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Exposure to household air pollution during first 3 years of life and IQ level among 6–8-year-old children in India – A cross-sectional study

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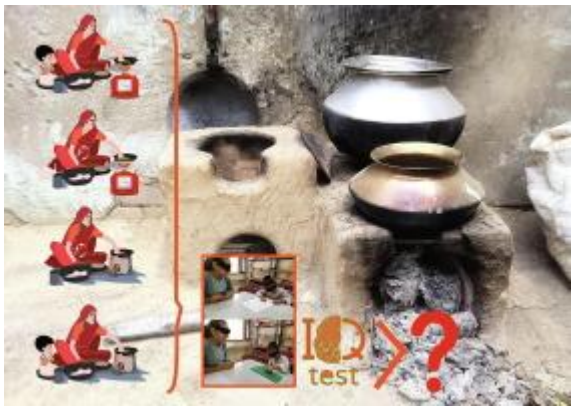
Highlights

- There are limited evidence on HAP & Cognitive performance of children.
- Exposure to HAP significantly affects IQ among children.
- Low IQ during childhood predicts poor academic performance during later years of life.
- HAP significantly effects the maze, digit span & arithmetic component of IQ.
- Cognitive defects in children due to HAP exposures could be prevented.

Abstract

Many illnesses have been attributed to the exposure of solid biomass smoke but the effect on intelligence has largely been unexplored. The study aims to examine the effect of exposure to solid biomass smoke during the first 3 years of life on intelligence among 6–8-year-old children. Children aged 6–8 years were enrolled from a primary school and their houses were visited to collect data on socio-economic status and household exposure assessment. Households using LPG as cooking fuel were considered as the unexposed group. All the children were tested for their Intelligence Quotient (IQ) using Malin's Intelligence Scale for Indian Children (MISIC). The mean IQ was calculated as the average of Verbal and Performance score. Potential confounders were adjusted using multivariate general linear model. About 45% of children had average or above-average IQ while the rest had below-average IQ. The mean scores for the arithmetic component of IQ were found to be significantly lower among solid biomass fuel users as compared to LPG users after adjusting for confounders. The mean IQ of LPG users were 5.58 points higher (95% CI: 0.46–10.1) for the arithmetic component as compared to solid biomass users. Children living in the houses using solid biomass fuel for cooking have lower IQ as compared to the children living in the houses using LPG for cooking for arithmetic component even after adjusting for potential confounders.

Graphical abstract



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Introduction

The recent WHO report highlights that 4.3 million premature deaths could be associated with the use of solid biomass fuel for cooking. According to the WHO report, about 3 billion people burn solid biomass for cooking and heating which include wood, animal

dung, and crop waste. Most of these people are poor, and live in developing countries (WHO, 2011). The Lancet Commission on pollution and health and Global Burden of Disease estimate also identify household air pollution as a major risk factor for human health (Landrigan et al., 2018, Cohen et al., 2017). Though outdoor air pollution has long been known to cause several diseases including respiratory, cardiovascular and neurological conditions there are limited studies linking the illnesses caused by indoor or household air pollution (HAP). The health effects of solid biomass smoke include respiratory illness in children and adults, structural birth defects, low birth weight and infant mortality, nutritional deficiencies, interstitial lung disease, Chronic Obstructive Pulmonary Disease (COPD), pulmonary tuberculosis, lung cancer, nasopharyngeal and laryngeal cancers, cardiovascular diseases, cataracts and exacerbation of health effects of HIV infection (Fullerton et al., 2008, Kaur-Sidhu et al., 2019a).

Several toxic substances which are released during combustion could be responsible for a range of physical and mental deficits in children. There are studies linking nitrogen dioxide in indoor air pollution with mental retardation and Attention Deficit Hyperactivity Disorder (ADHD) (Morales et al., 2009). Exposure to second-hand tobacco smoke is a well-known factor that has detrimental effects on children's cognition (Chen et al., 2013). Though there are some studies on the effect of outdoor air pollution (Suades-Gonzalez et al., 2015), urban vehicular pollution (Garcidueñas et al., 2016) and environmental tobacco smoke (Jedrychowski et al., 2015), on cognitive and academic performance of students, the association of HAP (Vrijheid et al., 2012) and the cognitive performance has not yet been fully explored. Further, most of the studies have assessed the effects of nitrogen dioxide (NO_2) and particulate matter (PM) on the cognitive disorders in children exposed during both the prenatal and postnatal period. Few studies have also focussed on the elemental composition of PM that affects the developing brain of the children (Bellinger, 2018). Studies focussing on comparison of different types of fuels (LPG, Solid biomass fuel) and their cognitive effects on children have not been studied previously.

Physical and mental development is more rapid in infants under one year of age than at any other age and hence they are highly vulnerable to the effects of HAP toxic substances that can interfere with the biological systems. Developmental and neurological toxins present in HAP are likely of greater concern to the developing fetus because of the even more rapid physical and brain development that occurs in-utero. Adding to this risk, the infants are almost always carried by their mothers or allowed to roam around or play around them wherever they work, which mostly involve cooking in rural areas of India. This practice exposes the child to harmful HAP, which can be detrimental to their development. Studies have also shown that women exposed to solid biomass smoke suffer more from health and respiratory illness compared to women using other fuels,

due their poorly ventilated kitchen in their house (Kaur-Sidhu et al., 2019a, Kaur-Sidhu et al., 2019b Sukhsohale et al., 2013).

Thus, exposure to solid biomass fuel during fetal life and during early life can produce children with neurological deficits, which can, in turn, affect the society, economy, and growth of the country to a large extent since less intelligent children by being less productive, can further hinder development in developing countries or Least Developed Countries (LDCs). Hence, the World Health Organization (WHO, 2018) also stress that efforts should be made to prevent the HAP exposure to improve their health. In India, 72.2% of population reside in rural areas with widespread use of solid fuel, and 86.5% of the rural people use solid biomass fuel for cooking (Census of India, 2011, Ravindra et al., 2019a, Kaur-Sidhu et al., 2019a, Sharma et al., 2020.). Further, cooking with solid biomass fuel also alter the thermal comfort of rural household and could synergistically add to adverse health impact of HAP (Ravindra et al., 2019b) Thus, intervention on the usage of solid biomass fuel gains significance in the step towards prevention of health problems due to their use and betterment of health of the most vulnerable sections of the society, i.e. the women and the children.

Hence, there is a need to look into the association between household air pollution due to solid biomass smoke and its effects. Thus, the current study aims to investigate the association of HAP during first three years of life with cognitive development at the age of 6–8years.

Section snippets

Participants and recruitment

A cross-sectional study was conducted from July 2012 to June 2013. Children from two villages (Kheri and Samlehri), where the Department of Community Medicine and School of Public Health, PGIMER is providing community-based health services were selected for the study. The estimated sample size was 108, assuming an anticipated effect size (Cohen's f^2) for multiple regression as 0.15, with the power of the study as 80%, 95% Confidence Interval and the number of predictors as 7. The study …

Results

The socio-demographic characteristics, birth history and health characteristics of the respondents are shown in Table 1. There were more females (55%), compared to males (45%). The mean age of the respondents was 7 years (SD: 0.742 years). Three fourth of the respondents belong to either middle or lower socio-economic status. Most of the mothers were literate (78%). Most of the respondents were born by normal vaginal delivery (84%) and two-thirds of them were born in hospitals (68%). Nearly …

Discussion

The IQ of the children exposed to the smoke of solid biomass fuel used for cooking is on average 5.5 points lower for the arithmetic component of IQ as compared to those who were exposed to smoke of LPG fuel used for cooking. An earlier study had shown the neuropsychological impact on exposure to carbon monoxide from kerosene stoves, in which digit span along with few other components in Wechsler's intelligence scale were found to be affected (Amitai et al., 1998). A similar study on Carbon …

Limitations

Though outdoor air pollution due to factories and heavy vehicular traffic was not present at the place of study and the level of pollution was not taken into consideration, it was assumed to have an equal impact on all the children geographically. The level of exposure due to solid biomass smoke measured in terms of $PM_{2.5}$ and PM_{10} levels could have been a better estimate of the exposure levels but was not carried due to financial constraints. Lead and pesticide exposure to the children was a …

Recommendations

More studies with varied methodology with larger sample size and accurate measurements of toxic chemicals in the smoke and particulate matters ($PM_{2.5}$ and PM_{10}) may provide further insight into the effects of solid biomass fuel on neurological development.

Effective government policies are needed to reduce the use of solid biomass fuels in rural areas and switch over to cleaner fuel to increase productivity, decrease morbidity and tackle climatic changes (Ravindra et al., 2019c). Further, efforts …

Contributorship statement

AP conducted the field work and wrote the first draft of the manuscript. PVML, PM, and KR helped to develop the intellectual content of the protocol and manuscript including review/editing. …

Data sharing statement

A MD thesis is available on the topic and can be provided by e-mail to Dr. PVML. …

Ethical approval

The protocol was approved by Dissertation Approval Committee of the Institute and Departmental Peer Review committee. …

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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