KNOWLEDGE OF HAZARDS FROM INDOOR AIR POLLUTION FROM HOUSEHOLD ENERGY USE IN RURAL CHINA

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ABSTRACT
Indoor air pollution from household use of biomass and coal is a leading environmental health risk in many developing nations, and directly or indirectly linked to a number of the Millennium Development Goals, such as environmental sustainability, reducing child mortality, and gender equity. We use data from four poor provinces in China (Gansu, Guizhou, Shaanxi, and Neimeng) to assess the knowledge of hazards associated with indoor air pollution. Using this detailed comparative study in these four Chinese provinces, we conclude that broad health education – which simply provides information on the hazards of risk and available interventions – is insufficient for successful risk mitigation. Rather, there should be emphasis on the economic and infrastructure needs of technology dissemination, coupled with understanding the details of behaviors that affect exposure and presenting users with alternative behaviors.

INDEX TERMS
Household energy, indoor air pollution, technology diffusion, knowledge

INTRODUCTON

Globally, almost three billion people rely on biomass (wood, charcoal, crop residues, and dung) and coal as their primary source of domestic energy (*1*). Hundreds of harmful pollutants are emitted during the burning of biomass or coal in the form of gases, liquids (suspended droplets) or solids (suspended particulates), in particularly large quantities when burned in open or poorly ventilated stoves. Exposure to indoor air pollution (IAP) from the combustion of solid fuels has been implicated, with varying degrees of evidence, as a causal agent of several diseases in developing countries including acute respiratory infections (ARI), chronic obstructive pulmonary disease (COPD), lung cancer (for coal smoke), asthma, nasopharyngeal and laryngeal cancers, tuberculosis, low birth weight, and diseases of the eye (*1*). Conservative estimates of mortality due to indoor air pollution from solid fuels show that in 2000, more than 1.6 million deaths and nearly 3% of the total burden of disease worldwide were caused by this risk factor(*1*), making indoor air pollution the 11th leading cause of global mortality and 8th leading cause of global disease burden among more than 25 major risk factors.

There is limited knowledge from empirical research to form the basis for design and dissemination of effective interventions. This limitation arises because much of the initial research overlooked the complex interactions of technological, behavioral, economic, and infrastructure factors that determine the success of environmental health interventions, especially those with non-health dimensions such as household energy. Household energy use is tightly coupled with both access to fuel and multiple non-health welfare outcomes (*2*). As a result, the risk perception and behavioral aspects of household energy use are likely to have complex linkages to socioeconomic factors beyond health knowledge. In this paper, we use data from four poor provinces in China (Gansu, Guizhou, Shaanxi, and Neimeng) to assess knowledge and perceptions of indoor air pollution. The interactions of behavioral, infrastructural, and technological factors are particularly relevant in China where the diversity of climate and geography, socioeconomic and socio-cultural factors such as income or food types and food preparation, housing, and fuels and stoves require designing intervention technologies and programs appropriate for local conditions. Nearly 80% of China's households rely on solid fuels (biomass and coal) for their domestic energy (*1, 3*). Although until the 1980s and 1990s biomass was the dominant source of household energy in China, deforestation – and

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policies to reduce and reverse it – have compelled many rural residents to switch to coal (while some urban households, especially in the more prosperous coastal areas, have switched to non-solid fuels with increasing income and development) (*3, 4*). China has also implemented an ambitious program to disseminate improved (high-efficiency and low-emissions) stoves (*4, 5*). The program has primarily targeted reducing IAP exposure during cooking. Home heating remains an important route of exposure, as does the absence of improved stove programs in poorest provinces and communities. A recent evaluation of the program has also illustrated that the design and performance of the new stoves cover a large range, with many of the stoves labeled as "improved" lacking flues or other characteristics necessary for reducing exposure (*4*). Using this comparative study in four Chinese provinces, we conjecture that broad health education – which simply provides information on the hazards of risk and available interventions – is insufficient for successful risk mitigation. Rather, there should be emphasis on the economic and infrastructure needs of technology dissemination, coupled with understanding the details of behaviors that affect exposure and presenting users with alternative behaviors.

METHOD

Study Location and Study Populations

The study took place in Gansu, Guizhou, Shaanxi, and Neimeng provinces of China. Among 31 Chinese provinces and autonomous regions, GDP per capita ranks 25th in Shaanxi, 29th in Neimeng, 30th in Gansu, and 31st in Guizhou. Three townships were selected for the study in Gansu, Guizhou, and Shaanxi provinces and two in Neimeng such that: (i) the townships had relatively similar socioeconomic, lifestyle, and environmental conditions; (ii) the majority of households used solid fuels as the main source of energy (coal in Guizhou and Shaanxi and biomass in Gansu and Neimeng); (iii) there was no common market between any two townships; (iv) township community groups accepted and approved the study. In each township, approximately 150 households were selected for a survey of household energy technology and energy/IAP knowledge and behaviors based on the following criteria: (i) having lived in the study area for at least one year; (ii) using solid fuels as the main source of energy; (iii) including a female member older than 18 years of age and a child younger than 14 years of age; and (iv) joining the study voluntarily. In addition to face-to-face interviews with uniform questionnaires, interviewers collected information on energy use behaviors through field observation and interviews with key informants.

RESULT

Current Knowledge about IAP Risks and Interventions

Knowledge and perceptions of risk and hazard are important determinants of, or obstacles to, adoption of interventions. Risk knowledge, in turn, may depend on socio-demographic factors such as age or education which affect access to, and utilization of, information. Table 1 presents the respondents' general knowledge of IAP as a health hazard stratified on province as well as socio-demographic characteristics. The questions focused on health as a broad concept. This was because perceiving an exposure as a health hazard should contribute to intervention adoption, even without specialized knowledge on the etiology of specific diseases affected by it. Questions were also asked about smoking and environmental tobacco smoke (ETS).

Table 1. *Knowledge of the health effects of "respirable pollutants". All numbers are % respondents in each province or age/education/income category.*

By province				
	Guizhou N=476	Shaanxi N=479	Gansu N=463	Neimeng N=323
Smoking is a health hazard	60.1	80.1	93.3	90.4
ETS is a health hazard	47.7	74.9	76.0	83.3
Smoke from burning fuel or from cooking is a health hazard	53.8	59.7	74.5	77.3
By age				
	< 40 years N=1226	40-59 years N=455	≥60 years N=60	
Smoking is a health hazard	82.2	76.9	60.3	
ETS is a health hazard	71.7	65.0	52.5	
Smoke from fuel use for cooking or heating is a health hazard	67.5	60.3	58.3	
By education				

	Illiterate N=472	Elementary school N=760	Junior High school N=387	Senior High School and higher N=63
Smoking is a health hazard	71.5	82.2	85.4	92.1
ETS is a health hazard	60.2	70.0	76.9	82.3
Smoke from fuel use for cooking or heating is a health hazard	53.6	68.6	70.8	85.5
By income (combined value of cash income and subsistence food)				
	<1500 N=137	1500-3000 N=442	3000-4500 N=452	≥4500 N=684
Smoking is a health hazard	62.2	75.6	79.2	86.8
ETS is a health hazard	50.4	63.1	67.6	77.8
Smoke from fuel use for cooking or heating is a health hazard	55.6	65.0	61.9	62.2

Table 1 shows that in all provinces and socio-demographic groups, the majority of respondents were aware that smoke from cooking and heating is a health hazard. Guizhou, a poor province with a high proportion of population from ethnic minorities and limited health education for most health risks, and a tobacco growing region, had the lowest knowledge of health risks associated with respirable pollutants from any source. The youngest respondents (<40 years) had the highest knowledge of health hazards. There was a slight gradient by education and income, with those in higher socioeconomic status generally having higher knowledge of risk, for smoking, ETS, and smoke from cooking and heating.

Knowledge of risk and hazard associated with energy use may exist in forms other than direct linkages with health, including perceptions about how energy use may affect the quality of air inside the home. Table 2 shows the knowledge of the causes of indoor air pollution (defined as “contaminated/polluted/bad air inside the house” in the household survey). Further, 15.5%, 11.5% and 4.8% of interviewees knew that smoke from fuel combustion contains harmful components, including dust, carbon monoxide (CO), sulfur dioxide (SO_2), fluoride, arsenic and/or “other chemicals” in Guizhou, Shaanxi and Gansu provinces respectively. The proportions in Table 2 are generally lower than those in Table 1, which illustrates that, while people may be aware of the health hazards of cigarette or stove smoke, they do not necessarily link this hazard with indoor air quality, per se. The only exception was Neimeng, where there have been recent efforts to encourage the installation of ventilation fans in homes to “improve indoor air quality”.

Table 2. *Knowledge of the sources of “indoor air pollution” by province.*

	Guizhou (n=476)	Shaanxi (n = 479)	Gansu (n=463)	Neimeng (n =323)
Cooking	51.6	63.1	36.7	77.7
Heating	38.3	54.1	16.8	57.6
Smoking	42.4	55.7	16.0	71.5
Poor/limited ventilation	49.0	42.3	23.3	63.8

Even if knowledge about health risks exists, it should be coupled with knowledge about effective interventions (or solutions) for individuals and households to choose alternative energy, housing, or behavioral options. The knowledge of interventions for reducing smoke inside the house is shown in Table 3. As seen in Table 3**,** awareness of interventions for reducing indoor smoke was relatively low, except for “improving stove and chimney” in Shaanxi province, where an improved stove program has been in place, and in Neimeng, where new efforts are under way to improve the design of the bed-stove configuration in newly-constructed houses. 77%, 79% and 49% of respondents could not identify alternative fuels in Guizhou, Shaanxi and Gansu, respectively.

Table 3. *Knowledge of methods for reducing smoke from energy use.*

	Guizhou (n=476)	Shaanxi (n = 479)	Gansu (n=463)	Neimeng (n = 323)
Improving stove	32.4	71.6	29.2	61.9
Improving chimney	29.7	68.4	21.4	26.0
Improving the skills of stove handling (such as splitting wood into small pieces, adding some water in coal and clean the burning ash regularly so that to make fire more quickly and efficiently etc.)	19.4	13.9	12.5	19.8
Improving ventilation (such as opening windows and doors)	34.8	46.6	57.7	65.9
No smoking indoors	22.4	15.7	4.5	44.3
Spending less time using stove	17.6	8.3	6.9	10.8

CONCLUSION AND IMPLICATIONS

The comparative study of four Chinese provinces illustrates that knowledge of health hazards of an exposure, while likely to be a necessary factor in behavior change, is not sufficient when (i) exposure behaviors are closely linked to day-to-day activities of households such as cooking and heating, or have other welfare effects (e.g. food drying or maintaining constant temperature for raising silk worms), and hence cannot be simply "stopped" (versus smoking for example where the desired alternative behavior is cessation) and (ii) alternative behaviors that provide the same welfare effects without considerable additional effort are not readily available, or are not perceived to be available, to users. In particular, in all provinces, small proportions of respondents thought that improving stove handling skill would reduce indoor smoke from energy use.

There is a great deal of interest in interventions to reduce the health hazards associated with indoor smoke from household use of solid fuels in international development and public health. Limited economic resources and lack of political or individual resolve are the commonly cited reasons for the low coverage or community effectiveness of IAP interventions, appropriately leading to public health advocacy (*6*). Early experiences of improved stove programs illustrate that technology diffusion and utilization may be hindered by social and behavioral factors. Therefore, beyond advocacy, scientific research must contribute to designing new technologies and implementation strategies that recognize and are robust to, the existing limits in economic resources, social norms, and human behavior, as described here in the case of four poor provinces in China.

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