The Health Impact Assessment of Particulate Matter (PM 2.5) in Thailand

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การประเมินผลกระทบต่อสุขภาพจากฝุ่ นละอองขนาดเล็กกว่า 2.5 ไมครอน (PM2.5)
ในประเทศไทย

น.ส.ฟรีสซิลลา เฮอร์มายูริสคา

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
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Field of Study	Public Health
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ฟรีสซิลลา เฮอร์มายูริสคา : การประเมินผลกระทบต่อสุขภาพจากฝุ นละอองขนาดเล็กกว่า 2.5 ไมครอน (PM2.5) ในประเทศไทย . (The Health Impact Assessment of Particulate Matter (PM 2.5) in Thailand) อ.ที่ปรึกษาหลัก : รศ.ณัฏฐา ฐานีพานิชสกุล

ฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอน (พีเอ็ม 2.5) เป็นหนึ่งในมลพิษอากาศที่มีความสำคัญที่สามารถส่งผลกระทบต่อสุขภาพมนุษย์ จากการศึกษาทางระบาดวิทยาก่อนหน้าได้มีการรายงานผลกระทบของฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนต่อการเกิดโรคเรื้อรังและการเสียชีวิตก่อนวัยอันควรของประชากร

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อประเมินผลกระทบต่อสุขภาพทั้งในระยะสั้นและระยะยาว รวมถึงการประเมินจำนวนและอัตราส่วนการเจ็บป่วยและการเสียชีวิตของประชากรไทยที่สามารถลดลงได้ เมื่อฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนลดลงถึงตามค่าต่างๆที่กำหนด

ในการศึกษาครั้งนี้ได้รวบรวมข้อมูลคุณภาพอากาศฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอน จากสถานีตรวจวัดคุณภาพอากาศของกรมควบคุมมลพิษ และใช้โมเดล kriging เพื่อทำนายฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนในแต่ละจังหวัดในระหว่างวันที่ 1 มกราคม 2562–31 ธันวาคม 2562 ส่วนของข้อมูลการเจ็บป่วยและการเสียชีวิตในการศึกษาครั้งนี้เก็บรวบรวมจากกองยุทธศาสตร์และแผนงาน สำนักงานปลัดกระทรวงสาธารณสุข กระ ทรวงสาธารณสุข ในช่วงเวลาเดียวกัน จำนวนประชากรอายุมากกว่า 30 ปีในแต่ละจังหวัดได้ถูกนำมาใช้ในการศึกษาครั้งนี้ โปรแกรม Air Q+ ที่ถูกพัฒนาขึ้นโดยองค์การอนามัยโลก เพื่อประเมินผลกระทบต่อสุขภาพจากการรับสัมผัสมลพิษอากาศ

ในปี 2562 จำนวนประชากรอายุมากกว่า 30 ปีเท่ากับ 40,572,731 หรือ 60,957.6 ต่อ 100,000 ประชากร ใน 77 จังหวัดของประเทศไทย ซึ่งคิดเป็น 60.98% ของกลุ่มประชากรทั้งหมด ค่าเฉลี่ยรายวันความเข้มข้นของฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอน ระหว่าง 1.28 – 229.52 ไมโครกรัมต่อลูกบาศก์เมตร ค่าเฉลี่ยรายปีของฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนเท่ากับ 24.14 ไมโครกรัมต่อลูกบาศก์เมตร จังหวัดพระนครศรีอยุธยามีค่าฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอน 32.79 ไมโครกรัมต่อลูกบาศก์เมตร ตามด้วยจังหวัดอ่างทอง และกาฬสินธุ์ จากการประเมินประเมินผลกระทบต่อสุขภาพโปรแกรม Air Q+ พบว่าเมื่อลดค่ากำหนดลงจะส่งผลต่อการลดลงของจำนวน และอัตราส่วนการเจ็บป่วยและการเสียชีวิตของประชากรไทย เช่น เมื่อลดค่าฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนลงเหลือ 37.5 ไมโครกรัมต่อลูกบาศก์เมตร พบว่าในผลกระทบระยะสั้นสามารถลดการเสียชีวิตทั้งหมดของประชากรลง 2 คนต่อ 100,000 ประชากร และผลกระทบระยะยาวเมื่อลดค่าฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนลงเหลือ 15 ไมโครกรัมต่อลูกบาศก์เมตรจะสามารถลดการเสียชีวิตของประชากรลงได้ 82 คนต่อ 100,000 ประชากร

จากผลการศึกษาพบว่าฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนส่งผลกระทบทั้งระยะสั้นและระยะยาวต่อประชากรไทย ผู้กำหนดนโยบายและผู้ที่เกี่ยวข้องควรร่วมกันพิจารณาแนวทางการจัดการการลดมลพิษอากาศเพื่อปกป้องสุขภาพของประชาชนต่อไปในอนาคต

สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อนิสิต	
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Friscilla Hermayurisca : The Health Impact Assessment of Particulate Matter (PM 2.5) in Thailand. Advisor: Assoc. Prof. NUTTA TANEEPANICHSKUL, Ph.D.

Particular Matter with diameter <2.5 microns or micrometers (a pollutant PM2.5) is highlighted as dangerous kind of pollutant in the worldwide. There were epidemiological studies reporting the harmful effects of PM2.5 in population due to the particle can lead various chronic diseases and premature deaths.

The aim of this study is to assess the changes in health due to short- and long-term exposure and to provide the estimation attributed cases and proportion in the Thai population which could be avoid where the PM2.5 concentration reduce to the cut-off values that respected

I collected data of PM2.5 concentration from 70 air monitoring stations of Pollution Department Control Thailand to indicate all provinces. For missing data, the values were calculated using the single imputation technique. The Ordinary Kriging Techniques were applied to construct the interpolations of PM2.5 concentration data for each district. I collected national health data including total number morbidity and mortality incidences related with negative effects from PM2.5 exposure in all provinces from Ministry of Public Health, Thailand. Total numbers of population all ages for specific province have been collected, where people ages >30 years old as population at risk on this study. This study presents all data that collected in 2019. Air Q+ Software is a tool that developed by World Health Organization, and it used to calculate the changes and health effects of air pollutant PM2.5 in population. All data were input to Air Q+ tool and the calculation parameters are based on epidemiological analysis.

In 2019, Total population at risk or people ages >30 years old was 40,572,731 people or 60,957.6 per 100,000 population for 77 provinces in Thailand, where 60.98% from the total population for all ages. The range of daily PM2.5 concentration in 2019 for entwere provinces was between 1.28 and 229.52 ug/m^3. The annual mean PM2.5 for national level was 24.14 μg/m^3. Phra Nakhon Si Ayutthaya had high PM2.5 mean at 32.79 μm^3 in 2019, followed by Ang Thong and Kalasin. The results from Air Q+ software estimated attributed proportion and cases in variation of cut-off values. All estimations indicate the reduction proportion and case that can be achieved if PM2.5 concentration meets the cut-off value. If the daily average in Thailand meets the targeted standard at 37.5 μg/m^3 it can reduce around 2 per 100,000 population from the burden all short-term mortality cases in 2019. And, if the annual average in Thailand meets the targeted standard at 15 μg/m^3 it can reduce around 82 per 100,000 population from the burden all long-term mortality cases in 2019.

The result demonstrated the significant impacts of short- and long-term exposure of PM2.5 on Thai population. From this study, the estimations suggest the roadmap for policy maker and stakeholder to improve air pollution risk and management actions as the ways to protect population.

Field of Study: Public Health		Student's Signature ....
Academic Year: 2021		Advisor's Signature ....

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Hopefully, this study can provide a valuable contribution and high benefit to the public health field, mainly for air pollution control programs in Thailand

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CHAPTER I INTRODUCTION

1.1 Background

In recent periods, air pollution becomes the biggest environmental problem to human health. Based on World Health Organization (WHO) global guidelines on the ambient air quality, the exposure of poor air condition recognized increasing the number of global burden, and it was estimated the higher of death cases and human healthy years lost in every years There are many types of air pollutants including nitrogen dioxide (NO_2), ground level ozone (O_3), sulfur dioxide (SO_3), carbon monoxide (CO), violate organic compounds (VOC5), particular matter 10 (PM10), and particular matter 2.5 (PM2.5). Regarding to the kind of pollutants in the atmosphere, PM 2.5 is the most dangerous particle because of the harm effects. PM 2.5 particle can enter to human body and will be causing chronic and acute health problems, and the mortality as the severe impact (Mohseni Bandpi, 2017).

Particular Matter (PM2.5) was highlighted as harmful kind of pollutant in the worldwide and raising awareness about public access to air quality data. PM 2.5 is described as an ambient airborne particle which the size measures to 2.5 microns (WHO, 2021). Because of the extra small size, the particles could enter the blood stream through respiratory system and moving to the whole of human body, The effects of PM 2.5 in human health might be vary due to the chemical characteristics, type of sources, and area sizes (F. Cavalli, 2016). Cardiovascular diseases and respiratory problems have strongly associated with PM 2.5 concentrations, where it can affect the increasing on mortality and morbidity rates (Avino P, 2016).

Some country still faces the difficulty to control the increasing of PM 2.5 concentrations. The main contributing factors of increasing the number of PM 2,5 in many countries are the exhaust waste disposal from automobile, in particular older buses and trucks that still overflow in the roads across the country and cause the air is contaminated with their polluting and excessively outdated machines. PM 2.5 potentially distributed from these defunct and old transportation that extremely relevant. In addition, factories and industry activities, contraction works, crop burning, housing activities give potential effects to the increasing air pollution. In Thailand, the burning activities using biomass, factories, traffic, and power plants energy uses are the main contributors of emissions of pollutants (Vongmahadlek, 2009). However, In Bangkok, the capital city of Thailand, according to study in 2017 showed there are exceeds 10 million automobile in the road where the number of population just over than 12 million. The condition also represented the enormous sources of PM 2.5 (Cheewaphongphan et al., 2017) . On the entire of major cities, these can increase dangerous particles and chemicals level in the atmosphere and it encourages the Air Quality Index (AQI) rising up to potentially hazardous level for this country. Hence, Thailand is highly polluted due to the factors that related to urban disease main focus, such as overcrowding and uncontrolled population, industry sector development as well as less stringent regulation being placed on companies or individuals that produce substantial amounts of noxious emissions.

Ambient air pollution is related to around 4.2 million of the average annual deaths of stroke, heart disease, lung cancer, lung cancer, acute and chronic respiratory diseases (Aaron J Cohen, 2015). Ninety nine percent of the populations of the world reside in area where the quality of air in the atmosphere constantly exceeds the WHO limits. Low- and middle-income countries (LMICs) are affected by highest-burden cause of air pollution, whereas air pollution in the environment impacted to developed and developing countries, and the big cases occurred in Western Pacific and South-East Asia regions (WHO, 2021). In low developing countries, around 98% of with the population age under five years old are exposed to toxic air. Air pollution is the majority cause of death case for children under the age of 15, where around 600,000 people died every year (WHO, 2018).

In economy terms, in 2016, The World Bank reported, there was high burden in pollution cost about USD5 trillion in welfare losses worldwide due to premature death cases linked with the air pollution exposure. In 2016, ambient worldwide air pollution has been recorded at 29% of entire mortality and disease from lung cancer, 17% of all mortality and disease from acute lower respiratory infection, 24% from stroke, 25% accounted for ischemic heart disease, and all mortality and disease due to chronic obstructive pulmonary disease was responsible at (WHO, 2018d)

Furthermore, Thailand also faces many problems with air pollution. According to the report from IQ Air's world in 2019, the concentration of air quality Thailand are accounted at 24.3μg/m^3 annually as the 28th most polluted country from other 98 countries. The estimation of all-cause mortality among Thai population is around 40 000 per year. Where, it just nearly at 17% was accounted for the percentage of lung cancer (Pinichka C, 2017). A Health Impact Assessment (HIA) among Thai population Were conducted by Muller et all in 2021 found the most death due to PM 2.5 exposure was Acute Lower Respiratory Infection (ALRI) accounted at 16,419 death with Population Attributable Fraction (PAFs) at 48%, where this study used health data from 2016. It was followed by Ischemic Heart Disease (IHD) was responsible for 15,489 death and PAFs at 33%. The poor air quality condition in Thailand have encourage the government to concern with some strategic as responds, and create solutions to solve the issue, as well as considering at long term goals that can be applied to control the environmental crisis for this country. To encourage the implementation of the effectiveness local, national and global policies to restrict the number of air pollution, the health impact assessment is crucial to demonstrate an estimation of impact of the changes of air pollution on human life.

There are several tools with computer-based to lead the process of assessment, mainly AIRQ+ provided by World Health Organizations, The AIRQ+ software is a popular tool to assess the effects of air pollution on human health. Using the application of mathematical integration and the analysis of air pollution exposure to health risk, AIRQ+ tool works to estimate the number of particular health outcome mainly the attribute proportion cases, the number of attribute cases per 100,000 population at risk, and proportion of cases in for one category of air pollutant concentrations and the years of life lost (WHO, 2014a). The software has adjustable Relative Ratio (RRs) and counterfactual levels. The default Risk Ratio leads the tool applicable for more specific regions, hence the adjustable RRs makes the tool applicable for any population when have been received from epidemiological studies (Brenk, 2018). The main result of this study or known as central estimation has ninety-nine percent confidence intervals that described as the bound. It makes possible to calculate the standard error that can estimate the uncertainty of the main result World Health Organization developed Air Q+ with the purpose to be support tool for decision making process (Sacks, 2020). The estimation of health impacts at vary spatial scales can be used to provide potential air actions. Air Q+ software also has considerable on educational focus for public health authorities, hence it can quantify the health impacts of some kind of pollutants in specific scientific areas.

The aimed of this study is to analyze the short-term impacts particularly the number of hospital admission due to respiratory and cardiovascular cases and the estimation of as the long-term impacts of PM2.5 exposure for mortality cases due to the exposure of PM2.5, including Chronic Obstructive Pulmonary Disease (COPD), Ischemic Heart Disease (IHD), Brain Stroke (BS), and other deaths in Thailand based AIRQ+ software. The previous study published by Mueller et al in 2021 based on Microsoft excel modeling for analysis health impacts assessment and BenMAP for economy costs analysis showed that significant impacts of PM 2.5 exposure to mortality in Thailand. However, there are no specific studies to explain both short- and long-term impacts while it could make severe impacts in population. Therefore, until today, there are no specific study that mention the usage of Air Q+ software to analyze the health impact PM 2.5 exposure to human in Thailand.

With regard to expected results of this study, the findings will be reference to encourage the strategies planning and control program regarding to air pollution impacts. The result of this study also will be used as an alternative to revise the new national ambient air quality standard PM 2.5 in Thailand.

1.2 Research Questions

a. What are the estimation numbers of health impacts due to short-term PM2.5 exposure in the Thai population?

b. What are the estimation numbers of health impacts due to long-term PM2.5 exposure in the Thai population?

1.3 Research Objectives

a. To provide the estimated numbers of health impacts due to short-term PM2.5 exposures in the Thai population.

b. To provide the estimated numbers of health impacts due to long-term PM2.5 exposures in the Thai population

1.4 Research Hypothesis

There are the significant estimated numbers of health impacts due to short- and long-term PM2.5 exposure in the Thai population.

1.5 Conceptual Framework

Independent Variables

PM2.5 concentration (Province-specific)

Province characteristic

- Total population at risk in a year
- Area size (km^2)
- Total Population all ages

Health Data (Province-specific)

- Short-term
    a. Hospital Admissions, Respiratory disease in adults ages ≥30 years
    b. Hospital Admissions, Cardiovascular disease (CVD) (including stoke) in adults ages ≥30 years
    c. All natural mortality cases in adults ages ≥30 years
- Long-term
    a. All natural mortality cases in adults ages ≥30 years
    b. Chronic Obstructive Pulmonary Diseases (COPD) mortality cases in adults ages ≥30 years
    c. Ischemic Heart Diseases (IHD) mortality cases in adults ages ≥30 years
    d. Stroke mortality cases in adults ages ≥30 years

Dependent Variables

Estimated Attributed Proportions and cases for Mortality and Morbidity incidence

1.6 Operational Definition

VARIABLE		DEFINITION
PM 2.5 concentration		Refers to the annual and daily average of pollutant particulate matter (PM) 2.5 in the atmosphere for each specific province in Thailand in 2019.
Province Characteristic	Total Population at Risk	Refers to the number of population at risk or people ages ≥30 years in specific province in Thailand in 2019.
	Area size	Describe the size of specific province in Thailand that measured on Kilometers (km2) in 2019. It will be a reference for the analysis.
	Total Population All Ages	Refers to the number of population all ages in Thailand in 2019 that adding as references
Health Data Short-term	Hospital Admissions, Respiratory disease in adults ages ≥30 years **(ICD 10 codes are J00–J99)**	Refers to the total number of hospital visited with respiratory diseases indication in adults ages ≥30 years from private or governmental hospital in each specific province in Thailand in 2019.
	Hospital Admissions, Cardiovascular disease (CVD) (including stoke) in adults ages ≥30 years **(ICD 10 codes are I00–I99)**	Refers to the total number of hospital visited with Cardiovascular (CVD) diseases indication in adults ages ≥30 years from private or governmental hospital in each specific province in Thailand in 2019.
	All natural mortality cases in adults ages ≥30 years **(ICD 10 codes are A00-R99)**	Refers to the total number of mortality cases in annual period of adults age ≥30 years in each specific province in Thailand in 2019. The number will be used as incidences number due to PM2.5 exposure in short-term period.

Health Data Long-term	All natural mortality cases in adults ages ≥30 years **(ICD 10 codes are A00-R99)**	Refers to the total number of mortality cases in annual period of adults ages ≥30 years in each specific province in Thailand in 2019. The number will be used as incidences number due to PM2.5 exposure in long-term period.
	Chronic Obstructive Pulmonary Diseases (COPD) mortality cases in adults ages ≥30 years **(ICD 10 codes are J44)**	Refers to the total number of mortality cases in annual period due to Chronic Obstructive Pulmonary Disease (COPD) diseases on adults ages ≥30 years in each specific province in Thailand in 2019.
	Ischemic Heart Diseases (IHD) mortality cases in adults ages ≥30 years **(ICD 10 codes are I20-I25)**	Refers to the total number of mortality cases in annual period due to Ischemic Heart Disease (IHD) on adults ages ≥30 years in specific province in Thailand in 2019.
	Stroke mortality cases in adults ages ≥30 years **(ICD 10 codes are I60-I69)**	Refers to the total number of mortality cases in annual period due to Stroke on adults ages ≥30 years in each specific province in Thailand in 2019.

CHAPTER II LITERATURE REVIEW

2.1 Air Pollution- Particulate Matter (PM) 2.5

Air pollution is a complicated mix of complex particles, liquid droplets, and gases. It can produced from a variety of sources including the fuel burning in household, industrial chimneys, the exhaust of transportation modes, energy production, open waste burning, agricultural activities, natural desert dust, and many other resources (WHO, 2013a). There are approximately seven million deaths due to the result of air pollution exposure every year. Based on annual data from World Health Organization (WHO), around 99% of entire population in worldwide breathes with air condition which exceeds the WHO guideline limits and contains high number of pollutant, with low- and middle-income countries suffering the most. Air pollution can be produced by many of sources, resulting in a diverse range of air pollution mixtures. Particulate matter from sea salt, road dust, and diesel engine smoke, for example, may be present in an urban city with area in the coastal side. A rural area which is close to forest, on the other hand, may have particulate matter from soil, smoke from cook stoves, and forest fires. According to the World Health Organization (WHO), one of the primary sources of environmental health risk factors is air pollution. The most significant relationship is that between morbidity and mortality due to respiratory and cardiovascular disorders (Lefler, 2019).

Air pollutants are substance in the air that can harm humans and the environment. Solid particles, liquid droplets, or gases can all be used as the substance. A pollutant can be either natural or man-made. Pollutants are divided into two types: primary and secondary. Primary pollutants are typically produced by processes such as volcanic ash. Other examples include carbon monoxide gas emitted by automobiles and sulfur dioxide emitted by factories. Secondary pollutants are not directly emitted. Rather, they form in the air as a result of primary pollutants reacting or interacting. Ozone at ground level is a well-known example of a secondary pollutant. Some pollutants are both primary and secondary in nature, meaning they are both emitted directly and formed from other primary pollutants. Particulate Matter (PM), regarding to WHO air pollution guideline in 2021, is a combination of solid and liquid particles in the atmosphere that are tiny to not settle out on the Earth's surface due to gravity, and is classified by aerodynamic diameter. The pollutant is also an important component, because of harmful effects to human health, such as cardiovascular and respiratory mortality and hospitalizations, are commonly cited as two of their two side effects (Mohseni Bandpi, 2017). There are two kinds of Particulate Matter: PM 2.5 and PM 10, which are classified by size. PM 2.5 is a particulate matter suspended in the air with diameter that less than 2.5 microns or micrometers. These particles can react with water vapor, smoke, and other gases in the atmosphere. These types of specific matters have an effect on the human respiratory system. Short-term exposures can aggravate and worsen the symptoms of chronic respiratory diseases. Allergic rhinitis, asthma, and chronic obstructive pulmonary disease are examples of such conditions. Long term exposures increase the risk of emphysema and lung cancer. Aside from the effect on the respiratory system, the majority of studies on PM 2.5 health effects concentrate on aspects of public health and epidemiology. In studies that conducted on animal, both acute and long-term increases in the number of PM 2.5 have been linked to the increasing of case incidence of heart and blood vessel diseases affecting the cardiovascular system and the brain (Hamanaka & Mutlu, 2018). The continuing exposure to high levels of PM 2.5 has been linked to development of dementia disease. The processes by which PM 2.5 affect diseases are thought have relation to an incline in radical free, which increases inflammation in specific areas of the body. Furthermore, PM 2.5 may be a carrier of other harmful toxins such as heavy metals and carcinogens, such as polycyclic aromatic hydrocarbons (PAHs), which have been linked to lung cancer.

2.2 Air Pollutant PM 2.5 and its health impact associations

There are several studies have found the evidence relation of disease and adverse effects to dangerously low levels of PM and its toxic components. Many elements, such as organics like PAHs and inorganics like heavy metals, are found as carcinogens and cause a variety of adverse health effects in humans. Aside from that, PM exposure has been contributed to increased hospitalizations, carcinogenicity, the development disorders, nervous system effects, respiratory symptoms, cardiovascular diseases, decreased lung function, and untimely mortality ((Guaita R, 2011) & (Samoli E, 2008)). The contribution of nanoparticles on the foetal side of the placenta was recently linked, there was indication of the placenta barrier can be easily penetrated by PM, resulting in faotal exposure (Bové H, 2019). Hence, it explains the effect of PM toxicity extends not only to adults but also to the fetus. Furthermore, the long-term exposure to PM pollution makes a population more susceptible to COVID-19, and increased hospitalizations of patients with predisposed asthma or other respiratory ailments have been reported. As a result, the impact and toxicity of PM and its constituents are influenced by a several factors such as the water solubility, residence time, the composition of element, the size of particle, and chemical reactivity; and natural environmental factors, for example season, wind speed, and topography.

Population-based research studies have been difficultly to explain more the evidence to distinguish differences in the effects of particulate matter with different chemical constituents (Halonen JI, 2009). However, the references for the hazardous nature of particulate matter generated during the burning process from automobile and stationary sources is more constantly than evidence from other sources (Samoli E, 2008). The PM2.5 black carbon fractions are produced by incomplete of burning process. Where, it is one of great concern due to have contribution to negative effects on human health and climate. Other components of particulate matter attached to black carbon are indicated of causing a variety of health effects, including PAHs, which are familiar as carcinogens and toxic to cells, for example metals and inorganic salts. It should be concerned that the International Agency for Research on Cancer has defined and divided diesel engine exhaust, which is majority particulate matter, as a carcinogen to human body (Jiang XQ, 2016). This also includes some PAHs and some solid fuels in the household consumption.

2.2.1 Short-term Effects of PM 2.5 Exposure

2.2.1.1 Hospital Admission due to Respiratory and Cardiovascular Diseases

All types of air pollutants have a significant impact on the respiratory system. High concentration of sulphur dioxide, nitrogen oxides, ozone, and particularly pollutant PM 2.5 are related to respiratory diseases symptoms such as nose and throat irritation, coughing, chest discomfort due to narrowing of airways, increased mucous production on upper airway walls, and inflammatory reactions, these air pollutants lead to asthma and the more severe condition COPD (Kurt OK, 2016). People who more sensitive to air pollution are they that have respiratory problems. The risks of PM to human health are attributed to their deposition and transportation in the human body. The PM particles enter the lungs through the processes of impaction, interception, sedimentation, and diffusion. The larger PM size (> PM2.5) are primarily deposited in the upper respiratory tract via impaction. Smaller particle sizes (PM2.5) can deposit deeper into the lower airways and alveoli, depending on flow rates and diffusion, and can be moving to other tissues and organs via the bloodstream. Several studies have also found that exposure to smaller particles can have serious health consequences. However, the competition of particles are contribute to a variety of the impact (heavy metals and PAHs are carcinogens), concentration, and period of exposure times. Although there are many in vitro studies on human health effects of PM pollution, some of the studies have not focus on the epidemiological aspects. Additionally, the relevant evidence of the adverse effects related to short-term exposure to cardiovascular diseases such as hypertension has been found, whereas few studies have addressed the longer-term health impacts (Simoni M, 2015). Another study found short-term exposure to traffic emissions has been linked to hypertension, stroke, myocardial infarctions, and heart abnormalities (Katholi RE, 2009). PM 2.5 exposure can exacerbate the heart condition of people with cardiovascular diseases and caused death as long-term impact (Hamanaka & Mutlu, 2018).

With regard to that, the relation of PM 2.5 exposure on human health can be assessed through looking on the prevalence morbidity due to respiratory and cardiovascular disease. The numbers of hospital admission due to cardiovascular and respiratory diseases Were positively correlated with the increasing of PM 2.5 concentrations (RW Atkinson, 2014). Some study in population aged ≥15 years provided the increasing daily admission of respiratory and cardiovascular diseases related to the increasing PM 2.5 concentration per 10μg/m3 (Massimo Stafoggia, 2013).

2.2.1.2 Effects of short-term PM2.5 exposure on all-cause mortality

The premature death due to short-term PM 2.5 exposure Were strongly associated (Samoli E, 2008). There was estimation around 4,000 people died due to direct smog exposure and more than 100,000 people suffered adverse health effects in London (Logan, 1953). The APED meta-analysis found the increasing percentage of the mean number of death due to increasing 10μg/m3 PM 2.5 concentration in 12 single-city time-series studies in Europe (WHO, 2013b). The finding from studies in 20 U.S cities in 2000 demonstrated PM 2.5 concentration are significantly related to daily all-cause, cardiovascular, and respiratory mortality (Samet et al., 2000).

2.2.2 Long-term Effects of PM 2.5 Exposure

2.2.2.1 Cardiovascular Effects

Multiple cardiovascular effects have been documented in recent studies as a consequent by exposure of air pollution. According to the 2018 Burden of Disease global report, air pollution contributed to 19% of cardiovascular deaths in 2015. Air pollution is related to approximately 21% of stroke mortality and 24% of coronary heart disease mortality. The exposure of PM 2.5 plays a potential role of inflammatory pathway in pulmonary system directly. This process has been proved that particulate matter particle can trigger the inflammation when the particle accounted in the human lung (Huang W, 2012). The report from(Wang J, 2014) and (Astort F, 2014) found similar result in the process of in vivo animal models and the usage in vitro cellular methods, when the exposure of PM 2.5 increase the level of circulating of pro-inflammatory, for example CRP, the IL-6, the IL-8, and the IL-I when it observed in subject that have healthy condition. Inflammatory systematic has been familiar as risk factor in progress of atherosclerosis, and the mediator of pro-inflammatory are linked to the rising coagulability of blood and endothelial dysfunction closely, which it can contribute to the development of myocardial ischemia as the consequence. Additionally, the mechanism of ROS-dependent demonstrated to involving in the particle PM 2.5 triggered the pathway of pro-inflammatory. The rising of ROS amounts Were demonstrated after exposure PM 2.5 in rats lung and heart by in situ chemical luminescence means (Gurgueira SA, 2002). Some previous studies published the relation of ROS to atherosclerosis, vascular dysfunction, cardiac arrhythmias and myocardial injury has been shown ((Schriewer et al., 2013); (Ying et al., 2009)).

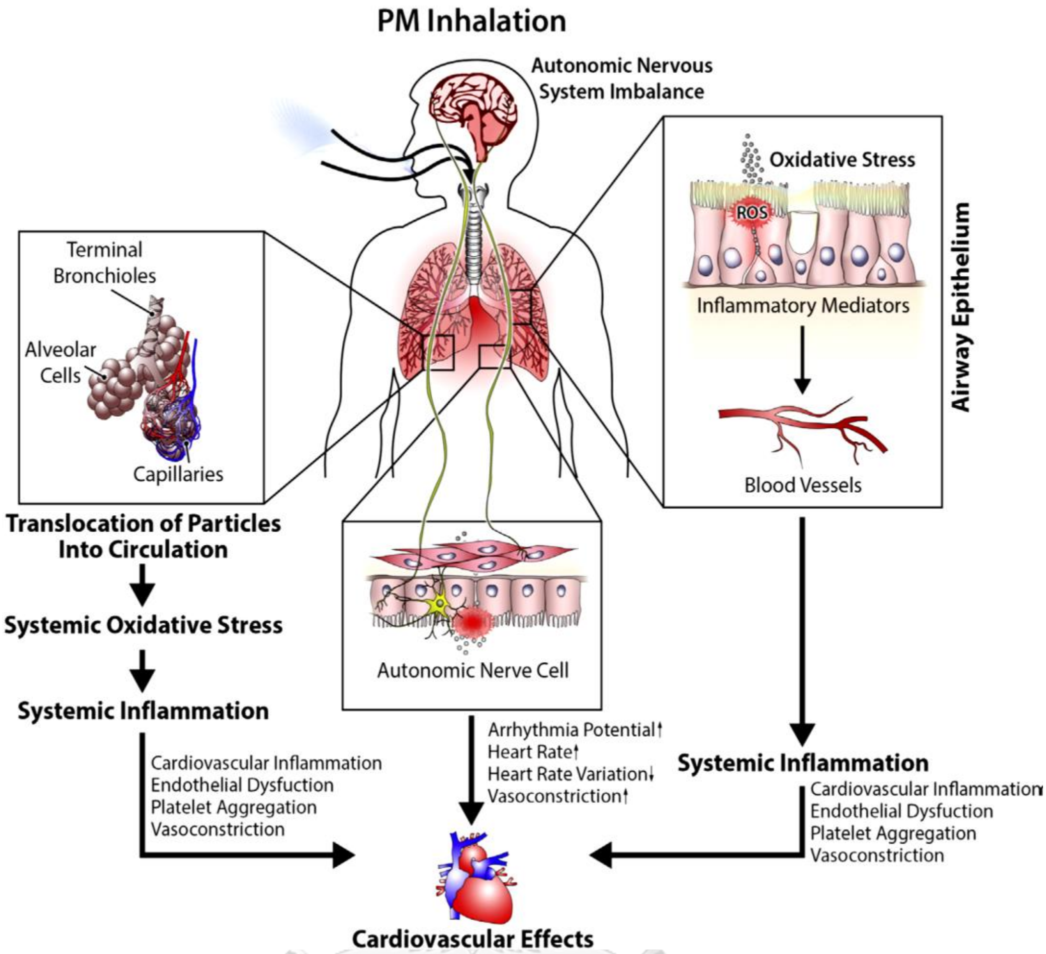
An increase of the risks on ischemic heart disease and myocardial infarction are shown in some groups regarding to the occupational exposed to gaseous emissions, whereas short-term exposure studies have provided changes in vasomotor function and an increase in prothrombogenic effects in healthy individuals. Long-term exposure has been linked to coronary arteriosclerosis, while short-term exposure has been linked to hypertension, stroke, myocardial infarctions, and heart abnormalities. In vitro studies in experimental animals exposed to PM show that it causes systemic inflammation and oxidative stress in the cardiovascular system, which may hasten the progression of atherosclerosis in animals predisposed to the disease. Furthermore, chronic exposure to nitrogen oxide may cause ventricle hypertrophy (Katholi RE, 2009).

2.2.2.2 Neurological Effects

Heavy metals (e.g., lead, mercury) and dioxins are linked to a variety of human neurological effects. Lead is absorbed into the body through inhalation, ingestion, and dermal absorption. Chronic lead exposure is linked with conditions such as the damage on neurological systems (mimics cancer and disrupts homeostasis cancer), lower intelligent quotient (IQ) and attention impairment, hand-eye co-ordination impairment, and encephalopathy. It is a Ill-known teratogen found in human placenta and blood-brain barrier, where it potentially causes harmful effect for the foetus. Another heavy metal that affects the nervous system is mercury (methyl mercury). Organic mercury is fat-soluble and can enter the central nervous system, where it oxidizes to Hg2+ and causes neurological damage. Memory loss, narrowing of vision, loss of muscle coordination and emotional instability are the symptoms of these problems (Genc S, 2012).

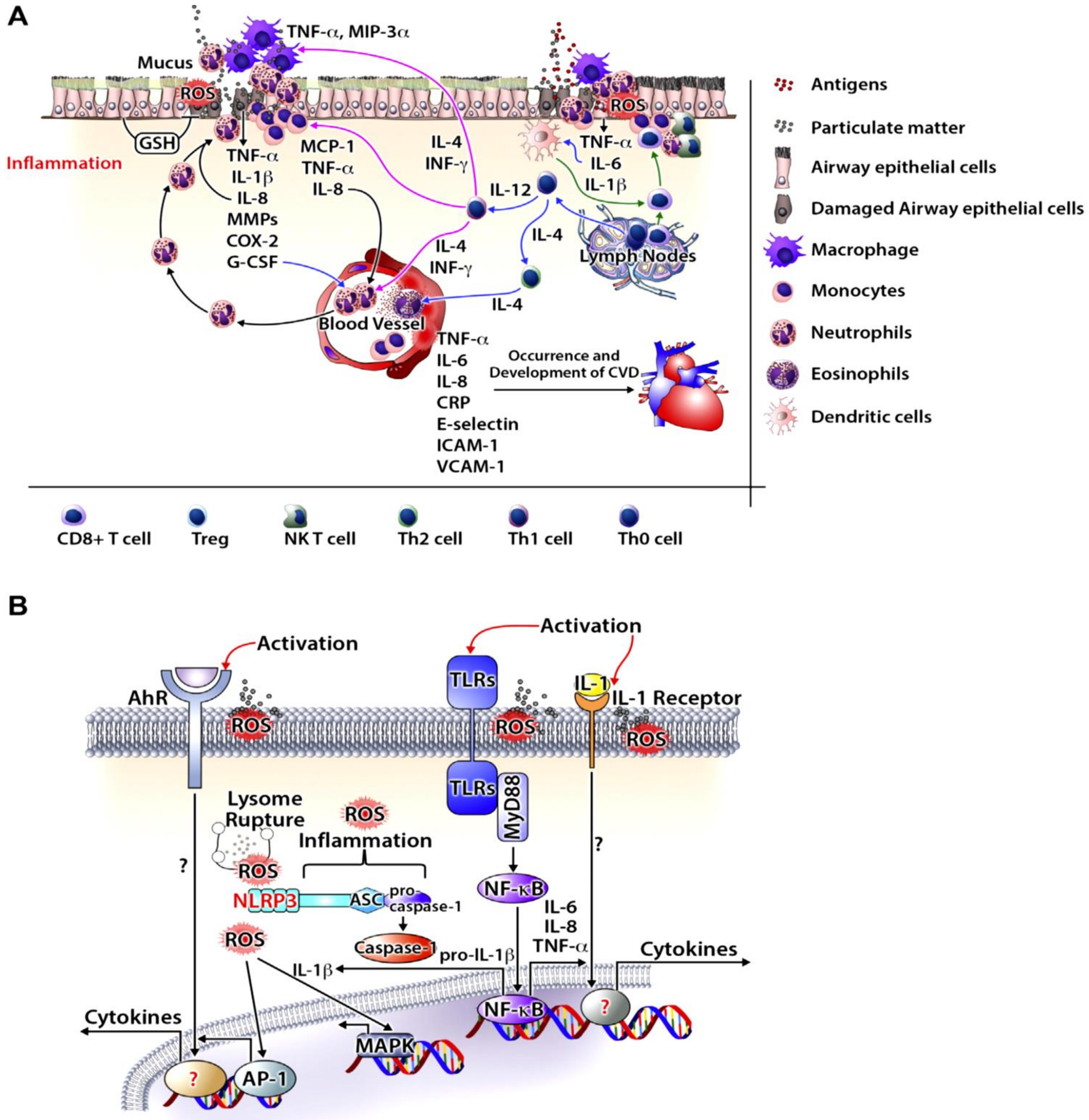
2.2.2.3 Carcinogenicity

Heavy metals, dioxins, and other pollutants have a negative impact on cell function because they bio accumulate and interfere with normal cell function (PK, 2015). Metals in their ionic form are more reactive chemically and easily to interact with biological systems in a variety of ways, such as cadmium and mercury, which can readily attach to sulphur in proteins. Aside from that, they are known to mimic and replace essential metals, such as cadmium can substitute zinc, and arsenic, which mimics phosphate. The processes are known as the cause to oxidative stress, resulting in oxidative modification of biomolecules, which may be a critical step in the initiation of cancer cells.



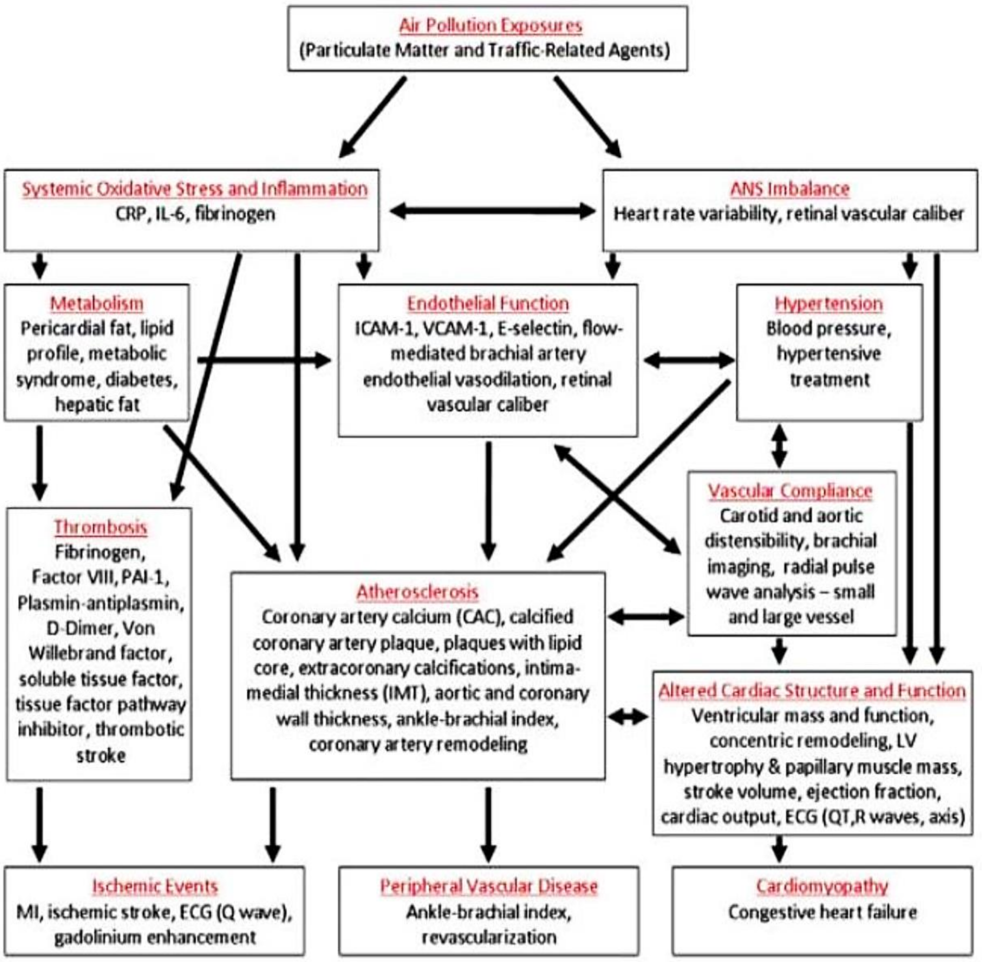
Source: the study from inflammatory health effects of indoor and outdoor particulate matter by Iidong Wu, et al, 2018

Figure 1 The illustration of Schematic Pathways the of Effect of PM2.5 Exposure on the Respiratory and Systemic through Inhalation Process



Source: the study from inflammatory health effects of indoor and outdoor particulate matter by Iidong Wu, et al, 2018

Figure 2 The Pathways of Cellular of Inflammatory due to Effects by Combustion Activities-Derived PM Exposure



Source: Gill et all, 2011. Air Pollution and Cardiovascular Disease in the Multi-Ethnic Study of Atherosclerosis

Figure 3 Potential Mechanism of Cardiovascular and Stroke Even Caused by Air Pollution

2.3 Health Impact Assessment tools

Health Impact Assessment (HIA) is a method used to focus on public health sectors as a respond for the effects of pollutant exposure. HIA is an estimation methodology that focuses on analyzing the changes in health impacts with certain pollutants. As a prediction of the impacts for variety of policy and regulation options, has been applied to identify the entire burden of disease from the exposure of pollutants. With the result of HIS, policy makers will receive necessary information to create and legitimate actions plans with purpose to reduce the number of harmful impacts pollutant exposure in human life and environment (Hassan Bhat, 2021). The governmental, intergovernmental, and nongovernmental organizations over the last decade have invested in tools that are better able to meet the growing demand for more specific and timely information about the health effects of air pollution exposure. The tools of health risk assessment of pollutant exposure are identically as preloaded with health and demographic data as well as the association on concentration-response, though some do allow for user-specified inputs air pollution assessment tools have different methods and benefits when it can lead user to work easier, accessible, and has consistency and good quality of the result. Some of these tools include built in air pollution exposure data that connects emissions to the exposure metric, requiring users to enter only information about emission changes; others read in user-specified exposure estimates. The analyses typically begin with key demographic and economic data of the relevant geographic area and population, including per capita income, health-care delivery systems, smoking prevalence, climate (including use of air conditioning), use of combustion sources indoors (e.g., for cooking and heating), and the nature of the air quality monitoring system. The availability of high-quality data set for these parameters varies depending on context, such as country and spatial scale. (Susan C. Annenberg et al, 2016).

Health Impact Assessment tools can help to estimate negative impact air pollutant exposures to population. The United States Environmental Protection Agency created the Environmental Benefits Mapping and Analysis Program (BenMAP-CE) in part to help the Office of Management and Budget and the Clean Air Act fulfill requirements to characterize the benefits and costs of U.S. air pollution regulations (Hubbell BJ et al, 2005). This program initially published in 2003, and has focus to estimate the health and economic benefit of attaining recent situation and potential future National Ambient Air Quality Standard (NAAQS). The program also can be used to predict the potential public health impact of improving air quality in multiple research efforts. Followed to analyze the impact of air pollutant to human health, World Health Organization also introduces a program as a contribution to reduce and increase the quality of human health. The program named Air Q+ software that originally started in 1999, and was developed as a success building in 2016. The program have specific target to reflect the current state of the science on the health effects of air pollution, ensuring that researchers and governmental officials worldwide have access to a tool to inform and ultimately support actions to improve air quality, and providing a large audience with an educational tool that includes summaries of the information that needs to be gathered and organized to understand the health impacts of air pollution (WHO, 2001). The tool, which is in the form of software, is intended for any stakeholder who wishes to conduct an HIA. To conduct an impact assessment, concentration and population data must be entered. In addition, an incidence rate for the chosen health indicator should be included. RRs and counterfactual levels are initially set to default values but can be changed. As a result, the tool can be used in any population where relative risks have been determined through epidemiological studies. Because the majority of scientific evidence comes from studies in these regions, the tool's default RRs make it usable for populations in Western Europe and North America. The HRAPIE project has reviewed these default RRs .However, the two health indicators 'Mortality due to ALRI for children (0-5 years) due to PM2.5and 'Mortality, all (natural causes) due to BC were not reviewed in the HRAPIE project, and there is no reference to the default relative risks in the tool. The WHO AQG is used as the default counterfactual value, but this can be changed. Many morbidity and mortality health indicators are included in the software, but each health indicator requires a separate analysis. As a result, conducting a comprehensive HIA that includes all available health indicators is time consuming. The Air Q+ tool also allows the user to perform life table calculations to calculate the decline in life expectancy, provided that population and mortality hazard rates for age groups of at least five years are known.

Table 1 Health Impact Assessment Tools Comparison

Tool	Provider	Area of Study	Advantages	limitations
Air Quality (Air Q+)	World Health Organization (WHO)	Iran, Italy	City Level : + The Output have Rich Model: + Different kind of pollutant: + Have Adjustable parameter: + Up-to-date value of RRs : + Accessibility in general : + Requires to Modest data : + Could assess health impact in indoor and outdoor air pollution Estimate the quantity of the risk of cancer, and including additional features for the value of unit risk for Chromium, arsenic, nickel, benzene, vinyl chloride and benzophyrene. The software has Multilanguage version	The relationship between Evidence-Based health outcome are not really strong, particularly for some kind of pollutant such NO2, BC, and Ozone.
Environmental benefit mapping and analysis program-community edition (BenMap-	The United States Environmental Protection Agency (USEPA)	USA, Turkey, Spain	City Level : + The Output have Rich Model : + Different kind of pollutant: + Have Adjustable parameter:	Estimation of health impacts because of air quality are restricted to just a one year period, it cannot be a multiple-year assessment.

CE)			+ Up-to-date value of RRs : - Accessibility in general : + Requires to Modest data : + The CFRs has been merging with the basic pooling strategies, for example the random effect and fixed effects. It has purpose to build new function which it can emphasis the considering the diverse of data demographics.	
Co-Benefit Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool	The United States Environmental Protection Agency (USEPA)	USA	City Level : - (Country level) The Output have Rich Model: + Different kind of pollutant: + Have Adjustable parameter: + Up-to-date value of RRs : - Accessibility in general : + Requires to Modest data : + Provide the estimation of health and economic impact more detailed and comprehensive, which it is related to the decreasing PM 2.5 concentrations in the atmosphere on given year of the study.. Can help researcher create a new scenario to suggest the improvements in air pollution control through the baseline of smoothly and efficiently of emissions.	Whole concentration of the pollutants is in The US, it making more challenging to conduct in other nations. Then, the matrix also does not describe the interaction which takes place in the environment between the all kinds of pollutant.
Greenhouse gas-Air Pollution	International Institute for Applied	European countries	City Level : - The Output have Rich	The health assessment just according to general

Interactions And Synergies (GAINS) model	Systems Analysis (IIASA)		Model: - Different kind of pollutant: - Have Adjustable parameter: - Up-to-date value of RRs : + Accessibility in general : +/- Requires to Modest data : + The software has comprehensive transport model and chemistry in the atmosphere which it can stimulate physical and chemical reactions more complex.	RR values that received from epidemiological study by European and American, which is not really appropriate and accurate for other region. The dispersion model of this software also basic linear function based on regression of TM5. Hence it has uncertain result and irrelevant of the responds.
Combination of AIR Q+ and BenMap-CE				
Household Air Pollution Intervention Tool (HAPIT)	Household Energy, Climate And Health Research Group At The University Of California, Berkeley	India	City Level : - The Output have Rich Model: + Different kind of pollutant: - Have Adjustable parameter: + Up-to-date value of RRs : - Accessibility in general : + Requires to Modest data : + Simple tool, and could help user to estimate the DALYs, premature death average, and intervention for cost-effectiveness Provides the informative of total number household in the intervention, the concentration of PM 2.5 pre and post intervention, the	The result provides just the estimation of short impact, cannot explain in long term. The level of exposure among household members can change.

			mean of population proportion in order to estimate the cost per intervention.	
Ecosense	Institute of energy economics and rational energy use (IER), University of Stuttgart	Greece France, Brazil	City Level : n/a The Output have Rich Model: n/a Different kind of pollutant: n/a Have Adjustable parameter: n/a Up-to-date value of RRs : n/a Accessibility in general : - Requires to Modest data : n/a Comprehensive estimation the impacts of air pollution exposure to health of human and the ecosystem. Provides the robust database, such as details of the major pollutant, heavy metals, and hydrocarbon.	The software performs a non-linear behavior in nature because of the usage of simple linear source-receptor models to assess the chemistry interaction in the atmosphere.
Aphekom	France Institute of Public Health Surveillance	25 European Cities, 10 European Cities,	City Level : + The Output have Rich Model: - Different kind of pollutant: +/- Have Adjustable parameter: + Up-to-date value of RRs : - Accessibility in general : + Requires to Modest data : +	
HEAT	WHO		City Level : + The Output have Rich Model: - Different kind of pollutant: -	

			Have Adjustable parameter: + Up-to-date value of RRs : + Accessibility in general : + Requires to Modest data : -	
TM5-FASST	JRC Ispra (taly)	China, Multinational Study	City Level : + The Output have Rich Model: n/a Different kind of pollutant: + Have Adjustable parameter: n/a Up-to-date value of RRs : + Accessibility in general : - Requires to Modest data : n/a Simple and friendly used for user.	The present version of TM5-FASST have a missing on SR relation, hence it might arise a bias when estimate PM2.5 and Oz pollutant.
GGD	Dutch Public Health Services	Netherland	City Level : + The Output have Rich Model: + Different kind of pollutant: + Have Adjustable parameter: + Up-to-date value of RRs : + Accessibility in general : + Requires to Modest data : + Provide pragmatic interface system The tool has display such the spreadsheet of excel system, which only show a few of number that have to be input. For that, user can receive at glimpse of effects of all air pollutant and the indicator of	Applicable for Netherland. There fixed number of age, incidence, and RR of Dutch information, it that can be traced in model but cannot be changed

			health.	
SHERPA			City Level : + The Output have Rich Model: - Different kind of pollutant: - Have Adjustable parameter: - Up-to-date value of RRs : + Accessibility in general : + (European country) Requires to Modest data : + This software provides data input model use RIAT+ to integrate the modeling system of assessment for measuring cost effectiveness.	Assess PM 2.5 ONLY
IOMLIFE			City Level : + The Output have Rich Model: - Different kind of pollutant: + Have Adjustable parameter: + Up-to-date value of RRs : + Accessibility in general : + Requires to Modest data : +	
The Simple Interactive Model for better Air Quality (SIM-air)	Urban Emissions	India, Europe	City Level : + The Output have Rich Model: + Different kind of pollutant: + Have Adjustable parameter: +	The analysis of spatial resolution matching project is uncertain, mainly for urban area assessment.

			Accessibility in general : + Requires to Modest data : + Multiple benefit analysis (Environmental-economic-health) assessment of the climate changes actions.	

2.4 Recent studies in the air pollution health risk assessment

Table 2 Previous Study Using Air Pollution Health Risk Assessment Tools

1.	Title	Apheis: Health impact assessment of long-term exposure to PM2.5 in 23 European cities
	Citation	Author: Elena Boldo1 et al (Boldo, 2006) Published in 2006
	Objective & Method	Quantified the PH impact of long-term exposure to PM2.5 (particulate matter <2.5) in terms of attributable number of deaths and the potential gain in life expectancy in 23 European cities. HIA used Air Q+ software
	Result	The result of HIA have estimated the reduction of premature death for all causes was 16,926 cases, for cardiopulmonary death was 11,612 cases, and lung cancer at 1901 could be obtained if annual concentration of PM 2.5 exposure could be reduced at 15 $\mu g/m^3$ for each city in Europe
2.	Title	An Assessment of Annual Mortality Attributable to Ambient PM2.5 in Bangkok, Thailand
	Citation	Author : Nathniel R. Folda et al (Fold, 2020) Published in 2020
	Objective & Method	Investigated annual mortality associated with PM2.5in Bangkok based on available air quality monitoring data. BenMAP-CE
	Result	The findings showed if the annual PM2.5concentration would be decreasing in Bangkok to the Thai NAAQS and WHO air quality standards, the estimation of a consequential reduction

		premature mortality attributable to PM2.5exposure could be obtained at 1393 and 3159.
3.	Title	Health impact assessment of a reduction in ambient PM2.5 levels in Spain
	Citation	Author: Elena Boldo et al (Boldo, 2010) Published in 2011
	Objective & Method	To estimate the association the number of attributable deaths with reducing PM2.5levels in Spain. Used BenMap-CE
	Result	The findings of this study described the improvement of air quality when the annual average PM 2.5 was reduced to be 0.7μg/m^3. The analysis of long term health impact assessment used BenMAP estimated the reduction at 1720 of all cause of death with (or 6 people per 100,000 population) in group people age 30+ years, and at 1450 was accounted for the decreasing all cause of death in people age 25-74 years old. It could limit annual mortality rate.
4.	Title	Estimation of long-term and short-term health effects attributed to PM 2.5 standard pollutants in the air of Ardabil (using Air Q + model)
	Citation	Author: Mina Moradi et all (Moradi, 2021) Published in 2021
	Objective & Method	To analyze the estimation the health impact attributed to PM2.5pollutants in the atmosphere of Ardabil in 2018 used Air Q+ model
	Result	The findings described that the average annual concentrations of PM2.5and PM10, and the total number of deaths due to ALRI, COPD, lung cancer, IHD, and stroke deaths on average during the study period. In some condition when the PM 2.5 and PM 10 concentration increasing just above 5 μg/m^3, it was estimated the total number of attributed cases and number of attributed cases per 100,000 population due to cardiovascular diseases (with moderate RR and CL at 95%) cardiovascular diseases was responsible for103 people and 42.19 people. Then, the attributed proportion, the total number of attributable cases, and the number of attributable cases per 100,000 population for the

		hospital case of people with respiratory disease (with moderate relative risk and confidence of 95%) for the number of admission for respiratory diseases have been estimated respectively at 97.1%, 68 people and 3 people.
5.	Title	Cardiovascular, respiratory, and total mortality ascribed to PM 10 and PM 2.5 exposure in Isfahan, Iran
	Citation	Author: Ali Abdolahnejad, et al (Abdolahnejad A, 2017) Published in 2017
	Objective & Method	To analyze the estimation of particulate matter 2.5 and PM 10 attribution in the prevalence of cardiovascular and respiratory diseases, and premature deaths in Isfahan in one year(from 2013 to 2014) Used Air Q+ Model
	Result	The result provided the number of estimation deaths due to PM2.5exposure was 670 cases, and at 713 cases caused by PM10 exposures. Then, The number of annual deaths due to cardiovascular and respiratory diseases related to PM 10 respectively was 316 and 68 cases.
6.	Title	Quantifying the Public Health Benefits of Reducing Air Pollution: Critically Assessing the Features and Capabilities of WHO's AirQ+ and U.S. EPA's Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP – CE)
	Citation	Author: Jason D. Sacks et al (Sacks, 2020) Published in 2020
	Objective & Method	Analysis the health impact assessment of air pollution using AirQ+ and BenMAP – CE software with common input parameters. Used BenMAP-CE and Air Q+ tools
	Result	BenMAP – CE and AirQ+ software resulted almost identical for the core estimation at the integer level with minimal differences at digit at the decimal level. Additionally, to the primary result, or central estimation, both of the software have confidence intervals that bounding the main result
7.	Title	Analysis of PM2.5Using the Environmental Benefits Mapping

		and Analysis Program (BenMAP)
	Citation	Author: Kenneth Davidson, et al (Davidson, 2007) Published in 2007
	Objective & Method	Demonstrated the estimation of attributed health impact to PM 2.5 exposure using BenMAP model. Used BenMAP-CE software.
	Result	The decreasing of deaths cases related when average PM 2.5 concentration was dropped to 15 μg/m3.

CHAPTER III RESEARCH METHODOLOGY

3.1 Research Design

The research study is a descriptive cross-sectional study. Air Q+ Software was used to elaborate the changes and health impact of air pollution PM 2.5 in Thai population. This study analyzed PM2.5 concentration and health impact data from 1st January 2019 until December 31st, 2019. The whole data has been considered on calculation of the estimated short- and long- term of PM 2.5 exposures to Thai Population. The data analysis has been done from March to May 2022.

3.2 Study Area

The study has been conducted in Thailand composed 77 provinces in all 6 regions: Bangkok Metropolitan Region (BMR), Central Region, West Region, East Region, Northeast Regions, and Northern Region with 77 Provinces. Total area of Thailand is 510,890 km^2 or at 197,256 square miles. The total country size and specific area size of each province have been input to Air Q+ software.

3.3 Data Collection Methods

3.3.1 The data of PM 2.5 Concentration

The daily data of PM 2.5 concentration during 1st January until 31st December 2019 in this study was employed from Thai NAAQS PM 2.5 revision project. Regarding to the project, the real-time hourly PM2.5 concentration during 1st January until 31st December 2019 was collected from the Division of Air Quality Data, Air Quality and Noise Management Bureau, Thailand Pollution Control Department. The data of air quality concentrations were obtained from 70 air stations.

For missing data, the values were calculated using the single imputation technique. The mathematical convention of 0 degrees and 360 degrees indicating the same wind direction was used. The mean of the cosines and sinus of each angle was calculated in order to determine the mean of the series of angles in the interval 0°-360° and find the angle by calculating the inverse tangent. To construct the interpolations of air pollutant measurements data of each district, the Ordinary Kriging Technique was used, considering the data from each monitoring station by date. The daily data of PM 2.5 concentration in each province was calculated from an average of district concentration. A Kriging equation using the following expression;

$$\gamma(h) = \frac{1}{2M(h)} \sum_{i=1}^{M(h)} \{Z(x_i) - Z(x_i + h)\}^2$$

where γ(h) is the estimated semi-variance at a separation distance; z(xi) and z(xi+h) are the observed values at xi and xi+h separated by h, of which there are M(h) pairs (Wong et al., 2004).

3.3.2 Population

Data of total population at national level and specific province in 2019 was collected and included on analysis. The total Thai population was accounted for 66,558,935 in 2019. This study analyzed the health impacts in Thai population which focused on population at risk particularly adult ages ≥30 years old were accounted for 40,572,731 or 60,957.6 per 100,000 populations. Hence, total adult both male and female ages ≥30 years old in 2019 were calculated on this study. All data of population was obtained from National Statistical Office of Thailand.

3.3.3 The Data of Diseases and Mortality Cases in Population

The data about selected health end-point from January-December 2019 for short- and long-term impact analysis have been taken from The Strategy and planning division, Office of the Permanent Secretary Ministry of Public Health, Thailand. This center collected whole data of population from all health care facilities, including Public and Private Hospitals in Thailand. The data related hospital admission of respiratory disease cases, hospital admission of cardiovascular disease cases, Chronic Obstructive Pulmonary Diseases (COPD), Ischemic Heart Diseases (IHD), stroke, and mortality of all-natural cases Were collected. Air Q+ tools provides spaces for calculation between total morbidity and mortality cases related the assessment of estimation health impacts on this study and total population at risk, where the result was used to describe the Baseline Incidence (BI) in each city per 100,000 adult age ≥ 30 years. The data for short-term health end-point such as restricted activity days (RADs) all ages and work days lost for working age population only, and long-term impact including mortality due to Acute Lower Respiratory Infection (ARLI) in children ≤5 years old and Mortality due to lung cancer are excluded for this study.

3.3.4 Relative Risks (RRs)

The estimation of short and long-term health effects of the pollutant PM 2.5 needs pre-load data set including Relative Risks (RRs) value. The recent study employed RRs value from meta-analysis studies that were conducted by Thailand NAAQS PM 2.5 revision project and studies are provided by WHO air pollution guideline in 2021.

Briefly, the Thai NAAQS PM 2.5 revision project conducted a "Systematic review and meta-analysis for the association between short-term and long-term PM2.5 exposure on mortality and morbidity in Asian Countries". A short-term respiratory morbidity and cardiovascular morbidity were analyzed based on 32 and 29 published articles respectively. In the analysis, the published article in January 2011 - December 2020 with case-crossover, ecological study, and cohort study were included. These analysis data are unpublished.

Table 3 Relative Risks (RRs) Values

Health Indicators		RR Values (95% CI) per 10 μg/m^3	Source
Short-term Analysis	Respiratory morbidity Hospital Admissions, Respiratory diseases ICD-10 health database code J00–J99	1.0056 [1.0043; 1.0070]	Thai NAAQS PM 2.5 revision project
	Cardiovascular Morbidity Hospital admissions, cardiovascular diseases ICD-10 health database code I00–I99	1.0039 [1.0029; 1.0049]	Thai NAAQS PM 2.5 revision project
	Mortality due to all nature causes ICD-10 health database code A00-R99	1.0065 (1.0044;1.0086)	Orellano et al, 2020
Long-Term Analysis	Mortality due to all nature causes ICD-10 health database code A00-R99	1.08 (1.06;1.09)	Chen & Hoek, 2020

3.3.5 PM 2.5 Concentration Cut-off Values

The Air Q+ software requests the average of daily and annual concentration of air pollution as cut-off which used to estimate the health effect attributed short- and long term PM2.5 exposure. This study applied recommendation from World Health Organization in Air Pollution Guideline in 2021, The United States Environmental Protection Agency (USEPA) standard, PM 2.5 national standard in Thailand following study year in 2019, and purposed standard by Thai NAAQS PM 2.5 revision project.

Table 4 Cut-Off Values

Cut Off for Short-Term Analysis		Cut Off for Long-Term Analysis	
Option 1: 37.5 ug/m^3	Interim target-3 daily standard by WHO Air Pollution Guideline in 2021	Option 1: 15 ug/m^3	Interim target-3 annual standard by WHO Air Pollution Guideline in 2021
Option 2: 15 ug/m^3	Gold standard daily AQG Level WHO Air Pollution Guideline in 2021	Option 2: 5 ug/m^3	Gold standard annual AQG Level WHO Air Pollution Guideline in 2021
Option 3: 35 ug/m^3	United State PM 2.5 Daily standard provided US EPA 2016	Option 3: 12 ug/m^3	United State PM 2.5 Annual standard provided US EPA 2016
Option 4: 50 ug/m^3	Thai PM 2.5 Daily NAAQS in 2019	Option 4: 25 ug/m^3	Thai PM 2.5 Annual NAAQS in 2019
Option 5: 25 ug/m^3	Daily standard interim target-4 by WHO Air Pollution Guideline in 2021	Option 5: 15 ug/m3	Annual standard interim target-4 by WHO Air Pollution Guideline in 2021
Option 6: 37 ug/m^3	Purposed daily standard by Thai NAAQS PM 2.5 revision project	Option 6: 20 ug/m^3	Purposed annual standard by Thai NAAQS PM 2.5 revision project

**The cut-off values following the standard in 2019 that updated during period of study until June of 2021*

3.4 Data Processing and Analysis

The data has analyzed using two different software including Statistical software and AirQ + software.

3.4.1. IBM Statistical Package for Social Science (SPSS)

IBM Statistical Package for Social Sciences (SPSS) version 22.0 analyzed the data of total population, the number of hospital admission, and the number of mortality cases. The data have been tested to elaborate the normality of data and summary descriptive statistic particularly for frequency distribution, proportion, mean, minimum, maximum, and standard deviation.

3.4.2. Microsoft Excel 2010 Version

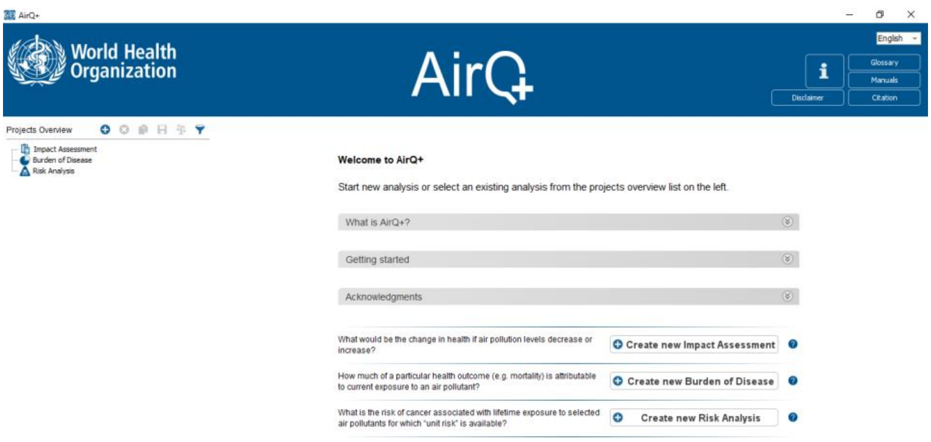
The software checked the duplication and missing data on daily PM2.5 concentration for each province. The average of daily and annual concentration PM2.5 also has been analyzed through MS Excel.

3.4.3. Air Q+ software

World Health Organization (WHO) Regional Office for Europe provided this program in 2016. The purposes are to evaluate changes of the average air quality, and analyze the short-term and long term impacts to health of society. Using this software, the pollutants including PM2.5 and 10, NO2, O3, and black carbon can be managed. It was designed more simply to follow the route strategies regard to estimation of the short and long-term impact. The Air Q+ software apply mathematical and integration, which it will use at least 40,000 elements matrix calculations, logarithm functions and statistical functions. It can be used to estimate the how much the particles of the air pollutant impact to human health. Air Q+ Software tool performs the calculation which allows the number of the health effects because of the exposures of air pollutants, including estimates of the reduction in life expectancy. The short exposure effects will be estimated based on the risk estimates from time-series studies, whereas the impact of long exposure comes from life-tables approach and based on risk estimates from cohort studies. The analysis the amount of a particular health effect is attributable to selected air pollutants, and what would be the change in health effects if air pollution levels changed in the future can be analyzed. There are different health outcome with morbidity and mortality assessments which necessarily for a technical background or an expertise in air pollution control and health risk management for some country.

3.4.3.1 Installation Air Q+ Software

The first step to run the software, user can click two times on AirQplus.jar which will automatically install. The application used technology that has Java based, and it could operate alone that compatibility with Window system start from 7 to the update version, Linux or Ubuntu, and Apple Machintosh. The Air Q+ software is possible to operate with combination input and output on ‘CSV’ files data. It is because the process and stores of this software using the numerical value that using decimal points, hence it will work even the setting of language and format of number are different. Using ‘CSV’ files, it stands for the value that separated by comma. However, it could make user has the confusion, because a decimal that are used by commas became separator in various languages. To separate the character, Air Q+ used semicolon sign (;), for instance-7.5;8.002;17.3. this software can be easily operated without internet connection. The result will be automatically saving and presenting in the tree of project. Figure 6 displays the first-time used Air Q+ window.



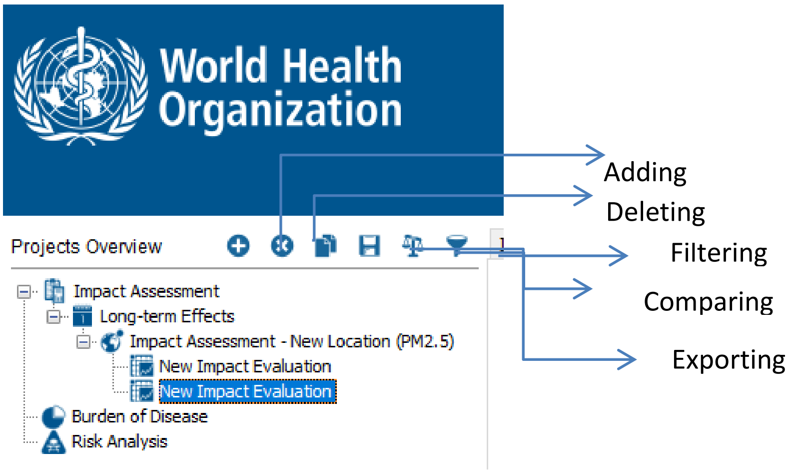


Figure 4 The Display of Starting Window of Air Q+ Software

As a differentiation of the codes in this software, the four colors are used to define the type of data entry, where will be explained in table 5.

Table 5 Description of color in Air Q+ Software

Color	Description
White	This color describes the analysis properties of the tab that represented the optional of data.
Green	This color describe the correction of values which compulsory and voluntary part. Mandatory sections important to be filled for Air Q+ software assessment.
Yellow	Optional fields that are recommended to fill due to purpose of documentation process. For the computation, the voluntary section is not fundamental to be filled
Red	In some condition when the supplied of mandatory fields are incorrect values, the sections will be turn on red color. To illustrate, the mean of concentrations must not be negative values.

3.4.3.2 Data Input in Air Q+ Software

The next process after user installed the software is need to input the main three data categories, including 1) the ambient air pollution, 2) the number of population, 3) two option of the effects from the particular pollutant which will be followed by input the average concentration. The options are short-term or frequent of daily exposure and long-term or annual exposure. Figure 7 shows the window of analysis options

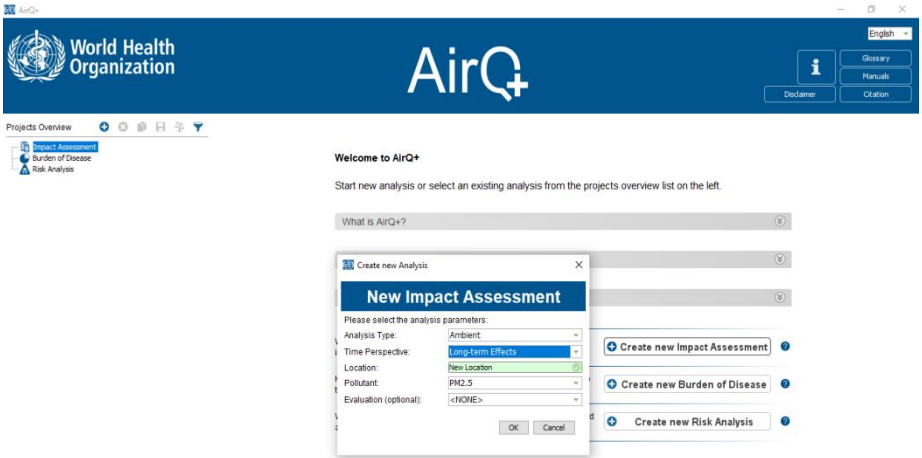


Figure 5 The Window of Baseline Data Input for Air Q+ Software

On the window of health impact assessment processing, user need to input the mandatory columns. Therefore, the data of the specific target population, the standard or cut-off value of pollutant in µg/m3 as a consideration, and the Relative Risk (RR) that must be filled (Figure 8). On this study the Relative Risk was received from a meta-analysis under a Revised National Ambient Air Quality Standard for Particulate Matter (PM2.5) Project, which it become a numerator of the health impact of targeted population per concentration unit of a particular air pollutant.

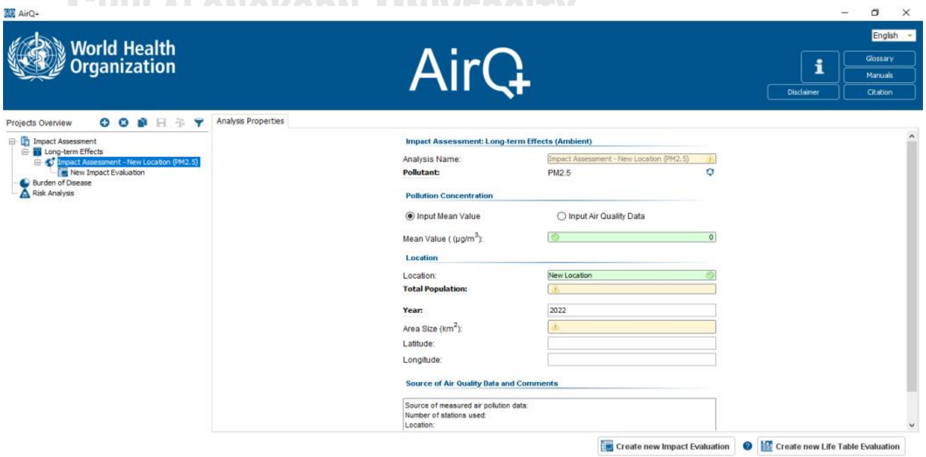


Figure 6 The First Page of Input Data Use with Mean Value of Health Risk Assessment Processing in Air Q+ Software Model.

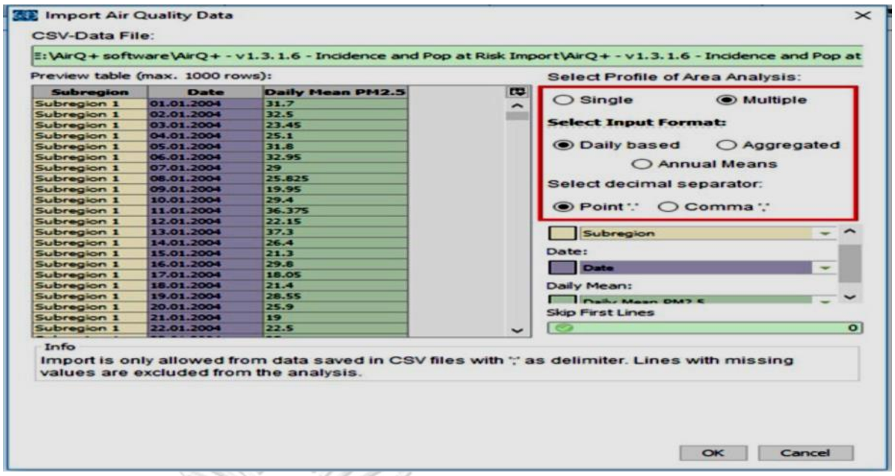


Figure 7 The First Page of Input Data Use with Air Quality Data of Health Risk Assessment Processing in Air Q+ Software Model

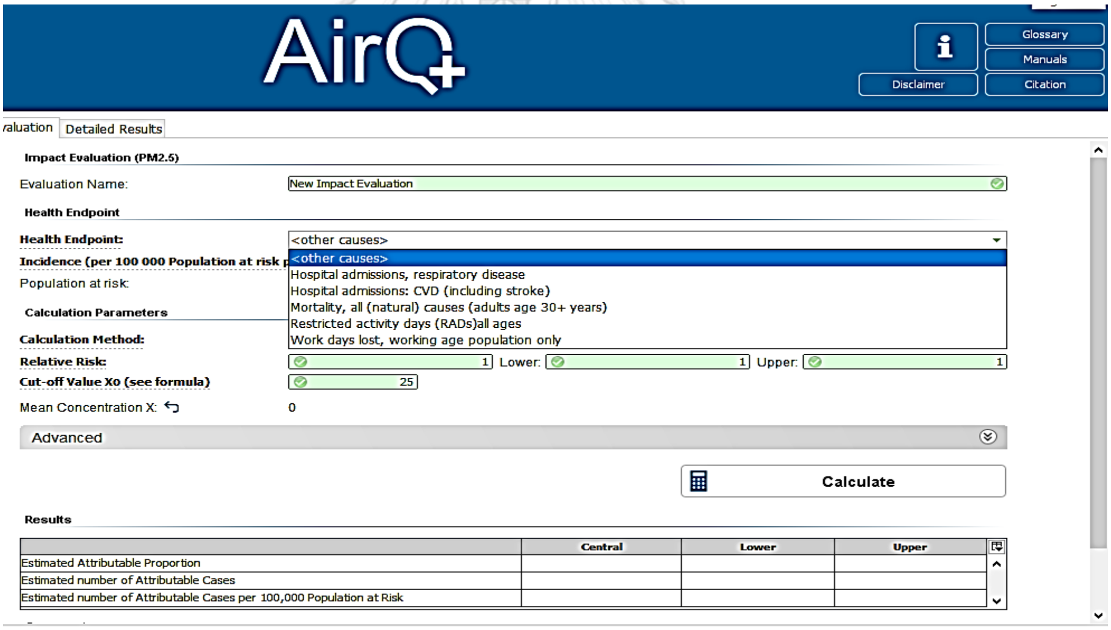


Figure 8 The Diagram Flow of Short-Term of Health Risk Assessment Processing in Air Q+ Software

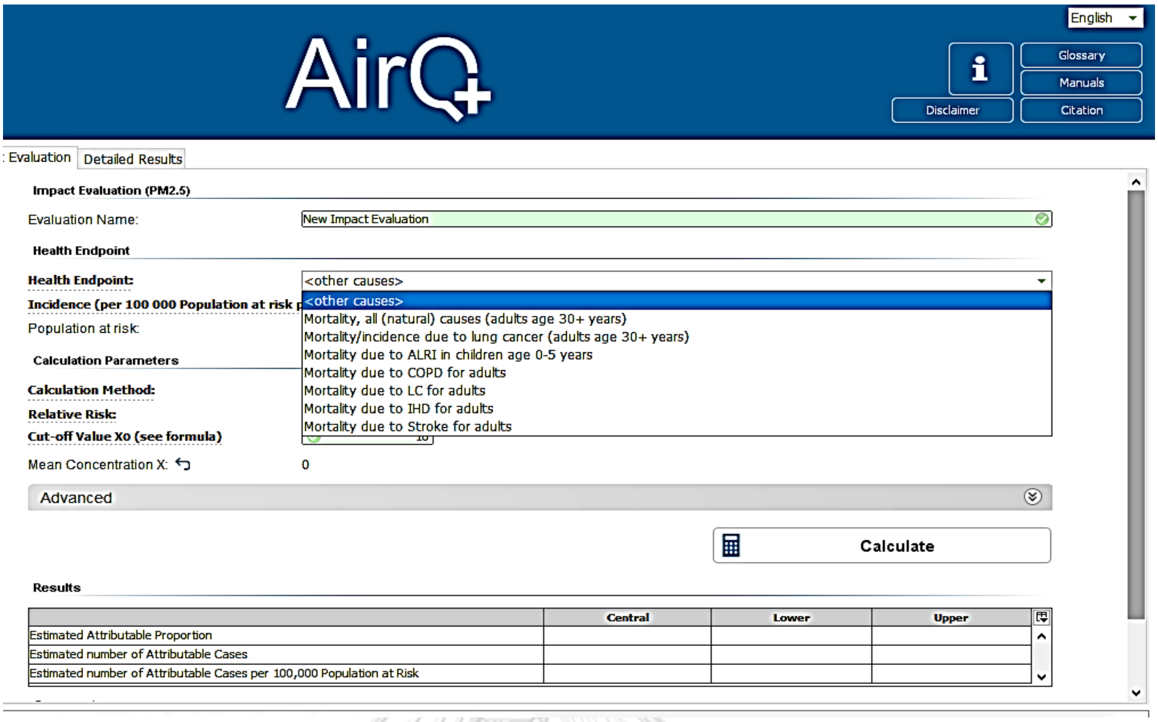
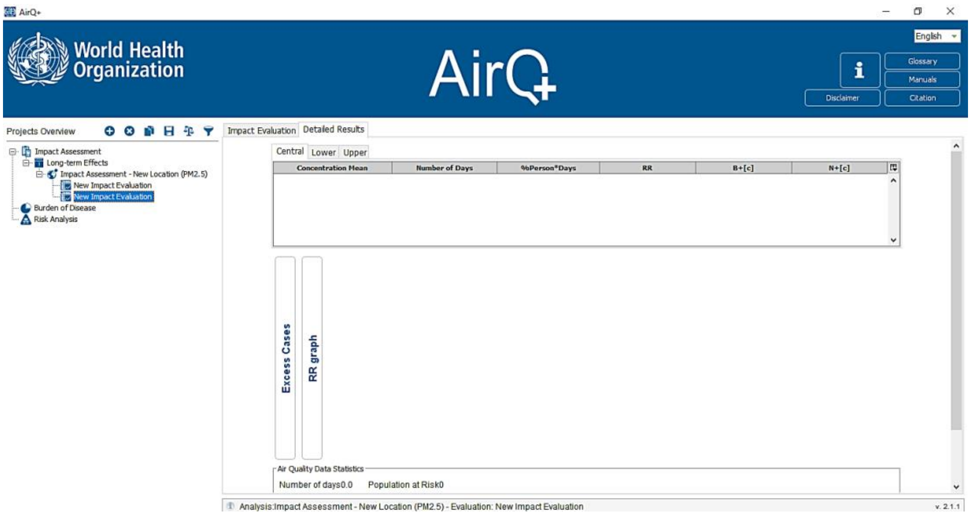
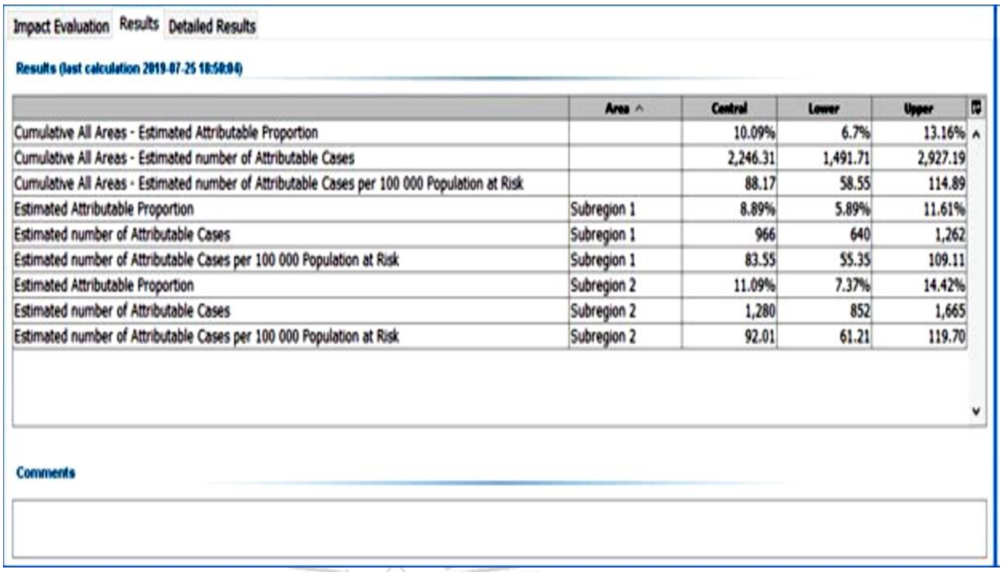


Figure 9 The Diagram Flow of Long-Term of Health Risk Assessment Processing in Air Q+ Software

After user input all data and click the process of analysis the impact, it will guide to the next process in order to acquire the output of the software assessment. As the result, user will obtain the estimation of the attributed proportion, the number of attributed cases, and the number of attributed cases per 100,000 populations at risk that will be illustrated in figure 9.





	Area	Central	Lower	Upper
Cumulative All Areas - Estimated Attributable Proportion		10.09%	6.7%	13.16%
Cumulative All Areas - Estimated number of Attributable Cases		2,246.31	1,491.71	2,927.19
Cumulative All Areas - Estimated number of Attributable Cases per 100 000 Population at Risk		88.17	58.55	114.89
Estimated Attributable Proportion	Subregion 1	8.89%	5.89%	11.61%
Estimated number of Attributable Cases	Subregion 1	966	640	1,262
Estimated number of Attributable Cases per 100 000 Population at Risk	Subregion 1	83.55	55.35	109.11
Estimated Attributable Proportion	Subregion 2	11.09%	7.37%	14.42%
Estimated number of Attributable Cases	Subregion 2	1,280	852	1,665
Estimated number of Attributable Cases per 100 000 Population at Risk	Subregion 2	92.01	61.21	119.70

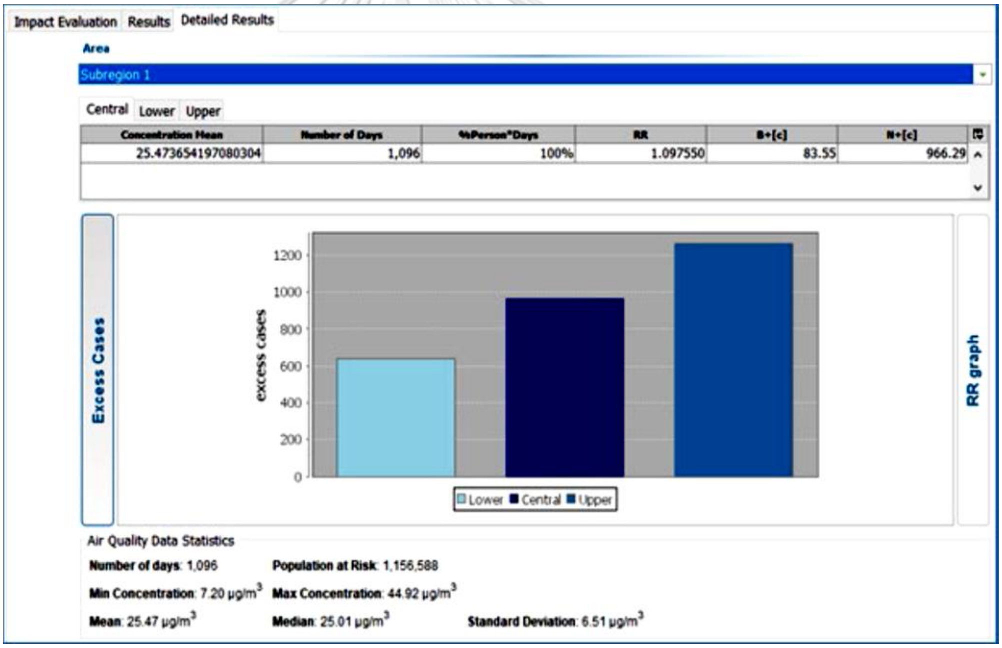


Figure 10 The Result of Estimation Health Risk Assessment Using Air Q+ Software Model

3.5 Data Input framework

3.51 Short-Term Impact Assessment

Input Data

1. Mean concentration (Province-specific)
    - Specific Mean values of PM2.5 daily in a year(μg/m^3)
    - Total population in a year
    - Area sizes (km^2)

2. Health data (Province-specific)
    - The number of Hospital Admissions due to Respiratory disease in a year
    - The number of Hospital Admissions due to Cardiovascular disease (CVD) (including stoke) in a year
    - The number Mortality cases, due to all-natural cause (adults age 30+ years) in a year

3. Relative Risk (from Meta-analysis) (Province-specific)
    - Hospital Admissions, Respiratory disease
    - Hospital Admissions, Cardiovascular disease (CVD) (including stoke)
    - Mortality, all natural cause (adults age 30+ years)

4. Cut-off value of PM2.5 daily (1 year)
    - Option 1: 37.5 μg/m^3 (Interim target -3 : WHO)
    - Option 2: 15 μg/m^3 (WHO gold standard 2021)
    - Option 3: 35 μg/m^3 (US EPA)
    - Option 4: 50 μg/m^3 (Current Thai Standard)
    - Option 5: 25 μg/m^3 (WHO interim target- 4 standard 2021)
    - Option 6: 37 μg/m^3 (purposed standard)

→

Outcomes

Results (Province-specific)

- Attributed Proportions for Hospital admission estimations: Respiratory Diseases, Hospital admission CVD(Include stroke), all natural cause of Mortality adults age 30+ years)
- Estimated number of Attributable Cases for Hospital admission: Respiratory Diseases, Hospital admission CVD(Include stroke), all natural cause of Mortality adults age 30+ years)
- Estimated number of Attributable Cases per 100,000 population at risk for Hospital admission: Respiratory Diseases, Hospital admission CVD(Include stroke), all natural cause of Mortality adults age 30+ years)

Interpretation

“ xxxx premature death could be avoid if “cut-off values”

3.52 Long-Term Impacts Assessment

Input Data

1. Mean concentration (Province-specific)
    - Specific Mean values of PM2.5 annually in a year($\mu g/m^3$)
    - Total population in a year
    - Area sizes (km^2)

2. Health data (Province-specific)
    - The number Mortality cases, due to all-natural cause (adults age 30+ years) in a year
    - The number of Mortality cases due to COPD for adults +30 years in a year
    - The number of Mortality cases due to IHD for adults +30 years in a year
    - The number of Mortality cases due to Stroke for adults +30 years in a year

3. Relative Risk (from Meta-analysis) (Province-specific)
    - Mortality, all natural cause (adults age 30+ years)
    - Mortality COPD for adults
    - Mortality IHD for adults
    - Mortality Stroke for adults

4. Cut-off value of PM2.5 annually (1 Year)
    - Option 1: 15 $\mu g/m^3$ (Interim target -3 : WHO)
    - Option 2: 5 $\mu g/m^3$ (WHO gold standard (AQG Level) 2021)
    - Option 3: 12 $\mu g/m^3$ (US EPA 2016)
    - Option 4: 25 $\mu g/m^3$ (Current Thai Standard)
    - Option 5: 15 $\mu g/m^3$ (WHO gold standard 2021)
    - Option 6: 20 $\mu g/m^3$ (purposed standard)

Outcomes

Results (Province-specific)

- Estimated Attributed Proportions for Mortality, all natural cause (adults age 30+ years), Mortality COPD for adults, mortality IHD for adults, and mortality Stroke for adults.
- Estimated number of Attributable Cases for Mortality, all natural cause (adults age 30+ years), Mortality COPD for adults, Mortality IHD for adults, Mortality Stroke for adults.
- Estimated number of Attributable Cases per 100,000 population at risk for Mortality, all natural cause (adults age 30+ years), Mortality COPD for adults, Mortality IHD for adults, Mortality Stroke for adults.

Interpretation

" xxxx premature death could be avoid if "cut-off values" are respected"

3.6 Ethical Considerations

The certificate of approval for this study was received from Chulalongkorn University Research Ethics Review Committee for Research Involving Human Research Participants Group I with Certificate of Analysis (COA) number 093/65.

3.7 Administration and Time Schedule

Process	Time schedule Year: 2022						
	January	February	March	April	May	June	July
Literature review							
Tool Development							
Ethical committee consideration							
Field arrangement and data collection							
Data Analysis							
Final result and Conclusion							

CHAPTER IV RESULT

This Chapter presents the characteristics of provinces including total number population at risk or people ages ≥30 years old, PM2.5 concentration, and total number incidences for morbidity and mortality related PM2.5 short-and long-term exposure in Thai population. The health impact assessment result from all analysis using the measurement tool also shows and explains in this chapter. Total number population all ages and area size for whole provinces in Thailand was input as additional information

During running on Air Q+ software, I input pre-load data including total population ages ≥30 years old, annual mean PM2.5 concentration, morbidity and mortality rate as baseline where the software calculated automatically form total incidence and total population at risk regarding the analysis. All data was recorded for province specific, and I also calculated data to describe all provinces as a whole. From the statistics data in 2019, I obtained total population was 66,558,935 people for 77 provinces in Thailand, where 60.98% from the total was population at risk or people ages ≥30 years old, it was 40,572,731 people or 60,957.6 per 100,000 population at risk. In 2019, total population of Bangkok Metropolis reported at 5,666,264 for all ages both female and male, and placed as a province with the biggest population for that year. I just included people who recorded living permanent in this country. Total population for specific group also was accounted regarding type of analysis. I followed WHO Air Quality Guideline where the population at risk for all health indicators on short- and long-impact assessments was people ages ≥30 years old. In this study year, total population ages ≥30 years old already passed a half of total population for all ages in Thailand, hence it can be a representative group. The characteristic of provinces specific and annual average concentration PM2.5 have presented on table 4.1.

The annual mean PM2.5 for national level was 24.14 $\mu g/m^3$ for the period on this study. The range of daily PM2.5 for entire provinces started from 1.28 to 229.52 $\mu g/m^3$. Phra Nakhon Si Ayutthaya was responsible for province with the higher PM2.5 mean at 32.79 $\mu g/m^3$ in 2019. It was followed by Ang Thong, Kalasin, Chiang Mai, and Mae Hong Son at 32.5 $\mu g/m^3$, 32.19 $\mu g/m^3$, 31.7 μg/m3, and 31.96 $\mu g/m^3$, respectively. As top three the lowest provinces, Prachuap Khiri Khan, Chumphon, and Ranong showed annual mean just under 8 $\mu g/m^3$ in 2019. The annual standard for most provinces located in Bangkok Metropolitan Region (BMR), Central and North region recorded just over 25 $\mu g/m^3$. However, annual PM2.5 average all provinces located in south region showed completely opposite. The specific-province results regarding short-term and long-term mortality and morbidity were reported in Appendix 1.

Table 6 Characteristic All Provinces in 2019

Province	Area Size (Km^3)	Total Population All Ages	Annual PM 2.5 Concentration ($\mu g/m^3$) in 2019	Province	Area Size (Km^3)	Total Population All Ages	Annual PM 2.5 Concentration ($\mu g/m^3$) in 2019
Amnat Charoen	3161.248	378,438	31.37	Phatthalung	3424.473	524,865	16.48
Ang Thong	968.372	279,654	32.47	Phayao	6335.06	472,356	19.84
Bangkok Metropolis	1568.737	5,666,264	25.70	Phetchabun	12668.416	992,451	22.42
Bueng Kan	4305	424,091	29.01	Phetchaburi	6225.138	485,191	23.63
Buri Ram	10322.885	1,595,747	26.03	Phichit	4531.013	536,311	25.47
Chachoengsao	5351	720,113	18.66	Phitsanulok	10815.854	865,247	24.56
Chai Nat	2469.746	326,611	30.17	Phra Nakhon Si Ayutthaya	2556.64	820,188	32.80
Chaiyaphum	12778.287	1,137,357	24.29	Phrae	6538.598	441,726	28.68
Chanthaburi	6338	537,698	20.57	Phuket	543.034	416,582	13.66
Chiang Mai	20107.057	1,779,254	31.97	Prachin Buri	4762.362	494,680	21.29
Chiang Rai	11678.369	1,298,304	31.56	Prachuap Khiri Khan	6367.62	554,116	5.61
Chon Buri	4363	1,558,301	18.55	Ranong	3298.045	193,370	7.70
Chumphon	6009.849	511,304	5.91	Ratchaburi	5196.462	873,101	24.17
Kalasin	6946.746	983,418	32.19	Rayong	3552	734,753	19.49
Kamphaeng Phet	8607.49	725,867	27.39	Roi Et	8299.449	1,305,211	31.50
Kanchanaburi	19483.148	895,525	26.39	Sa Kaeo	7195.436	566,303	23.51
Khon Kaen	10885.991	1,802,872	28.74	Samut Nakhon	9605.764	1,153,390	30.41
Krabi	4708.512	476,739	13.43	Samut Prakan	1004.092	1,344,875	24.92
Lampang	12533.961	738,316	28.41	Samut Sakhon	872.347	584,703	27.69
Lamphun	4505.882	405,075	31.48	Samut Songkhram	416.707	193,305	24.33
Loei	11424.612	642,950	16.36	Saraburi	3576.486	645,911	29.53
Lop Buri	6199.753	755,556	29.92	Satun	2478.977	323,586	14.41
Mae Hong Son	12681.259	284,138	31.96	Si Sa Ket	8839.976	1,472,859	29.34
Maha Sarakham	5291.683	962,665	31.78	Sing Buri	822.478	208,446	31.39
Mukdahan	4339.83	353,174	31.89	Songkhla	7973.894	1,435,968	17.81
Nakhon Nayok	2122	260,751	20.48	Sukhothai	6596.092	595,072	27.55
Nakhon Pathom	2168.327	920,030	27.24	Suphan Buri	5358.008	846,334	30.19
Nakhon Phanom	5512.668	719,136	31.29	Surat Thani	12891.469	1,068,010	10.60
Nakhon Ratchasima	20493.964	2,648,927	24.04	Surin	8124.056	1,396,831	28.17
Nakhon Sawan	9597.677	1,059,887	27.22	Tak	16406.65	665,620	29.11
Nakhon Si Thammarat	9942.502	1,561,927	13.90	Trang	4917.519	643,164	14.68
Nan	11472.072	478,227	28.19	Trat	2819	229,958	20.28
Narathiwat	4475.43	808,020	17.02	Ubon Ratchathani	15774	1,878,146	30.46
Nong Bua Lam Phu	3859.086	512,780	21.20	Udon Thani	11730.302	1,586,646	26.13
Nong Khai	3027.28	522,311	23.85	Uthai Thani	6730.246	328,618	28.01
Nonthaburi	622.303	1,265,387	25.17	Uttaradit	7838.592	453,103	26.23
Pathum Thani	1525.856	1,163,604	24.11	Yala	4521.078	536,330	16.97
Pattani	1940.356	725,104	16.68	Yasothon	4161.664	537,299	31.21
Phangnga	4170.895	268,788	12.75				

Average Annual PM2.5 All Provinces = 24.149

Maximum Annual Average = 32.79912329 *: Phra Nakhon Si Ayutthaya*

Minimum Annual Average = 5.607479452 *: Prachuap Khiri Khan*

Maximum Total Population All Ages = 5,666,264 *: Bangkok Metropolis*

Minimum Total Population All Ages = 193,305 *: Samut Songkhram*

I calculated all data followed Air Q+ software guideline. The tool provides default Relative Risk (RRs) and cut-off value from the previous study. Several health indicator particularly hospitalized number due to respiratory and cardiovascular diseases, and analysis on mortality for all-natural cases in short impact study applied RRs values following the meta-analysis from previous studies. The RRs value for health indicator of mortality number related COPD, IHD, and Stroke used default number that provide automatically in this software. Air Q+ has different calculation for these analyses. I applied six options of annual and daily average from some certain references as the counterfactual factors for this study. All Cut-off followed WHO guideline, USEPA daily and annually national standard for United States, and the current Thai national standard. The result of Health impact due to short exposure PM2.5 was showed in the following tables.

4.1 Evaluation Result Health Impact Estimation PM2.5 Exposure to Hospital Admission for Respiratory Diseases in Thai Population Ages ≥30 Years Old

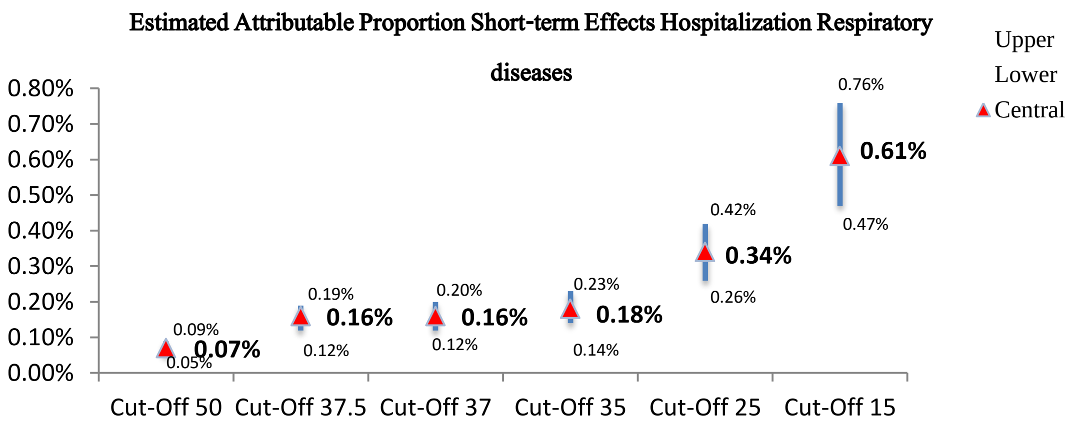


Figure 11 Estimation of Attributable Proportion of PM 2.5 Short-term Exposures to Hospital Admission of Respiratory Diseases Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Figure 11 shows the estimation of attributed proportion on the number of hospital admission for all respiration diseases at population at risk impacted of short exposure PM2.5 in few daily averages. At 0.07% [0.05;0.09%] demonstrated proportion to the reduction of burden on hospitalized due to respiratory diseases when the average of daily concentration PM2.5 is 50 μg/m^3. The application cut-off value 37.5 μg/m3 shows an achievement around 0.16% reduction of attributed cases proportion to PM2.5 exposure. Beside on that, all estimated number of attributed cases for all provinces is showed at table 7. The attributed cases for hospital admission due to respiratory diseases at 50 μg/m^3 were 18,511 cases or 46 per 100,000 population at risk, and 40,910 hospital admission due to respiratory diseases incidences could be avoided if 37.5 μg/m^3 cut-off values are respected. From this analysis, the estimated proportion and number cases shows increasing following the smaller cut-off value that applied.

Table 7 Estimation Health Impact of PM2.5 Short-term Exposures to Hospital Admission for Respiratory Diseases Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Cut-Off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-Off 50 µg/m^3	18,511 (14,187;23,185)	46 (35;57)
Cut-Off 37.5 µg/m^3	40,910 (31,371;51,211)	101 (77;126)
Cut-Off 37 µg/m^3	42,245 (32,396;52,882)	104 (80;130)
Cut-Off 35 µg/m^3	47,940 (36,766;60,005)	118 (91;148)
Cut-Off 25 µg/m^3	88,797 (68,130;111,090)	219 (168;274)
Cut-Off 15 µg/m^3	159,902 (122,764;199,910)	394 (303;493)

4.2 Evaluation Result Health Impact Estimation PM2.5 Exposure to Hospital Admission for Cardiovascular Diseases Incidences in Thai Population Ages ≥30 Years Old

The short-term exposure of PM2.5 also affected the proportion hospitalized for cardiovascular diseases. The higher number of counterfactual factors that applied the lower attributed proportion cases at population at risk. It is clearly, in every decreasing daily average can describe how much the estimation burden number in population that have high risk exposed PM2.5 (**Figure 12**). Indeed, at 0.43% [0.31%;0.53%] are estimated for proportion of burden cases due to cardiovascular diseases related PM2.5 effects if the daily mean do not exceed 15 µg/m^3. In contrast, just around 0.05% [0.04%;0.06%] attributable proportion that recorded, if the daily average was 50 µg/m^3.

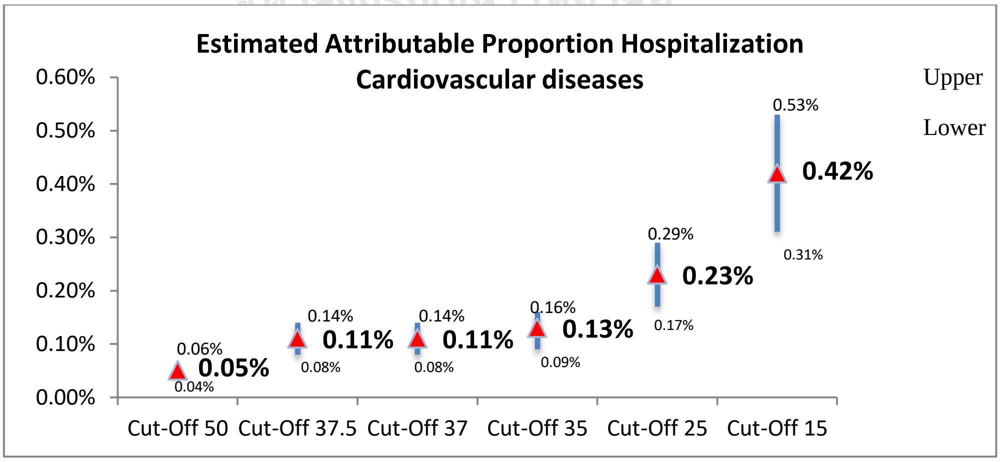


Figure 12 The Estimation of Attributable Proportion of PM 2.5 Short-term Exposures to Hospital Admission for Cardiovascular Diseases Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

The data was calculated with six cut-off values, and detailed result of attributed cases and rate are presented (Table 8). If 37.5 μg/m^3 cut-off values are respected, 117 hospital admission numbers due to cardiovascular diseases incidences per 100,000 population could be avoided.

Table 8 Estimation Health Impact of PM 2.5 Short-term Exposures to Hospital Admission for Cardiovascular Diseases Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Cut-off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-Off 50 μg/m^3	21390 (15883;26914)	53 (39;66)
Cut-Off 37.5 μg/m^3	47308 (35142;59499)	117 (87;147)
Cut-Off 37 μg/m^3	48854 (36291;61443)	120 (89;151)
Cut-Off 35 μg/m^3	55446 (41190;69728)	137 (102;172)
Cut-Off 25 μg/m^3	102759 (76365;129185)	253 (188;318)
Cut-Off 15 μg/m^3	185199 (137697;232712)	456 (339;574)

4.3 Evaluation Result Health Impact Estimation PM2.5 Exposure to All-natural Mortality Incidences in Thai Population Ages ≥30 Years Old

For number of all-natural mortality cases, Bangkok has 1188.25 incidences per population at risk, and claimed as the highest burden in 2019. Figure 13 demonstrated the estimated proportion for all cut-off that used for short-term analysis in mortality cases, where figure 14 shows the estimation for long-term exposure PM2.5 to all-natural cases mortality in Thailand.

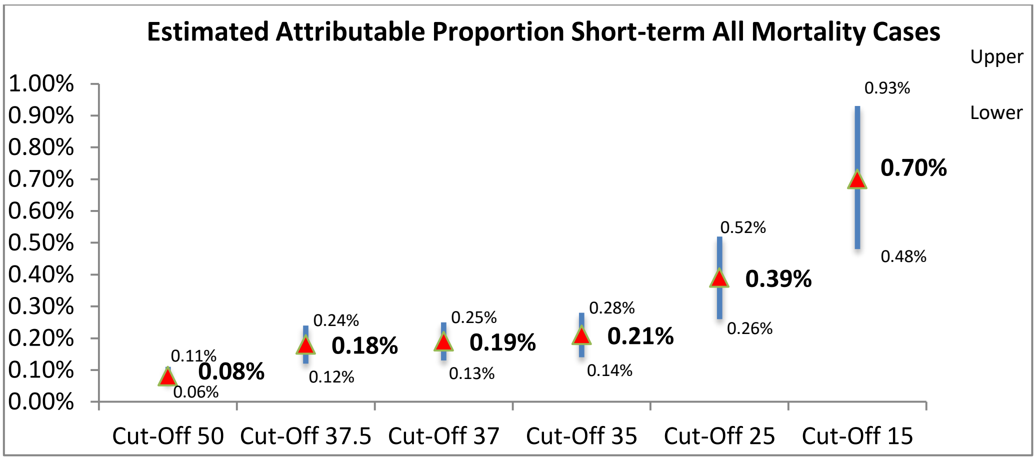


Figure 13 Estimation of Attributable Proportion of PM 2.5 Short-term Exposures to All-natural Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019.

If the daily average in Thailand meets the targeted standard 37.5 µg/m3 it can reduce around 0.18% from the burden all short-term mortality cases in 2019. The gold standard AQG 2021 that is provided by WHO can estimate 0.70% cases reduction for all short-term mortality. Around 3,193 short-term mortality estimation cases or 8 persons per 100,000 population at risk could be avoided if the daily mean PM2.5 meet at 15 µg/m3 (**Table 9**).

Table 9 Estimation Health Impact of PM 2.5 Short-term Exposures to All-natural Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Cut-Off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-off 50 µg/m^3	370 (250;491)	1 (1;1)
Cut-Off 37.5 µg/m^3	818 (552;1084)	2 (1;3)
Cut-Off 37 µg/m^3	844 (570;1119)	2 (1;3)
Cut-Off 35 µg/m^3	958 (647;1270)	2 (2;3)
Cut-Off 25 µg/m^3	1,774 (1,199;2,350)	4 (3;6)
Cut-Off 15 µg/m^3	3,193 (2,161;4,225)	8 (5;10)

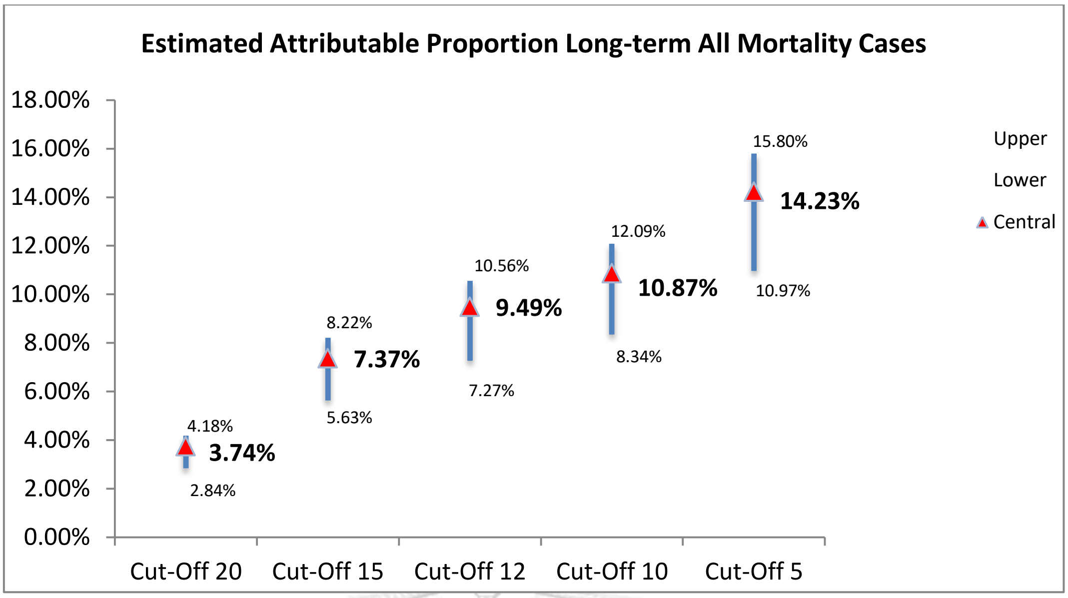


Figure 14 Estimation of Attributable Proportion of PM 2.5 Long-term Exposures to All-natural Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Table 10 The Estimation Health Impact of PM 2.5 Long-term Exposures to All-natural Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Cut-Off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-off 25 μg/m^3	-	-
Cur-off 20 μg/m^3	16,940 (12,885;18,926)	42 (32;47)
Cut-off 15 μg/m^3	33,409 (25,528;37,241)	82 (63;92)
Cut-off 12 μg/m^3	42,991 (32,940;47,858)	106 (81;118)
Cut-off 10 μg/m^3	49,257 (37,809;54,784)	121 (93;135)
Cut-off 5 μg/m^3	64,506 (49,737;71,588)	159 (123;176)

4.4 Evaluation Result Health Impact Estimation PM2.5 Exposure to Chronic Obstructive Pulmonary Diseases (COPD) Mortality Incidences in Thai Population Ages ≥30 Years Old

Looking for analysis health impact long-term exposure to the number of mortality due to COPD, the highest number incidences was accounted for Bangkok at 246 or 6.16 cases per 100,000 population ages ≥30 years old. The estimation for attributable proportion will obtained around 6.57% reduction for total deaths if the annual standard meets to the target at 15 μg/m^3 or over 11% at 10 μg/m^3. More than 300 incidences for burden of COPD mortality can calculate if the annual average can meet recommendation standard at 10 or 15 μg/m^3 (Table 11).

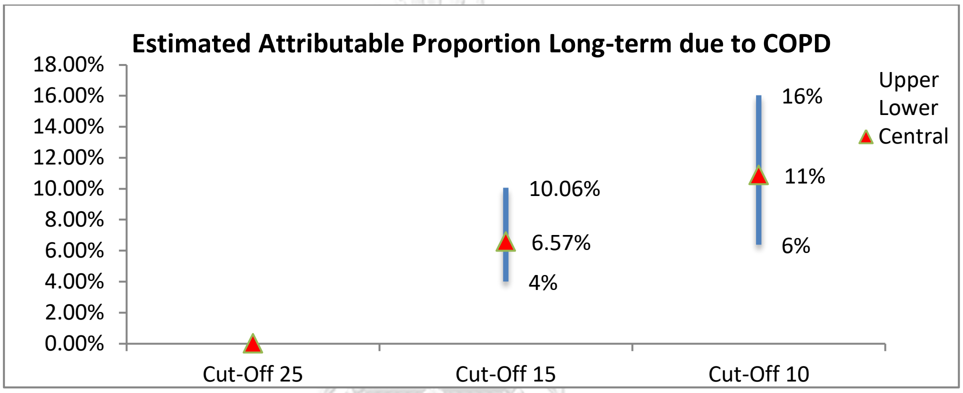


Figure 15 Estimation of Attributable Proportion of PM 2.5 Long-term Exposures to COPD Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Table 11 The Estimation Health Impact of PM 2.5 Long-term Exposures to COPD Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Cu-Off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-Off 25 μg/m^3	-	-
Cut-Off 15 μg/m^3	300 (182;460)	1 (0;1)
Cut-Off 10 μg/m^3	496 (291;732)	1 (1;2)

4.5 Evaluation Result Health Impact Estimation PM2.5 Exposure to Ischemic Heart Diseases (IHD) incidences in Thai Population Ages ≥30 Years Old

Regarding others analysis, the analysis for IHD impacts also shows similar results. The recommendation annual mean PM2.5 at 15 μg/m^3 and 10 μg/m^3 estimated the decreasing proportion of burden to IHD mortality around 6.58% and 12.63 in 2019, respectively.

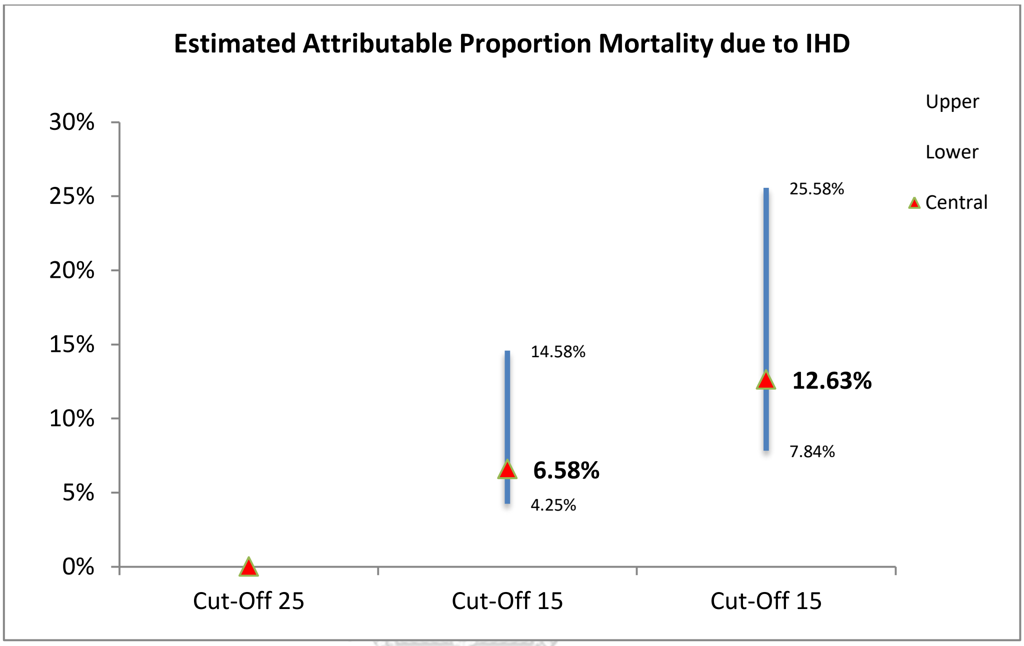


Figure 16 The Estimation of Attributable Proportion of PM 2.5 Long-term Exposures to Ischemic Health Diseases Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Table 12 The Estimation Health Impact of PM 2.5 Long-term Exposures to IHD Mortality Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Cut-Off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-Off 25 μg/m3	-	-
Cut-Off 15 μg/m3	1,341 (866;2,971)	3 (2;7)
Cut-Off 10 μg/m3	2,573 (1,596;5,212)	6 (4;13)

From the result, we can receive estimated the increasing PM2.5 concentration in the atmosphere, will increase the attributed number of proportion and cases on mortality incidences in Thai population due to Ischemic Heart Diseases (IHD).

4.6 Evaluation Result Health Impact Estimation PM2.5 Exposure to Stroke Mortality Incidences in Thai Population Ages ≥30 Years Old

The estimation of attributable cases number of Stroke mortality can be predicted around 1,341 or 3 cases per 100,000 population at risk if the annual mean meets 15 µg/m^3. The reduction around 5.85% and 10.01% of burden of mortality due to stroke at population at risk was estimated when the annual mean can achieve the AQG recommendation at 10 µg/m^3 and 15 µg/m^3. Figure 19 and 13 showed the detail of analysis and elaborate the higher number of attributed proportion and cases that accounted, when the PM2.5 concentration in Thailand increase.

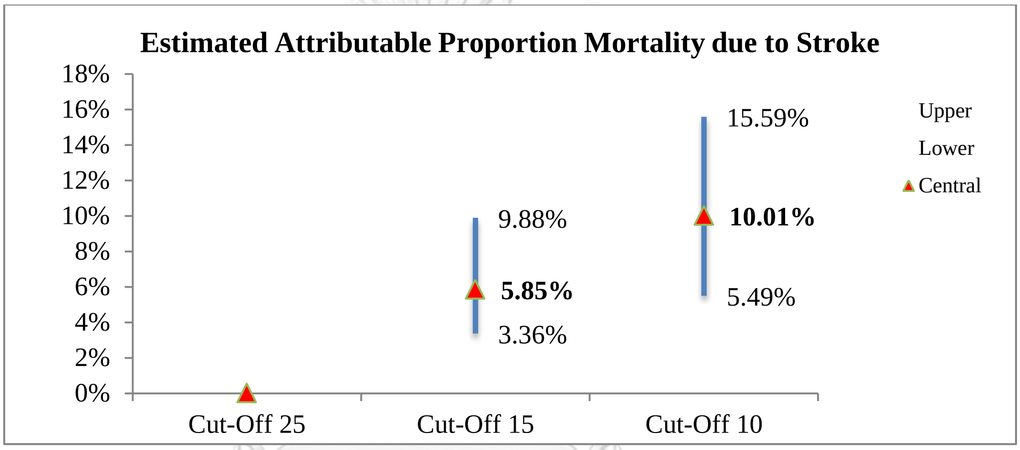
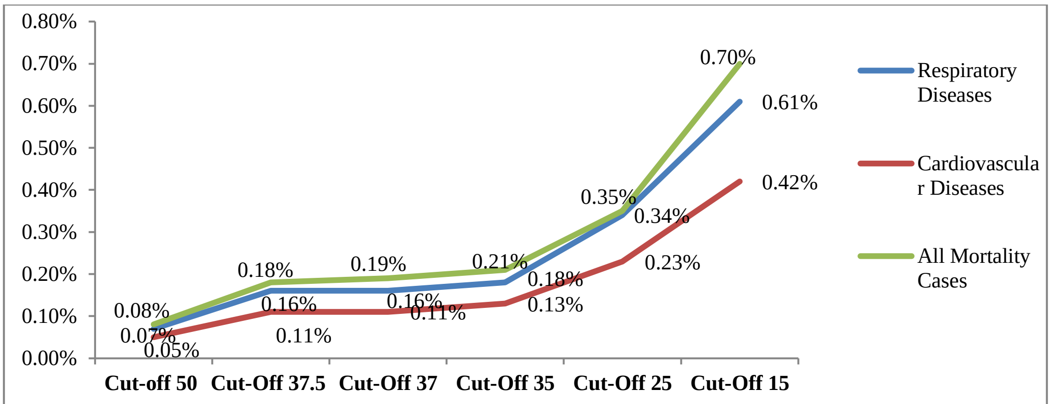


Figure 17 The Estimation of Attributable Proportion of PM 2.5 Long-term Exposures to Stroke Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Table 13 The Estimation Health Impact of PM 2.5 Long-term Exposures to Stroke Incidences (95% CI) at population at risk (Ages ≥30 years old) for All Provinces in 2019

Cut-Off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-Off 25 µg/m^3	-	-
Cut-Off 15 µg/m^3	2041 (1170;3445)	5 (3;9)
Cut-Off 10 µg/m^3	3489 (1916;5437)	9 (5;13)

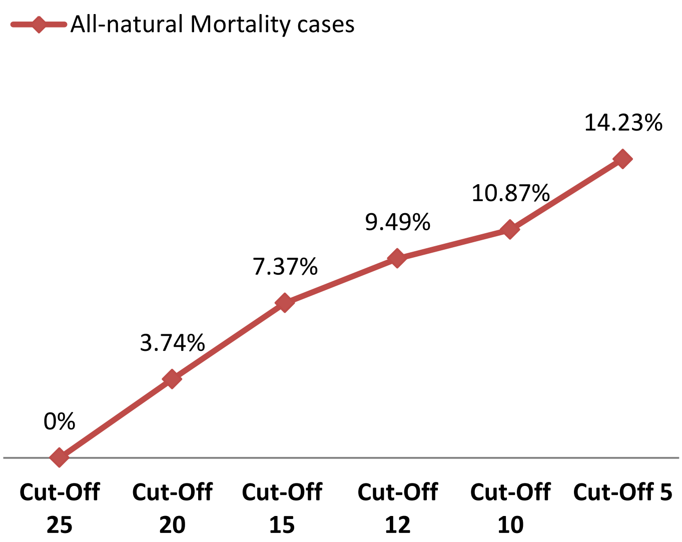
The results of this study presents different estimation of proportions and cases when I applied various counterfactual values or daily and annual average PM2.5. The estimations elaborate burden of diseases or deaths attributed to ambient PM2.5 as impacts of short- or long- term exposure to human health, mainly for population with special condition. When, the PM2.5 level can record meeting the recommendation or under the interim target standard, it could provide many health benefits for the society in one country especially for number of hospital admission and premature death. The summarizing of health impact PM2.5 short- and long-term exposure is presented on figure 20-22.



Estimated number of Attributable Cases

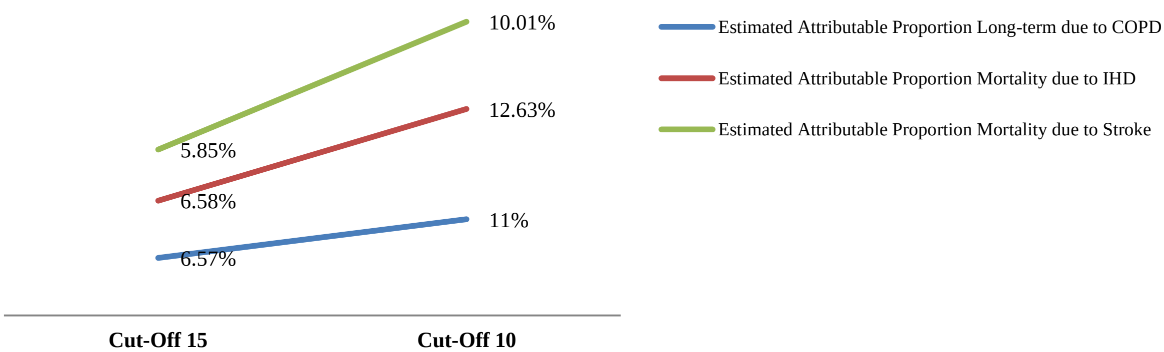
Cut-Off Values	Hospital admision for Respiratory Diseases Incidence	Hospital admision for Cardiovascular Diseases Incidence	All-natural Mortality Incidences
Cut-Off 50 $\mu g/m^3$	18511	21390	370
Cut-Off 37.5 $\mu g/m^3$	40910	47308	818
Cut-Off 37 $\mu g/m^3$	42245	48854	844
Cut-Off 35 $\mu g/m^3$	47940	55446	958
Cut-Off 25 $\mu g/m^3$	88797	102759	1774
Cut-Off 15 $\mu g/m^3$	159902	185199	3193

Figure 18 Short-term Health Impact of PM2.5 Exposure To Hospital Admission Number For Respiratory Diseases, And Hospital Admission Number For Cardiovascular Diseases, And All-Natural Mortality Cases.



Cut-off	Estimated Attributable Proportion	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-Off 25	0	0
Cut-Off 20	3.74%	42
Cut-Off 15	7.37%	82
Cut-Off 12	9.49%	106
Cut-Off 10	10.87%	121
Cut-Off 5	14.23%	159

Figure 19 Long-term Health Impact of PM2.5 Exposure to All-Natural Mortality Cases.



	Stroke Mortality Incidences		IHD Mortality Incidences		COPD Mortality Incidences	
Cut-Off Value	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Cut-Off 15	2041 (1170;3445)	5 (3;9)	1341 (866;2971)	3 (2;7)	300 (182;460)	1 (0;1)
Cut-Off 10	3489 (1916;5437)	9 (5;13)	2573 (1596;5212)	6 (4;13)	496 (291;732)	1 (1;2)

Figure 20 Long-term Health Impact of PM2.5 Exposure to COPD Mortality, IHD Mortality, and Stroke Mortality

Chapter V Discussion

Regarding to the aim of this study, I observed and analyzed the data set of ambient PM2.5 in all provinces in Thailand during 2019. I conducted calculation to investigate the average annual PM2.5. When, the high number concentration in several provinces occurred in Thailand in 2019, the possible causes the high number concentration impact of burning activities. This province also recorded as the industrial zone and faced the increasing automobile number. Another province that has high concentration was Mae Hong Son that located in the northern region of Thailand. While the concentration PM2.5 high in this province, the location also can be reason where this province placed near Chiang Mai and Chiang Rai that has problem on PM2.5 level. PM2.5 is kind of pollutant that easy to move in the air. Some studies in Bangkok (Fold et al., 2020) showed the correlation between meteorological condition and PM2.5 concentration, and the study in Hong Kong described the wind direction have contribution to PM2.5 level (Li et al., 2017). Bangkok as the capital city recorded just around 25 $\mu g/m^3$ during 2019. This annual average almost met Thai PM2.5 standard.

Air Q+ software analysis presented the results of number estimation health impact on morbidity and mortality to short- and long-term of PM2.5 exposure in Thailand in 2019. The application variety of cut-off values as well as global recommendation presented the scenario analysis that can be achieved when the PM2.5 level in Thailand meeting the target value. The analysis produced different estimation burden impact PM2.5 short- and long-term exposure to incidences cases in Thai population.

5.1 The Estimation Health Impact of Short-term PM2.5 Exposure to Hospital Admission Number for Respiratory Diseases

The analysis of negative effects on respiratory system due to PM 2.5 at short-term exposure supported from many epidemiological studies. For instance, every increasing 10 $\mu g/m^3$ in daily mean PM2.5 associated with 0.53% increasing proportion admission number hospitalized with respiratory diseases indication in Taiyuan (Luo et al., 2018).Study in Europe countries also provided substantially effect of increasing for each 10 $\mu g/m^3$ PM2.5 daily average was correlated with 1.90% increasing respiratory disease hospital number (WHO, 2013b)

The studies used Air Q+ health impact assessment tool in Ardanil showed around 1.97% attributed proportion for Hospital number due to respiratory diseases when the daily average was above 5 $\mu g/m^3$ (Moradi et al., 2022). From this similar study, the total number of attributable cases, and the number of attributable cases per 100,000 population (with 95% confidence level) for the admission of respiratory diseases in hospital have been estimated at 68 persons and 19.42 persons, respectively. A study in 708 cities US resulted an increase of 2.57% has been associated with the inclining 10 $\mu g/m^3$ PM2.5. An increase each 10 $\mu g/m^3$ PM2.5 also showed significant correlation with average 38% hospital admission number in 20 million Beijing population (Wang et al., 2017).

Looking at the result for province specific, the usage many cut-off provide differences estimation attributed cases and proportion. I compared the current daily mean PM2.5 in Thailand and the target related new version of Air Quality Guideline. Mae Hong Son reported the highest attributed rate for daily cut-off value at 37.5 μg/m^3 were around 731 cases per 100,000 population at risk or ages ≥30 years old. It was followed by Chiang Rai and Chiang Mai at 460 persons and 462 persons per 100,000 population at risk, respectively. Meanwhile, for the recent Thailand National standard daily average PM2.5 is 50 μg/m^3, the estimation attributed cases rate that reported lower if compared with 37.5 μg/m^3. To conclude that, an illustration if the daily mean met with the cut-off value at 37.5 μg/m^3, the achievement is could reduce 0,16% decrease in total death cases attributed or 101 cases per 100,000 population at risk to short-term PM2.5 exposure compare the number of exposure in Thailand in 2019 where accounted at 24.149 μg/m^3.

5.2 The Estimation Health Impact of Short-term PM2.5 Exposure to Hospital Admission Number for Cardiovascular diseases

I calculated total cases of cardiovascular diseases in whole hospital from 77 provinces. All kind of cardiovascular diseases with ICD 10 code start from I00 to I99 was recorded as health baseline for this analysis. Total incidences CVD in 2019 for Thai population ages ≥30 years old was 43,826,989 cases or 108,020.8 cases per 100,000 population. Nakhon Ratchasima indicated as the province with the highest burden CVD cases at 104,412.9 cases per 100,000 population at risk, and Ranong presented in contrast.

The exposure of PM2.5 can give potential severe health effects. Due to the size of this pollutant, it can be easier to enter the cardiovascular system. The significant relation the morbidity incidences with PM2.5 exposure in short-term has been shown (Di et al., 2017).The level of daily exposure of PM2.5 in extreme and heavy was associated with the great number hospital admission in some area ((Zhang et al., 2021);(Chen et al., 2013)). The result from study in the past in Wuhan province described lag patterns of association PM2.5 impact on total cardiorespiratory hospital admissions (Zhang et al., 2021). Several studies also reported the substantially correlation of short-term PM2.5 exposure with increasing number of cardiovascular hospitalized ((Qiu et al., 2020);(Chen et al., 2019);(Tian et al., 2019)). In specific kind of cardiovascular diseases, an increase PM2.5 level in daily was significantly associated with specific causes of diseases including heart failure, myocardial infarction, ischemic stroke, and arrhythmia ((Wei et al., 2019);(Lanzinger et al., 2016)). The increasing of ambient PM2.5 by 10 μg/m^3 was significantly correlated with 1 to 3 mm Hg elevation in systolic and diastolic blood pressure ((Münzel et al., 2017);(Wold et al., 2012)).

The result of this study elaborates the estimation health impact due to PM2.5 exposure to admission number cardiovascular diseases in hospital. From the health baseline and the daily PM2.5 level and calculation from six cut-off values, there was around 21,390 (15,883;2,691) incidence or 53 per 100,00 population at risk was observed when the used daily PM2.5 in national level at 50 μg/m^3. This calculation illustrated the current burden situation related current national standard. To compare that, if the average PM2.5 in 2019 meet an option at 37.6 μg/m^3, the reduction of attributed proportion CVD hospital admission case can be 0.11% with attributed incidences around 117 cases per 100,000 population. The health impact analysis from several studies described when the PM2.5 concentration is not more than 10 μg/m^3, the attributed cases of hospital admissions Were 186 and 134 can be prevented (De Marco et al., 2018). Another study demonstrated 0.95% reduction or just 103 case of hospital admission due to CVD if the level not exceeds 10 μg/m^3 (Moradi et al., 2022). Hence, the lower PM2.5 level, the higher number reduction of hospital admission due to cardiovascular diseases can be avoided.

5.3 The Estimation Health Impact of PM2.5 Exposure to All-natural Mortality Cases

Air Q+ analysis provides the estimation of Attributed proportion and cases to all-natural mortality cases in targeted population due to concentration of PM2.5. This recent study obtained the annual average was 24.149 10 μg/m^3. When I compared to others PM2.5 standard, in short-term analysis for mortality case, the reduction around 0.18% at 37.5 μg/m^3 and over than 0.70% for WHO global standard. On the other hand, the result of long-term impact based on the health baseline in 2019, over 3.5% reduction was estimated if the PM2.5 level in 2019 meets the cut-off values that I used. I did not receive the estimation on current annual PM2.5 standard due to the total average not exceed 25 μg/m^3. In general the estimation of attributed proportion and case at national level has not shown high number. However, on province specific the results demonstrated the high estimation of reduction proportion if concentration decreases, particularly for provinces that exceed the national average in 2019 and having high health baseline. For instance, Chiang Rai, Chiang Mai, and Bangkok recorded having high estimation attributed proportion and cases if compare to other provinces.

Some study in Pakistan used AirQ+ model, reported an estimation of the decreasing proportion attributed cases at 9.9% every 10 μg/m^3 at 7,786 population at risk or people with ages≥30 years old (Nasir et al., 2022). Study in Rome (Moradi et al., 2022) also estimated a decrease at 6.12% or 35.66 cases per 100,000 population can be protected when the concentration could decline 10 μg/m^3. It is clearly to explain the lower concentration short- or long-term PM2.5 exposure will cause a low health impact mainly in all natural morality cases.

5.4 The Estimation Health Impact of Long-term PM2.5 Exposure to Mortality Cases due to Cardio Obstructive Pulmonary Diseases (COPD)

The interpretation of estimated attributable proportion and cases as health impact of PM2.5 long-term exposure to COPD mortality incidences was presented in this study. I considered the association Impact PM 2.5 exposure to COPD showed the significantly. The previous study resulted that an increase at 1.5% (95% CI: 0.9-2.2%) in COPD mortality substantially related with the increasing PM2.5 concentration (Zhu et al., 2020). The elderly people influenced higher on COPD burden attributable to ambient PM2.5 than the young population. Several studies have investigated strong and consistent evidence that people on elderly group are more susceptible to PM exposure ((Bell et al., 2005); (Simoni M, 2015); (Xu et al., 2016)). Similar study used Air Q+ software also estimated 15.79% or 11 cases can be avoided if PM2.5 annual level can decline to 10 μg/m^3. Study in Tehran showed at 57% of attributed proportion of COPD mortality if the annual level decline to 10 μg/m^3. The result described highest burden compared with other analysis (Faridi et al., 2018). Mortality incidences in Thailand Were not high if compare to other countries with PM2.5 problem, such as China. However, the estimation of attributed proportion can be reduced up to 11% if the PM2.5 annual level can decrease to 10 μg/m^3. The percentage showed a greater impact when it was calculated based on data of the health baseline and PM2.5 level in 2019. The greater result of estimation attributed proportion compared to all-cause mortality cases in this study indicated the significant effect of PM2.5 exposure to COPD incidence in Thai population.

5.5 The Estimation Health Impact of Long-term PM2.5 Exposure to Mortality Cases due to Ischemic Heart Diseases (IHD)

The number of premature death due to IHD was observed for 77 provinces in Thailand. The total incidence cases in all provinces Were 20,374 or 50.22 per 100,000 population at risk. Bangkok Metropolis showed the highest incidence rate at 69.67 per 100,000 population. There were many studies that conducted to investigate the relation between long-term PM2.5exposure to IHD mortality. Most of the studies showed significant association ((Cesaroni et al., 2013);(Xie et al., 2015)). The result on this study estimated at 12.63% and 6.53% reduction form IHD burden in 2019 when the annual mean PM2.5 dropping to 15 μg/m^3 and 10 μg/m^3, respectively. It demonstrated 1,341 and 2,573 attributed cases that can be avoided.

5.6 The Estimation Health Impact of Long-term PM2.5 Exposure to Mortality Cases due to Stroke

The significant estimation was observed for health impact PM2.5 in long-term exposure to stroke incidence. The concentrations of particulate matter are related with high blood pressure and plasma viscosity. These conditions can increases inflammation in circulation system and one factor that influence hemodynamic disorders. These are risk factor increasing stroke tragedy (Hoek et al., 2013). Study in Rome estimated around 301 mortality cases due to stroke could be avoided each year if the PM2.5 concentration not exceed 10 μg/m^3 (Amoatey et al., 2018). In the same concentration, this study estimated around 3,478 mortality cases related stroke or 10.01% could be avoided in Thai population in 2019.

Table 14 The Results of Health Impact Assessment PM2.5 Exposure Used Air Q+ software in Several Studies

Authors	Published Year	Country	Health outcomes	PM2.5 Mean value (or Cut-off values)	Results
Nasir Ha. Et al	2022	Chakwal district, Pakistan	Long-term All-cause mortality in adults age 30+	27.33 μg/m^3	9.9% Attributable proportion
Moradi M. et al.,	2022 (Study year : 2018)	Ardabil, Iran	Long-term All-cause mortality in adults age 30+	annual concentrations 15.47 μg/m^3	6.12% (4.03–8.03) Attributable proportion
Hopke PK, et all,	2017 (study year: March 2015-March 2016)	Tehran, Iran	Short-term all-cause mortality adults age 30+	Cut-off value = 25 μg/m^3	1.04% (0.38;1.7) Attributable proportion
Hadei M et all	2020	25 Iranian cities.	Long-term All-cause mortality in adults age 30+	Cut-off Value = 10 μg/m^3	9.4% (6.2–12.2) Attributable proportion

The strengths of this study provide estimation attributed number that could be avoided if the national average PM2.5 can reduce to cut-off values. This study was the first study that combined analysis health impacts due to short- and long-term PM2.5 exposure. The data set that was received also presenting 77 provinces hence it can elaborate whole condition in Thailand more detailed. The PM2.5 concentration also recorded based on district specific to show the entire days in 2019. The bias due duplicate data or missing data was checked through appropriate software. Because of Air Q+ software ignores the duplicate on date, user will be noticed before continuing to input the data. Hence, the possibility bias was limited.

On the other hand, I realize the study have some limitations. First, this study is a 2019 single-year analysis, hence the estimation proportion and cases impact of short-and long-term PM.25 exposure cannot compare to another year if the concentration will be increase or decrease. Second, Air pollution data was considered 70 air stations represented 77 provinces through kriging analysis. Although it can increase the uncertainty PM2.5 level, this model is proved to describe the concentration exactly. Another limitation is the analysis on COPD, IHD, and Stroke was used the default calculation parameter, hence the risk ratio from health baseline can described the real condition in Thailand. However, from Air Q+ guideline and AQG 2021, all parameter that applied in this tool already evaluated. Hence, user from another region can calculate the data if the baseline incidence related. In addition, health outcomes data was considered only a source from the Ministry of Public Health, Thailand

CHAPTER VI CONCLUSION

6.1 Conclusion

The result of estimation attributed health impacts PM2.5 exposure resulted variety significant health burden base on concentration, incidence rate, and total population at risk in Thailand during 2019. Air Q+ is health impact assessment tool that can estimate number cases that can be avoided if the concentration in period of study meeting the target concentration that used as cut-off value. Calculation of annual average PM2.5 in Thailand during study period was 24.149 μg/m^3, where it reported under the Thai NAAQS for annual average. However, the daily mean PM2.5 in Thailand was recorded up to 50 μg/m^3 in several times (the range was from 5.60 to 32.79 μg/m^3). This condition should be considered when the exposure PM2.5 potentially giving potential impact to human health. The area that having high number population such as Bangkok Metropolitan, Phra Nakhon Si Ayutthaya, Nakhon Ratchasima, Chiang Mai and Chiang Rai will suffer high burden on morbidity and mortality rate. Daily exposure was substantially increased the number of hospital admission for Respiratory and cardiovascular disease, and impact to premature death in population, especially people with special condition. In addition, Long-term exposure also influence people will lost years of life due to diseases related respiratory and cardiac system mainly COPD, IHD, and stroke. From the result analysis, the high number PM2.5 level and increasing incidence rate and number population at risk can result the high burden estimation. Area with high average concentration will not report as the highest burden. However, the severe impact will be received of population that resides on that area. PM2.5 concentration also influenced by metrological factors. The area located nearest with polluted problem potentially report similar level. Particle PM2.5 also carried on the wind simply.

6.2 Suggestions

From this study, the result can be roadmap to combat severe impact of PM2.5 exposure to human and environment. There are various estimation on short- and long-term impact used six cut-off values that can support policy maker and stakeholder create any regulation and to reduce the NAAQS in order to protect population which appropriate with Thai condition. The assessment of health impacts PM2.5 exposure should be conducted frequently, so that the burden number can be evaluated year by year as a protection on population. Air Q+ has three calculation methods not only for health impact assessment, I recommend the combination of health Impact assessment, burden of diseases and risk analysis can be conducted in the future study.

REFERENCES

Aaron J Cohen, M. B., Richard Burnett, H Ross Anderson, Joseph Frostad, Kara Estep, Kalpana Balakrishnan, Bert Brunekreef, Lalit Dandona, Rakhi Dandona, Valery Feigin, Greg Freedman, Bryan Hubbell, Amelia Jobling, Haidong Kan, Luke Knibbs, Yang Liu, Randall Martin, Lidia Morawska, C Arden Pope, Hwashin Shin, Kurt Straif, Gavin Shaddick, Matthew Thomas, Rita van Dingenen, Aaron van Donkelaar, Theo Vos, Christopher J L Murray, Mohammad H Forouzanfar, . (2015). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. *The Lancet*, *389*(10082, 2017), 1907-1918. https://doi.org/https://doi.org/10.1016/S0140-6736(17)30505-6

Amoatey, P., Omidi Khaniabadi, Y., Sicard, P., & Hopke, P. (2018). Mortality and morbidity for cardiopulmonary diseases attributed to PM2.5 exposure in the metropolis of Rome, Italy. *European Journal of Internal Medicine*. https://doi.org/10.1016/j.ejim.2018.07.027

Astort F, S. M., Ferraro SA. (2014). Pulmonary inflammation and cell death in mice after acute exposure to air particulate matter from an industrial region of Buenos Aires. *Arch Environ Contam Toxicol 2014*, *67*, 87-96. https://doi.org/http://dx.doi.org/10.1007/s00244-013-9975-4

Avino P, M. M. (2016). Dynamic of submicrometer particles in urban environment. . *Environ Sci Pollut Res Int. 2017 26*(16), 13908-13920. https://doi.org/10.1007/s11356-016-6752-8

Bell, M. L., Dominici, F., & Samet, J. M. (2005). A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. *Epidemiology (Cambridge, Mass.)*, *16*(4), 436.

Bové H, B. E., Slenders E, Bijnens EM, Saenen ND, Gyselaers W, Van Eyken P, Plusquin M, Roeffaers MB, Ameloot M, Nawrot TS. (2019). Ambient black carbon particles reach the fetal side of human placenta. . *Nature communications*, *17*(10(1)), 1-7. https://doi.org/https://doi.org/10.1038/s41467-019-11654-3

Brenk, I. V. d. (2018). The Use Health Impact Assessment Tools in European Cities. *Urban Agenda-Partenershipon Air Quality, Action 4 deliverable*.

Cesaroni, G., Badaloni, C., Gariazzo, C., Stafoggia, M., Sozzi, R., Davoli, M., & Forastiere, F. (2013). Long-term exposure to urban air pollution and mortality in a cohort of more than a million adults in Rome. *Environ Health Perspect*, *121*(3), 324-331. https://doi.org/10.1289/ehp.1205862

Cheewaphongphan, P., Junpen, A., Garivait, S., & Chatani, S. (2017). Emission Inventory of On-Road Transport in Bangkok Metropolitan Region (BMR) Development during 2007 to 2015 Using the GAINS Model. *Atmosphere*, *8*(9), 167. https://www.mdpi.com/2073-4433/8/9/167

Chen, D., Zhang, F., Yu, C., Jiao, A., Xiang, Q., Yu, Y., Mayvaneh, F., Hu, K., Ding, Z., & Zhang, Y. (2019). Hourly associations between exposure to ambient particulate matter and emergency department visits in an urban population of Shenzhen, China. *Atmospheric Environment*, *209*, 78-85. https://doi.org/https://doi.org/10.1016/j.atmosenv.2019.04.021

Chen, R., Zhao, Z., & Kan, H. (2013). Heavy smog and hospital visits in Beijing, China. *American journal of respiratory and critical care medicine*, *188*(9), 1170-1171.

De Marco, A., Amoatey, P., Khaniabadi, Y. O., Sicard, P., & Hopke, P. K. (2018). Mortality and morbidity for cardiopulmonary diseases attributed to PM2. 5 exposure in the metropolis of Rome, Italy. *European Journal of Internal Medicine*, *57*, 49-57.

Di, Q., Wang, Y., Zanobetti, A., Wang, Y., Koutrakis, P., Choirat, C., Dominici, F., & Schwartz, J. D. (2017). Air pollution and mortality in the Medicare population. *New England Journal of Medicine*, *376*(26), 2513-2522.

F. Cavalli, A. A., H. Areskoug, D. Ceburnis, J. Čech, J. Genberg, R.M. Harrison, J.L. Jaffrezo, G. Kiss, P. Laj, N. Mihalopoulos, N. Perez, P. Quincey, J. Schwarz, K. Sellegri, G. Spindler, E. Swietlicki, C. Theodosi, K.E. Yttri, W. Aas, J.P. Putaud. (2016). A European aerosol phenomenology -4: Harmonized concentrations of carbonaceous aerosol at 10 regional background sites across Europe, Atmospheric Environment. *144*, 133-145. https://doi.org/https://doi.org/10.1016/j.atmosenv.2016.07.050

Faridi, S., Shamsipour, M., Krzyzanowski, M., Künzli, N., Amini, H., Azimi, F., Malkawi, M., Momeniha, F., Gholampour, A., & Hassanvand, M. S. (2018). Long-term trends and health impact of PM2. 5 and O3 in Tehran, Iran, 2006–2015. *Environment international*, *114*, 37-49.

Fold, N., Allison, M., Wood, B., Thao, P., Bonnet, S., Garivait, S., Kamens, R., & Pengjan, S. (2020). An Assessment of Annual Mortality Attributable to Ambient PM 2.5 in Bangkok, Thailand. *International Journal of Environmental Research and Public Health*, *17*, 7298. https://doi.org/10.3390/ijerph17197298

Genc S, Z. Z., Fuss SH, Genc K. (2012). The adverse effects of air pollution on the nervous system. *Journal of toxicology*. https://doi.org/http://dx.doi.org/10.1155/2012/782462

Guaita R, P. M., Maté T, Linares C, Díaz J. (2011). Short-term impact of particulate matter (PM2. 5) on respiratory mortality in Madrid. . *International journal of environmental health research*, *1*(21 (4)), 260-274. https://doi.org/https://doi.org/10.1016/j.scitotenv.2010.07.083

Gurgueira SA, L. J., Coull B, et al. (2002). Rapid increases in the steady-state concentration of reactive oxygen species in the lungs and heart after particulate air pollution inhalation. *Environ Health Perspect 2002*, *110*. https://doi.org/https://doi.org/10.1289/ehp.02110749

Halonen JI, L. T., Yli-Tuomi T, Tiittanen P, Kulmala M, Pekkanen J. (2009). Particulate air pollution and acute cardiorespiratory hospital admissions and mortality among the elderly. . *Journal of Epidemiology*, *1*, 143-153. https://doi.org/https://doi.org/10.1136/thx.2007.091371

Hamanaka, R. B., & Mutlu, G. M. (2018). Particulate Matter Air Pollution: Effects on the Cardiovascular System [Review]. *Frontiers in Endocrinology*, *9*. https://doi.org/10.3389/fendo.2018.00680

Hoek, G., Krishnan, R. M., Beelen, R., Peters, A., Ostro, B., Brunekreef, B., & Kaufman, J. D. (2013). Long-term air pollution exposure and cardio-respiratory mortality: a review. *Environmental Health*, *12*(1), 1-16.

Huang W, W. G., Lu SE, et al. (2012). Inflammatory and oxidative stress responses of healthy young adults to changes in air quality during the Beijing Olympics. *American Journal Respiratory Critical Care Medicene 186*, 1150-1159.

https://doi.org/http://dx.doi.org/10.1164/rccm.201205-0850OC

Jiang XQ, M. X., Feng D. (2016). Air pollution and chronic airway diseases: what should people know and do?. . *Journal of thoracic disease*, *8(1)*, E31. https://doi.org/https://doi.org/10.3978/j.issn.2072-1439.2015.11.50

Katholi RE, C. D. (2009). Left ventricular hypertrophy: major risk factor in patients with hypertension: update and practical clinical applications. *International journal of hypertension. 2011* https://doi.org/http://dx.doi.org/10.4061/2011/495349

Kurt OK, Z. J., Pinkerton KE. (2016). Pulmonary health effects of air pollution *Current opinion in pulmonary medicine.*, *22(2)*, 138. https://doi.org/https://doi.org/10.1097/mcp.0000000000000248

Lanzinger, S., Schneider, A., Breitner, S., Stafoggia, M., Erzen, I., Dostal, M., Pastorkova, A., Bastian, S., Cyrys, J., & Zscheppang, A. (2016). Ultrafine and fine particles and hospital admissions in Central Europe. Results from the UFIREG study. *American journal of respiratory and critical care medicine*, *194*(10), 1233-1241.

Lefler, J. S., Higbee, J.D., Burnett, R.T. et al. (2019). Air pollution and mortality in a large, representative U.S. cohort: multiple-pollutant analyses, and spatial and temporal decompositions. *Environmental Health*, *18*, 101. https://doi.org/https://doi.org/10.1186/s12940-019-0544-9

Li, X., Feng, Y. J., & Liang, H. Y. (2017). The Impact of Meteorological Factors on PM2.5 Variations in Hong Kong. *IOP Conference Series: Earth and Environmental Science*, *78*, 012003. https://doi.org/10.1088/1755-1315/78/1/012003

Logan, W. P. (1953). Mortality in the London fog incident, 1952. *Lancet*, *1*(6755), 336-338. https://doi.org/10.1016/s0140-6736(53)91012-5

Luo, L., Zhang, Y., Jiang, J., Luan, H., Yu, C., Nan, P., Luo, B., & You, M. (2018). Short-Term Effects of Ambient Air Pollution on Hospitalization for Respiratory Disease in Taiyuan, China: A Time-Series Analysis. *International Journal of Environmental Research and Public Health*, *15*(10), 2160. https://www.mdpi.com/1660-4601/15/10/2160

Massimo Stafoggia, E. S., Ester Alessandrini, Ennio Cadum, Bart Ostro, Giovanna Berti, Annunziata Faustuini, Benedicte Jacquemin. (2013). Short-term Association between Fine and Coarse Particulate Matter and Hospitalization in Southerm

Europe: Result From the MED-PARTICLES Project. *Environmental health perspectives*, *121*(9), 1026-1033. https://doi.org/10.1289/ehp.1206151

Mohseni Bandpi, A. E., A. Shahsavani, F. Khodagholi, A. Aliaghaei & A. Alinejad. (2017). Water-soluble and organic extracts of ambient PM2.5 in Tehran air: assessment of genotoxic effects on human lung epithelial cells (A549) by the Comet assay. *Toxin Reviews*, *36:2*, 116-124. https://doi.org/https://doi.org/10.1080/15569543.2016.1259634

Moradi, M., Mokhtari, A., Mohammadi, M. J., Hadei, M., & Vosoughi, M. (2022). Estimation of long-term and short-term health effects attributed to PM2.5 standard pollutants in the air of Ardabil (using Air Q + model). *Environmental Science and Pollution Research*, *29*(15), 21508-21516. https://doi.org/10.1007/s11356-021-17303-x

Münzel, T., Sørensen, M., Gori, T., Schmidt, F. P., Rao, X., Brook, J., Chen, L. C., Brook, R. D., & Rajagopalan, S. (2017). Environmental stressors and cardio-metabolic disease: part I–epidemiologic evidence supporting a role for noise and air pollution and effects of mitigation strategies. *European heart journal*, *38*(8), 550-556.

Nasir, A. H., Nawaz, R., Haider, R., & Irshad, M. A. (2022). Modeling Air Pollution Health Risk for Environmental Management of an Internationally Important Site: The Salt Range (Kallar Kahar), Pakistan. *Atmosphere*, *13*(1), 100.

Pinichka C, M. N., Sukkumnoed D, Chariyalertsak S, Inchai P, Bundhamcharoen K. (2017). Burden of disease attributed to ambient air pollution in Thailand: A GIS-based approach. *PLoSONE*, *12(12):e0189909*. https://doi.org/https://doi.org/10.1371/journal.pone.0189909

PK, M. (2015). Dioxin: a review of its environmental effects and its aryl hydrocarbon receptor biology. . *Journal of Comparative Physiology B*, *174(4)*, 221-230. https://doi.org/http://dx.doi.org/10.1007/s00360-005-0483-3

Qiu, X., Wei, Y., Wang, Y., Di, Q., Sofer, T., Awad, Y. A., & Schwartz, J. (2020). Inverse probability weighted distributed lag effects of short-term exposure to PM2.5 and ozone on CVD hospitalizations in New England Medicare participants - Exploring the causal effects. *Environmental Research*, *182*, 109095. https://doi.org/https://doi.org/10.1016/j.envres.2019.109095

RW Atkinson, S. K., H R Anderson, IC Mils, HA Walton. (2014). Epidemiological Time Series Studies of PM 2.5 and Daily Mortality and Hospital Admissions: A Systematic Revies and Meta-analysis. *Thorax*, *69*(7), 660-665. https://doi.org/10.1136/thoraxjnl-2013-204492

Sacks, J. D., Neal Fann, Sophie Gumy, Ingu Kim, Giulia Ruggeri, and Pierpaolo Mudu. (2020). Quantifying the Public Health Benefits of Reducing Air Pollution: Critically Assessing the Features and Capabilities of WHO's AirQ+ and U.S. EPA's Environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP—CE. *Atmosphere* *11*(5), 516. https://doi.org/https://doi.org/10.3390/atmos11050516

Samet, J. M., Dominici, F., Curriero, F. C., Coursac, I., & Zeger, S. L. (2000). Fine particulate air pollution and mortality in 20 US cities, 1987–1994. *New England journal of medicine*, *343*(24), 1742-1749.

Samoli E, P. R., Ramsay T, Pipikou M, Touloumi G, Dominici F, Burnett R, Cohen A, Krewski D, Samet J, Katsouyanni K. (2008). Acute effects of ambient particulate matter on mortality in Europe and North America: results from the APHENA study. . *Environmental health perspectives*, *116(11)*, 1480-1486. https://doi.org/https://doi.org/10.1289/ehp.11345

Schriewer, J. M., Peek, C. B., Bass, J., & Schumacker, P. T. (2013). ROS-Mediated PARP activity undermines mitochondrial function after permeability transition pore opening during myocardial ischemia–reperfusion. *Journal of the American Heart Association*, *2*(2), e000159.

Simoni M, B. S., Maio S, Cerrai S, Sarno G, Viegi G. (2015). Adverse effects of outdoor pollution in the elderly. *7*, 34-45. https://doi.org/https://doi.org/10.3978/j.issn.2072-1439.2014.12.10

Tian, Y., Liu, H., Liang, T., Xiang, X., Li, M., Juan, J., Song, J., Cao, Y., Wang, X., & Chen, L. (2019). Fine particulate air pollution and adult hospital admissions in 200 Chinese cities: a time-series analysis. *International Journal of Epidemiology*, *48*(4), 1142-1151.

Vongmahadlek, C. T., Pham & Satayopas, Boonsong. (2009). A Compilation and Development of Spatial and Temporal Profiles of High-Resolution Emissions Inventory over Thailand. *Journal of the Air & Waste Management Association (1995)*, *59*, 845-856. https://doi.org/http://dx.doi.org/10.3155/1047-3289.59.7.845

Wang J, T. B., Liu X, et al. (2014). Pulmonary inflammation and cell death in mice after acute exposure to air particulate matter from an industrial region of Buenos Aires. *Arch Environ Contam Toxicol 2014*, *67*, 87-96. https://doi.org/http://dx.doi.org/10.1007/s00244-013-9975-4

Wang, J., Yin, Q., Tong, S., Ren, Z., Hu, M., & Zhang, H. (2017). Prolonged continuous exposure to high fine particulate matter associated with cardiovascular and respiratory disease mortality in Beijing, China. *Atmospheric Environment*, *168*, 1-7. https://doi.org/https://doi.org/10.1016/j.atmosenv.2017.08.060

Wei, Y., Wang, Y., Di, Q., Choirat, C., Wang, Y., Koutrakis, P., Zanobetti, A., Dominici, F., & Schwartz, J. D. (2019). Short term exposure to fine particulate matter and hospital admission risks and costs in the Medicare population: time stratified, case crossover study. *BMJ*, *367*, l6258. https://doi.org/10.1136/bmj.l6258

WHO. (2013a). *Health and environment: communicating the risks.* World Health Organization. Regional Office for Europe. https://apps.who.int/iris/handle/10665/108629

WHO. (2013b). *Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide*. WHO Regional Office for Europe. https://apps.who.int/iris/handle/10665/153692

WHO. (2013b). *Health and environment: communicating the risks.* Copenhagen: WHO Regional Office for Europe https://apps.who.int/iris/handle/10665/108629

WHO. (2014a). WHO handbook for guideline development,. In. https://apps.who.int/iris/handle/10665/145714 (Geneva: World Health Organization) (Reprinted from 2nd Editon)

WHO. (2018). *Burden of disease from ambient air pollution for 2016* (G. W. H. Organization., Ed.).

https://www.who.int/airpollution/data/AAP_BoD_results_May2018_final.pdf?ua=1

WHO. (2018d). *Global Health Observatory Data: Ambient air pollution'* (World health organization, Issue. https://www.who.int/gho/phe/outdoor_air_pollution/en

WHO. (2021). *WHO global air quality guidelines. Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. file:///C:/Users/Lenovo/Downloads/9789240034228-eng.pdf

Wold, L. E., Ying, Z., Hutchinson, K. R., Velten, M., Gorr, M. W., Velten, C., Youtz, D. J., Wang, A., Lucchesi, P. A., & Sun, Q. (2012). Cardiovascular remodeling in response to long-term exposure to fine particulate matter air pollution. *Circulation: Heart Failure*, *5*(4), 452-461.

Wong, D. W., Yuan, L., & Perlin, S. A. (2004). Comparison of spatial interpolation methods for the estimation of air quality data. *J Expo Anal Environ Epidemiol*, *14*(5), 404-415. https://doi.org/10.1038/sj.jea.7500338

Xie, W., Li, G., Zhao, D., Xie, X., Wei, Z., Wang, W., Wang, M., Li, G., Liu, W., & Sun, J. (2015). Relationship between fine particulate air pollution and ischaemic heart disease morbidity and mortality. *Heart*, *101*(4), 257-263.

Xu, Q., Li, X., Wang, S., Wang, C., Huang, F., Gao, Q., Wu, L., Tao, L., Guo, J., & Wang, W. (2016). Fine particulate air pollution and hospital emergency room visits for respiratory disease in urban areas in Beijing, China, in 2013. *PLoS one*, *11*(4), e0153099.

Ying, Z., Yue, P., Xu, X., Zhong, M., Sun, Q., Mikolaj, M., Wang, A., Brook, R. D., Chen, L. C., & Rajagopalan, S. (2009). Air pollution and cardiac remodeling: a role for RhoA/Rho-kinase. *American Journal of Physiology-Heart and Circulatory Physiology*, *296*(5), H1540-H1550.

Zhang, Y., Ma, R., Ban, J., Lu, F., Guo, M., Zhong, Y., Jiang, N., Chen, C., Li, T., & Shi, X. (2021). Risk of cardiovascular hospital admission after exposure to fine particulate pollution. *Journal of the American College of Cardiology*, *78*(10), 1015-1024.

Zhu, R.-X., Nie, X.-H., Chen, Y.-H., Chen, J., Wu, S.-W., & Zhao, L.-H. (2020). Relationship Between Particulate Matter (PM_{2.5}) and Hospitalizations and

Mortality of Chronic Obstructive Pulmonary Disease Patients: A Meta-Analysis. *The American Journal of the Medical Sciences*, *359*(6), 354-364. https://doi.org/10.1016/j.amjms.2020.03.016

Appendix 1

Amnat Charoen

Characteristic Province

Total Population		378,438 *people*
Total Population at Risk		232,936 *people*
Area Size		3161.248 km^2
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*69734.18*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*101492.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*983.53*
	Mortality due to COPD ***(ICD Code= J44)***	*4.19*
	Mortality due to IHD ***(ICD Code= 120-125)***	*31.34*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*60.53*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,496	642	**All Natural Cases Mortality**	**5**	421	181
	25	878	377		**10**	347	149
	35	471	202		**12**	317	136
	37	411	176		**15**	271	116
	37.5	396	170		**20**	192	82
	50	153	66		**25**	110	47
CVD Admission	**15**	1,518	652	**Mortality due to COPD**	**5**	-	-
	25	890	382		**10**	2	1
	35	478	205		**15**	1	0
	37	416	179		**25**	0	0
	37.5	401	172	**Mortality due to IHD**	**5**	-	-
	50	155	66		**10**	11	5
All Natural Cases Mortality	**15**	24	11		**15**	7	3
	25	14	6		**25**	2	1
	35	8	3	**Mortality due to Stroke**	**5**	-	-
	37	7	3		**10**	18	8
	37.5	6	3		**15**	12	5
	50	3	1		**25**	4	2

Ang Thong

Characteristic Province

Total Population		*279,654 people*
Total Population at Risk		*183,564 people*
Area Size		*968,372 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*67646.16*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*166794.1*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1331.96*
	Mortality due to COPD ***(ICD Code= J44)***	*4.44*
	Mortality due to IHD ***(ICD Code= 120-125)***	*69.19*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*90.43*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,229	670	**All Natural Cases Mortality**	**5**	466	254
	25	722	393		**10**	388	212
	35	393	214		**12**	356	194
	37	348	190		**15**	308	168
	37.5	337	184		**20**	224	122
	50	135	74		**25**	137	74
CVD Admission	**15**	2,113	1,151	**Mortality due to COPD**	**5**	-	-
	25	1,239	675		**10**	1	1
	35	675	368		**15**	1	1
	37	597	325		**25**	0	0
	37.5	579	315	**Mortality due to IHD**	**5**	-	-
	50	232	126		**10**	20	11
All Natural Cases Mortality	**15**	28	15		**15**	13	7
	25	16	9		**25**	5	3
	35	9	5	**Mortality due to Stroke**	**5**	-	-
	37	8	4		**10**	22	12
	37.5	8	4		**15**	15	8
	50	3	2		**25**	6	3

Bangkok Metropolis

Characteristic Province

Total Population		*5,666,264 People*
Total Population at Risk		*3,608,333 people*
Area Size		*1,568.737 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*8032.41*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*22025.93*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1188.25*
	Mortality due to COPD ***(ICD Code= J44)***	*6.16*
	Mortality due to IHD ***(ICD Code= 120-125)***	*69.67*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*93.45*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,803	50	**All Natural Cases Mortality**	**5**	6314	175
	25	851	24		**10**	4879	135
	35	399	11		**12**	4290	119
	37	344	10		**15**	3389	94
	37.5	331	9		**20**	1840	51
	50	128	4		**25**	230	6
CVD Admission	**15**	3,445	95	**Mortality due to COPD**	**5**	-	-
	25	1,625	45		**10**	28	1
	35	761	21		**15**	17	0
	37	656	18		**25**	1	0
	37.5	631	17	**Mortality due to IHD**	**5**	-	-
	50	244	7		**10**	327	9
All Natural Cases Mortality	**15**	310	9		**15**	175	5
	25	146	4		**25**	10	0
	35	69	2	**Mortality due to Stroke**	**5**	-	-
	37	59	2		**10**	349	10
	37.5	57	2		**15**	209	6
	50	22	1		**25**	12	0

Bueng Kan

Characteristic Province

Total Population		*424,091 people*
Total Population at Risk		*252604 people*
Area Size		*4,305 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*66326.74*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*96125.16*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*982.96*
	Mortality due to COPD ***(ICD Code= J44)***	*4.24*
	Mortality due to IHD ***(ICD Code= 120-125)***	*49.09*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*57.01*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,406	556	**All Natural Cases Mortality**	**5**	419	166
	25	895	354		**10**	338	134
	35	537	213		**12**	305	121
	37	481	190		**15**	254	101
	37.5	468	185		**20**	166	66
	50	226	89		**25**	76	30
CVD Admission	**15**	1,419	562	**Mortality due to COPD**	**5**	-	-
	25	902	357		**10**	11	1
	35	541	214		**15**	7	1
	37	485	192		**25**	1	0
	37.5	472	187	**Mortality due to IHD**	**5**	-	-
	50	227	90		**10**	47	5
All Natural Cases Mortality	**15**	24	10		**15**	25	3
	25	15	6		**25**	2	0
	35	9	4	**Mortality due to Stroke**	**5**	-	-
	37	8	3		**10**	105	11
	37.5	8	3		**15**	64	7
	50	4	2		**25**	5	1

Buriram

Characteristic Province

Total Population		*1,595,747 people*
Total Population at Risk		*954,465 people*
Area Size		*10,322.855 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*77636.37*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*98032.51*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1044.15*
	Mortality due to COPD ***(ICD Code= J44)***	*8.94*
	Mortality due to IHD ***(ICD Code= 120-125)***	*37.3*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*104.88*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	4,615	484	**All Natural Cases Mortality**	**5**	1489	156
	25	1,883	197		**10**	1156	121
	35	617	65		**12**	1020	107
	37	475	50		**15**	811	85
	37.5	442	46		**20**	452	47
	50	78	8		**25**	78	8
CVD Admission	**15**	4,063	426	**Mortality due to COPD**	**5**	-	-
	25	1,656	173		**10**	11	1
	35	542	57		**15**	7	1
	37	418	44		**25**	1	0
	37.5	389	41	**Mortality due to IHD**	**5**	-	-
	50	68	7		**10**	47	5
All Natural Cases Mortality	**15**	72	8		**15**	25	3
	25	29	3		**25**	2	0
	35	10	1	**Mortality due to Stroke**	**5**	-	-
	37	7	1		**10**	105	11
	37.5	7	1		**15**	64	7
	50	1	0		**25**	5	1

Chachoengsao

Characteristic Province

Total Population		*720,113 people*
Total Population at Risk		*443,246 people*
Area Size		*5,351 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*72298.9*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*109237.1*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1077.28*
	Mortality due to COPD ***(ICD Code= J44)***	*12.73*
	Mortality due to IHD ***(ICD Code= 120-125)***	*52.57*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*88.21*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,010	228	**All Natural Cases Mortality**	**5**	476	107
	25	316	71		**10**	308	69
	35	56	13		**12**	239	54
	37	35	8		**15**	133	30
	37.5	30	7		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	1,063	240	**Mortality due to COPD**	**5**	-	-
	25	333	75		**10**	5	1
	35	59	13		**15**	2	0
	37	37	8		**25**	0	0
	37.5	32	7	**Mortality due to IHD**	**5**	-	-
	50	0	0		**10**	20	5
All Natural Cases Mortality	**15**	17	4		**15**	7	1
	25	5	1		**25**	0	0
	35	1	0	**Mortality due to Stroke**	**5**	-	-
	37	1	0		**10**	26	6
	37.5	1	0		**15**	10	2
	50	0	0		**25**	0	0

Chai Nat

Characteristic Province

Total Population		*326,611 people*
Total Population at Risk		*216,389 people*
Area Size		*2,469.746 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*75509.38*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*175471*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1364.21*
	Mortality due to COPD ***(ICD Code= J44)***	*25.18*
	Mortality due to IHD ***(ICD Code= 120-125)***	*75.79*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*135.87*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,430	661	**All Natural Cases Mortality**	**5**	520	240
	25	811	375		**10**	424	196
	35	452	209		**12**	385	178
	37	400	185		**15**	325	150
	37.5	387	179		**20**	222	103
	50	149	69		**25**	115	53
CVD Admission	**15**	2,316	1,070	**Mortality due to COPD**	**5**	-	-
	25	1,313	607		**10**	8	4
	35	731	338		**15**	6	3
	37	647	299		**25**	2	1
	37.5	627	290	**Mortality due to IHD**	**5**	-	-
	50	242	112		**10**	25	11
All Natural Cases Mortality	**15**	30	14		**15**	15	7
	25	17	8		**25**	5	2
	35	9	4	**Mortality due to Stroke**	**5**	-	-
	37	8	4		**10**	36	17
	37.5	8	4		**15**	24	11
	50	3	1		**25**	7	3

Chaiyaphum

Characteristic Province

Total Population		*1,137,357 people*
Total Population at Risk		*717,757 people*
Area Size		*12,778,287 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*63110.5*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*97737.54*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1160.42*
	Mortality due to COPD ***(ICD Code= J44)***	*6.13*
	Mortality due to IHD ***(ICD Code= 120-125)***	*33.99*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*75.79*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,500	348	**All Natural Cases Mortality**	**5**	1149	160
	25	1,056	147		**10**	867	121
	35	360	50		**12**	751	105
	37	278	39		**15**	574	80
	37.5	260	36		**20**	270	38
	50	53	7		**25**	0	0
CVD Admission	**15**	2,698	376	**Mortality due to COPD**	**5**	-	-
	25	1,139	159		**10**	5	1
	35	388	54		**15**	3	0
	37	300	42		**25**	0	0
	37.5	281	39	**Mortality due to IHD**	**5**	-	-
	50	57	8		**10**	30	4
All Natural Cases Mortality	**15**	53	7		**15**	15	2
	25	23	3		**25**	0	0
	35	8	1	**Mortality due to Stroke**	**5**	-	-
	37	6	1		**10**	53	7
	37.5	6	1		**15**	30	4
	50	1	0		**25**	0	0

Chanthaburi

Characteristic Province

Total Population		*537,698 People*
Total Population at Risk		*334804 people*
Area Size		*6,338 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*60196.41*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*130765.2*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1174.42*
	Mortality due to COPD ***(ICD Code= J44)***	*18.79*
	Mortality due to IHD ***(ICD Code= 120-125)***	*42.11*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*125.15*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	775	231
	25	248	74
	35	43	13
	37	28	8
	37.5	24	7
	50	0	0
CVD Admission	15	1,173	350
	25	376	112
	35	65	20
	37	42	12
	37.5	36	11
	50	0	0
All Natural Cases Mortality	15	18	5
	25	6	2
	35	1	0
	37	1	0
	37.5	1	0
	50	0	0

Long-term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	444	133
	10	307	92
	12	251	75
	15	165	49
	20	17	5
	25	0	0
Mortality due to COPD	5	-	-
	10	6	2
	15	3	1
	25	0	0
Mortality due to IHD	5	-	-
	10	14	4
	15	6	2
	25	0	0
Mortality due to Stroke	5	-	-
	10	33	10
	15	15	5
	25	0	0

Chiang Mai

Characteristic Province

Total Population		*2,779,254 people*
Total Population at Risk		*1046415 people*
Area Size		*20,107.057 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*81531.32*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*147908.1*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1312.39*
	Mortality due to COPD ***(ICD Code= J44)***	*12.26*
	Mortality due to IHD ***(ICD Code= 120-125)***	*45.97*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*77.98*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	9,026	863	**All Natural Cases Mortality**	**5**	2539	243
	25	6,708	641		**10**	2100	201
	35	5,143	492		**12**	1919	183
	37	4,893	468		**15**	1643	157
	37.5	4,833	462		**20**	1169	112
	50	3,624	346		**25**	676	65
CVD Admission	**15**	11,376	1,087	**Mortality due to COPD**	**5**	-	-
	25	8,446	807		**10**	20	2
	35	6,471	618		**15**	14	1
	37	6,156	588		**25**	5	0
	37.5	6,079	581	**Mortality due to IHD**	**5**	-	-
	50	4,557	436		**10**	76	7
All Natural Cases Mortality	**15**	169	16		**15**	46	4
	25	126	12		**25**	17	2
	35	96	9	**Mortality due to Stroke**	**5**	-	-
	37	92	9		**10**	104	10
	37.5	91	9		**15**	71	7
	50	68	6		**25**	24	2

Chiang Rai

Characteristic Province

Total Population		*1,298,304 people*
Total Population at Risk		*743742 people*
Area Size		*11,678.369 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*81236.77*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*136274.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1124.58*
	Mortality due to COPD ***(ICD Code= J44)***	*20.84*
	Mortality due to IHD ***(ICD Code= 120-125)***	*39.4*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*73.01*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value ($\mu g/m^3$)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value ($\mu g/m^3$)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	6,392	859	**All Natural Cases Mortality**	**5**	1546	208
	25	4,751	639		**10**	1279	172
	35	3,643	490		**12**	1169	157
	37	3,465	466		**15**	1001	135
	37.5	3,422	460		**20**	712	96
	50	2,566	345		**25**	412	55
CVD Admission	**15**	7,450	1,002	**Mortality due to COPD**	**5**	-	-
	25	5,531	744		**10**	24	3
	35	4,238	570		**15**	17	2
	37	4,031	542		**25**	6	1
	37.5	3,981	535	**Mortality due to IHD**	**5**	-	-
	50	2,984	401		**10**	46	6
All Natural Cases Mortality	**15**	103	14		**15**	28	4
	25	76	10		**25**	10	1
	35	59	8	**Mortality due to Stroke**	**5**	-	-
	37	56	8		**10**	69	9
	37.5	55	7		**15**	47	6
	50	41	6		**25**	16	2

Chon Buri

Characteristic Province

Total Population		*1,558,301 people*
Total Population at Risk		*915,224 people*
		4,363 km²
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*74713.29*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*109074.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1100.39*
	Mortality due to COPD ***(ICD Code= J44)***	*8.68*
	Mortality due to IHD ***(ICD Code= 120-125)***	*54.52*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*97.46*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,135	233	**All Natural Cases Mortality**	**5**	997	109
	25	704	77		**10**	641	70
	35	150	16		**12**	495	54
	37	103	11		**15**	271	30
	37.5	92	10		**20**	0	0
	50	4	0		**25**	0	0
CVD Admission	**15**	2,172	237	**Mortality due to COPD**	**5**	-	-
	25	716	78		**10**	6	1
	35	153	17		**15**	2	0
	37	104	11		**25**	0	0
	37.5	94	10	**Mortality due to IHD**	**5**	-	-
	50	4	0		**10**	43	5
All Natural Cases Mortality	**15**	36	4		**15**	14	2
	25	12	1		**25**	0	0
	35	3	0	**Mortality due to Stroke**	**5**	-	-
	37	2	0		**10**	60	7
	37.5	2	0		**15**	21	2
	50	0	0		**25**	0	0

Loei

Characteristic Province

Total Population		*642,950 people*
Total Population at Risk		*402,139 people*
Area Size		*11,424.612 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*71849.29*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*111579.8*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1096.64*
	Mortality due to COPD ***(ICD Code= J44)***	*7.83*
	Mortality due to IHD ***(ICD Code= 120-125)***	*45.01*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*85.79*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	708	176	**All Natural Cases Mortality**	**5**	369	92
	25	292	73		**10**	211	52
	35	118	29		**12**	145	36
	37	97	24		**15**	46	11
	37.5	92	23		**20**	0	0
	50	15	4		**25**	0	0
CVD Admission	**15**	765	190	**Mortality due to COPD**	**5**	-	-
	25	316	79		**10**	2	0
	35	127	32		**15**	0	0
	37	105	26		**25**	0	0
	37.5	100	25	**Mortality due to IHD**	**5**	-	-
	50	16	4		**10**	13	3
All Natural Cases Mortality	**15**	13	3		**15**	2	1
	25	5	1		**25**	0	0
	35	2	1	**Mortality due to Stroke**	**5**	-	-
	37	2	0		**10**	18	5
	37.5	2	0		**15**	3	1
	50	0	0		**25**	0	0

Lamphun

Characteristic Province

Total Population		*405,075 people*
Total Population at Risk		*276,749 people*
Area Size		*4,505.882 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*72491.32*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*157097.2*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1417.53*
	Mortality due to COPD ***(ICD Code= J44)***	*17.37*
	Mortality due to IHD ***(ICD Code= 120-125)***	*64.68*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*96.12*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (µg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	2,036	736
	25	1,415	511
	35	982	355
	37	913	330
	37.5	897	324
	50	551	199
CVD Admission	**15**	3,071	1,110
	25	2,132	770
	35	1,478	534
	37	1,375	497
	37.5	1,350	488
	50	829	299
All Natural Cases Mortality	**15**	46	17
	25	32	12
	35	22	8
	37	21	7
	37.5	20	7
	50	13	5

Long-term

Name of Analysis	Cut-Off Value (µg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	723	261
	10	598	216
	12	546	197
	15	467	169
	20	332	120
	25	191	69
Mortality due to COPD	**5**	-	-
	10	7	3
	15	5	2
	25	2	1
Mortality due to IHD	**5**	-	-
	10	28	10
	15	17	6
	25	6	2
Mortality due to Stroke	**5**	-	-
	10	34	12
	15	23	8
	25	8	3

Lampang

Characteristic Province

Total Population		*738,316 people*
Total Population at Risk		*507,071 people*
Area Size		*12,533 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*58954.07*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*155234.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1387.18*
	Mortality due to COPD ***(ICD Code= J44)***	*27.86*
	Mortality due to IHD ***(ICD Code= 120-125)***	*63.5*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*113.79*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (µg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	2,561	505
	25	1,675	330
	35	1,039	205
	37	937	185
	37.5	912	180
	50	467	92
CVD Admission	15	4,695	926
	25	3,069	605
	35	1,903	375
	37	1,716	338
	37.5	1,671	330
	50	854	168
All Natural Cases Mortality	15	70	14
	25	46	9
	35	28	6
	37	26	5
	37.5	25	5
	50	13	3

Long-term

Name of Analysis	Cut-Off Value (µg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	1160	229
	10	929	183
	12	835	165
	15	690	136
	20	441	87
	25	182	36
Mortality due to COPD	5	-	-
	10	20	4
	15	13	3
	25	3	1
Mortality due to IHD	5	-	-
	10	46	9
	15	27	5
	25	6	1
Mortality due to Stroke	5	-	-
	10	66	13
	15	43	8
	25	9	2

Krabi

Characteristic Province

Total Population		*476,739 people*
Total Population at Risk		*261,705 people*
Area Size		*4,708.512 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*61938.06*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*102060.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*882.29*
	Mortality due to COPD ***(ICD Code= J44)***	*12.07*
	Mortality due to IHD ***(ICD Code= 120-125)***	*55.79*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*72.6*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	150	57	**All Natural Cases Mortality**	**5**	145	55
	25	21	8		**10**	60	23
	35	7	3		**12**	25	10
	37	6	2		**15**	0	0
	37.5	5	2		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	172	66	**Mortality due to COPD**	**5**	-	-
	25	25	9		**10**	1	0
	35	8	3		**15**	0	0
	37	7	3		**25**	0	0
	37.5	6	2	**Mortality due to IHD**	**5**	-	-
	50	0	0		**10**	6	2
All Natural Cases Mortality	**15**	2	1		**15**	0	0
	25	0	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	-
	37	0	0		**10**	6	2
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Khon Kaen

Characteristic Province

Total Population		*1,802,872 people*
Total Population at Risk		*1137511 people*
Area Size		*10,885.991km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*70517.56*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*104259.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1191.46*
	Mortality due to COPD ***(ICD Code= J44)***	*4.8*
	Mortality due to IHD ***(ICD Code= 120-125)***	*35.87*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*72.35*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (µg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	6,296	554
	25	3,436	302
	35	1,651	145
	37	1,410	124
	37.5	1,354	119
	50	444	39
CVD Admission	**15**	6,489	570
	25	3,538	311
	35	1,699	149
	37	1,451	128
	37.5	1,394	123
	50	457	40
All Natural Cases Mortality	**15**	123	11
	25	67	6
	35	32	3
	37	28	2
	37.5	27	2
	50	9	1

Long-term

Name of Analysis	Cut-Off Value (µg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	2263	199
	10	1820	160
	12	1638	144
	15	1360	120
	20	882	78
	25	385	34
Mortality due to COPD	**5**	-	-
	10	8	1
	15	5	0
	25	1	0
Mortality due to IHD	**5**	-	-
	10	59	5
	15	34	3
	25	8	1
Mortality due to Stroke	**5**	-	-
	10	96	8
	15	62	5
	25	15	1

Kanchanaburi

Characteristic Province

Total Population		*895,525 people*
Total Population at Risk		*490768 people*
Area Size		*19,483 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*91228.24*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*139255.6*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1021.87*
	Mortality due to COPD ***(ICD Code= J44)***	*15.77*
	Mortality due to IHD ***(ICD Code= 120-125)***	*55.42*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*91.9*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	3,060	624	**All Natural Cases Mortality**	**5**	761	155
	25	1,630	332		**10**	594	121
	35	809	165		**12**	526	107
	37	692	141		**15**	421	86
	37.5	664	135		**20**	241	49
	50	208	42		**25**	53	11
CVD Admission	**15**	3,255	663	**Mortality due to COPD**	**5**	-	-
	25	1,733	353		**10**	10	2
	35	860	175		**15**	6	1
	37	735	150		**25**	1	0
	37.5	705	144	**Mortality due to IHD**	**5**	-	-
	50	221	45		**10**	36	7
All Natural Cases Mortality	**15**	40	8		**15**	20	4
	25	21	4		**25**	2	0
	35	11	2	**Mortality due to Stroke**	**5**	-	-
	37	9	2		**10**	48	10
	37.5	9	2		**15**	29	6
	50	3	1		**25**	3	1

Kamphaeng Phet

Characteristic Province

Total Population		*725,867 people*
Total Population at Risk		*449,230 people*
Area Size		*8,607.490 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*70806.05*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*138596*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1096.77*
	Mortality due to COPD ***(ICD Code= J44)***	*10.99*
	Mortality due to IHD ***(ICD Code= 120-125)***	*48.97*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*91.04*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,527	563	**All Natural Cases Mortality**	**5**	780	174
	25	1,534	341		**10**	617	137
	35	785	175		**12**	550	122
	37	670	149		**15**	448	100
	37.5	643	143		**20**	272	61
	50	198	44		**25**	90	20
CVD Admission	**15**	3,447	767	**Mortality due to COPD**	**5**	-	-
	25	2,091	466		**10**	7	1
	35	1,070	238		**15**	4	1
	37	913	203		**25**	1	0
	37.5	876	195	**Mortality due to IHD**	**5**	-	-
	50	269	60		**10**	31	7
All Natural Cases Mortality	**15**	45	10		**15**	17	4
	25	28	6		**25**	3	1
	35	14	3	**Mortality due to Stroke**	**5**	-	-
	37	12	3		**10**	45	10
	37.5	12	3		**15**	29	6
	50	4	1		**25**	5	1

Kalasin

Characteristic Province

Total Population		*983,418 people*
Total Population at Risk		*624,765 people*
Area Size		*6,946.746 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*63340.94*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*103785.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1148.43*
	Mortality due to COPD ***(ICD Code= J44)***	*6.74*
	Mortality due to IHD ***(ICD Code= 120-125)***	*29.45*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*58.58*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	3,842	615	**All Natural Cases Mortality**	**5**	1355	217
	25	2,368	379		**10**	1126	180
	35	1,357	217		**12**	1032	165
	37	1,198	192		**15**	889	142
	37.5	1,162	186		**20**	642	103
	50	533	85		**25**	386	62
CVD Admission	**15**	4,387	702	**Mortality due to COPD**	**5**	-	-
	25	2,702	432		**10**	7	1
	35	1,548	248		**15**	5	1
	37	1,367	219		**25**	2	0
	37.5	1,325	212	**Mortality due to IHD**	**5**	-	-
	50	607	97		**10**	29	5
All Natural Cases Mortality	**15**	81	13		**15**	18	3
	25	50	8		**25**	7	1
	35	29	5	**Mortality due to Stroke**	**5**	-	-
	37	25	4		**10**	47	8
	37.5	24	4		**15**	33	5
	50	11	2		**25**	12	2

Chumphon

Characteristic Province

Total Population		*511,304 people*
Total Population at Risk		*313,179 people*
Area Size		*6,009.849 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*65052.89*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*117162.1*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*992.72*
	Mortality due to COPD ***(ICD Code= J44)***	*10.03*
	Mortality due to IHD ***(ICD Code= 120-125)***	*64.18*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*74.4*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	6	2	**All Natural Cases Mortality**	**5**	22	7
	25	0	0		**10**	0	0
	35	0	0		**12**	0	0
	37	0	0		**15**	0	0
	37.5	0	0		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	7	2	**Mortality due to COPD**	**5**	-	-
	25	0	0		**10**	0	0
	35	0	0		**15**	0	0
	37	0	0		**25**	0	0
	37.5	0	0	**Mortality due to IHD**	**5**	-	-
	50	0	0		**10**	0	0
All Natural Cases Mortality	**15**	0	0		**15**	0	0
	25	0	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	-
	37	0	0		**10**	0	0
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Lop Buri

Characteristic Province

Total Population		*755,556 people*
Total Population at Risk		*469,013 people*
Area Size		*6,199.753 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*53602.35*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*113989.8*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1241.76*
	Mortality due to COPD ***(ICD Code= J44)***	*8.83*
	Mortality due to IHD ***(ICD Code= 120-125)***	*62.9*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*88.7*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,217	473	**All Natural Cases Mortality**	**5**	1016	217
	25	1,310	279		**10**	828	176
	35	756	161		**12**	750	160
	37	673	143		**15**	632	135
	37.5	653	139		**20**	428	91
	50	285	61		**25**	216	46
CVD Admission	**15**	3,285	700	**Mortality due to COPD**	**5**	-	-
	25	1,939	413		**10**	6	1
	35	1,119	239		**15**	4	1
	37	996	212		**25**	1	0
	37.5	966	206	**Mortality due to IHD**	**5**	-	-
	50	422	90		**10**	44	9
All Natural Cases Mortality	**15**	60	13		**15**	26	6
	25	35	8		**25**	8	2
	35	20	4	**Mortality due to Stroke**	**5**	-	-
	37	18	4		**10**	50	11
	37.5	18	4		**15**	33	7
	50	8	2		**25**	9	2

Yasothon

Characteristic Province

Total Population		*537,299 People*
Total Population at Risk		*342,254 people*
Area Size		*4161.664km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*66,359.2 Cases*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*107,483 Cases*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1153.82 Cases*
	Mortality due to COPD ***(ICD Code= J44)***	*6.82 Cases*
	Mortality due to IHD ***(ICD Code= 120-125)***	*51.42 Cases*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*105.77 Cases*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	2,070	605
	25	1,200	350
	35	631	184
	37	548	160
	37.5	528	154
	50	199	58
CVD Admission	15	2,337	683
	25	1,353	395
	35	711	208
	37	617	180
	37.5	595	174
	50	224	65
All Natural Cases Mortality	15	42	12
	25	24	7
	35	13	4
	37	11	3
	37.5	11	3
	50	4	1

Long-term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	721	211
	10	595	174
	12	543	159
	15	463	135
	20	327	95
	25	184	54
Mortality due to COPD	5	-	
	10	4	1
	15	3	1
	25	1	0
Mortality due to IHD	5	-	
	10	27	8
	15	17	5
	25	6	2
Mortality due to Stroke	5	-	
	10	46	13
	15	31	9
	25	10	3

Yala

Characteristic Province

Total Population		*536,330 people*
Total Population at Risk		*259,367 people*
Area Size		*4,521.078 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*110211.4 Cases*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*114564.7 Cases*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1082.64 Cases*
	Mortality due to COPD ***(ICD Code= J44)***	*8.23 Cases*
	Mortality due to IHD ***(ICD Code= 120-125)***	*58.6 Cases*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*74.41 Cases*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	569	219
	25	162	63
	35	50	19
	37	38	15
	37.5	36	14
	50	6	2
CVD Admission	15	412	159
	25	118	45
	35	36	14
	37	28	11
	37.5	26	10
	50	4	2
All Natural Cases Mortality	15	6	3
	25	2	1
	35	1	0
	37	0	0
	37.5	0	0
	50	0	0

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	247	95
	10	147	57
	12	105	41
	15	42	16
	20	0	0
	25	0	0
Mortality due to COPD	5	-	
	10	4	1
	15	3	1
	25	0	0
Mortality due to IHD	5	-	
	10	23	8
	15	12	4
	25	1	0
Mortality due to Stroke	5	-	
	10	31	10
	15	19	6
	25	2	1

Uttaradit

Characteristic Province

Total Population		*453,103 people*
Total Population at Risk		*300,436 people*
Area Size		*7838.592 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*48828.04 Cases*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*163214.8 Cases*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1328.07 Cases*
	Mortality due to COPD ***(ICD Code= J44)***	*10.91 Cases*
	Mortality due to IHD ***(ICD Code= 120-125)***	*57.25 Cases*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*98.86 Cases*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,110	369	**All Natural Cases Mortality**	**5**	601	200
	25	666	222		**10**	468	156
	35	365	121		**12**	414	138
	37	319	106		**15**	330	110
	37.5	308	102		**20**	187	62
	50	128	43		**25**	38	12
CVD Admission	**15**	2,584	860	**Mortality due to COPD**	**5**	-	-
	25	1,550	516		**10**	4	1
	35	848	282		**15**	3	1
	37	741	247		**25**	0	0
	37.5	716	238	**Mortality due to IHD**	**5**	-	-
	50	299	99		**10**	23	8
All Natural Cases Mortality	**15**	35	12		**15**	12	4
	25	21	7		**25**	1	0
	35	12	4	**Mortality due to Stroke**	**5**	-	-
	37	10	3		**10**	31	10
	37.5	10	3		**15**	19	6
	50	4	1		**25**	2	1

Uthai Thani

Characteristic Province

Total Population		*328,618 people*
Total Population at Risk		*208,866 people*
Area Size		*6,730.246 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*77974.87*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*183504.7*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1187.84*
	Mortality due to COPD ***(ICD Code= J44)***	*15.99*
	Mortality due to IHD ***(ICD Code= 120-125)***	*55.54*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*89.05*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	1,317	631
	25	798	382
	35	402	192
	37	343	164
	37.5	330	158
	50	103	49
CVD Admission	15	2,160	1,034
	25	1,308	626
	35	658	315
	37	563	269
	37.5	540	259
	50	169	81
All Natural Cases Mortality	15	23	11
	25	14	7
	35	7	3
	37	6	3
	37.5	6	3
	50	2	1

Long-term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	403	193
	10	321	154
	12	288	138
	15	236	113
	20	148	71
	25	57	27
Mortality due to COPD	5	-	
	10	5	2
	15	3	1
	25	1	0
Mortality due to IHD	5	-	
	10	16	8
	15	9	4
	25	2	1
Mortality due to Stroke	5	-	
	10	21	10
	15	13	6
	25	3	1

Udon Thani

Characteristic Province

Total Population		*1,586,646 people*
Total Population at Risk		*964,072 people*
Area Size		*11,730.302 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*63037.62*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*102640.2*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1083.63*
	Mortality due to COPD ***(ICD Code= J44)***	*3.05*
	Mortality due to IHD ***(ICD Code= 120-125)***	*39.93*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*82.05*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	4,112	427	**All Natural Cases Mortality**	**5**	1568	163
	25	2,226	231		**10**	1219	126
	35	1,036	107		**12**	1076	112
	37	863	90		**15**	857	89
	37.5	823	85		**20**	481	50
	50	239	25		**25**	90	9
CVD Admission	**15**	4,666	484	**Mortality due to COPD**	**5**	-	
	25	2,524	262		**10**	4	0
	35	1,174	122		**15**	2	0
	37	978	101		**25**	0	0
	37.5	932	97	**Mortality due to IHD**	**5**	-	
	50	271	28		**10**	51	5
All Natural Cases Mortality	**15**	82	9		**15**	28	3
	25	44	5		**25**	3	0
	35	21	2	**Mortality due to Stroke**	**5**	-	
	37	17	2		**10**	83	9
	37.5	16	2		**15**	51	5
	50	5	0		**25**	4	0

Ubon Ratchathani

Characteristic Province

Total Population		*1,878,146 people*
Total Population at Risk		*1,111,699 people*
Area Size		*15,774 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*75985.32*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*104931.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1047.77*
	Mortality due to COPD ***(ICD Code= J44)***	*5.57*
	Mortality due to IHD ***(ICD Code= 120-125)***	*36.88*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*77.99*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	7,344	661
	25	4,102	369
	35	2,020	182
	37	1,725	155
	37.5	1,659	149
	50	537	48
CVD Admission	**15**	7,070	636
	25	3,946	355
	35	1,943	175
	37	1,658	149
	37.5	1,595	144
	50	516	46
All Natural Cases Mortality	**15**	117	11
	25	66	6
	35	32	3
	37	28	2
	37.5	27	2
	50	9	1

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	2073	186
	10	1697	153
	12	1543	139
	15	1307	118
	20	901	81
	25	479	43
Mortality due to COPD	**5**	-	
	10	9	1
	15	7	1
	25	2	0
Mortality due to IHD	**5**	-	
	10	63	6
	15	37	3
	25	12	1
Mortality due to Stroke	**5**	-	
	10	107	10
	15	72	6
	25	22	2

Trat

Characteristic Province

Total Population		*229,958 people*
Total Population at Risk		*137,268 people*
Area Size		*2,819 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*60879.45*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*121077*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1026.46*
	Mortality due to COPD ***(ICD Code= J44)***	*15.05*
	Mortality due to IHD ***(ICD Code= 120-125)***	*58.28*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*82.32*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	317	231	**All Natural Cases Mortality**	**5**	156	114
	25	106	77		**10**	107	78
	35	18	13		**12**	87	63
	37	12	9		**15**	56	41
	37.5	10	8		**20**	3	2
	50	0	0		**25**	0	0
CVD Admission	**15**	439	320	**Mortality due to COPD**	**5**	-	
	25	146	107		**10**	2	1
	35	24	18		**15**	1	1
	37	16	12		**25**	0	0
	37.5	14	10	**Mortality due to IHD**	**5**	-	
	50	0	0		**10**	8	6
All Natural Cases Mortality	**15**	6	5		**15**	3	2
	25	2	2		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	
	37	0	0		**10**	9	6
	37.5	0	0		**15**	4	3
	50	0	0		**25**	0	0

Trang

Characteristic Province

Total Population		*643,164 people*
Total Population at Risk		*381,380 people*
Area Size		*4,917.519 m^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*84315.38*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*118775.2*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*922.96*
	Mortality due to COPD ***(ICD Code= J44)***	*13.95*
	Mortality due to IHD ***(ICD Code= 120-125)***	*63.72*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*97.02*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	411	108	**All Natural Cases Mortality**	**5**	1264	209
	25	88	23		**10**	1048	174
	35	28	7		**12**	959	159
	37	21	6		**15**	822	136
	37.5	20	5		**20**	588	97
	50	4	1		**25**	345	57
CVD Admission	**15**	403	106	**Mortality due to COPD**	**5**	-	
	25	86	23		**10**	3	1
	35	27	7		**15**	0	0
	37	21	6		**25**	0	0
	37.5	20	5	**Mortality due to IHD**	**5**	-	
	50	4	1		**10**	13	3
All Natural Cases Mortality	**15**	5	1		**15**	0	0
	25	1	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	
	37	0	0		**10**	15	4
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Tak

Characteristic Province

Total Population		*665,620 people*
Total Population at Risk		*289,884 people*
Area Size		*16,406.650 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*84649.72*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*143475.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1060.77*
	Mortality due to COPD ***(ICD Code= J44)***	*22.35*
	Mortality due to IHD ***(ICD Code= 120-125)***	*40.02*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*67.61*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,250	776	**All Natural Cases Mortality**	**5**	521	180
	25	1,498	517		**10**	420	145
	35	931	321		**12**	379	131
	37	835	288		**15**	316	109
	37.5	811	280		**20**	208	72
	50	369	127		**25**	96	33
CVD Admission	**15**	2,657	917	**Mortality due to COPD**	**5**	-	
	25	1,768	610		**10**	10	3
	35	1,098	379		**15**	6	2
	37	985	340		**25**	2	1
	37.5	957	330	**Mortality due to IHD**	**5**	-	
	50	435	150		**10**	17	6
All Natural Cases Mortality	**15**	33	11		**15**	10	3
	25	22	8		**25**	3	1
	35	14	5	**Mortality due to Stroke**	**5**	-	
	37	12	4		**10**	23	8
	37.5	12	4		**15**	15	5
	50	5	2		**25**	4	1

Surin

Characteristic Province

Total Population		*1,396,831 people*
Total Population at Risk		*people*
Area Size		*8,124.056 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*72921.08*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*94812.25*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1078.71*
	Mortality due to COPD ***(ICD Code= J44)***	*4.26*
	Mortality due to IHD ***(ICD Code= 120-125)***	*31.33*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*76.12*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (µg/m3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	4,506	541
	25	2,186	262
	35	876	105
	37	716	86
	37.5	680	82
	50	138	17
CVD Admission	15	4,084	490
	25	1,980	238
	35	793	95
	37	649	78
	37.5	615	74
	50	125	15
All Natural Cases Mortality	15	77	9
	25	38	5
	35	15	2
	37	12	1
	37.5	12	1
	50	2	0

Long-term

Name of Analysis	Cut-Off Value (µg/m3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	1468	176
	10	1173	141
	12	1051	126
	15	866	104
	20	548	66
	25	217	26
Mortality due to COPD	5	-	
	10	5	1
	15	3	0
	25	1	0
Mortality due to IHD	5	-	
	10	37	4
	15	21	3
	25	5	1
Mortality due to Stroke	5	-	
	10	72	9
	15	46	6
	25	10	1

Surat Thani

Characteristic Province

Total Population		*1,068,010 people*
Total Population at Risk		*630,311 people*
Area Size		*12,891.469 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*77612.48*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*131084.8*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*924.15*
	Mortality due to COPD ***(ICD Code= J44)***	*9.33*
	Mortality due to IHD ***(ICD Code= 120-125)***	*50.77*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*79.64*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	114	18	**All Natural Cases Mortality**	**5**	246	39
	25	13	2		**10**	27	4
	35	0	0		**12**	0	0
	37	0	0		**15**	0	0
	37.5	0	0		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	134	21	**Mortality due to COPD**	**5**	-	
	25	15	2		**10**	0	0
	35	0	0		**15**	0	0
	37	0	0		**25**	0	0
	37.5	0	0	**Mortality due to IHD**	**5**	-	
	50	0	0		**10**	3	0
All Natural Cases Mortality	**15**	2	0		**15**	0	0
	25	0	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	
	37	0	0		**10**	3	1
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Suphan Buri

Characteristic Province

Total Population		*846,334 people*
Total Population at Risk		*544,679 people*
Area Size		*5,358.008 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*61536.98*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*144223.1*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1256.34*
	Mortality due to COPD ***(ICD Code= J44)***	*12.6*
	Mortality due to IHD ***(ICD Code= 120-125)***	*50.74*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*120.63*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value ($\mu g/m^3$)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value ($\mu g/m^3$)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,915	535	**All Natural Cases Mortality**	**5**	1206	221
	25	1,628	299		**10**	985	181
	35	870	160		**12**	894	164
	37	762	140		**15**	755	139
	37.5	737	135		**20**	516	95
	50	262	48		**25**	268	49
CVD Admission	**15**	4,762	874	**Mortality due to COPD**	**5**	-	
	25	2,657	488		**10**	10	2
	35	1,419	261		**15**	7	1
	37	1,244	228		**25**	2	0
	37.5	1,203	221	**Mortality due to IHD**	**5**	-	
	50	427	78		**10**	38	8
All Natural Cases Mortality	**15**	69	13		**15**	22	5
	25	39	7		**25**	7	1
	35	21	4	**Mortality due to Stroke**	**5**	-	
	37	18	3		**10**	72	15
	37.5	17	3		**15**	48	10
	50	6	1		**25**	14	3

Sukhothai

Characteristic Province

Total Population		*595,072 people*
Total Population at Risk		*391,656 people*
Area Size		*6,596.092 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*54822.34*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*170638.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1212.54*
	Mortality due to COPD ***(ICD Code= J44)***	*7.88*
	Mortality due to IHD ***(ICD Code= 120-125)***	*52.34*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*87.83*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,752	447	**All Natural Cases Mortality**	**5**	757	193
	25	1,082	276		**10**	600	153
	35	603	154		**12**	536	137
	37	527	135		**15**	437	112
	37.5	510	130		**20**	268	68
	50	191	49		**25**	92	24
CVD Admission	**15**	3,799	970	**Mortality due to COPD**	**5**	-	-
	25	2,345	599		**10**	4	1
	35	1,306	333		**15**	3	1
	37	1,143	292		**25**	0	0
	37.5	1,105	282	**Mortality due to IHD**	**5**	-	-
	50	413	105		**10**	29	7
All Natural Cases Mortality	**15**	45	11		**15**	16	4
	25	28	7		**25**	3	1
	35	15	4	**Mortality due to Stroke**	**5**	-	-
	37	14	3		**10**	38	10
	37.5	13	3		**15**	24	6
	50	5	1		**25**	4	1

Songkhla

Characteristic Province

Total Population		*1,435,968 people*
Total Population at Risk		*822,993 people*
Area Size		*7,973. 894 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*76597.74*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*112863.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1066.59*
	Mortality due to COPD ***(ICD Code= J44)***	*12.51*
	Mortality due to IHD ***(ICD Code= 120-125)***	*50.67*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*85.06*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	1,520	185
	25	497	60
	35	196	24
	37	159	19
	37.5	151	18
	50	35	4
CVD Admission	**15**	1,560	189
	25	510	62
	35	201	24
	37	163	20
	37.5	155	19
	50	36	4
All Natural Cases Mortality	**15**	25	3
	25	8	1
	35	3	0
	37	3	0
	37.5	2	0
	50	1	0

Long-term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	824	100
	10	512	62
	12	384	47
	15	188	23
	20	0	0
	25	0	0
Mortality due to COPD	**5**	-	
	10	8	1
	15	2	0
	25	0	0
Mortality due to IHD	**5**	-	
	10	34	4
	15	9	1
	25	0	0
Mortality due to Stroke	**5**	-	
	10	44	5
	15	14	2
	25	0	0

Sing Buri

Characteristic Province

Total Population		*208,446 people*
Total Population at Risk		*139,448 people*
Area Size		*822.478 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*60976.13*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*186584.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1348.17*
	Mortality due to COPD ***(ICD Code= J44)***	*9.15*
	Mortality due to IHD ***(ICD Code= 120-125)***	*39.44*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*81.03*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	795	570
	25	461	330
	35	257	185
	37	228	163
	37.5	221	158
	50	87	62
CVD Admission	15	1,697	1,217
	25	982	704
	35	548	393
	37	485	348
	37.5	471	337
	50	185	133
All Natural Cases Mortality	15	20	15
	25	12	8
	35	7	5
	37	6	4
	37.5	6	4
	50	2	2

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	346	248
	10	285	205
	12	261	187
	15	223	160
	20	158	113
	25	90	65
Mortality due to COPD	5	-	
	10	2	1
	15	1	1
	25	0	0
Mortality due to IHD	5	-	
	10	9	6
	15	5	4
	25	2	1
Mortality due to Stroke	5	-	
	10	14	10
	15	10	7
	25	3	2

Si Sa Ket

Characteristic Province

Total Population		*1,472,859 people*
Total Population at Risk		*896,164 people*
Area Size		*8,839.976 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*88144.25*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*100040.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1024.7*
	Mortality due to COPD ***(ICD Code= J44)***	*3.28*
	Mortality due to IHD ***(ICD Code= 120-125)***	*37.16*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*48.43*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	6,361	710	**All Natural Cases Mortality**	**5**	253	66
	25	3,323	371		**10**	124	33
	35	1,465	164		**12**	72	19
	37	1,232	137		**15**	0	0
	37.5	1,179	132		**20**	0	0
	50	290	32		**25**	0	0
CVD Admission	**15**	5,033	562	**Mortality due to COPD**	**5**	-	
	25	2,627	293		**10**	4	0
	35	1,158	129		**15**	3	0
	37	974	109		**25**	1	0
	37.5	931	104	**Mortality due to IHD**	**5**	-	
	50	230	26		**10**	49	5
All Natural Cases Mortality	**15**	86	10		**15**	29	3
	25	45	5		**25**	8	1
	35	20	2	**Mortality due to Stroke**	**5**	-	
	37	17	2		**10**	52	6
	37.5	16	2		**15**	34	4
	50	4	0		**25**	9	1

Satun

Characteristic Province

Total Population		*323,586 people*
Total Population at Risk		*175,001people*
Area Size		*2,478.977 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*95096.03*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*97221.73*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*866.85*
	Mortality due to COPD ***(ICD Code= J44)***	*8*
	Mortality due to IHD ***(ICD Code= 120-125)***	*40.57*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*72*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	241	138	**All Natural Cases Mortality**	**5**	106	61
	25	75	43		**10**	51	29
	35	33	19		**12**	28	16
	37	27	16		**15**	0	0
	37.5	26	15		**20**	0	0
	50	6	4		**25**	0	0
CVD Admission	**15**	172	98	**Mortality due to COPD**	**5**	-	-
	25	54	31		**10**	1	0
	35	23	13		**15**	0	0
	37	19	11		**25**	0	0
	37.5	19	11	**Mortality due to IHD**	**5**	-	-
	50	4	3		**10**	4	2
All Natural Cases Mortality	**15**	3	1		**15**	0	0
	25	1	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	-
	37	0	0		**10**	5	3
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Saraburi

Characteristic Province

Total Population		*645,911 people*
Total Population at Risk		*392,712 people*
Area Size		*3,576.486 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*81705.17*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*134035.9*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1311.9*
	Mortality due to COPD ***(ICD Code= J44)***	*16.17*
	Mortality due to IHD ***(ICD Code= 120-125)***	*69.77*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*131.14*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	2,772	706
	25	1,667	425
	35	938	239
	37	831	212
	37.5	805	205
	50	331	84
CVD Admission	15	3,169	807
	25	1,905	485
	35	1,071	273
	37	949	242
	37.5	920	234
	50	377	96
All Natural Cases Mortality	15	52	13
	25	31	8
	35	17	4
	37	15	4
	37.5	15	4
	50	6	2

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	15	5
	10	0	0
	12	0	0
	15	0	0
	20	0	0
	25	0	0
Mortality due to COPD	5	-	-
	10	9	2
	15	6	2
	25	2	0
Mortality due to IHD	5	-	-
	10	41	10
	15	24	6
	25	7	2
Mortality due to Stroke	5	-	-
	10	62	16
	15	41	10
	25	11	3

Samut Prakan

Characteristic Province

Total Population		*1,344,875 people*
Total Population at Risk		*833,707 people*
Area Size		*1,004.092 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*47176.05*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*67986.47*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*955.73*
	Mortality due to COPD ***(ICD Code= J44)***	*9.59*
	Mortality due to IHD ***(ICD Code= 120-125)***	*59.01*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*92.72*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,261	271	**All Natural Cases Mortality**	**5**	1132	136
	25	986	118		**10**	864	104
	35	434	52		**12**	754	90
	37	367	44		**15**	586	70
	37.5	351	42		**20**	296	36
	50	107	13		**25**	0	0
CVD Admission	**15**	2,271	272	**Mortality due to COPD**	**5**	-	-
	25	989	119		**10**	10	1
	35	436	52		**15**	6	1
	37	368	44		**25**	0	0
	37.5	352	42	**Mortality due to IHD**	**5**	-	-
	50	107	13		**10**	62	7
All Natural Cases Mortality	**15**	53	6		**15**	32	4
	25	23	3		**25**	0	0
	35	10	1	**Mortality due to Stroke**	**5**	-	-
	37	9	1		**10**	77	9
	37.5	8	1		**15**	45	5
	50	3	0		**25**	0	0

Samut Songkhram

Characteristic Province		
Total Population		*193,305 people*
Total Population at Risk		*129,216 people*
Area Size		*416.707 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*75872.96*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*132434.8*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1147.69*
	Mortality due to COPD ***(ICD Code= J44)***	*11.31*
	Mortality due to IHD ***(ICD Code= 120-125)***	*58.04*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*68.1*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	594	460
	25	298	231
	35	134	104
	37	111	86
	37.5	106	82
	50	26	20
CVD Admission	**15**	723	559
	25	362	280
	35	163	126
	37	135	105
	37.5	129	100
	50	32	25
All Natural Cases Mortality	**15**	10	8
	25	5	4
	35	2	2
	37	2	2
	37.5	2	1
	50	0	0

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	205	159
	10	155	120
	12	134	104
	15	103	79
	20	49	38
	25	0	0
Mortality due to COPD	**5**	-	-
	10	2	1
	15	1	1
	25	0	0
Mortality due to IHD	**5**	-	-
	10	9	7
	15	5	4
	25	0	0
Mortality due to Stroke	**5**	-	-
	10	9	7
	15	5	4
	25	0	0

Samut Sakhon

Characteristic Province

Total Population		*584,703 people*
Total Population at Risk		*339,306 people*
Area Size		*339,3067 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*102945.7*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*115829.7*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1162.96*
	Mortality due to COPD ***(ICD Code= J44)***	*8.43*
	Mortality due to IHD ***(ICD Code= 120-125)***	*60.12*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*99.32*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,694	794	**All Natural Cases Mortality**	**5**	632	186
	25	1,686	497		**10**	502	148
	35	1,083	319		**12**	449	132
	37	991	292		**15**	367	108
	37.5	969	286		**20**	227	67
	50	527	155		**25**	81	24
CVD Admission	**15**	2,110	622	**Mortality due to COPD**	**5**	-	-
	25	1,319	389		**10**	4	1
	35	848	250		**15**	3	1
	37	776	229		**25**	0	0
	37.5	758	223	**Mortality due to IHD**	**5**	-	-
	50	412	121		**10**	29	8
All Natural Cases Mortality	**15**	35	10		**15**	16	5
	25	22	7		**25**	3	1
	35	14	4	**Mortality due to Stroke**	**5**	-	-
	37	13	4		**10**	38	11
	37.5	13	4		**15**	24	7
	50	7	2		**25**	4	1

Sakon Nakhon

Characteristic Province

Total Population		*1,153,390 people*
Total Population at Risk		*699,714 people*
Area Size		*9,605.764 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*56553.25*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*106587*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1039.85*
	Mortality due to COPD ***(ICD Code= J44)***	*4.21*
	Mortality due to IHD ***(ICD Code= 120-125)***	*24.01*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*57.59*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	3,513	502	**All Natural Cases Mortality**	**5**	1293	185
	25	2,172	310		**10**	1058	151
	35	1,251	179		**12**	961	137
	37	1,110	159		**15**	814	116
	37.5	1,076	154		**20**	560	80
	50	467	67		**25**	297	42
CVD Admission	**15**	4,614	659	**Mortality due to COPD**	**5**	-	-
	25	2,850	407		**10**	4	1
	35	1,641	235		**15**	3	0
	37	1,455	208		**25**	1	0
	37.5	1,411	202	**Mortality due to IHD**	**5**	-	-
	50	612	87		**10**	26	4
All Natural Cases Mortality	**15**	75	11		**15**	15	2
	25	46	7		**25**	5	1
	35	27	4	**Mortality due to Stroke**	**5**	-	-
	37	24	3		**10**	50	7
	37.5	23	3		**15**	33	5
	50	10	1		**25**	10	1

Sae Keo

Characteristic Province

Total Population		*566,303 people*
Total Population at Risk		*332,732 people*
Area Size		*7,195.436 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*56,442.72 Cases*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*10,2776.1 Cases*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*996.3 Cases*
	Mortality due to COPD ***(ICD Code= J44)***	*12.84 Cases*
	Mortality due to IHD ***(ICD Code= I20-I25)***	*31.56 Cases*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*84.75 Cases*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	980	294	**All Natural Cases Mortality**	**5**	440	132
	25	412	124		**10**	327	98
	35	137	41		**12**	281	84
	37	108	32		**15**	210	63
	37.5	101	30		**20**	88	27
	50	16	5		**25**	0	0
CVD Admission	**15**	1,243	374	**Mortality due to COPD**	**5**	-	-
	25	522	157		**10**	5	1
	35	174	52		**15**	3	1
	37	137	41		**25**	0	0
	37.5	128	39	**Mortality due to IHD**	**5**	-	-
	50	21	6		**10**	12	4
All Natural Cases Mortality	**15**	20	6		**15**	6	2
	25	8	3		**25**	0	0
	35	3	1	**Mortality due to Stroke**	**5**	-	-
	37	2	1		**10**	26	8
	37.5	2	1		**15**	15	4
	50	0	0		**25**	0	0

Roi Et

Characteristic Province

Total Population		*1,305,211 people*
Total Population at Risk		*833,021 people*
Area Size		*8,299.449 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*71047.31*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*103497.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1092.29*
	Mortality due to COPD ***(ICD Code= J44)***	*6.98*
	Mortality due to IHD ***(ICD Code= 120-125)***	*36.13*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*80.91*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	5,484	658	**All Natural Cases Mortality**	**5**	1679	202
	25	3,207	385		**10**	1388	167
	35	1,703	204		**12**	1268	152
	37	1,484	178		**15**	1085	130
	37.5	1,433	172		**20**	771	93
	50	565	68		**25**	444	53
CVD Admission	**15**	5,569	669	**Mortality due to COPD**	**5**	-	
	25	3,254	391		**10**	9	1
	35	1,727	207		**15**	6	1
	37	1,505	181		**25**	2	0
	37.5	1,453	174	**Mortality due to IHD**	**5**	-	
	50	573	69		**10**	47	6
All Natural Cases Mortality	**15**	98	12		**15**	29	3
	25	57	7		**25**	10	1
	35	30	4	**Mortality due to Stroke**	**5**	-	
	37	26	3		**10**	86	10
	37.5	26	3		**15**	58	7
	50	10	1		**25**	20	2

Rayong

Characteristic Province

Total Population		*734,753 people*
Total Population at Risk		*433,823 people*
Area Size		*3,552 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*67876.53*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*89007.27*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1021.85*
	Mortality due to COPD ***(ICD Code= J44)***	*11.08*
	Mortality due to IHD ***(ICD Code= 120-125)***	*59.7*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*98.66*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,024	236	**All Natural Cases Mortality**	**5**	468	108
	25	325	75		**10**	312	72
	35	57	13		**12**	248	57
	37	30	7		**15**	151	35
	37.5	25	6		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	935	216	**Mortality due to COPD**	**5**	-	
	25	297	68		**10**	4	1
	35	52	12		**15**	2	0
	37	27	6		**25**	0	0
	37.5	23	5	**Mortality due to IHD**	**5**	-	
	50	0	0		**10**	24	6
All Natural Cases Mortality	**15**	18	4		**15**	9	2
	25	6	1		**25**	0	0
	35	1	0	**Mortality due to Stroke**	**5**	-	
	37	1	0		**10**	31	7
	37.5	0	0		**15**	13	3
	50	0	0		**25**	0	0

Ratchaburi

Characteristic Province

Total Population		*873,101 people*
Total Population at Risk		*535,763 people*
Area Size		*5,196.462 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*69233.04*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*133260*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1231.33*
	Mortality due to COPD ***(ICD Code= J44)***	*9.06*
	Mortality due to IHD ***(ICD Code= 120-125)***	*29.49*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*93.7*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,199	410	**All Natural Cases Mortality**	**5**	905	169
	25	1,082	202		**10**	682	127
	35	475	89		**12**	590	110
	37	396	74		**15**	450	84
	37.5	378	71		**20**	208	39
	50	94	17		**25**	0	0
CVD Admission	**15**	2,949	550	**Mortality due to COPD**	**5**	-	
	25	1,451	271		**10**	6	1
	35	637	119		**15**	4	1
	37	531	99		**25**	0	0
	37.5	506	94	**Mortality due to IHD**	**5**	-	
	50	126	23		**10**	19	4
All Natural Cases Mortality	**15**	45	8		**15**	10	2
	25	22	4		**25**	0	0
	35	10	2	**Mortality due to Stroke**	**5**	-	
	37	8	2		**10**	48	9
	37.5	8	1		**15**	28	5
	50	2	0		**25**	0	0

Ranong

Characteristic Province

Total Population		*193,370 people*
Total Population at Risk		*104,557 people*
Area Size		*3,298.045 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*67385.25*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*105584.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*862.69*
	Mortality due to COPD ***(ICD Code= J44)***	*18.67*
	Mortality due to IHD ***(ICD Code= 120-125)***	*54.52*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*69.82*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	5	5
	25	0	0
	35	0	0
	37	0	0
	37.5	0	0
	50	0	0
CVD Admission	**15**	6	5
	25	0	0
	35	0	0
	37	0	0
	37.5	0	0
	50	0	0
All Natural Cases Mortality	**15**	0	0
	25	0	0
	35	0	0
	37	0	0
	37.5	0	0
	50	0	0

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	19	18
	10	0	0
	12	0	0
	15	0	0
	20	0	0
	25	0	0
Mortality due to COPD	**5**	-	
	10	0	0
	15	0	0
	25	0	0
Mortality due to IHD	**5**	-	
	10	0	0
	15	0	0
	25	0	0
Mortality due to Stroke	**5**	-	
	10	0	0
	15	0	0
	25	0	0

Prachuap Khiri Khan

Characteristic Province

Total Population		*554,116 people*
Total Population at Risk		*327,481 people*
Area Size		*6,367.620 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*21514.53*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*137709.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*993.34*
	Mortality due to COPD ***(ICD Code= J44)***	*13.92*
	Mortality due to IHD ***(ICD Code= 120-125)***	*44.58*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*58.02*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2	1	**All Natural Cases Mortality**	**5**	247	95
	25	0	0		**10**	147	57
	35	0	0		**12**	105	41
	37	0	0		**15**	42	16
	37.5	0	0		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	10	3	**Mortality due to COPD**	**5**	-	
	25	0	0		**10**	0	0
	35	0	0		**15**	0	0
	37	0	0		**25**	0	0
	37.5	0	0	**Mortality due to IHD**	**5**	-	
	50	0	0		**10**	0	0
All Natural Cases Mortality	**15**	0	0		**15**	0	0
	25	0	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	
	37	0	0		**10**	0	0
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Prachin Buri

Characteristic Province

Total Population		*494,680 people*
Total Population at Risk		*299,675 people*
Area Size		*4,762.362 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*68973.05*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*115171.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1182.28*
	Mortality due to COPD ***(ICD Code= J44)***	*11.03*
	Mortality due to IHD ***(ICD Code= 120-125)***	*52.06*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*103.78*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	894	298	**All Natural Cases Mortality**	**5**	417	139
	25	365	122		**10**	295	98
	35	130	43		**12**	244	82
	37	102	34		**15**	167	56
	37.5	96	32		**20**	35	12
	50	17	6		**25**	0	0
CVD Admission	**15**	1,040	347	**Mortality due to COPD**	**5**	-	
	25	424	142		**10**	3	1
	35	151	51		**15**	2	1
	37	119	40		**25**	0	0
	37.5	111	37	**Mortality due to IHD**	**5**	-	
	50	20	7		**10**	16	5
All Natural Cases Mortality	**15**	18	6		**15**	7	2
	25	7	2		**25**	0	0
	35	3	1	**Mortality due to Stroke**	**5**	-	
	37	2	1		**10**	26	9
	37.5	2	1		**15**	12	4
	50	0	0		**25**	0	0

Phuket

Characteristic Province

Total Population		*416,582 people*
Total Population at Risk		*230,315 people*
Area Size		*543.034 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*71413.5*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*101888.7*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*913.53*
	Mortality due to COPD ***(ICD Code= J44)***	*8.42*
	Mortality due to IHD ***(ICD Code= 120-125)***	*42.98*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*82.5*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	201	87	**All Natural Cases Mortality**	**5**	136	59
	25	41	18		**10**	58	25
	35	12	5		**12**	27	12
	37	10	4		**15**	0	0
	37.5	9	4		**20**	0	0
	50	2	1		**25**	0	0
CVD Admission	**15**	200	87	**Mortality due to COPD**	**5**	-	
	25	41	18		**10**	1	0
	35	12	5		**15**	0	0
	37	10	4		**25**	0	0
	37.5	9	4	**Mortality due to IHD**	**5**	-	
	50	2	1		**10**	4	2
All Natural Cases Mortality	**15**	3	1		**15**	0	0
	25	1	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	
	37	0	0		**10**	6	3
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Phrae

Characteristic Province

Total Population		*441,725 people*
Total Population at Risk		*305,129 people*
Area Size		*6,538.598 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*53178.49*
	Cardiovascular Hospital Admission ***(ICD Code= J00-J99)***	*172890.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1444.63*
	Mortality due to COPD ***(ICD Code= J44)***	*29.17*
	Mortality due to IHD ***(ICD Code= 120-125)***	*56.37*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*114.71*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (µg/m3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	1,442	473
	25	965	316
	35	607	199
	37	549	180
	37.5	535	175
	50	277	91
CVD Admission	**15**	3,265	1,070
	25	2,183	715
	35	1,373	450
	37	1,241	407
	37.5	1,209	396
	50	626	205
All Natural Cases Mortality	**15**	45	15
	25	30	10
	35	19	6
	37	17	6
	37.5	17	6
	50	9	3

Long-term

Name of Analysis	Cut-Off Value (µg/m3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	734	241
	10	590	193
	12	531	174
	15	440	144
	20	285	93
	25	123	40
Mortality due to COPD	**5**	-	
	10	12	4
	15	8	3
	25	2	1
Mortality due to IHD	**5**	-	
	10	25	8
	15	14	5
	25	4	1
Mortality due to Stroke	**5**	-	
	10	41	13
	15	26	9
	25	6	2

Phra Nakhon Si Ayutthaya

Characteristic Province

Total Population		*820,188 people*
Total Population at Risk		*524.096 people*
Area Size		*2,556.650 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*75567.64*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*120599.7*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1170.4*
	Mortality due to COPD ***(ICD Code= J44)***	*7.58*
	Mortality due to IHD ***(ICD Code= 120-125)***	*74.22*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*97.5*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	3,998	763	**All Natural Cases Mortality**	**5**	1181	225
	25	2,402	458		**10**	987	188
	35	1,334	255		**12**	907	173
	37	1,178	225		**15**	785	150
	37.5	1,140	218		**20**	575	110
	50	472	90		**25**	357	68
CVD Admission	**15**	4,449	849	**Mortality due to COPD**	**5**	-	
	25	2,670	509		**10**	6	1
	35	1,482	283		**15**	5	1
	37	1,308	250		**25**	2	0
	37.5	1,267	242	**Mortality due to IHD**	**5**	-	
	50	525	100		**10**	63	12
All Natural Cases Mortality	**15**	72	14		**15**	39	7
	25	43	8		**25**	16	3
	35	24	5	**Mortality due to Stroke**	**5**	-	
	37	21	4		**10**	67	13
	37.5	21	4		**15**	47	9
	50	8	2		**25**	18	3

Phitsanulok

Characteristic Province

Total Population		*865,247 people*
Total Population at Risk		*544,616 people*
Area Size		*10,815.854 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission P* ***(ICD Code= J00-J99)***	*68596.04*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*147478*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1242.34*
	Mortality due to COPD ***(ICD Code= J44)***	*11.92*
	Mortality due to IHD ***(ICD Code= 120-125)***	*72.34*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*123.39*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	2,409	442
	25	1,287	236
	35	562	103
	37	470	86
	37.5	449	83
	50	121	22
CVD Admission	15	3,608	663
	25	1,926	354
	35	841	154
	37	703	129
	37.5	673	123
	50	181	33
All Natural Cases Mortality	15	51	9
	25	27	5
	35	12	2
	37	10	2
	37.5	9	2
	50	3	0

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	945	174
	10	717	132
	12	623	114
	15	480	88
	20	233	43
	25	0	0
Mortality due to COPD	5	-	
	10	8	1
	15	5	1
	25	0	0
Mortality due to IHD	5	-	
	10	49	9
	15	25	5
	25	0	0
Mortality due to Stroke	5	-	
	10	66	12
	15	38	7
	25	0	0

Phichit

Characteristic Province

Total Population		*536,311 people*
Total Population at Risk		*347,938 people*
Area Size		*4,531.013 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*67743.97*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*167700.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1214.3*
	Mortality due to COPD ***(ICD Code= J44)***	*5.2*
	Mortality due to IHD ***(ICD Code= 120-125)***	*47.42*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*77.89*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,582	455	**All Natural Cases Mortality**	**5**	616	177
	25	851	244		**10**	474	136
	35	357	103		**12**	416	120
	37	291	84		**15**	327	94
	37.5	276	79		**20**	174	50
	50	65	19		**25**	15	4
CVD Admission	**15**	2,729	784	**Mortality due to COPD**	5	-	-
	25	1,467	422		**10**	2	1
	35	616	177		**15**	1	0
	37	502	144		**25**	0	0
	37.5	475	137	**Mortality due to IHD**	**5**	-	-
	50	112	32		**10**	21	6
All Natural Cases Mortality	**15**	33	9		**15**	11	3
	25	18	5		**25**	0	0
	35	7	2	**Mortality due to Stroke**	**5**	-	-
	37	6	2		**10**	28	8
	37.5	6	2		**15**	17	5
	50	1	0		**25**	1	0

Phetchaburi

Characteristic Province

Total Population		*485,191 people*
Total Population at Risk		*306,113 people*
Area Size		*6,225.`38 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*70981.3*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*142773.1*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1103.19*
	Mortality due to COPD ***(ICD Code= J44)***	*8.24*
	Mortality due to IHD ***(ICD Code= 120-125)***	*51.61*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*67.3*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,265	413	**All Natural Cases Mortality**	**5**	451	147
	25	631	206		**10**	336	110
	35	278	91		**12**	289	94
	37	229	75		**15**	217	71
	37.5	217	71		**20**	93	30
	50	52	17		**25**	0	0
CVD Admission	**15**	1,773	579	**Mortality due to COPD**	25		
	25	884	289		**10**	3	1
	35	390	127		**15**	2	1
	37	321	105		**25**	0	0
	37.5	304	99	**Mortality due to IHD**	25		
	50	72	24		**10**	19	6
All Natural Cases Mortality	**15**	23	7		**15**	9	3
	25	11	4		**25**	0	0
	35	5	2	**Mortality due to Stroke**	25		
	37	4	1		**10**	19	6
	37.5	4	1		**15**	11	4
	50	1	0		**25**	0	0

Phetchabun

Characteristic Province

Total Population		*992,451 people*
Total Population at Risk		*623,217 people*
Area Size		*12,668.416 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*49748.48*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*110338.1*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1149.52*
	Mortality due to COPD ***(ICD Code= J44)***	*11.12*
	Mortality due to IHD ***(ICD Code= 120-125)***	*36.1*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*77.18*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (µg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	1,529	245
	25	650	104
	35	217	35
	37	173	28
	37.5	164	26
	50	37	6
CVD Admission	15	2,363	379
	25	1,003	161
	35	336	54
	37	268	43
	37.5	253	41
	50	58	9
All Natural Cases Mortality	15	41	7
	25	17	3
	35	6	1
	37	5	1
	37.5	4	1
	50	1	0

Long-term

Name of Analysis	Cut-Off Value (µg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	997	109
	10	653	105
	12	552	89
	15	398	64
	20	132	21
	25	0	0
Mortality due to COPD	5	-	-
	10	7	1
	15	4	1
	25	0	0
Mortality due to IHD	5	-	-
	10	25	4
	15	12	2
	25	0	0
Mortality due to Stroke	5	-	-
	10	42	7
	15	22	4
	25	0	0

Phayao

Characteristic Province

Total Population		*472,356 people*
Total Population at Risk		*316,576 people*
Area Size		*6,335.060 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*70897.04*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*135452.8*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1243.94*
	Mortality due to COPD ***(ICD Code= J44)***	*22.84*
	Mortality due to IHD ***(ICD Code= 120-125)***	*66.02*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*77.71*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	985	311	**All Natural Cases Mortality**	**5**	425	134
	25	494	156		**10**	287	91
	35	232	73		**12**	231	73
	37	200	63		**15**	144	45
	37.5	192	61		**20**	0	0
	50	75	24		**25**	0	0
CVD Admission	**15**	1,310	414	**Mortality due to COPD**	**5**	-	-
	25	657	208		**10**	6	2
	35	309	97		**15**	3	1
	37	265	84		**25**	0	0
	37.5	255	81	**Mortality due to IHD**	**5**	-	-
	50	100	32		**10**	20	6
All Natural Cases Mortality	**15**	20	6		**15**	8	2
	25	10	3		**25**	0	0
	35	5	1	**Mortality due to Stroke**	**5**	-	-
	37	4	1		**10**	18	6
	37.5	4	1		**15**	8	2
	50	2	0		**25**	0	0

Phatthalung

Characteristic Province

Total Population		*524,865 people*
Total Population at Risk		*325,553 people*
Area Size		*3,424.473 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*90424.6*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*140922.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*981.41*
	Mortality due to COPD ***(ICD Code= J44)***	*8.81*
	Mortality due to IHD ***(ICD Code= 120-125)***	*54.37*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*79.86*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	562	172
	25	141	43
	35	46	14
	37	37	11
	37.5	34	11
	50	5	2
CVD Admission	15	610	187
	25	153	47
	35	50	15
	37	40	12
	37.5	37	11
	50	6	2
All Natural Cases Mortality	15	7	2
	25	2	1
	35	1	0
	37	0	0
	37.5	0	0
	50	0	0

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	270	83
	10	155	48
	12	108	33
	15	36	11
	20	0	0
	25	0	0
Mortality due to COPD	5	-	-
	10	2	1
	15	0	0
	25	0	0
Mortality due to IHD	5	-	-
	10	13	4
	15	2	1
	25	0	0
Mortality due to Stroke	5	-	-
	10	14	4
	15	3	1
	25	0	0

Phangnga

Characteristic Province

Total Population		*268,788people*
Total Population at Risk		*159,585 people*
Area Size		*4,170.895 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*63475.89*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*137557.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*941.19*
	Mortality due to COPD ***(ICD Code= J44)***	*12.32*
	Mortality due to IHD ***(ICD Code= 120-125)***	*56.4*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*72.69*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	102	64	**All Natural Cases Mortality**	**5**	87	54
	25	19	12		**10**	31	20
	35	4	3		**12**	9	5
	37	3	2		**15**	0	0
	37.5	3	2		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	155	97	**Mortality due to COPD**	**5**	-	-
	25	28	18		**10**	1	0
	35	7	4		**15**	0	0
	37	5	3		**25**	0	0
	37.5	4	3	**Mortality due to IHD**	**5**	-	-
	50	0	0		**10**	3	2
All Natural Cases Mortality	**15**	2	1		**15**	0	0
	25	0	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	-
	37	0	0		**10**	3	2
	37.5	0	0		**15**	0	0
	50	0	0		**25**	0	0

Pattani

Characteristic Province

Total Population		*725,104 people*
Total Population at Risk		*342,363 people*
Area Size		*1,940.356 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*106489*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*94415.87*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1204.28*
	Mortality due to COPD ***(ICD Code= J44)***	*19.9*
	Mortality due to IHD ***(ICD Code= 120-125)***	*99.89*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*126.47*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	775	227	**All Natural Cases Mortality**	**5**	354	104
	25	230	67		**10**	207	60
	35	69	20		**12**	146	43
	37	54	16		**15**	53	15
	37.5	51	15		**20**	0	0
	50	4	1		**25**	0	0
CVD Admission	**15**	479	140	**Mortality due to COPD**	**5**	-	-
	25	142	42		**10**	5	1
	35	43	13		**15**	1	0
	37	34	10		**25**	0	0
	37.5	31	9	**Mortality due to IHD**	**5**	-	-
	50	3	1		**10**	25	7
All Natural Cases Mortality	**15**	10	3		**15**	5	1
	25	3	1		**25**	0	0
	35	1	0	**Mortality due to Stroke**	**5**	-	-
	37	1	0		**10**	24	7
	37.5	1	0		**15**	5	2
	50	0	0		**25**	0	0

Pathum Thani

Characteristic Province

Total Population		*1,163,604 people*
Total Population at Risk		*718,263 people*
Area Size		*1,525.856 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*47315.4*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*71550.25*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*976.94*
	Mortality due to COPD ***(ICD Code= J44)***	*7.01*
	Mortality due to IHD ***(ICD Code= 120-125)***	*63.9*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*81.45*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,946	271	**All Natural Cases Mortality**	**5**	960	134
	25	930	130		**10**	722	101
	35	414	58		**12**	624	87
	37	351	49		**15**	475	66
	37.5	337	47		**20**	218	30
	50	116	16		**25**	0	0
CVD Admission	**15**	2,051	285	**Mortality due to COPD**	**5**	-	-
	25	980	136		**10**	6	1
	35	435	61		**15**	3	0
	37	370	51		**25**	0	0
	37.5	354	49	**Mortality due to IHD**	**5**	-	-
	50	122	17		**10**	56	8
All Natural Cases Mortality	**15**	47	6		**15**	28	4
	25	22	3		**25**	0	0
	35	10	1	**Mortality due to Stroke**	**5**	-	-
	37	8	1		**10**	56	8
	37.5	8	1		**15**	32	4
	50	3	0		**25**	0	0

Nonthaburi

Characteristic Province

Total Population		*1,265,387 People*
Total Population at Risk		*829.146 people*
Area Size		*622.303 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*49478.26*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*93026.92*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*993.55*
	Mortality due to COPD ***(ICD Code= J44)***	*8.1*
	Mortality due to IHD ***(ICD Code= 120-125)***	*54.76*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*75.02*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	2,526	305
	25	1,296	156
	35	641	77
	37	554	67
	37.5	534	64
	50	209	25
CVD Admission	15	3,309	399
	25	1,696	205
	35	839	101
	37	725	87
	37.5	698	84
	50	274	33
All Natural Cases Mortality	15	59	7
	25	30	4
	35	15	2
	37	13	2
	37.5	12	2
	50	5	1

Long-term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	1184	143
	10	908	109
	12	794	96
	15	620	75
	20	321	39
	25	11	1
Mortality due to COPD	5	-	-
	10	8	1
	15	5	1
	25	0	0
Mortality due to IHD	5	-	-
	10	58	7
	15	30	4
	25	0	0
Mortality due to Stroke	5	-	-
	10	63	8
	15	37	4
	25	1	0

Nong Khai

Characteristic Province

Total Population		*522,311 people*
Total Population at Risk		*318,079 people*
Area Size		*3,027.280 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*60521.44*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*116542.8*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1057.6*
	Mortality due to COPD ***(ICD Code= J44)***	*1.69*
	Mortality due to IHD ***(ICD Code= 120-125)***	*26.41*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*49.04*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,129	355	**All Natural Cases Mortality**	**5**	454	143
	25	604	190		**10**	340	107
	35	263	83		**12**	293	92
	37	217	68		**15**	222	70
	37.5	206	65		**20**	98	31
	50	78	25		**25**	0	0
CVD Admission	**15**	1,515	476	**Mortality due to COPD**	**5**	-	-
	25	810	255		**10**	1	0
	35	353	111		**15**	0	0
	37	290	91		**25**	0	0
	37.5	276	87	**Mortality due to IHD**	**5**	-	-
	50	105	33		**10**	10	3
All Natural Cases Mortality	**15**	23	7		**15**	5	2
	25	12	4		**25**	0	0
	35	5	2	**Mortality due to Stroke**	**5**	-	-
	37	4	1		**10**	15	5
	37.5	4	1		**15**	8	3
	50	2	0		**25**	0	0

Nong Bua Lam Phu

Characteristic Province

Total Population		*512,780 people*
Total Population at Risk		*313,815 people*
Area Size		*3,859.086 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*64375.19*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*73413.32*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*965.54*
	Mortality due to COPD ***(ICD Code= J44)***	*3.98*
	Mortality due to IHD ***(ICD Code= 120-125)***	*45.89*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*60.23*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	875	279
	25	357	114
	35	117	37
	37	88	28
	37.5	82	26
	50	11	3
CVD Admission	**15**	695	222
	25	284	90
	35	93	29
	37	70	22
	37.5	65	21
	50	8	3
All Natural Cases Mortality	**15**	15	5
	25	6	2
	35	2	1
	37	2	0
	37.5	1	0
	50	0	0

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	355	113
	10	250	80
	12	207	66
	15	141	45
	20	28	9
	25	0	0
Mortality due to COPD	**5**	-	-
	10	1	0
	15	1	0
	25	0	0
Mortality due to IHD	**5**	-	-
	10	15	5
	15	6	2
	25	0	0
Mortality due to Stroke	**5**	-	-
	10	15	5
	15	7	2
	25	0	0

Narathiwat

Characteristic Province

Total Population		*808,020 people*
Total Population at Risk		*396,215 people*
Area Size		*4,475.430 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*100175.2*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*109607.9*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1119.59*
	Mortality due to COPD ***(ICD Code= J44)***	*10.83*
	Mortality due to IHD ***(ICD Code= 120-125)***	*55.02*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*86.57*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	716	181	**All Natural Cases Mortality**	**5**	392	99
	25	65	16		**10**	233	59
	35	3	1		**12**	168	42
	37	2	1		**15**	69	17
	37.5	2	0		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	546	138	**Mortality due to COPD**	**5**	-	-
	25	50	13		**10**	3	1
	35	3	1		**15**	1	0
	37	2	0		**25**	0	0
	37.5	1	0	**Mortality due to IHD**	**5**	-	-
	50	0	0		**10**	16	4
All Natural Cases Mortality	**15**	9	2		**15**	4	1
	25	1	0		**25**	0	0
	35	0	0	**Mortality due to Stroke**	**5**	-	-
	37	0	0		**10**	20	5
	37.5	0	0		**15**	5	1
	50	0	0		**25**	0	0

Nan

Characteristic Province

Total Population		*478,227 people*
Total Population at Risk		*312,202 people*
Area Size		*11,472,072 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*76494.06*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*136711.5*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1003.52*
	Mortality due to COPD ***(ICD Code= J44)***	*64.85*
	Mortality due to IHD ***(ICD Code= 120-125)***	*67.58*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*83.92*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	2,094	671
	25	1,457	467
	35	1,026	329
	37	956	306
	37.5	939	301
	50	583	187
CVD Admission	**15**	2,603	834
	25	1,809	579
	35	1,273	408
	37	1,186	380
	37.5	1,165	373
	50	723	232
All Natural Cases Mortality	**15**	32	10
	25	22	7
	35	16	5
	37	15	5
	37.5	14	5
	50	9	3

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	512	164
	10	409	131
	12	367	118
	15	302	97
	20	191	61
	25	76	24
Mortality due to COPD	**5**	-	-
	10	28	9
	15	19	6
	25	4	1
Mortality due to IHD	**5**	-	-
	10	30	10
	15	17	6
	25	4	1
Mortality due to Stroke	**5**	-	-
	10	30	10
	15	19	6
	25	4	1

Nakhon Si Thammarat

Characteristic Province

Total Population		*1,561,927 people*
Total Population at Risk		*940,881 people*
Area Size		*9,924.677 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*74847.3*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*115170.9*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*998.32*
	Mortality due to COPD ***(ICD Code= J44)***	*13.5*
	Mortality due to IHD ***(ICD Code= 120-125)***	*74.72*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*76.74*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	625	66	**All Natural Cases Mortality**	**5**	622	66
	25	78	8		**10**	278	30
	35	20	2		**12**	136	15
	37	13	1		**15**	0	0
	37.5	12	1		**20**	0	0
	50	0	0		**25**	0	0
CVD Admission	**15**	670	71	**Mortality due to COPD**	**5**	-	-
	25	84	9		**10**	5	1
	35	21	2		**15**	0	0
	37	14	2		**25**	0	0
	37.5	13	1	**Mortality due to IHD**	**5**	-	-
	50	0	0		**10**	33	4
All Natural Cases Mortality	**15**	670	71		**15**	0	0
	25	84	9		**25**	0	0
	35	21	2	**Mortality due to Stroke**	**5**	-	-
	37	14	2		**10**	26	3
	37.5	13	1		**15**	0	0
	50	0	0		**25**	0	0

Nakhon Sawan

Characteristic Province

Total Population		*1,059,887 people*
Total Population at Risk		*675,699 people*
Area Size		*9,597.677 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*65855.95*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*154553.6*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1241.23*
	Mortality due to COPD ***(ICD Code= J44)***	*12.82*
	Mortality due to IHD ***(ICD Code= 120-125)***	*53.72*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*123.13*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	3,375	499	**All Natural Cases Mortality**	**5**	1319	195
	25	1,949	288		**10**	1041	154
	35	910	135		**12**	927	137
	37	763	113		**15**	753	111
	37.5	729	108		**20**	454	67
	50	196	29		**25**	142	21
CVD Admission	**15**	5,520	817	**Mortality due to COPD**	**5**	-	-
	25	3,186	471		**10**	12	2
	35	1,488	220		**15**	7	1
	37	1,246	184		**25**	1	0
	37.5	1,191	176	**Mortality due to IHD**	**5**	-	-
	50	321	47		**10**	50	7
All Natural Cases Mortality	**15**	74	11		**15**	28	4
	25	43	6		**25**	5	1
	35	20	3	**Mortality due to Stroke**	**5**	-	-
	37	17	2		**10**	92	14
	37.5	16	2		**15**	57	8
	50	4	1		**25**	9	1

Nakhon Ratchasima

Characteristic Province

Total Population		*2,648,927 people*
Total Population at Risk		*1,656,923people*
Area Size		*20,493 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*77876.76*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*104412.9*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1111.04*
	Mortality due to COPD ***(ICD Code= J44)***	*10.14*
	Mortality due to IHD ***(ICD Code= 120-125)***	*39.83*
	Mortality due to Stroke	*94.21*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	15	6,700	404
	25	2,369	143
	35	779	47
	37	621	37
	37.5	585	35
	50	153	9
CVD Admission	15	6,261	378
	25	2,211	133
	35	727	44
	37	579	35
	37.5	546	33
	50	142	9
All Natural Cases Mortality	5	111	7
	25	39	2
	35	13	1
	37	10	1
	37.5	10	1
	50	3	0

Long-term

Name of Analysis	Cut-Off Value (μg/m³)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	5	2509	151
	10	1885	114
	12	1629	98
	15	1237	75
	20	563	34
	25	0	0
Mortality due to COPD	5	-	-
	10	19	1
	15	11	1
	25	0	0
Mortality due to IHD	5	-	-
	10	80	5
	15	40	2
	25	0	0
Mortality due to Stroke	5	-	-
	10	150	9
	15	85	5
	25	0	0

Nakhon Phanom

Characteristic Province

Total Population		*719,136 people*
Total Population at Risk		*435,080 people*
Area Size		*5,512.668 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*67878.55*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*74907.14*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1075.66*
	Mortality due to COPD ***(ICD Code= J44)***	*2.67*
	Mortality due to IHD ***(ICD Code= 120-125)***	*22.98*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*55.16*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	2,753	633	**All Natural Cases Mortality**	**5**	857	197
	25	1,741	400		**10**	707	163
	35	1,050	241		**12**	646	148
	37	943	217		**15**	551	127
	37.5	917	211		**20**	389	89
	50	428	98		**25**	221	51
CVD Admission	**15**	2,117	486	**Mortality due to COPD**	**5**	-	-
	25	1,337	307		**10**	2	0
	35	807	185		**15**	1	0
	37	724	166		**25**	0	0
	37.5	704	162	**Mortality due to IHD**	**5**	-	-
	50	329	76		**10**	16	4
All Natural Cases Mortality	**15**	51	12		**15**	9	2
	25	32	7		**25**	3	1
	35	19	4	**Mortality due to Stroke**	**5**	-	-
	37	17	4		**10**	30	7
	37.5	17	4		**15**	21	5
	50	8	2		**25**	7	2

Nakhon Pathom

Characteristic Province

Total Population		*920,030 People*
Total Population at Risk		*570,220 people*
Area Size		*2,168.327 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*79682.4*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*136496.3*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1083.27*
	Mortality due to COPD ***(ICD Code= J44)***	*10.21*
	Mortality due to IHD ***(ICD Code= 120-125)***	*58.22*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*101.89*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	3,327	583	**All Natural Cases Mortality**	**5**	972	170
	25	1,940	340		**10**	768	135
	35	1,116	196		**12**	684	120
	37	998	175		**15**	555	97
	37.5	970	170		**20**	335	59
	50	440	77		**25**	106	19
CVD Admission	**15**	3,970	696	**Mortality due to COPD**	**5**	-	-
	25	2,313	406		**10**	8	1
	35	1,331	233		**15**	5	1
	37	1,190	209		**25**	1	0
	37.5	1,157	203	**Mortality due to IHD**	**5**	-	-
	50	525	92		**10**	46	8
All Natural Cases Mortality	**15**	52	9		**15**	26	4
	25	31	5		**25**	4	1
	35	18	3	**Mortality due to Stroke**	**5**	-	-
	37	16	3		**10**	64	11
	37.5	15	3		**15**	40	7
	50	7	1		**25**	6	1

Nakhon Nayok

Characteristic Province

Total Population		*260,751 people*
Total Population at Risk		*163,476 people*
Area Size		*2,122 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*75839.88*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*126810.7*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1435.68*
	Mortality due to COPD ***(ICD Code= J44)***	*18.16*
	Mortality due to IHD ***(ICD Code= 120-125)***	*78.91*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*130.29*

Evaluation Result

Short Term				**Long-term**			
Name of Analysis	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (µg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	508	311	**All Natural Cases Mortality**	**5**	264	161
	25	209	128		**10**	182	111
	35	74	45		**12**	148	91
	37	57	35		**15**	97	59
	37.5	53	33		**20**	9	5
	50	9	6		**25**	0	0
CVD Admission	**15**	592	362	**Mortality due to COPD**	**5**	-	-
	25	243	149		**10**	3	2
	35	86	52		**15**	1	1
	37	67	41		**25**	0	0
	37.5	62	38	**Mortality due to IHD**	**5**	-	-
	50	11	6		**10**	13	8
All Natural Cases Mortality	**15**	11	7		**15**	5	3
	25	5	3		**25**	0	0
	35	2	1	**Mortality due to Stroke**	**5**	-	-
	37	1	1		**10**	17	10
	37.5	1	1		**15**	8	5
	50	0	0		**25**	0	0

Mukdahan

Characteristic Province

Total Population		*353,174 people*
Total Population at Risk		*213,687 people*
Area Size		*4,339.83 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*65882.34*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*85020.61*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*991.64*
	Mortality due to COPD ***(ICD Code= J44)***	*4.18*
	Mortality due to IHD ***(ICD Code= 120-125)***	*21.99*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*59.43*

Evaluation Result

Short Term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
Respiratory Admission	**15**	1,342	628
	25	822	385
	35	474	222
	37	419	196
	37.5	406	190
	50	177	83
CVD Admission	**15**	1,207	565
	25	739	346
	35	425	199
	37	376	176
	37.5	365	171
	50	159	74
All Natural Cases Mortality	**15**	23	11
	25	14	7
	35	8	4
	37	7	3
	37.5	7	3
	50	3	1

Long-term

Name of Analysis	Cut-Off Value (μg/m^3)	Estimated number of Attributable Cases	Estimated number of Attributable Cases per 100 000 Population at Risk
All Natural Cases Mortality	**5**	396	185
	10	329	154
	12	301	141
	15	258	121
	20	185	87
	25	109	51
Mortality due to COPD	**5**	-	-
	10	1	1
	15	1	0
	25	0	0
Mortality due to IHD	**5**	-	-
	10	7	3
	15	5	2
	25	2	1
Mortality due to Stroke	**5**	-	-
	10	16	8
	15	11	5
	25	4	2

Maha Sarakham

Characteristic Province

Total Population		*284,138 people*
Total Population at Risk		*603,771 people*
Area Size		*5,291 km²*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*65412.05*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*87499.57*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*1124.6*
	Mortality due to COPD ***(ICD Code= J44)***	*4.6*
	Mortality due to IHD ***(ICD Code= 120-125)***	*32.13*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*69.07*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m³)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	3,721	616	**All Natural Cases Mortality**	**5**	886	226
	25	2,191	363		**10**	719	183
	35	1,176	195		**12**	650	166
	37	1,026	170		**15**	545	139
	37.5	991	164		**20**	364	93
	50	413	68		**25**	176	45
CVD Admission	**15**	3,470	575	**Mortality due to COPD**	**5**	-	-
	25	2,041	338		**10**	4	1
	35	1,095	181		**15**	3	1
	37	956	158		**25**	1	0
	37.5	923	153	**Mortality due to IHD**	**5**	-	-
	50	385	64		**10**	31	5
All Natural Cases Mortality	**15**	74	12		**15**	19	3
	25	44	7		**25**	7	1
	35	23	4	**Mortality due to Stroke**	**5**	-	-
	37	20	3		**10**	53	9
	37.5	20	3		**15**	37	6
	50	8	1		**25**	13	2

Mae Hong Son

Characteristic Province

Total Population		*284,138 People*
Total Population at Risk		*128,036 people*
Area Size		*12,681 km^2*
Total Incidence Rate (per 100,000 population at risk)	*Respiratory Hospital Admission* ***(ICD Code= J00-J99)***	*114959.1*
	Cardiovascular Hospital Admission ***(ICD Code= I00-I99)***	*106686.4*
	All-Natural Mortality Cases ***(ICD Code= A00-R99)***	*945.05*
	Mortality due to COPD ***(ICD Code= J44)***	*10.12*
	Mortality due to IHD ***(ICD Code= 120-125)***	*33.58*
	Mortality due to Stroke ***(ICD Code= I60-I69)***	*67.17*

Evaluation Result

Short Term				Long-term			
Name of Analysis	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**	**Name of Analysis**	**Cut-Off Value (μg/m^3)**	**Estimated number of Attributable Cases**	**Estimated number of Attributable Cases per 100 000 Population at Risk**
Respiratory Admission	**15**	1,619	1,265	**All Natural Cases Mortality**	**5**	227	177
	25	1,258	982		**10**	188	147
	35	994	777		**12**	172	135
	37	948	740		**15**	148	116
	37.5	936	731		**20**	106	83
	50	708	553		**25**	63	49
CVD Admission	**15**	1,043	815	**Mortality due to COPD**	**5**	-	-
	25	810	632		**10**	2	2
	35	640	500		**15**	2	1
	37	610	476		**25**	1	0
	37.5	602	470	**Mortality due to IHD**	**5**	-	-
	50	455	356		**10**	7	5
All Natural Cases Mortality	**15**	15	12		**15**	4	3
	25	12	9		**25**	2	1
	35	10	7	**Mortality due to Stroke**	**5**	-	-
	37	9	7		**10**	11	9
	37.5	9	7		**15**	8	6
	50	7	5		**25**	3	2

VITA

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