WORKING PAPER

GENDER, HEALTH AND AIR POLLUTION

ESCAP 75
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Table of Contents

Abstract

Air pollution is universally recognised as one of the most pressing environmental challenges Asia and the Pacific. And the crisis has only heightened in recent years, leading to a rise in premature deaths, threatening livelihoods and the sustainable development of the region, particularly in many cities where air pollution rises with the exponentially rising urban population.

Even though biomass burning is the most significant seasonal air pollution factor in Chiang Mai and its region, traffic contributes significantly to the air pollution problems throughout the year and will continue to be a threat in the future as the levels of NO_2, CO, and SO rise. This paper examines the relationship between traffic congestion effect and ambient air pollution through the use of quantitative modelling, correlational analysis, linear regression analysis, and Copula analysis.

Introduction

Air pollution due to particulate matter is significantly associated with increased morbidity and mortality for several health indicators including lung cancer (Cohen & Pope, 1995), cardiovascular disease and respiratory disease (Bernstein et al., 2004; Brunekreef & Holgate, 2002), birth defect and pregnancy outcomes (Fleischer et al., 2014; Hoover, 2002; Li et al., 2017; Liu et al., 2017). This working paper examines Thailand as a case study example for other countries in the region.

As Thailand develops, the country faces a major air pollution problem, resulting in health inequity (Vichit-Vadakan & Vajanapoom, 2011; Vichit-Vadakan et al., 2008). While the impacts of air pollution on public health have been a matter of increasing research interest, gender-specific risk factors and outcomes remain comparatively under studied. This working paper summarizes the ongoing research efforts of ESCAP to conduct a gender-aware analysis this important problem. Based on the scientific findings of this line of inquiry, policy makers and stakeholders will be better able to take action to focus on the needs of this vulnerable population and highlight the suggested direction for future research.

Daily exposure to high levels of pollution threatens public health in Thailand, with many complex risk factors (ESCAP, 2021). Hence, there is a clear need to identify the local gender-based determinants of activity patterns and exposure. Impacts of air pollution effects are attributable primarily to exposure differences (e.g., work-related exposures), access to health care, inequalities in unpaid household labor, or to some interplay thereof should be better investigated (Clougherty, 2010; WHO, 2010).

Occupationally, the low-wage workers such as agricultural workers, commercial drivers and construction workers are disproportionately exposed to air pollution and are vulnerable to adverse health impacts (WHO, 2010). As such, those women face a greater risk of serious health problems including lung cancer, cardio-vascular disease and birth defects (Hoover, 2002). Additionally, several studies have identified preliminary findings suggesting a correlation between long-term exposure to particulate matter and the increase in Covid-19 death rates (Wu et al., 2020).

Despite the continuous effort of the government to improve air quality, there remains huge gaps in existing policies. Therefore, a better scientific understanding of the consequences of air pollution is necessary in order to help focus scarce resources on the most effective action to alleviate both environmental degradation and gender inequality. These findings will assist in providing the scientific findings necessary to enable decision making at local and national levels appropriate to Thailand's economic and social conditions and provide a methodology which could be used by countries in similar environments.

Causes of Air Pollution in Thailand

The determinants and the sources of pollution in Southeast Asia are mainly anthropogenic; vehicular traffic and construction have contributed to high levels of particulate matter in urban areas including Bangkok whereas the main sources in rural areas including Chiang Mai are agricultural residues and industrial emissions (Rankantha et al., 2018).

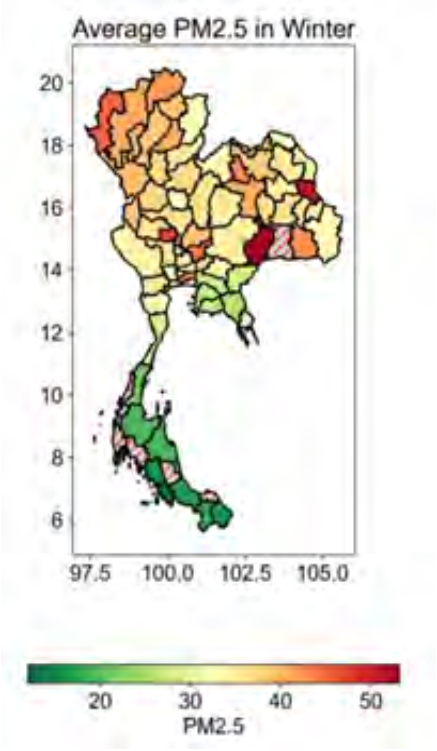
The northern region and northeast region were the most polluted provinces in Thailand. At the city level, Bangkok has experienced a significant amount of air pollution, with strong seasonal aspects. The assessment of exposure and burden of disease showed the $PM_{2.5}$ concentrations are higher in the northern region than the southern region, it exacerbates the health disparities in Thailand. Furthermore, high levels of particulate pollution resulted in increases in hospital emissions and outpatient visits (Phosri et al., 2019).

Health, Gender, and Air Pollution

Background

In order to undertake a localized analysis of the impact of air pollution on public health, it is necessary to obtain baseline exposure data by province. Because ground-based sensors have not been widely used for a suitable timeseries, it is necessary to obtain approximations using groups of provinces and averaged exposure. For illustrative purposes, the average $PM_{2.5}$ levels during the high pollution (winter) season is displayed below:

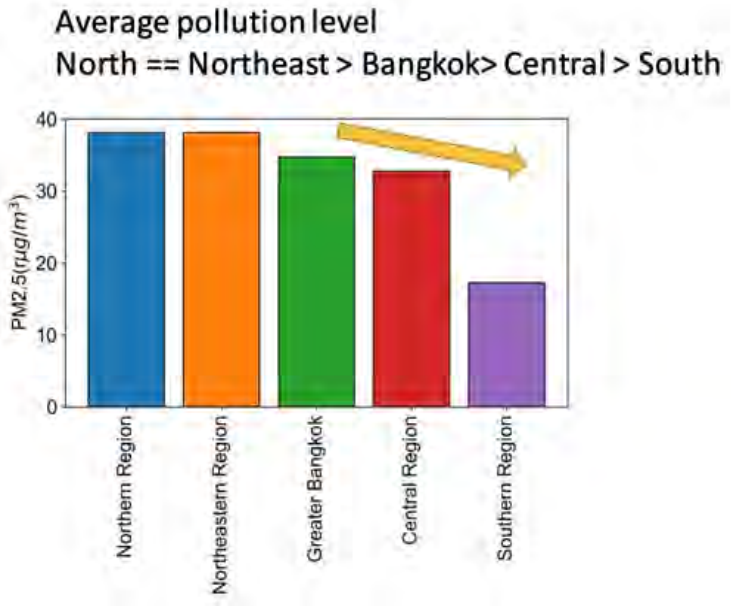
Figure 1: Visualizations of the average $PM_{2.5}$ in Thailand in Winter



Source: ESCAP, 2021

For the purposes of this analysis the data limitations of the ground-based network have been addressed by aggregating provinces into specific categorical groups. The exposure variances for those areas can then be more clearly seen and analyzed.

Figure 2: Average $PM_{2.5}$ level in Thailand by Region



Source: ESCAP, 2021

The adverse impact of smoking on respiratory systems and the association with lung cancer has been generally observed. In this regard, smoking is by far the well-documented risk factor for lung cancer. Besides smoking, the effect of exposure to environmental carcinogens significantly contributes to the risk of lung cancer in Thailand (Chang et al., 2018).

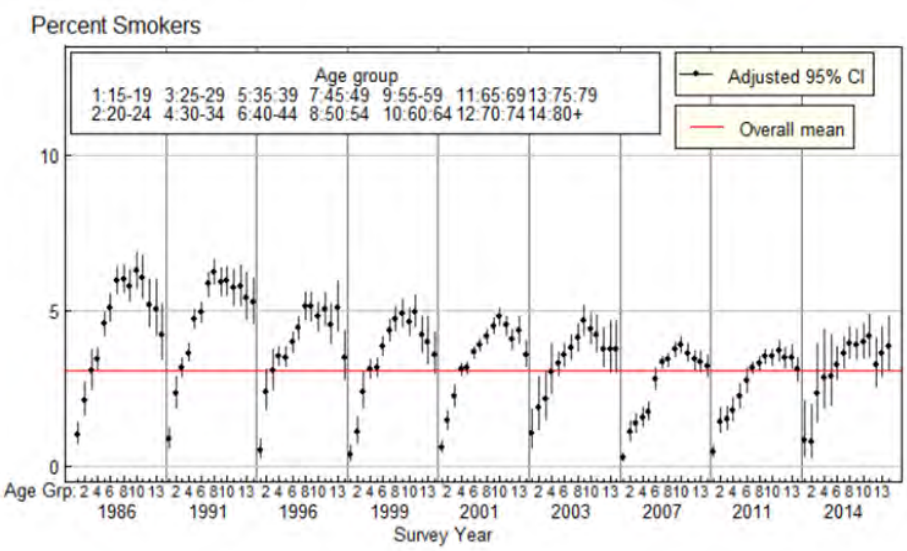
It is therefore necessary to include this factor in understanding the factors which impact adverse health outcomes in the context of air pollution exposure. United Nations ESCAP has analyzed the illness caused by air pollution by using out-patient, in-patient and cause of death data to better understand the trends of lung-related diseases in various regions.

Overall, smoking prevalence has been highest in the south for males and north for females. While timeseries data on smoking prevalence generally shows high variability among sources, the best available data suggests a smoking rate of between 3 per cent - 5 per cent for women in Thailand.

Even after adjustment for income, smoking rates, and other predictive factors there was distinct geographical variation and sex differences in risk patterns of lung-related diseases; the risk of tuberculosis and malignant neoplasm of lung was the highest in the northern region with females being at a higher risk than males (ESCAP, 2021).

This highlights the need for regional prevention strategies and surveillance systems to evaluate the region-specific risk patterns in lung-related illness when developing implementation plans and allocating health resources.

Figure 3: Demographic and Regional Trends of Smoking among Thai Females from 1986 to 2014



Source: Gautam, Nirmal & Lim, Apiradee & Ueranantasun, Attachai. (2019)

Heart Disease

Exposure to air pollution also has adverse health effects on cardiovascular diseases (Brook et al., 2010). Under long-term exposure to air pollution including $PM_{2.5}$ and PM_{10}, pulmonary symptoms such as decreased lung function, chronic cough, bronchitis, and conjunctivitis will emerge and become health burdens to the exposed group (Joad et al., 2007).

Moreover, study shows that air pollution not only causes adverse health effects on the respiratory system but also cardiovascular system. Studies show that there is a significant increase in cardiovascular diseases from 0.5 per cent to 1.5 per cent for every 5~6 μg/m³ increase in $PM_{2.5}$ (Mueller et al., 2021).

Currently, Thailand has been experiencing serious air pollution issues due to urbanization and development. Attempts to link air pollution and public health impacts have proven difficult, as the available data suggests that the models for estimating these effects require localization to enhance their accuracy . To illustrate this point, Table 1 illustrates the discrepancies identified in the literature among the avoided mortality estimates available.

This highlights the need for further localization of analysis on burden of disease and avoided mortality.

Table 1: Avoided deaths in Bangkok from a 10 ug/m³ rollback of $PM_{2.5}$ in the year 2016

	United States [a]		China [b]	
Health Endpoints	β Values (Standard Deviation)	Avoided Mortality	β Values (Standard Deviation)	Avoided Mortality
Mortality, All-cause non-accidental	0.00583 (±0.00096)	2772	0.000896 (±0.000538)	374
Mortality, cardiopulmonary	0.0122 (±0.00135)	1686	0.002547 (±0.006250)	316
Mortality, lung cancer	0.0131 (±0.00379)	291	0.00334 (±0.001758)	67

Source: R Fold N, Allison MR, C Wood B, et al, 2020

Birth Defects

As is well established in the existing scientific research, women who are exposed to a higher level of $PM_{2.5}$ air pollution are more likely to giving birth to babies with different serious defects. Substantial evidence has demonstrated the profound negative impacts of air pollution on perinatal outcomes as a result of biomass and anthropogenic mixture $PM_{2.5}$ (Fleischer et al., 2014; Hoover, 2002; Li et al., 2017; Liu et al., 2017).

Further studies also suggest that women who are exposed to the increased level of ozone and carbon monoxide will have a higher chance of having babies with heart defects (Hoover, 2002). Most studies in developed countries have highlighted adverse birth outcomes due to air pollution. At the regional level, a recent study has demonstrated how children under five in several Asian countries face the burden of morbidity and mortality from acute respiratory diseases and asthma (Lien et al., 2019).

The major factor of concern happens on fetal development; maternal exposure to ambient particulate matter has serious health outcomes in offspring and increases risk of the children being born with birth defects such as abnormal hearts (Cincinnati Children's Hospital Medical Center, 2017). Furthermore, air pollution can adversely affect cognitive and behavioral development in children (Lopuszanska & Samardakiewicz, 2020) and is associated with ADHD and autism spectrum disorders (Oudin et al., 2019).

In order to localize these findings together with on the ground data, UNESCAP has collected and analyzed the outpatient data from the Ministry of Public Health of Thailand, Health Data Center, including various conditions during the perinatal period for Thailand. The preliminary results of the analysis indicates that northern, northeastern, and central provinces have a higher rates of birth defects compared to the provinces in southern regions.

Figure 4: Prevalence of Conditions Compared by Provincial Groupings

Condition	Ratio N/S	Ratio NE/S	Ratio Central/S
(M) Other congenital malformations of the nervous system (Q00-Q04, Q06-Q07)	208%	146%	109%
(F) Other congenital malformations of the nervous system (Q00-Q04, Q06-Q07)	185%	134%	109%
(M) Intrauterine hypoxia and birth asphyxia (P20-P21)	134%	145%	110%
(F) Intrauterine hypoxia and birth asphyxia (P20-P21)	134%	148%	113%

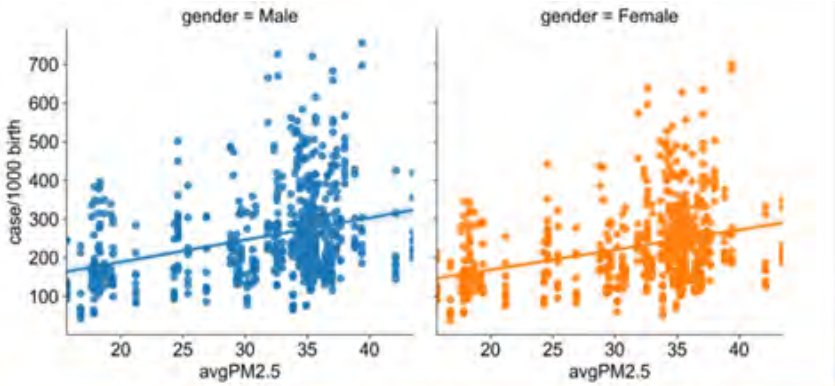
Source: ESCAP, 2021

Additionally, ESCAP's preliminary quantitative analysis has identified a positive correlation between birth defect rates and high $PM_{2.5}$ levels. The chart below indicates the correlation with $PM_{2.5}$ levels and specific ICD10 condition codes, which can help increase the accuracy of global modeling efforts when localized to conditions in Thailand.

Figure 5: Linear model of conditions originating in the perinatal period in Thailand

Other conditions originating in the perinatal period (P08, P29, P50-P54, P56-P96): linear model

R2 = 0.83



(FEMALE)	coef	P-value	Lower interval [0.025	Upper Interval 0.975]
ncome	-0.0011	0.028	-0.039	0.969
pop_per_avg	0.1206	0.027	4.425	0.000
20-29	0.0028	0.005	0.535	0.593
birth_rate	-0.0010	0.002	-0.579	0.563
avgPM2.5	0.0087	0.001	7.252	0.000

(MALE)	coef	P-value	Lower interval [0.025	Upper Interval 0.975]
income	0.1232	0.044	2.817	0.005
pop_per_avg	0.1561	0.044	3.586	0.000
20-29	0.0003	0.007	0.042	0.966
birth_rate	0.0002	0.002	0.069	0.945
avgPM2.5	0.0125	0.002	6.687	0.000

Source: ESCAP

To further enhance these findings, additional variables should be considered, including such as lifestyle factors, access to healthcare and patters of human migration, among others.

Ways Forward: Areas for Further Research

Further work is necessary to develop and refine models which are adapted to local conditions. This work should be aimed to quantify the magnitude and distribution of disease burden caused by ambient air pollution at the city, provincial and national level. As a result, an integrated exposure assessment, using a spatial interpolation model from empirical data, population distribution exposure and health impact functions should be developed.

Advanced methods, such as machine learning and spatial clustering should be utilized in order to address persistent problems such as data availability, transboundary effects and understanding the mixture of pollutants and sources. Because women suffer from inequalities such as differential access to health care, burdens of care for disabled or sick family members, and the impact of medically complicated pregnancies, a gender aware approach to this research should be adopted in a cross-cutting manner.

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