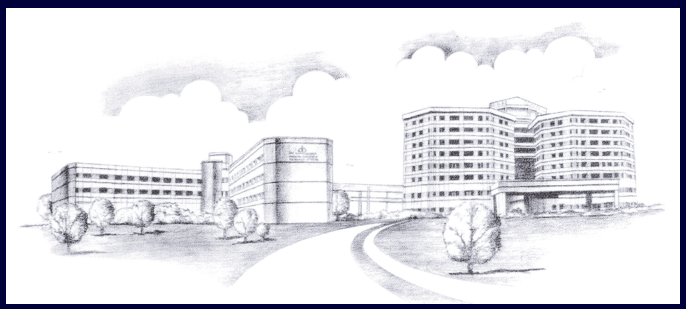
POLICY BRIEF

The Tamil Nadu Air Pollution and Health Effects (TAPHE) Study

ICMR CENTER FOR ADVANCED RESEARCH ON ENVIRONMENTAL HEALTH: AIR POLLUTION



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SRI RAMACHANDRA UNIVERSITY
CHENNAI, TAMIL NADU

THE TAMIL NADU AIR POLLUTION AND HEALTH EFFECTS (TAPHE) STUDY

Establishing exposure-response relationships for fine particulate matter, birth weight, acute respiratory infections in children and adult respiratory health in integrated rural - urban cohorts

A Policy Brief

ICMR CENTER FOR ADVANCED RESEARCH ON ENVIRONMENTAL HEALTH: AIR POLLUTION
SRI RAMACHANDRA UNIVERSITY, CHENNAI, INDIA

Background and Scope

INSIDE THIS BRIEF

Air pollution in the household and ambient environment ranks among the leading risk factors contributing to the national burden of disease in India. The ubiquity of air pollution sources in urban and rural communities, often results in ambient and household exposures, significantly in excess of the health based air quality guidelines with overlapping implications for a range of acute and chronic health conditions. Few efforts however, have been directed at studying this continuum and establish quantitative exposure-response relationships for air pollution related health effects in these settings. With a view to strengthen this evidence base and generate policy relevant recommendations, The Indian Council for Medical Research (ICMR) Govt. of India launched The Tamil Nadu Air Pollution and Health Effects (TAPHE) study, to examine the association between fine particulate matter ($PM_{2.5}$) exposures and select maternal, child and adult health outcomes in integrated rural–urban cohorts. The study was executed by the ICMR Center for Advanced Research on Environmental Health (Air Pollution) at Sri Ramachandra University, Chennai between 2010 and 2015.

Study Methods

The TAPHE study was organized as five interlinked component studies with data collection on air pollution exposures and health outcomes spread across two cohorts that included a pregnant mother-child (M-C) cohort and an adult cohort. Participants in the cohort were drawn from 110 villages of Thiruvallur and Kancheepuram districts and 10 municipal zones of Chennai District in Tamil Nadu.

Primary health care centres and urban health posts served as the primary recruitment sites for the cohort. 1416 pregnant women were enrolled after screening for eligibility and seeking an informed consent. **1285 pregnant women** were followed to collect information on antenatal health parameters and birth weight while **948 infants** were followed to collect information on prevalence of acute respiratory infections(ARI) from birth until 2 years of age, within the M-C cohort. 1341 (920 women and 421 men) were enrolled in the adult cohort, after screening for eligibility and seeking an informed consent. **1060 adults** were followed up to assess prevalence of chronic respiratory symptoms using a field validated respiratory symptom questionnaire and undergo pulmonary function tests within the adult cohort.

Integrated measurements of 24-hr $PM_{2.5}$ area concentrations were performed in all households enrolled in the M-C and adult cohorts that included kitchen, living and outdoor(near household) area measurements with repeat (2-4) measurements in a sub-set of these households. Further, 24-72 hr ambient outdoor measurements were performed across 82 locations that included measurements of PM_{10} and $PM_{2.5}$ concentrations. Personal $PM_{2.5}$ exposure measurements were performed on 10% of participants in each cohort to validate the use of specific micro - environmental measures as reliable surrogates for personal exposures. Additional exploratory exposure assessment components included profiling cooking period concentrations of air toxics including CO, VOCs and PAHs in a subset of rural and urban households and the development of Land use regression (LUR) models for $PM_{2.5}$ in Chennai city. The study also piloted and established protocols for creating a bio-repository for future biomarker studies.

"The study has established exposure response relationships between household concentrations of $PM_{2.5}$, birth-weight, child ARI, adult chronic respiratory symptoms and lung function while adjusting for an extensive range of co-variates commonly associated with these outcomes. Results from the study close a critical gap in exposure-response information from India and other developing countries, especially in settings where populations experience dual burdens from ambient and household air pollution".

Recruitment of cohort subjects at primary health care centers

Key findings

The global pool of studies on health effects of air pollution draws predominantly on studies conducted in developed countries. In particular, studies from India have largely focused on using cross-sectional or case-control designs with limited abilities to establish exposure-response relationships. The exposure-response relationships established through the TAPHE studies are unique in many respects in contributing to the global pool of evidence as listed below

1. By performing more than **4000 measurements** of 24-hrhousehold area concentrations of $PM_{2.5}$ across rural and urban **households,** 24-72 hr ambient measurements across **82** (rural and urban) **locations** and time-activity assessments on nearly 2400 subjects , the study was able to generate robust 24-hr $PM_{2.5}$ exposure estimates for both rural and urban populations in Tamil Nadu. The household and ambient concentrations consistently exceeded the WHO air quality guideline values, with rural pregnant women in biomass using households experiencing some of the highest exposures. The detailed measures also served to considerably reduce exposure misclassification in models developed to examine exposure-response relationships within the TAPHE cohorts.

2. Among pregnant women, a 10µg/m^3 change in household $PM_{2.5}$ concentrations was associated with a **4 gm (95% CI: 1.38 gm,7.18gm) decrease in birth weight** or a **2% increase in low birth weight (OR =1.02; 95% CI, 1.003-1.037)**. Models were adjusted for cohort location (rural vs. urban), type of house construction (a SES indicator), SES, family size, primary cook fuel, location of kitchen, maternal education, occupation, age and BMI, sex of the child, maturity (term vs. pre-term), birth order (gravida) and previous history of a low birth weight child. Restricting the analysis to term births reduced the effects estimates slightly.

3. Among children <2 years, a 10 µg/m^3 change in household $PM_{2.5}$ concentrations was associated with a **0.3% (95%CI: 0.02%-0.69%)increase in the longitudinal prevalence of ARI** and **a 0.9% (OR=1.009;95%CI: 1.001-1.016) increase in the number of episodes of ARI**(in linear and Poisson regression models), respectively. Models were adjusted for malnutrition (weight-for-age z-score < -2), low birth weight, lack of exclusive breastfeeding during first 4 months, lack of measles immunization, solid fuel use, crowding, parental smoking, maternal illiteracy, season and birth order.

4. Among adults, a 10µg/m^3 change in household $PM_{2.5}$ concentrations was significantly associated with a **10% (OR=1.10; 95% CI: 1.048, 1.153) increase in prevalence of respiratory symptoms, a lower FVC [17ml (95% CI:5.9ml, 28ml)] and a lower FEV_1[15ml (95% CI:4.9ml, 24ml)]**.Models were adjusted for gender, age, BMI, literacy status and cohort location (rural vs. urban).

Study Implications

Inclusion of evidence from India within the global pool

Few studies report exposure-response relationships for household air pollution exposures and pregnancy outcomes while studies concerning ambient air pollution exposures have been focused primarily on low exposure settings of developed countries. Previous air pollution related burden of disease assessments therefore did not include pregnancy related outcomes on account of insufficient evidence. Exposure-response functions for ARI have been reported in the household and ambient air pollution literature, but seldom has the continuum been examined. The exposure-response functions for birth weight and child ARI established through the TAPHE study thus add important new information to the global pool of evidence while also informing national efforts directed at maternal and child health.

Integrated indoor and outdoor $PM_{2.5}$ area measurements

The exposure-response relationships for adult respiratory health fill a critical gap in the national and global literature for potential effects of air pollution on young, non-smoking populations. The significant association observed in this population indicates the potential for much larger impacts on more exposed populations as well as on populations with additional underlying vulnerabilities. The exposure models can also be potentially applied in a large pool of national studies that have used categorical indicators of exposure in respiratory health assessments, thereby increasing the strength of evidence within the global pool.

The use of continuous exposure and outcome variables together with detailed information on multiple co-variates make it possible to include the effects estimates from the TAPHE study in future meta-analyses of the global pool of studies concerning these outcomes.

Inputs for on-going and future cohort studies

The large base of household measurements of $PM_{2.5}$ concentrations and exposures generated in the TAPHE study has allowed the development of exposure models based on information on household, land use or demographic variables that are more easily collected. Data sets on ground level measurements of ambient $PM_{2.5}$ are also sparse in India, especially for rural areas impacted by substantial contributions from solid cook fuel emissions. The rural and the urban ground level measurements of ambient $PM_{2.5}$ provide important additional information required for ground truthing satellite based measurements, in high exposure settings. Exposure estimates and models developed in the TAPHE study can be applied in on-going and future cohort studies including those focusing on chronic diseases and requiring long-term exposure reconstruction.

Contributions to intervention programs

Although air pollution has been recognized as a risk factor for adverse pregnancy child health and adult respiratory health outcomes, national programs directed at improving maternal/child health and non-communicable disease have not explicitly included air pollution. Evidence from this study argues for reduction of air pollution exposures in such intervention efforts. In particular it provides strong evidence for a dual and simultaneous focus on efforts to address household and ambient air pollution within rural and urban communities to achieve efficient health gains. It emphasizes the need to achieve health relevant exposure reductions in intervention efforts through the use of "clean technologies" that target community wide "exposure reductions" instead of a focus on only a few strong sources. Transitions to the exclusive use of LPG as cook fuels and widespread use of mass transportation represent examples of achieving such reductions. The study results can make a compelling case for the "health basis" for such efforts by local, state and national authorities.

"The study provides important results for inclusion of effects estimates within the global pool of studies for air pollution and health effects. Exposure estimates and models generated from the study can provide important inputs for on-going cohort studies focused on chronic diseases. Finally, it provides strong evidence for launching intervention efforts that can jointly address household and ambient air pollution within rural and urban communities to achieve efficient health gains."

Recommendations and Next Steps

The study results provide important information for the design of intervention trials as well as evaluation of natural experiments concerning ambient and household air pollution such as the introduction of Metro transportation and clean auto-fuel/vehicular emission norms in urban areas; roll out of LPG access services in rural areas. A concerted and coordinated effort to design and execute a national multi-centric (intervention trial/evaluation) effort would provide persuasive evidence to structure future policy efforts. Inter-sectoral engagement of relevant Governmental agencies is imminently needed accomplish such an effort. The Ministry of Health and Family Welfare has recently constituted a Steering Committee on Air Quality and Health that for the first time jointly addresses ambient and household air pollution within a policy context in India. The TAPHE study results and methods could potentially be used by the committee to leverage resources for research and policy recommendations.

The exposure and effects estimates from the TAPHE studies may not be generalizable across all states in India, but yet provide some of the first in country inputs for health impact assessments. Results from the study are being used in sensitivity analyses to compare study derived impact estimates (in terms of population attributable fractions) with global exposure-response models for select outcomes.

The study methods especially surrounding exposure assessment and exposure modeling can provide useful inputs for training of field staff engaged in research studies concerning air pollution and health effects in India. The methods are being packaged as training modules for dissemination through ICMR/SRU websites and the ICT initiatives of The University Grants Commission, Govt. of India.

Several follow up research proposals are being submitted to national and international research funding agencies to continue the next phases of the cohorts and sustain the advanced research capacities created by the TAPHE study at the ICMR Center at Sri Ramachandra University in Chennai.

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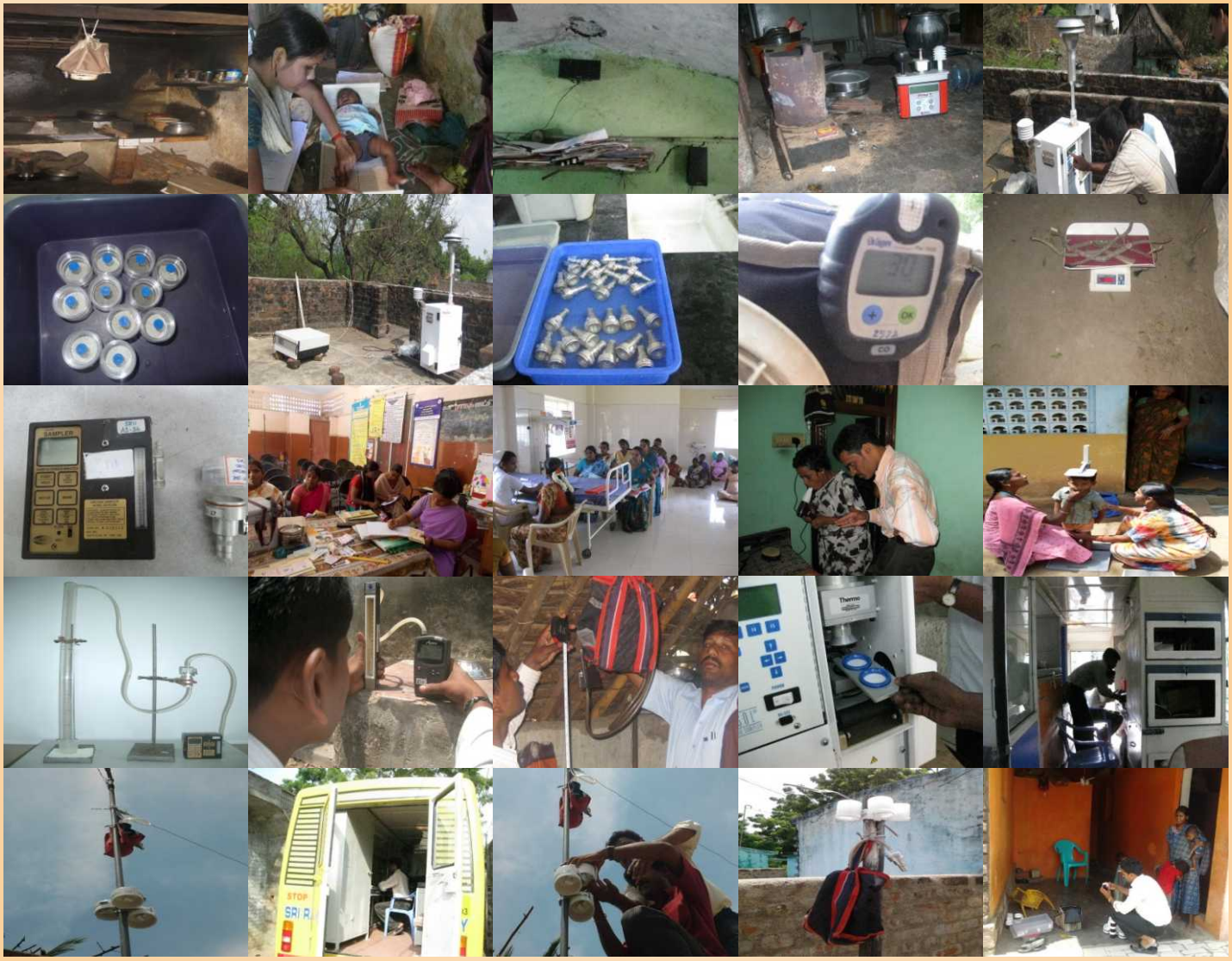

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