CHARACTERISTICS OF ETS EXPOSURE IN INTERNET CAFES, PUBS, AND POOL HALLS AROUND A UNIVERSITY CAMPUS

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ABSTRACT

The aims of this study were to determine the indoor level of environmental tobacco smoke (ETS) and to assess the implementation rate of smoke-free law at hospitality venues around a university campus by measuring particulate matter smaller than 2.5 μm ($PM_{2.5}$) as an indicator of ETS. We measured the indoor $PM_{2.5}$ concentrations at 20 internet cafes, 20 pubs, and 20 pool halls using Sidepak AM510, a direct reading portable real time monitor, from October to December 2015. Smoking was observed in 65% of internet cafes, 10% of pubs, and 85% of pool halls. The average of $PM_{2.5}$ concentration was 98.2 μg/m^3, 29.0 μg/m^3, and 134.2 μg/m^3 at internet cafes, pubs, and pool halls, respectively. $PM_{2.5}$ concentrations in internet cafes and pool halls were 2 to 2.7 times higher than the 24 hour exposure standard for outdoor $PM_{2.5}$ (50 μg/m^3) of the Ministry of the Environment. Although a smoking ban had been implemented at internet cafes and pubs, smoking is still taking place in those places. More stringent legal action are required for the success of legal action to protect patrons and workers from second-hand smoke exposure. The ban on smoking in pool halls should be introduced as soon as possible.

Keywords: ETS (environmental tobacco smoke), internet café, pool hall, $PM_{2.5}$.

1 INTRODUCTION

Environmental tobacco smoke (ETS) is produced when smoking cigarettes, pipe tobacco, cigars, etc., causing second-hand smoke. It is composed of sidestream smoke (SS) and mainstream smoke (MS) generated at the end of cigarette during smoking. Passive smoking can lead to a variety of diseases, disorders and deaths in the human body [1], which is scientifically confirmed [2].

ETS is important because it is one of the important pollutants that determine indoor air quality and it contains substances confirmed or suspected human carcinogens of 60 kinds such as nitrosamines, benzopyrenes, betanaphthylamine, and polonium 210. It is estimated that 30% of all cancer deaths are caused by smoking, and second-hand smoke has been reported to have various health effects such as lung cancer, cardiovascular disease, and asthma as well as direct smoking [3]. Based on this, the Environmental Protection Agency (EPA) classifies ETS as a Group A Carcinogen [4]. The US National Institute of Occupational Safety and Health (NIOSH) has also designated ETS as a carcinogenic substance of the same grade as asbestos or benzene. In addition, tobacco smoke can easily spread and cannot easily be removed, so that it is exposed to a wide range of people irrespective of the intention of the person, second-hand smoke. On the basis of these risks, the Centers for Disease Control and Prevention (CDC) has stipulated the Anti-Smoking Act for public spaces such as workplaces, restaurants and pubs [5]. A large number of studies have been done on indicator materials [6], to measure and evaluate the airborne concentrations of ETS, which is composed of about 6,000 chemicals [7]. It is not easy to find an indicator material of perfect condition that changes physically and chemically according to ETS generation time. The indicators with most specificity of ETS exposure is 3-Ethenyl Pyridine and Nicotine. However, because of the disadvantages of time and expense for

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sample collection and analysis, $PM_{2.5}$ (particulate matter less than 2.5 μm in dimeter, particulate matter with an aerodynamic diameter of less than 2.5 μm) with excellent convenience is proposed as an indicator material by the World Health Organization (WHO) [8].

It is demanding a practical anti-regulatory effort to lower the use of tobacco among young people with relatively high smoking rates. As a result, in Korea, the National Health Promotion Act requires smoking cessation in a variety of indoor environmental spaces used by the public such as teachers in schools, internet cafes, and restaurants, and the facilities are gradually being expanded. However, in the case of pool halls, a small-scale sports facility, such a smoking policy has not yet been applied.

According to the National Health and Nutrition Examination Survey (2015), 39.3% of male adults (aged 19 and over) smoked, and it is reported that they are gradually declining. In addition, it reported 23.7% of smoking cessation rates among the university students in the 20–30 age group, the third highest in the 10-year age group [9]. It is very important to have good health habits because health habits when young are maintained throughout the lifespan and can greatly affect individual health.

In this study, we measured the level of second-hand smoke exposure by measuring $PM_{2.5}$, an indicator of ETS, in Internet cafes, pubs, and pool halls, where young adults in their 20s spend a lot of time around a university campus in Changwon, South Korea. And evaluate the rate of implementation of smoking cessation at the internet cafes and pubs, designated as smoking cessation areas in the National Health Promotion Act, and investigate the necessity of smoking cessation for pool halls not yet designated as a smoking cessation facility.

2 STUDY SUBJECTS AND METHOD

2.1 Study subjects

This study covers 60 indoor spaces including 20 internet cafes, 20 pubs and 20 pool halls around a university campus for about 2 months from October 12 to December 18, 2015. ETS exposure characteristics were investigated by sampling $PM_{2.5}$, an indicator of air ETS concentration.

2.2 Study method

2.2.1 Measurement of airborne $PM_{2.5}$

The airborne $PM_{2.5}$concentrations in the indoor air were measured at a flow rate of 2 L/min using Sidepak (Model AM510, TSI Inc., USA), which is a light scattering type direct-acting device that determines the mass concentration by scattering light with a wavelength of 670 nm. Samples were taken at 1 minute intervals for a total of 40 minutes including outdoor (background concentration) 5 minutes, indoor 30 minutes, and outdoor 5 minutes during 7:00 pm to 11:00 pm. In order to remove particulate matter with a diameter of 2.5 μm or more, an impactor was attached to the instrument, and zero point correction was performed using a HEPA filter before starting sampling. The volume of the indoor space, the number of smokers, and the ventilation conditions that could affect the concentration distribution during the irradiation were also recorded.

2.2.2 Measurement and calculation of smoking density (SD)

The smoking density was calculated by the number of smokers per unit volume as shown in eqn (1). The number of smokers was counted every five minutes during the sampling period,

and the area and volume of the hopper house were measured using DLR130 (Robert Bosch Tool Corp., Mt. Prospect, Malaysia)

$$Smoking\ Density(SD) = \frac{\text{No.of smoked cigarettes}}{\text{Indoor volume,㎥}}. \quad (1)$$

2.2.3 Statistics and analysis

The collected $PM_{2.5}$ concentrations were analyzed using TRAKPRO™ (version 4.6.10, TSI, USA) program. Since Sidepak is a direct-reading type instrument, the conversion factor of 0.295 [10] was used for the accuracy. The unit of $PM_{2.5}$ concentration is expressed in μg/m^3. The $PM_{2.5}$ concentration distribution was tested by the Shapiro-Wilk test (W-test). Statistical analysis was performed using SPSS (ver. 23.0.0.0) and Microsoft Excel 2013 and cumulative probability plot distribution were obtained from SigmaPlot (ver. 10.0 for window, Sysstat Software, Inc., USA).

3 RESULTS AND DISCUSSIONS

3.1 Smoking status and exposure levels of second-hand smoke

As shown in Table 1, the smoking rates of the three types of facilities around a campus were 85% in the pool halls, 10% in the pubs and 65% in the internet cafes. In the case of the pubs and the internet cafes, the smoking ban was designated as a complete smoking cessation area from January 1, 2015 through enactment of laws and regulations, and pool halls not designated as a smoking cessation area showed the highest smoking rate. The smoking rate of the pubs in Changwon was 42% in 2014 [10], before the enforcement of the smoke-free laws, but it decreased by 10% to 32% in 2015 when the law was implemented.

The distributions of $PM_{2.5}$ concentrations in the indoor air of the facilities were log normal distribution by W-test ($p<0.01$). The cumulative probability plot of each facility was shown in Fig. 1. The average $PM_{2.5}$ concentrations were 134.2 μg/m^3 (range 8.9–277.5 μg/m^3) in pool hall, 98.2 μg/m^3 (range 4.7–291.9 μg/m^3) in internet cafes, and 29.0 μg/m^3 (range 4.7–291.9 μg/m^3) in pubs in order. There was a statistically significant difference in the distribution of $PM_{2.5}$ concentrations among the three types of facilities ($p < 0.001$). The mean concentration of pool hall was the highest, but the highest concentration of 291.9 μg/m^3 was internet cafes. The distribution of $PM_{2.5}$ concentrations in pool halls was about 4.6 times higher than that in pubs, and the concentration distribution in the highest and lowest places

Table 1: Summary of average $PM_{2.5}$ concentrations and smoking conditions of sampling sites.

Facility	No. of sites	Smoking observation no. of venues (%)	Average no. of fans	Average volume, (m^3)	Smoking density (#bc/m^3)	$PM_{2.5}$ concentration (μg/m^3)			
						AM	GM	GSD	Range
Internet cafés	20	13 (65)	10.5	441.6	0.023	98.2	58.0	3.2	4.7–291.2
Pubs	20	2(10)	4.4	345.3	0.0005	29.0	22.8	2.2	5.9–74.0
Pool halls	20	17(85)	5.9	451.2	0.017	134.2	101.8	2.4	8.9–277.5

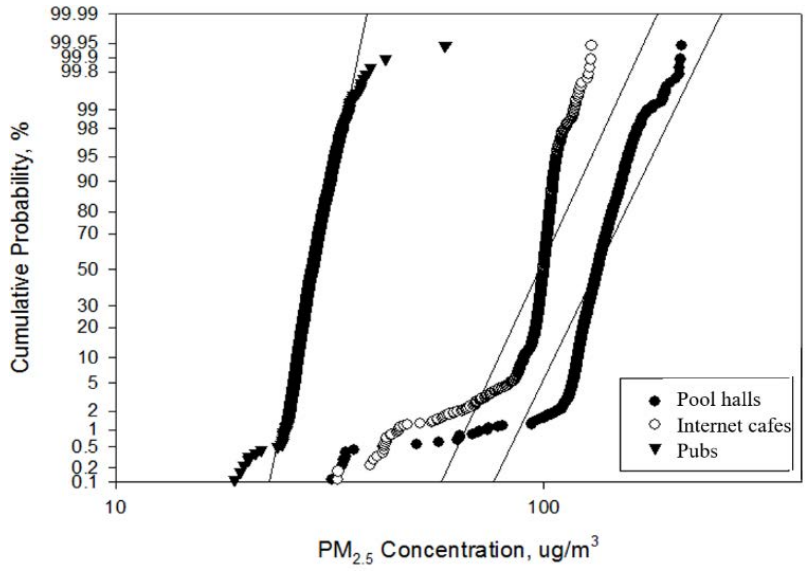

Figure 1: Comparison of the cumulative probability plots of $PM_{2.5}$ concentrations in facilities.

was about 30 times ($p < 0.001$). In a study conducted in 2014, before the smoking cessation law was enacted, the distribution of $PM_{2.5}$ concentrations were measured 180.4 μg/m^3 (median, range 24.5–273.1 μg/m^3) in internet cafes, 44.3 μg/m^3 (3.0–116.2) in pubs, and 41.2 μg/m^3(23.2–241.0) in pool hall [10]. There was a difference between the internet cafes and the pool halls in the $PM_{2.5}$ distributions in the facilities before and after the smoking cessation act.

To determine the correlation between smoking density and $PM_{2.5}$ concentrations in internet cafes, the coefficient of the correlation analysis was 0.55, as shown in Fig. 2. In a study by Kim et al. [10], there was some correlation between smoking density and smoking intensity ($r = 0.576$, $p < 0.005$). The concentration of $PM_{2.5}$ was identified as the surrogate substance that best reflects the smoking situation. The average $PM_{2.5}$ concentration in smoking allowed internet cafes (13 out of 20) was 127.5 μg/m^3, which was statistically higher ($p < 0.05$) than smoking prohibited internet cafes (43.8 μg/m^3). In case of pool halls, the mean of $PM_{2.5}$ concentration in smoking permitted places was about three times higher than that of smoking prohibited places. However, in the case of pubs, the significance of statistical difference was not confirmed.

In accordance with the Framework Convention on Tobacco Control (FCTC) proposed by the World Health Organization [8], cigarette smoking rates have been gradually decreasing in Korea as a result of strengthening smoking cessation laws. In Korea, the Korea Center for Disease Control and Prevention [9] reported that the rate of secondhand smoke among non-smokers declined to 57.9% in 2013, 52.1% in 2014 and 35.4% in 2015 after the smoke-free regulations were enacted in public areas. However, since the pool halls is not subject to legal regulation yet, it has the highest concentration of $PM_{2.5}$ and there is possibility of exposure to secondhand smoke. Therefore, in order to minimize the risk caused by secondhand smoke, education and public relations should be strengthened and the smoking cessation policy should be extended.

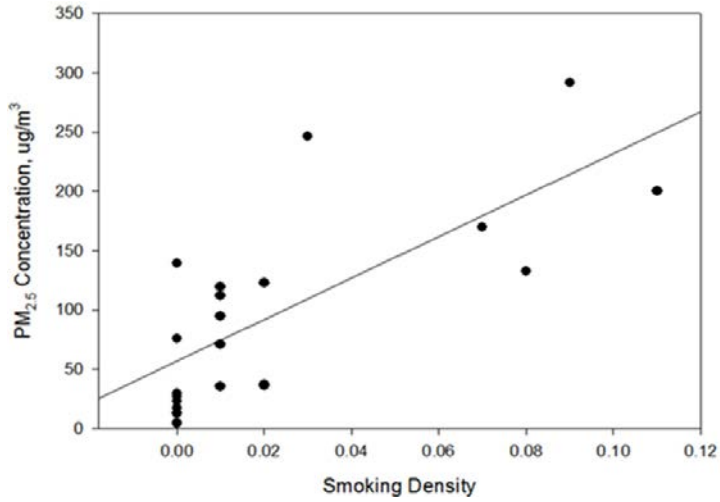

Figure 2: Regression analysis of $PM_{2.5}$ levels and smoking densities in internet cafes ($y = 57.2 + 1746.6x$, $r = 0.55$).

3.2 Evaluation of air quality using AOI

EPA has proposed Air Quality Index (AQI) based on $PM_{2.5}$ concentrations for people to predict the degree of air pollution [4]. According to AQI, air quality is good for 0–12.0 μg/m^3, moderate for 12.1–35.4 μg/m^3, unhealthy for sensitive groups for 35.5–55.4 μg/m^3, unhealthy for 55.5–150.4 μg/m^3, very unhealthy for 150.5–250.4 μg/m^3, and hazardous for 250.5 μg/m^3 or more. The indoor air quality in facilities were assessed according to AQI and pool hall (134.2 μg/m^3) and the internet cafes (98.2 μg/m^3) were unhealthy levels, assuming that $PM_{2.5}$ concentrations level of indoor air were exposed for 24 hours. In the case of pool halls, where smoking is allowed, 5 (29%) out of 17 business premises exceeded 150.5 μg/m^3, which is very unhealthy level.

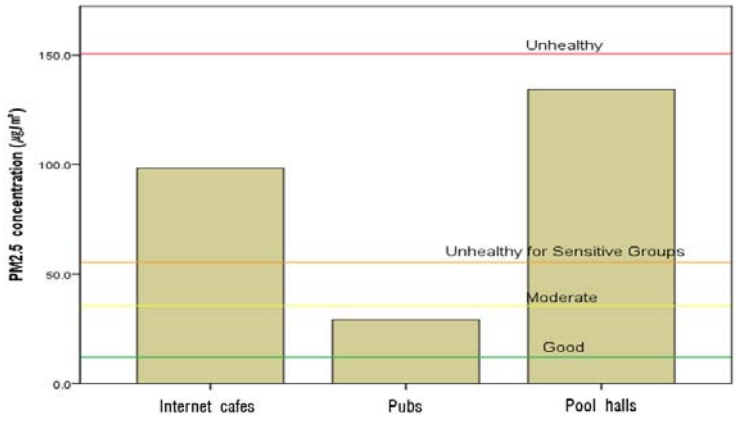

Figure 3: Assessment of indoor air quality of internet cafes, pubs, and pool halls using AQI (Air Quality Index) of EPA.

The limitations of this study are as follows: First, $PM_{2.5}$, the indicator for ETS, can be affected by a wide variety of sources, such as combustion in indoor and outdoor, indoor activities, cooking and cleaning etc., other than tobacco smoke. Second, It may be an underestimated result because sampling is done at the time of the test for student and there are few users. In order to accurately identify the reference value for each facility, the sample measurement period and the number of samples should be considered. In the future, it will be possible to improve the health level of the public by monitoring the status of second-hand smoke in the venues of these multi-use facilities, confirming the implementation rate of the smoking cessation policy, and strengthening the regulations.

4 CONCLUSION

Facilities such as internet cafes and pubs, which are used frequently by college students with high smoking rates, have been expanded from January 2015 to the smoking cessation area according to the National Health Promotion Act. Around 60 campuses including internet cafes, pubs, and pool halls near a university campus be assessed the degree of implementation of the smoking cessation policies for 2 months from October 12 to December 18, 2015, and ETS exposure levels were examined. The results of this study were as follows.

First, the smoking rates of the facilities near the campus were 65% for internet cafes, 10% for pubs, and 85% for pool halls. The smoking cessation rate was the highest in pool halls where the law was not regulated, and smoking was still taking place in the internet cafes or pubs where the law (smoking cessation) regulation is being implemented.

Second, the concentrations of $PM_{2.5}$, the indicator substance of environmental tobacco smoke, was measured to be 98.2 $\mu g/m^3$ for internet cafes, 29.0 $\mu g/m^3$ for pubs and 134.2 $\mu g/m^3$ for pool halls. AQI evaluation showed that pubs maintained proper air quality, but the internet cafes and pool halls were harmful to health.

Third, in the case of internet cafes and pubs, the $PM_{2.5}$ concentrations levels of the shops allowed to smoking were statistically higher than that of the prohibited sites ($p < 0.05$).

Fourth, according to legal regulations, the rate of smoking cessation is increasing, and the distribution of $PM_{2.5}$ concentration in the indoor air is also decreasing.

Fifth, in order to prevent passive smoking of visitors and employees and to protect the health of the pool halls where the concentration level of ETS was highest, it is necessary to expand the scope of the National Health Promotion Act.

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