



# Indoor and Ambient Air Pollution in Chennai, India during COVID-19 Lockdown: An Affordable Sensors Study

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## ABSTRACT

The Tamil Nadu Air Pollution and Health Effects study (TAPHE-2) aims to evaluate the relationship between air pollution and birth outcome in a rural-urban cohort of 300 pregnant women. Due to COVID-19 related lockdowns, some TAPHE-2 activities were delayed; however, continuous indoor and outdoor air quality data were collected in and around Chennai, India. We report here the impact of graded COVID-19 lockdown on indoor particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>) levels based on calibrated data from affordable real-time PM sensors called *atmos*<sup>™</sup> and ambient PM levels from publicly available regulatory monitors. The study period was between 11 March and 30 June 2020 (i.e., 100 days of continuous monitoring), which coincided with four phases of a nationwide graded lockdown. Field calibration coefficients for the *atmos* PM were derived by collocating them with reference-grade PM monitors. The normalized root mean square error (NRMSE) of the *atmos* hourly PM<sub>2.5</sub> (PM<sub>10</sub>) improved from 41% to 15% (33% to 18%) after applying the field calibration coefficients. Lockdowns resulted in significant reductions in indoor and ambient PM levels, with the highest reduction observed during lockdown phase 2 (L2) and phase 3 (L3). Reductions as high as 70%, 91%, and 62% were observed in ambient PM<sub>2.5</sub>, indoor PM<sub>2.5</sub>, and indoor PM<sub>10</sub> relative to pre-lockdown levels (PL), respectively. The indoor PM<sub>2.5</sub>/PM<sub>10</sub> ratio decreased during the lockdown, suggesting a decline in the fine mode dominance in PM<sub>10</sub>. The indoor-to-outdoor (I/O) ratios in PM<sub>2.5</sub> marginally increased during L1, L2, and L3 phases compared to that of PL levels, suggesting an uneven reduction in indoor and ambient PM<sub>2.5</sub> levels during the lockdown.

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## 1 INTRODUCTION

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Air pollution continues to be a significant environmental and public health issue in Indian megacities. The disease burden attributable to air pollution is predominantly driven by PM<sub>2.5</sub> (mass concentration of particulate matter with an aerodynamic diameter of 2.5 μm and less). An estimated 0.67 million (95% uncertainty interval: 0.55–0.79) and 0.48 million (95% uncertainty interval: 0.39–0.58) premature deaths in India (in 2017) were attributed to ambient and household particulate matter pollution, respectively (Balakrishnan *et al.*, 2019). The annual average population-weighted PM<sub>2.5</sub> exposures in India have been increasing steadily from 62 μg m<sup>-3</sup> in

# Household air pollution and COPD: cause and effect or confounding by other aspects of poverty?

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## SUMMARY

**SETTING:** Household air pollution (HAP) and chronic obstructive pulmonary disease (COPD) are both major public health problems, reported to cause around 4 million and 3 million deaths every year, respectively. The great majority of these deaths, as well as the burden of disease during life is felt by people in low- and middle-income countries (LMICs).

**OBJECTIVE AND DESIGN:** The extent to which HAP causes COPD is controversial; we therefore undertook this review to offer a viewpoint on this from the Global Initiative for COPD (GOLD).

**RESULTS:** We find that while COPD is well-defined in many studies on COPD and HAP, there are major limitations to the definition and measurement of HAP. It

is thus difficult to disentangle HAP from other features of poverty that are themselves associated with COPD. We identify other limitations to primary research studies, including the use of cross-sectional designs that limit causal inference.

**CONCLUSION:** There is substantial preventable morbidity and mortality associated with HAP, COPD and poverty, separately and together. Although it may not be possible to define clear causal links between HAP and COPD, there is a clear urgency to reduce the avoidable burden of disease these inflict on the world's poor.

**KEY WORDS:** household air pollution; COPD; lung disease; LMICs

The WHO estimates that roughly 4 million people die prematurely every year as a result of exposure to household air pollution (HAP). Of these deaths, around one third (1.5 million) are attributable to chronic obstructive pulmonary disease (COPD). The more recent Global Burden of Disease (GBD) study estimates suggest that the number of deaths related to HAP is lower than this, but nevertheless substantial, at 2.31 million deaths,<sup>1</sup> which accounts for 3.6% disability-adjusted life-years (DALYs).<sup>2,3</sup> COPD itself is a leading cause of death globally – the third most common cause of death – responsible for just over 3 million deaths a year.<sup>4</sup>

HAP is caused by the use of dirty-burning fuels to provide energy for cooking, heating and lighting. Almost all the people living with and dying from HAP-associated COPD are born into households in low- and middle-income countries (LMICs), by which time their exposures to COPD risk factors have already started.<sup>5</sup>

This paper aims to highlight HAP and COPD as two major causes of avoidable global morbidity and mortality and to explore the nature of their relationship. We do this by posing four questions and suggesting priorities for action now and priorities for future research: 1) How is HAP measured in studies on HAP and COPD? 2) How is COPD diagnosed in studies on HAP and COPD? 3) Are the respiratory symptoms and spirometric abnormalities commonly observed in association with HAP exposure in LMICs due to COPD? 4) Is the phenotype of fixed airflow obstruction associated with HAP similar or different from tobacco smoke-induced COPD?

## HOW IS HAP MEASURED IN STUDIES ON HAP AND COPD?

Although conceptually the definition of HAP is



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## Resources and Geographic Access to Care for Severe Pediatric Pneumonia in Four Resource-limited Settings

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### Abstract

**Rationale:** Pneumonia is the leading cause of death in children worldwide. Identifying and appropriately managing severe pneumonia in a timely manner improves outcomes. Little is known about the readiness of healthcare facilities to manage severe pediatric pneumonia in low-resource settings. **Objectives:** As part of the HAPIN (Household Air Pollution Intervention Network) trial, we sought to identify healthcare facilities that were adequately resourced to manage severe pediatric pneumonia in Jalapa, Guatemala (J-GUA); Puno, Peru (P-PER); Kayonza, Rwanda (K-RWA); and Tamil Nadu, India (T-IND). We conducted a facility-based survey of available infrastructure, staff, equipment, and medical consumables. Facilities were georeferenced, and a road network analysis was performed. **Measurements and Main Results:** Of the 350 healthcare facilities surveyed, 13% had adequate resources to manage severe pneumonia, 37% had pulse oximeters, and 44% had supplemental oxygen. Mean ( $\pm$ SD) travel time to an adequately resourced facility was  $41 \pm 19$  minutes in J-GUA,  $99 \pm 64$  minutes in P-PER,  $40 \pm 19$  minutes in K-RWA, and  $31 \pm 19$  minutes in T-IND. Expanding pulse oximetry coverage to all facilities reduced travel time by 44% in J-GUA, 29% in P-PER, 29% in K-RWA, and 11% in T-IND (all  $P < 0.001$ ). **Conclusions:** Most healthcare facilities in low-resource settings of the HAPIN study area were inadequately resourced to care for severe pediatric pneumonia. Early identification of cases and timely referral is paramount. The provision of pulse oximeters to all health facilities may be an effective approach to identify cases earlier and refer them for care in a timely manner.

**Keywords:** health service accessibility; low- and middle-income country; pneumonia; pulse oximetry.

### Figures



## LPG stove and fuel intervention among pregnant women reduce fine particle air pollution exposures in three countries: Pilot results from the HAPIN trial<sup>☆</sup>

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### ABSTRACT

The Household Air Pollution Intervention Network trial is a multi-country study on the effects of a liquefied petroleum gas (LPG) stove and fuel distribution intervention on women's and children's health. There is limited data on exposure reductions achieved by switching from solid to clean cooking fuels in rural settings across multiple countries. As formative research in 2017, we recruited pregnant women and characterized the impact of the intervention on personal exposures and kitchen levels of fine particulate matter (PM<sub>2.5</sub>) in Guatemala, India, and Rwanda. Forty pregnant women were enrolled in each site. We measured cooking area concentrations of and personal exposures to PM<sub>2.5</sub> for 24 or 48 h using gravimetric-based PM<sub>2.5</sub> samplers at baseline and two follow-ups over two months after delivery of an LPG cookstove and free fuel supply. Mixed models were used to estimate PM<sub>2.5</sub> reductions. Median kitchen PM<sub>2.5</sub> concentrations were 296 µg/m<sup>3</sup> at baseline (interquartile range, IQR: 158–507), 24 µg/m<sup>3</sup> at first follow-up (IQR: 18–37), and 23 µg/m<sup>3</sup> at second follow-up (IQR: 14–37). Median personal exposures to PM<sub>2.5</sub> were 134 µg/m<sup>3</sup> at baseline (IQR: 71–224), 35 µg/m<sup>3</sup> at first follow-up (IQR: 23–51),

<sup>☆</sup> This paper has been recommended for acceptance by Payam Dieleman.

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# Developing Visual Messages to Support Liquefied Petroleum Gas Use in Intervention Homes in the Household Air Pollution Intervention Network (HAPIN) Trial in Rural Guatemala

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## Abstract

**Background.** Household air pollution adversely affects human health and the environment, yet more than 40% of the world still depends on solid cooking fuels. The House Air Pollution Intervention Network (HAPIN) randomized controlled trial is assessing the health effects of a liquefied petroleum gas (LPG) stove and 18-month supply of free fuel in 3,200 households in rural Guatemala, India, Peru, and Rwanda. **Aims.** We conducted formative research in Guatemala to create visual messages that support the sustained, exclusive use of LPG in HAPIN intervention households. **Method.** We conducted ethnographic research, including direct observation ( $n = 36$ ), in-depth ( $n = 18$ ), and semistructured ( $n = 6$ ) interviews, and 24 focus group discussions ( $n = 96$ ) to understand participants' experience with LPG. Sixty participants were selected from a pilot study of LPG stove and 2-months of free fuel to assess the acceptability and use of LPG. Emergent themes were used to create visual messages based on observations and interviews in 40 households; messages were tested and revised in focus group discussions with 20 households. **Results.** We identified 50 codes related to household air pollution and stoves; these were reduced into 24 themes relevant to LPG stoves, prioritizing 12 for calendars. Messages addressed fear and reluctance to use LPG; preference of wood stoves for cooking traditional foods; sustainability and accessibility of fuel; association between health outcomes and household air pollution; and the need for inspirational and aspirational messages. **Discussion.** We created a flip chart and calendar illustrating themes to promote exclusive LPG use in HAPIN intervention households.

## Keywords

audiovisual aids, behavioral change communication, health literacy, household air pollution

Visual messages used with printed materials, such as flip charts, brochures, posters, and calendars are central to health education, enhancing delivery of behavioral interventions, increasing awareness and reminding people to engage, or disengage, in a specific behavior (Lipkus, 2007). Visual images may be more impactful than written messages, particularly among people with lower levels of literacy (Devakumar et al., 2018; Houts et al., 2006). However, an effective visual message needs to encompass the sociocultural context of people situated within their communities and be consistent with their perceived roles and practices (Chen, 1989; Jensen, 2012; Kreuter, 1999). Since notions

are flexible and context dependent, we need to understand how individuals interpret visual messages about an idea or concept. Engaging people in the process of developing visual messages overcomes potential barriers that materials may not be understandable or applicable in a given setting or with a group of people.

Social science researchers use visual image methodology to elicit and interpret research findings (Bagnoli, 2009; Copeland & Agosto, 2012; Guillemin, 2004; Harper, 2002; Ross et al., 2009). Posters and calendars are two examples of visual methods that have been used to reinforce behavioral change communication, including the promotion of



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# Heat-health vulnerabilities in the climate change context—comparing risk profiles between indoor and outdoor workers in developing country settings

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E-mail: [vvidhya@ehe.org.in](mailto:vvidhya@ehe.org.in)**Keywords:** climate change, occupational heat stress, physiological heat strain, dehydration, indoor organized sector, outdoor unorganized sector

## Abstract

Occupational heat stress is a crucial risk factor for a range of Heat-Related Illnesses (HRI). Outdoor workers in unorganized work sectors exposed to high ambient temperatures are at increased risk in developing countries. We aim to compare HRI, Productivity Loss (PL), and reduced renal health risk between workers from outdoor unorganized ( $N = 1053$ ) and indoor organized ( $N = 1051$ ) work sectors. Using descriptive methods and a large epidemiological cross-sectional study using mixed methods, we compared risk patterns between the two groups. We analyzed the risk of self-reported HRI symptoms, Heat Strain Indicators (HSIs), PL, and reduced kidney function using Multivariate Logistic Regression (MLR) models. Although Wet Bulb Globe Temperature (WBGT) exposures were high in both the outdoor and indoor sectors, significantly more Outdoor Unorganized Workers (OUWs) reported heat stress symptoms (45.2% vs 39.1%) among 2104 workers. OUWs had a significantly higher share of the heavy workload (86.7%) and long years of heat exposures (41.9%), the key drivers of HRIs, than the workers in indoor sectors. MLR models comparing the indoor vs outdoor workers showed significantly increased risk of HRI symptoms (Adjusted Odds Ratio) ( $AOR_{\text{outdoor}} = 2.1$ ; 95% C.I.:1.60–2.77), HSI ( $AOR_{\text{outdoor}} = 1.7$ ; 95% C.I.:1.00–2.93), PL ( $AOR_{\text{outdoor}} = 11.4$ ; 95% C.I.:7.39–17.6), and reduced kidney function (Crude Odds Ratio) ( $COR_{\text{outdoor}} = 1.4$ ; 95% C.I.:1.10–1.84) for the OUWs. Among the heat-exposed workers, OUW had a higher risk of HRI, HSI, and PL even after adjusting for potential confounders. The risk of reduced kidney function was significantly higher among OUWs, particularly for those with heat exposures and heavy workload ( $AOR_{\text{outdoor}} = 1.5$ ; 95% C.I.: 0.96–2.44,  $p = 0.073$ ) compared to the indoor workers. Further, in-depth studies, protective policies, feasible interventions, adaptive strategies, and proactive mitigation efforts are urgently needed to avert health and productivity risks for a few million vulnerable workers in developing nations as climate change proceeds.

## 1. Background

Global Climate Change (CC) is increasing, posing a threat, either directly or indirectly, to a wide range of sustainable development issues, including health, food security, and employment [1]. Notably, CC affects the living and working environments that create health threats for millions of working people [2, 3]. One of the most direct health effects of CC is

an increased mortality and morbidity rate associated with exposure to high-ambient temperatures that is already a leading cause of fatalities and a health burden for developing countries [2, 4–7]. The risk is even greater for individuals performing strenuous work in hot-environments [8].

Workplace heat is a potential hazard for workers in many indoor and outdoor settings, leading to a spectrum of Heat-Related Illnesses (HRIs) that may

# Implementing a ventilation index for assessing indoor air PM<sub>2.5</sub> concentrations in biomass-using households

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**Abstract** Biomass combustion in indoor kitchens contributes a lot to the PM<sub>2.5</sub> exposure burden among millions of people worldwide. Emitted potential pollutants from the biomass combustion oven may enormously degrade indoor air quality during cooking time and impact crowded rooms with inadequate indoor ventilation. The concept of developing a “ventilation index” may be a valuable alternative to assess indoor air quality. A new empirical formula of the ventilation index has been proposed recently, in which multiple studies need to be validated by various studies. This study is a part of the validation process and has ended up with supportive evidence-based insight into residential indoor air quality. Ninety-three households were selected from 25 villages of Tamil Nadu, India, to monitor the parameters required to apply in the empirical formula. However, the association between indoor air velocity and PM<sub>2.5</sub> (considered a surrogate component of indoor air quality) was focused on emphatically. Other important variables, e.g., used amount of biomass cooking fuel, kitchen room index, room temperature, and relative humidity, were also monitored to observe the ventilation index. Indoor PM<sub>2.5</sub> data were compared categorically with variable air velocities. Those who were

using only biomass for cooking in indoor kitchens were recruited in the study. The air pollution exposure burden among the community population is expected to be minimized when the desired ventilation index is optimized and applied in configured kitchens and living rooms. Then, it may attract government policy to accept the ventilation index as a critical parameter for green housing schemes.

**Keywords** Air pollution · Biomass · Cooking · Households · Room index · Ventilation

## Abbreviations

PM <sub>2.5</sub>	Particulate matter of 2.5-µm aerodynamic diameter
VI	Ventilation index
RR	Respiratory rate
PIP	Peak inspiratory pressure
PEEP	Positive end-expiratory pressure
PaCO <sub>2</sub>	Partial pressure of arterial carbon dioxide
COPD	Chronic obstructive pulmonary disease
ALRI	Acute lower respiratory tract infection
ARI	Acute respiratory infections
HVAC	Heating, ventilation, and air-conditioning
CFM	Cubic feet per minute
CFH	Cubic feet per hour
ACH	Air change per hour
ANSI	American National Standards Institute

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Review

# An Overview of Experiences Made and Tools Used to Inform the Public on Ambient Air Quality

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**Abstract:** Legislative regulations on atmospheric pollution have been established in different parts of the world for addressing air quality management. An important public commitment, common among all nations, is to ensure environmental safety and health protection, particularly for the most fragile population groups. Each country has its own rules and practices to provide adequate and timely information on ambient air quality. Information is given either through easily accessible media, including websites and apps, or by traditional means of telecommunication. An air quality index (AQI) is definitely a valuable tool for disseminating data on the main regulated pollutants and represents a readable indicator of the prevailing situation of air quality in the area. Several calculating expressions were formulated to combine, in a unique value, different parameters, and a few methods were created to determine and compare different AQIs. This paper gives almost a global overview of approaches and tools used to inform the public about the status of the ambient air quality. Different AQIs are analyzed to contribute to the sharing of air quality management practices and information to raise public awareness and to help policymakers to act accordingly.

**Keywords:** air quality; air quality index; air quality index comparison; environmental information

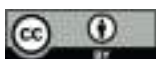


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## 1. Introduction

It is generally recognized that air pollution is one of the most relevant causes of negative impacts on human health. According to the World Health Organization (WHO), it is linked to several health problems, including cardiovascular illness, stroke, respiratory disease, and cancer; outdoor air pollution led to approximately 4.2 million deaths globally in 2016, with most of this disease burden registered in developing countries [1]. Clear evidence of high morbidity and mortality due to air pollution comes also from the yearly report titled “Air quality in Europe” produced by the European Environmental Agency (EEA); according to the 2020 report, in Europe the number of premature deaths associated with particulate matter (PM<sub>2.5</sub>) concentrations in 2018 is about 379,000 while the numbers associated to nitrogen dioxide and ozone concentrations are, respectively, 54,000 and 19,400 [2].

Considering the huge impact of air quality on human health, it is really necessary to implement all possible policies and measures to reduce air pollutant emissions, but also to inform the people on the levels of pollution in the places where they live, on the associated health risks, and on what they can do in order to reduce their exposure and to contribute to a general reduction of the pollution levels.

To such an extent, all countries use a set of instruments and media in order to spread data and information on air quality, both in terms of assessed concentrations and reduction



## Developing Empirical Formula of Ventilation Index for Assessing $PM_{2.5}$ Exposure in Biomass-Fuel Using Households

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### Abstract

Equations of 'ventilation index' in industrial and medical sectors are already established, but not yet been worked out for domestic household environments. This study intended to establish an empirical formula for 'ventilation index' for domestic indoor environments. Measurements of 2.5 micron size particulate matter ( $PM_{2.5}$ ) with biomass, air velocity, room index, temperature and relative humidity were used for developing the empirical formula. A total of 54 households from rural Andhra Pradesh and Karnataka states of India were selected. Average air velocity ranges in selected kitchens were categorised into three parts for developing ventilation indices in household kitchen environments. Observations in kitchen environments were found to be very interesting and promising. The formula captured inverse relation between  $PM_{2.5}$  and air velocities, consistently.



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Biomass Fuel;  
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### Introduction

More than three billion people in the world use solid fuels collectively in the form of biomass and coal and meet their energy demands for cooking foods or lighting etc.<sup>1,2</sup> The percentage of biomass use is more visible in Africa, South-East Asia and in Central and South America.<sup>3</sup> Biomass burning is more common in the rural area than the urbans and people use traditional cooking stoves of inadequate combustion chamber and poor ventilation. Sometimes, open burning of biomass for heating water and cooking are also observed.<sup>4,5</sup>


In India, almost 770 million people living in approximately 160 million households use solid fuels as their primary cooking source.<sup>6</sup> Exposure to household air pollution from cooking results with almost 925000 premature deaths per year which amounts to about 25 million lost disability-adjusted life years (DALYs). About 4 % child death occurs under the age of 5 years due to pneumonia.<sup>7</sup>

The term 'Ventilation Index' is familiar in industries and hospitals. However, establishing the same index

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# Chronic Kidney Disease of Unknown Etiology in India: What Do We Know and Where We Need to Go



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Chronic kidney disease (CKD) not associated with known risk factors has been reported from parts of India and is presumed to be similar to CKD of unknown etiology (CKDu) that has been described from Central America. The reports from India have been fragmented without clear description of the disease phenotype or its determinants. This paper summarizes the current state of knowledge around CKDu in India based on a review of literature, multi-stakeholder consultation, and a survey of Indian nephrologists. We also contacted individual research groups to solicit data. Our findings suggest that CKDu is reported from most regions in India; however, it is interpreted differently from the phenotype described from Central America and Sri Lanka. The differences include lack of a clear demographic or occupation group, older age of affected participants, and presence of mild hypertension and low-grade proteinuria. Well-designed prospective field studies with appropriate diagnostic workup are needed to establish the disease burden and identify etiologies, along with socioeconomic and health consequences, the intersection with the environment, and the public health response. Community-based research should phenotype the entire CKD population rather than be restricted to cases with presumed CKDu based on predefined criteria. Guidelines are needed for clinical evaluation, referral, management, and harmonization of clinical documentation and health records. More data are needed to support the existence of a unique CKDu phenotype in India.

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KEYWORDS: chronic kidney disease; chronic kidney disease of uncertain etiology; climate change; heat stress nephropathy

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In the past 2 decades, a form of CKD has been described in people without any known risk factors such as diabetes, hypertension, glomerulonephritis, or genetic kidney disease from several geographically distinct, predominantly rural locations in diverse regions across the world.<sup>1</sup> Initially reported from Central

America<sup>2</sup> and Sri Lanka,<sup>3</sup> this entity has now been documented or suspected in Nicaragua, El Salvador, Costa Rica, Guatemala, Mexico, Panama, Sri Lanka, India, Egypt, Tunisia, Cameroon, Egypt, South Africa, the Philippines, Taiwan, Indonesia, Thailand, the United States, and the United Kingdom.<sup>4</sup>

There is no agreement on whether the CKD in all these clusters represents a single disease or a group of different diseases. The clinical features indicate the presentation to be consistent with the predominant tubulointerstitial pattern of injury. As the cause of

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# Heat-health vulnerabilities in the climate change context—comparing risk profiles between indoor and outdoor workers in developing country settings

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E-mail: [vvidhya@ehe.org.in](mailto:vvidhya@ehe.org.in)**Keywords:** climate change, occupational heat stress, physiological heat strain, dehydration, indoor organized sector, outdoor unorganized sector

## Abstract

Occupational heat stress is a crucial risk factor for a range of Heat-Related Illnesses (HRI). Outdoor workers in unorganized work sectors exposed to high ambient temperatures are at increased risk in developing countries. We aim to compare HRI, Productivity Loss (PL), and reduced renal health risk between workers from outdoor unorganized ( $N = 1053$ ) and indoor organized ( $N = 1051$ ) work sectors. Using descriptive methods and a large epidemiological cross-sectional study using mixed methods, we compared risk patterns between the two groups. We analyzed the risk of self-reported HRI symptoms, Heat Strain Indicators (HSIs), PL, and reduced kidney function using Multivariate Logistic Regression (MLR) models. Although Wet Bulb Globe Temperature (WBGT) exposures were high in both the outdoor and indoor sectors, significantly more Outdoor Unorganized Workers (OUWs) reported heat stress symptoms (45.2% vs 39.1%) among 2104 workers. OUWs had a significantly higher share of the heavy workload (86.7%) and long years of heat exposures (41.9%), the key drivers of HRIs, than the workers in indoor sectors. MLR models comparing the indoor vs outdoor workers showed significantly increased risk of HRI symptoms (Adjusted Odds Ratio) ( $AOR_{\text{outdoor}} = 2.1$ ; 95% C.I.:1.60–2.77), HSI ( $AOR_{\text{outdoor}} = 1.7$ ; 95% C.I.:1.00–2.93), PL ( $AOR_{\text{outdoor}} = 11.4$ ; 95% C.I.:7.39–17.6), and reduced kidney function (Crude Odds Ratio) ( $COR_{\text{outdoor}} = 1.4$ ; 95% C.I.:1.10–1.84) for the OUWs. Among the heat-exposed workers, OUW had a higher risk of HRI, HSI, and PL even after adjusting for potential confounders. The risk of reduced kidney function was significantly higher among OUWs, particularly for those with heat exposures and heavy workload ( $AOR_{\text{outdoor}} = 1.5$ ; 95% C.I.: 0.96–2.44,  $p = 0.073$ ) compared to the indoor workers. Further, in-depth studies, protective policies, feasible interventions, adaptive strategies, and proactive mitigation efforts are urgently needed to avert health and productivity risks for a few million vulnerable workers in developing nations as climate change proceeds.

## 1. Background

Global Climate Change (CC) is increasing, posing a threat, either directly or indirectly, to a wide range of sustainable development issues, including health, food security, and employment [1]. Notably, CC affects the living and working environments that create health threats for millions of working people [2, 3]. One of the most direct health effects of CC is

an increased mortality and morbidity rate associated with exposure to high-ambient temperatures that is already a leading cause of fatalities and a health burden for developing countries [2, 4–7]. The risk is even greater for individuals performing strenuous work in hot-environments [8].

Workplace heat is a potential hazard for workers in many indoor and outdoor settings, leading to a spectrum of Heat-Related Illnesses (HRIs) that may

**Objectives** To enumerate and characterize HR-AKI cases among U.S. workers in a range of industries.

**Methods** Two data sources were analyzed: (1) archived case files of the Occupational Safety and Health Administration's (OSHA) Directorate of Technical Support and Emergency Management's Office of Occupational Medicine and Nursing from 2010 through 2020, and (2) the Severe Injury Reports database of work-related hospitalizations that employers reported to OSHA as required by regulation from 2015 to 2020. Confirmed cases of HR-AKI were ascertained by serum creatinine measurements. When creatinine measurements were unavailable, probable and possible cases of HR-AKI were ascertained from narrative incident descriptions. Industry-specific incidence rates of HR-AKI were computed. Capture-recapture methods assessed underreporting.

**Results** There were 607 cases of HR-AKI, including 22 confirmed cases and 585 probable or possible cases. HR-AKI occurred in a variety of indoor and outdoor industries including manufacturing, construction, mail and package delivery, and solid waste collection. Among the confirmed cases, 95.2% were male, 50.0% had hypertension, and 40.9% were newly hired workers. Incidence rates from 1.0 to 2.5 HR-AKI hospitalizations per 100,000 workers per year were observed in high-risk industries. The capture-recapture analysis suggested that employers accurately reported only 41.2% of eligible HR-AKI hospitalizations.

**Conclusions** Workers experienced HR-AKI in a diverse range of industries, including indoor facilities. Because of underreporting, data on work-related hospitalizations likely underestimate the true burden of occupational HR-AKI. Clinicians should be aware of kidney risk from recurrent heat stress. Employers should provide interventions to prevent kidney injury in heat-exposed workers.

0-163

#### PROTECTION, RESILIENCE, EFFICIENCY AND PREVENTION (PREP), PREPARING WORKERS AND EMPLOYERS FOR A CHANGING CLIMATE

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**Introduction** Chronic kidney disease of nontraditional cause (CKDnt), is a risk for millions of workers in Latin America and Asia. Treatment is expensive, resulting in early death for those affected. Strenuous work in extreme heat without sufficient rest and hydration is an important driver. Without prevention, this epidemic will likely accelerate due to climate change.

**Objectives** We established the Adelante Initiative, a workplace intervention focusing on heat stress mitigation, together with improved ergonomics, and organizational assessment designed to prevent CKDnt among workers at a sugarcane mill in Nicaragua. We aim to adapt the program to other geographies and industries.

**Methods** PREP builds on Adelante, investigating the following: 1)immediate and long-term impact of the intervention has on workforce health and productivity; 2)economic and social impacts on those affected by CKDnt and whether intervention promotes resilience 3)the economic burden on health systems treating CKDnt; 4) analysis of public and private policies to understand what policy factors (present or absent), have

contributed to the disease and what policies are required to address it.

**Preliminary observations** Despite the inconsistent implementation of intervention there is a 72% reduction of kidney injury. The economic burden in households with CKDnt is dire. CKDnt is depleting health systems. Current public and private policies are insufficient to address CKDnt though signs are encouraging within the development sector and some industries.

**Conclusions** Knowledge gained will create the groundwork to expand to other sugarcane mills and eventually other industries at-risk for heat stress and CKDnt. Climate change means more extreme temperatures in already impacted regions and the likelihood that regions further north and south of the equator will also be impacted by CKDnt. It is essential to develop a model to protect worker health and productivity. Occupational heat stress and resulting CKDnt require increased attention and resources.

0-370

#### HOT AMBIENT TEMPERATURE AND ITS IMPACTS ON ADVERSE PREGNANCY OUTCOME (APO) -A SYSTEMATIC REVIEW

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10.1136/OEM-2021-EPI.56

**Introduction** Exposures to hot ambient temperature have been associated with pregnancy complications and congenital abnormalities among working pregnant women. Workplace heat is likely to exacerbate the Adverse Pregnancy Outcomes (APO) especially with rising temperatures in tropical countries. Research evidence that associates occupational heat stress and APO are scarce and there is a need for new types of knowledge in this research area.

**Objective** Review the evidence from published literature on the association between exposure to hot ambient temperature and APOs.

**Methods** We conducted a systematic literature review of the published literature on the effects of hot ambient/occupational temperature and its impacts on pregnancy outcomes from databases such as Pub Med, Cochrane, Web of Science, and Science direct. We searched more than 500 related original & review articles, short communications, dissertations, newsletters, and book chapters. We systematically grouped the reviewed literature into the following categories: Heat stress/strain, adverse maternal, fetal outcome, and interventions. The categorized literature was then analyzed and examined the principal findings of the studies.

**Results** This review found a convincing association between heat stress and APOs among the exposed pregnant women, including miscarriages, preterm birth, stillbirth, low birth weight (LBW), and congenital anomalies. Furthermore, few articles found occupational heat may intensify the complications, an anticipated risk, which may trigger APOs during all the trimesters. Our review informs the magnitude and significance of the impacts of heat stress on pregnant women's health, providing useful information for exploring the biological mechanisms of APOs and also outlines various interventions to prevent heat-related APOs.

**Conclusions** The limited quantity of existing review gave us key insights and reemphasized the need for more extensive

cohort studies, and strong evidence to design robust policies to protect pregnant women from heat stress risks in developing countries for improved reproductive health.

0-371

### OCCUPATIONAL HEAT EXPOSURES AND RENAL HEALTH IMPLICATIONS – A CROSS-SECTIONAL STUDY AMONG COMMERCIAL KITCHEN WORKERS IN SOUTH INDIA

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10.1136/OEM-2021-EPI.57

**Introduction** Strenuous jobs in hot working environments, such as in commercial kitchens, are proven risk factors for adverse renal implications for workers working without adequate interventions. Evidence is scarce on the heat exposures and their impacts on commercial kitchen workers' renal health.

**Objectives** To investigate the renal health implications due to the workers' exposures to heat stress and exertion in commercial kitchens.

**Methods** We conducted a cross-sectional study among 266 workers in 7-commercial kitchens in the summer and winter of 2018. We monitored the Wet Bulb Globe Temperatures (WBGT), the physiological indicators of heat strain viz., rise in Core Body Temperature (CBT), Sweat Rate (SwR), and Urine specific gravity (USG) and analyzed the post-shift serum creatinine to calculate the estimated Glomerular Filtration Rate (eGFR). We administered a validated questionnaire to capture the workers' self-reported renal health symptoms of heat stress.

**Results** About 66% of workers were exposed to WBGTs levels higher than the safer Threshold Limit Value (TLV) with an average exposure of  $30.1^{\circ}\text{C} \pm 2.7^{\circ}\text{C}$ . Among the exposed workers, 82% reported experiencing heat strain symptoms such as excessive sweating, exhaustion, headache irrespective of the season. Above TLV-WBGT exposures were significantly associated with self-reported symptoms of dehydration (Adjusted Odds Ratio (AOR):2.3; 95% CI:1.2–4.3) and measured heat strain indicators (AOR: 2.9; 95% CI:1.6–5.1). Prevalence of heat strain indicators viz., rise in CBT (9.1%), SwR (17%), USG (75%), was observed among heat-exposed workers. Heat-exposed workers had a 2.8-fold higher risk of reduced kidney function (eGFR of  $< 90 \text{ mL/min/1.73 m}^2$ ) even after adjusting for the potential confounders (AOR:2.8; 95% CI:1.1–6.9).

**Conclusion** The preliminary study results show adverse renal impacts of heat exposures among commercial kitchen workers that warrant further investigation to arrive at conclusive results. A need for adaptation and interventions is imperative to protect few million kitchen workers from hazards of occupational heat stress.

0-418

### OCCUPATIONAL HEAT EXPOSURES, PHYSIOLOGICAL RESPONSES AND RENAL HEALTH OUTCOMES AMONG BRICK WORKERS IN SOUTH INDIA

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10.1136/OEM-2021-EPI.58

**Introduction** Rising temperature with consequent heat stress is likely to subject millions of workers exerting outdoors at risk of heat-related illnesses and adverse renal health outcomes. Need for such research evidence is urgently needed to address this issue especially in the changing climate scenario.

**Objective** To investigate the relationship between occupational heat stress, physiological indicators of heat strain, and associated renal health outcomes among brick workers in South India.

**Methods** We conducted a cross-sectional survey with 327 brick workers during the summer of 2017 & 2018. We collected Wet Bulb Globe Temperatures (WBGT $^{\circ}\text{C}$ ), pre-and post-shift Core Body Temperature (CBT), Urine Specific Gravity (USG), and post-shift Sweat rate (SwR), and serum creatinine/uric acid for calculating eGFR (estimated Glomerular Filtration Rate), a kidney function indicator.

**Results** Workers were exposed to an average WBGT of  $27.7^{\circ}\text{C} \pm 2.2$  with more than 51% of measurements above the ACGIH-Threshold Limit Value (TLV). 69% of the workers reported heat-strain symptoms such as excessive sweating, exhaustion, and headaches. The workers exposed to above TLV-WBGT had 1.8-fold higher risk of dehydration (Adjusted Odds Ratio (AOR):1.8; 95%CI: 1.0–3.0,  $p=0.03$ ), rise in CBT (AOR=2.2, CI: 1.0–4.7,  $p=0.02$ ) and measured heat-related symptoms (AOR=2.5, 95%CI: 1.5–4.2,  $p=0.0001$ ). Heat-exposed workers had CBT $>1^{\circ}\text{C}$  (14%), SwR $>1\text{lit/hr}$  (24%), and USG $>1.020$  (35%). The prevalence of low eGFR ( ; 95%CI: 1.6–4.2) compared to workers exposed to WBGT below TLV.

**Conclusion** The preliminary study results only give a clue to the impacts of occupational heat stress on renal health. To have conclusive results, further epidemiological investigations are warranted with stratification for various personal and exposure factors that determine the disease etiology. With or without evidence, the drive for precautionary protective labor policies/welfare measures does not diminish for better occupational health outcomes.

0-427

### RISK FACTORS FOR ELEVATED CORE BODY TEMPERATURE IN FARMWORKERS

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10.1136/OEM-2021-EPI.59

**Introduction** Heat-related illness (HRI) poses a serious occupational health risk for farmworkers, particularly considering harvest season corresponds to peak summertime heat. The California Heat Illness Prevention Study (CHIPS) collected objective data on the physiological responses of farmworkers to environmental heat, covering a wide range of crops and working conditions.

**Objectives** The primary objective of this analysis is to identify risk factors for elevated core body temperature (CBT).

**Methods** A convenience sample of farmworkers was recruited through farms and farm labor contractors. Bilingual researchers administered questionnaires pre- and post-shift. CBT and work rate were measured using an ingestible wireless thermistor and an accelerometer, respectively. Ambient weather conditions, including wet bulb globe temperature (WBGT), were recorded using two weather stations at the work site. Multiple



Environmental Epidemiology (ISEE). This abstract was presented at an [ISEE annual meeting](#) and has not been peer reviewed.

## {Protection, Resilience, Efficiency and Prevention} (PREP), preparing workers and employers for a changing climate

Jason Glaser, Erik Hanson, Vidhya Venugopal, Esteban Arias, Heath Prince, Rebekah Lucas, Ilana Weiss, David Wegman, Catharina Wesseling, and Kristina Jakobsson

### *Abstract*

**BACKGROUND AND AIM:** Expensive, often inaccessible, treatment, early death, and economic hardship faces millions of workers in Latin America and Asia due to Chronic Kidney Disease of nontraditional cause (CKDnt). Strenuous work in extreme heat without sufficient rest and hydration is an important driver. We established the Adelante Initiative workplace intervention to prevent CKDnt and kidney injury among workers at a sugarcane mill in Nicaragua. The Initiative focused on heat stress mitigation, hydration and rest systems including electrolyte solutions, mobile tents, rest schedules and education, for workers and management, combined with an organizational assessment to address barriers to implementation.

**METHODS:** PREP builds on Adelante, investigating: 1) impact of the intervention on workforce health and productivity; 2) economic and social impacts of CKDnt 3) economic burden on health systems; 4) public and private-sector policy gaps and solutions. **RESULTS:** Workers with the heaviest workload had a 12-fold higher risk (95%CI=3.93-35.4) of kidney injury than those with lower workload in the same environment. Despite implementation challenges at the mill including inconsistent provision of shade, hydration and mandated rest, there was a 72% (95%CI=50-90%) reduction of incident kidney injury post intervention. Economic burden on households and health systems is considerable. Public and private sector policies are either nonexistent or inadequate to provide guidance for prevention, or to support detection and

treatment of CKDnt. However, the inclusion of initial investments in technical assistance for workplace protections within the development sector and some industries is encouraging.

CONCLUSIONS. PREP lays the groundwork to expand to other industries and geographies at risk for heat stress and CKDnt. Occupational heat stress and resulting CKDnt require increased attention and resources for surveillance, prevention and treatment. Climate change means more extreme temperatures in already impacted regions, and regions further north and south of the equator, putting more workers at risk of CKDnt. KEYWORDS: Temperature extremes and variability, Health co-benefits, Socio-economic factors, Occupational exposures, Exposure assessment-general



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Article

# Fidelity and Adherence to a Liquefied Petroleum Gas Stove and Fuel Intervention during Gestation: The Multi-Country Household Air Pollution Intervention Network (HAPIN) Randomized Controlled Trial

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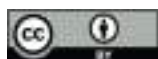


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**Abstract:** Background: Clean cookstove interventions can theoretically reduce exposure to household air pollution and benefit health, but this requires near-exclusive use of these types of stoves with the simultaneous disuse of traditional stoves. Previous cookstove trials have reported low adoption of new stoves and/or extensive continued traditional stove use. Methods: The Household Air Pollution Intervention Network (HAPIN) trial randomized 3195 pregnant women in Guatemala, India, Peru, and Rwanda to either a liquefied petroleum gas (LPG) stove and fuel intervention ( $n = 1590$ ) or to a control ( $n = 1605$ ). The intervention consisted of an LPG stove and two initial cylinders of LPG, free fuel refills delivered to the home, and regular behavioral messaging. We assessed intervention fidelity (delivery of the intervention as intended) and adherence (intervention use) through to the end of gestation, as relevant to the first primary health outcome of the trial: infant birth weight. Fidelity and





## Impact of acute exposure to ambient PM<sub>2.5</sub> on non-trauma all-cause mortality in the megacity Delhi

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### HIGHLIGHTS

- Novel use of high-resolution (1-km) satellite data to study acute impact of PM<sub>2.5</sub> exposure in Delhi.
- The impact on all-cause mortality is two-fold higher in winter than in summer.
- Spatially disaggregated exposure of PM<sub>2.5</sub> exhibits a higher effect on mortality.

### ARTICLE INFO

#### Keywords:

Mortality

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Time series analysis

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### ABSTRACT

Exposure to ambient fine particulate matter (PM<sub>2.5</sub>) is the largest environmental health risk in India. All previous studies in India focused on PM<sub>10</sub> exposure for acute impact assessment; even the single study examining the PM<sub>2.5</sub> acute exposure impact used data from a single site. Here we estimated the impact of acute PM<sub>2.5</sub> exposure on non-trauma all-cause mortality in the megacity Delhi using a quasi-Poisson regression model and satellite-derived high-resolution (1-km) exposure data. Our satellite-PM<sub>2.5</sub> dataset was calibrated and validated against coincident measurements from ground-based reference-grade monitors. This allowed us to minimize exposure misclassification, which otherwise would have happened due to reliance on limited ground-based monitoring sites with a large spatial gap. The annual average (median) PM<sub>2.5</sub> exposure (with interquartile range) during this period was 108.5 (63.5–133.6) µg/m<sup>3</sup>. We found a 0.52% (95% confidence interval, CI: 0.42–0.62%) increase in non-trauma all-cause mortality for every 10 µg/m<sup>3</sup> increase in 6-days cumulative PM<sub>2.5</sub> exposure with a relatively higher impact on men (0.57%, 95% CI: 0.46–0.69%) than on women (0.52%, 0.38–0.65%). The impact of PM<sub>2.5</sub> was almost two-fold higher in winter (0.55%, 0.45–0.66%) per 10 µg/m<sup>3</sup> increase in PM<sub>2.5</sub> than in summer (0.29%, 0.14–0.45%). The district-level aggregated 6-days cumulative PM<sub>2.5</sub> exposure had the largest impact on mortality (1.10%, 0.84–1.35%). The impact of acute exposure to PM<sub>2.5</sub> on all-cause mortality was larger than that of PM<sub>10</sub> exposure (from previous studies). Our study adds to the global evidence pool, fills the critical gap of evidence of acute PM<sub>2.5</sub> exposure impact on mortality in India, and most importantly, demonstrates the significance of disaggregated exposure assessment using satellite data to reduce exposure misclassification in health impact studies, particularly in data-poor regions.

**Main finding:** We estimate a 0.52% increase in all-cause mortality for every 10 µg/m<sup>3</sup> rise in short-term PM<sub>2.5</sub> exposure with a two-fold higher impact in the winter than in the summer and a higher impact on male (0.57%) than on female (0.52%) in the megacity Delhi.

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## Personal exposure to outdoor particulate matter and greenspace in Delhi, India

William Mueller, Paul Wilkinson, James Milner, Miranda Loh, Sotiris Vardoulakis, Zoë Petard, Naveen Puttaswamy, Kalpana Balakrishnan, and DK Arvind

### *Abstract*

**BACKGROUND AND AIM:** Research suggests urban greenspace promotes better health, with reduced air pollution being a potential mechanism; however, much of this work is based on static environments in lower air pollution settings. Our aim was to study the association between particulate matter of 2.5  $\mu\text{m}$  ( $\text{PM}_{2.5}$ ) and greenspace during outdoor walking trips in a higher air pollution context. **METHODS:** Study subjects included adolescents (age 10-18 years) with asthma recruited within the Delhi Air Pollution and Health Effects (DAPHNE) study. Participants were provided with an AirSpeck personal sensor to monitor continuously their exposure to  $\text{PM}_{2.5}$  during 48-hour monitoring periods. We identified walking journeys based on personal GPS data and assigned three indicators of greenspace according to four buffer sizes (25m, 50m, 100m, 250m): the mean Normalised Difference Vegetation Index (NDVI), mean tree cover density (TCD), and proportion overlap with green land use (GLU). We assessed the relationship between greenspace and  $\text{PM}_{2.5}$  using multilevel modelling, controlling for individual (e.g., age, sex), spatial (e.g., roads, population density) and temporal (e.g., season, meteorology) covariates. **RESULTS:** There were 86 participants who provided 219 walking journeys, a cumulative total of 2029 minutes. The mean  $\text{PM}_{2.5}$  concentration was 129  $\mu\text{g}/\text{m}^3$  (standard deviation=121). Results from preliminary analyses have not elucidated clear associations with greenspace. For example, in fully adjusted models (100 m buffer), the corresponding change in  $\text{PM}_{2.5}$  ( $\mu\text{g}/\text{m}^3$ ) for a 1-unit change in greenspace was 0.03 (95% confidence interval [CI]: -0.71 to 0.78) for NDVI, -1.4 (95% CI: -5.5 to 2.7) for TCD, and 0.42

(95% CI: -0.04 to 0.87) for GLU. CONCLUSIONS: Our initial findings do not support lower exposure to PM<sub>2.5</sub> with greenspace. A possible explanation is that any reductions linked to vegetation may be

too modest to detect in the presence of substantial spatiotemporal variation as that which exists in Delhi. KEYWORDS: Air pollution, Particulate matter, Green space, Short-term exposure, Built environment

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# Sanitation access, behavior, and practices and their health and social implications for on-duty female police officials — a perceptual study in South India

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## Abstract

**Aim** Access to clean sanitation is closely linked to women's dignity, health, and wellbeing, and lack of these is a significant concern. We explore the perceptions about the poor sanitation access for on-duty female police officials working at off-site locations and its implications with regard to their behavior, health, and social lives.

**Subject and methods** We conducted a cross-sectional questionnaire-based survey study with 150 on-duty female police officials in the period January–March, 2020 in South India to elicit their perceptions about access to sanitation in off-site locations, their behavioral modifications to tackle this issue, and its impacts on their health and social lives. Data analysis was done using SPSS software.

**Results** A high percentage of female police officials (69%) reported not having toilet access while on duty in off-site locations, and 80% avoided drinking water during duty to avoid accessing toilets. Poor toilet access was significantly associated with higher risk of genitourinary symptoms (OR: 2.1; 95% CI: 0.96–4.83) and urinary tract Infections (OR: 2.5; 95% CI: 1.05–5.48). About 11% of participants abstained from work for hygiene purposes during their menstruation owing to discomfort without toilet access, with consequent wage loss and significant adverse social impacts (OR: 10.8; 95% CI: 4.7–25.2; *p* value = 0.0001).

**Conclusion** Reduced access to clean sanitation facilities for on-duty female police officials has adverse implications on their toileting and hydration behavior, health, and social lives. Gender-sensitive policies and enhanced welfare facilities are needed to motivate and to obviate health and social risks for the female police force engaged in protecting the country's citizens.

**Keywords** Female police officials · Genitourinary issues · Hydration behavior · Sanitation facilities · Social impacts · Urinary tract infections

## Introduction

Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces (WHO). Proper sanitation facilities (for example, toilets and latrines) promote health because they allow people to dispose of their waste appropriately (CDC 2017). It may be a purely technical discipline that mainly includes environmental considerations, economic, gender, and social factors (Tilley et al.

2013). Sanitation access is recognized as a fundamental human right that springs from an adequate standard of living right (De Albuquerque and Roaf 2012). Poor access to sanitation facilities can cause an apparent reduction in health and nutritional outcomes (Freeman et al. 2017), and individual health behaviours that may increase the chance of tract infections (Nygaard and Linder 1997). In the absence of sanitation access, open defecation and urination may contribute to the spread of diseases such as cholera, diarrhoea, hepatitis, typhoid, and parasitic infections (Mara et al. 2010).

Lack of toilet facilities for women at public places and workplaces is a significant and current feminist issue (Wei and Pillai 2014). For women, lack of sanitation access has significant impacts on their safety, well-being, and academic prospects, and has long-term impacts on women's health and livelihoods, and it also impacts the economy, as failing to supply for the sanitation needs of ladies ultimately risks thus

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## Determination of Arsenic Uptake Potential In an Edible Plant Species (*Trigonella Foenum- Granecum*) and Assessment of Human Health Risk

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### Abstract

Arsenic is a carcinogenic and toxic element that possesses a high health risk from its presence in crops, water, and soil. The present study has been conducted by fenugreek (*Trigonella foenum-granecum*) seeds which is a very common spice used for cooking, especially in India. An equal number of seeds have been germinated in laboratory conditions. Three concentrations e.g. 1, 2, and, 3 mg/L of arsenite ( $As^{+3}$ ) and arsenate ( $As^{+5}$ ) salt solutions were used throughout the experiments for the treatment of plants. After 10 days of germination, the concentration of the arsenic accumulated into the plant edible parts was estimated and health risk was assessed. Effects of arsenic concentration were observed through estimating the total chlorophyll (a, b, c), carotenoid content, and taking the fresh weight and dry weight of both the control and treatment plants. The results of the biochemical analysis revealed that chlorophyll and carotenoid contents were decreased than that of control plants. Moreover, fresh weight and dry weight results also showed lower values in treatments than in controls. The bioaccumulation factor results demonstrated that an increased level of soil arsenic doesn't certainly result in high arsenic uptake by the Fenugreek plants. From the concentration estimated in the plant body, the health risk was assessed in adults and children and found that both adults and children having a potential health risk upon consumption of fenugreek. Moreover, Incremental Life Time Cancer Risk was found high which indicates the presence of potential cancer risk. Hence, it is possible to conclude from the present study that fenugreek can bio-accumulate arsenic and it may be used as an indicator plant for arsenic-contaminated areas.



### Article History

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### Keywords

Arsenic Toxicity;  
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# Maternal Vitamin B<sub>12</sub> Status and Risk of Cleft Lip and Cleft Palate Birth Defects in Tamil Nadu State, India

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## Abstract

**Background and Objective:** The causal role of maternal nutrition in orofacial clefts is uncertain. We tested hypotheses that low maternal vitamin B<sub>12</sub> and low folate status are each associated with an increased risk of isolated cleft lip with or without cleft palate (CL±P) in a case–control study in Tamil Nadu state, India.

**Methods:** Case-mothers of CL±P children (n = 47) and control-mothers of unaffected children (n = 50) were recruited an average of 1.4 years after birth of the index child and plasma vitamin B<sub>12</sub>, methylmalonic acid (MMA), total homocysteine (tHcy), and folate were measured at that time. Logistic regression analyses estimated associations between nutrient biomarkers and case–control status.

**Results:** Odds ratios (ORs) contrasting biomarker levels showed associations between case-mothers and low versus high plasma vitamin B<sub>12</sub> (OR = 2.48, 95% CI, 1.02-6.01) and high versus low plasma MMA, an indicator of poor B<sub>12</sub> status (OR = 3.65 95% CI, 1.21-11.05). Case–control status was not consistently associated with folate or tHcy levels. Low vitamin B<sub>12</sub> status, when defined by a combination of both plasma vitamin B<sub>12</sub> and MMA levels, had an even stronger association with case-mothers (OR = 6.54, 95% CI, 1.33-32.09).

**Conclusions:** Mothers of CL±P children in southern India were 6.5 times more likely to have poor vitamin B<sub>12</sub> status, defined by multiple biomarkers, compared to control-mothers. Further studies in populations with diverse nutritional backgrounds are required to determine whether poor maternal vitamin B<sub>12</sub> or folate levels or their interactions are causally related to CL±P.

## Keywords

orofacial clefts, cleft lip, cleft palate, congenital anomalies, birth defects, pregnancy, maternal nutrition, vitamin B<sub>12</sub>, cobalamin, methylmalonic acid, folate, homocysteine, India, Tamil Nadu

## Introduction

Orofacial clefts (OFCs) are among the most common birth defects with considerable geographic, racial, ethnic, and socio-economic variation in occurrence (Mossey et al., 2009). Maternal folate nutrition is of interest, given the success of folic acid in preventing neural tube defects (NTDs; MRC Vitamin Study Research Group, 1991) and the fact that OFCs and NTDs share some developmental pathways (Kousa et al., 2017); however, the role of folate in OFCs is uncertain (Munger et al., 2004; Johnson & Little 2008; Munger et al., 2011; De-Regil et al., 2015). Vitamin B<sub>12</sub> is an essential cofactor in folate-related 1-carbon metabolism, but its possible role in OFCs has

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## Challenges in conducting epidemiological field studies evaluating associations between heat stress and renal health among workers in informal sectors: experiences from India

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### ARTICLE INFO

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Occupational heat stress  
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### ABSTRACT

Well-designed Environmental Epidemiological Studies (EES) play a crucial role in quantifying the influence of environmental exposures and their associated risks on health in the wider population. They provide critical research evidence for identifying and developing interventions to avert adverse health consequences from those exposures. However, uncertainty and variability inherent to any field based EES could hinder the nature and magnitude of association between an exposure and health outcome. This is particularly pronounced in resource limited settings and resource-tight research projects. The present study evaluated the association between occupational heat stress and renal health among informal work sectors in India which had some significant challenges. Informal workers exposed to chronic occupational heat stress had significantly higher adverse renal health outcomes than the unexposed workers. Our field challenges included gaining access and permissions to conduct the study, participant recalls bias and attrition, accurately estimating exposures, confounding from causes of both exposure and disease, and to a large extent tight-funding. Though opportunities are abundant, we must ensure field conditions are optimized to attain study objectives. A keen understanding and sensitivity towards the cultural and work settings is essential for successful project completion. Based on our experiences, we provide strategies to adopt to improve fieldwork and provide recommendations to help overcome the field challenges and achieve better results for future EES studies in developing country settings.

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RESEARCH ARTICLE

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# A risk assessment tool for resumption of research activities during the COVID-19 pandemic for field trials in low resource settings

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## Abstract

**Rationale:** The spread of severe acute respiratory syndrome coronavirus-2 has suspended many non-COVID-19 related research activities. Where restarting research activities is permitted, investigators need to evaluate the risks and benefits of resuming data collection and adapt procedures to minimize risk.

**Objectives:** In the context of the multicountry Household Air Pollution Intervention (HAPIN) trial conducted in rural, low-resource settings, we developed a framework to assess the risk of each trial activity and to guide protective measures. Our goal is to maximize the integrity of research aims while minimizing infection risk based on the latest scientific understanding of the virus.

**Methods:** We drew on a combination of expert consultations, risk assessment frameworks, institutional guidance and literature to develop our framework. We then systematically graded clinical, behavioral, laboratory and field environmental health research activities in four countries for both adult and child subjects using this framework. National and local government recommendations provided the minimum safety guidelines for our work.

(Continued on next page)

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Suzanne M. Simkovich - Change in institution

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● *Original Contribution*

## ULTRASOUND CORE LABORATORY FOR THE HOUSEHOLD AIR POLLUTION INTERVENTION NETWORK TRIAL: STANDARDIZED TRAINING AND IMAGE MANAGEMENT FOR FIELD STUDIES USING PORTABLE ULTRASOUND IN FETAL, LUNG, AND VASCULAR EVALUATIONS

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**Abstract**—Ultrasound Core Laboratories (UCL) are used in multicenter trials to assess imaging biomarkers to define robust phenotypes, to reduce imaging variability and to allow blinded independent review with the purpose of optimizing endpoint measurement precision. The Household Air Pollution Intervention Network, a multicountry randomized controlled trial (Guatemala, Peru, India and Rwanda), evaluates the effects of reducing household air pollution on health outcomes. Field studies using portable ultrasound evaluate fetal, lung and vascular imaging endpoints. The objective of this report is to describe administrative methods and training of a centralized clinical research UCL. A comprehensive administrative protocol and training curriculum included standard operating procedures, didactics, practical scanning and written/practical assessments of general ultrasound principles and

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# Epidemic of heat-related illnesses among workers exposed to hot working environments in the changing climate scenario

By Vidhya Venugopal, PK Latha, Tord Kjellstrom, Rebekah Lucas, Kristina Jakobsson, Jason Glaser, Seichi Horie, Marvin González-Quiroz, Sandra Peraza, Ilana Weiss, David Wegman, Theo Bodin, Cathrina Wessling, Hannu Rintamaki and Sirkka Rissanen, 12 April 2021

## Research article

Rising global temperatures, coupled with decreasing access to clean drinking water, may enhance the effects of heat exposure to general and working populations across the globe. People working in jobs that require moderate or heavy manual labor in hot environments are at particular risk caused by the combined effect of exposures to high environmental heat and internal heat production. Exposures to heat can lead to a range of clinical health effects such as fatigue, exhaustion, heat syncope, fainting, heat stroke or even death. Furthermore, heat-related physical exhaustion leads to a reduction of the worker's ability to work with consequent productivity losses that may cause substantial economic losses for the businesses. The result of such continuous heat exposures, manual work and repeated dehydration are also known to cause acute kidney injuries that can further develop into chronic kidney diseases. With



## Evaluation of health risks associated with exposure to volatile organic compounds from household fuel combustion in southern India



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### ABSTRACT

Volatile organic compounds (VOCs) from household cook-fuel use are a major public health concern in low and middle income countries (LMICs), but health risk assessments have largely been based on measurements of fine particulate matter. We report results from cooking period measurements of 21 non-methane VOCs (NMVOCs) and estimated lifetime cancer risk for women cooks in the Tamil Nadu Air Pollution and Health Effects (TAPHE) cohort in Southern India. We enrolled 112 (56 biomass, 23 kerosene and 33 liquefied petroleum gas (LPG) using) TAPHE households to perform kitchen area measurements during the cooking period. VOC samples were collected on mixed-bed sorbent thermal desorption tubes using low-volume air samplers and analyzed using automated thermal desorption on a GC-MS system. Pentafluorobenzene, 1,4-difluorobenzene and chlorobenzene-d5 were used as internal standards that provided recoveries ranging from 81.7% to 119.9%. Total VOC concentrations were 4617  $\mu\text{g}/\text{m}^3$ , 2839  $\mu\text{g}/\text{m}^3$  and 1639  $\mu\text{g}/\text{m}^3$  while total BTEXS (i.e. benzene, toluene, ethylbenzene, m,p-xylene, o-xylene and styrene) concentrations were 139  $\mu\text{g}/\text{m}^3$ , 121  $\mu\text{g}/\text{m}^3$  and 245  $\mu\text{g}/\text{m}^3$  among biomass, LPG and kerosene using households, respectively. Sampling season, type of food cooked and kitchen ventilation were significantly associated with measured total NMVOC concentrations. Lifetime cancer risks were estimated to be  $2.93 \times 10^{-3}$ ,  $1.55 \times 10^{-4}$  and  $8.18 \times 10^{-5}$ , for biomass, kerosene and LPG fuel users, respectively with 1,2,3-trichloropropane, benzene, 1,4-dichlorobenzene, 1,2-dibromoethane and chloroform contributing maximally to excess cancer risks. Health risk assessments for women cooks in LMICs should be expanded to include NMVOCs as these risks may not be adequately addressed through measurements of fine particulate matter (PM<sub>2.5</sub>) pollution alone.

### 1. Introduction

Ambient air pollution (AAP) and household air pollution (HAP) are a leading contributor to the disease burden in India with more than 95% of the population experiencing fine particulate matter (PM<sub>2.5</sub>) exposures well in excess of the World Health Organization (WHO) guidelines (Balakrishnan et al., 2019). Current methods of estimating the disease burden rely primarily on using population weighted averages of ambient and household PM<sub>2.5</sub> exposures and integrated exposure-response functions to measure long-term mortality risks (Cohen et al., 2017; Burnett et al., 2014). Risks from exposure to air toxics such as volatile organic compounds (VOCs) can be substantial on account of the ubiquity of ambient and household sources among rural and urban populations but remain largely unaddressed because of the paucity of exposure data (Balakrishnan et al., 2014; Gordon et al., 2018).

Household fuel combustion is a major source of VOC emissions (Fleming et al., 2018), with an estimated 73 Gg year<sup>-1</sup> (17% of annual total VOC emissions) resulting from biomass use in India (Verma et al., 2018). Further, in addition to the type of cook-fuel, indoor emissions are heavily influenced by cooking methods (such as boiling, steaming, frying and grilling), meal ingredients (such as cooking oil, meat or vegetables), cooking temperature and kitchen ventilation (Abdullahi et al., 2013; Klein et al., 2019). Emissions of carcinogenic VOCs have also been previously reported in relation to these factors (Klein et al., 2019; Wang et al., 2018; Sun et al., 2019; Pandit et al., 2001; Chambers et al., 2018; Chin et al., 2014).

Exposures to particulate matter from cook-fuel use are widely characterized in India (Balakrishnan et al., 2002, 2004 and 2015) and elsewhere (WHO 2014), but only a handful of studies report on VOC exposures for women who are the primary cooks (Shupler et al., 2018). Being the primary cooks in households, women in India experience some of the highest exposures to PM<sub>2.5</sub> from biomass based cooking (Saksena et al.,

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## Developing Empirical Formula of Ventilation Index for Assessing $PM_{2.5}$ Exposure in Biomass-Fuel Using Households

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### Abstract

Equations of 'ventilation index' in industrial and medical sectors are already established, but not yet been worked out for domestic household environments. This study intended to establish an empirical formula for 'ventilation index' for domestic indoor environments. Measurements of 2.5 micron size particulate matter ( $PM_{2.5}$ ) with biomass, air velocity, room index, temperature and relative humidity were used for developing the empirical formula. A total of 54 households from rural Andhra Pradesh and Karnataka states of India were selected. Average air velocity ranges in selected kitchens were categorised into three parts for developing ventilation indices in household kitchen environments. Observations in kitchen environments were found to be very interesting and promising. The formula captured inverse relation between  $PM_{2.5}$  and air velocities, consistently.



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### Introduction

More than three billion people in the world use solid fuels collectively in the form of biomass and coal and meet their energy demands for cooking foods or lighting etc.<sup>1,2</sup> The percentage of biomass use is more visible in Africa, South-East Asia and in Central and South America.<sup>3</sup> Biomass burning is more common in the rural area than the urbans and people use traditional cooking stoves of inadequate combustion chamber and poor ventilation. Sometimes, open burning of biomass for heating water and cooking are also observed.<sup>4,5</sup>

In India, almost 770 million people living in approximately 160 million households use solid fuels as their primary cooking source.<sup>6</sup> Exposure to household air pollution from cooking results with almost 925000 premature deaths per year which amounts to about 25 million lost disability-adjusted life years (DALYs). About 4 % child death occurs under the age of 5 years due to pneumonia.<sup>7</sup>

The term 'Ventilation Index' is familiar in industries and hospitals. However, establishing the same index

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