Challenges of Achieving Sustainability in Rural China: Energy Poverty & Indoor Air Pollution Policy

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Introduction

Energy poverty, such as clean energy availability and affordability, has been an ongoing problem in low and middle income countries (LMICs). According to recent studies, energy poverty has been strongly correlated with use of non-renewable energy sources such as biomass, crop residues and elevated levels of indoor air pollution (IAP) (Wang & Li, 2016). Although IAP is a widely researched topic in environmental public health, it is generally overlooked and ignored particularly in rural China because of low numbers of sufficient data compared to more urbanized populations (Shen & Xue, 2014). The common source of IAP is the overconsumption of non-renewable energy sources such as biomass (e.g., crop residues and wood) and solid fuel (e.g., coal) in low and middle income households (Liao, *et. al*., 2016). In this commentary, I argue that rural China needs to develop and promote clean and affordable energy sources to ameliorate the devastating health effects attributed to IAP.

Overconsumption of solid fuels has been one major source of energy poverty in rural areas of China for decades (Hou et al., 2017). Solid fuels (coal, wood, and crop residue) are non-renewable, and are typically used for heating and cooking in low to middle income regions, particularly in rural China. Solid fuels are generally burned in areas with little or no ventilation, which can create devastating effects on one's health. In addition, IAP can negatively environment in which they live by exacerbating climate change (Baumgartner et al., 2013).

According to a survey conducted by Shan et al., residents in rural China used about 317 million tons of standard coal, 192 million tons of raw coal, and 219 million tons of raw biomass in the year 2015 alone (Shan et al., 2015). Each year, IAP accounts for nearly 420,000 premature deaths in China and is responsible for 35.7% of all lower respiratory infections, 22% of

cardiopulmonary disease, 1.5% of tracheobronchial and lung cancer, and a 2.5% loss of Disability Adjusted Life Years (DALYs) (Mestl et al., 2007).

Barriers to Affordable, Clean Energy Sources

Energy poverty (clean fuel unaffordability and unavailability) has been a serious problem in rural areas of China for years. Compared to urban populations, 60% of the residents in rural China use coal and biomass in their daily lives (Hou et al., 2017). One of the major external factors associated with solid fuel use is the problem regarding access and availability of environmentally non-pollutant alternatives. For example, in the Northern part of China, wood and crop biomass is commonly used as trees are highly abundant while other areas primarily use coal in areas where trees and other forms of biomass are scarce (Wang et al., 2017).

Distance from clean energy sources is one determinant of overconsumption of biomass and solid fuels. This problem has persisted due to poor quality of infrastructure which can prevent residents from traveling to one region from another. According the literature, the most common trend is that there was a positive correlation between biomass use and distance, and a negative correlation between distance and clean fuel usage. In other words, the closer residents lived to sources of clean energy, the more likely they are to use them (Shan et al., 2016). As a consequence of these barriers, residents have no other option but to use nonrenewable energy sources to warm their dwellings and cook their meals.

Another external factor that needs to be addressed is fuel affordability and accessibility to cleaner energy sources. The average cost of coal per ton is $641 yuan or ($98.77 USD), but the cost of renewable energy sources would require a 2.8 billion yuan ($441,125 USD) investment for construction of renewable energy generators, wind turbines, and solar panels (Zheng, 2007). Not

much is known as to how much the prices will be marketed for rural residents, or how the prices will be regulated by the Chinese Government.

The most common barrier to access involves the type of landscape upon which an individual resides. There are multiple types of landscapes in China: plains, hills, basins, plateaus, and mountains (Hou et al., 2016). Areas with plains are less likely to use biomass while mountainous areas and plateaus are not (Wang et al., 2017). These geographical barriers can be tied into infrastructure problems and access to clean energy sources. Proximity to urban areas can also be taken into consideration in terms of access to sustainable energy sources.

In addition, the level education that one has is a common predictor for biomass use and solid fuel use in rural China. Higher levels of education may increase household income, which in turn, could encourage household members to adopt more sustainable energy practices in their homes, but more research is needed to provide sufficient evidence (Hou et al., 2016).

Biological Impact of Biomass Fuel Use

Carbonaceous aerosols are products of incomplete coal combustion. These types of aerosols come in the form of organic carbon (OC), and black carbon (BC). OC and BC are known to bioaccumulate in the lungs if inhaled, and depending on how fine those particles are, they could travel farther inside the body via the bloodstream, causing further damage to internal organs, eventually leading to severe illness and death if left unchecked (Shen et al., 2015). Other examples of aerosols include sulfur dioxide, polyaromatic hydrocarbons (PAHs), toxic metals, ammonia, nitrogen oxides, and particulate matter (PM). These types of materials can be easily absorbed into the bloodstream (Shen & Xue, 2014).

Each year, the WHO estimates that PM concentrations of biomass or solid fuels in China exceed their Annual Air Quality guideline of 10 microns per millimeter by a factor of 10 or more (Baumgartner, et al., 2014). Current regulations are in place to control for particulate matter that come in diameters of 2.5 to 10 microns ($PM_{2.5}$, PM_{10}, respectively). It has been noted that 33-47% of $PM_{2.5}$ emissions in China come from residential use of biomass fuel sources (Shen, 2016). Those with a diameter of 10 can be inhaled and can bioaccumulate in the lungs and cause damage, while those with a diameter of 2.5 or less can be further absorbed into the body via the bloodstream (Hu, et al., 2016). This is because PM of 2.5 or less in diameter can pass through tissue and cause damage to vital organs (e.g., the lungs) leading to more severe health problems.

In Northern China, for example, housewives are two times more susceptible to $PM_{2.5}$ than men because they are the ones who are directly exposed to particulate matter come incomplete combustion of coal and other solid fuels while they cook the meals and heat up their homes (Li et al., 2016). In addition to particulate matter exposure, housewives are exposed to other hazardous chemical products from incomplete combustion of solid fuels such as sulfoxides, nitrogen oxides, and carbon monoxide. These types of compounds can also create deleterious health effects indoors and outdoors such as chronic obstructive pulmonary disease, asphyxiation, and lung cancer (Shen & Xue, 2014).

Limitations

Unfortunately, there have been no feasible developments of affordable clean energy in rural China. There have been some efforts to use solar energy instead of fossil fuel-powered energy. However, pushback from the fossil fuel and fracking companies has slowed down progress to provide rural areas of China with affordable and clean energy sources for both cooking and heating purposes. It is important to note that survey data does not fully illustrate the actual numbers

pertaining to biomass and solid fuel use in rural China. It is imperative to implement a more reliable measurement tool to improve the quality of the data that is presented to global government agencies, and to the general public (Shan et al., 2016).

In 1982, China's Ministry of Agriculture of China initiated a program known as the National Improved Stove Program (NISP). The overall goal of the program was to promote and deliver cleaner energy sources and stoves to areas that rely primarily on coal and biomass fuels (Hou et al., 2016). The stoves were given to the public free of charge since the program was grant funded. Despite the presence of policy, many villages did not adopt the practice of using the improved stoves for cooking and heating their homes (Hou et al., 2016). The reason why the adoption process among residents failed was that they did not receive formal education on the usage and the benefits (regarding health and the environment) of using the improved stoves in their homes.

In addition, regulations and policy enforcement are some of the most common barriers to giving access to clean and affordable energy sources, and ensuring a sustainable environment for those living at or below the poverty line. Global outreach efforts, backed by research from the World Health Organization and the Centers for Disease Control and Prevention (CDC) have worked to engage rural communities through education, and using community engagement to shift cultural and societal norms. Using those tactics, there is an opportunity to mobilize policies regarding the challenge of sustainability in low to middle income countries.

Recommendations for Abating IAP in Rural China

In order to address the overconsumption of biomass, the Chinese government has to develop systemic enforcement of government policy. For example, use of biogas and delivering biogas digesters to communities that heavily rely on biomass to cook their meals and fuel their

homes is one recommendation. Biogas digesters take in human waste, animal waste and other organic materials to produce natural sources of methane gas for heating and cooking (Li et al., 2017). For biogas use, government policy can be implemented to help regulate the usage of biogas digesters in rural homes and dwellings to ensure indoor air safety among the residents. The policy should also include maintenance of those digesters to provide residents with a reliable source for energy and heat and to ensure proper ventilation of burning fuel sources. For those who live in areas that have rough terrain, and rely primarily on biomass fuels such as wood and crop residues, they should receive additional government assistance to make biogas digesters more adaptable to the land scape in which they live (Li, et al., 2017).

With policy reform, formal education about the use of non-renewable energy could help the public understand the gravity and severity of the hazardous effects biomass and coal burning can create. By combing policy with education, it would drive more people to seek out cleaner sources of energy without having to worry about affordability or barriers to access. If people obeyed the policy and became more literate in environmental health, their collective change in behaviors could help prevent the incidence of asthma among children, chronic obstructive pulmonary disease (COPD), and lung cancer.

Affordability and access are two of the most difficult challenges that can impede progress in achieving sustainability in rural and remote areas of China. If poverty is a concern, then there should be programs implemented to reduce the poverty, increase educational attainment among residents. There is also a dire need to encourage the public to consume sustainable energy sources by equipping them with the knowledge and skills necessary to use cleaner stoves and avoid use of biomass and coal for energy and heat (Shen, 2016). To address the concerns of access, infrastructure transportation improvement with government regulations to maintain and control

foot and vehicle traffic could facilitate clean and affordable energy delivery efforts to rural areas in China.

Conclusions

It is unsurprising that there may be some pushback at the community, organizational, and policy level. However, the evidence collected from empirical studies could support the roles of community health workers and public health officials to effectively convey to the public and to government officials the true severity of prolonged exposure to $PM_{2.5}$ pollutants and other volatile chemicals that are produced by the incomplete combustion process of biomass and solid fuels. Although biomass and solid fuel consumption rates are declining in rural China (Hou et al., 2016), exposure to incomplete combustion products and particulate matter in households is still a growing public health concern. Despite the prevalence of biomass and solid fuel use, there is still an opportunity to promote affordable clean energy sources to better suit the needs of those who are living in low to middle income areas in rural China.

The overarching goal of receiving more funding for cleaner and more affordable alternatives for fuel is to promote and sustain good health and well-being and reduce the deleterious effects of climate change in the developing world. Moreover, promoting sustainability and normalizing clean, renewable energy would provide low to middle income communities the opportunity to lead healthier lives and understand the impact of human activity on the environment not just in the short-term, but for future generations.

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