.047]
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	0.875	[0.828, 0.921]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	NA	NA
		Does anyone in the family have respiratory related health problem? (Yes)	0.166	[0.113, 0.218]
		How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months? Please enter number	NA	NA
	High LPG Secondary Village (6)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	NA	NA
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.166	[0,0.533]
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	0.667	[0.19,100]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	NA	NA

		Does anyone in the family have respiratory related health problem? (Yes)	0.112	[0,0.46]
		How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months? Please enter number	NA	NA
	Low LPG Village (53)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY? (Decreased)	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	NA	NA
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.528	[0.393, 0.662]
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	0.810	[0.704, 0.915]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	NA	NA
		Does anyone in the family have respiratory related health problem? (Yes)	0.132	[0.040, 0.223]
		How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months? Please enter number	NA	NA
	Low Chulha Village (35)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	NA	NA
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	NA	NA
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	NA	NA
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	NA	NA
		Does anyone in the family have respiratory related health problem? (Yes)	0.0286	[0,0.083]
		How many times have you visited your local doctor for family members experiencing	NA	NA

		respiratory issues since LPG connections in the last six months? Please enter number		
	Low LPG Chulha Village (109)	Have you noticed any change in occurrence of respiratory illnesses among the villagers since using LPG under PMUY?	NA	NA
		How has the general health of other people in the home been affected post LPG (PMUY)? (Improved)	NA	NA
		How has the general health of the primary cooking person been affected post LPG (PMUY)? (Improved)	0.596	[0.503, 0.688]
		Have the number of visits to doctors changed since the use of LPG? (Decreased)	0.663	[0.574, 0.751]
		How do you find occurrence of respiratory illnesses in you or your family members, in comparison to that of other fuel like kerosene, fuel wood, coconuts, cow dung cakes etc.? (Please exclude seasonal occurrences and ask about persistent problems) (Lesser number of episodes)	NA	NA
		Does anyone in the family have respiratory related health problem? (Yes)	0.0836	[0.031, 0.135]
		How many times have you visited your local doctor for family members experiencing respiratory issues since LPG connections in the last six months? Please enter number	NA	NA

Table 18: Statistical analysis of the survey responders in Madhya Pradesh

State	Connection type (Sample Size)	Health questions	Sample Proportion	95% confidence interval
Madhya Pradesh	High LPG Primary Village (178)	Does anyone in the family have respiratory related health problem? (Yes)	NA	NA
	High LPG Secondary Village (22)	Does anyone in the family have respiratory related health problem? (Yes)	NA	NA
	Low LPG Village (150)	Does anyone in the family have respiratory related health problem? (Yes)	0.11	[0.059,0.16]
	Low Chulha Village (45)	Does anyone in the family have respiratory related health problem? (Yes)	0.11	[0.018,0.20]

Table 19: Statistical analysis of the survey responders in West Bengal

State	Connection type (Sample Size)	Health questions	Sample Proportion	95% confidence interval
West Bengal	High LPG Primary Village (133)	Does anyone in the family have respiratory related health problem? (Yes)	NA	NA
	High LPG Secondary Village (68)	Does anyone in the family have respiratory related health problem? (Yes)	NA	NA
	Low LPG Village (115)	Does anyone in the family have respiratory related health problem? (Yes)	0.100	[0.045, 0.154]
	High Chulha Village	Does anyone in the family have respiratory related health problem? (Yes)	NA	NA
	Low Chulha Village (85)	Does anyone in the family have respiratory related health problem? (Yes)	0.020	[0, 0.049]

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Analysis of PM2.5 from installed low cost sensor

We have collected 3 months of data from 16 households in the selected states, in which 8 were installed in high PMUY connection village and 8 were installed in low connection village and compare this data with NAAQ standard data to see the long-term effect of cooking to the general health of the family. The results show in the table below.

Table 20: Calculation of $PM_{2.5}$ level in terms of probability for different villages of India (NAAQ Standard 60 microgram per cubic meter)

State	High Village Cylinder (µgm/m^3)	Low Village Chula (µgm/m^3)
Rajasthan	[33.34, 40.91] (95% confidence level)	[66.98, 70.78] (95% confidence level)
Bihar	[108.14,117.85] (95% confidence level)	[113.84,127.31] (95% confidence level)
Jharkhand	[54.89, 57.56] (95% confidence level)	[46.95, 48.36] (95% confidence level)
Uttar Pradesh	[85.9, 89.8] (95% confidence level)	[94, 100] (95% confidence level)

Limitations

Major limitations in the survey have risen because of the timing of the survey. The survey was conducted between the months of February to May 2021. At this time, India was severely affected by the novel coronavirus pandemic. Since the symptoms of respiratory illnesses targeted in this survey are very similar to symptoms of Covid-19, a certain reluctance in open and honest answers from the survey responders may be assumed. To decrease the level of discomfort, the surveyors were accompanied by local Government healthcare workers (ASHA workers). Though instructions were sent to the Local Governments and primary healthcare centres in all the selected villages, adequate support was not obtained in some States (West Bengal). This has led to certain limitations in the surveys. Another limitation is that the villages with low PMUY roll-out are not necessarily dependent on solid fuel for cooking. We have observed that the villages with low PMUY roll-out are also using LPG cylinders where the households are not 'below poverty line' and they are able to afford it themselves. This created a problem in choosing the control set. To solve this problem, further categories of chulha and LPG in the villages were made. Based on the field experiences of the surveyors, it was found that the respondents had felt difficulty in giving responses to the respiratory health-related questions This also led to a limitation in getting the precise perceptions of the respondents for the improvement in respiratory-related illnesses post LPG connection.

Key findings

The analysis of the survey results shows a clear influence of LPG connection with general health of the primary cooking person along with other members of the family. More than 40% of the LPG users have reported significant ($p<0.05$) improvement in the general health of the primary cooking person. Around 55% of the surveyed LPG users have reported a significant ($p<0.05$) decrease in the number of episodes of the respiratory illnesses in themselves and their family members post- LPG (PMUY) connections. Around 40% of the LPG users have also reported a decrease in the number of visits to doctors since using LPG as primary cooking fuel. Around 99% of the LPG users have reported less time spent cooking using LPG than other fuels. Similarly, 97% of the LPG users have reported ease of utensils cleaning after using PMUY LPG connection for cooking. The survey responses from Rajasthan, Bihar and Uttar Pradesh show a strong signal ($p<0.05$) for improvement using LPG, while the other three States show mild improvement.

After further analysis we have found that in three states (Rajasthan, Uttar Pradesh and Bihar), for the PMUY high village (high number of PMUY connection) when people are using LPG as primary source of cooking, their general health has improved by almost 50% more than in comparison with low PMUY villages. Regarding direct effect like reported respiratory problem, we have observed an average of 2 to 5 times more reported respiratory problems

in villages where PMUY connection is low compared with high PMUY villages for the above mentioned three states. For example, in Rajasthan, reported respiratory illness for PMUY high villages is only 1.2%, whereas for low connection villages it is 19.2%. For the States of Jharkhand and Madhya Pradesh, we have observed an improvement of 10%.

The quality of life of the people using PMUY LPG connections was found improving in terms of time spent for cooking, ease in utensils cleaning and daily usage of warm water since using PMUY LPG. Except Low_Chulha village, all respondents have reported lesser time spent for cooking and ease in utensils cleaning for all the studied states. Uttar Pradesh High_LPG_Primary have reported highest, i.e., ~30% increase in warm water usage while Madhya Pradesh High LPG Primary has reported only ~0.5% increase in usage of warm water since using PMUY LPG connections. The Out-of-pocket expenditure on care seeking was found to be decreased in terms ofchange in numbers of visits to doctor since using PMUY LPG. The highest ~88% decrease in visits to doctors was observed for Jharkhand High LPG Primary while lowest was reported Madhya Pradesh High LPG Primary Village.

The access to LPG cylinders and periodic refills of LPG cylinders was another important finding in this survey. More than 38% of the LPG users had refilled their LPG cylinders less than two times in the last six months. Around 6% of the LPG users have reported inconvenience, and 4% have reported availability issues in LPG cylinder refilling. More than 47% of the LPG users have reported refilling cost as a limiting factor for LPG cylinder refilling. In states like Rajasthan, over 90% of the respondents in the Low LPG village have indicated that they were getting their LPG refill from outside their village. This indicates a bottleneck in easy access to LPG refills. Also, the number of LPG refills undertaken by Low LPG villages is substantially less as compared to High LPG villages, indicating that households in those villages are not frequently refilling their LPG cylinders. These are challenges which need to be overcome as part of the PMUY scheme.

In terms of exposure of $PM_{2.5}$ particles to the primary cooking person, our low-cost sensor analysis data shows high PMUY connection villages' indoor environments have 10 to 20 percent less average exposure than the low connection village. This value becomes highly significant considering long-time exposure. The other confounders such as industrial emissions, crop/residue burning, indoor smoking and incense burning may have contributed indoor $PM_{2.5}$ concentrations in the studied houses along with the burning of cooking fuels. Therefore, only 10- 20 percent difference was observed in indoor $PM_{2.5}$ concentrations. A small-scale study may further be carried out to characterize the contribution of individual indoor sources and the contribution from cooking flues to indoor air pollution may be assess.

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Conclusion and Recommendations

The analysis of the PMUY survey conducted as a part of this project clearly demonstrates the health benefits of using LPG cooking fuel distributed under PMUY to the household respondents, especially to the primary cooking persons. The low-cost sensor data from the households also shows that air quality levels were nearly 2x improved during cooking hours in households with LPG cylinder as compared to Low LPG and Chulha households. Both the survey and air quality monitoring data clearly point to the significantly large benefits to health and well-being of PMUY beneficiaries.

The PMUY scheme launched in 2016 provided LPG connections to 5 crore women members of BPL households which was expanded to 8 crore households in August 2019. The benefits from that are clearly evident in the results presented here. The PMUY 2.0 launched in the 2021-22 budget aims to expand the coverage and reach of the distribution by another one crore households.

This evaluation of PMUY beneficiaries in 6 states of India has quantified the survey-based health benefits between Low Chulha villages and High and Low LPG villages. This study strongly recommends the following:

- Encourage LPG cylinder refills to existing PMUY beneficiaries by demonstrating the health and air quality benefits of using LPG cylinders via health survey metrics shown in this evaluation study.
- Build easier access to LPG cylinders within the village to relieve PMUY beneficiaries from having to travel long distances to get their cylinders refilled.
- Conducting periodic monitoring and evaluation of health and air quality benefits of new PMUY beneficiary households to understand the "before and after" impact of the PMUY scheme and to build a stronger framework for evaluation of the scheme.
- Display of air quality data from households with LPG cylinders and Chulha to encourage behavioural changes in PMUY beneficiaries for continued refill of LPG cylinders.
- Utilizing community-based platforms like Village Health, Sanitation and Nutrition Committee (VHSNC) and Jan Arogya Samitis to generate awareness on health benefits using LPG.
- Community based fora and existing community mobilization activities may also be used for dissemination of information on PMUY scheme and entitlements.

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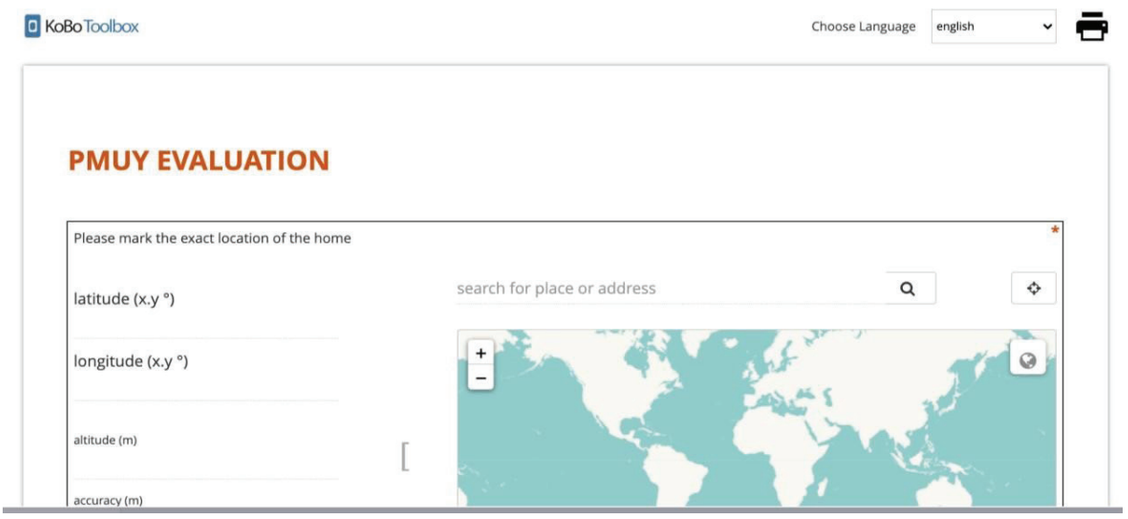
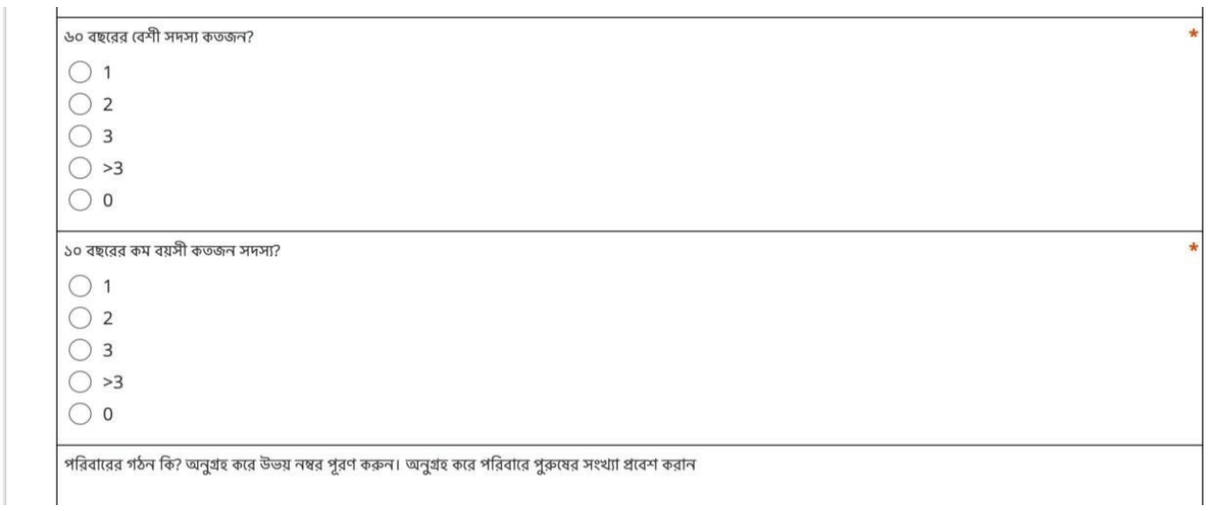
APPENDIX A

SURVEY APP

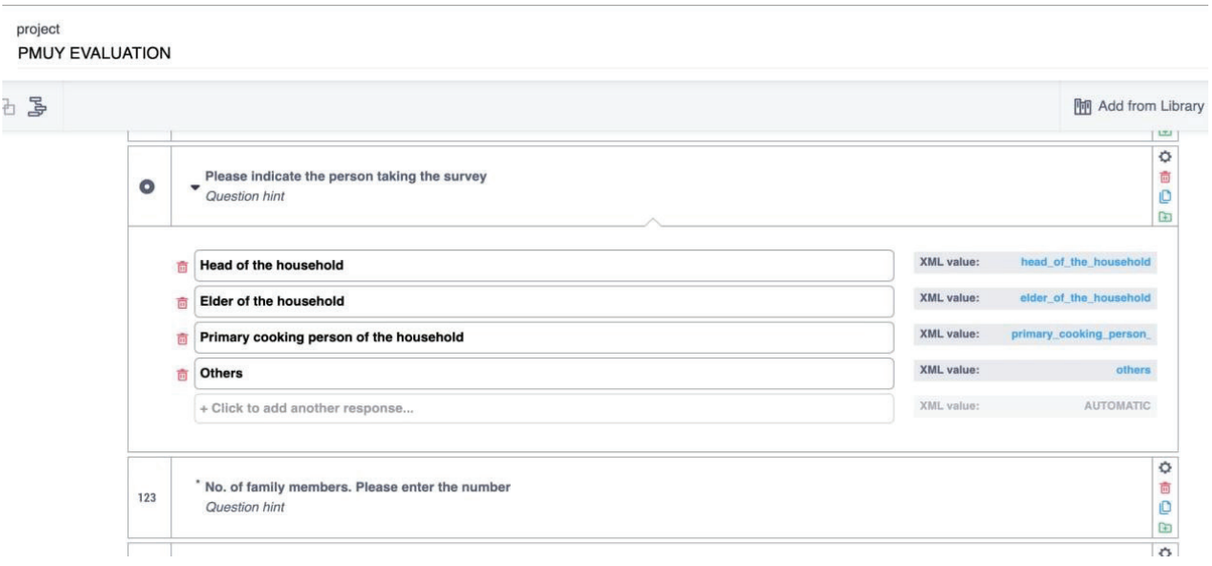


PMUY Forms. We can select form in three languages from top right

PMUY Form in Hindi



PMUY Form in Bengali



Types of Question

The workflow for field survey data collection would involve the following:

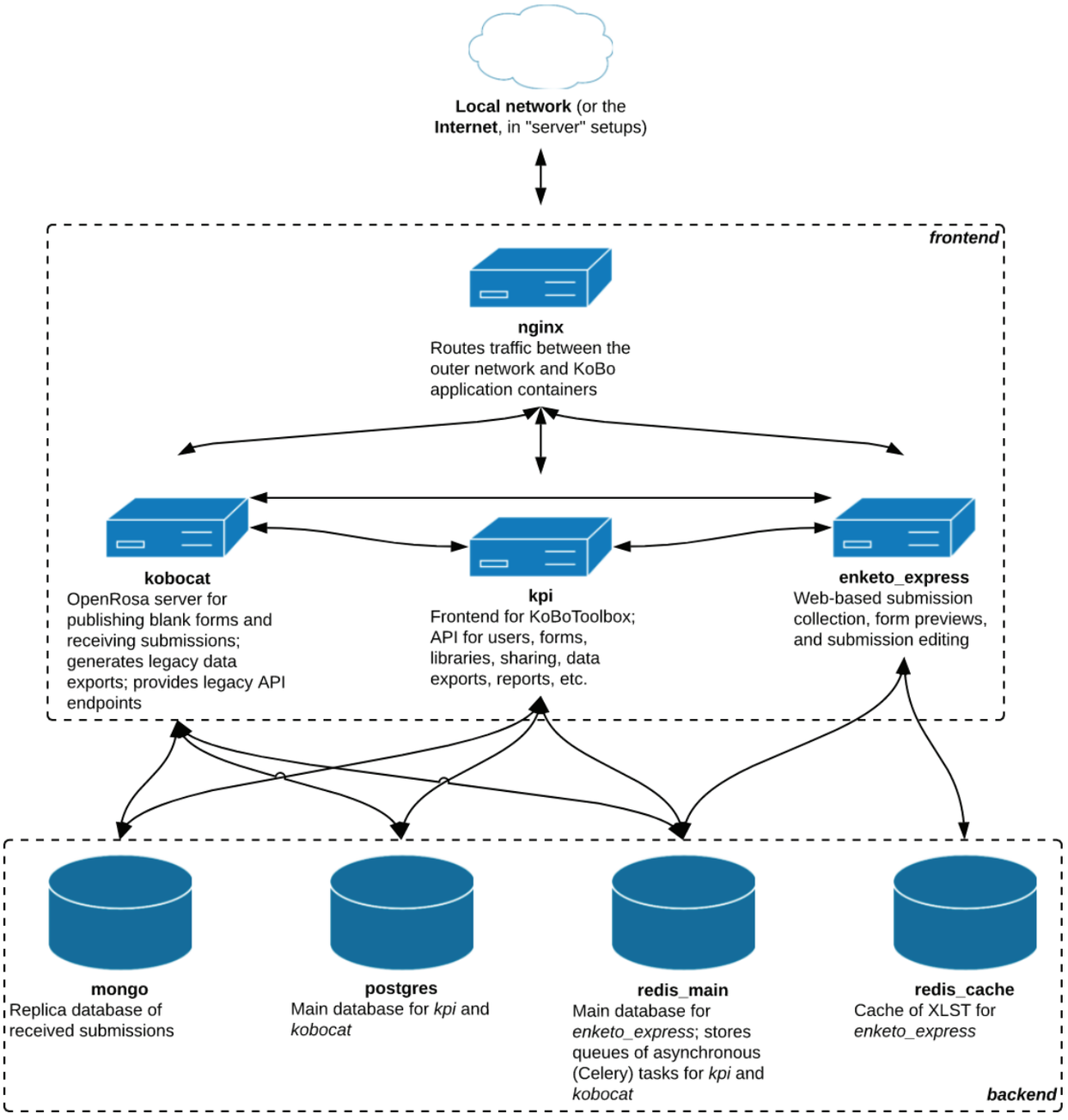
1) Download a questionnaire for data collection, which is available for offline use.
2) Collect the data, even if device is offline.
3) Submit collected data (when the survey device comes online) to a cloud connected server.
4) Validate data consistency and provide real time graphs and analytics of the survey on daily basis.

For accessing PMUY Survey app in phone -

1) Download survey app https://play.google.com/store/apps/details?id=org.koboc.collect.android&hl=en
2) Click on to open settings.
3) Enter the server URL and your username and password.
4) Open "Get Blank Form" and select the 'PMUY EVALUATION' project.

State ▾ Name of Village, block and District ▾

State	Name of Village, block and District	PMUY Classification	Survey Count ▾
Uttar Pradesh	Hardatt Nagar Giant (Shrawasti), UP	High	205
Bihar	Gaiaspur Krauta Patna	Low	168
Madhya Pradesh	Sidhi (Hanumangarh)	High	160
Uttar Pradesh	Raunija, Jewar, Gautam Buddha Nagar	Low	152
Rajasthan	Ramsinghpura, Jaipur	Low	145
Bihar	Basmati, Araria	High	130
Jharkhand	Kachanpur, Garhwa	High	125
Jharkhand	Lupung, Ranchi	Low	123
Madhya Pradesh	Nolana, Depalpur, Indore	Low	122
West Bengal	Uttar Dinajpur, Birghai	High	83
West Bengal	North24porgona,rajarhat	Low	83
		Grand total	**1,496**

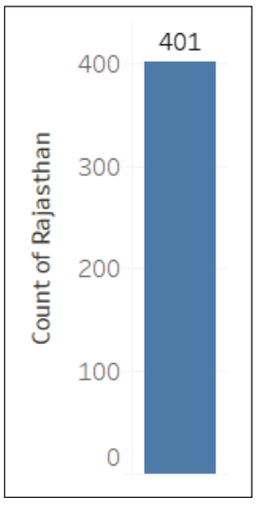

Local network (or the Internet, in "server" setups)
frontend
nginx
Routes traffic between the outer network and KoBo application containers
kobocat
OpenRosa server for publishing blank forms and receiving submissions; generates legacy data exports; provides legacy API endpoints
kpi
Frontend for KoBoToolbox; API for users, forms, libraries, sharing, data exports, reports, etc.
enketo_express
Web-based submission collection, form previews, and submission editing
mongo
Replica database of received submissions
postgres
Main database for kpi and kobocat
redis_main
Main database for enketo_express; stores queues of asynchronous (Celery) tasks for kpi and kobocat
redis_cache
Cache of XLST for enketo_express
backend

Survey Analysis Methodology

- Handling Multiple Choice Question Options as per priority
- Handling Multiple Choice Question Options as per priority
- Summarizing Survey Responses
- Identifying Applicable Health Questions
- Summarizing Survey Responses for classifications
- Summary of Inferences drawn for the state

Classification for Rajasthan

Total Responses

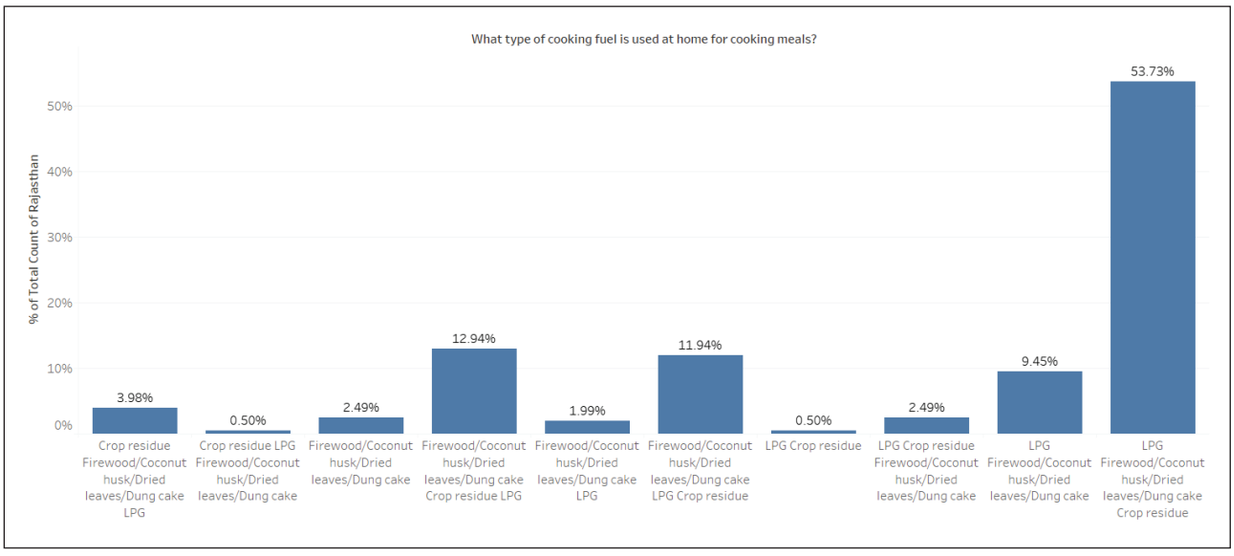


Type	What type of cooking fuel is used at home for cooking meals?/LPG 0	1
High	2.49%	97.51%
Low	42.50%	57.50%

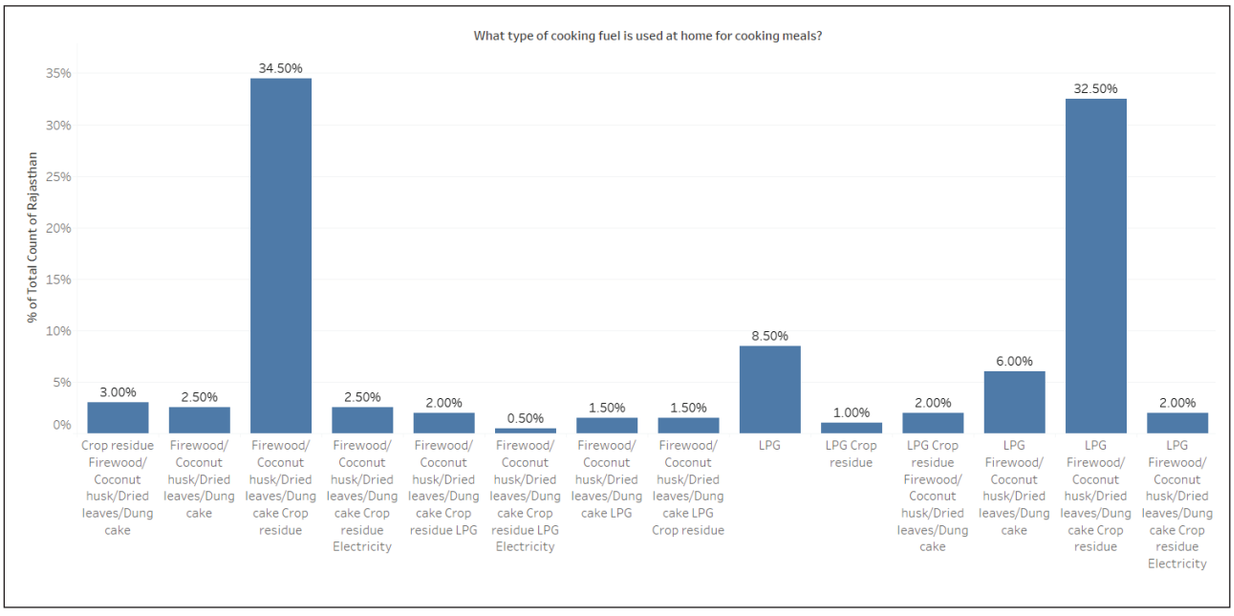
Thus,

- Rajasthan High can be classified as,
- **Rajasthan High LPG Primary Village**
- **Rajasthan High LPG Secondary Village**
- Rajasthan Low can be classified into,
- **Rajasthan Low LPG Village**
- **Rajasthan Low Chulha Village**

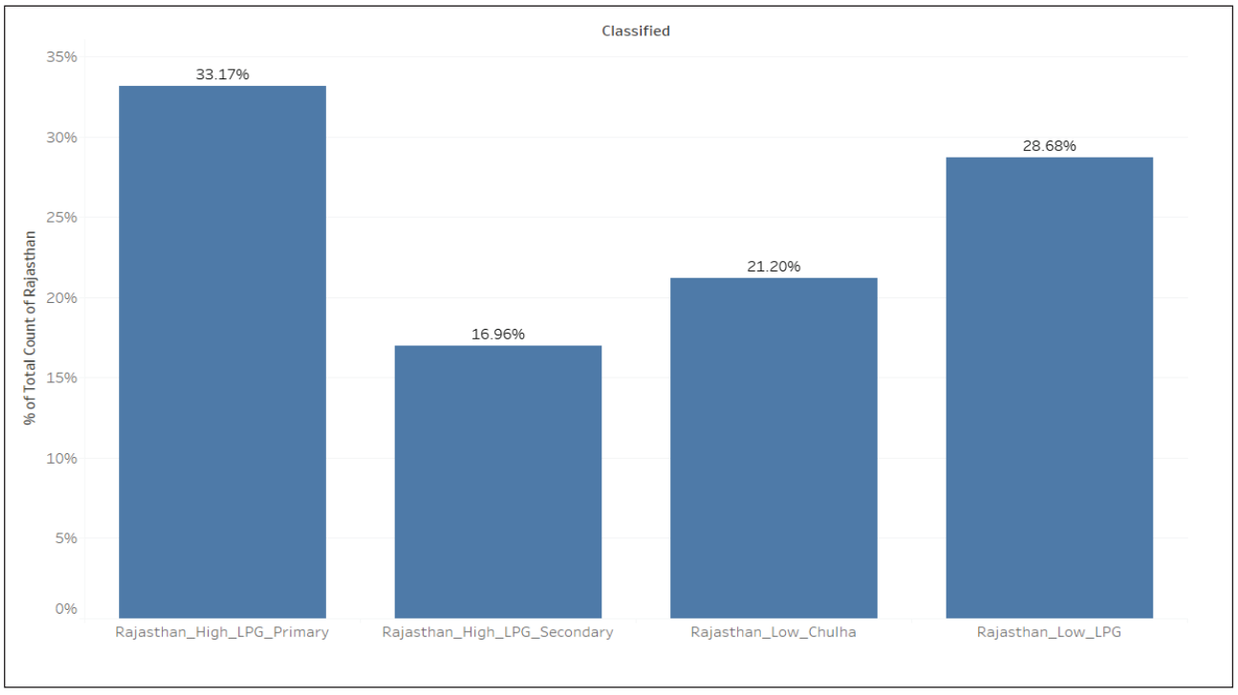
Rajasthan High Village



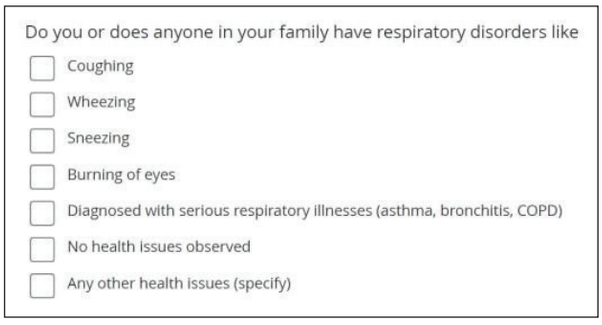
Rajasthan Low Village



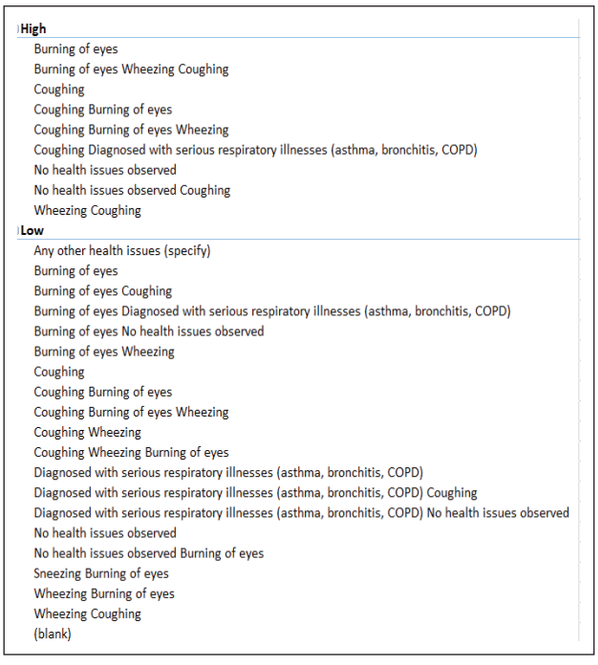
After Classification



Respiratory Disease Combination

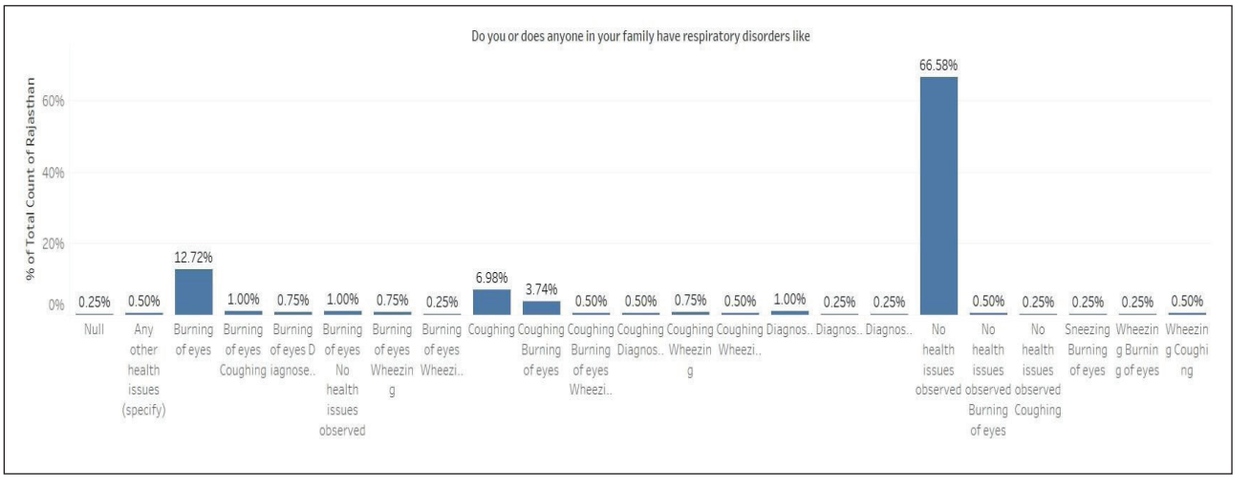


Respiratory Disorder	Priority
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)	1
Coughing	2
Wheezing	3
Sneezing	4
Burning of Eyes	5

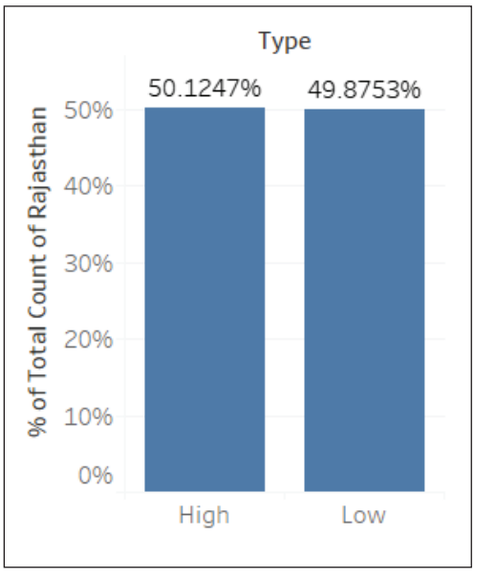


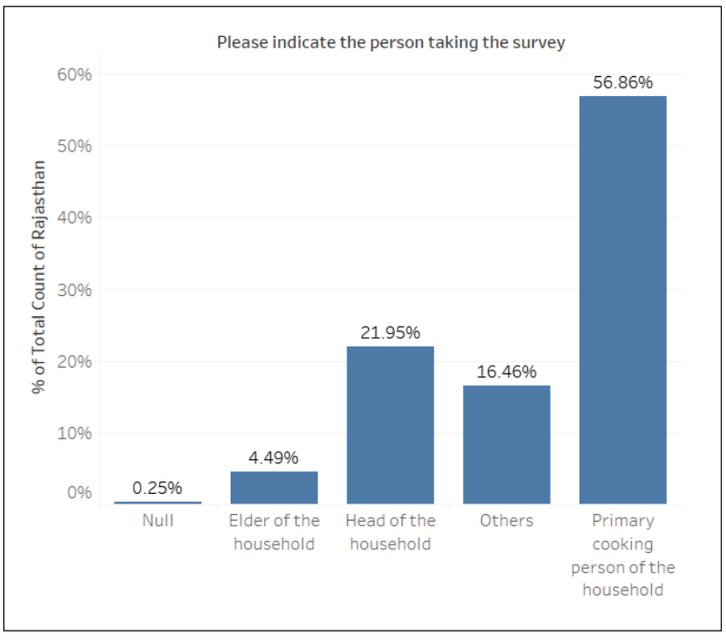
- For Any other + Illness: Take illness
- For None + Illness: Take Illness

Respiratory Disease Combination



Summarizing Survey Responses

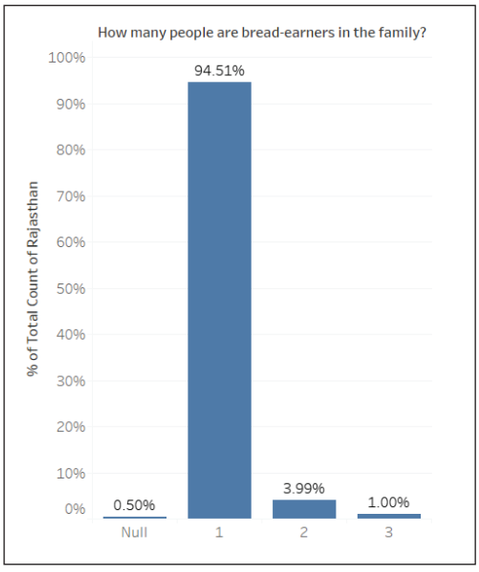




Summarizing Survey Responses

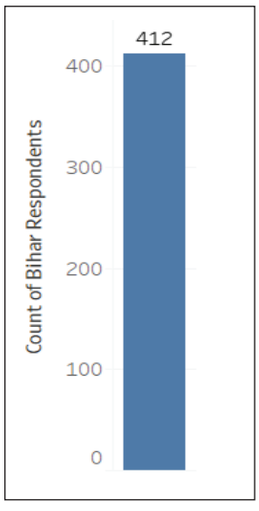
Who is the primary person cooking food for the family?	
Null	0.50%
The Man	0.75%
The Woman	98.75%

No. of family members. Please enter the number	
1	0.50%
2	3.24%
3	5.99%
4	20.70%
5	25.94%
6	17.96%
7	11.97%
8	6.73%
9	2.49%
10	1.25%
11	1.25%
12	1.00%
13	0.50%
14	0.25%
15	0.25%



Classification for Bihar

Total Responses

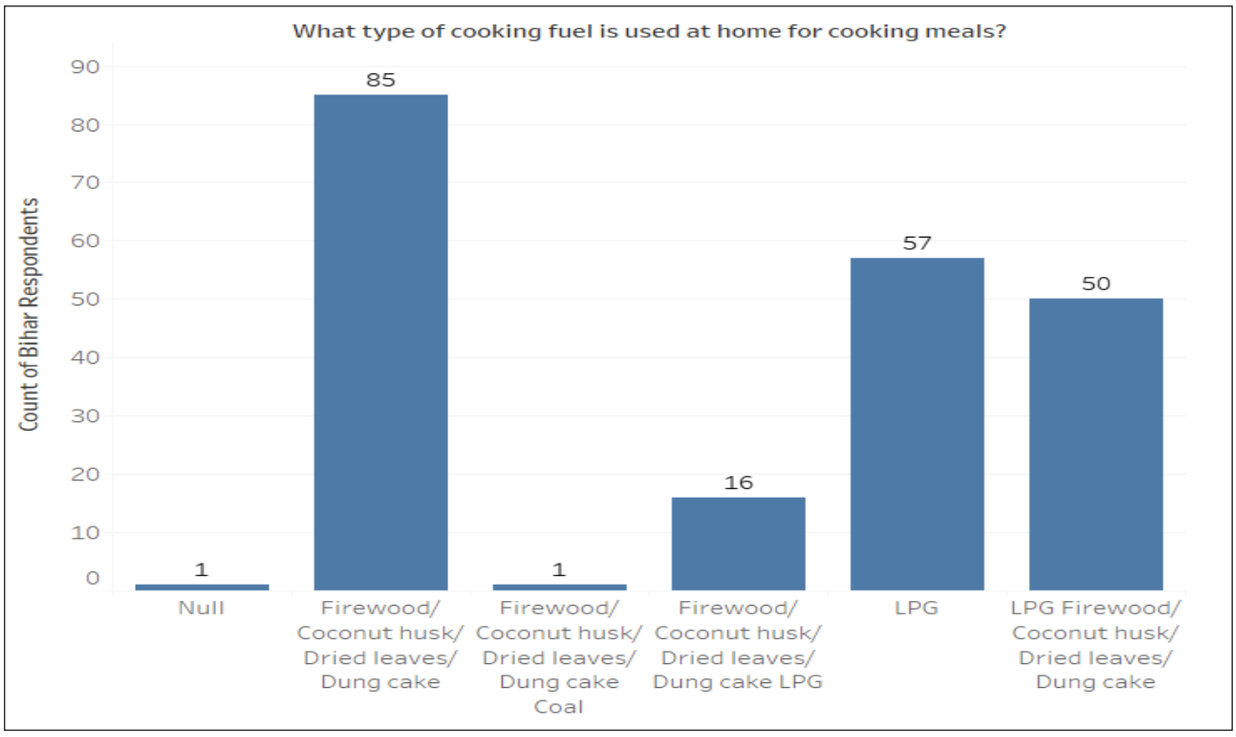


What type of cooking fuel is used at home for cooking meals?/LPG			
Type	Null	0	1
High	0.48%	40.95%	58.57%
Low	0.99%	57.92%	41.09%

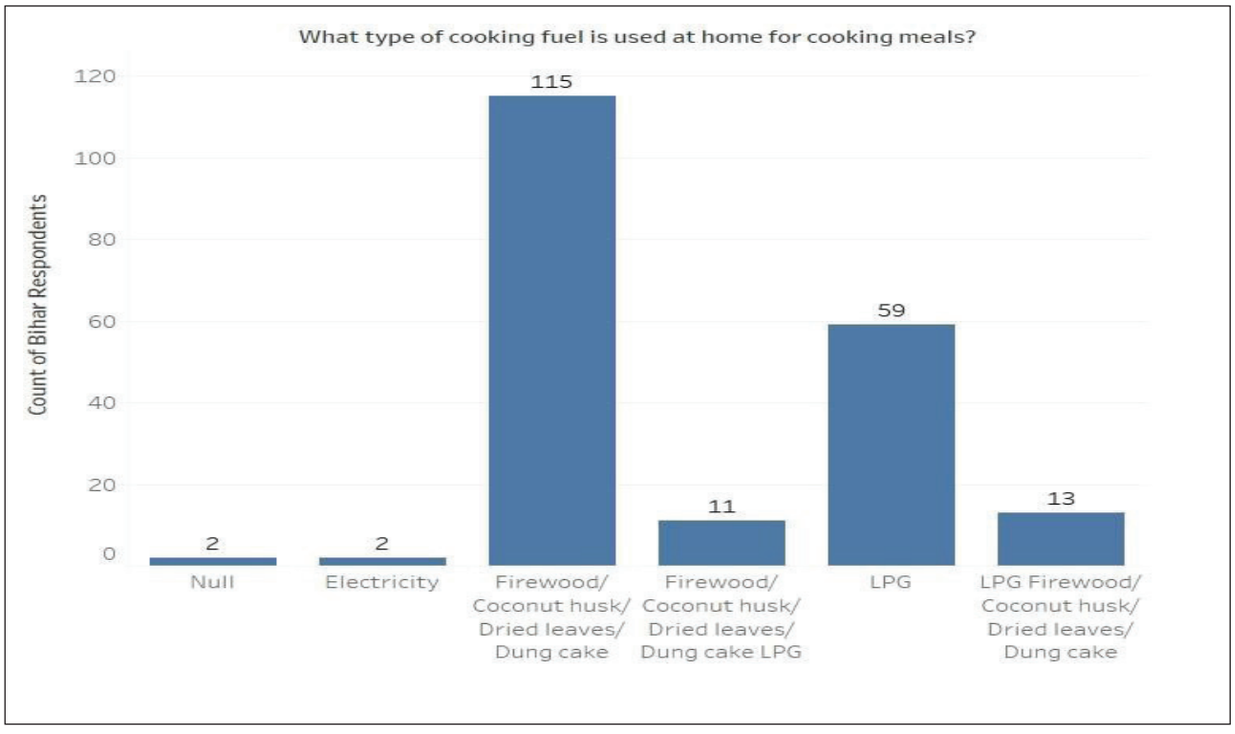
Thus,

- Bihar High can be classified as,
- **Bihar High LPG Primary Village**
- **Bihar High LPG Secondary Village**
- Bihar High Chulha Village
- **Bihar Low can be classified into,**
- **Bihar Low LPG Village**
- **Bihar Low Chulha Village**

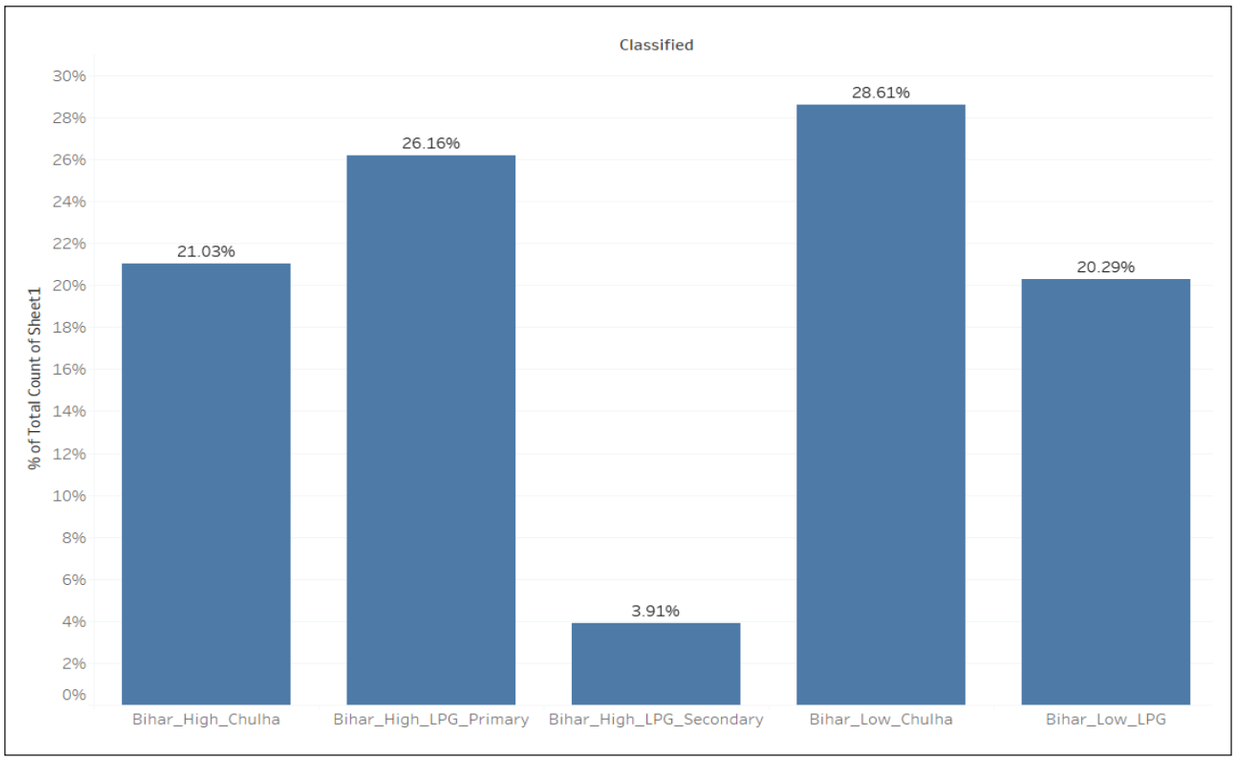
Bihar High Village



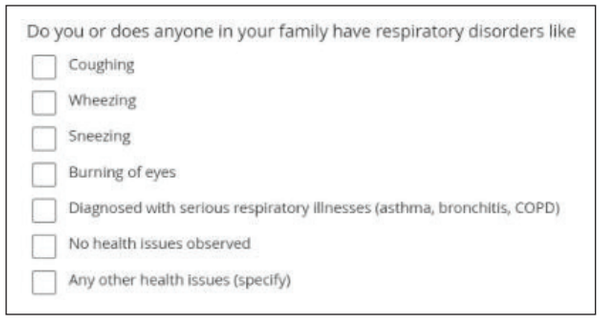
Bihar Low Village



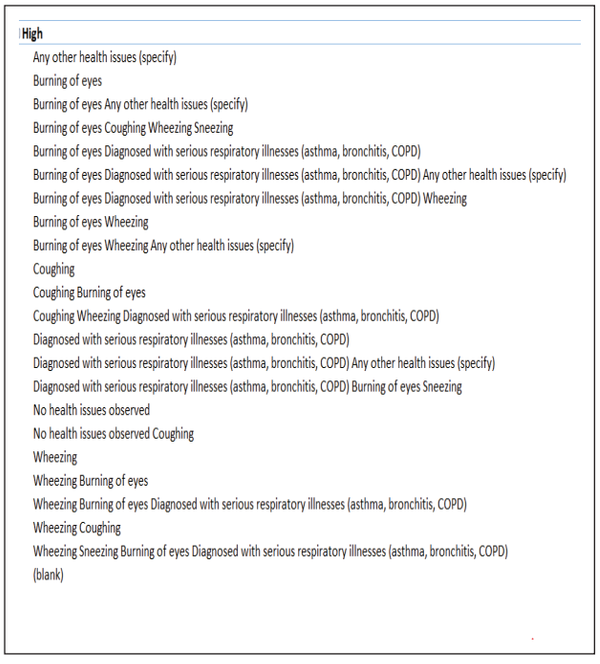
After Classification



Respiratory Diseases Combination

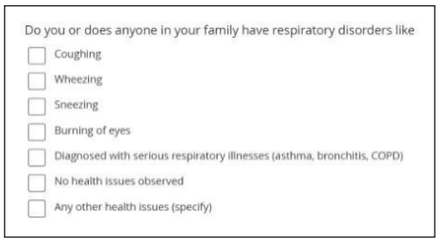


Respiratory Disorder	Priority
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)	1
Coughing	2
Wheezing	3
Sneezing	4
Burning of Eyes	5



- For Any other + Illness: Take illness
- For None + Illness: Take Illness

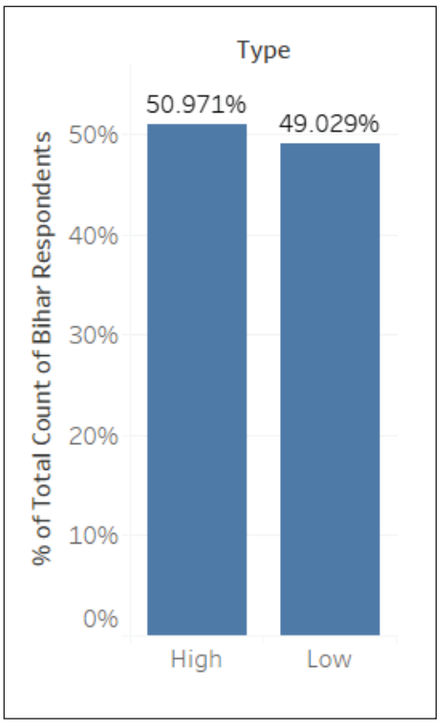
Summarizing Survey Responses

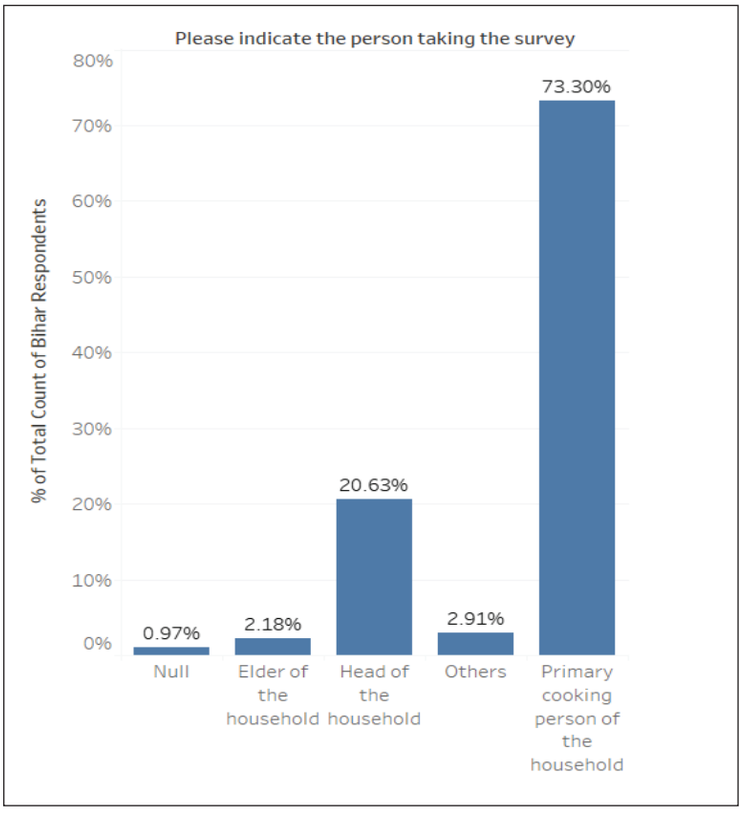


Respiratory Disorder	Priority
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)	1
Coughing	2
Wheezing	3
Sneezing	4
Burning of Eyes	5

- For Any other + Illness: Take illness
- For None + Illness: Take Illness

Summarizing Survey Responses

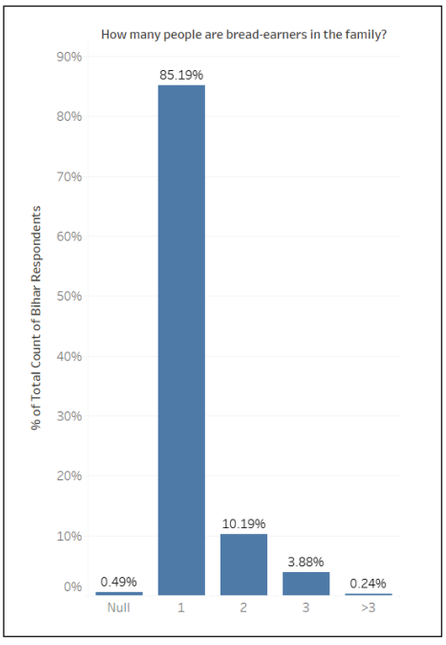




Summarizing Survey Responses

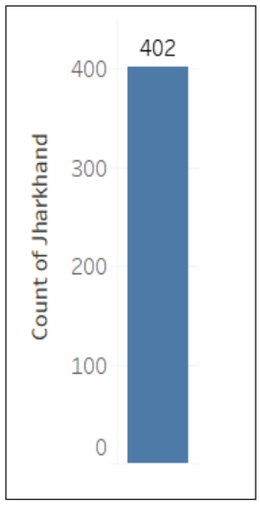
Who is the primary person cooking food for the family?	
Null	0.49%
The Man	1.46%
The Woman	98.06%

No. of family members. Please enter the number	
1	0.49%
2	6.07%
3	7.52%
4	17.96%
5	23.06%
6	19.42%
7	13.11%
8	7.28%
9	1.21%
10	1.70%
11	0.49%
12	0.24%
14	0.49%
15	0.49%
16	0.24%
19	0.24%



Classification for Jharkhand

Total Responses

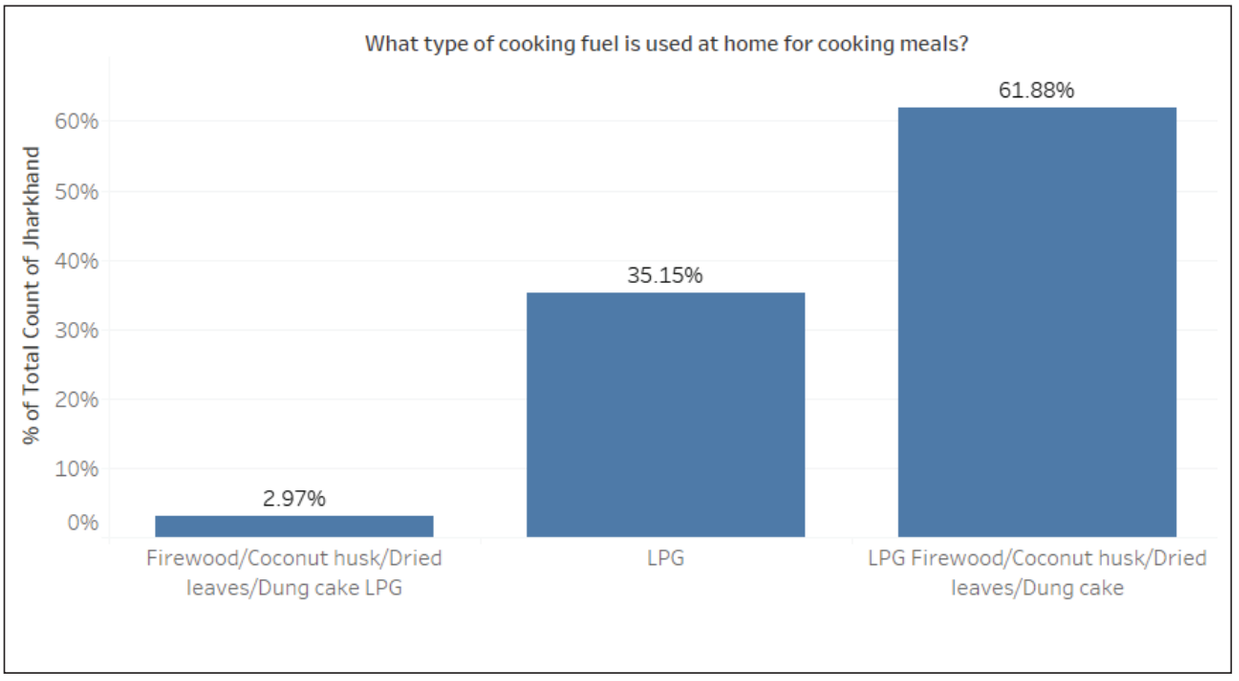


What type of cooking fuel is used at home for cooking meals?/LPG			
Type	Null	0	1
High			100.00%
Low	1.50%	17.50%	81.00%

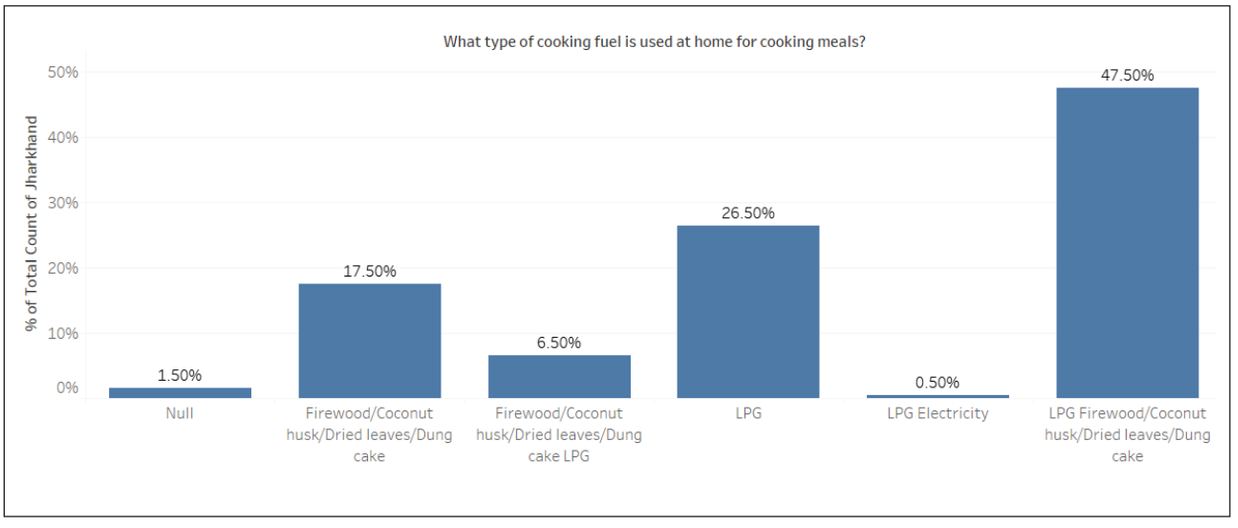
Thus,

- Jharkhand High can be classified as,
- **Jharkhand High LPG Primary Village**
- **Jharkhand High LPG Secondary Village**
- Jharkhand Low can be classified into,
- **Jharkhand Low LPG Village**
- **Jharkhand Low Chulha Village**
- **Jharkhand Low LPG Chulha Village**

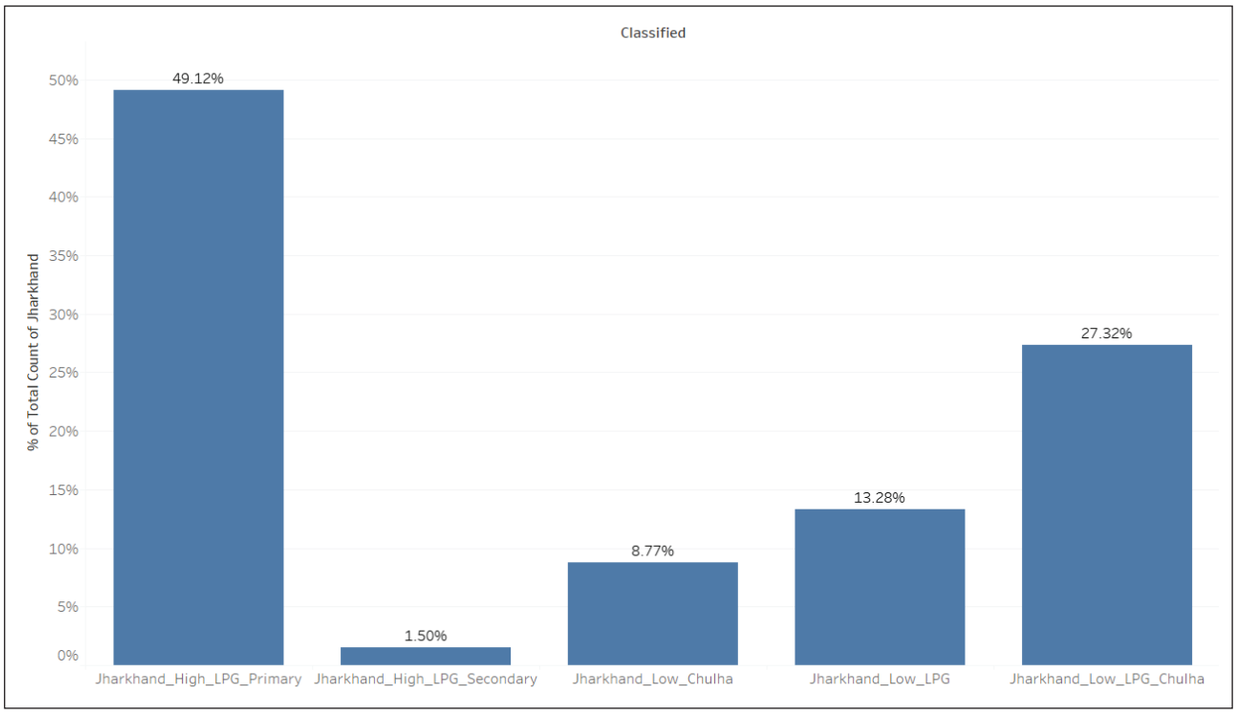
Jharkhand High



Jharkhand Low



After Classification



Respiratory Disease: Combination

Do you or does anyone in your family have respiratory disorders like

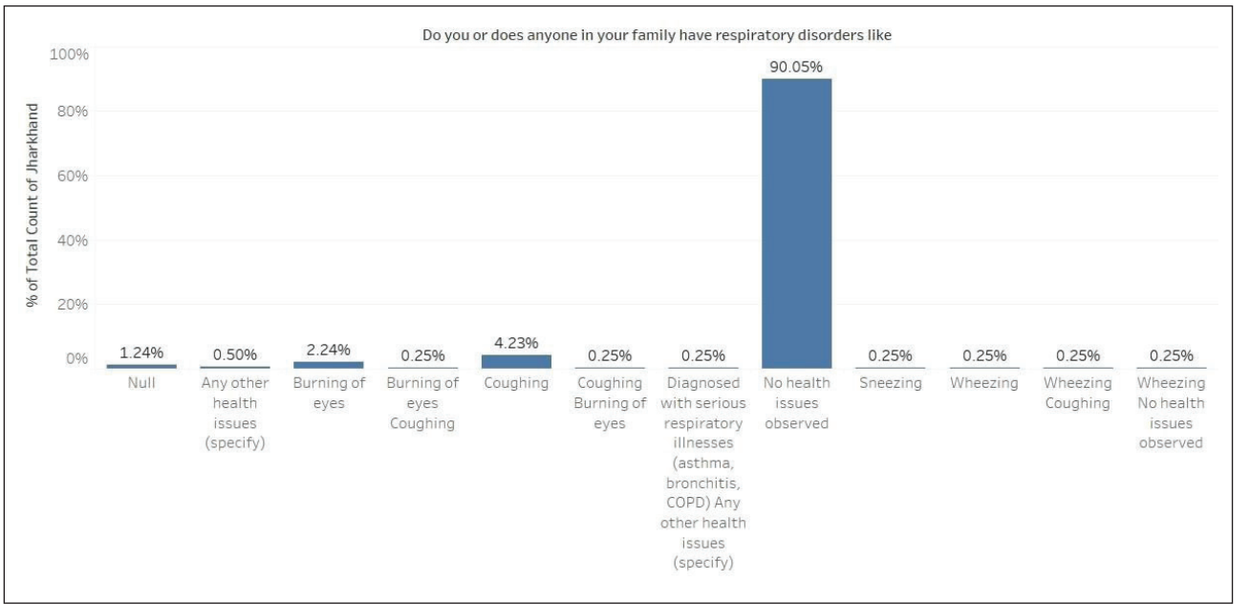
- ☐ Coughing
- ☐ Wheezing
- ☐ Sneezing
- ☐ Burning of eyes
- ☐ Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- ☐ No health issues observed
- ☐ Any other health issues (specify)

Respiratory Disorder	Priority
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)	1
Coughing	2
Wheezing	3
Sneezing	4
Burning of Eyes	5

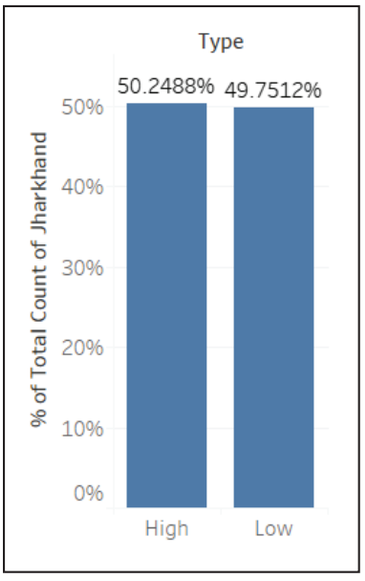
High
- Any other health issues (specify)
- Burning of eyes
- Coughing
- No health issues observed
- Wheezing
- Wheezing Coughing

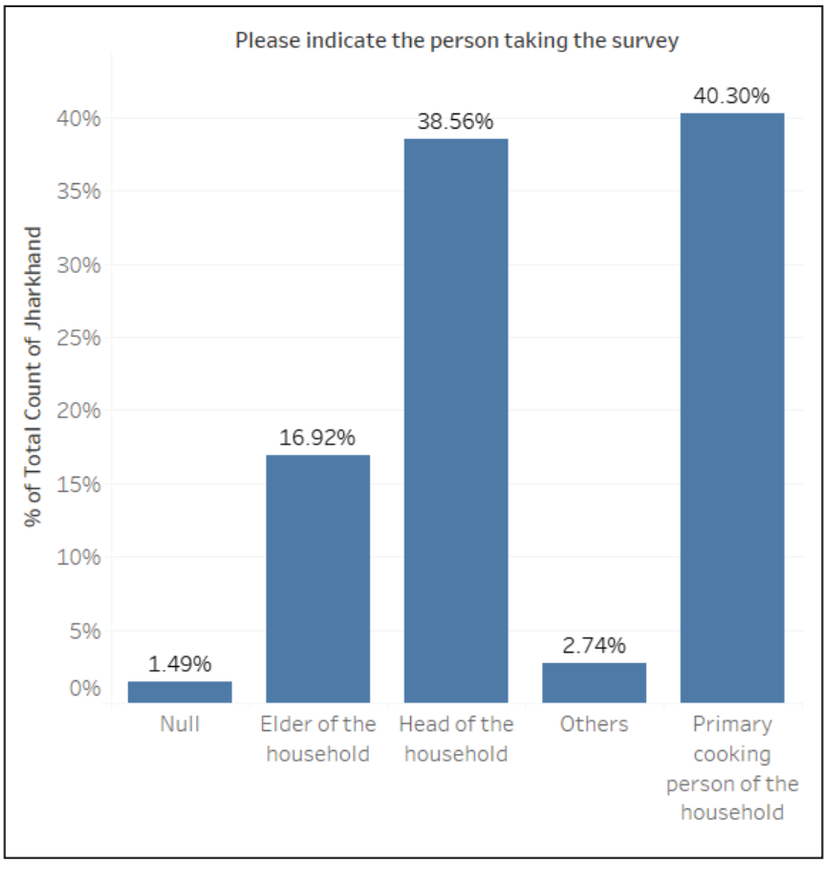
Low
- Any other health issues (specify)
- Burning of eyes
- Burning of eyes Coughing
- Coughing
- Coughing Burning of eyes
- Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD) Any other health issues (specify)
- No health issues observed
- Sneezing
- Wheezing No health issues observed
- (blank)

Respiratory Diseases



Summarizing Survey Responses

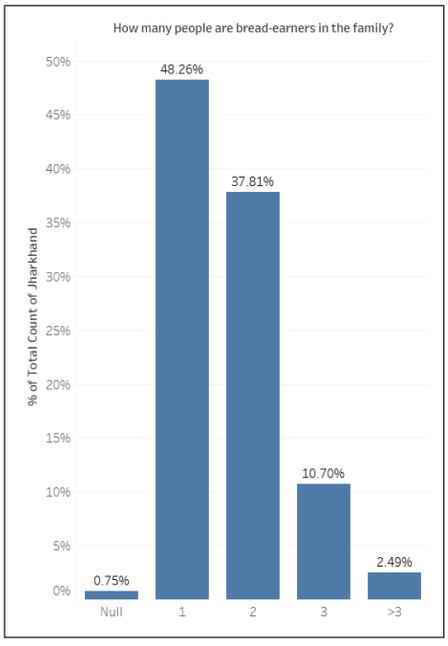




Summarizing Survey Responses

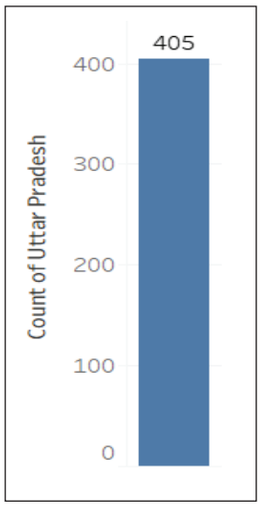
Who is the primary person cooking food for the family?	
Null	0.25%
The Man	0.25%
The Woman	99.50%

No. of family members. Please enter the number	
1	1.49%
2	5.97%
3	7.21%
4	20.40%
5	23.38%
6	17.66%
7	10.20%
8	6.97%
9	1.99%
10	1.74%
11	1.24%
12	0.50%
13	0.50%
14	0.50%
17	0.25%



Classification for Uttar Pradesh

Total Responses



What type of cooking fuel is used at home for cooking meals?/LPG		
Type	0	1
High	0.49%	99.51%
Low	13.00%	87.00%

Thus,

- UP High can be classified as,
- **UP High LPG Primary Village**
- **UP High LPG Secondary Village**
- UP Low can be classified into,
- **UP Low LPG Chulha Village**
- **UP Low Chulha Village**

Fuel Type: Responses Combination

Question:

What type of cooking fuel is used at home for cooking meals?

- [ ] LPG
- [ ] Firewood/Coconut husk/Dried leaves/Dung cake
- [ ] Crop residue
- [ ] Kerosene
- [ ] Coal
- [ ] Electricity
- [ ] Any other

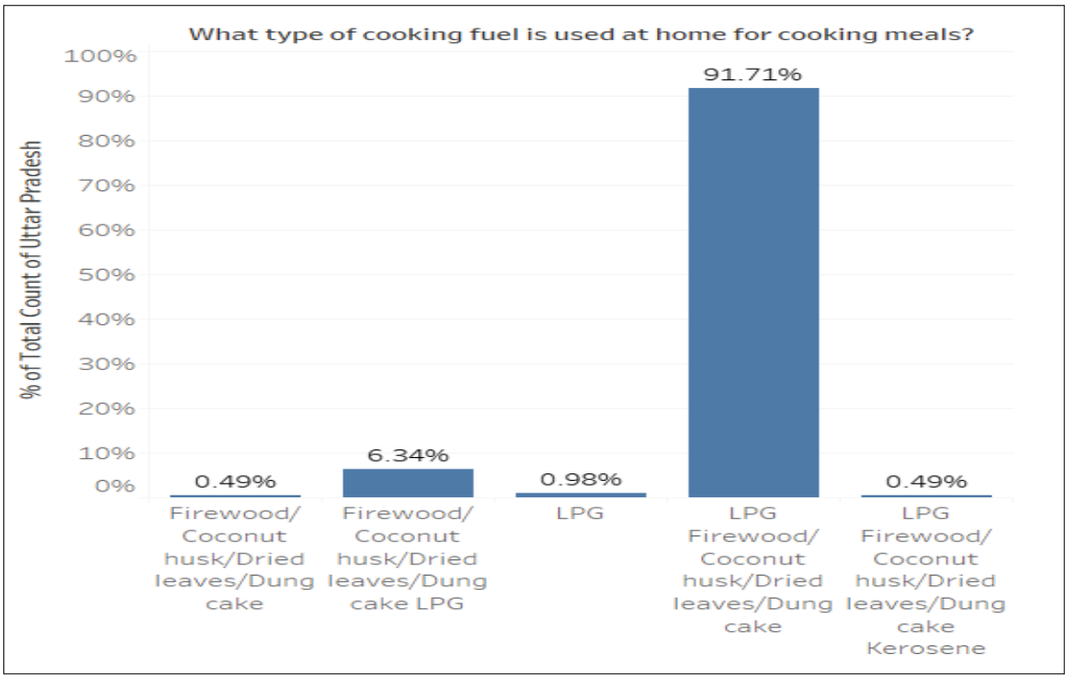
High

- Firewood/Coconut husk/Dried leaves/Dung cake
- Firewood/Coconut husk/Dried leaves/Dung cake LPG
- LPG
- LPG Firewood/Coconut husk/Dried leaves/Dung cake
- LPG Firewood/Coconut husk/Dried leaves/Dung cake Kerosene

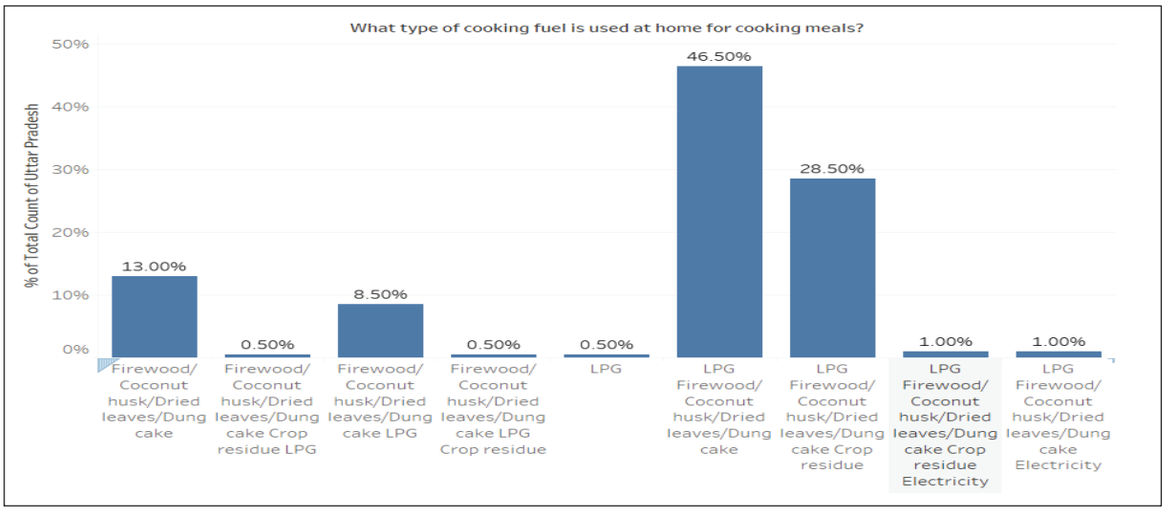
Low

- Firewood/Coconut husk/Dried leaves/Dung cake
- Firewood/Coconut husk/Dried leaves/Dung cake Crop residue LPG
- Firewood/Coconut husk/Dried leaves/Dung cake LPG
- Firewood/Coconut husk/Dried leaves/Dung cake LPG Crop residue
- LPG
- LPG Firewood/Coconut husk/Dried leaves/Dung cake
- LPG Firewood/Coconut husk/Dried leaves/Dung cake Crop residue
- LPG Firewood/Coconut husk/Dried leaves/Dung cake Crop residue Electricity
- LPG Firewood/Coconut husk/Dried leaves/Dung cake Electricity

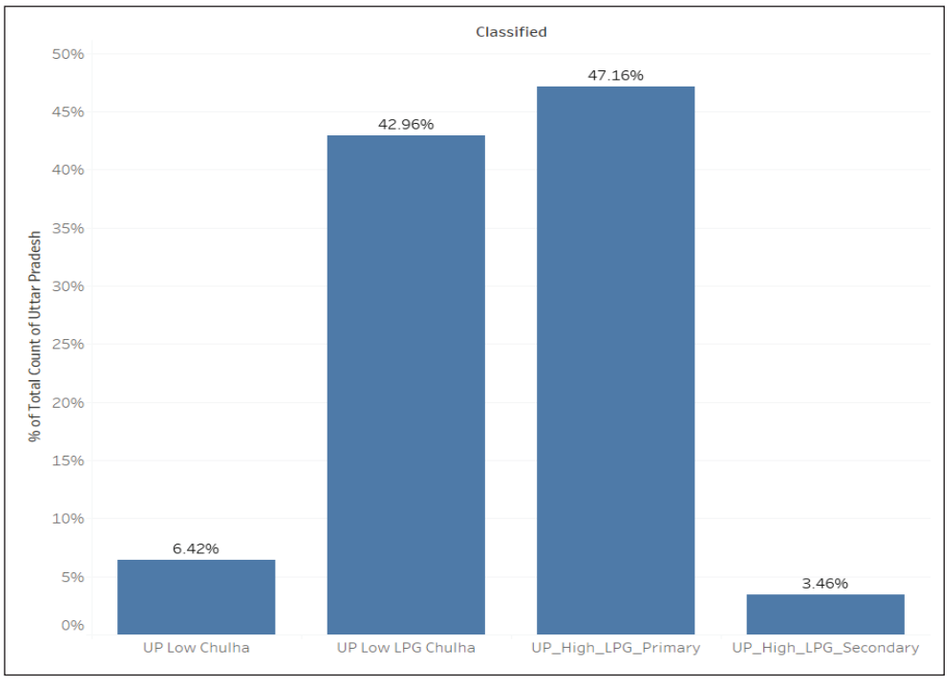
UP High Village



UP Low Village



After Classification



Respiratory Disease Combination

Do you or does anyone in your family have respiratory disorders like

- ☐ Coughing
- ☐ Wheezing
- ☐ Sneezing
- ☐ Burning of eyes
- ☐ Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- ☐ No health issues observed
- ☐ Any other health issues (specify)

Respiratory Disorder	Priority
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)	1
Coughing	2
Wheezing	3
Sneezing	4
Burning of Eyes	5

- For Any other + Illness: Take illness
- For None + Illness: Take Illness

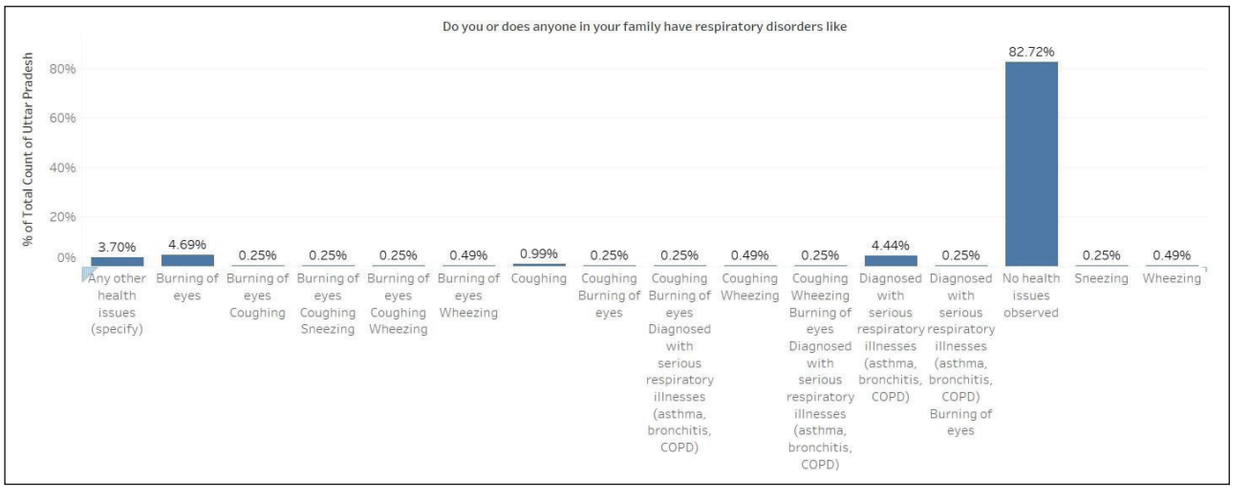
High

- Any other health issues (specify)
- Burning of eyes
- Burning of eyes Coughing
- Burning of eyes Coughing Sneezing
- Burning of eyes Coughing Wheezing
- Burning of eyes Wheezing
- Coughing
- Coughing Burning of eyes Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- Coughing Wheezing Burning of eyes Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD) Burning of eyes
- No health issues observed
- Wheezing

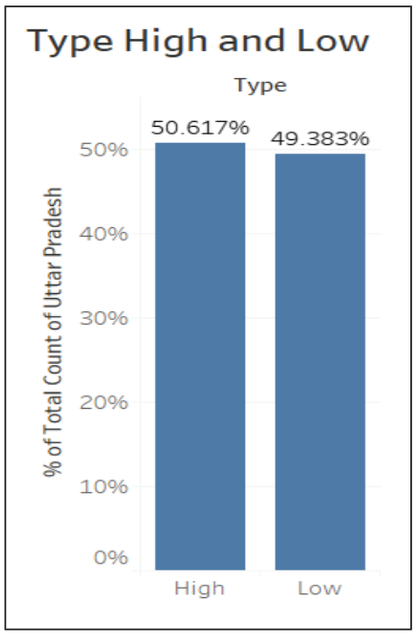
Low

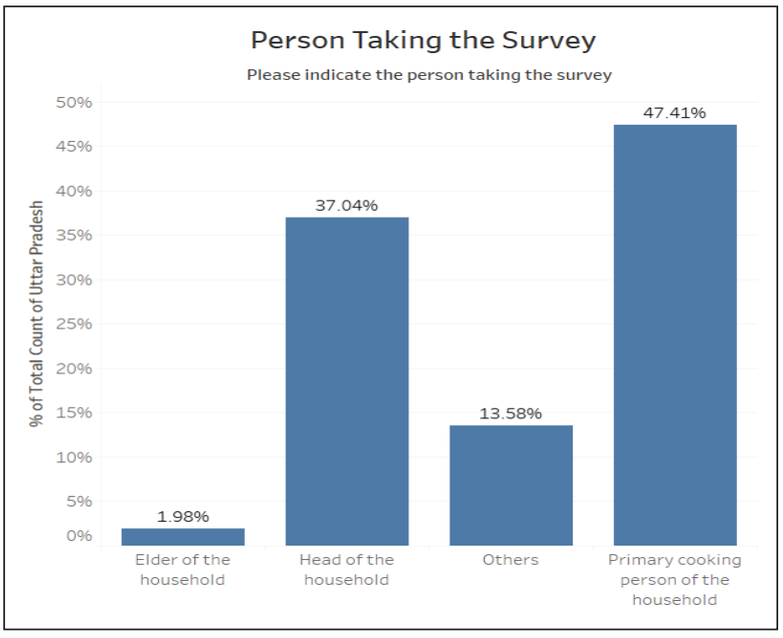
- Any other health issues (specify)
- Burning of eyes
- Coughing
- Coughing Burning of eyes
- Coughing Wheezing
- Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- No health issues observed
- Sneezing
- Wheezing

Respiratory Disease

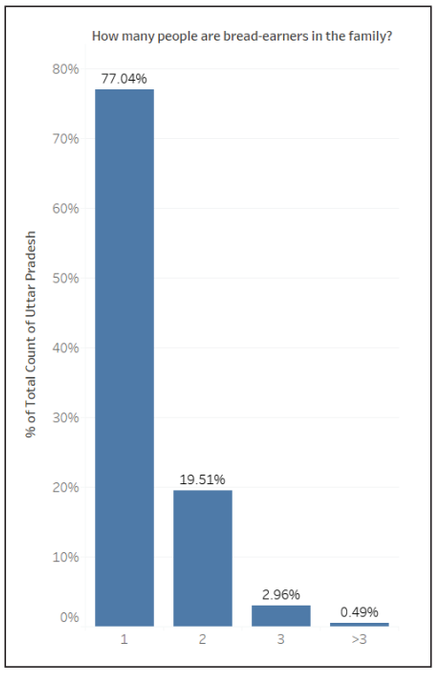


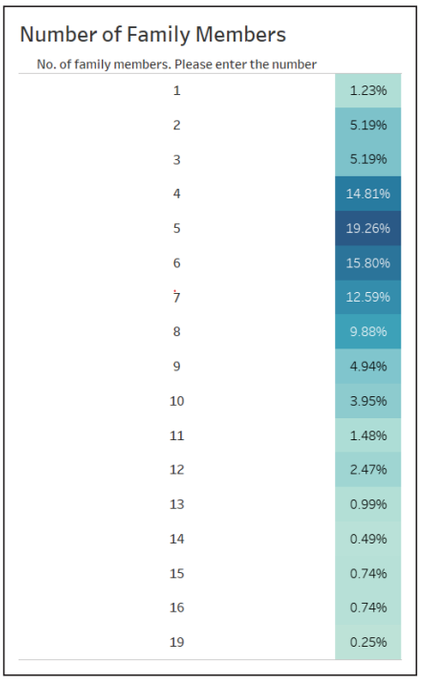
Respiratory Disease Combination

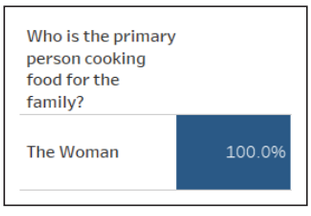




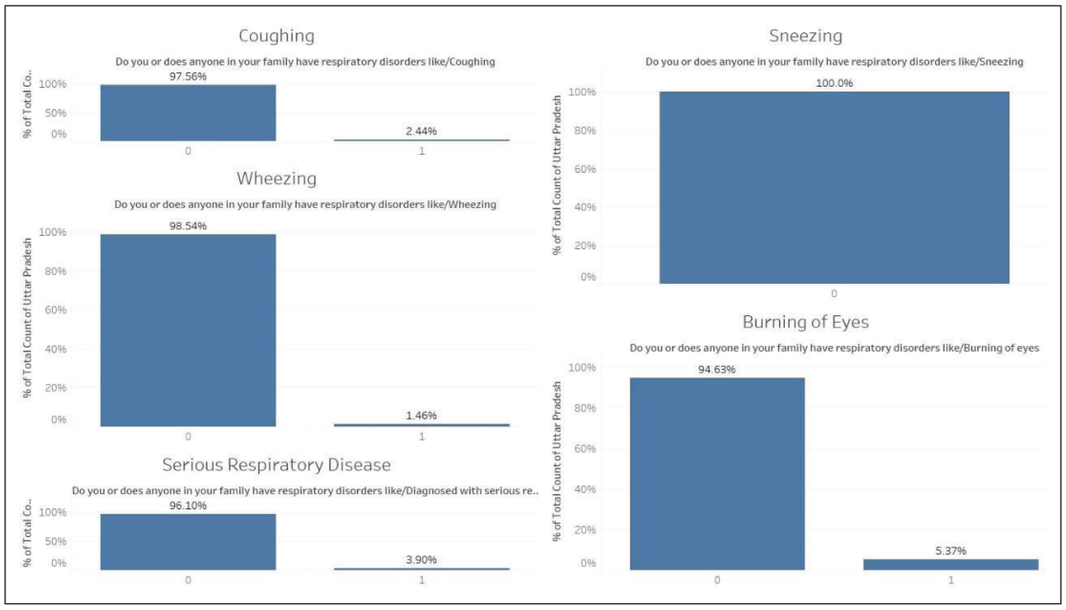
Respiratory Disease



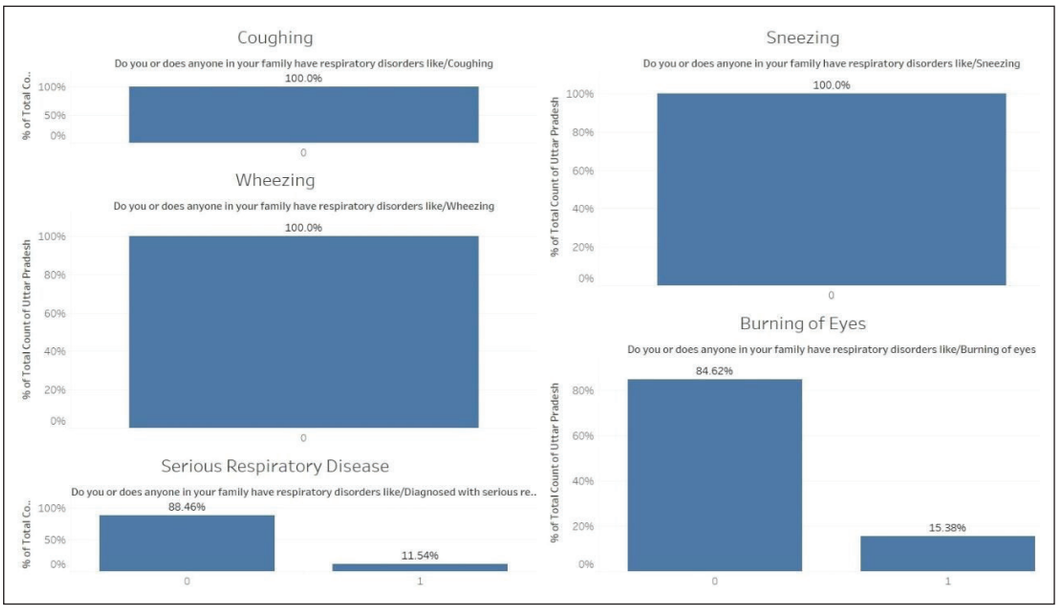




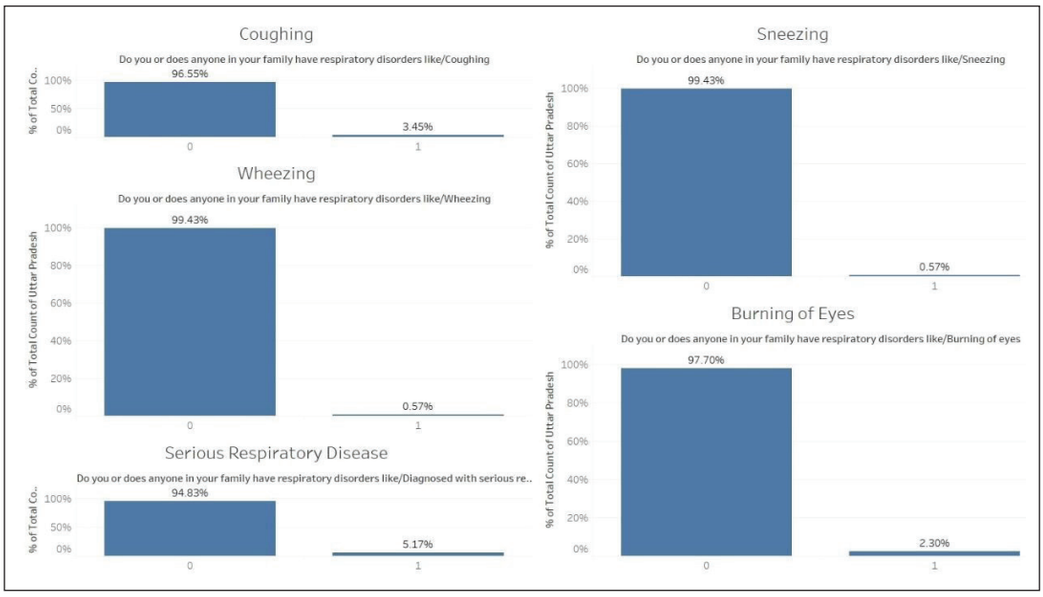
Respiratory Diseases in Uttar Pradesh High LPG



Respiratory Diseases in Uttar Pradesh Low Chulha

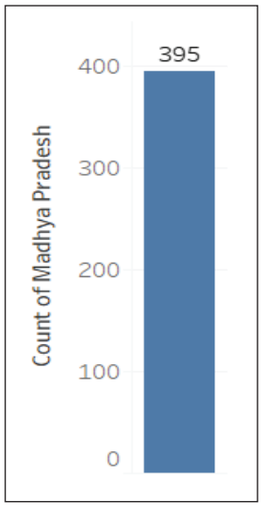


Respiratory Diseases in Uttar Pradesh Low LPG Chulha



Classification for Madhya Pradesh

Total Responses



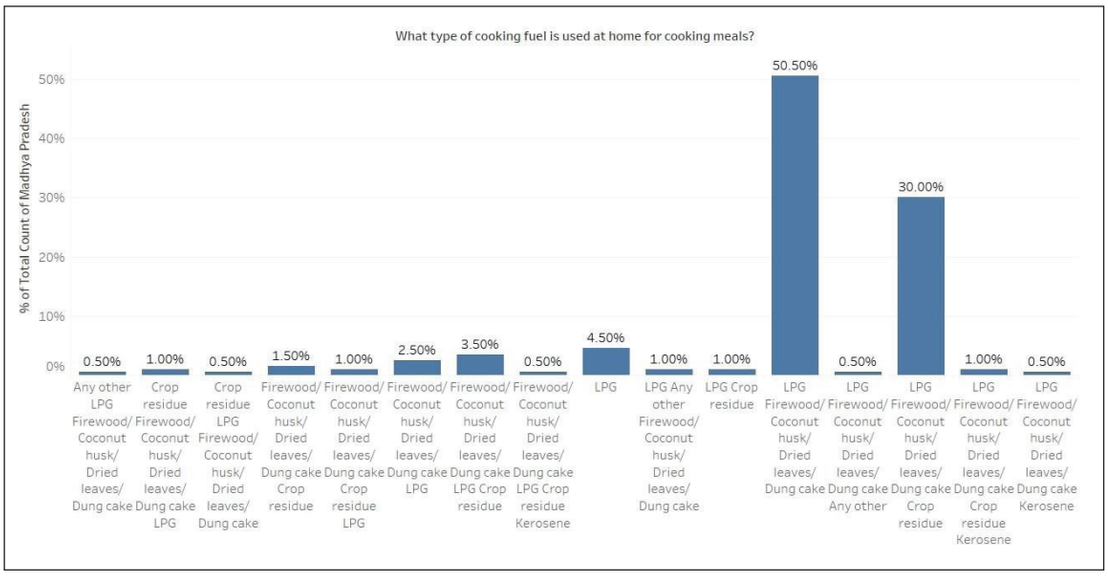
What type of cooking fuel is used at home for cooking meals?/LPG

Type	0	1
High	1.50%	98.50%
Low	23.08%	76.92%

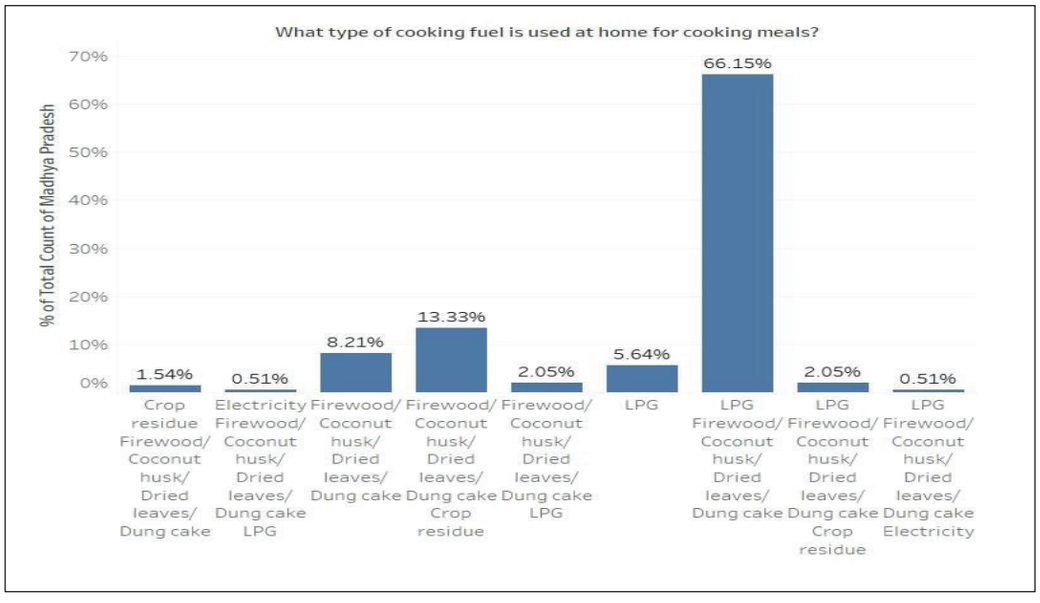
Thus,

- MP High can be classified as,
- **MP High LPG Primary Village**
- **MP High LPG Secondary Village**
- MP Low can be classified into,
- **MP Low LPG Village**
- **MP Low Chulha Village**

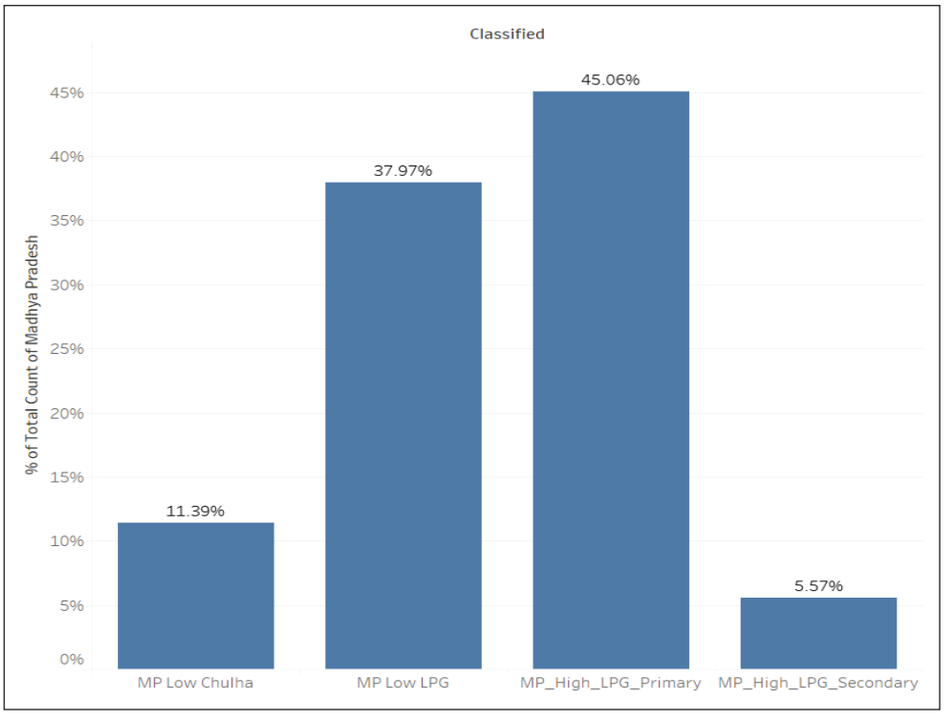
MP High Village



MP Low Village



After Classification



Respiratory Disease Combination

Do you or does anyone in your family have respiratory disorders like

- ☐ Coughing
- ☐ Wheezing
- ☐ Sneezing
- ☐ Burning of eyes
- ☐ Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- ☐ No health issues observed
- ☐ Any other health issues (specify)

Respiratory Disorder	Priority
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)	1
Coughing	2
Wheezing	3
Sneezing	4
Burning of Eyes	5

- **For Any other + Illness: Take illness**
- **For None + Illness: Take Illness**

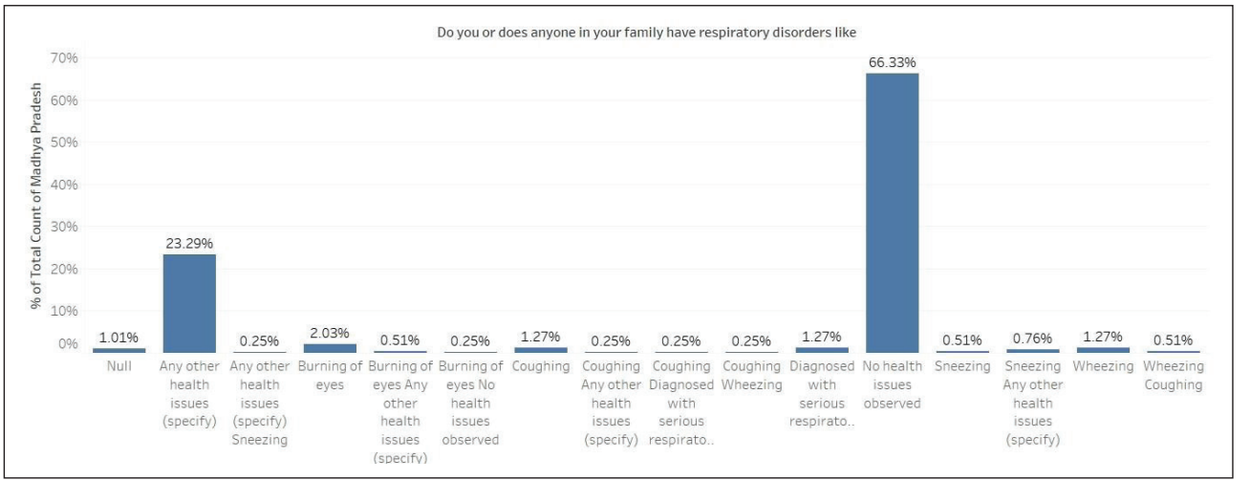
High

- Any other health issues (specify)
- Any other health issues (specify) Sneezing
- Burning of eyes
- Burning of eyes Any other health issues (specify)
- Burning of eyes No health issues observed
- Coughing Any other health issues (specify)
- Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- No health issues observed
- Sneezing
- Sneezing Any other health issues (specify)
- (blank)

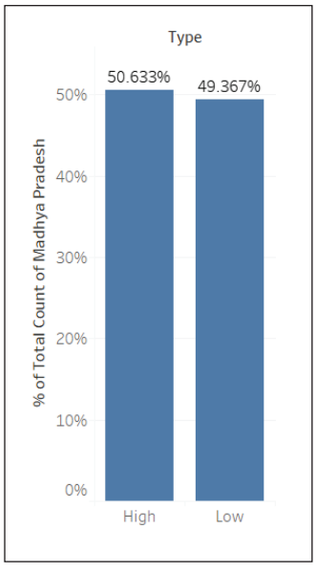
Low

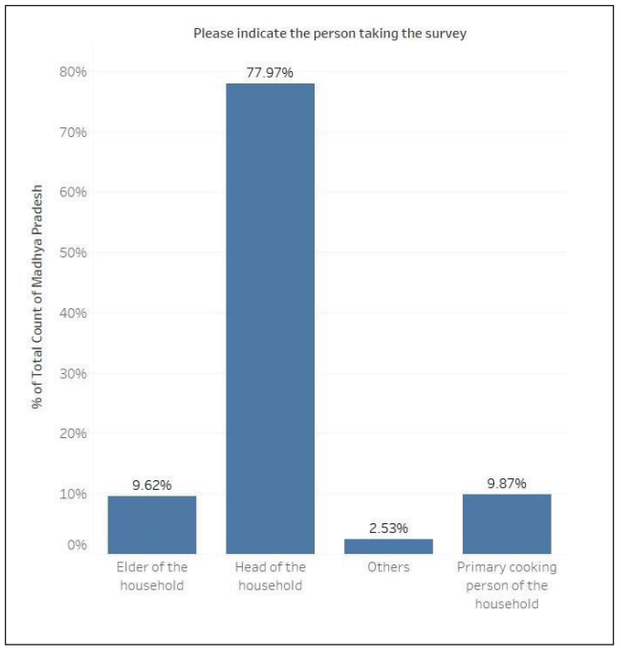
- Any other health issues (specify)
- Burning of eyes
- Coughing
- Coughing Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- Coughing Wheezing
- Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- No health issues observed
- Wheezing
- Wheezing Coughing
- (blank)

Respiratory Disease



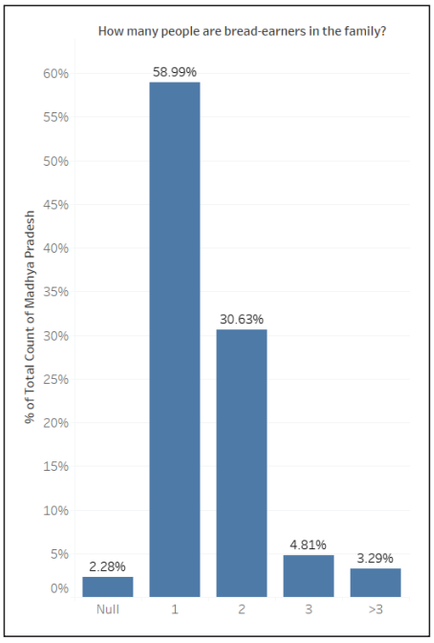
Summarizing Survey Responses





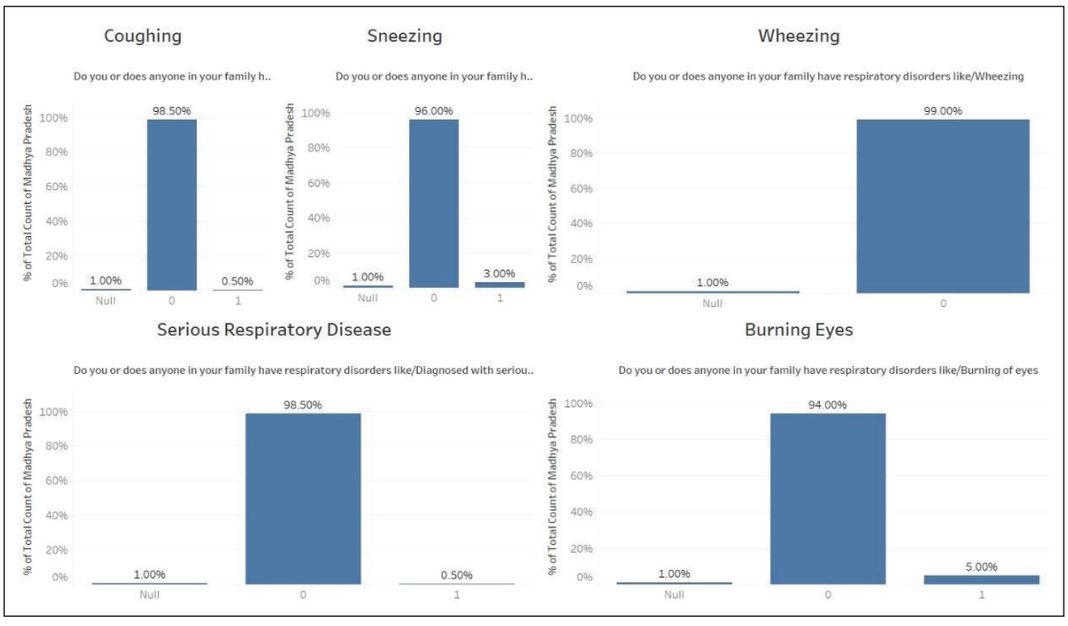
Summarizing Survey Responses

Who is the primary person cooking food for the family?	
Kids	0.76%
The Man	1.77%
The Woman	97.47%

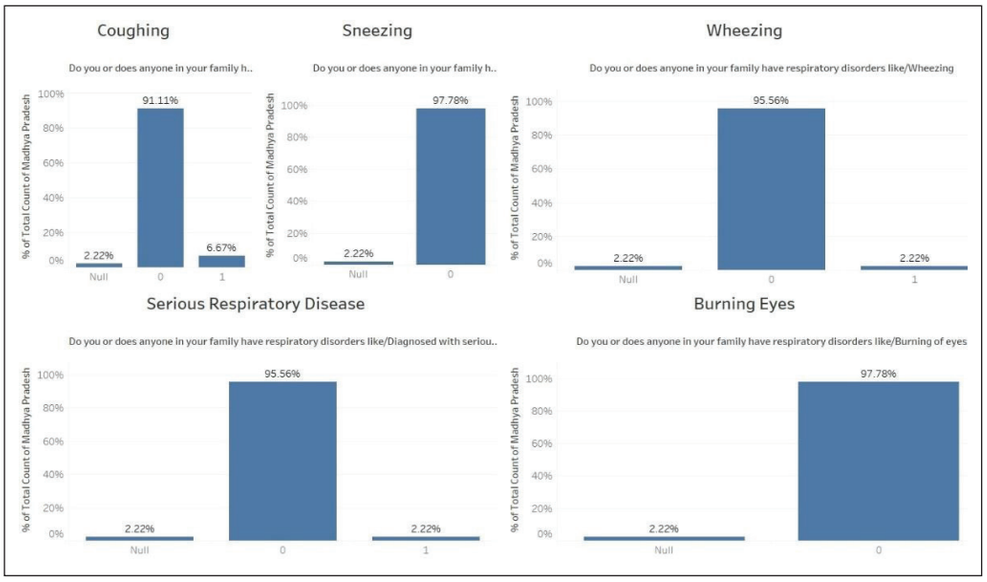


No. of family members. Please enter the numbe	
0	0.25%
1	4.05%
2	7.09%
3	6.84%
4	17.97%
5	23.80%
6	13.42%
7	8.35%
8	6.58%
9	3.80%
10	1.52%
11	2.78%
12	1.77%
13	0.25%
14	0.51%
16	0.25%
17	0.25%
20	0.25%
25	0.25%

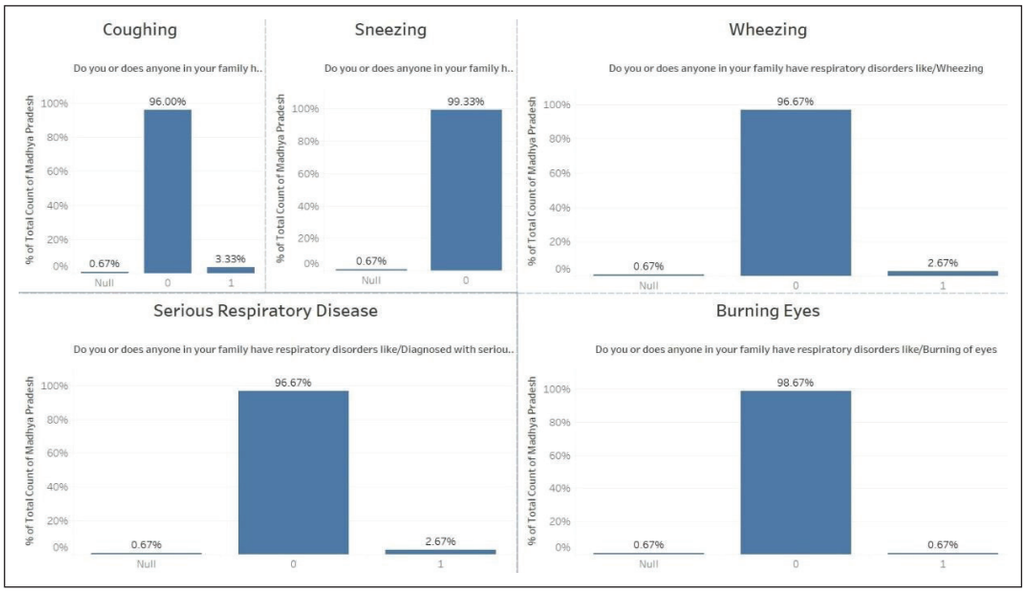
Respiratory Diseases in MP High LPG



Respiratory Diseases in MP Low Chulha

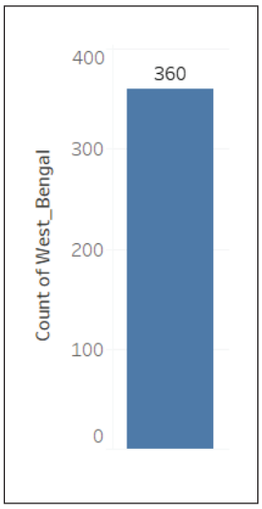


Respiratory Diseases in MP Low LPG



Classification for West Bengal

Total Responses



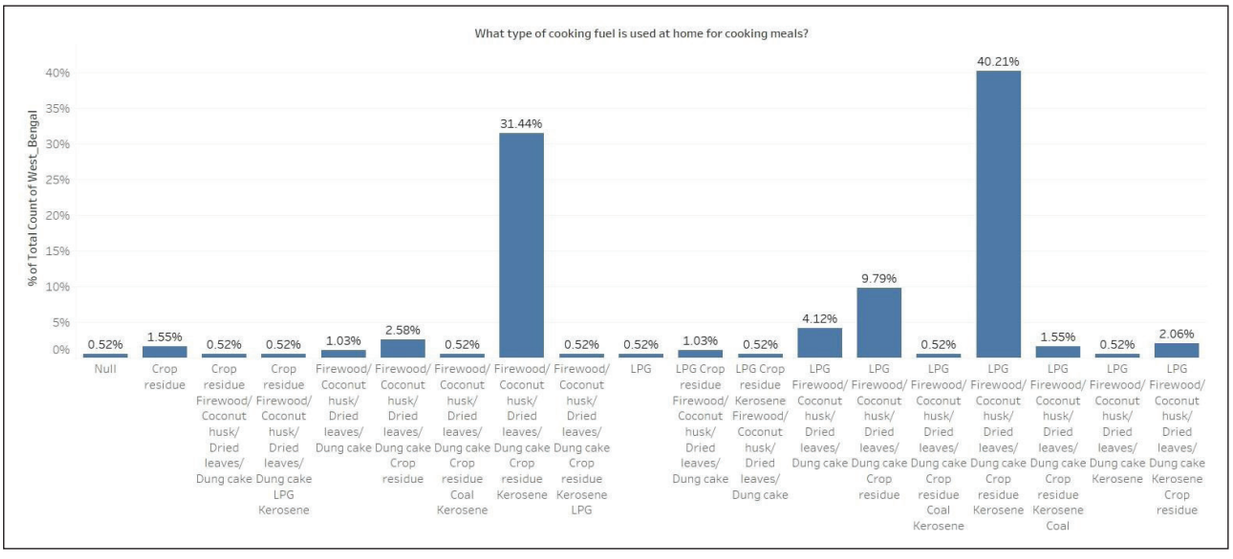
What type of cooking fuel is used at home for cooking meals?/LPG

Type	Null	0	1
High	0.52%	37.63%	61.86%
Low	1.20%	86.75%	12.05%

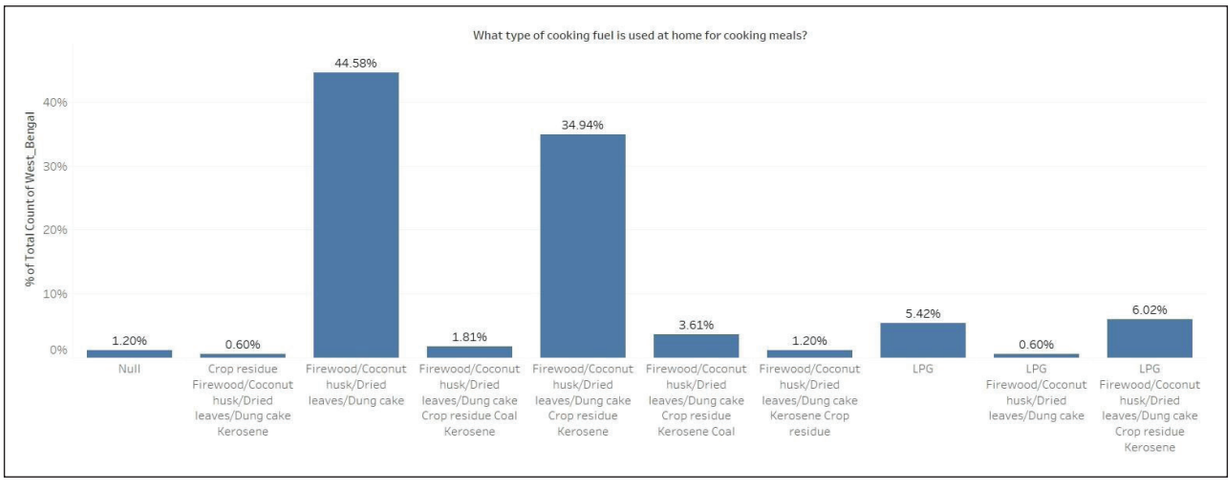
Thus,

- WB High can be classified as,
- **WB High LPG Primary Village**
- **WB High LPG Secondary Village**
- **WB High Chulha Village**
- WB Low can be classified into,
- **WB Low LPG Village**
- **WB Low Chulha Village**

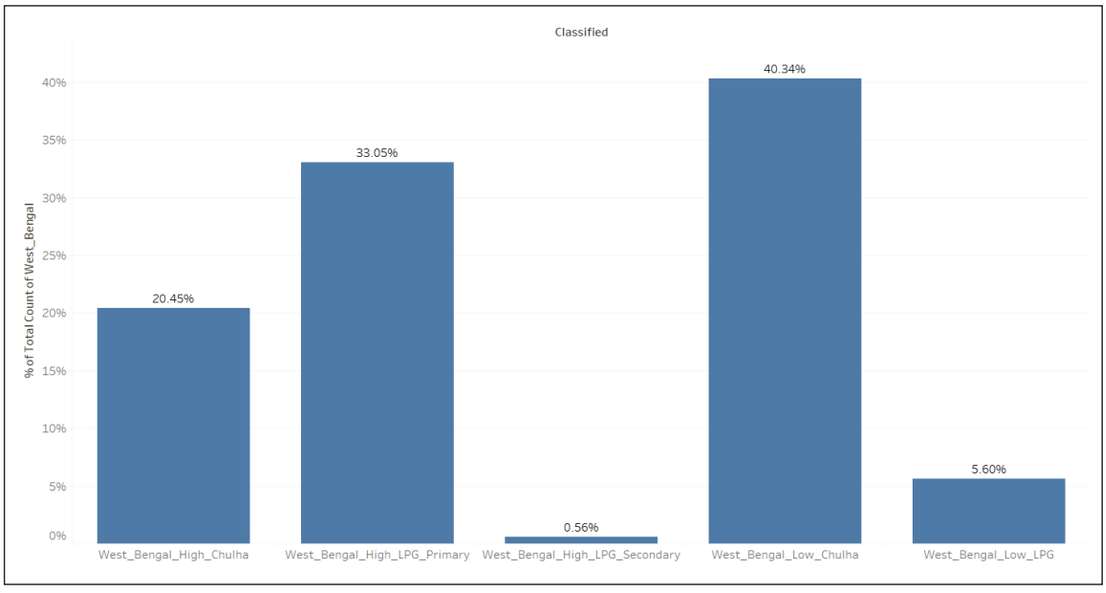
West Bengal High



Respiratory Diseases in MP Low Chulha



Respiratory Diseases in MP Low LPG



Respiratory Disease Combination

Do you or does anyone in your family have respiratory disorders like

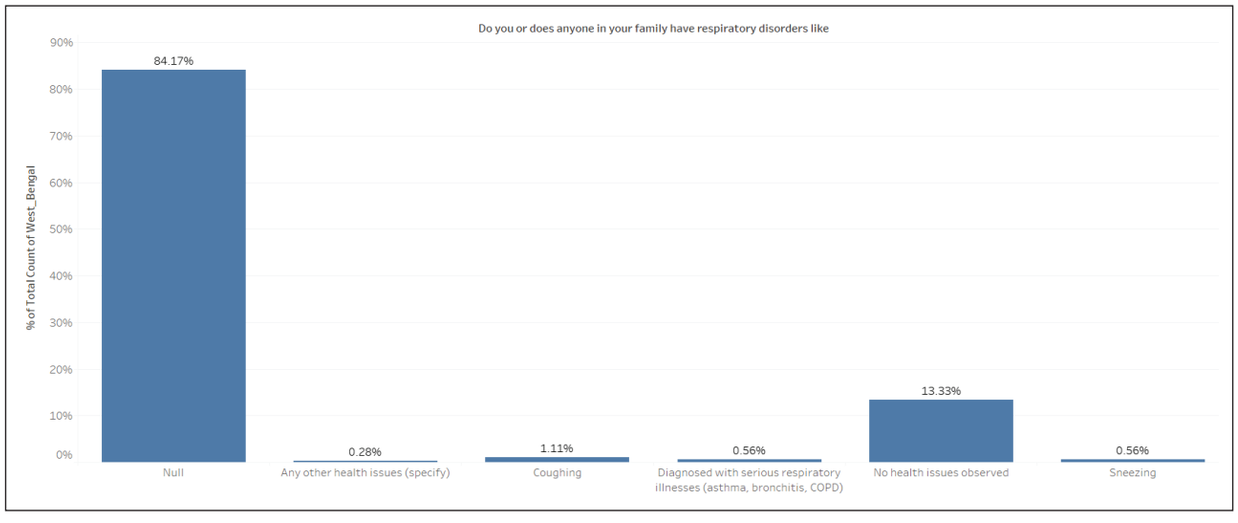
- ☐ Coughing
- ☐ Wheezing
- ☐ Sneezing
- ☐ Burning of eyes
- ☐ Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
- ☐ No health issues observed
- ☐ Any other health issues (specify)

High
(blank)
Low
Any other health issues (specify)
Coughing
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)
No health issues observed
Sneezing
(blank)

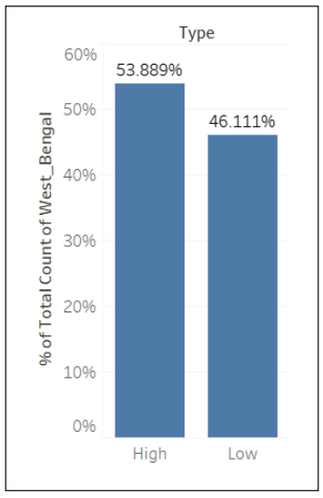
Respiratory Disorder	Priority
Diagnosed with serious respiratory illnesses (asthma, bronchitis, COPD)	1
Coughing	2
Wheezing	3
Sneezing	4
Burning of Eyes	5

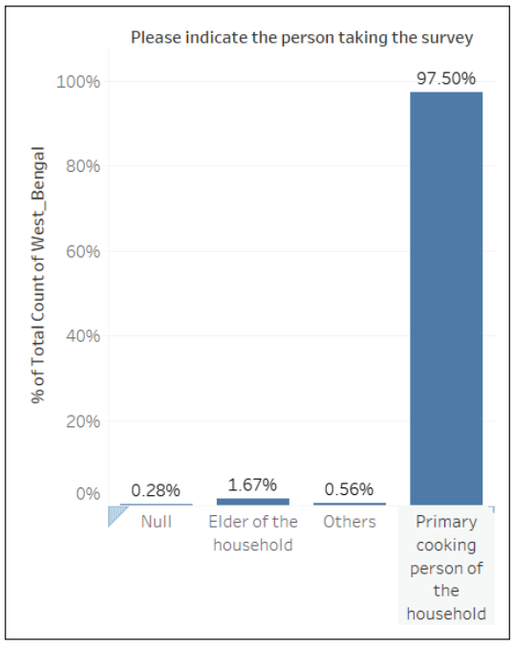
- **For Any other + Illness: Take illness**
- **For None + Illness: Take Illness**

Respiratory Disease

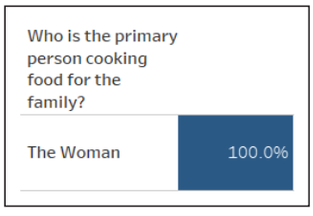


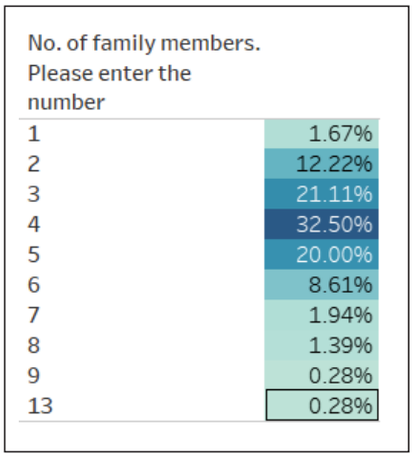
Respiratory Diseases in MP Low Chulha

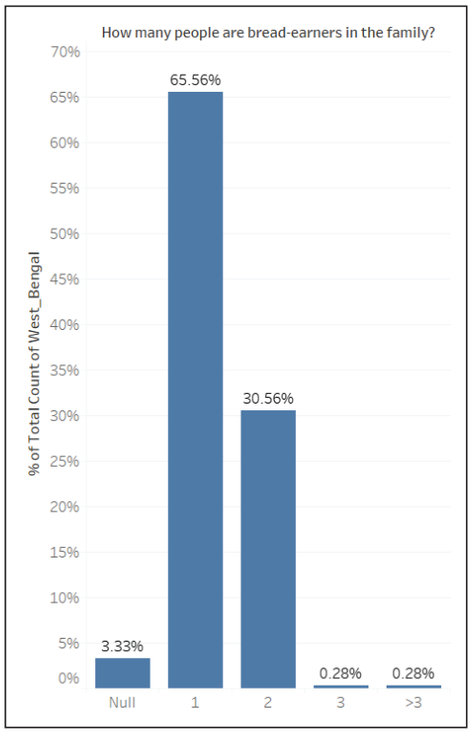




Respiratory Diseases in MP Low LPG







APPENDIX B

Ethics Committee approval

Institutional Ethics Committee
(IEC)
Indian Institute of Technology Kanpur

Decision of Institutional Ethics Committee (IEC)

IEC Communication Number: IITK/IEC/2020-21/II/24

Protocol Title: Evaluation of Pradhan Mantri Ujjwala Yojana (PMUY) in 6 states of India. **Principal Investigator/Student:** Prof. S.N. Tripathi and Mr. Ronak Sutaria
Name & Address of the Institution: IIT Kanpur
Type of Review: New √ Revised. Expedited
Date of Review: 17/02/21 **Date of Previous Review (for revised applications):** NA **Decision of the IEC:** **Recommended √ Recommended with Suggestions** **Revision Rejected** **Suggestions/Remarks/Reasons:**
Recommended for a period of: 1 year from date of issue of the IEC Certificate.

Please note:

- The applicant has to inform the IEC immediately, in case of any adverse events or serious mishaps/accidents etc. during the course of the approved study.
- The applicant has to inform the IEC in case of any change in the procedure of the study, site of the study, and investigators.
- The IEC approval is valid only for the period mentioned above.
- Annual report of the study has to be submitted to the IEC.
- Members of the IEC have the right to monitor the trials/study with prior intimation.

17Feb2021

Member Secretary,
IEC,
IIT Kanpur.

Consent Form

Your are invited to participate in a survey on the "Evaluation of Pradhan Mantri Ujjwala Yojana (PMUY) in 6 states of India". This is a research project being conducted by Indian Institute of Technology Kanpur, sponsored by NHSRC. The survey is not related to Covid-19 symptoms are seen, the survey team will direct you to the nearest primary health facility.

PARTICIPATION

Your participation in this survey is voluntary. You may refuse to take part in the research of exit the survey at any time without penalty. You are free to decline to answer any particular question you do not wish to answer for any reason. You have the right to withdraw from the participating in th survey without any question being asked and at any state of the same.

BENEFITS

You will receive no direct benefits from participating in the research study.

RISKS

There are no foreseeable risks involved in participating in this study.

CONFIDENTIALITY

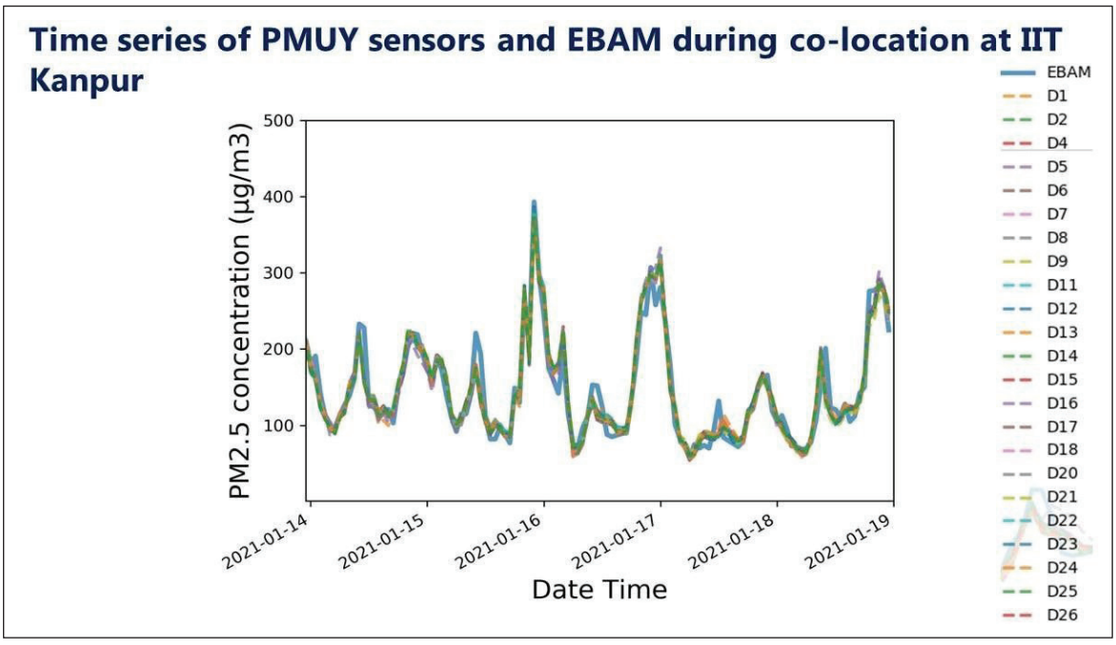
Your survey answer will be kept secure and confidential.

ELECTRONIC CONSENT: Please sign the form if you agree to the following:

- You have understood the above information
- You voluntarily agree to participate
- You are 18 years of age or older

(Electronic Signature)

APPENDIX C


Time series of PMUY sensors and EBAM during co-location at IIT Kanpur
PM2.5 concentration (µg/m3)
500
400
300
200
100
2021-01-14
2021-01-15
2021-01-16
2021-01-17
2021-01-18
2021-01-19
Date Time
EBAM
D1
D2
D4
D5
D6
D7
D8
D9
D11
D12
D13
D14
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D17
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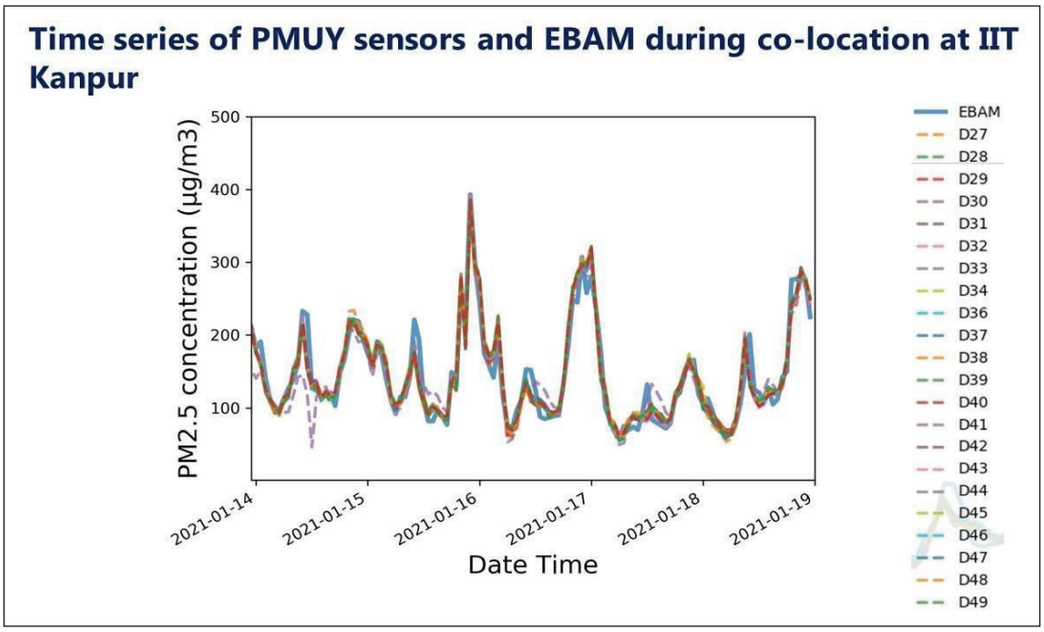
D26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2021-01-17
2021-01-18
2021-01-19
Date Time
EBAM
D27
D28
D29
D30
D31
D32
D33
D34
D36
D37
D38
D39
D40
D41
D42
D43
D44
D45
D46
D47
D48
D49

R^2 for sensors with respect to EBAM

Device w.r.t. EBAM	R2
1D w.r.t. IITK EBAM	0.83
2D w.r.t. IITK EBAM	0.86
4D w.r.t. IITK EBAM	0.86
5D w.r.t. IITK EBAM	0.69
6D w.r.t. IITK EBAM	0.86
7D w.r.t. IITK EBAM	0.85
8D w.r.t. IITK EBAM	0.84
9D w.r.t. IITK EBAM	0.82
11D w.r.t. IITK EBAM	0.87
12D w.r.t. IITK EBAM	0.86
13D w.r.t. IITK EBAM	0.86
14D w.r.t. IITK EBAM	0.86
15D w.r.t. IITK EBAM	0.86
16D w.r.t. IITK EBAM	0.84
17D w.r.t. IITK EBAM	0.84

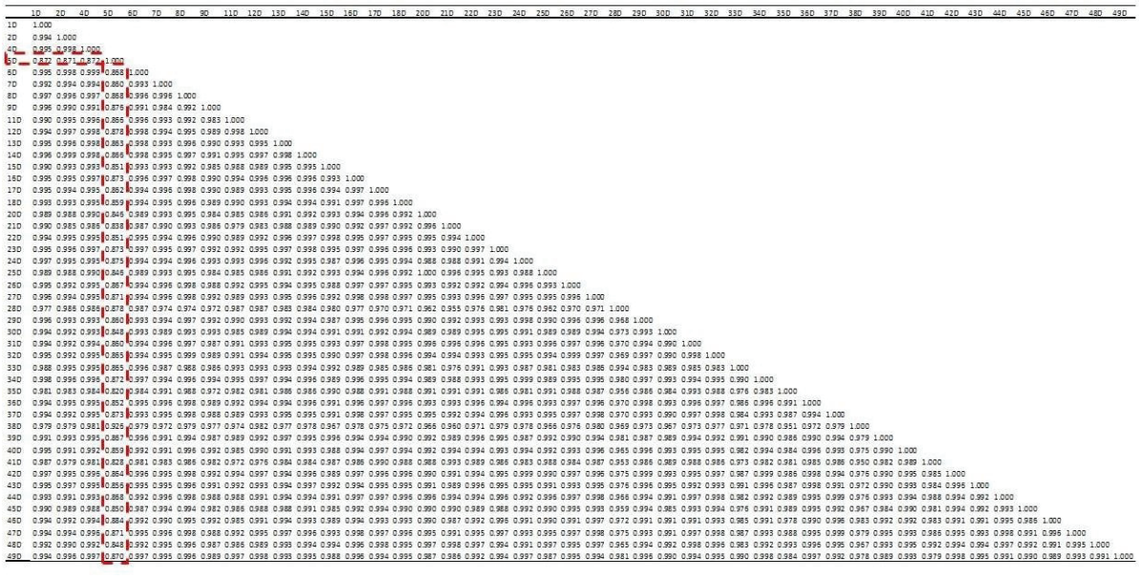
Device w.r.t. EBAM	R2
18D w.r.t. IITK EBAM	0.84
20D w.r.t. IITK EBAM	0.83
21D w.r.t. IITK EBAM	0.82
22D w.r.t. IITK EBAM	0.85
23D w.r.t. IITK EBAM	0.85
24D w.r.t. IITK EBAM	0.83
25D w.r.t. IITK EBAM	0.83
26D w.r.t. IITK EBAM	0.83
27D w.r.t. IITK EBAM	0.83
28D w.r.t. IITK EBAM	0.88
29D w.r.t. IITK EBAM	0.82
30D w.r.t. IITK EBAM	0.84
31D w.r.t. IITK EBAM	0.84
32D w.r.t. IITK EBAM	0.83
33D w.r.t. IITK EBAM	0.87

Device w.r.t. EBAM	R2
34D w.r.t. IITK EBAM	0.84
35D w.r.t. IITK EBAM	0.84
36D w.r.t. IITK EBAM	0.84
37D w.r.t. IITK EBAM	0.84
38D w.r.t. IITK EBAM	0.81
39D w.r.t. IITK EBAM	0.85
40D w.r.t. IITK EBAM	0.82
41D w.r.t. IITK EBAM	0.82
42D w.r.t. IITK EBAM	0.84
43D w.r.t. IITK EBAM	0.84
44D w.r.t. IITK EBAM	0.83
45D w.r.t. IITK EBAM	0.83
46D w.r.t. IITK EBAM	0.83
47D w.r.t. IITK EBAM	0.84
48D w.r.t. IITK EBAM	0.83
49D w.r.t. IITK EBAM	0.85

Sensor IMEI:

D1	84CCA8AE76C8	D6	84CCA8B000E4	D12	84CCA8B04724	D16	84CCA8B06646	D21	84CCA8B08508	D25	84CCA8B0845B	D29	84CCA8B0C6B1	D42	84CCA8B152C5	D46	84CCA8B15967	D34	84CCA8B0F0BB	D38	84CCA8B11AEA
D2	84CCA8AE77E3	D7	84CCA8B0029F	D13	84CCA8B04B09	D17	84CCA8B0674B	D22	84CCA8B094E8	D26	84CCA8B09FDD	D30	84CCA8B0C9C2	D43	84CCA8B15544	D47	84CCA8B16BAC	D35	84CCA8B0F6F0	D39	84CCA8B12AAD
D4	84CCA8AFE1AF	D8	84CCA8B007C7	D14	84CCA8B04D7E	D18	84CCA8B067AE	D23	84CCA8B09763	D27	84CCA8B0AB9B	D31	84CCA8B0DF50	D44	84CCA8B15583	D48	84CCA8B16FB7	D36	84CCA8B10181	D40	84CCA8B14B07
D5	84CCA8AFE3CB	D9	84CCA8B030D5	D15	84CCA8B0511E	D20	84CCA8B0845B	D24	84CCA8B09832	D28	84CCA8B0B9DB	D32	84CCA8B0E490	D45	84CCA8B155DE	D49	84CCA8B1763D	D37	84CCA8B11515	D41	84CCA8B1512E
		D11	84CCA8B039D8									D33	84CCA8B0E97A								

Inter-sensor R^2



The EBAM data Vs Atmos data co-location evaluations.

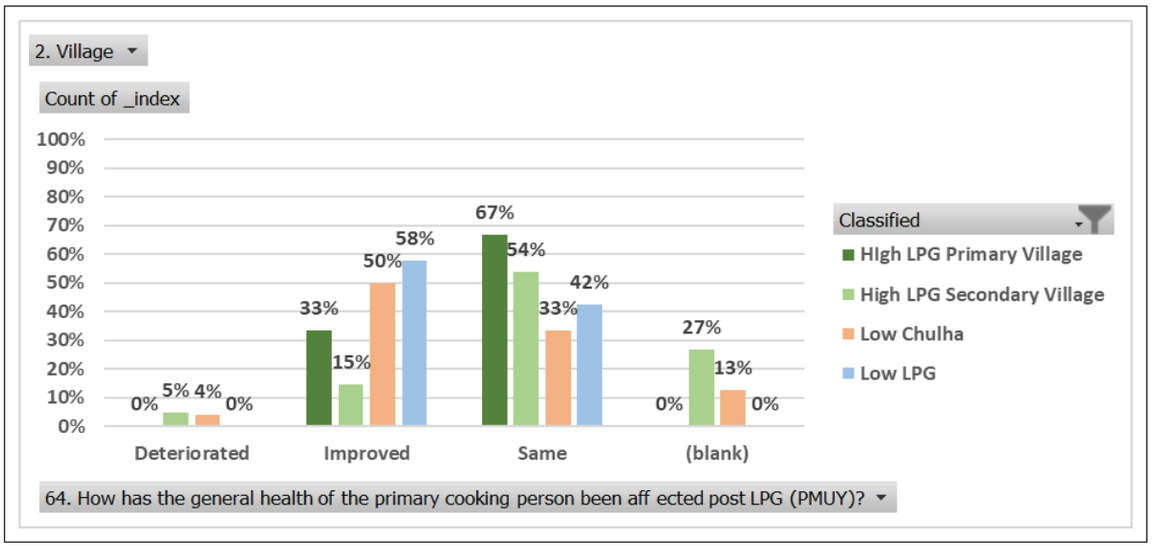
The colocation results are as follows:

MAE ($\mu g/m^3$) = 14.13, RMSE ($\mu g/m^3$) = 20.19, R^2 = 0.90, and MAPE (%) = 11.0

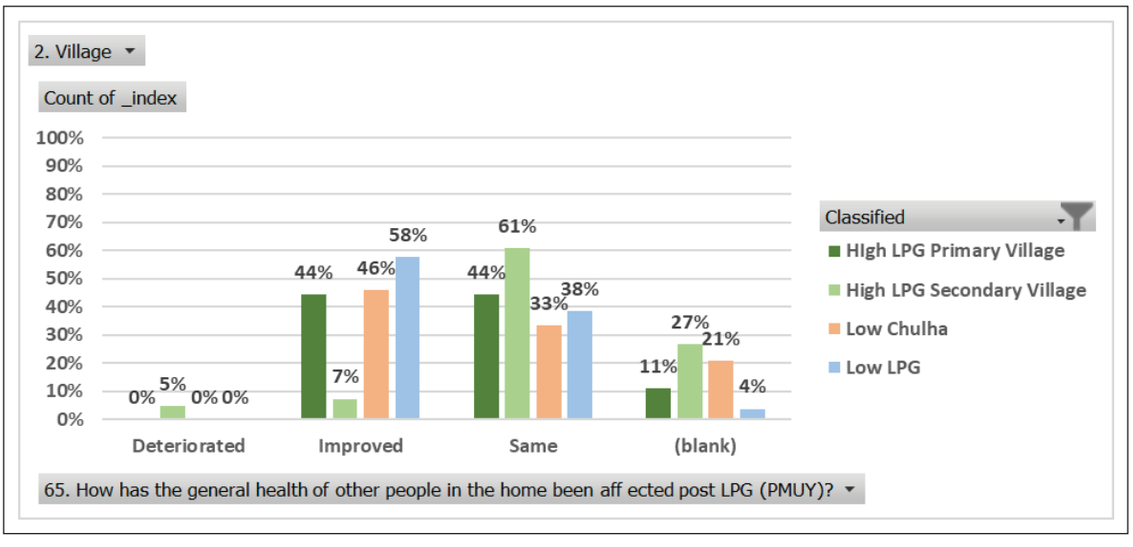
APPENDIX D

Madhya Pradesh dipstick study results

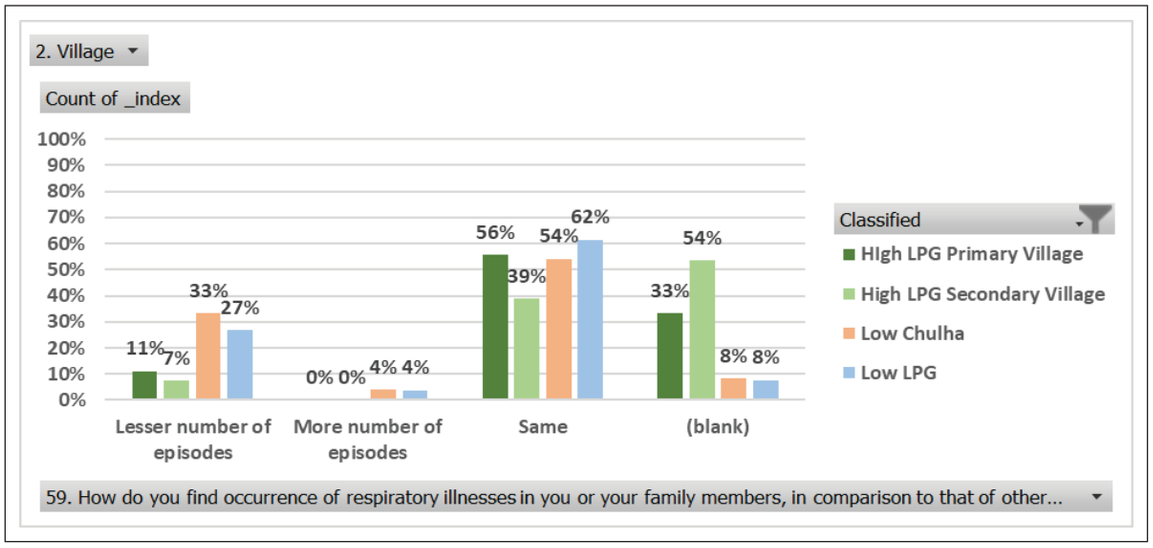
Question 1: How has the general health of the primary cooking person been affected post-LPG (PMUY)?



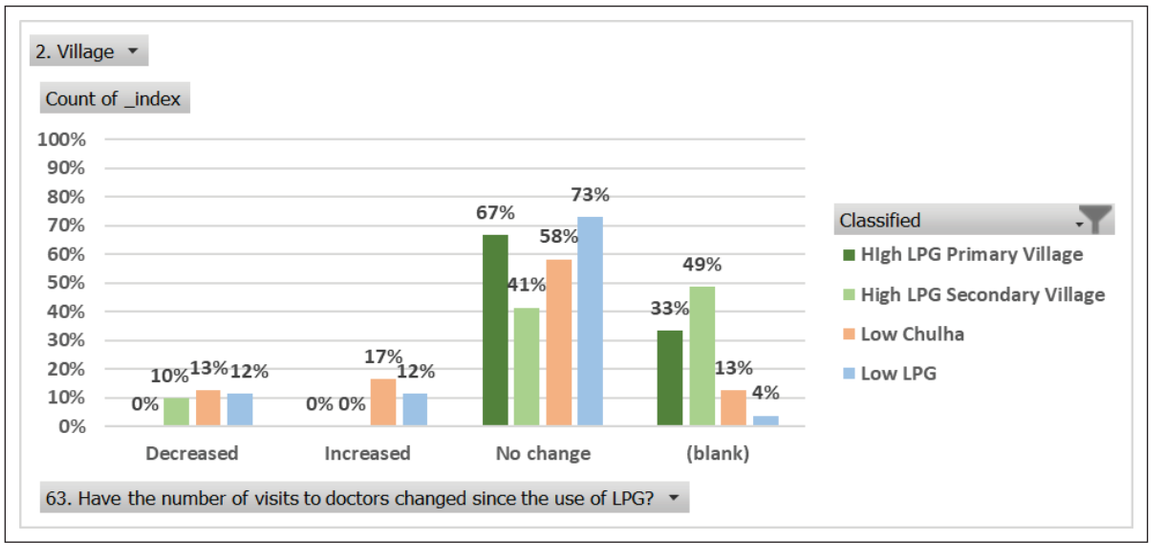
Question 2: How has the general health of other people in the home been affected post LPG (PMUY)?



Question 3: How do you find the occurrence of respiratory illnesses in you or your family members, compared to that of other fuel like kerosene, fuelwood, coconuts, cow dung cakes etc.?



Question 4 : Have the number of visits to doctors changed since the use of LPG?



Institutional Ethics Committee
(IEC)
Indian Institute of Technology Kanpur

Decision of Institutional Ethics Committee (IEC)

IEC Communication Number: IITK/IEC/2020-21/II/24

Protocol Title: Evaluation of Pradhan Mantri Ujjwala Yojana (PMUY) in 6 states of India. **Principal Investigator/Student:** Prof. S.N. Tripathi and Mr. Ronak Sutaria
Name & Address of the Institution: IIT Kanpur
Type of Review: New √ **Revised.** **Expedited**
Date of Review: 17/02/21 **Date of Previous Review (for revised applications):** NA **Decision of the IEC:** **Recommended** √ **Recommended with Suggestions** **Revision** **Rejected** **Suggestions/Remarks/Reasons:**
Recommended for a period of: 1 year from date of issue of the IEC Certificate.

Please note:

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- The applicant has to inform the IEC in case of any change in the procedure of the study, site of the study, and investigators.
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17Feb2021

Member Secretary,
IEC,
IIT Kanpur.

Consent Form

Your are invited to participate in a survey on the "Evaluation of Pradhan Mantri Ujjwala Yojana (PMUY) in 6 states of India". This is a research project being conducted by Indian Institute of Technology Kanpur, sponsored by NHSRC. The survey is not related to Covid-19 and only aims to understand the Impact of LPG on health issues. If any Covid-19 symptoms are seen, the survey team will direct you to the nearest primary health facility.

PARTICIPATION

Your participation in this survey is voluntary. You may refuse to take part in the research of exit the survey at any time without penalty. You are free to decline to answer any particular question you do not wish to answer for any reason. You have the right to withdraw from the participating in th survey without any question being asked and at any state of the same.

BENEFITS

You will receive no direct benefits from participating in the research study.

RISKS

There are no foreseeable risks involved in participating in this study.

CONFIDENTIALITY

Your survey answer will be kept secure and confidential.

ELECTRONIC CONSENT: Please sign the form if you agree to the following:

- You have understood the above information
- You voluntarily agree to participate
- You are 18 years of age or older

(Electronic Signature)