ENVIRONMENT

PIDE Working Papers
No. 2020:12

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PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS
ISLAMABAD
2020

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Designed, composed, and finished at the Publications Division, PIDE.

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ABSTRACT

About 3 billion people are relying on polluting sources of energy in developing countries. These polluting sources are responsible for 4 million deaths and 2.7 percent of the global burden of disease. Ninety-four percent of households in rural areas of Pakistan are using solid biomass for cooking and heating. Being mainly involved in cooking, rural women are highly vulnerable to hazardous pollutants. The extant literature has rarely explored the impact of indoor air pollution on women health in Pakistan. The present study unveils the effect of polluting fuel burning on symptoms of acute upper respiratory infections such as sore throat, cough, congestion, breathing difficulties, and fatigue. A household survey was conducted by employing a multi-stage sampling technique to collect data from 252 households from Abbottabad and Haripur districts of Khyber Pakhtunkhwa province. The diversification in domestic tasks, number of windows in kitchen and use of mask in close kitchen have negative and significant correlation with respiratory health symptoms. However, solid fuels, exposure to pollution, and close kitchen are found to have positive and significant impacts on respiratory health symptoms. The results of standardized regression model reveal that use of polluting energy sources in close kitchen are contributing more than twice to respiratory symptoms than in open kitchen. Exposure to pollution, solid fuels and close kitchen are major culprits for respiratory health symptoms among rural women responsible for kitchen work. The study concludes that awareness campaigns on the benefits of using clean energy sources, importance of windows and masks in close kitchen and open kitchen among rural women may help to significantly reduce the burden of respiratory health problems.

Keywords: Indoor air pollution, polluting fuel and respiratory symptoms, Pakistan

INTRODUCTION

Nearly half of the World's population (about 3 billion) including more than 90 percent of rural population in developing countries primarily depends on solid fuel (wood, crop residues, and animal cake) for cooking and heating (Desai, Mehta and Smith, 2004; Mishra and Retherford, 2007; WHO, 2006; WHO, 2011, Jan et al. 2017; Imran et al. 2019). These poor communities will continue to depend on solid fuels for cooking and heating mainly because of unreliable supply and unaffordability to cleaner sources of energy (Rahut et al. 2014; IEA, 2017; Bailis et al. 2017; and Rahut et al. 2019). The research conducted in developing countries provides empirical evidence of negative impact of exposure to indoor air pollution on human health (Torres et al. 2008; Masera et al. 2000; Nansaior et al. 2001; Mensah and Adu 2012; Ingale et al. 2013; Rahut et al. 2016). Literature reveals that more than half of the global burden of respiratory diseases is borne by people in developing countries (WHO, 2011). In South Asian countries (India, Nepal, Pakistan, and Sri Lanka), the use of biomass fuel for cooking and heating is comparatively high and varies between 67-88 percent (Chakraborty et al. 2014) which can also threatened the long-term sustainability of natural forests in developing countries (Bhattacharya and Salam 2002; Ouedraogo 2006). Since, sustainable economic development and environment is directly linked to the quality of energy used at home (Spalding-Fecher et al. 2005; Agecc, 2010; Onoja and Idoko 2012; Behera et al. 2015; UN 2016). Therefore, societies heavily depending on solid fuels are also failing to achieve sustainable development goal.

There are more than 4 million deaths annually that have been attributed to acute respiratory infection (ARI), and 75 percent of them are pneumonia, indicating the dependency on poor quality of energy (Stansfield, 1993; IEA, 2017; WHO, 2018). Therefore, ARI is considered a major cause of deaths among children and women due to indoor air pollution in the world. Women exposed to indoor pollution suffer twice from obstructive pulmonary diseases (COPD) while children have three times greater risk of acute respiratory infection compared to those living in cleaner environment (WHO, 2018; Smith et al., 2000, Smith et al. 2004).

Solid fuels are containing multiple pollutants including, suspended particulate matter, carbon monoxide, sulfur oxide and nitrogen dioxide (Smith, et al., 2000; Mensah and Adu 2012; Rahut et al. 2016). However, first two components (suspended particulate matter and carbon monoxide) are considered most hazardous to human health (WHO, 2006a; WHO, 2009; Mondal and Chakraborty, 2015). Suspended particulate matter ranges between PM10 and PM2.5 but it is worth mentioning that PM10 particulates are 30 times smaller than the width of a hair on our heads. It can easily pass through the defensive nose hairs to reach our lungs but PM2.5 is even smaller than PM10 and can be seen only with electronic microscope. These smallest particulate can penetrate through lungs tissues and then enter in blood where it can remain for prolonged time periods (Li et al., 2017a, 2017b). By travelling through blood these particulate reaches to every part of the body. Hence, PM2.5 are responsible for serious negative health impacts (Badamassi, Xu, and Leyla, 2017) and appears as “invisible killer”. Carbon monoxide affect the blood circulation by displaces oxygen in the blood and deprives the brain, heart and other vital organs that leads to loss of consciousness and suffocate (WHO, 2005). Hydrocarbon emission comes from dung which affects the women and children to varying levels of risk depending on intensity of exposure (WHO, 2009). These pollutants have been tested, with varying degree of evidence as a causal agent of several respiratory symptoms including dry cough, phlegm production and breathing difficulties, most commonly reported. However, other health related issues such as back pain, lung cancer, asthma, blindness, low birth rates and weight and respiratory infection are also linked to indoor air pollution (Ezzati, and Kammen, 2001; Quansah et al., 2017). Hence, pollution due to solid fuel burning has emerged as one of the ten most important threats to public health.

In Pakistan, rural households are using three stone stoves (made of clay and husk) without chimneys to burn biomass. This leads to incomplete combustion and thus high concentration of particullate matter, carbon monoxides and other organic compounds (Bruce et al. 2000; WHO, 2005). Archer (1993) reported that on an average 38 percent of the total sampled households have single room with close kitchen. Due to inefficient stove and close kitchen, households face different type of diseases including acute and chronic respiratory illnesses. The economic burden of indoor air pollution is significant, and its annual cost is about 1 percent of the GDP in Pakistan (Colbeck et al., 2010; Zheer et al., 2015). It is estimated that indoor air pollution accounts for 28,000 deaths per year and 40 million cases of acute respiratory illness are reported (World Bank 2006c). Langbein (2017) concludes that outdoor cooking reduces respiratory diseases by around 9 percent among young children aged 0-4. Ngahane (2015) explored the impacts of indoor pollution on respiratory symptoms and lung function in semi-rural women by employing univariate and multivariate analysis. Khan and Lohano (2018) studied the relationship between cooking fuel and respiratory health risk among children in Pakistan. Moeen et al. (2016), Rahut et al. (2019) and Imran et al. (2019) investigated the factors affecting the cooking fuel choices among rural communities in Pakistan. The literature is focusing to develop empirical evidence of negative health impacts of solid fuel consumption on children and female health and also investigating the factors affecting the fuel choices among poor rural communities.

Empirical evidence reveals that poor communities are heavily depending on polluting sources of energy because financial constraints are limiting their substitution ability to cleaner sources of energy (Leach, 1975, 1992; Narasimha and Reddy, 2007; Ekholm et al. 2010; Kowsari and Zerriffi 2011). In the energy ladder, income and relative prices are considered to be the important driver of transition from dirty to cleaner source of energy (Rahut et al. 2014; Leach, 1992 and Barnes, 1999). This implies that low income household will continue to depend on solid fuels and suffer from adverse health impacts (Rehfuess et al. 2006 and Holdren et al. 2000). Alim et al. (2014) compared the respiratory symptoms between biomass and gas fuel users in Bangladesh and concluded that female using biomass fuels are facing significantly higher respiratory symptoms than their counterparts. Scott et al. (2016) studied the impact of indoor air pollution on respiratory health among adults of urban and rural China. Mohapatra, et al. (2018) has explored the relationship between length of exposure (measured in years) to polluting sources of energy and health symptoms faced by female of age group of 20-40 in India. Siddiqui et al. (2005) have revealed a positive relation of solid fuel burning on eye and respiratory symptoms while Akther et al. (2007) with chronic bronchitis among women in Pakistan. In the literature household cooking fuel choices (Alem et al. 2016; Uttam et al. 2018; Imran et al. 2019 and Rahut et al. 2019) and negative health impact of solid fuel on children (Khan and Lohano 2018; Adaji et al. 2019) and women (Siddiqui et al. 2005; Akther et al. 2007; Mohapatra, et al. (2018)) have been extensively explored but factors that can help to minimise the negative health impact of solid fuels on women is less commonly explored. Hence, empirical evidence need to establish that pre-emptive measures such as kitchen type, number of windows in kitchen, diversification in working habits and using protective measures could significantly contribute to reduce the negative health impacts of indoor air pollution on women while continuously depending on the solid fuels. We also define the exposure variable more precisely than earlier studies by taking time spend in cooking. The present study is contributing in the literature by investigating the role of pre-emptive measures in reducing the respiratory health symptoms by specifically focusing on women working in polluted environment of household kitchen. Study also addressing SDG target 3.9 which is focusing on sustainable reduction index and illnesses from air pollution.

The remaining study is divided into three sections. The following section describes the data collection procedure and empirical methods employed. Results and discussion are provided in the third section. This section discusses descriptive statistics and empirical findings supported with the literature. The last section discusses the possible policy implications.

DATA COLLECTION AND METHODOLOGY

Data Collection

A multistage sampling technique is employed in data collection procedure. At first stage, two districts Abbottabad and Haripur of Khyber Pakhtunkhwa is purposely selected because rural population varies between 97-87 percent respectively, in these districts. The major source of energy for cooking and heating in these districts is based on solid fuels which are assumed to be highly polluted. Among these solid fuels includes, fuel wood, crop residues, and animal cake. However, fuel wood is contributing a dominant share in total energy supply in the region because of easy excess to forests. Both Abbottabad and Haripur districts have three tehsils and at the second stage we selected all three tehsil in each district. At the third stage we randomly selected 2 union council from each tehsil and finally from each union council we selected 21 respondents making our sample 252 (=2*3*2*21) but two observations are found to be extremely outlier which we excluded from the analysis. Therefore, our analysis is based on 250 observations. The data on respiratory health symptoms (sore throat, cough, congestion, breathing difficulties, and fatigue) and other socioeconomic variables is collected in 2018 by employing well-structured questionnaire. Information about health symptoms and per day average time spends for cooking in the kitchen by females older than 15 years of age is collected.

Methodology

Our dependent variable is dichotomous i.e. counts of symptoms (total frequency of health symptoms faced by females involved in kitchen work) which can be analysed by employing different econometric models. The normality assumption of Ordinary Least Squares (OLS) regression is inappropriate for count data (McClendon, 1994; Maxfield & Babbie, 2001). This implies that traditional linear model is not applicable. A GLM extends the traditional linear model to a broader range of distribution (normal, inverse Gaussian, gamma, Poisson, binomial) and a function can be used to link the expected response mean and a linear function of the explanatory variables. Hence, GLM procedure helps to choose an appropriate link function and response probability distribution (McCullagh and Nelder, 1989; Agresti, 2002). The best known GLMs for count variable are Poisson or a negative binomial distribution.

The Poisson and negative binomial regression models are specifically designed to analyse count data which differ in terms of assumptions. Poisson regression model assumes that distribution of mean and variance are equal but negative binomial regression model is appropriate when this assumption violates. The detailed discussion about Poisson regression can be found in Lindsey (1995) and Agresti (2002). Choosing between Poisson and negative binomial models depends on the nature of the distribution of dependent variable.

We used number of respiratory health symptoms (sore throat, cough, congestion, breathing difficulties, and fatigue) faced by adult females in a family during the last one month as dependent variable in our model. The Poisson distribution has been described in detail by Cameron and Trivedi (1998) which is summarised as below;

$$Prob\ (Y_i = y_i / x_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i\,!} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

Where, y_i is the number of respiratory symptoms faced by the females of i-th family during the last one month and it varies across families (*i = 1,…., n*). Poisson distribution is assumed to have conditional mean (λ_i), which in turn depends on vector (x_i) of exogenous variables. The most common functional form of λ_i used in the literature is loglinear model which can be expressed as:

$$\ln \lambda_i = \beta_i x_i + \epsilon_i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

Where, β_i is a vector of coefficients and x_i is a vector of explanatory variables and ϵ_i stands for unobservable family specific random effect that affects female health status working in the kitchen. Among explanatory variables includes, Exposure to pollution (time spend in cooking per day by all household females and is measured in hours), dummy for energy source, dummy for kitchen type, number of windows in kitchen, diversification strategy (measured as proxy with the number of females involved in cooking), dummy for mask (if using mask=1, otherwise=0) and district dummy to capture the effect of environmental related variation across districts. Dummy for energy source (solid fuel =1 otherwise zero) and kitchen type (close kitchen=1, otherwise= 0) are expected to have positive impact on respiratory health symptoms while pre-emptive measures that includes, diversification strategy, female education, dummy for protective measures and number of windows in closed kitchen are expected to have negative impact on respiratory health symptoms.

RESULTS AND DISCUSSION

Descriptive Analysis

We divided our sample into two groups based on energy type, clean (treated group) and polluted (non-treated group) energy users. It is observed that 166 and 84 families used solid fuels and LPG, respectively for cooking and heating during the last one month. It allows us to compare different variable of interest among two groups. It is observed that 166 (66 percent) households in our sample are using solid fuels while only 84 (34 percent) are depending on cleaner sources of energy. During the last one month, average frequency of symptoms is 4.26 for families using polluted source of energy which is significantly higher than their counterparts (2.67) using cleaner source of energy (Table 1). This implies that females involved in kitchen work using solid fuels are facing respiratory health symptoms more frequently than their counter parts i.e. clean energy users. These findings are line with Ellegard (1997) and Khushk (2005). Fullerton et al., (2009) also concludes that smoke of solid fuels leads to develop multiple respiratory health symptoms. The unit of analysis is family and therefore, someone may hypothesise that higher frequency of symptoms among polluted energy users could be due to large number of females involved in kitchen work in this group. However, results reported in the last row of Table 1, negate this argument because females involved in kitchen work are significantly higher (2.5) among households depending on cleaner source of energy than their counterparts (2.18). Pollution exposure is measured as per day average time spent in cooking related activities by each family and is measured in hours. Descriptive analysis indicates that exposure or time spend in cooking is significantly higher (4.85 hours) among families using polluted energy sources compared to those using cleaner source of energy (3.84 hours). This seems to be consistent with the literature indicating that solid fuels are inefficient compared to cleaner sources of energy (Rosenthal et al. 2018). Among pre-emptive measures we considered kitchen type, number of windows in kitchen and use of mask while cooking. Closed kitchen has important implication in deciding the number of health symptoms faced by females involved in kitchen work. It is observed that 34.80 percent and 20.00 percent families using polluting and cleaner source of energy, respectively have closed kitchen. Closed kitchen plays a role of catalyst in creating health symptoms among females. Higher percentage of families using polluted source of energy in closed kitchen might be one of the major contributing factor in health symptoms. If at least 50 percent females involved in kitchen work are using mask in a family while cooking then we considered that family preventive measure users and otherwise not. Our mean value analysis indicates that only 6 to 7 percent families among our sample are using preventive measures (mask). Numbers of window in the kitchen are higher among clean energy users (1.35) compared to those depending on solid fuels (1.08). It is observed that the difference is significant only at 10 percent probability level. Similarly, it is observed that education of females involved in kitchen work is significantly higher among polluted energy users (6.70) compared to those depending cleaner source of energy (5.25).

Table 1

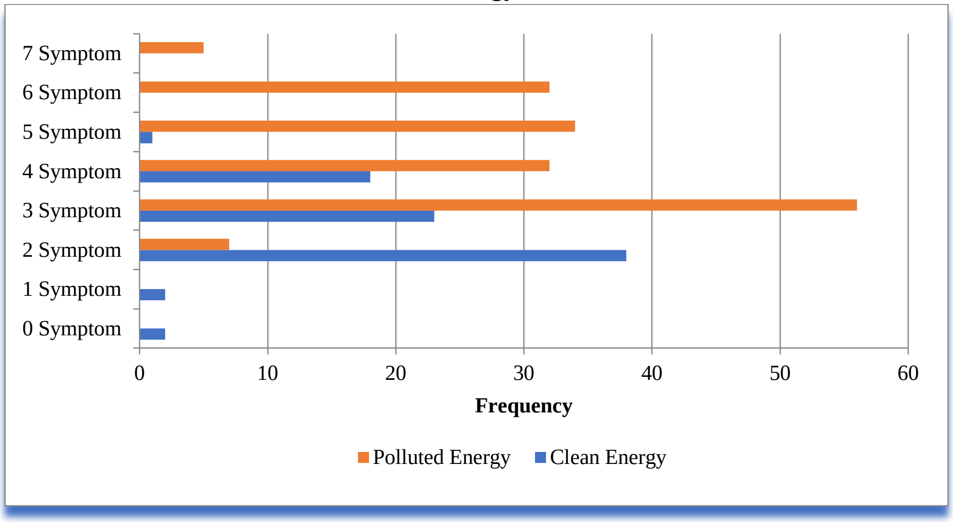
Comparison of Different Health Symptom between Wood and Natural Gas Users

Health symptom	Polluted energy users (solid fuel) (N=166)	Clean energy users (N=84)
Frequency of diseases	4.26***	2.67
	(1.30)	(0.96)
Pollution exposure (hours)	4.81***	3.84
	(1.24)	(0.70)
Dummy for close kitchen (%)	34.80	20.00
Preventive measures-Mask dummy (%)	6.40	6.80
Number of windows (numbers)	1.08*	1.35
	(0.88)	(1.41)
Female education (year of schooling)	6.70***	5.25
	(3.86)	(3.30)
Diversification in domestic tasks is measured as proxy with number of female above 15 years of age and involved in cooking	2.18***	2.5
	(0.88)	(0.85)

Notes: t-tests are used for continuous and chi-square tests for categorical variables to identify differences in mean values. Values in parentheses are standard deviations.
***, **, and * indicate that the mean values between polluted and clean energy sources are significantly different at 1 percent, 5 percent, and 10 percent, respectively.

Figure 1 shows that majority of the families using cleaner sources of energy fall in the category of symptoms 2, 3 and 4, while families using solid fuels reported higher symptoms 4, 5, 6 and 7. This indicates that families using solid fuels are facing acute symptoms more frequently than clean energy users. Number of families fall in the category of symptoms 3 and 4 and are using solid fuels are almost double than clean energy users. It is observed that there is only one family falls in the category of symptoms 5 and none of the family facing symptoms more than 5 using clean source of energy.

Fig. 1. Frequency of Incidence of Acute Symptoms Faced by Polluted and Clean Energy Users



Empirical Results

It is important to note that unit of analysis is family because data about health symptoms of each female member older than 15 years of age and involved in kitchen work is obtained. The large numbers of studies dealing with health symptoms are based on single response which could underestimate the severity of indoor pollution risk. We added the health symptoms faced by each female working in the kitchen to get the total number of health symptoms at the family level which generate a count data on health symptoms at the family level. We attempt to relate these symptoms with pre-emptive measures taken in terms of infrastructure (i.e. kitchen type, windows in the kitchen), protective measures (i.e. mask) and exposure to indoor pollution measured as average time per day spend in the kitchen (hours) and diversification in domestic work (measured as proxy with number of female above 15 years of age and involved in kitchen work). Family size (total family members) is correlated with the total time spends in the kitchen and therefore, dropped from the analysis.

We employed a generalised linear model (GLM) to investigate the impact of pre-emptive measures along with other demographic and socio-economic factors affecting the frequency of respiratory health symptoms faced by females working in the kitchen. Our response variable is the total number of respiratory health symptoms spontaneously recalled, is a count data. The likelihood ratio test for detecting over dispersion proposed by Cameron and Trivedi (1998) accepts the null hypothesis of $\alpha=0$, implying that negative binomial regression model is rejected in favour of Poisson regression model. Therefore, Poisson process is performed.

Our empirical results reported in column 1 of Table 2 demonstrate that exposure to pollution, energy type, kitchen type have significant positive impact on frequency of health symptoms while using mask, number of windows in the kitchen and diversification in domestic work are found to have negative and significant impact. The coefficient of cooking duration is 0.100 which implies that one hour increase in cooking hours contributes to the difference in logs of expected counts of health symptom by 0.100 unit/month (Table 2). The positive impact of exposure to pollution is consistent with general understanding because the person who gets more exposure to indoor air pollution is expected to faces higher number of health symptoms. Our results are in line with the existing literature (Regalado et al. 2006). Solid fuels (fuel wood, animal dung and crop residue) is positively affecting the frequency of health symptom. The coefficient of energy sources is 0.291 and it is statistically significant at one percent level. The coefficient provides comparison of solid fuels users to natural gas users. The difference in log of expected count of health symptom is 0.291unit/month higher for polluted energy users compared to natural gas users (Table 2). The positive impact of polluted energy users on health symptoms is consistent with the economic theory and existing literature because working in polluted environment (carbon monoxide, particulate matter, sulfur oxide and nitrogen dioxide) leads to increase the risk of respiratory health symptom (Fullerton et al. 2008; Po et al. 2011; Dutt et al. 1996; Ellegard 1996; Smith et al. 2014; Pop et al. 2014) That is why it is emphasised to provide conducive working environment to females so that they can contribute more productively and can also produce healthy future generation. The coefficient of kitchen type (taken as dummy where 1 stand for close kitchen and otherwise zero) is offering the comparison of close and open kitchen.

The coefficient of close kitchen type demonstrates that people working in close kitchen has 0.360unit/month greater impact on log counts of respiratory health symptom (Table 2). The higher frequency of health symptoms faced by females working in close kitchen is consistent with the findings of earlier literature (Langbein, 2017) because closed kitchen intensify indoor air pollution. High intensity of air pollution leads to deteriorate human health badly (Ballis et al. 2017). Using mask during the cooking is negatively affecting the log counts of health symptom and coefficient indicates that the mask users have 0.243unit/month less log counts of health symptoms than their counter parts (non-users). The negative impact of using mask is again consistent with medical sciences because mask help to reduce inhaling poisonous particles through breath which is expected to have negative impacts on respiratory health symptoms. Our empirical analysis indicates that number of window in the kitchen is negatively affecting the frequency of respiratory health symptoms. More specifically our results demonstrate, when one window increases in the kitchen then log counts of health symptom is declined by 0.075unit/month. The negative impact of number of windows in the kitchen helps to reduce the intensity of indoor air pollution and thus have negative impacts on respiratory health symptoms. Female education has negative but insignificant impact on log counts of health symptoms. The diversification in domestic work is negatively affecting the log count of respiratory health symptoms in our analysis. The coefficient indicates that one person increase in cooking process leads to decline in log counts of respiratory health symptoms by 0.078unit/month. The negative impact of diversification in domestic work is consistent with economic theory because as number of females involved in cooking process increases, the exposure to stay in polluted environment declines. Reduction in exposure to polluted environment is expected to lessen the burden of respiratory health symptoms and our empirical finding is supporting this hypothesis.

Marginal effects are reported in column 2 of Table 2. The marginal effects are more straightforward to explain than coefficient of Poisson regression model. The marginal effect of exposure to pollution indicates that one hour increase in cooking contributes 0.352 symptoms per month. Because explanatory variables have different units of measurement and therefore, on the basis of marginal effect it is hard to make comparison and thus, conclude which variable is more responsible to increase or decrease the burden of respiratory health symptoms. To overcome this issue we estimated standardised scaled coefficient reported in column 3 of Table 2. Our results reveal that close kitchen is highly responsible to contribute in respiratory health symptoms followed by exposure to pollution and solid fuels. Close kitchen and exposure to pollution leads to accumulation of pollutants in the body which exasperate female breathing, trigger asthma symptoms and promote lung and heart related diseases. Therefore, positive and significant impact of exposure to pollution on respiratory health symptoms (respiratory health risk) is expected and consistent with the existing literature (Colbeck et al. 2010; Ali Mir et al. 2012; Janjua et al. 2012; Pop et al. 2014; Acharya et al. 2015). Contrary, numbers of windows in the kitchen have highest contribution in the reduction of respiratory health symptoms followed by averting measures (using mask while cooking) and diversification in domestic work. This implies that awareness campaign about the use of open kitchen could help to mitigate respiratory health symptoms significantly. Similarly, awareness about diversification of domestic work within female family

Table 2

Factors Affecting the Respiratory Health Symptoms of Indoor Air Pollution

	Poisson regression			Modified Poisson regression		
Variables	Coefficients	Marginal Effect	Scaled Coefficient (SSC)[a]	Coefficients	Marginal Effect	Scaled Coefficient
Exposure to Pollution (hours)	0.100***	0.352***	0.351***	0.102***	0.363***	0.365***
	(0 031)	(0.109)	(0.038)	(0.031)	(0.110)	(0.037)
Energy type (solid fuels =1,	0.291***	0.982***	0.326***	-	-	
others=0)	(0 095)	(0.305)	(0.041)			
Kitchen Type (If close=1,	0.360***	1.256***	0.499***	0.342*	1.194*	0.371***
Otherwise=0)	(0.094)	(-0.323)	(0.047)	(0.182)	(0.628)	(0.079)
Preventive measures (If mask	-0.243**	-0.785**	-0.175***	-	-	
used=1, otherwise=0)	(0.117)	(0.346)	(0.033)			
Number of windows in kitchen	-0.075*	-0.265*	-0.249***	-0.073*	-0.257*	-0.206***
(numbers)	(0.040)	(0.141)	(0.042)	(0.043)	(0.153)	(0.044)
Female education (years)	-0.006^{ns}	-0.022^{ns}	-0.050^{ns}	-0.007^{ns}	-0.025^{ns}	-0.069*
	(0.012)	(0.043)	(0.040)	(0.012)	(0.043)	(0.039)
Diversification in domestic	-0.078*	-0.274*	-0.169***	-0.077*	-0.272*	-0.166***
tasks	(0.042)	(0.149)	(0.035)	(0.042)	(0.149)	(0.034)
Area dummy	0.022^{ns}	0.077^{ns}	0.031^{ns}	0.020^{ns}	0.073^{ns}	0.037^{ns}
	(0.082)	(0.292)	(0.042)	(0.083)	(0.293)	(0.040)
Solid fuels in close kitchen	-	-		0.293***	1.083**	0.386***
				(0.119)	(0.463)	(0.053)
Solid fuels in open kitchen	-	-		0.251*	0.931*	0.188***
				(0.142)	(0.553)	(0.055)
Mask in close kitchen	-	-		-0.330**	-1.012**	-0.200***
				(0.166)	(0.440)	(0.034)
Mask in open kitchen	-	-		-0.135^{ns}	-0.449^{ns}	-0.041^{ns}
				(0.169)	(0.532)	(0.034)
Intercept	0.944***	-		0.959***		
	(0.182)			(0.187)		
Model Statistics						
Log likelihood	-409.50			-409.09		
Wald χ^2 (8)	99.59			100.39		
Total observations	250			250		

***, **, *and [ns] represents the significance level at 1 percent, 5 percent, 10 percent and not significant respectively.
Note: Standard errors are given in parentheses.

members and shifting from solid fuels to cleaner sources of energy could alleviate the burden of respiratory health symptoms. Shifting from solid fuels to cleaner sources of energy might limit to certain extent due to financial and availability constraints. However, awareness about the importance of open kitchen and diversification in domestic work within female family member could significantly contribute to reduce the burden of respiratory health symptoms among females. Similarly, awareness about the usefulness of windows while constructing kitchen can be used as long run strategy to minimise the impact of indoor air pollution on respiratory health symptoms.

We further attempt to explore that how solid fuels behave in open and closed kitchen in terms of affecting respiratory health symptoms by including respective interaction terms in the model. Similarly, we also investigate the impact of use of mask in close and open kitchen, respectively by creating respective interaction terms of two dummies. We named this modified Poisson regression model. The coefficients and marginal effects of modified Poisson regression model are reported in column 4th and 5th while standardised scaled coefficients are reported in column 6th of Table 2. The coefficient of Poisson regression model and marginal effect are reported only for comparison purpose but discussion below is mainly based on standardised scaled coefficients.

The contribution of exposure to pollution in respiratory health symptoms is almost the same as in earlier model. However, earlier close kitchen was the major contributor in respiratory health symptoms but in modified Poisson regression model, solid fuels and close kitchen (i.e. solid fuels when used in close kitchen) are jointly responsible for major contribution in respiratory health symptoms followed by close kitchen and solid fuels when used in open kitchen. The results of modified Poisson regression model also reveals that solid fuels when used either in close or open kitchen is perilous for female health. The comparison of magnitude of standardised scaled coefficient revealed that solid fuels in closed kitchen are contributing twice compared to the situation when use in open kitchen. These results are consistent with the earlier findings that particulate matter PM_{10}, $PM_{2.5}$ and PM_1 increases to 35 percent, 22 percent and 24 percent respectively in close kitchen (Nasir et al; 2013). This clearly demonstrates that close kitchen is major culprit for respiratory health symptoms and its severity further intensifies in the presence of solid fuels. Hence, provision of clean energy in line with SDG 7.1.2 target (aim to insure the provision of clean energy in home) and awareness about the importance of open kitchen could lead to reduce respiratory health burden significantly on female. In the preliminary model, the contribution of female education in reducing respiratory health symptoms was insignificant but in modified Poisson regression model, impact of female education is statistically significant with negative sign and magnitude of the coefficient has also improved. This implies that educated female because of having higher consciousness about their health able to lessen the burden of respiratory health symptoms through diversification in domestic work. The numbers of windows in the kitchen are still significantly contributing to reduce respiratory health symptoms and size of standardised scaled coefficient has slightly declined. Finally, we also attempt to explore and compare the role of using mask in open and close kitchen environment. For this, we took the interaction of mask dummy with open and closed kitchen dummies but then we did not include the mask dummy as an explanatory variable because it exactly correlates with interactions terms developed. Our empirical results demonstrate that use of averting measures (using mask) in close kitchen is contributing significantly to reduce respiratory health symptoms while in open kitchen the use of mask is not effective. It might be because intensification of pollution is not as severe in open kitchen.

CONCLUSION

The current study employs a sample of 250 randomly selected household from two districts of KPK (Abbottabad and Haripur) of Pakistan. The number of respiratory health symptoms faced by females involved in kitchen work is taken as dependent variable. The likelihood ratio test is employed to test over dispersion which rejects the negative binomial in favour of Poisson regression model.

The empirical results reveal that close kitchen, exposure to pollution and solid fuels (fuel wood, crop residues, and animal cake) are key factors contributing to respiratory health symptoms faced by females involved in kitchen work. It is also observed that use of pre-emptive measures that include number of windows in the kitchen, preventive measures (use of mask) and diversification in domestic work could play significant in reducing the burden of respiratory health symptoms on females involved in kitchen work. The results of standardised scaled coefficient in modified Poisson regression model depicts that when solid fuels is used in closed kitchen then it is found to have highest impact on respiratory health symptoms. Our empirical findings further revealed that the impacts of solid fuels in closed kitchen is more than double if the same solid fuels is used in open kitchen, implying that polluted energy in closed kitchen generates highest respiratory health risk. It suggests that promotion of LPG through subsidised prices may help to alleviate respiratory health burden in the study areas. Similarly, length of exposure to polluted environment and closed kitchen are found to have positive and significant impact on respiratory health symptoms. Hence, creating awareness among females about the danger of solid fuel use in closed kitchen and adverse impact of staying longer period of time in polluted environment could significantly help to reduce respiratory health burden on female. Our empirical results also indicate that number of windows in the kitchen have negative and significant impact on respiratory health symptoms. This implies, as a reliable strategy for a longer period of time, awareness about the importance of open kitchen and number of windows in closed kitchen could help to reduce the burden of respiratory health symptoms. The results of standardised scaled coefficient in modified regression model also reveals that using mask in closed kitchen is found to have significant negative impact on respiratory health symptoms, demonstrating that use of preventive measures especially in close kitchen help to reduce respiratory health risk. Our empirical findings suggest launching an integrated public awareness campaign by involving all stakeholders, followed by practical intervention would be an appropriate approach.

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