International Growth Centre

Authors

Nidhiya Menon

Associate Professor of Economics

Brandeis University

Published on: 9 Sep 2013

Countries: India - Central

Research themes: Firms

The Unintended Child Health Consequences of the Green Revolution in India

While the Green Revolution in India greatly enhanced agricultural production, the enhanced use of fertilisers led to the contamination of surface and ground water. This column analyses the impact of fertiliser agrichemicals in water on infant and child health. It is found that exposure of mothers to these contaminants in the month after conception increases the chances of infant death within a month of birth, and also has long-lasting negative effects on child health.

The Green Revolution in India transformed the country from one heavily reliant on imported grains and prone to famine to a country largely able to feed itself and successful in achieving its goal of food security. Yields of the country's main crops, wheat and rice, increased dramatically and farmers prospered from the use of Green Revolution technologies including high-yield variety seeds, irrigation and nitrogenous fertiliser. The growth in agricultural production improved the well-being of millions of Indians by reducing the incidence of hunger and raising the living standard of the rural poor, but it also exacted a toll on the country's environment. In particular, the heavy use of fertilisers to increase yields led to high levels of toxicity and contamination of surface and ground water in India. . Elizabeth Brainerd and I examine the impact of fertiliser agrichemicals in water on infant and child health in India (Brainerd and Menon 2013).

Outside evidence

Our motivation for focusing on agrichemicals stems from biomedical and epidemiological studies in the United States and other countries which show that there is a strong relationship between total agrichemical content in water and common birth defects such as Down's syndrome and Spina Bifida (Winchester 2009). US researchers note that the incidence of these defects is especially pronounced for children conceived between April and June, the crop-sowing months in the northern hemisphere, and among children of agrichemical applicators who are consistently exposed to toxins. Lacking credible data on birth defects, we focus on documenting health impacts among a group that is especially vulnerable to environmental insults – infants and very young children.

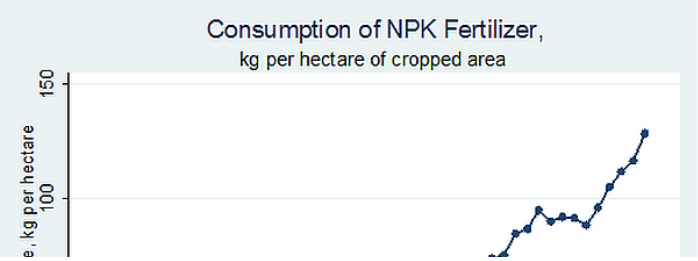
Evaluating the link between water agrichemical contamination and child health in India is important for several reasons. In rural India, women form 55-60% of the agricultural labor force and are often at the forefront of farming activities. Hence they

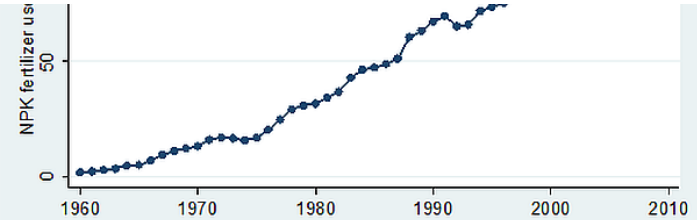
are directly exposed to chemical applications that are made to the soil to improve productivity; their children are exposed to these contaminants both before and after birth. This exposure may contribute to the relatively poor indicators of child health in India: Indian children have one of the highest rates of stunting and wasting among all developing countries. These rates are higher than predicted given the level of per capita income and infant mortality rates in the country (Deaton and Dreze 2009). Further, evidence from biomedical studies such as those above indicates that seasonal exposure to water toxins can affect health outcomes not only in the current population but also in subsequent generations. For example, illnesses such as coronary heart disease – which have been shown to be more likely in adults who as babies were of low-birth weight – are inheritable and may be bequeathed to subsequent generations. With a few exceptions, the impact of water pollution on all of these dimensions of health in developing countries has largely been neglected and we were eager to investigate this issue in India.

Why India?

India provides a uniquely favourable environment given that its particular soil endowment and geography lead to both seasonal and state-level variation in fertiliser agrichemical contamination of ground and surface water. At independence in 1947, agriculture in India was characterised by labour-intensive subsistence farming methods that resulted in low yields and continued vulnerability to inadequate food supplies. Indian leaders considered food security to be of paramount importance and implemented programmes to achieve this goal, including promotion of modern farming techniques broadly referred to as the 'Green Revolution'. Green Revolution methods primarily entailed increased use of irrigation; double-cropping, that is planting two crops annually; adoption of high-yield variety (HYV) seeds; and significantly increased use of inorganic fertilisers. HYV seeds can increase crop yields by two to four times those of indigenous seeds, but they require relatively more fertiliser and water. The diffusion of HYV seeds proceeded rapidly in India, particularly for wheat. For example the share of acreage under wheat sown with HYV seeds increased from 4.1% in the first year of the programme (1966-1967) to 30% only two years later. Production of the country's main crops – wheat and rice, increased dramatically after the Green Revolution. At the same time, consumption of synthetic nitrogen-based fertilisers such as Urea and Nitrogen-Phosphate-Potassium (NPK) fertilisers rose dramatically. Figure 1 below illustrates the rapid increase in the use of NPK fertilisers per hectare under cultivation between 1960 and 2008.

Figure 1. Trend in consumption of NPK fertiliser in India





Source: Statistical abstract of India. Various years.

Our study analyses agro-contaminants in water using data on water quality from monitoring stations run by India's Central Pollution Control Board combined with data on the health outcomes of infants and children from the 1992-1993, 1998-1999, and 2005-2006 Demographic and Health Surveys of India. Fertilisers have relatively clear application times – since they are applied early in the growing season and residues may subsequently seep into water through soil run-off, the concentrations of agrichemicals in water vary seasonally. Water contamination also varies regionally by cropped area in India because states in northern India (primarily Punjab, Haryana, Uttar Pradesh, Gujarat, Bihar and Madhya Pradesh) plant predominantly winter crops (Rabi wheat) while southern and eastern Indian states (mainly Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal and Assam) plant mainly summer crops (Kharif rice). We exploits the increase in fertiliser use over time in India, the differing timing of the crop planting seasons across India's states, and the differing seasonal prenatal exposure of infants and children to identify the impact of fertiliser agrichemicals on various measures of child health.

Results and implications

Our analysis provides several noteworthy results. We find that the presence of fertiliser chemicals in water in the month of conception significantly increases the likelihood of infant mortality (child was born alive but died at or before 11 months of age), particularly neo-natal mortality (child was born alive but died in the first month). This is as expected since neo-natal mortality is understood to result from things that occurred at the pre-natal stage (before birth) whereas post-natal mortality (child was born alive but died between 2-11 months of age) is more likely to be due to diseases (diarrhea), poor nutrition, child living circumstances/ environment or accidents. More surprisingly, the presence of toxins in water in the first month after conception is also significantly associated with reduction in other measures such as height-for-age and weight-for-age for children below five years of age. This was an unexpected result since we had not thought month of conception exposure could have such long-lasting effects. The negative consequences of early agrichemical exposure are not uniform – the effects are most pronounced among vulnerable populations, in particular the children of uneducated poor women living in rural India.

The findings of our study highlight the tension between greater use of fertiliser to increase yields and the negative child health effects that result from such use. In order to reduce harm from agrichemical exposure, it may be necessary to implement programmes to raise consciousness and improve the nutrition of

mothers who are most exposed. These strategies are likely to be costly for cash-strapped developing countries such as India. However, their adoption may be vital to slowing the unintended health consequences of the widespread use of inorganic fertilisers in Indian agriculture. More broadly, our study raises a fundamental question regarding one's assessment of the Green Revolution and its contributions to well-being. By significantly increasing agricultural output in developing countries, Green Revolution techniques unquestionably raised living standards and improved the caloric intake and nutrition of millions of people. However, these results indicate that an assessment focusing on only increased agricultural output excluding the health costs of environmental contamination is incomplete. The Green Revolution represented a significant change in the agricultural production system: production based on indigenous seeds and organic inputs was, over time, replaced with an agricultural system reliant on hybrid seeds and agrichemicals. The implementation of this system was widespread across the developing world, and policymakers continue to advocate for increased use of agrichemicals by farmers. While we are not the first analysts to document the environmental impact of this fundamental shift in agricultural production, to the best of our knowledge, this paper is one of the first attempts to credibly identify the effect of agrichemicals on child health in a developing country. However, we examine a relatively short-term impact of Green Revolution technologies on child health in a single country. Much research remains to be done to investigate whether there are any significant, negative long-term consequences for adult health outcomes of the implementation of these techniques, in India as well as in other countries.

Further Reading

- Brainerd, Elizabeth and Nidhiya Menon (2013), "Seasonal Effects of Water Quality: The Hidden Costs of the Green Revolution on Infant and Child Health in India", Brandeis University, Working Paper.
- Deaton, Angus and Jean Drèze (2009), "Food and Nutrition in India: Facts and Interpretations," Economic & Political Weekly 44(7): 42-65.
- Winchester, P.D., J. Huskins, and J. Ying (2009), "Agrichemicals in Surface Water and Birth Defects in the United States," Acta Paediatrica 98: 664-66.