



Household air pollution from cooking fuel and respiratory health risks for children in Pakistan

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Abstract

Around 2.7 billion people in the world cook with polluting fuels, such as wood, crop residue, animal dung, charcoal, coal, and kerosene. Household air pollution from cooking with polluting fuels is recognized as a major risk factor for the disease burden. In this study, we examine the effect of using polluting fuels for cooking on the respiratory health of children in Pakistan. This study uses cross-sectional data from Pakistan Demographic and Health Survey 2012–13, with the sample size of 11,040 children under 5 years of age. Using logistic regression model, we control for factors such as averting activities, child characteristics, household characteristics, mother characteristics, and the unobserved factors using fixed effects. The results show that children in households using polluting fuels are 1.5 times more likely to have symptoms of acute respiratory infection (ARI) than children in households using cleaner fuels.

Keywords Air pollution · Acute respiratory infection · Morbidity · Child health · Solid fuels, polluting fuels

JEL Classification I10 · I120 · I150 · Q510 · Q530 · Q580

Introduction

With advancements in almost all aspects of our life, it is hard to imagine that around 2.7 billion people in the world still rely on solid fuels such as wood, crop residue, animal dung, charcoal, and coal to meet their energy needs for cooking (International Energy Agency 2016; Watts et al. 2017). Smoke from burning these polluting fuels inside homes has profound negative impact on respiratory health. The respiratory illness from such exposures would not only raise morbidity but also reduce productivity and life expectancy (Duflo et al. 2008). Household air pollution from solid fuels is the leading risk factor for the disease burden in South Asia and the fourth largest risk factor for the global burden of disease (Lim

et al. 2012). Worldwide, around 2.854 million people each year die prematurely from illness attributable to household air pollution from solid fuels according to the Global Burden of Disease study (GBD 2016).

Household air pollution from the use of solid fuels for cooking is a major threat to children's health. Exposure to high level of cooking smoke leads to high incidence of respiratory morbidity, especially in infants and children, who mostly stay at home (Das et al. 2018; Horne et al. 2018). In developing countries, most women spend a great amount of time in kitchen while keeping infants and young children with them (Toman and Bluffstone 2017). A research study conducted in Pakistan finds that particulate matter (PM₁₀) concentrations can reach up to 8555 µg/m³ in the kitchens where solid fuel is used for cooking (Colbeck et al. 2008). Thus, the use of solid fuels poses a serious threat to health, especially for women and children (Colbeck et al. 2010). Furthermore, smoke-driven respiratory diseases may also hamper cognitive growth and thus may lead to other diseases and illnesses in children as their immune system becomes vulnerable (Munroe and Gauvain 2012).

The issue of household air pollution from cooking fuel has been recognized in the literature since 1960s (Jacobs et al. 1962; Wohlers et al. 1967; Wilson 1968). Study by Lawther

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et al. (1970) is one of the pioneer studies in epidemiological literature establishing a relationship between health and indoor air pollution using data from London. Other studies thereafter improved upon methodology, such as developing theoretical model and estimation methods to control for confounding variables (Spengler and Sexton 1983; Samet et al. 1987; Bruce et al. 1998; Freeman et al. 2014).

As the literature on evaluating the impacts of household air pollution grows, increasingly there is a focus on respiratory health outcomes that are directly related to the cooking smoke. A number of empirical studies have been conducted to examine the effect of household air pollution from cooking fuel on respiratory health, especially on acute respiratory infection (ARI) in children (Ezzati and Kammen 2002; Torres-Duque et al. 2008). Mishra et al. (2005) studied the effects of cooking smoke and environmental tobacco smoke on ARI in young Indian children, using data for 29,768 children aged 3 years or younger collected from the National Family Health Survey of 1998–99. They found that, after controlling for other covariates such as age, sex of child, birth order, and nutritional status of child and other factors, children in households using biofuels (wood, crop residue, and animal dung) were 1.58 times more likely to have ARI symptoms than children in households using cleaner fuels. Another study by Mishra (2003) used data for 3559 children under 5 years from the Zimbabwe Demographic and Health Survey of 1999, and found that the children in households using biofuels were more than twice as likely to have ARI symptoms as children in households using cleaner fuels. Acharya et al. (2015) used the data from Nepal Demographic and Health Survey of 2011 to study the impact of solid fuel smoke on ARI in children less than 5 years old. They found that children in households using solid fuels had 1.79 times greater odds of having ARI symptoms than children in households using cleaner fuels. Capuno et al. (2018) used the data from the Philippine Demographic Health Survey of 2013 and found that the use of clean fuels for cooking reduces the incidence of respiratory illness symptoms in young children by 2.4% points. However, the studies cited above did not take into account any variable representing averting activity, which is an important determinant of health outcome as given in theoretical models (Freeman et al. 2014).

Pakistan is an energy-deficient country. According to Demographic Health Survey report, 62% of households in Pakistan cook with solid fuels, such as wood, crop residue, animal dung, charcoal, and coal (NIPS and ICF International 2013). Household air pollution is a big issue in Pakistan due to the use of solid fuels by majority of households. Siddiqui et al. (2009) compared indoor air pollution between the households using wood and those using natural gas in the kitchen. They found that wood users have much higher levels of carbon monoxide and particulate matter (PM_{2.5}) as compared to natural gas users. According to Demographic Health Survey

report, 16% of children aged less than 5 years have ARI symptoms in Pakistan (NIPS and ICF International 2013). Given the high incidence of ARI symptoms in children and high proportion of households using polluting fuels in Pakistan, there is a need to evaluate whether and to what extent the use of polluting fuels in cooking has the effect on ARI symptoms in children of Pakistan.

The existing literature on the effect of household air pollution on respiratory health outcomes in Pakistan is scarce. Janjua et al. (2012), using data for 566 children from a village in Dadu district in Sindh province, found that a higher incidence of ARI symptoms in children was associated with the use of biomass fuels for cooking. Similarly, another study by Ali Mir et al. (2012) used the data from Kashmir valley and found higher prevalence of ARI symptoms in children in households using biomass fuel for cooking as compared the households using LPG. However, these studies were limited to a very small geographical area in Pakistan. There have been no previous studies in Pakistan on examining the effect of household air pollution from cooking fuel on ARI in children using large and nationally representative data. Furthermore, it is important to control for averting activities and other factors that are important determinants of ARI in children. It may cause omitted variable bias if other factors are not controlled. Thus, controlling for other factors is particularly important for obtaining an unbiased estimate of the actual effect.

The purpose of this paper is to investigate the effect of household air pollution from cooking fuel on the prevalence of ARI in children under 5 years in Pakistan. We use data from nationally representative sample of 11,040 children under 5 years collected from Pakistan Demographic Health Survey (NIPS and ICF International 2013). Given the rich dataset, we control for not only averting activities and other observed factors but also unobserved location-specific factors such as outdoor air pollution using the fixed effects of geographic locations.

Data

This study uses data from Pakistan Demographic and Health Survey 2012–2013, conducted under the aegis of the Ministry of National Health Sciences, Regulations and Coordination and implemented by the National Institute of Population Studies (NIPS). The Pakistan Bureau of Statistics (PBS) provided technical assistance for the execution of the survey. For this survey, 14,000 households were selected from 500 primary sampling units, which are the enumeration blocks demarcated as part of the urban sampling frame in the urban domain and mouzas/dehs/villages in the rural domain. In this survey, out of an initial sample of 14,000 households, 12,943 households were interviewed with a response rate of 96%. The sampling design was a two-stage stratified cluster sampling

with weights calculated based on sampling probabilities separately for each sampling stage and each block/village. The data is cross-sectional in nature, and the unit of analysis is children under the age of 5 years that are alive, as children in this age group are most vulnerable to the adverse effects of household air pollution (UNICEF 2016; Khan et al. 2017; Devakumar et al. 2018). The dataset included data for 11,040 children under 5-year age, which we use in this study. In this dataset, the age of children is reported based on birth certificate records available with relevant civil authorities of Pakistan (NIPS and ICF International 2013).

Model and estimation method

This study develops model based on the household health model, described in Freeman et al. (2014) originally formulated by Grossman (1972), and extended by Harrington and Portney (1987). Consider the case where a household has children whose health status may be affected by household air pollution from cooking fuel and other factors. A child's health associated with the pollution level is described by a dose-response function. The econometric model of dose-response function is specified as follows:

$$H = H(F, A, X, \varepsilon) \quad (1)$$

where the outcome variable H is the status of ARI in child with $H = 1$ if the child has symptoms of ARI, otherwise 0. The status of ARI in child is a function of type of cooking fuel F used by the household, averting activities A undertaken by the household, and a set of other exogenous variables, denoted by vector X , including child characteristics, household characteristics, and mother characteristics. The error component ε includes the location-specific component u and the random error term e . $H(\cdot)$ is a function taking on values strictly between zero and one. Below, we describe the variables and discuss how the outcome variable can be affected by the explanatory variables given in Eq. (1).

Health outcome of child In Eq. (1), the response variable is dichotomous in nature, that is, it is a dummy variable where $H = 1$ if the child has symptoms of ARI; otherwise 0. In the survey, mothers were asked if their child had been ill with a cough in the 2-week period preceding the survey. Those who answered in the positive to the question above were additionally asked if the child, when ill with cough, breathed faster than usual with short, rapid breaths. Children who suffered an illness related to cough accompanied by short and rapid breathing anytime during the last 2 weeks are defined as having symptoms of ARI. This measure of ARI symptoms has been used in previous studies (Mishra 2003; Mishra et al. 2005; Kilabuko and Nakai 2007).

We also define an alternative measure of ARI symptoms, as used in other previous studies (Acharya et al. 2015; Capuno et al. 2018). In this case, in addition to having cough and trouble breathing with short and rapid breaths, the child also has a chest-related problem. We also estimate the regression model using this alternative measure of ARI symptoms for robustness checks.

Cooking fuel Type of cooking fuel affects the level of concentration of pollution, as Colbeck et al. (2008) found a higher level of PM_{10} in the kitchen where solid fuel was used for cooking. Exposure to the concentration of pollution, in turn, affects the health outcome (Freeman et al. 2014). Thus, type of cooking fuel is used as a predictor of ARI (Mishra et al. 2005; Acharya et al. 2015; Capuno et al. 2018).

Two groups were formed to categorize the cooking fuels according to their polluting behavior. One group includes all polluting fuels including solid fuels and kerosene, where solid fuels include wood, animal dung, charcoal, coal, and shrubs/grass/straw. The other group includes cleaner fuels, namely natural gas, LPG, biogas, and electricity. We define a dummy variable for the fuel type, that is, $F = 1$ if any polluting fuel is mainly used for cooking, otherwise 0.

Kerosene has recently been added to the list of polluting fuels (WHO 2016). We consider kerosene in the category of polluting fuels as recent research has shown that kerosene's effect on household air pollution is highly positive (WHO 2016). We also define an alternative measure of cooking fuel type by excluding kerosene from polluting fuel. In this case, the dummy variable equals one if any of solid fuels is mainly used for cooking, and zero otherwise. For robustness checks, we also estimate the regression model using this alternative measure of cooking fuel type.

Averting activities Averting activities are taken to reduce the exposure to pollution and thus affect the health outcome (Freeman et al. 2014). In this study, we use separate kitchen in the house and vaccination status of child as averting activities. We define a dummy variable for each averting activity.

Child characteristics Child characteristics include age, sex, birth order, and whether the child is breast-fed. Age is an important predictor of ARI. Children are most vulnerable to infections during their early months after birth, as their immune system is not fully developed (Simon et al. 2015). Sex of a child is an interesting predictor of ARI as it can indicate if there is any difference in immunity levels for each sex in the early months after birth. Birth order can highlight the high vulnerability of children those are first-borns. Children that are breastfed are less vulnerable to infections and therefore the expected relationship between ARI and breastfed children is negative (Naz et al. 2017).

Child's age is considered in months with five equal intervals of 12 months. We define dummy variable for each age group. Sex of the child is a dummy variable where 1 is for males and 0 for females. Birth order is a categorical variable with four categories including first, second, third, and fourth order, where the fourth category represents the fourth birth or greater. For each category, a dummy variable is used for estimating the model.

Household characteristics In this category, we use household crowding as a predictor of ARI. Household crowding means four or more people sleeping in a single room at one time. This increases the likelihood of respiratory infections (Cardoso et al. 2004; Prietsch et al. 2008; Baker et al. 2013); however, in certain cases, the evidence is not so convincing (Murray et al. 2012). This is a dummy variable equals 1 if the household is crowded, otherwise it is 0.

Mother characteristics Mother's characteristics include mother's education, whether or not she smokes tobacco and her age at childbirth. Educated mothers are more likely to engage in averting activities as they are more aware of their children's health and the risks associated with it (Gitawati 2014; Tekle et al. 2015; Tazinya et al. 2018). Children of tobacco smoking mothers are likely to be exposed to passive smoke, increasing the risk of respiratory infections including ARI symptoms, especially if children are less than 3 months old (Dahal et al. 2009; Gitawati 2014; Shibata et al. 2014). Children born to mothers older in age are likely to be at a lesser risk of ARI symptoms as such mothers are relatively healthier reproductively and pass on their stronger immune system to their children through breastfeeding (Prietsch et al. 2008). Mother's education is a dummy variable which is equal to 1 if the mother is educated, otherwise 0. Similarly, "mother smokes tobacco" is a dummy variable which is equal to 1 if the mother smokes tobacco, otherwise 0. Mother's age at childbirth is categorically divided into yearly brackets of 14–24, 25–35, and 36–49. For each category, a dummy variable is used for estimating the model.

We control for unobserved factors such as outdoor air pollution, accessibility of fuels, and other location-specific factors using the fixed effects of geographic locations. For geographic location fixed effect, we use primary sampling units (PSU), defined in data section.

Model in Eq. (1) is estimated using logistic regression model with the fixed effects by employing the conditional logit fixed-effects model. This approach removes any underlying omitted variable bias caused by the unobserved explanatory variables that may be correlated with the other explanatory variables included in the model. Because of the large sample properties, maximum likelihood estimation technique is used to produce consistent coefficient estimates. We account for the survey design and sample weights for estimation

of coefficients so that over/under sampling and non-response rates do not influence the representativeness of the sample towards the population.

Results and discussion

Descriptive statistics

Table 1 presents the descriptive statistics of variables. The statistics show that around 22% of the children had ARI symptoms (cough with short and/or rapid breathing). Based on the alternative measure, 16% of the children had ARI symptoms (cough with short and/or rapid breathing and problem in chest). Around 68% of children are from households who mainly use polluting fuel for cooking purposes. Roughly, 51% of children are from households with a separate kitchen and on average 33.33% children are vaccinated. The distribution of children according to age and sex is equal while most of the children belong to the fourth birth order or more. A healthy 57% of the children are breastfed while 66% of children live in crowded conditions. Children belonging to educated mothers account for 44%, with some 3% of the mothers that smoked tobacco. More than half of the mothers belonged to 25–35 age group at childbirth while only 9% mothers belonged to 36–49 age group at childbirth.

Regression results

We present logistic regression results in this section. Table 2 presents the results with dependent variable health outcome of ARI symptoms (cough with short and/or rapid breathing). The table presents results for four models. In model (1), the explanatory variables include cooking fuel type and averting activities. In model (2), child characteristics are added in the explanatory variables. We add household characteristic in model (3). Finally, we add mother's characteristics in model (4), which includes all explanatory variables. All models are estimated using fixed effects.

The results show that cooking fuel type is statistically significant at 5% level in all model specifications. We find that children belonging to households using polluting fuels are around 1.5 times more likely to have ARI symptoms as compared to households using cleaner fuels. The results match with those of India (Mishra et al. 2005). Results show that a separate kitchen is not statistically significant. Kilabuko and Nakai (2007) found that there was no significant difference in PM₁₀ pollution levels from cooking indoors in a separate kitchen and cooking outdoors or cooking in the living room for Tanzania. Vaccination however, significantly reduces the likelihood of ARI symptoms in neonate children.

Age of child is statistically significant. The results show that children older than 2 years are less likely to have ARI

Table 1 Descriptive statistics

Variable name	Variable categories	Percent	Number of children
Health outcome of child			
ARI symptoms (a) (cough with short and/or rapid breathing)	Yes	21.73	2384
	No	78.27	8589
ARI symptoms (b) (cough with short and/or rapid breathing and problem in chest)	Yes	15.86	1610
	No	84.14	9325
Cooking fuel used by household			
Cooking fuel type (a)	Polluting (solid fuel or kerosene)	67.66	7072
	Cleaner	32.34	3380
Cooking fuel type (b)	Polluting (solid fuel)	67.65	7071
	Cleaner	32.35	3381
Averting activities by household			
Separate kitchen	Yes	50.97	5220
	No	49.03	5022
Vaccination DPT 1	No	26.29	2887
	Vaccination date on card	24.70	2713
	Reported by mother	48.78	5358
	Vaccination marked on card	0.23	26
Vaccination DPT 2	No	32.37	3556
	Vaccination date on card	21.92	2408
	Reported by mother	45.52	5000
	Vaccination marked on card	0.19	20.5
Vaccination DPT 3	No	41.78	4590
	Vaccination date on card	19.59	2151
	Reported by mother	38.37	4215
	Vaccination marked on card	0.26	29
Child characteristics			
Age of child (months)	0–12	19.81	2187
	13–24	18.79	2074
	25–36	20.62	2277
	37–48	20.71	2286
	49–59	20.07	2216
Sex of child	Male	50.95	5625
	Female	49.05	5415
Birth order	1	23.26	2568
	2	20.70	2285
	3	16.40	1811
	4+	39.64	4376
Breastfeeding status	Yes	57.02	6295
	No	42.98	4745
Household characteristics			
Crowding	Yes	65.68	7251
	No	34.32	3789
Mother characteristics			
Mother is educated	Yes	43.61	6226
	No	56.39	4814
Mother smokes tobacco	Yes	3.02	333
	No	96.98	10,676
Mother's age at childbirth	14–24	36.67	4048
	25–35	54.34	5998
	36–49	8.98	992
Sample size	Total number of children	11,040	

Number of children varies for some variables due to missing observations. Polluting fuels: solid fuel (coal/lignite, charcoal, wood, straw/shrubs/grass, or animal dung) or kerosene; Cleaner fuels: electricity, LPG, natural gas or biogas. The data in the table is adjusted for survey sample weights

Table 2 Logistic regression results

Model		(1)	(2)	(3)	(4)
		Odds ratio	Odds ratio	Odds ratio	Odds ratio
Dependent variable: ARI symptom (a)					
Explanatory variables					
Cooking fuel used by household					
Cooking fuel type (a)	Cleaner fuel	1.00	1.00	1.00	1.00
	Polluting fuel	1.52** (1.05–2.21)	1.58** (1.08–2.32)	1.54** (1.06–2.22)	1.51** (1.03–2.21)
Averting activities by household					
Separate kitchen	No	1.00	1.00	1.00	1.00
	Yes	1.18 (0.96–1.45)	1.14 (0.92–1.41)	1.17 (0.95–1.43)	1.17 (0.95–1.45)
Vaccination DPT 1	No	1.00	1.00	1.00	1.00
	Vaccination date on card	1.32 (0.80–2.16)	1.15 (0.71–1.86)	1.15 (0.71–1.86)	1.16 (0.72–1.90)
	Reported by mother	1.12 (0.74–1.70)	1.12 (0.74–1.68)	1.12 (0.74–1.69)	1.12 (0.73–1.70)
Vaccination DPT 2	Vaccination marked on card	0.19* (0.03–1.24)	0.16** (0.23–1.08)	0.15** (0.02–1.08)	0.15** (0.02–1.09)
	No	1.00	1.00	1.00	1.00
	Vaccination date on card	1.49 (0.77–2.91)	1.56 (0.80–3.01)	1.56 (0.80–3.05)	1.57 (0.81–3.06)
Vaccination DPT 3	Reported by mother	0.86 (0.56–1.31)	0.89 (0.59–1.36)	0.90 (0.59–1.36)	0.89 (0.58–1.35)
	Vaccination marked on card	3.3 (0.50–21.5)	3.62 (0.59–22.1)	3.59 (0.58–22.0)	3.67 (0.57–23.6)
	No	1.00	1.00	1.00	1.00
Vaccination DPT 3	Vaccination date on card	0.79 (0.48–1.29)	0.87 (0.52–1.47)	0.87 (0.52–1.47)	0.87 (0.52–1.46)
	Reported by mother	1.09 (0.81–1.45)	1.18 (0.89–1.58)	1.18 (0.89–1.58)	1.20 (0.91–1.61)
	Vaccination marked on card	1.11 (0.25–4.76)	1.12 (0.27–4.67)	1.14 (0.27–4.67)	1.18 (0.29–4.78)
Child characteristics					
Age of child (months)	0–12		1.00	1.00	1.00
	13–24		1.03 (0.81–1.31)	1.10 (0.86–1.39)	1.01 (0.80–1.30)
	25–36		0.72*** (0.57–0.90)	0.79** (0.63–0.99)	0.71** (0.57–0.89)
	37–48		0.63*** (0.49–0.82)	0.68*** (0.53–0.87)	0.62*** (0.48–0.81)
	49–59		0.54*** (0.41–0.71)	0.59*** (0.44–0.79)	0.53*** (0.41–0.71)
Sex of child	Female		1.00	1.00	1.00
	Male		1.11 (0.97–1.27)	1.11 (0.97–1.27)	1.11 (0.98–1.27)
Birth order	1		1.00	1.00	1.00
	2		0.89 (0.74–1.07)	0.89 (0.74–1.07)	0.92 (0.76–1.11)
	3		1.07 (0.86–1.35)	1.05 (0.86–1.37)	1.18 (0.92–1.50)
	4+		1.02 (0.80–1.28)	1.02 (0.82–1.30)	1.22 (0.94–1.58)
Breastfeeding status	No		1.00	1.00	1.00
	Yes		0.79*** (0.66–0.95)	0.78*** (0.67–0.95)	0.79*** (0.66–0.94)
Household characteristics					
Household crowding	No			1.00	1.00
	Yes			0.96 (0.78–1.17)	0.94 (0.77–1.14)
Mother characteristics					
Mother's education	Not educated				1.00
	Educated				0.84* (0.69–1.00)
Mother smokes tobacco	No				1.00
	Yes				1.01 (0.54–1.91)
Mother's age at child birth	14–24				1.00
	25–35				0.81** (0.67–0.97)
	36–49				0.64*** (0.45–0.89)
Observations		8150	8114	8114	8098
F-statistics		3.191	4.71	4.47	4.46
p value		0.0422	0.000	0.000	0.000

*, **, and *** indicate statistical significance at the 10, 5 and 1%, respectively. The table reports odds ratios. The 95% confidence intervals for the odds ratios are reported in parentheses

symptoms as compared to those who are younger. Children that are breastfed are at a lesser risk of ARI symptoms with results at 1% significance across the four models. Household crowding is not a significant predictor of ARI symptoms. Children of educated mothers are less susceptible to have ARI symptoms. Mother's age at child birth is statistically significant. Children of mothers between the

age group of 25–35 years and 36–49 years face a lower risk of having ARI symptoms as compared to those of mothers belonging to age group of 14–24 years. Younger mothers are more susceptible to having weaker immune systems resulting in the delivery of children with weaker immune systems as well, which increases their chances of having ARI among other infections.

Table 3 Robustness analysis

Dependent variable	Coefficient (sample weight adjusted)	Coefficient (without sample weight adjustment)
ARI symptoms (a) (cough with short and/or rapid breathing)	1.51** (1.03–2.21)	1.29** (1.00–1.66)
ARI Symptoms (b) (cough with short and/or rapid breathing and problem in chest)	1.37 (0.84–2.24)	1.30 (0.94–1.80)

*, **, and *** indicate statistical significance at the 10, 5, and 1%, respectively. The table reports odds ratios. The 95% confidence intervals for the odds ratios are reported in parentheses

For robustness checks, we estimate four different models and report the estimated odds ratio for the effect of polluting fuel on ARI symptoms. Table 3 shows odds ratios, our primary definition of ARI symptoms (cough with short and/or rapid breathing), and our alternate definition of ARI symptoms (cough with short and/or rapid breathing and problem in chest), with and without sample weight adjusted coefficients. We find that polluting fuel in cooking fuel type is statistically insignificant, with the estimate of odds ratio as 1.38 and 1.30 in adjusted and unadjusted coefficients respectively. The results for other explanatory variables are similar as presented above. For robustness checks, we also estimate the regression model with solid fuels as an explanatory variable in place of polluting fuels. We find that the results were unchanged as there was only one observation where kerosene was used as main fuel for cooking. However, in Pakistan, kerosene is rarely used in cooking such as for making tea occasionally.

Even though this study is the first of its kind for Pakistan, it has some limitations. This study is based on indirect exposure assessment, which reduces the strength of causality. Using cooking fuel as a proxy for pollution exposure ignores the causal linkage between smoke inhalation and its impact on the respiratory health of children. In addition, many households, especially in rural areas do not consume a single type of cooking fuel, rather they use a combination of fuels for their cooking needs. For example, the wood from the trees does not make an attractive fuel choice in winter as the moisture in the wood limits its burning potential, so households combine animal dung and wood to cook food. Even though we have tried to control for the confounding factors by using the fixed-effects approach, there may well be certain variables such as ambient air pollution or the distance of market from the household, which may influence the risk of ARI symptoms indirectly. Lastly, our response variable of health outcome is ARI symptoms as reported by the mother, not a laboratory diagnosis, due to limitations in available dataset from DHS. Even though DHS offers a large nationally representative dataset, it lacks the holistic framework, which can allow for a more integrated assessment of exposure-response studies. For example, questions

on type of cook stove used and duration of cooking can allow for better research studies.

This paper argues that there is a need for better alternatives for household energy consumption in Pakistan. Improved cook stoves have proven to dampen the harmful effects of cooking smoke on the respiratory system of women in Pakistan (Jamali et al. 2017). Efficient use of biomass fuels has also shown to reduce the burden of respiratory diseases among children in Pakistan (Butt et al. 2013). However, at a policy level, there is a need for direct exposure assessment studies (Clark et al. 2013), randomized controlled trials (RCTs) and a more comprehensive DHS survey which accounts for combined cooking fuel usage. Execution of initiatives such as the inclusion of pneumococcal vaccine in the index of Pakistan's Expanded Program on Immunization (EPI) in October 2012 help in reducing the vulnerability of children under the age of 5 to respiratory infections and diseases.

Conclusion

This study finds that children living in households using polluting fuels for cooking purposes are 1.5 times more likely to have ARI symptoms than children living in households consuming cleaner fuels. Solid fuel consumption for cooking accounts for 62% in Pakistan. The burden of disease from household air pollution is likely to increase in Pakistan if counter-measures are not taken. The relationship between household air pollution and respiratory infections in young children is well established. Vaccination at childbirth, breastfeeding, education of mothers, and giving birth at a later age are factors, which reduce the risk of ARI in young Pakistani children. Informing and educating the young girls in Pakistan about the negative effects of household air pollution may be an effective short-term strategy to reduce incidence of ARI cases in the future.

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