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Exposure to indoor air pollution from household energy use in rural China: The interactions of technology, behavior, and knowledge in health risk management

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Abstract

Indoor air pollution (IAP) from household use of biomass and coal is a leading environmental health risk in many developing nations. Much of the initial research on household energy technology overlooked the complex interactions of technological, behavioral, economic, and infrastructural factors that determine the success of environmental health interventions. Consequently, despite enormous interest in reducing the large and inequitable risks associated with household energy use in international development and global health, there is limited empirical research to form the basis for design and delivery of effective interventions. We used data from four poor provinces in China (Gansu, Guizhou, Inner Mongolia, and Shaanxi) to examine the linkages among technology, user knowledge and behavior, and access and infrastructure in exposure to IAP from household energy use. We conclude that broad health risk education is insufficient for successful risk mitigation when exposure behaviors are closely linked to day-to-day activities of households such as cooking and heating, or have other welfare implications, and hence cannot be simply stopped. Rather, there should be emphasis on the economic and infrastructure determinants of access to technology, as well as the details of behaviors that affect exposure. Better understanding of technology–behavior interface would also allow designing technological interventions that account for, and are robust to, behavioral factors or to provide individuals and households with alternative behaviors. Based on the analysis, we present technological and behavioral interventions for these four Chinese provinces.

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Keywords: Household energy; Indoor air pollution; Global health; Sustainable development; Health behavior; Risk; Technology diffusion; Environment and development; China

Introduction

Globally, almost three billion people rely on biomass (wood, charcoal, crop residues, and dung) and coal as their primary source of domestic energy

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(Smith, Mehta, & Maeusezahl-Feuz, 2004). Hundreds of harmful pollutants are emitted during the burning of biomass and coal, 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 (Boy, Bruce, & Delgado, 2002; Bruce, Perez-Padilla, & Albalak, 2000; Ezzati & Kammen, 2001; Mishra, Dai, Smith, & Mika, 2004; Smith et al., 2004; Smith, Samet, Romieu, & Bruce, 2000). In the year 2000, more than 1.6 million deaths and nearly 3% of the total burden of disease worldwide were caused by IAP from solid fuel use, making this risk factor the 11th leading cause of global mortality and 8th leading cause of global disease burden among 26 major global risks (Ezzati et al., 2002; WHO, 2002).

The magnitude of the health risk associated with exposure to indoor smoke and its concentration among the marginalized socioeconomic and demographic groups (women and children in poor households and the rural population) have motivated efforts towards interventions in international development and public health arenas. Solid fuel use is also an indicator for goal 7 (environmental sustainability) of the millennium development goals (MDGs). At the same time, there is limited knowledge from empirical research to form the basis for designing effective interventions and intervention delivery programs. This limitation arises because much of the initial research overlooked the complex interactions of technological, behavioral, economic, and infrastructural factors that determine the success of environmental health interventions, especially those with non-health dimensions such as household energy (Agarwal, 1983; Ezzati & Kammen, 2002a, b; Kammen, 1995a, b; Karekezi, 1994; Krugmann, 1987; Manibog, 1984).

The initial emphasis of research on household energy in developing countries was on the environmental impacts of energy use, such as deforestation, resulting in a level of zeal for increased stove efficiency (Agarwal, 1986; Kammen, 1995a). The public health benefits from reducing exposure to indoor smoke became the subject of attention soon after. This perceived ''double-dividend''—improving public health while reducing adverse environmental impacts—focused a great deal of effort on the design and dissemination of ''improved'' (high-efficiency and low-emissions) cookstoves (Barnes, Openshaw, Smith, & van der Plas, 1994; Kammen, 1995b; Smith, Gu, Huang, & Qui, 1993). Initial improved stove programs, however, were often marked by a lack of detailed data on technology performance in field conditions (Kammen, 1995b; Krugmann, 1987; Manibog, 1984). Efficiencies and emissions, for example, were often measured in controlled environments with technical experts using the stoves under conditions very dissimilar to those in the field. More recently, research on IAP interventions has shifted from ideal operating conditions to monitoring stove performance under actual conditions of use, taking into account the various social, behavioral and physical factors that would limit the use of these stoves altogether, or result in ''sub-optimal'' performance (Agarwal, 1983; Ravindranath & Ramakrishna, 1997; Sinton et al., 2004). Household energy use is tightly coupled with both access to fuel and has multiple non-health welfare outcomes (Ezzati et al., 2004). As a result, household energy choices and energy use behaviors are likely to have complex linkages to household economics and energy infrastructure, as well as knowledge of health hazards and risk perceptions. Characterizing these determinants is important for designing and delivering interventions in diverse environmental and sociocultural conditions.

In this paper, we use data from four poor provinces in China (Gansu, Guizhou, Inner Mongolia, and Shaanxi) to assess the linkages among technology and user knowledge and behavior in IAP exposure from household energy use. Based on the analysis, we present technological and behavioral intervention options for these four Chinese provinces. We also draw general lessons for technological interventions, especially as related to environmental health and other risks with significant non-health dimensions.

Study setting and study populations

More than 70% of China's households rely on solid fuels (biomass and coal) for their domestic energy (Florig, 1997; Smith et al., 2004). IAP caused an estimated 500,000 annual deaths in the developing countries of the Western Pacific region (approximately 85% of the region's population lives in

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