The Association between Particulate Matter 10 and Severity of Chronic Obstructive Pulmonary Disease, Northern Thailand

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***Abstract*—The purpose of this study was to determine the association between particulate matter with ≤ 10 μ/m^3 (PM_{10}) and the severity of Chronic Obstructive Pulmonary Disease (COPD). A retrospective cohort study design was conducted and collected data by using completed and tested questionnaires. Data were collected from the medical records among the COPD cases from local hospitals in Chiang Rai Province, Thailand. The PM_{10} was calculated based on two settings of PM_{10} monitoring system in Chiang Rai Province. The severity of COPD was measured by the Modified Medical Research Council Dyspnea Score (mMRC) method. Logistic regression was applied to test the association between independent and dependent variables. The levels of statistical significance were 0.10 and 0.05 in univariate and multivariate models respectively. Results; the different PM_{10} exposing level was found in the group for exposure to PM_{10} ($p<0.10$) in dry season. Those people who exposed PM_{10} had a greater in severity of COPD with 5.85 times when compare to un-exposed group (OR= 5.85, 95% CI: 4.12-8.30). Increasing of PM_{10} level is directly associated with the severity of the COPD, then the increasing of people awareness to avoid and protect from the PM_{10} are necessary for a better of quality of life among the COPD.**

***Index Terms*—COPD, PM_{10}, severity of COPD.**

I. Introduction

Chronic obstructive pulmonary disease (COPD) is a common disease and characterized by airflow obstruction. In the population-based studies, COPD affects 5.0-19.0% of adult population ≥ 40 years old [1]. It was known that almost 90.0% of COPD deaths occurred in the low and middle-income countries [2]. COPD is also predominantly caused by smoking. However, other factors, particularly occupational exposures, air pollution are recognized as significant contributors to the development and progression of COPD. According to the latest WHO estimates, currently 64 million people have COPD and 3 million people died from COPD in each year [3].

WHO predicted the COPD will become the third leading cause of death worldwide by 2030 [3]. In Asia-Pacific Countries, the total number of moderate to severe COPD cases among 12 countries of this region was 56.6 million with an overall prevalence proportion of 6.3%. The COPD prevalence proportions among the countries range from 3.5% (Hong Kong and Singapore) to 6.7% (Vietnam) and 5.0% in Thailand [4]. The proportion of death and ill which defined the causes of COPD found from 4.0% in New Zealand to more than 40.0% in Sri Lanka and Thailand [5].

Fig. 1. Air pollution in Mae Sai District, Chiang Rai Province, Thailand, March 2012.

All the pollutants, inhalable particulate matter less than 10 micrometer size (PM_{10}) shows the association with adverse respiratory health effects. Acute exacerbations of COPD have been associated with short-term exposure to air pollution [6]. Abbey and others [7] found the positive association between PM_{10} and development of symptoms of COPD productive cough and increased severity of airway obstructive disease, asthma, and stronger than who exposed occupationally to dust and fumes.

During forest fires, northern Thailand and parts of neighboring Myanmar had been covered in layers of smoke, hundreds of kilometers away from the actual fires caused by the burning of forest and agricultural waste. The increasing of small level of smoking could affect to a large proportion of human respiratory system. In Chiang Rai Province found that the number of COPD cases have trended to increase every year, The prevalent proportion of COPD in 2006 to 2008 were 368.32, 405.45 and 423.50 by 100,000 population [8].

Chiang Rai Province was ranked as the highest PM_{10} concentrations in Thailand in the year 2009-2010 which had been reported that higher than the standard level. It was indicated that very dangerous for human health particularly in the people who had the medical conditions which related to the respiratory system. In generally, the standard level is 120 micrograms per cubic meter [9]. Since, the little studies on the effect of PM_{10} and severity of COPD in Thailand particularly in the severe areas as northern Thailand. Then this study was aimed to determine the association between the PM_{10} level and the severity of COPD in Chiang Rai Province, Thailand.

II. Materials and Methods

A. Study Design and Study Settings

The study was a retrospective cohort study design. The

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study sites were 5 districts in Chiang Rai Province, Thailand. The subjects were people who recently diagnosed of COPD from 5 hospitals: Mae Chan, Mae Sai, Payamengrai, Chiang Saen, and Somdet Prayannasungworn Hospitals.

The exposure and un-exposure groups were the same individual. The subjects were measured on March-May 2012 (highest peak PM_{10} period) as exposure group, meanwhile, in the same individual had been re-measured as the un-exposed on August-October 2011 (lowest peak PM_{10} period). Then in this study, both of exposure and un-exposure was the same person.

B. Study Population

The study population was Thai people who had diagnosed with COPD and lived in Chiang Rai Province, Thailand.

C. The Study Sample and Recruitment

The samples were patients who recently diagnosed of COPD from 5 local hospitals. The samples size was calculated to arrive at a minimum sample size of 304 cases. The simple random sampling technique was used for selecting the subjects after met the list of COPD cases from hospitals. After providing the information by verbal to the subjects about the objective and process of the study, then the informed consent had been obtained before interview. *Inclusion* criteria*:* a) COPD subjects had diagnosed for COPD and visited at the COPD clinics, Chiang Rai Province, b) with the complete medical records. *Exclusion Criteria:* a) COPD cases who could not speak Thai, b) who refused to participate.

D. Research Instruments

The research instruments were the constructed questionnaires with tested for reliability and validity before used. All questions had been tested in the pilot phase and developed before implementing. The questionnaire had been divided into 4 parts. The first part was composed of the questions about general information, socio-economic characteristics. The second part was composed of exposing of the varies of the smoke. The third part was composed of medical history. The last part was composed of environment characteristics. The PM_{10} concentrations data were collected from secondary information which source from The Pollution Control Department, Ministry of Natural Resources and Environment, Thailand.

E. Data Collection

All subjects had been asked by the questionnaires in the private and confidential room. Some information had been collected from the medical records. The data collection process was being done during March1, 2012 - May31, 2012. The questions which measured on the severity of COPD were assessed twice: the first time on the low PM_{10} period (August-October 2011), and the second time the high PM_{10} period (March-May 2012).

The information of PM_{10} had been obtained from the Department of Air Pollution Control, Thailand for the year of 2011 – 2012. There were two sites of the PM_{10} monitoring system were available for obtaining the PM_{10} information during August-October 2011 and March to May 2012.

F. Statistical Methods

Descriptive statistics included mean, median, percentile and standard deviation were used to explain the general characteristics of the samples.

Inferential statistics were selected the unconditional logistic regression model for finding the association between the severity of chronic obstructive pulmonary disease and PM_{10} concentrations. The statistical association for multivariate was considered significance at α=0.05.

III. Results

TABLE I: Twenty-Four Hours Average PM_{10} Concentrations in Chiang RAI Province, Thailand, 2011-2012.

Months	PM_{10} concentrations	
	Range ($\mu g/m^3$)	Mean(SD)
August 2011	14.50-33.70	20.37(12.66)
September 2011	13.90-33.10	22.92(1.06)
October 2011	20.40-47.40	31.15(2.33)
March 2012	48.13-239.38	173.99(73.15)
April 2012	24.33-122.79	69.41(27.70)
May 2012	14.42-58.46	36.47(12.40)

TABLE II: General Characteristics of Subjects

Characteristics	n	%
Total	304	100.0
Sex		
Male	144	47.4
Female	160	52.6
Age (years old)		
40-50	14	46
51-60	40	13.2
61-70	104	34.3
71-80	113	37.3
>80	33	10.6
Marital status		
Single	2	0.7
Married	210	69.1
Widowed	1	0.3
Divorced	91	29.9
Religion		
Buddhism	294	96.7
Others	10	3.3
Income (Baht/month)		
<5,000	249	81.9
5,001-10,000	49	16.1
10,001-15,000	5	1.6
≥15,001	1	0.4

Table I shows the PM_{10} concentrations in Chiang Rai Province, Thailand in the year 2011-2012. The highest PM_{10} level was 239.38 $\mu g/m^3$ on March 2012, whereas the lowest level was 13.90 $\mu g/m^3$ on September 2011. The highest mean of PM_{10} was 173.99 with SD 73.15 $\mu g/m^3$ on March 2012. The average level of PM_{10} during the exposure period (March-May 2012) had a higher than the un-exposure period (August-October 2011). March and April had a higher standard level of PM_{10} which indicated 120 $\mu g/m^3$.

The general characteristics of subjects were shown in Table II. It was found that 52.6% were female, 37.3% aged 71-80 years old, 81.9% had an income ≤ 5,000 baht/month, and 63.1% were retired, 69.1% were married, and 96.7% Buddhism.

Table III shows the risk behaviors among the subjects, 85.2% smoked, 67.4% used beedi, 72.7% exposed passive smoke from their family, 85.2% had been diagnosed COPD

for 1-5 years, 80.8% had got influenza vaccine. 39.1% had co-morbidities with hypertension, and 61.2% had acute exacerbation in winter season.

After controlling the possible confounder factors in the unconditional logistic regression model, found in Table IV the PM_{10} was found the statistically significant association with the severity of COPD with 5.85 times comparing between exposure and non-exposure periods. The COPD had a greater to be severity stage on COPD when came to the dry season with 5.85 time compared to raining season (95%CI=4.12-8.30).

TABLE III: RISK BEHAVIORS AND MEDICAL HISTORY

Characteristics	N	%
Smoked		
No	35	11.6
Yes	10	3.2
Quit	259	85.2
Types of smoking		
None	34	11.2
Beedi	205	67.4
Cigarette	26	8.6
Both	39	12.8
Passive cigarette smoking	221	72.7
No	83	27.3
Yes		
Diagnosis of COPD (years)		
≤5	259	85.2
6-10	15	4.9
11-15	16	5.2
16-20	4	1.3
21-25	8	2.6
>25	2	0.6
Receiving Influenza vaccine		
Yes	246	80.8
No	58	19.1
Co-morbidities		
No	169	55.6
DM	7	2.3
HT	119	39.1
DM and HT	9	3.0
Acute exacerbation		
No	41	13.5
Rainy season	41	13.8
Winter season	186	61.2
All	35	11.5

TABLE IV: MULTIVARIATE ANALYSIS OF PM_{10} AND SEVERITY OF COPD

Factor	OR	95%CI
PM_{10}	5.85	4.12 - 8.30

IV. DISCUSSION

The study was retrospective study design therefore we could not collect all of factors completely and classified the severity of COPD clearly. In some hospitals, they did not have the instruments for assessing the severity of COPD, therefore the classification of severity of COPD method were used clinical symptoms from the medical record cards and self-interview instead. Wan and others [4] found that the proportion of COPD hospitalization by sex in Singapore was 94:16 (male to female).This proportion was difference from our study which shown 47:53.

WHO [10] estimated that in the high-income countries, 73.0% of COPD mortality was related to smoking, whereas only 40.0% related to smoking in the low and middle income countries. However, in our study we found the factors influenced with the severity of COPD was active cigarette smoking 88.4 %.

Since the outcome of COPD is always occurring when people reach old age, and most of the COPD cases had the co-morbidity. This is might be the factors influencing to the severity of COPD. In our study, we found that many people had co-morbidity either DM or HT. The result also consisting with the study of van Manen and colleagues [11] which reported that over 50.0% of 1,145 patients with COPD had 1 to 2 co-morbidities, 15.8% had 3 to 4 co-morbidities, and 6.8% had 5 or more co-morbid conditions.

Liu and others [12] found the significant association between the prevalence of COPD and exposing to biomass fuel for cooking in rural China. Our study also found that 4.0% were typically cooked by charcoal, 1.0% used wood, and 39.0% used in both.

In our study, we found that most of the COPD patients had been diagnosed 1 to 5 years and had received influenza vaccine in every year. This is a good indicator of accessing health care system for people who need help by vaccination in Thailand. Cao and colleagues [13] found that the COPD patients who required frequent hospitalizations, the prevalence of influenza vaccination were less than 12.0%. However, in this study found 80.8% got influenza vaccination.

Donaldson and colleagues [14] found that the exacerbations had found in the cold seasons (November to February), of which 42.5% and 50.6% than in warm seasons (May to August) of which 31.4% and 45.4%. This could make a conclusion that the weather is directly related to the exacerbation.

Since 2008, early of March in every year, there is facing a big environmental problem in the northern of Thailand. The air pollution due to the forest fires covered many kilometers in this area. The study found that the concentrations of PM_{10} on March 2012 were higher than others and found the lowest PM_{10} concentrations on September 2011. Usanee and others measured the PM_{10} concentrations in Chiang Mai Province and found PM_{10} concentrations on March 2005 had a higher than PM_{10} concentrations on August and September 2004 [15].

This study found the strongly association between PM_{10} and severity of COPD statistically significant with 5.85 times comparing between exposure and un-exposure periods. However, Chen and colleagues [16] had done the time series study from Brisbane to investigate the association between forest fires PM_{10} on respiratory hospital admissions. The results had shown that an increasing in respiratory hospital admissions of 19.0% for forest fire days and of 13.0% for days without the presence of forest fires smoke. The study of Johnson and others [17] found an increasing of 10 μg/m3 in PM_{10} was significantly associated with COPD admission (OR 1.21 95% CI: 1.00-1.47).

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