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Scientific Evidence Supporting Policy Change: A Study on Secondhand Smoke Exposure in Non-smoking Areas of PC Rooms in Korea

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Purpose

The objective of this study was to measure secondhand smoke (SHS) exposure in personal computer (PC) rooms with the purpose of determining the strength of scientific evidence supporting the legislative ban on smoking in PC rooms located in the Republic of Korea.

Materials and Methods

From June to September 2012, particulate matter ($PM_{2.5}$) and air nicotine concentration (ANC) were measured in the smoking and non-smoking areas of PC rooms in Goyang City, Korea. In 28 randomly sampled PC rooms, field investigators completed an observational questionnaire on building characteristics, smoking policies, and evidence of smoking. The geometric means (GM) of $PM_{2.5}$ and ANC in smoking and non-smoking areas were compared.

Results

Evidence of smoking was identified in both the smoking and non-smoking areas of all PC rooms. The GMs of $PM_{2.5}$ and ANC in both areas were high and did not differ significantly (174.77 $\mu g/m^3$ and 48.95 $\mu g/m^3$ in smoking areas; 93.38 $\mu g/m^3$ and 41.30 $\mu g/m^3$ in non-smoking areas). Overall $PM_{2.5}$ concentrations were 5.5-fold higher than those listed in the World Health Organization guidelines.

Conclusion

This study supported previous reports that a partial smoking ban did not protect individuals from SHS exposure. Furthermore, the results from our study suggest how research can support policy. Countries in which smoke-free policies are not yet comprehensive may find our results useful.

Key words
Tobacco smoke pollution, Personal computer room, Smoke-free policy, Air nicotine, $PM_{2.5}$

Introduction

Substantial evidence indicates that smoking bans reduce the adverse effects of exposure to tobacco smoke. As a result of this evidence, smoking bans in public places have been implemented in many countries. Furthermore, partial smoking bans in indoor public places and workplaces are becoming a common occurrence [1,2]. However, the issue of implementing complete smoking bans in all indoor public places has been debated in several countries. This disagreement depends on several factors including the societal view of smoking, compliance with existing smoke-free legislation, and other sociopolitical considerations.

In 1995, the Republic of Korea passed a law that banned smoking in public places. Excluded from this ban were restaurants, recreational facilities, and entertainment venues, although some were subject to a partial smoking ban (i.e., facilities had to have both smoking and non-smoking areas that were physically separated) [3]. For example, one type of

recreational facility, personal computer (PC) rooms, underwent a partial smoking ban. However, it is well-known that individuals within PC rooms will still be exposed to secondhand smoke (SHS), as there is air flow between the separated smoking and non-smoking areas. In Korea, there are 15,817 PC rooms, all of which provide a facility for individuals to play computer games. Survey data indicated that 45.2% of the population spends their leisure time in PC rooms. This percentage is higher than that at cinemas (33.5%), cafés (31.2%), or bars (26.2%). Furthermore, approximately 63.8% of adolescents regularly spend their leisure time in PC rooms [4].

PC rooms became a top priority for the 2011 Complete Smoking Ban placed on public indoor facilities. However, the implementation of this ban on PC rooms was delayed until 2013. This ban was delayed because owners of PC rooms and smokers' groups argued that the ban was not necessary, citing smokers' rights and the lack of evidence supporting the effectiveness of a partial ban in protecting individuals from SHS exposure.

In this study, we investigated the levels of SHS exposure in smoking and non-smoking areas of PC rooms prior to 2013, to determine whether a complete smoking ban in PC rooms in necessary. Thus, the results from this study will provide data that will impact the debate on a complete smoking ban in PC rooms.

Materials and Methods

From June to September 2012, particulate matter ($PM_{2.5}$) and air nicotine concentrations (ANC) were measured in the smoking and non-smoking areas of a random sample of 28 PC rooms. PC rooms were located in Goyang City, a residential satellite city of the capital Seoul. For each PC room, field researchers completed an observational questionnaire on the ventilation, air conditioning, and heating systems as well as the facility's policies on smoking (e.g., restricted or permitted smoking, tobacco sales permitted, tobacco advertising allowed). In addition, field researches looked for evidence of smoking. Monitoring equipment was concealed and measurements occurred in a blind manner (i.e., owners, employees, patrons, etc. had no knowledge of this study).

$PM_{2.5}$ concentrations were measured using a MetOne Acrocet 531 Aerosol Particulate Profiler (Grants Pass, OR) for a minimum of 30 minutes in the smoking and non-smoking areas of each PC room. Researchers waited 10 minutes between measurements taken in each PC room. All $PM_{2.5}$ concentrations measured were multiplied by 8.33 to adjust for the underestimation associated with monitoring the gravimetric $PM_{2.5}$ concentration using that machine [5].

ANC was measured using passive samplers (a 37-mm polystyrene sampling cassette holding a Teflon-coated glass fiber filter treated with 4% sodium bisulfate and 5% ethanol). Passive samplers were hung 1-2 m from the floor and at least 1 m from open windows and ventilation systems in order to avoid air circulation (i.e., "dead spots"). The sampling rate was 24 mL/min and the calculated limit of detection was 0.05 $\mu g/m^3$ over a 7-day sampling period. Exposed filters were extracted and nicotine was analyzed using a gas chromatograph equipped with a nitrogen phosphorous detector (7820A, Agilent Technologies, Santa Clara, CA) [6], with 10% of the samples duplicated. Final ANC values were calculated by subtracting out background levels measured using blank samples.

Geometric means (GM) and geometric standard deviations were calculated and statistical analyses were performed using SAS ver. 9.3 (SAS Institute Inc., Cary, NC). This study was approved by the Institutional Review Board of National Cancer Center of Korea.

Results

All PC rooms had centralized air conditioning and heating systems that were functioning during the rooms' hours of operation. According to the partial smoking ban implemented at the time this study was performed, all PC rooms were required to obey the following regulations: install a ventilation system for extracting smoke, prohibit the sale of tobacco, ban promotion and advertisement of tobacco, and had to post "no smoking" signs in non-smoking areas. In all PC rooms, we observed the implementation of these regulations. Despite these rules being followed, evidence of smoking was identified in both smoking and non-smoking areas in all PC rooms.

The GM of $PM_{2.5}$ concentration in both smoking (GM, 174.77 $\mu g/m^3$; range, 45.81 to 399.51 $\mu g/m^3$) and non-smoking areas (GM, 93.38 $\mu g/m^3$; range, 31.57 to 250.48 $\mu g/m^3$) was significantly higher than the guidelines set forth by the World Health Organization (WHO). The WHO recommends a level of 25 $\mu g/m^3$ during a 24-hour period. $PM_{2.5}$ concentrations in smoking areas were approximately twofold higher than those in non-smoking areas (Table 1).

The GM of ANC in smoking and non-smoking areas was not significantly different, 48.95 $\mu g/m^3$ (range, 38.97 to 82.71 $\mu g/m^3$) and 41.30 $\mu g/m^3$ (range, 37.75 to 70.38 $\mu g/m^3$), respectively. Nine PC rooms had ANCs lower than the limit of detection. We did not observe any difference in the GM of $PM_{2.5}$ concentrations between PC rooms in which ANC was

Table 1. Geometric mean and standard deviation of $PM_{2.5}$ and air nicotine concentration (ANC) in smoking and non-smoking areas of 28 personal computer (PC) rooms in the Republic of Korea

Measure	Place	No.	GM	GSD	Min	Median	Max
$PM_{2.5}$	Smoking and non-smoking combined	28	136.07	1.65	48.11	137.33	324.99
	Smoking areas	28	174.77	1.70	45.81	189.49	399.51
	Non-smoking areas	28	93.38	1.73	31.57	104.13	250.48
ANC[a)]	Smoking and non-smoking combined	19	45.25	1.16	38.53	44.05	69.16
	Smoking areas	19	48.95	1.20	38.97	47.08	82.71
	Non-smoking areas	19	41.30	1.15	37.75	39.28	70.38

PM, particulate matter; GM, geometric mean; GSD, geometric standard deviation; Min, minimum value; Max, maximum value. [a)]Nine PC rooms that showed values lower than the limit of detection were not included in the calculation.

detected (n=19; GM, 98.81 μg/m^3; range, 41.07 to 250.48 μg/m^3) and those rooms in which the ANC was below the limit of detection (n=9; GM, 82.88 μg/m^3; range, 31.57 to 239.24 μg/m^3) (Table 1).

Discussion

On May 16, 2005, Korea ratified the Framework Convention on Tobacco Control, which accelerated implementation of laws protecting individuals from the negative side effects of SHS and reduced the prevalence of smoking (48.1% males and 6.1% females) [7]. In June 2011, the amended National Health Promotion Law expanded the complete smoking ban to include recreational facilities. Recreational facilities, such as PC rooms, are a location in which individuals spend the majority of their leisure time [3,8]. The partial smoking ban implemented prior to the Rewritten National Health Promotion Law of 2011 required facilities to construct a wall or air curtain between smoking and non-smoking areas as well as install ventilation systems to combat tobacco smoke [9]. However, the partial smoking ban did not prevent the flow of tobacco smoke between areas.

Opponents of the 2011 law, including the owners of PC rooms, organized to repeal the complete smoking ban and argued that the law was unconstitutional. This action was ultimately unsuccessful, but did delay implementation until June 8, 2013. In this study, we measured the levels of tobacco smoke in PC rooms prior to June 8, 2013, during the period of delay of the complete smoking ban. Our results indicated that the $PM_{2.5}$ concentrations and ANC in the smoking and non-smoking areas of PC rooms were similar. Thus, the results of this study support implementation of a complete smoking ban.

We observed ANCs that were greater than 10-fold higher that those in a previous report of ANCs in an entertainment venue in Seoul that permits smoking without restriction [10]. The $PM_{2.5}$ concentration observed in non-smoking areas of PC rooms was very high. The $PM_{2.5}$ concentration in smoking and non-smoking areas combined was similar to those previously reported in cafés, bars/clubs, entertainment venues, and smoking rooms worldwide [11-15]. Our results support previous data in that we observed that SHS exposure in PC rooms was very high and that the partial smoking ban is unlikely to protect individuals in non-smoking areas from SHS exposure [11,13,15,16].

By means of an official government report and an article in a major daily newspaper [17], we announced our findings to the public and informed Korean citizens that the most effective protection from SHS exposure in non-smoking areas is implementation of a complete smoking ban in PC rooms. Although our study sampled only a small number of PC rooms in one city, it supports the necessity of a complete smoking ban.

The complete ban on smoking in PC rooms has been in force since January 1, 2014 [3,8]. Furthermore, it stimulated governmental efforts to expand smoke-free legislation in Korea.

Conclusion

We conclude that our research supports the complete smoking ban and may provide the necessary scientific evidence for other countries that have not yet implemented comprehensive smoke-free policies.

Conflicts of Interest

Conflict of interest relevant to this article was not reported.

Acknowledgments

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