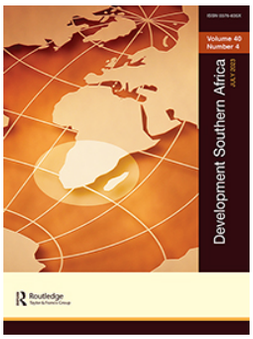

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RESEARCH ARTICLE

Does the choice of cooking fuel empower Ghanaian women? An empirical analysis

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ABSTRACT

Cooking, an important household activity is often done using heavy polluting fuels by a majority of households in sub-Sahara Africa (SSA). In this study, we examine how the choice of cooking fuel affects women empowerment using nationwide household level data from Ghana. We examine whether fuel choices could lead to women's social and economic empowerment. By employing the Survey-based Women Empowerment Index (SWPER) and Principal Component Analysis to construct comprehensive indices of women empowerment, we find that using clean cooking fuel has significant positive associations with women empowerment across all domains and could consequently help reduce inequality to the advantage of women. Other socioeconomic factors such as household size and wealth were found to significantly determine women empowerment status. Both clean cooking fuel use and the reduction of social and economic inequalities are important targets to be met under the Sustainable Development Goals.

KEYWORDS
Cooking fuel; women; empowerment; Ghana; SWPER

JEL Codes
D0; D1; R2; Q4

1. Introduction

Cooking is an important activity performed predominantly by women particularly in sub-Saharan Africa (SSA). This important role is accomplished by applying different fuels such as biomass, kerosene, electricity and liquified petroleum gas (LPG) in conjunction with technologies such as improved stoves, three-stone open fire, electric stoves and brick and mortar models. Solid and liquid fuels such as biomass and kerosene have been observed to pose significant environmental health risks in the world (Newell et al., 2022). Household activities such as cooking, lighting and heating using such fuel, account for about 21% of world encompassing particulate substance and 25% discharges of black carbon in the world, which forms an integral part of PM2.5, a major driver of climate change (Odo et al., 2021).

The objective of this study is three-fold. First, we evaluate the effect of dirty fuel on women empowerment in Ghana. Second, we examine whether clean fuel can promote

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women empowerment. Finally, the study determines whether the impact of dirty and clean fuels is different using distinct women empowerment indicators. In SSA, about 82% of the population cook with high polluting fuels which are predominantly dominated by firewood (WHO, 2016). Even though other cooking fuels such as LPG and electricity are used by urban dwellers, they are used in conjunction with the heavy polluting ones such as firewood, dung, charcoal and kerosene. In 2018, an estimated number of 500,000 premature deaths in Africa were attributed to polluting fuels (IEA, 2019) as well as diseases such as obstructive pulmonary, acute lower respiratory tract infection, bronchial asthma etc. Furthermore, the collection, cleaning and use of firewood exposes women and children to several health risks, decreases time available for education among girls and reduces female labour-hours to undertake other economic activities which can improve their income level (Dutta, 2021). According to the Ghana Statistical Service (GSS) (2008, 2014), less than 1% (0.39% and 0.84%) of 11,440 and 11,362 households in 2008 and 20014, respectively, use electricity for cooking. Again, 12.0% and 20.14% of the households had access to LPG/Natural Gas for cooking. In the case of kerosene/coal/lignite, firewood and charcoal, the percentages of households who used them for cooking decreased from 0.43% to 0.18%; 52.05% to 46.56% and 34.82% to 31.23%. Though there is an increase in the usage of clean-cooking fuel sources and a decrease in high emitting and dirty fuel sources, the percentages of increase and decrease are low. This implies the persistence of a high usage of dirty cooking-fuel sources which has a serious implications on the health and empowerment of women.

The choice of cooking fuel by a household is dependent on among other things; income, availability of the fuel, awareness of the potential health risks associated with its usage and the position of women in the family (Reddy et al., 2000; Dutta, 2021). A fuel is generally considered an essential good and thus an increase in income makes households move closer to cleaner and less polluting ones. Thus, the household goes up in the energy ladder, making income an important variable that can be used to eliminate energy poverty. Availability of the fuel plays an important role as most efficient and less polluting fuel technologies are usually not present in some parts of developing countries. In the rural setting, the existence and lives of most people are dependent on biomass rather than electricity and LPG for cooking since it is readily available and accessible. Awareness of the household head of the health dangers associated with a fuel type matter greatly, since he or she is the principal decision maker of the type of fuel to purchase. Women are usually not the main financiers of their families and are therefore underprivileged in decision-making processes and access to financial resources. Therefore, women who may be aware of the potential risks associated with using dirty cooking solutions may not be able to transit to clean and efficient fuels which are relatively expensive. Even though clean fuel is expensive compared to the dirty ones, they can help to prevent women from burning their husbands' food which can reduce violence against women (World LPG Association, 2014), reduce the fatiguing work women endure and permit them to reallocate their time for other productive ventures, enhance health, education, nutrition, promote social independence and decision making (Reddy et al., 2000). The long-term effect will be increased independence of women, improved strategic life choices of women, enhanced access to and control of resources and the ability to make decisions that impact relevant life indicators (Malhotra et al., 2002).

The advantages of using clean and efficient fuels for cooking have generated significant research interest in women empowerment and fuel choice. Reddy et al. (2000) argued that 'poverty possesses a woman's face'[1] and pointed out that fuel and women are connected to energy poverty via the characteristic of the fuel available, the nature of the community in which the household resides, the structure of energy policy and the position of women in their families. The author found that the use of clean and efficient fuel is important for improving women's position in their families. WHO (2016) observed that the advancement toward achieving the objective of worldwide access to clean energy for cooking is very slow as a significant percentage of the global population still uses heavy polluting fuels which are harmful to human lives. Similarly, de Groot et al. (2017) disclosed that access to clean and sustainable energy will provide women the opportunity to establish enterprises, enhance the expansion of their businesses and create the conducive atmosphere for empowering women in the long term. James et al. (2020) also found that the use of biomass as a cooking fuel by women is significantly related to age, level of education, occupation and socio-economic status. High socio-economic status encourages the use of clean fuel while low socio-economic status makes women use dirty and heavy polluting fuel. Dutta (2021) and Odo et al. (2021) revealed that women empowerment exerts a weighty effect on family expenditure on clean fuels. In addition, awareness and empowerment of females greatly increased the transition to clean fuels (Dutta, 2021). Using five indicators of women empowerment, Samad & Zhang (2019) found that electrification improves women empowerment in India. Similarly, Gould & Urpelainen (2020) and Choudhuri & Desai (2020) evaluated the effect of gender inequality on fuel choice of Indian households and unearthed that women employed in the formal sector as well as those in charge of household expenditure decision-making are most likely to use efficient fuels. In addition, Gould & Urpelainen (2020) disclosed that LPG access and cost of cylinder are inversely related to usage of LPG. However, Standal & Winther (2016) argued that electricity access strengthens the pathways of gender inequality in Uttar Pradesh, India and attributed this to gender neutrality of electricity intervention policies.

The above analyses show that past studies have concentrated on how women empowerment influences fuel choice; cooking fuel choice and health implications of women; fuel choice and empowerment; and the relationship between energy, gender and poverty. However, the extant studies have sparsely concentrated on investigating whether the choice of clean fuel can influence women empowerment. Even though Standal & Winther (2016) and Samad & Zhang (2019) have examined fuel choice and women empowerment, their studies are limited to only electricity and a few indicators of women empowerment. However, apart from electricity, there are other important clean fuel sources such as LPG and biogas that can improve the health of women since they emit fewer pollutants and contribute significantly to women empowerment. Our study endeavours to fill this literature gap by providing new evidence on how the choice of clean and efficient cooking fuel can engender empowerment of women in Ghana using a multiple fuel framework (biogas, electricity and LPG) and 15 indicators of women empowerment. We provide multifaceted contributions to the literature.

[1](Women face burden such as child-bearing, childcare, unpaid domestic labour, low growth opportunities, less access to health, education and low income which together make them highly prone to poverty).

First, we examine the effect of dirty fuel on women empowerment by applying the Survey-based Women's Empowerment Index (SWPER) developed by Ewerling et al. (2017). This index was constructed using Principal Component Analysis (PCA) based on 15 indicators that are related to women empowerment in the Ghana Demographic and Health Survey in 2014. SWPER has the capability to enlarge and accommodate significant variables on women empowerment and provides improved estimates on fuel choice. In addition, it has the potential of capturing within-group and between-country comparison as well as being suitable for time trend analysis (Ewerling et al., 2017). Second, we examine the effect of clean fuel on women empowerment and finally we ascertain whether the effect of dirty and clean cooking fuels differs with different women empowerment dimensions.

The next section is devoted to the materials and methods where we draw the relevant estimations techniques for the study and describe the data used for the analyses. In section 3, we present the empirical results. Discussions of empirical results are presented in section 4, while section 5 presents the conclusion and policy recommendations.

2. Materials and methods

2.1. Materials/data description

The data for this study are taken from the 2014 round of Ghana Demographic and Health Survey (GDHS). This survey was implemented by the Ghana Statistical Service (GSS), Ghana Health Service (GHS) and the National Public Health Reference Laboratory (NPHRL) of the GHS. This is a national representative sample with the primary objective of generating reliable information on fertility, family planning, infant and child mortality, maternal and child health, and nutrition (GSS et al., 2015). The survey collects key information from households, couples, men and women. This current data is the sixth round with the other five rounds collected in the years 1988, 1993, 1998, 2003 and 2008. The sampling frame for the survey was the population living in private households, excluding nomadic and institutional populations such as persons in hotels, barracks and prisons.

The sampling frame is based on a two-stage stratified sampling. In the first stage, a total of 426 clusters which consists of enumeration areas (EAs) were selected. The EAs were stratified into the 10 administrative regions based on the population in each region. Out of the 426 clusters, 216 were in urban areas while 211 were located in rural areas. In the second stage, households were systematically and randomly sampled from a list of households in all selected EAs. For each EA, about 30 households were selected to constitute a total sample of 12,831 households. The data also contains information of women aged 15–49 who were either permanent residents of the selected households or visitors who stayed in the household the night before the survey. The total number of women aged 15–49 interviewed was 9,396. We used information from the household dataset and the women register dataset for the analysis. The women register data was used to construct the women empowerment scores and later merged with the household dataset. By implication, a woman in a union (married or partnered) represented a household.

2.2. Methods

2.2.1. Dependent variables

The main dependent variable of interest in this study is the Survey-based Women's empowerment index (SWPER) developed by Ewerling et al. (2017). The index was constructed based on the DHS survey that targeted women aged 15–49 years with particular focus on women in a union (married and partnered women). We use the same 15 questions in the survey as used by Ewerling et al. (2017). These questions, shown in Table A1 are key to women's empowerment. To make the interpretation of our results easier, we recoded the responses to these questions such that higher values would correspond to greater empowerment and lower values corresponding to lower empowerment. The recoded answers for these questions are shown in Table 1.

We applied Principal Component Analysis (PCA) to all the 15 questions. In the process, components, factor loadings and scree plots were examined to ascertain the number of components to be retained. Three components were retained and represented three dimensions of empowerment, namely attitude to violence, social independence and decision making, as shown in Table 2. For estimation purposes, we follow methods similar to Ewerling et al. (2017) and Smits & Steendijk (2015) to compute women empowerment scores. We standardised each index such that larger values would correspond to higher women empowerment and lower values would correspond to lower women empowerment. To compute the standardised score, eqns. (1), (2) and (3) are used.

$$SS_{ij} = \left[[\vartheta_{1j}(x_{1i} - \bar{x}_1)\right] \frac{+[\vartheta_{2j}(x_{2i} - \bar{x}_2)] + \cdots + [\vartheta_{15j}(x_{15i} - \bar{x}_{15})]]}{\sigma_j} \quad (1)$$

where SS_{ij} is the standardised score for individual i and component j; $x_{1i}, x_{2i}, \ldots, x_{15i}$ are the individual variables for values $x_1 - x_{15}$ used for the PCA analysis; σ_j is the standard deviation of the predicted scores of each component j; $\vartheta_{1j}, \vartheta_{2j}, \ldots, \vartheta_{15j}$ are the

Table 1. Recoded answers for some items used to measure women empowerment.

Item	Code or unit
Beating not justified if wife goes out without telling husband	Justified = −1; don't know = 0; not justified = 1
Beating not justified if wife neglects the children	Justified = −1; don't know = 0; not justified = 1
Beating not justified if wife argues with husband	Justified = −1; don't know = 0; not justified = 1
Beating not justified if wife refuses to have sex with husband	Justified = −1; don't know = 0; not justified = 1
Beating not justified if wife burns the food	Justified = −1; don't know = 0; not justified = 1
Who usually decides on respondent's health care	Husband or other alone = −1; joint = 0; respondent alone = 1
Who usually decides on large household purchases	Husband or other alone = −1; joint = 0; respondent alone = 1
Who usually decides on visits to family or relatives	Husband or other alone = −1; joint = 0; respondent alone = 1
Age of woman at first birth*	Years
Respondent worked in the past 12 months	No = 0; in the past year = 1; currently working = 2; have a job, but on leave last 7 days = 2

*Imputed through single hot-deck imputation.

Note: Table 1 is taken from 'The SWPER index for women's empowerment in Africa: development and validation of an index based on survey data' by Ewerling et al. (2017). Copyright © the Authors.

Table 2. Items used in constructing each women empowerment dimension.

Empowerment Dimension (as used in SWPER)	Variable	Code or unit
Attitude to violence	Beating NOT justified if: 1. wife goes out without telling husband 2. wife neglects the children 3. wife argues with husband 4. wife refuses to have sex with husband 5. wife burns the food	Yes = −1; Don't know = 0; No = 1
Social independence	6. Frequency of reading newspaper or magazine	Not all = 0; less than once a week = 1; at least once a week = 2
	7. Woman education in completed years of schooling	Years
	8. Education difference: woman minus husband completed years of schooling	Years
	9. Age difference: woman age minus husband age	Years
	10. Age at first cohabitation	Years
	11. Age of woman at first birth	Years
Decision-making	Who usually decides on: 12. Respondent's health care 13. Large household purchases 14. Visits to family or relatives	Husband or other alone = −1; joint = 0; respondent alone = 1
	15. Respondent worked in last 12 months	No = 0; in the past year = 1; currently working = 2; have a job, but on leave last 7 days = 2

weights assigned to each of the 15 variables in each component j defined as

$$\vartheta_{bj} = \frac{\varphi_{bj}}{\sigma_b}, \quad b = 1, \ldots, 15 \tag{2}$$

where φ_{bj} is the PCA factor loading for each variable b in each component j and σ_b is the standard deviation for each variable b.

Equation (1) can be further simplified to

$$SS_{ij} = \frac{\left[-\left(\sum_{b=1}^{15} \vartheta_{bj}\bar{x}_b\right) + \left(\sum_{vb}^{15} (\vartheta_{bj}x_{bi})\right)\right]}{\sigma_j} \tag{3}$$

After obtaining the standardised scores and following Ewerling et al. (2017), we compute the three dimensions of women empowerment as follows:

$$\text{Attitude to violence score} = \frac{\left[(-0.915) + \left(\sum_{\mathrm{b=1}}^{15} (\vartheta_{\mathrm{b1}}\mathrm{x}_{\mathrm{bi}})\right)\right]}{1.953} \tag{4}$$

$$\text{Social independece score} = \frac{\left[(-5.311) + \left(\sum_{\mathrm{vb}}^{15} (\vartheta_{\mathrm{b2}}\mathrm{x}_{\mathrm{bi}})\right)\right]}{1.44} \tag{5}$$

$$\text{Decision making score} = \frac{\left[(0.796) + \left(\sum_{\mathrm{b=1}}^{15} (\vartheta_{\mathrm{b3}}\mathrm{x}_{\mathrm{bi}})\right)\right]}{1.283} \tag{6}$$

Following the computation of the three dimensions of women empowerment, we proceed to create the second dependent variable by constructing three categories of women empowerment for each dimension. Using the three dimensions, each household/woman is categorised as low empowerment, medium empowerment or high

empowerment. This categorisation follows that of Ewerling et al. (2017) and defined as:

$$\text{Attitude to violence} = \begin{cases} \text{low, if score} < -0.7 \\ \text{medium, if} -0.7 < \text{score} < 0.4 \\ \text{High, if score} > 0.4 \end{cases} \tag{7}$$

$$\text{Social Independence} = \begin{cases} \text{low, if score} < -0.559 \\ \text{medium, if} -0.559 < \text{score} < 0.293 \\ \text{High, if score} > 0.293 \end{cases} \tag{8}$$

$$\text{Decision making} = \begin{cases} \text{low, if score} < -1.0 \\ \text{medium, if} -1.0 < \text{score} < 0.6 \\ \text{High, if score} > 0.6 \end{cases} \tag{9}$$

2.2.2. Explanatory variable

Our main explanatory variable is the primary cooking fuel used by the household. In the 2014 DHS dataset, households were asked about the main cooking fuel used in the household. We therefore create a dummy variable taking the values of 1 if the household uses clean cooking fuel which is made up of electricity, liquefied petroleum gas (LPG) and natural gas, and 0, otherwise. The complete list of all the variables used in our analysis and their definitions are shown in Table A2.

2.2.3. Econometric model

The goal of this paper is to ascertain the effect of clean or dirty cooking fuel on women empowerment in Ghana. We are also interested in understanding how the choice of a particular cooking fuel (clean or dirty) predicts the empowerment status of a woman. The empowerment status of a woman is divided into three categories namely low, medium and high. This categorisation is done for all three dimensions of women empowerment. We employ the ordered probit model since our women empowerment variable has now been classified as an ordinal variable.

Formally, consider a latent variable model given as:

$$y_i^* = x_i'\beta + \varepsilon_i \tag{10}$$

Where the variable y^* is unobservable. There is however information on when y^* crosses some threshold levels. Also, i is the household/woman, x_i is a vector of independent variables and ε_i is the error term.

A household/woman will be in a particular women empowerment category (labelled as j)if it passes a threshold. This is formally denoted as:

$$y_i = j \text{ if } \alpha_{j-1} < y_i^* < \alpha_j, \quad i = 1, 2, \ldots, n \tag{11}$$

Where α_{j-1} and α_j are the two thresholds.

In this paper, y_i takes the values of 1, 2 and 3 if a household/woman is classified as low empowerment, medium empowerment and high empowerment, respectively. As such,

the choice rule can be formally written as:

$$y_i = \begin{cases} 1, & \text{if } y_i^* \leq \alpha_1 \\ 2, & \text{if } \alpha_1 < y_i^* \leq \alpha_2 \\ 3, & \text{if } y_i^* > \alpha_2 \end{cases} \tag{12}$$

The probability that a household/woman i will be in category j is given as:

$$p_{ij} = p(y_i = j) = p(\alpha_{j-1} < y_i^* \leq \alpha_j) = F(\alpha_j - x'_i\beta) - F(\alpha_{J-1} - x'_i\beta) \tag{13}$$

where F is the standard normal cumulative distribution function.

Based on the equation above, the respective probabilities for the three categories are expressed as:

$$pr(y_i = 1) = F(\alpha_1 - x'_i\beta) \tag{14}$$

$$pr(y_i = 2) = F(\alpha_2 - x'_i\beta) - F(\alpha_1 - x'_i\beta) \tag{15}$$

$$pr(y_i = 3) = 1 - F(\alpha_3 - x'_i\beta) \tag{16}$$

The marginal effect of an increase in an independent variable x_m on the probability of being classified in category j is given as:

$$\frac{\partial p_{ij}}{\partial x_{mi}} = \{F'(\alpha_{J-1} - x'_i\beta) - F'(\alpha_J - x'_i\beta)\}\beta_m \tag{17}$$

3. Results

3.1. Descriptive analysis

Table 3 shows the summary statistics of the variables while Table 4 shows the mean values for the dependent variable after categorising the scores into three classes: low, medium and high women empowerment.

In Figure 1, we show the distribution of different fuel types used by Ghanaian households. Wood is chosen as the main cooking fuel by more than half of households (52%). The other major fuel types used are charcoal (28%) and LPG (18%). Few households use

Table 3. Summary statistics.

Variables	Observations	Mean	Minimum	Maximum
Decision making score	5234	0.444	−1.982	1.421
Attitude to violence score	5234	0.140	−2.450	0.911
Social independence score	5234	−0.093	−2.560	3.870
Electricity	5234	0.673	0	1
Clean fuel	5234	0.186	0	1
Household size	5234	5.385	1	25
Female Head	5234	0.174	0	1
Poorest	5234	0.291	0	1
Poorer	5234	0.191	0	1
Middle	5234	0.184	0	1
Richer	5234	0.169	0	1
Richest	5234	0.165	0	1

Table 4. Descriptive statistics of categorically measured women empowerment.

	Social independence		Attitude to violence		Decision making	
	Observations	Mean	Observations	Mean	Observations	Mean
Low	1892	0.362	921	0.176	396	0.076
Medium	1730	0.331	814	0.156	1620	0.310
High	1612	0.308	3499	0.669	3218	0.615

Note: Attitude to violence: score<−0.7(low); −0.7<score<0.4 (Medium); score>0.4(High); Social Independence: score< −0.559 (low); −0.559<score<0.293 (Medium); score>0.293; Decision Making: score<−1.0 (low); −1.0<score<0.6 (Medium); score>0.6.

other types of fuel for cooking. Cumulatively, over 81% of households use dirty fuels with less than 19% of households using clean fuels.

3.1.2. Principal component analysis of women empowerment

Table 5 shows the eigenvalues from the PCA. It is observed that the eigenvalues of the first three components explain about 50% of the total variation in the data. Therefore, those three components were retained as they explained 24%, 13% and 12%, respectively, of the total variability out of the 15 principal components.[2]

3.1.3. Empirical results

Empirical results are presented in Table 6. It shows the marginal effects from the ordered probit estimation. Women are categorised as having low, medium or high levels of empowerment according to the three measures of women empowerment i.e. social independence, attitude to violence and decision making.

We find that the type of cooking fuel used by the household has a significant association with the level of empowerment of the women in the household. The probability of having low and medium levels of women empowerment reduces with the use of clean fuel while the likelihood of having a high level of empowerment increases with the use of clean fuel. This finding is consistent across all domains of women empowerment. On social independence, a switch from dirty cooking fuel to clean cooking fuel reduces the probability of having low and medium levels of empowerment by 17% and 3%, respectively, while increasing the likelihood of having high level of

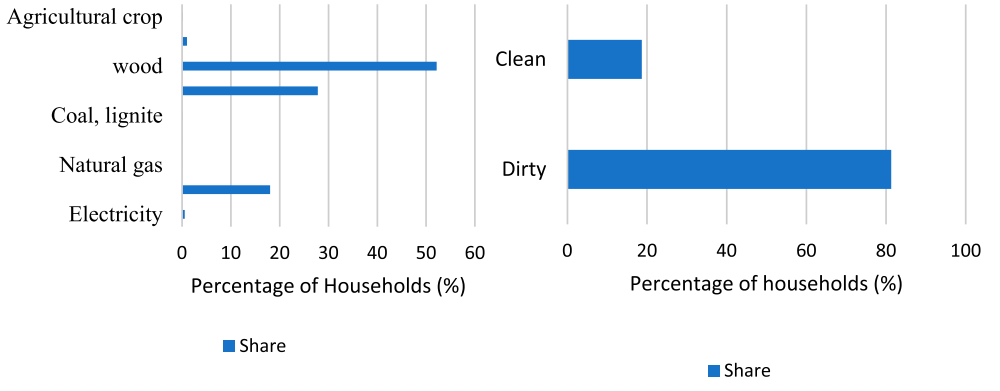

Figure 1. Distribution of main cooking fuels among households.

Table 5. Results from Principal Component Analysis (PCA).

Component	Eigenvalue	Variance proportion	Cumulative variance proportion
Component 1	3.640	0.243	0.243
Component 2	1.972	0.132	0.374
Component 3	1.801	0.120	0.494
Component 4	1.228	0.082	0.576
Component 5	0.983	0.066	0.642
Component 6	0.926	0.062	0.703
Component 7	0.820	0.055	0.758
Component 8	0.643	0.043	0.801
Component 9	0.580	0.039	0.840
Component 10	0.568	0.038	0.877
Component 11	0.498	0.033	0.911
Component 12	0.421	0.028	0.939
Component 13	0.360	0.024	0.963
Component 14	0.285	0.019	0.982
Component 15	0.276	0.018	1.000

empowerment by 20%. When judging women empowerment via the domain of attitude to violence, a switch to clean fuel is associated with a reduced probability of having low and medium levels of empowerment at 2% and 3.6%, respectively, while increasing the probability of having high level of empowerment by 5.5%. Levels of statistical significance are stronger under these two domains of women empowerment compared to using the decision making domain, where the use of clean fuel is associated with a reduced likelihood of having low and medium levels of empowerment of 0.6% and 3.7%, respectively, and an increased probability of having high level of empowerment by 4.4%. Summarily stated, using clean household fuel increases the chances of women being highly empowered and decreases the chances of them being less empowered.

The effect of household size on women empowerment is only significant under the social independence domain where an increase in household size by 10% increases the probability of having low empowerment by 1.9% and reduces the probability of having medium and high levels of empowerment by 0.1% and 1.9%, respectively. The effect of the woman being the head of the household on her empowerment is most strongly observed under the decision making domain. A female head is associated with a reduced probability of being low and medium level empowered of 0.9% and 5.7%, respectively, while it increases the chances of being highly empowered by 6.6%. Being a female head is significant in increasing the chances of having medium level empowerment by 0.02% under the social independence domain and has no significant effect on the attitude to violence domain.

Expectedly, wealth is significantly related to women empowerment under the social independence and attitude to violence domains with no observed significant relationship via the decision making domain. Relative to poor households, households in other wealth quintiles i.e. poorer, middle, richer and richest households have a lower likelihood of having low levels of empowerment under the social independence dimension and the magnitude of probability increases with each higher wealth quintile. Poorer, middle, richer and richest households are less likely to be in the low empowerment category by 6.2%, 12.2%, 23.5% and 30.7%, respectively, when compared with poor households.

[2]A scree plot showing this graphically is presented in Table A3. A PCA factor loadings report is also attached in Table A4.

Table 6. Marginal effects from Ordered Probit regression results (Dependent variable: Level of women empowerment).

	Social independence			Attitude to violence			Decision making		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Clean fuel	−0.174*** (0.021)	−0.029*** (0.009)	0.203*** (0.029)	−0.020*** (0.007)	−0.036*** (0.013)	0.055*** (0.020)	−0.006* (0.003)	−0.037* (0.022)	0.044* (0.025)
Electricity	0.006 (0.023)	−0.0002 (0.0005)	−0.006 (0.022)	−0.009 (0.007)	−0.014 (0.011)	0.023 (0.019)	0.003 (0.004)	0.018 (0.023)	−0.021 (0.027)
Household size	0.019*** (0.003)	−0.001*** (0.0001)	−0.019*** (0.003)	0.001 (0.001)	0.001 (0.001)	−0.002 (0.002)	0.0003 (0.0004)	0.002 (0.003)	−0.002 (0.003)
Female Head	−0.015 (0.017)	0.0002*** (0.00004)	0.015 (0.018)	0.004 (0.006)	0.007 (0.009)	−0.011 (0.002)	−0.009*** (0.002)	−0.057*** (0.017)	0.066*** (0.020)
Poorer	−0.062** (0.025)	0.017** (0.008)	0.045** (0.018)	−0.005 (0.009)	−0.006 (0.012)	0.011 (0.021)	−0.004 (0.005)	−0.020 (0.025)	0.024 (0.030)
Middle	−0.122*** (0.031)	0.026*** (0.008)	0.096*** (0.024)	−0.021** (0.010)	−0.031** (0.015)	0.052** (0.025)	−0.006 (0.006)	−0.030 (0.030)	0.036 (0.035)
Richer	−0.235*** (0.032)	0.012** (0.006)	0.223*** (0.031)	−0.037*** (0.011)	−0.060*** (0.017)	0.097*** (0.028)	−0.003 (0.006)	−0.017 (0.033)	0.021 (0.039)
Richest	−0.307*** (0.034)	−0.029** (0.012)	0.336*** (0.042)	−0.047*** (0.012)	−0.082*** (0.022)	0.129*** (0.033)	−0.011 (0.007)	−0.062 (0.040)	0.073 (0.047)
Observations	5234	5234	5234	5234	5234	5234	5234	5234	5234
Community FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors are clustered at the community and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: Attitude to violence: score<−0.7(low); −0.7<score<0.4 (Medium); score>0.4(High); Social Independence: score<−0.559 (low); −0.559<score<0.293 (Medium); score>0.293; Decision Making: score<−1.0 (low); −1.0<score<0.6 (Medium); score>0.

Table 7. Regression results (Dependent variable: women empowerment score).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Social independence		Attitude to violence		Decision making	
Clean fuel	0.709*** (0.055)	0.481*** (0.060)	0.149*** (0.026)	0.072** (0.032)	0.128*** (0.034)	0.077* (0.042)
Electricity		0.014 (0.045)		0.069 (0.047)		−0.047 (0.042)
Household size		−0.047*** (0.006)		−0.004 (0.007)		−0.012** (0.005)
Female Head		0.076* (0.040)		−0.034 (0.032)		0.102*** (0.030)
Poorer		0.097** (0.047)		0.027 (0.052)		0.030 (0.048)
Middle		0.233*** (0.056)		0.090 (0.059)		0.072 (0.053)
Richer		0.537*** (0.069)		0.205*** (0.065)		0.069 (0.055)
Richest		0.736*** (0.091)		0.271*** (0.076)		0.172** (0.070)
Observations	5234	5234	5234	5234	5234	5234
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.315	0.344	0.381	0.384	0.278	0.283

Note: Robust standard errors are clustered at the community and reported in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Similarly, other households tend to have a higher likelihood of being in the category of high empowerment when compared with poor households. The chances of being highly empowered (from poorer to richest households) increase by 4.5%, 9.6%, 22.3% and 33.6%, respectively, when compared with poor households. Under the attitude to violence dimension, poorer households are no significantly different from poor households. Other households, however, are less likely to be in the low and medium level categories of women empowerment compared to poor households and more likely to be in the high level category of women empowerment. Specifically, the probability of having low empowerment reduces by 2.1%, 3.7% and 4.7% for middle, richer and richest households, respectively, when compared with poor households while the probability of being highly empowered increases by 5.2%, 9.7% and 12.9%, respectively.

Table 7 shows regression results estimated by OLS on the raw scores of women empowerment by the various measures. The results in Table 7 confirm the details of the findings revealed through the ordered probit estimation. Clean fuel use significantly increases the empowerment score of the woman in the household across all measures while a female being the head increases the women empowerment score under the social independence and decision making dimensions with no significant effect under the attitude to violence dimension. Household size is negatively associated with the empowerment score under the social independence and decision making scores. Wealth is found to be positively associated with women empowerment. Relative to poor households, all other households have significantly higher empowerment scores under the social independence domain while the association is significant for richer and richest households under the attitude to violence measure. Under the decision making domain, only the richest households have a significant relationship with empowerment relative to poor households.

4. Discussion

The results show a positive association between clean fuel use and level of women empowerment. Households with a clean fuel as main cooking fuel have a higher women empowerment score and have increased probability of the woman in the

household being highly empowered compared to households using dirty cooking fuel as main fuel. This supports the findings of Burney et al. (2017) and de Groot et al. (2017). Clean fuel use potentially facilitates women empowerment in several ways. It has been established in the literature that use of clean fuel saves time spent collecting dirty fuel as well as cooking time (Anderman et al., 2015; Bensch & Peters, 2015; Lewis et al., 2017; Williams et al., 2020). The saved time resulting from clean fuel use could be spent by women, who are often the household members responsible for firewood collection and cooking, in education or income generating activities. These increase their independence, contribute to their wealth status and consequently makes them more empowered; a view supported by Simkovich et al. (2019). Time savings could also be channelled into leisure activities (Williams et al., 2020) which improve overall health and welfare. Furthermore, there is evidence of dirty fuel use having negative health implications on users with women at higher risk and the use of clean fuel reducing incidences of diseases in the household (Parikh, 2011; Upadhyay et al., 2015; Kurata et al., 2020; Adjei-Mantey & Takeuchi, 2021). Thus, by using clean fuel, the health of household members including women and children improves. Women will therefore have more healthy days to be productive while avoiding days off work due to having to care for sick children. These potentially increase the women's social independence thereby contributing to enhanced women empowerment.

The finding therefore fulfils the primary objective of this study by confirming that using clean cooking fuel promotes women empowerment. Furthermore, the results showed that the positive and significant association of clean fuel use to high women empowerment is consistent across different dimensions. While the coefficients for the different women empowerment dimensions differ in magnitude, they point in the same direction. Thus, the findings confirm that the different dimensions do not distort the women empowerment effect of clean fuel use.

This finding has several implications. By promoting clean cooking fuel use, developing countries not only contribute to achieving a low carbon economy through reduced use of wood fuels, but they contribute to enhancing women's empowerment as well through the pathways discussed. This helps to reduce gender inequalities, expand economic and social opportunities for women and subsequently promote inclusive economic development.

Household size negatively affected women empowerment especially under the social independence dimension. Households with larger sizes have a higher dependency ratio as the majority of the members are likely to be children who have to be cared for. This places stress on the incomes of the few working adults in the household. Meyer & Nishimwe-Niyimbanira (2016) confirmed poorer households with less resources are those likely to have larger household sizes. Without enough resources to share in such households, women are likely to be less socially independent and consequently have lower levels of empowerment. The opposite holds true as households with fewer members likely have fewer children. With less time needed for child care and enough resources to cater for children, women's incomes might be sufficient to cater for their children and increases their chances of being independent. Additionally, they can have a say in decision making as they may be contributing significantly to the household finances since they have less pressure on their incomes. We do not find evidence, however, of the association of household size with empowerment when viewed via the

attitude to violence domain. Female headship is positively associated with women empowerment and is strongest under the decision making domain. This is almost intuitive since household heads take the majority if not all decisions on behalf of the household. As such, in cases where the woman is the head, they take decisions for the household and will likely score high marks with respect to decision making.

Wealth is positively and significantly associated with empowerment under the social independence and attitude to violence dimensions but not so much under the decision making dimension. The increasing magnitude of the association between wealth and women empowerment as we move from lower to higher wealth quintiles shows that the higher the wealth of the household, the more the women are empowered. This agrees with the findings of Voronca et al. (2018). The association of wealth with women empowerment through decision making was rather weak and this supports the findings of Pambe et al. (2014). It is unclear why wealth may not be strongly associated with decision making. It could, however, be possibly due to either the household wealth being exclusively owned by male partners or that the male partners were the sole or major contributors to the wealth status. Thus, despite the women belonging to households with more wealth, they may still not be actively involved in decision making if they are deemed to have contributed insignificantly to the household wealth.

Overall, we present new evidence that supports the view that among the many benefits of clean fuel use at the household is the potential for clean cooking to facilitate and contribute to women empowerment. The reverse relationship, i.e. women empowerment leading to use of clean fuel is perhaps a more intuitive reasoning and has been empirically demonstrated to hold by Odo et al. (2021). However, we provide new evidence to show that using clean fuel also has pathways which could lead to greater women empowerment. Both factors – use of clean energy and increasing women empowerment are crucial to achieving the sustainable development goals.

5. Conclusion

This study examined the relationship between clean fuel use and women empowerment in Ghana. Employing the Survey-based Women's Empowerment Index (SWPER) as a measure of women empowerment, we find significant associations between clean cooking fuel use and women empowerment in Ghana. Clean fuel use in the household increases the chances of women being highly empowered and reduces the likelihood that they will have low levels of empowerment. The potential channel through which using clean fuel may result in high women empowerment is the saved time from firewood collection and longer cooking times when using firewood or other dirty fuels. The saved time could be spent enhancing women's education or investing in income generation. Additionally, the health benefits of using clean fuel afford women the opportunity to be more productive as they will have fewer sick days themselves or fewer days off work to care for sick children as a result of exposure to dirty fuels. The more days of good health, all else being equal, implies more productive days for which women can earn more income and thus be more active in decision making which potentially drives up their levels of empowerment. The study further found that the effect of using clean fuel on women empowerment was consistent for the different dimensions of women empowerment. Generally, all three dimensions responded positively and

significantly to clean fuel use. Thus, the effect of clean fuel on women empowerment did not differ by the women empowerment dimension even though the social independence and the attitude to violence dimensions showed stronger significance than the decision making dimension while the social independence dimension showed the largest response magnitudes compared to the other two dimensions. This points to the relevance of, among other things, education and information of women and how responsive these factors could be to their use of clean fuel since the woman's completed years of schooling and her frequency of reading newspapers and magazines are used to compute the social independence dimension.

The findings suggest that an investment in cooking fuel transition from dirty fuels to clean ones is necessary. Therefore, it is recommended that governments of developing countries implement policies that will promote clean cooking fuel use such as waiving levies and taxes on clean fuels such as LPG to make the fuel more affordable. Furthermore, vulnerable households should be supported with free clean fuel equipment and accessories to reduce initial cost constraints to switching to cleaner fuel. Additionally, intensifying public education on the clean fuel adoption is recommended. These measures will not only meet the usual fuel transition goals of addressing environmental and health concerns but will also be relevant in empowering women and reducing social and economic inequality among developing countries. Together, these will accelerate the achievement of the sustainable development agenda in these countries.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Adjei-Mantey, K & Takeuchi, K, 2021. The effect of in utero exposure to household air pollution on child health: Evidence from Ghana. Health Policy Open 2, 100029.

Anderman, TL, DeFries, RS, Wood, SA, Remans, R, Ahuja, R & Ulla, SE, 2015. Biogas cook stoves for healthy and sustainable diets? A case study in Southern India. Frontiers in Nutrition 2, 28.

Bensch, G & Peters, J, 2015. The intensive margin of technology adoption–Experimental evidence on improved cooking stoves in rural Senegal. Journal of Health Economics 42, 44–63.

Burney, J, Alaofè, H, Naylor, R & Taren, D, 2017. Impact of a rural solar electrification project on the level and structure of women's empowerment. Environmental Research Letters 12(9), 095007.

Choudhuri, P & Desai, S, 2020. Gender inequalities and household fuel choice in India. Journal of Cleaner Production 265, 121487.

de Groot, J, Mohlakoana, N, Knox, A & Bressers, H, 2017. Fuelling women's empowerment? An exploration of the linkages between gender, entrepreneurship and access to energy in the informal food sector. Energy Research & Social Science 28, 86–97.

Dutta, S, 2021. Indoor fuel choice and women empowerment: A demand-side analysis. In Mishra, AK, Aruna Chalam, V, & Patnaik, D (Eds.), Critical perspectives on emerging economies. Springer, Cham, 129–146.

Ewerling, F, Lynch, JW, Victora, CG, van Eerdewijk, A, Tyszler, M & Barros, AJ, 2017. The SWPER index for women's empowerment in Africa: Development and validation of an index based on survey data. The Lancet Global Health 5(9), e916–23.

Gould, CF & Urpelainen, J, 2020. The gendered nature of liquefied petroleum gas stove adoption and use in rural India. The Journal of Development Studies 56(7), 1309–29.

GSS (Ghana Statistical Service), 2008. Ghana Demographical and Health Survey 2008. Rockville, Maryland, USA: GSS, GHS and ICF International. https://www.dhsprogram.com/pubs/pdf/FR307/FR307.pdf.

GSS (Ghana Statistical Service), 2014. Ghana Living Standards Survey Round 6 (GLSS 6) Main Report. Ghana Statistical Service, Accra.

GSS (Ghana Statistical Service), GHS (Ghana Health Service), and ICF International, 2015. Ghana Demographical and Health Survey 2014. Rockville, Maryland, USA: GSS, GHS and ICF International. https://www.dhsprogram.com/pubs/pdf/FR307/FR307.pdf.

IEA, 2019. World energy outlook France: International energy agency. International Energy Agency, Paris.

James, BS, Shetty, RS, Kamath, A & Shetty, A, 2020. Household cooking fuel use and its health effects among rural women in southern India—A cross-sectional study. PloS One 15(4), e0231757. https://doi.org/10.1371/journal.pone.0231757

Kurata, M, Takahashi, K & Hibiki, A, 2020. Gender differences in associations of household and ambient air pollution with child health: Evidence from household and satellite-based data in Bangladesh. World Development 128, 104779.

Lewis, JJ, Hollingsworth, JW, Chartier, RT, Cooper, EM, Foster, WM, Gomes, GL, Kussin, PS, MacInnis, JJ, Padhi, BK, Panigrahi, P, Rodes, CE, Ryde, IT, Singha, AK, Stapleton, HM, Thornburg, J, Young, CJ, Meyer, JN, & Pattanayak, SK, 2017. Biogas stoves reduce firewood use, household air pollution, and hospital visits in Odisha, India. Environmental Science & Technology 51(1), 560–9.

Malhotra, A, Schuler, SR & Boender, C, 2002. Measuring women's empowerment as a variable in international development. In background paper prepared for the World Bank workshop on poverty and gender: New perspectives. Vol. 28, June. The World Bank, Washington, DC, 1–58.

Meyer, DF & Nishimwe-Niyimbanira, R, 2016. The impact of household size on poverty: An analysis of various low-income townships in the Northern Free State region, South Africa. African Population Studies 30(2), 2283–95.

Newell, K, Cusack, RP, Kartsonaki, C, Chaudhary, N & Kurmi, OP, 2022. Household air pollution and associated health effects in low and middle income countries. Encyclopedia of Respiratory Medicine 6, 387–401.

Odo, DB, Yang, IA, Green, D & Knibbs, LD, 2021. Women's empowerment and household fuel use in 31 African countries: A cross-sectional analysis of households in the Demographic and Health Survey. Environmental Research Letters 16(2), 025012.

Pambè, MW, Gnoumou, B & Kaboré, I, 2014. Relationship between women's socioeconomic status and empowerment in Burkina Faso: A focus on participation in decision-making and experience of domestic violence. African Population Studies 28, 1146–56.

Parikh, J, 2011. Hardships and health impacts on women due to traditional cooking fuels: A case study of Himachal Pradesh, India. Energy Policy 39, 7587–94.

Reddy, AK, Annecke, W, Blok, K, Bloom, D, Boardman, B, Eberhard, A & Ramakrishna, J, 2000. Energy and social issues. World Energy Assessment. United Nations Development Programme, New York, NY, 39–60.

Samad, HA & Zhang, F, 2019. Electrification and women's empowerment: Evidence from rural India. World Bank Policy Research Working Paper 8796, 1–30. https://documents1.worldbank.org/curated/en/112131553786901131/pdf/Electrification-and-Womens-Empowerment-Evidence-from-Rural-India.pdf.

Simkovich, SM, Williams, KN, Pollard, S, Dowdy, D, Sinharoy, S, Clasen, TF, Puzzolo, E, & Checkley, W, 2019. A systematic review to evaluate the association between clean cooking technologies and time use in low-and middle-income countries. International Journal of Environmental Research and Public Health 16(13), 2277.

Smits, J & Steendijk, R, 2015. The international wealth index (IWI). Social Indicators Research 122 (1), 65–85.
Standal, K & Winther, T, 2016. Empowerment through energy? Impact of electricity on care work practices and gender relations. Forum for Development Studies 43(1), 27–45.
Upadhyay, AK, Singh, A, Kumar, K & Singh, A, 2015. Impact of indoor air pollution from the use of solid fuels on the incidence of life threatening respiratory illnesses in children in India. BMC Public Health 15(1), 1–9.
Voronca, D, Walker, RJ & Egede, LE, 2018. Relationship between empowerment and wealth: Trends and predictors in Kenya between 2003 and 2008–2009. International Journal of Public Health 63(5), 641–9.
World LPG Association, 2014. Annual Report. https://www.wlpga.org/wp-content/uploads/2015/01/wlpga-ar2014.pdf
World Health Organization, 2016. Burning opportunity: Clean household energy for health, sustainable development, and wellbeing of women and children. https://apps.who.int/iris/bitstream/handle/10665/204717/9789241565233_eng.pdf.
Williams, KN, Kephart, JL, Fandiño-Del-Rio, M, Simkovich, SM, Koehler, K, Harvey, SA, Checkley, W, & CHAP trial Investigators, 2020. Exploring the impact of a liquefied petroleum gas intervention on time use in rural Peru: A mixed methods study on perceptions, use, and implications of time savings. Environment International 145, 105932.

Appendices

Table A1. Items used to measure women empowerment.

Item	Code or unit
Beating justified if wife goes out without telling husband	No = 0; 1 = Yes; 8 = don't know
Beating justified if wife neglects the children	No = 0; 1 = Yes; 8 = don't know
Beating justified if wife argues with husband	No = 0; 1 = Yes; 8 = don't know
Beating justified if wife refuses to have sex with husband	No = 0; 1 = Yes; 8 = don't know
Beating justified if wife burns the food	No = 0; 1 = Yes; 8 = don't know
Who usually decides on respondent's health care	Respondent alone = 1; respondent and husband/partner = 2; husband/partner alone = 4; someone else = 5; other = 6
Who usually decides on large household purchases	Respondent alone = 1; respondent and husband/partner = 2; husband/partner alone = 4; someone else = 5; other = 6
Who usually decides on visits to family or relatives	Respondent alone = 1; respondent and husband/partner = 2; husband/partner alone = 4; someone else = 5; other = 6
Woman's education in completed years of schooling	Years
Education difference: woman's minus husband's completed years of schooling	Years
Age difference: woman's age minus husband's age	Years
Age at first cohabitation	Years
Age at woman at first birth	Years
Frequency of reading newspaper or magazine	Not all = 0; less than once a week = 1; at least once a week = 2
Respondent worked in the past 12 months	No = 0; in the past year = 1; currently working = 2; have a job, but on leave last 7 days = 3

Table A2. List of variables and definitions.

Variables	Type of variable and definition
Social independence	Continuous
Attitude to violence	Continuous
Decision making	Continuous
Clean fuel	Dummy (Clean = 1, Dirty = 0)
Electricity	Dummy (Yes = 1, No = 0)
Household size	Continuous
Sex of household head (Female head)	Dummy (Female = 1, Male = 0)
Wealth Index (Poorer)	Dummy (Poorer = 1, Poorest = 0)
Wealth Index (Middle)	Dummy (Middle = 1. Poorest = 0)
Wealth Index (Richer)	Dummy (Richer = 1. Poorest = 0)
Wealth Index (Richest)	Dummy (Richest = 1. Poorest = 0)

Table A3. Scree plot of components.

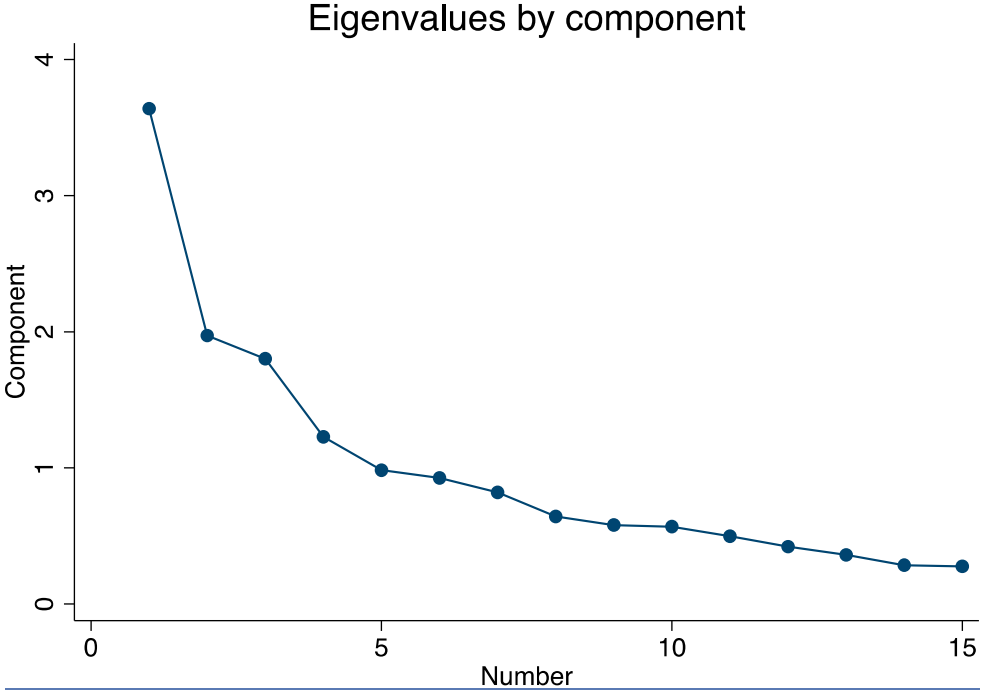

Table A4. Principal component analysis factor loadings.

Item	Comp 1	Comp 2	Comp 3	Comp 4
Beat if wife goes out without telling husband	0.412	−0.1892	−0.066	−0.006
Beat if wife neglects the children	0.410	−0.193	−0.076	0.001
Beat if wife argues with the husband	0.412	−0.191	−0.076	−0.022
Beat if wife refuses to have sex with husband	0.394	−0.176	−0.040	−0.013
Beat if wife burns the food	0.351	−0.191	−0.067	−0.023
Decides on respondent healthcare	0.124	0.037	0.550	−0.004
Decides on large household purchases	0.120	0.061	0.546	0.002
Decides on visits to family or relatives	0.096	0.068	0.530	−0.016
Woman's education	0.267	0.373	−0.030	0.389
Frequency of reading newspaper or magazine	0.169	0.335	−0.033	0.294
Education difference	0.034	0.222	−0.020	0.637
Age difference	0.108	0.141	0.022	−0.129
Age at woman at first birth	0.171	0.501	−0.142	−0.364
Age at first cohabitation	0.180	0492	−0.127	−0.385
Respondent worked in the past 12 months	0.016	0.026	0.241	−0.240