Self-adopted ‘natural users’ of liquid petroleum gas for household cooking by pregnant women in rural Bangladesh: characteristics of high use and opportunities for intervention

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Abstract

The use of clean fuel such as liquid petroleum gas (LPG) is globally recommended for household cooking to reduce exposure to household air pollution and its adverse health consequences. Adoption of LPG in resource-poor settings such as South Asia is low and driven by many factors. In Bangladesh, more than 90% of the rural population relies on biomass fuels for cooking. Identifying factors among households that self-adopt LPG, i.e. ‘natural users’ may provide insight into how LPG programs could be modified to improve the adoption of clean fuels. We aimed to assess factors that drive LPG adoption and use in a rural setting amongst natural users of LPG in Bangladesh. We conducted a household survey of natural users of LPG who were pregnant and were identified by a census listing of households in 63 villages of five unions of Tangail district. Of 337 existing pregnant natural users, we could complete interview of 299 women using a structured questionnaire which included socio-demographic, kitchen structure, cooking behaviours and potential factors related to LPG use. Nearly all natural users had multiple cookstoves, and 85% reported using LPG as an alternative fuel to their main cooking and fuel (traditional cooking with biomass fuels). Factors related to high use of LPG (defined as at least 50% of all cooking time in previous 24 h) included households in second wealth quintile, (adjusted Prevalence Ratio, aPR 3.03; 95% CI:1.15–8.00), middle wealth quintile, (aPR 2.72; 95% CI:1.01–7.30) and highest wealth quintile (aPR2.71;95% CI: 1.02–7.28. Health issues also influenced LPG use; if LPG was described as alleviating breathing problems (aPR 1.65; 95% CI: 1.08–2.52), there was more LPG use. Adoption of LPG stove as a backup option for emergency purpose cooking reduced greater use of LPG (aPR 0.59; 95% CI: 0.39–0.91). High use of LPG was associated with LPG cooking being reported as easy to use (aPR 4.13; 95% CI: 1.95–8.73). Women’s perception that LPG alleviated breathing difficulties was associated with high-use of LPG cooking, as was household wealth and ease of use. Women who reported to use LPG only for emergency purposes were less likely to be high users. Clean fuel programs as well as being financially supportive could be modified to include a trial period so that the experience of LPG would further support clean cooking adoption.

1. Background

Globally, household air pollution (HAP) has been recognised as one of the most detrimental environmental health risk factors in the recent decade, contributing to nearly one-third of the total deaths attributable to air pollution [1]. According to the latest available estimates of the global burden of disease, 1.6 million people died and 59 million years of healthy life lost from HAP in 2017, low-income countries often bearing the highest burden [1, 2]. The majority of these deaths are attributable...
to exposure to emissions from biomass combustion during household cooking and heating [1]. Dependency on biomass fuels for household cooking was estimated to be as high as 47% globally, 58% in South-Asia and 79% in Africa, amounting to 3.6 billion people with exposure to HAP from cooking fuels.

The emerging evidence of the association between exposure to HAP and adverse health outcomes has in part led to the WHO’s Guidelines for Indoor Air Quality which emphasised a transition to community-wide adoption of clean fuel including liquid petroleum gas (LPG) and low emission biomass stoves [3, 4]. However, the adoption of LPG and clean cooking stoves are highly reliant on a myriad of supply and demand-side factors. Key demand-side factors that influence the adoption of clean cooking options include household characteristics, income, education, household fuel need, fuel-saving, knowledge, perception, and technical know-how, whereas, key supply-side contextual factors include financing, presence of supportive programs, supply chain, demand creation, social marketing and overarching government legislation, standards and supportive policy environment [5, 6]. Critical information gaps still exist on the drivers for the choice of consistent and sustained use of clean fuel.

In Bangladesh, although the use of clean fuels such as LPG, natural gas or biogas in household cooking has improved over the last decade, it is predominantly restricted to urban areas. About 95% of the rural households are still dependant on biomass fuels in traditional stoves [7]. The Government of Bangladesh launched the Country Action Plan for Clean Cookstoves in partnership with key stakeholders to support their commitment to the gradual transition to 100% clean cooking by 2030 in line with the Sustainable Development Goals [8, 9]. However, the interim priority is the adoption of biomass burning cookstoves with improved combustion and smoke ventilation system, although even with government support distribution of these improved cookstoves is not high. Over 4 years (2013–2017) only one million improved cookstoves were distributed, the target for 2030 is 25 million households [10]. The main problem with this priority is that improved cookstoves have minimal to modest health and environmental benefits in comparison to cleaner fuels like LPG [11]. Therefore, a shift in focus to cleaner fuel transition is needed.

In this study, we aimed to explore practices and consistency of use of LPG stoves for cooking by rural pregnant women who self-initiated LPG, i.e. ‘natural users’, providing insights that can be used to develop programs, social marketing interventions or national policies targeted to improve adoption and use of LPG.

2. Method

2.1. Study design and settings

We adopted a cross-sectional household survey design to explore LPG fuel and stove use in pregnant women who were natural users of LPG, as part of a feasibility assessment of LPG stove and cylinder distribution. A detailed description of the LPG stove feasibility study has been described elsewhere [12]. This study was conducted in the district Tangail. Tangail is the largest district in the Dhaka division and about 110 km away from the capital Dhaka. We selected 63 villages from five Unions, (Unions are the lowest administrative unit in Bangladesh), each Union has ~25,000 people and is between 3 and 4 kilometres from Basail, a sub-district of the Tangail district. The Unions included in the study were Fulki, Habla, Kanchanpur, Kashil, and Kawajani. They have typical rural characteristics where agriculture is the main livelihood and have floodplain terrains.

We selected the villages based on their geographical proximity to a local urban centre and were not prone to seasonal monsoonal flooding. We conducted door-to-door visits of all households in the study villages and listed all women who self-reported as pregnant between May and June 2016. We updated the list of existing pregnant women in November-December 2016 and recorded if they had functioning LPG stove for household cooking, whom we defined as natural users.

We used a structured questionnaire for interviewing the participants. The questionnaire had separate sections on household and individual demographic characteristics, assets, amenities, brief reproductive history, household kitchen structure, stove type, cooking practices, reasons for purchasing an LPG stove and perceptions of LPG cooking. We developed the interview questionnaire in a three-step process. First, we developed a draft questionnaire including relevant, validated questions on household and women characteristics from the National Demographic and Health Survey tool and questions on cooking practices from our research [7, 12, 13]. Then we piloted the tool among 20 natural users who were residing in villages adjacent to our study area, and finally, we made modifications to the tool based on the pilot testing and restructured the semi-structured questions to close-ended response categories. Interviewers received training on interviewing skills, including consent and identification of different stoves and kitchen structures with illustrations.

Women were selected to participate in the interview as women have the primary responsibility of cooking in rural households in Bangladesh. Interviewers visited the households of the listed natural users of LPG stoves and interviewed the women. A maximum of two additional pre-scheduled visits were made to complete the interview when the woman
was unavailable at the first visit. Before starting the interview, written informed consent was obtained from the participants. We used paper-based interview questionnaires for data collection. We completed interviews of 299 natural users as research participants of this study during January–March 2017. After completing the interviews, data were checked for internal consistency range and completeness of the forms.

Ethical approval was obtained from the Ethics Review Committee (of Icddr,b PR-15 126).

2.2. Variables
In the analysis, we included woman’s age (≤ 19, 20–29, ≥ 30), woman’s education (up to primary level, or secondary or higher), husband’s education, woman’s employment status, wealth quintiles, previous history of stillbirth or miscarriage, household size (≤ 5 vs. > 5), gestational age (≤ 13 week, 14–27 week, > 27 week), number of living children (≤ 1, 2, 3 or more) and household ownership of mobile phone. The socioeconomic status of the households was defined by creating wealth scores from a composite measure of the household characteristics and assets using principal component analysis (PCA). This technique of creating scores using both continuous and categorical variables such as ownership of assets has been validated and used widely in previous studies [14]. We incorporated the source of drinking water, sanitation facility, materials used to build roof, wall and the floor of participant’s living unit, usable assets, ownership of vehicles, ownership of home, land, and livestock in the PCA model. The PCA score was categorised into five symmetrical quintiles, the lowest 20% being the ‘lowest’ quintile, the highest 20% being the highest quintile and the other categories were ‘second’, ‘middle’ and ‘fourth’. Higher wealth scores of the wealth index indicate more households that are affluent.

Variables to describe cooking practices of natural users involved the number and types of primary and alternative stoves used by respondents, fuel types, place of cooking (living room/place inside the house, a separate structure within the home, outdoor), kitchen structure and if the woman was the main cook in the household. We analysed attributes and perceptions of LPG adoption including the source of LPG cooking stove (purchased vs received as a gift), cost related to gas and cylinder, cylinder replacement or refill, source of information on LPG, primary decision maker for LPG adoption and perceived health benefits of using LPG stoves. We defined ‘high use’ of LPG for cooking as women who used the LPG stove for at least 50% of their total household cooking time in the previous 24 h to the interview. We defined ‘emergency cooking’ as needing to cook something quickly (warm milk for children), or cooking something that did not take very long (frying an egg)).

2.3. Statistical analysis
We first prepared descriptive statistics (percentage, mean or median), and then examined the predictors of high use of LPG, reported as prevalence ratio (PR) with 95% confidence intervals (95%CI) [15]. We conducted the crude (bivariate) analysis for exploring the association between high use of LPG and the explanatory variables. We estimated prevalence ratios (PR) to explore the associations as PR is a more appropriate measure than odds ratio in cross-sectional studies and avoids likely overestimation of the strength of association especially when the prevalence of outcome is low [16]. We used a Generalised Linear Model (GLM) with the Poisson family and log link to estimate the PRs [15]. Explanatory variables that were associated with high use of LPG in the crude analysis (p-value < 0.1) were included in the multivariable model. We considered multi-collinearly and overlapping nature among the variables in the selection of potential explanatory factors in the multivariable regression model using GLM with Poisson family. We used Stata version 13 (StataCorp LP, College Station, TX) for conducting all statistical analysis.

3. Results
3.1. Background characteristics
We identified 337 currently pregnant natural users of LPG and completed interviews with 299 between January and March 2017. We could not contact 32 women, and 6 women refused participation. Most women (88.3%) were aged ≤ 30 years, and 40% had a secondary or higher level of education. Slightly more men had completed secondary or higher education (46%). Only 5.3% of the women were engaged in any paid employment (formal or informal). Approximately 50% of the women were in the second trimester of pregnancy, and 48% had at least one child. One in every five respondents had a previous history of pregnancy loss (miscarriage or stillbirth). The mean size of households was 5.4 people (±2.1). Mobile phone ownership per household and electricity connections were almost universal (table 1).

3.2. Cookstove type and place of cooking
Almost all (99.7%) respondents had multiple cooking stoves in their homes (figure 1). Traditional clay-made stove, locally known as ‘Matir Chula’ was the primary stove for 84% of the participants. LPG and electric stoves were alternative cooking options in 85% and 54% of households respectively. The participants used a wide variety of fuel options, other than LPG, including wood or bamboo (96%), crop remnants (92%) and cow dung (62%). In ~13% of households, the cooking was done either inside the bed room or in a separate room of the house, a quarter of the households did not have any kitchen and cooked outdoors, and most had an independent structure used as a kitchen (63%). Of those, about half of the...
Table 1. Background and household characteristics of natural users of LPG fuel and stove for cooking.

| Characteristics                        | n (%), mean [± SD] |
|----------------------------------------|--------------------|
|                                        | \( N = 299 \)       |
| Women age in years                     |                    |
| ≤ 19                                   | 89 (29.8)          |
| 20–29                                  | 175 (58.5)         |
| ≥30                                    | 35 (11.7)          |
| Mean [±SD]                             | 23.0 [± 5.0]       |
| Women’s education                      |                    |
| Primary or below                       | 179 (59.9)         |
| Secondary or higher                    | 120 (40.1)         |
| Husband’s education                    |                    |
| Primary or below                       | 163 (54.5)         |
| Secondary or higher                    | 136 (45.5)         |
| Women currently employed               | 16 (5.3)           |
| Husbands currently employed            | 282 (94.3)         |
| Gestational age (week)                 |                    |
| ≤ 13 week                              | 61 (20.4)          |
| 14–27 week                             | 149 (49.8)         |
| > 27 week                              | 89 (29.8)          |
| Number of living children              |                    |
| ≤1                                      | 142 (47.5)         |
| 2                                       | 118 (39.5)         |
| 3 or more                              | 39 (13.0)          |
| Mean household size [±SD]              | 5.4 [±2.1]         |
| Electricity connection                 | 297 (99.3)         |
| Household ownership of cell phone      | 299 (100.0)        |
| Wealth quintile                        |                    |
| Lowest                                 | 60 (20.1)          |
| Second                                 | 60 (20.1)          |
| Middle                                 | 60 (20.1)          |
| Fourth                                 | 60 (20.1)          |
| Highest                                | 59 (19.7)          |

Figure 1. Cookstoves, fuel types, cooking place and kitchen characteristics of natural users of LPG stove.
households had a kitchen with a roof and four walls (51%) and a quarter (26%) had a kitchen with a roof and partial walls. Women participants were the primary cook in 82% of households.

3.3. Uptake, perception and LPG stove use

Approximately 95% of the participants, purchased the LPG stove and cylinder themselves as opposed to receiving as a gift, the median instalment cost (stove and filled cylinder) was ~USD63 (5,238BDT). The main reasons that influenced the initial purchase of the LPG stoves were that they can be used in all seasons (93%), LPG was very convenient for emergency cooking (91%) and was easy to use (82%). However, only about half (53%) of the participants reported knowing that LPG stoves were smokeless. Women initiated the LPG stove purchase in just over a third of households (35%), while other household members, including husbands, made the decision in most households (65%). Participants were asked about their perception of the potential benefits of cooking with LPG. Almost all (99%) of them reported that using LPG cooking alleviates eye irritation, reduces coughing (44%) and alleviated breathing difficulties from smoke inhalation (19%) (table 2).

Participants reported wide variations in LPG stove use. Most of the participants (77%) used the LPG stove intermittently, whereas 20% used the LPG stove regularly. Almost all the respondents reported that they would continue using the LPG stove after the pregnancy period. However, most of them (52%) would use their LPG stove for cooking selective meals, which do not require much cooking time (such as ‘emergency cooking’) and 35% would keep the LPG stove for intermittent use in addition to the traditional stove. Reasons for intended irregular use included gas price too high for regular use (52%) and fuel for the traditional stove is available at no cost (45%).

Variables associated with high use of LPG cooking in the crude analysis were the highest wealth quintile compared to the lowest wealth quintile (Prevalence ratio (PR) = 3.44, 95% CI = 1.21, 9.80), smaller households (<5) compared to larger households (>5) (PR = 0.45, 95% CI = 0.24, 0.85), whereas women with two children were more likely to be high users compared with women having one or no child (PR = 1.82, 95% CI = 1.06, 3.15) (table 3).

In the adjusted model, households with high wealth remained an influencing factor for the high use of LPG cooking (aPR 2.71, 95% CI = 1.02, 7.28) compared to the lowest quintile. Those who considered that LPG cooking reduced breathing difficulties were 1.65 times (aPR 95% CI = 1.08, 2.52) more likely to be higher users of LPG for cooking compared to those who did not report that LPG reduced breathing difficulty. If LPG was recognised as easy to use, then these users were also high users (aPR = 4.13, 95% CI = 1.95, 8.73). Alternatively, if LPG was adopted initially as an emergency fuel, then they were low users (aPR = 0.59, 95% CI = 0.39, 0.91), (table 3).

4. Discussion

In a population of rural households in Bangladesh that self-adopted LPG outside of a supported program, i.e. ‘natural users’, we found several factors that were related to high LPG cooking include the perception of ease of use, convenience for all-season cooking, and women decision-makers for adopting LPG. However, in the adjusted model, women who reported that LPG alleviated breathing difficulties, and those in the second, third and highest wealth quintiles were more likely to be high LPG users, whereas those women who initially adopted LPG as an emergency cooking fuel were less likely to be high users.

Our finding that women who reported that LPG alleviated their breathing difficulties were associated with high use of LPG is novel and suggests that experience of the benefits of LPG cooking increases use. Overall, awareness of health benefits is an enabler of adoption of healthier behaviours but has little impact on sustained use, including in clean cooking [6, 13, 17]. However, our finding was based on an experience of health benefits reported by the women in our study. Improving awareness of the health benefits of LPG is encouraged to be part of public awareness campaigns; however, it appears that the experiential sense is more powerful for transition [9]. An experience could certainly be adopted into an LPG adoption program where consumers are given a trial window in which they can ‘try before you buy’ the LPG stove set-up before they commit to the purchase. This approach may assist with adoption, and certainly, this and other related behavioural economic concepts have been considered in the household energy sector in high-income countries [18].

Unsurprisingly we found a high prevalence of mixed fuel use, which is frequently reported [11, 19–21]. Mixed fuel use is commonly practised in rural settings, and previous research suggests that even amongst households that had adopted LPG years previously had still not converted 100 per cent to LPG but rather relied on their original biomass fuel [22]. Reasons for mixed-fuel use or stove stacking are multifactorial and driven by the individual, household and community-level issues, including practical reasons such as meeting the cooking task, fuel cost, and ensuring fuel-security [6]. In this work, women reported using different fuels for different tasks, and previous work suggest that transition to cleaner fuel or stove is only likely if it meets consumer needs [13, 23]. In the unadjusted models, we found that the women with two children were more likely to be high users, but if they had three or more children, they were less likely to be high users, as were households greater than five. These again are likely to be practical reasons for lower
Table 2. Adoption, current use and perception of LPG stove by natural users.

| Attributes                                      | n (%)  | N = 299 |
|------------------------------------------------|--------|---------|
| Place of cylinder replenishment/gas refills    |        |         |
| Local market (union bazar)                     | 191(63.9) |        |
| Sub-district headquarter                       | 25(8.4)  |        |
| District headquarter                           | 5(1.7)   |        |
| Have not changed yet                           | 78(26.1) |        |
| Received information about LPG$^a$             |        |         |
| Husband                                        | 8(2.7)   |        |
| Relatives                                      | 284(95.0)|        |
| Neighbour                                      | 97(32.4) |        |
| Information received about LPG before uptake$^a$|        |         |
| Ease of use$^b$                                | 245(81.9)|        |
| Convenient for emergency use                   | 271(90.6)|        |
| Convenient for anytime all season cooking      | 278(93.0)|        |
| Creates no smoke and prevents eye irritation   | 159(53.2)|        |
| Ease of maintenance$^c$                        | 25(8.4)  |        |
| Decision maker for up-taking LPG               |        |         |
| Women by herself                               | 103(34.5)|        |
| Household members                              | 193(64.6)|        |
| Women and household members together           | 2(0.7)   |        |
| Others                                         | 1(0.3)   |        |
| Reasons for up taking LPG$^c$                  |        |         |
| Convenience for emergency use                  | 259(86.6)|        |
| Ease of use (cooking)                          | 149(49.8)|        |
| Convenience for all-season cooking             | 18(6.0)  |        |
| Cleaner or less harmful                        | 11(3.7)  |        |
| Perceived health benefits of using LPG$^a$     |        |         |
| Save from eye irritation/problem                | 297(99.3)|        |
| Save from coughing                             | 130(43.5)|        |
| Save from breathing difficulty                 | 58(19.4) |        |
| Can avoid cooking in excessive heat            | 52(17.4) |        |
| Other benefits                                 | 31(10.4)|        |
| No benefit                                     | 1(0.3)   |        |
| Purpose of using LPG stove                    |        |         |
| Regular cooking                                | 60(20.1) |        |
| Emergency cooking                              | 235(78.6)|        |
| Uses in monsoon season                         | 3(1.0)   |        |
| Backup support during pregnancy                | 1(0.3)   |        |
| Will continue using LPG                        | 298(99.7)|        |
| Purpose for future use of LPG                 |        |         |
| Use in regular cooking                         | 34(11.4) |        |
| Use intermittently with other stoves           | 105(35.1)|        |
| Use for selective cooking                      | 155(51.8)|        |
| Use in wet/monsoon season                      | 4(1.34)  |        |
| Will not continue using                        | 1(0.3)   |        |
| Reasons for selective use$^c$ [n = 265]        |        |         |
| Too high gas price to afford                   | 228(52.2)|        |
| Fuel for the traditional stove is available free of cost | 198(45.3)|        |
| Difficulty in accessing gas refills locally    | 2(0.5)   |        |
| Other reasons                                  | 9(2.1)   |        |

$^a$Multiple responses accepted.

$^b$Easy to cook, easy to set fire, other work can be done during cooking, cook faster and long hour cooking is not difficult.

$^c$Easy to collect and maintain fuel and stoves can be placed anywhere including living room.

LPG use, such as cost and possibly needing larger size pots that do not fit on the LPG burners. The cost of LPG has been consistently recognised as a barrier to clean fuel adoption and sustained use [11,21].

The relatively high cost of LPG and availability of free biomass fuel for traditional stoves is a key barrier to transition to clean fuels, and hence we found associations between household wealth indices and high use of LPG for cooking. In Bangladesh, there is no financing program for subsidised LPG, unlike neighbouring India [24]. There are, however, several maternal and child welfare programmes in place providing financial incentives to the ultra-poor for the adoption of good health care practices during...
Table 3. Characteristics associated with high use of LPG stove by natural users.

| Characteristics                              | Low user of LPG (used LPG < 50% cooking in last 24 h) | High user of LPG (used LPG for ≥ 50% cooking in last 24 h) | Prevalence Ratio (PR) (95% CI) | Adjusted PR (95% CI) |
|---------------------------------------------|--------------------------------------------------------|------------------------------------------------------------|-------------------------------|---------------------|
|                                             | n(%) [N = 222]                                         | n(%) [N = 51]                                              |                               |                     |
| Woman's age                                 |                                                        |                                                           |                               |                     |
| < 20                                        | 66 (29.7)                                              | 11(21.6)                                                   | 1.00                          |                     |
| 20–29                                       | 128(57.7)                                              | 34(66.7)                                                   | 1.47(0.79–2.74)               |                     |
| 30+                                         | 28 (12.6)                                              | 6(11.8)                                                    | 1.24(0.50–3.07)               |                     |
| Woman’s education                           |                                                        |                                                           |                               |                     |
| Primary or below                            | 128(57.7)                                              | 36(70.6)                                                   | 1.00                          | 1.00                |
| Secondary or higher                         | 94(42.3)                                               | 15(29.4)                                                   | 0.63(0.36–1.09)               | 0.72(0.43–1.21)     |
| Husband’s education                         |                                                        |                                                           |                               |                     |
| Primary or below                            | 123(55.4)                                              | 25(49.0)                                                   | 1.00                          |                     |
| Secondary or higher                         | 99(44.6)                                               | 26(51.0)                                                   | 1.23(0.75–2.02)               |                     |
| Wealth quintile                             |                                                        |                                                           |                               |                     |
| Lowest                                      | 50(22.5)                                               | 4(7.8)                                                     | 1.00                          | 1.00                |
| Second                                      | 40(18.0)                                               | 15(29.4)                                                   | 3.68(1.30–10.41)              | 3.03(1.15–8.00)     |
| Middle                                      | 44(19.8)                                               | 12(23.5)                                                   | 2.89(0.99–8.43)               | 2.73(1.01–7.30)     |
| Fourth                                      | 47(21.2)                                               | 6(11.8)                                                    | 1.53(0.46–5.12)               | 1.44(0.47–4.37)     |
| Highest                                     | 41(18.5)                                               | 14(27.5)                                                   | 3.44(1.21–9.80)               | 2.71(1.02–7.28)     |
| Household size                              |                                                        |                                                           |                               |                     |
| ≤ 5                                         | 130 (58.6)                                             | 40(78.4)                                                   | 1.00                          | 1.00                |
| > 5                                         | 92(41.4)                                               | 11(21.6)                                                   | 0.45(0.24–0.85)               | 0.73(0.41–1.31)     |
| Gestational age                             |                                                        |                                                           |                               |                     |
| 1st Trimester (≤ 13 week)                   | 45(20.5)                                               | 11(21.6)                                                   | 1.00                          |                     |
| 2nd Trimester (14–27 week)                  | 112(50.9)                                              | 23(45.1)                                                   | 0.87(0.45–1.66)               |                     |
| 3rd Trimester (> 27 week)                   | 63(28.6)                                               | 17 (33.3)                                                  | 1.05(0.54–2.08)               |                     |
| Number of living children                   |                                                        |                                                           |                               |                     |
| ≤ 1                                         | 106(47.8)                                              | 17(33.3)                                                   | 1.00                          | 1.00                |
| 2                                           | 83(37.4)                                               | 28(54.9)                                                   | 1.82(1.06–3.15)               | 1.27(0.77–2.10)     |
| 3 +                                         | 33(14.9)                                               | 6(11.8)                                                    | 1.11(0.47–2.63)               | 0.62(0.27–1.41)     |
| Who cooks at household                      |                                                        |                                                           |                               |                     |
| Other                                       | 27(12.2)                                               | 1(2.0)                                                     | 1.00                          | 1.00                |
| Respondent                                  | 195(87.8)                                              | 50(98.0)                                                   | 5.71(0.82–39.92)              | 2.73(0.35–21.13)    |
| Decision maker for up-taking LPG            |                                                        |                                                           |                               |                     |
| Other                                       | 146(65.8)                                              | 26(51.0)                                                   | 1.00                          | 1.00                |
| Woman herself                               | 76(34.2)                                               | 25(49.0)                                                   | 1.64(1.00–2.68)               | 1.25(0.78–2.00)     |
| Perceived benefit of LPG: save from breathing difficulty |                       |                                                           |                               |                     |
| No                                          | 185(83.7)                                              | 34(66.7)                                                   | 1.00                          | 1.00                |
| Yes                                         | 36(16.3)                                               | 17(33.3)                                                   | 2.08(1.26–3.42)               | 1.65(1.08–2.52)     |
| Perceived benefit of LPG: save from cough   |                                                        |                                                           |                               |                     |
| No                                          | 125(56.6)                                              | 25(49.0)                                                   | 1.00                          |                     |
| Yes                                         | 96(43.4)                                               | 26(51.0)                                                   | 1.28(0.78–2.10)               |                     |
| Perceived benefit of LPG: save from excess heat |                                      |                                                           |                               |                     |
| No                                          | 184(83.3)                                              | 38(74.5)                                                   | 1.00                          |                     |
| Yes                                         | 37(16.7)                                               | 13(25.5)                                                   | 1.53(0.88–2.64)               |                     |
| Reason for LPG uptake: convenience for emergency use |                     |                                                           |                               |                     |
| No                                          | 19(8.6)                                                | 16(31.4)                                                   | 1.00                          | 1.00                |
| Yes                                         | 203(91.4)                                               | 35(68.6)                                                   | 0.32(0.20–0.51)               | 0.59(0.39–0.91)     |
| Reason for LPG uptake: ease of use (cooking) |                                                        |                                                           |                               |                     |
| No                                          | 129(58.1)                                              | 7(13.7)                                                    | 1.00                          | 1.00                |
| Yes                                         | 93(41.9)                                               | 44(86.3)                                                   | 6.24(2.91–13.38)              | 4.13(1.95–8.73)     |

(Continued)
pregnancy and the first two years of life. The feasibility and effectiveness of expanding this programme to support clean cooking during pregnancy could be explored, although there are several major infrastructure issues extrinsic of personal adoption and use that need to be considered in the context of Bangladesh [11].

Before the adoption of LPG women in our study were informed by family and friends that LPG was convenient and easy to use, and these reasons were cited as the most important reasons for purchasing LPG and subsequently using LPG. Women did not report health benefits for adoption, although alleviation of breathing difficulties was the only health-related variable associated with high use. It is not clear from this data whether it was a lack of awareness of the health benefits among the general community who advised women before adoption or whether this was not as highly valued in the community when considering adoption. Nevertheless, our data suggest that women’s experience increased use.

Our study has the inherent flaws of cross-sectional study design, including unable to determine causality. Our data may also be prone to some biases as we interviewed the participants face-to-face and they may be more included to respond with answers they think will be more acceptable. We did conduct training of our interviewers to improve their skills, and any responder-bias is unlikely to be differential. More importantly, we were not able to observe or independently assess cooking practices or use the objective-based measurement tools like stove use monitors (SUMs) with temperature data logger and have therefore relied on participant’s recall. However, similar studies have used a questionnaire with a longer recall period to measure cookstove usage and found consistent findings with SUM measurement [25–27]. Nonetheless, to minimise recall bias, we limited cooking practices to the previous 24 h, which may also not be representative of their usual cooking practices. However, we believe the variation that may arise in findings would be non-differential as interviews were conducted on seven days a week except for one public holiday during the 3 month data collection period. Patterns of LPG uptake and use for household cooking reported in our study is from pregnant women’s household, and the findings may not be generalizable to all rural households in Bangladesh. We defined high users of LPG by the usage of LPG stove for at least 50% of the cooking in the last 24 h. Defining exclusive users with higher cut-off would give a clearer interpretation of findings [28]. We could not use those cut-offs due to infrequent and low use of LPG in regular cooking.

Adoption of clean fuels such as LPG in countries where traditional cooking with biomass fuels still dominates is urgently required, especially if we are going to meet the Sustainable Development Goals by 2030. Understanding the characteristics of women and their households who are ‘natural’ and high users of LPG may provide opportunities for intervention in clean cooking programs. Our data suggest that user experience in LPG cooking may help influence higher use.

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Competing interests

The authors declare that they have no competing interests

Author contributions

SMB, SI, CRG, and SEA conceived the study. SMB and SI coordinated the data collection. FT and SMB conducted the data analysis. SBM, SI, FT prepared the initial draft. CRG and NA reviewed the first draft and prepared the final draft expanding the interpretations. All authors reviewed and approved the final manuscript.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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