

Smoke-Free School Zone Policy and Its Association with Attitudes Toward Smoking and Secondhand Smoke Exposure Among School-Aged Children and Key Stakeholders

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Background: Smoke-free zone policies in school settings have been widely implemented; however, evidence regarding their impact on smoking-related attitudes and secondhand smoke (SHS) exposure remains limited. This study aimed to examine the association between a smoke-free zone policy implemented along school commuting routes and attitudes toward smoking and SHS exposure among elementary school students, their parents, and school staff in Seoul, South Korea.

Methods: A cross-sectional study was conducted. Participants were 210 students, 272 parents, and 137 school staff from the five schools randomly selected according to the criteria of regional deprivation index and prevalence of designated smoke-free zones from all the 25 districts of Seoul, South Korea. “Attitudes toward smoking” and “exposure to SHS” were the outcome variables, and the “presence of a smoke-free zone along the school commuting route” was the predictor variable. All variables were assessed using self-reported questionnaires. Data were collected between November 2020 and December 2020. The multiple logistic regression analysis was performed to test main hypotheses.

Results: Students and school staff in schools with designated smoke-free zones along school commuting routes were significantly less likely to be exposed to SHS along those routes, compared to their counterparts without such zones (odds ratio [OR] = 0.29; 95% confidence interval [CI], 0.098–0.853; $p = 0.025$ for students; OR = 0.09; 95% CI, 0.008–0.939; $p = 0.044$ for school staff). However, the presence of smoke-free zones along school commuting routes was not significantly associated with attitudes toward smoking among students, parents, or school staff.

Conclusion: Designation of smoke-free zones along school commuting routes may be effective in reducing exposure to SHS among students and school staff. The active and consistent enforcement of smoke-free policies within school settings may play a critical role in further reducing SHS exposure among children and related stakeholders.

Keywords: adolescent, smoke-free policy, smoking prevention, tobacco smoke pollution, environmental exposure, schools, social environment

Introduction

Smoking and secondhand smoke (SHS) exposure are global health issues as major causes of non-communicable disease morbidity and premature mortality.^{1,2} Tobacco smoke contains over 7000 harmful chemicals and 70 carcinogens.¹ In 2023, tobacco use was responsible for over eight million deaths worldwide, including approximately 1.6 million non-smokers who died due to SHS exposure.³ Meanwhile, nearly half of children worldwide have been exposed to SHS⁴ and the annual number of deaths due to smoking and SHS exposure is approximately 58,000 in South Korea.^{5,6} In this context, it is necessary to implement active public policy measures at the national and local government levels to prevent early smoking and SHS exposure.



Children are more susceptible to SHS exposure than adults owing to several physical conditions including small airways, fast breathing rates, and limited options to prevent SHS exposure.^{7,8} The health effects of SHS exposure in children may not only increase the risk of childhood asthma, malnutrition, and latent brain development but may also increase all-cause mortality in adulthood.⁹ Moreover, childhood is a critical period for the development of health-related attitudes and behaviors. Therefore, implementing anti-smoking measures and promoting smoke-free environments for children may contribute to preventing tobacco use in adulthood.^{4,10} In particular, increased negative attitudes toward smoking can predict future smoking intentions and subsequent smoking behaviors in children.¹¹

Schools can play a critical role in preventing smoking and the risk of SHS exposure in children. Following the ratification of the World Health Organization Framework Convention for Tobacco Control (WHO-FCTC) in 2005, many countries have introduced smoke-free legislative policies to prevent exposure to tobacco smoke in indoor workplaces and public places, including schools.⁴ Smoke-free school policies restrict tobacco use by defining schools and their surroundings as non-smoking areas and imposing penalties on those who break smoking rules.⁴ In total, 97 of the 181 parties (53.6%) included in the WHO-FCTC in 2018 had implemented full or partial bans on tobacco use in educational facilities; this figure increased substantially to 168 of 183 parties (91.8%) by 2023.^{12,13}

Based on the National Health Promotion Act in South Korea, public facilities and medical institutions, including schools, have been designated as non-smoking areas since 2012. In 2010, the Seoul Metropolitan Government enacted a municipal ordinance to promote a smoke-free environment and prevent the harms of SHS exposure,¹⁴ becoming the first in the country to designate outdoor non-smoking areas. Grounded in this legal framework, a pilot project to designate school commuting routes as smoke-free zones within a 50-meter radius of school commuting routes was initiated in 2017. Since 2017, Seoul has been implementing the “Student-led School Area Smoke-Free Zone Designation Project” and was actively designating school commuting routes as smoke-free zones through community participation and expanding these zones to all districts of Seoul.¹⁵ As of 2020, 21.1% of all schools in Seoul have designated their school commuting routes as smoke-free zones. Moreover, in 2017, the National Health Promotion Act was revised to designate a nationwide smoke-free zone within a 10-m distance from school facility boundaries; this range was expanded to 30-m in 2024.¹⁶ Despite such legislation, the smoking rate among youths remains at 4.2% overall (5.6% for boys and 2.7% for girls), and 42.2% of South Korean adolescents¹⁷ and 57.6% of adolescents worldwide¹⁸ were reported to be exposed to secondhand smoke in public places on at least one day per week.

The WHO has recently emphasized a comprehensive “whole school” approach with the participation of students and their stakeholders (ie, parents and school staff [including teachers]) to support school-based smoking cessation programs.¹⁹ In line with this approach, smoke-free school policies involving active participation of students and their stakeholders are being increasingly initiated.²⁰ The WHO has highlighted the urgency of protecting future generations from the consequences of tobacco use and exposure to tobacco smoke.⁴ Smoke-free zones within and around school environments represent a key component of tobacco control strategies aimed at preventing smoking initiation among adolescents.²¹ However, data on the impact of the policy for smoke-free zones on attitudes toward smoking and SHS exposure among students and their stakeholders remain scarce.^{20,22}

The purpose of this study was to investigate attitudes toward smoking and exposure to SHS among students, parents, and school staff in elementary schools following the implementation of a smoke-free zone policy, which designates school commuting routes as smoke-free zone. In particular, SHS exposure was assessed both within school buildings and along the smoke-free school commuting routes.

Methods

Study Design and Participants

A cross-sectional study was conducted to examine the association between a smoke-free zone policy implemented along school commuting routes and attitudes toward smoking and SHS exposure among elementary school students, their parents, and school staff in Seoul, South Korea. Data was collected between November and December 2020.

The participants were sampled in two stages. In the first stage, five elementary schools were selected from all 25 districts in Seoul. The districts were classified into four groups based on the “regional deprivation index”,²³ and “prevalence of smoke-free

zones along school commuting routes". Based on the regional deprivation index, 13 districts with higher-than-average socioeconomic levels were classified as high-level socioeconomic groups, and 12 districts with lower-than-average levels were classified as low-level groups (Figure 1). Based on the prevalence of smoke-free zones, the 25 districts were further divided into two groups: those with less than 90% and those with 90% or more designated smoke-free zones. Finally, we identified four groups: Group 1, two districts (high level and 90% or more zones); Group 2, 11 districts (high level and less than 90% zones); Group 3, four districts (low level and 90% or more zones); and Group 4, eight districts (low level and less than 90% zones) (Figure 1).

As of 2021, 568 elementary schools were present in Seoul, with 37 in Group 1, 303 in Group 2, 92 in Group 3, and 136 in Group 4 (Figure 1). From each group's school list, one school was randomly selected, and the selected school was contacted to explain the purpose and content of the study and to assess its willingness to participate. If a school declined to participate, the procedure was repeated until a school agreed to take part. Some schools were unable to participate due to the coronavirus disease 2019 (COVID-19) social distancing measures. In Group 2, two schools were recruited due to the limited number of school staff in the initially selected school. Finally, five elementary schools were sampled and analyzed (Figure 1).

In the second stage, students, parents, and school staff were recruited from the five schools selected initially in the first stage. The inclusion criteria were as follows: fifth- or sixth-grade students, parents who were legal guardians of the students, and school staff (including teachers) who worked five or more days per week.

The sample size was determined by a power analysis performed using G*Power 3.1, based on the following criteria: an odds ratio of 2.0, a significance level (α) of 0.05, a power ($1-\beta$) of 0.90, an R^2 of 0.2 for the predictor variables, and a normal distribution. The analysis indicated that at least 132 participants were required in each population group (students, parents, and school staff) to achieve adequate statistical power. As the COVID-19 situation had worsened, fewer participants than expected were recruited. From the five schools with eligible participants (295 students, 281 parents, and 143 school staff), 210 students, 272 parents, and 137 school staff were included.

Measures

A self-reported questionnaire was used to collect data on participants' general characteristics, the predictor variable (ie, presence of a designated smoke-free zone along the school commuting route), and outcome variables (ie, attitudes toward smoking and SHS exposure inside the school and along the school commuting routes).

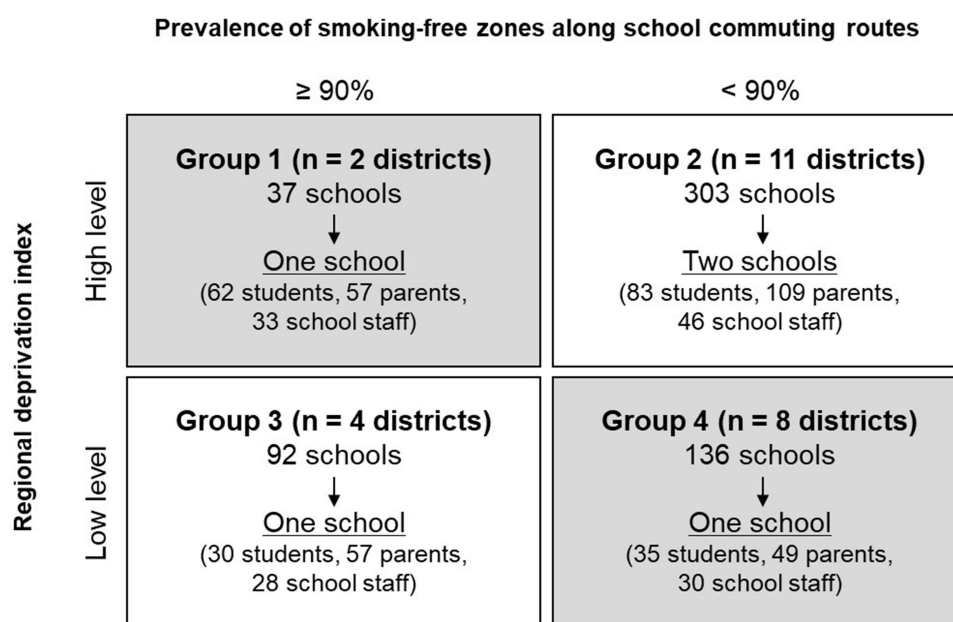


Figure 1 Participant flow across 25 districts in Seoul, stratified by the prevalence of smoke-free zones along school commuting routes and the regional deprivation index.

General Characteristics

Data on sex and age for students, and sex, age, and education level (college-educated or not) for parents and school staff were collected. In addition, data on the regional deprivation index, which was used to rank the 25 districts of Seoul by socioeconomic status,²³ local smoking rate,²⁴ and prevalence of smoke-free zones on school routes (as described above) were obtained. Local smoking rate refers to the rate of current smoking among the adult population in the district where the primary school was located.

Smoke-Free Zone and Outcome Variables

The smoke-free zone was defined as having a designated smoke-free zone along the school commuting routes.²⁵ Attitudes toward smoking were measured as follows: for students, 15 questions modified from the WHO's Global Youth Tobacco Survey (GYTS)²⁶ were used ([Supplementary Table 1](#)), including items such as "Smoking seems to make you feel better", "Smoking relieves loneliness", or "Smoking means you have grown up". Responses were measured on a 4-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree). Scoring information for the questions regarding attitudes toward smoking for students were reported in the [Supplementary Table 1](#). The total score ranges from 15 to 60 points and is converted to a total of 100 points. Based on the mean score (56.9 points), responses with scores equal to or above the mean were coded as "yes" (code = 1, indicating a negative attitude), while those below the mean were coded as "no" (code = 0, indicating a not-negative attitude). For parents and school staff, 20 questions with "yes", "no", and "don't know" responses were asked based on the WHO 1982 Guidelines for the Content of Tobacco Smoking Surveys of the General Population.²⁷ A score of 1 indicated "yes" for negative attitudes and 0 indicated "no" for not-negative attitudes or "don't know". Scoring information for the questions regarding attitudes toward smoking for parents and school staff were reported in the [Supplementary Table 1](#). The total score ranged from 0 to 20 and was converted to a total of 100. Based on the mean value (18.4 points for parents and 18.7 points for school staff), scores equal to or higher than the mean were coded as yes (code = 1, indicating a negative attitude) and those below the mean were coded as no (code = 0, indicating a not-negative attitude).

Exposure to SHS was assessed by asking all participants the following questions^{18,28} ([Supplementary Table 1](#)): "In the past week, have you ever smelled someone else's cigarette smoke inside the school?" (SHS exposure inside the school) and "In the past week, have you ever smelled someone else's cigarette smoke while walking to school? (SHS exposure along school commuting routes)" A positive response to either one was defined as the presence of SHS exposure.

Statistical Analysis

Data were analyzed using SPSS 28.0.²⁹ Statistical significance was set at $p < 0.05$. Participants' general characteristics, independent variables, and outcome variables are reported as n (%) or mean (standard deviation, SD).

Differences in the prevalence of SHS exposure inside the school and along school commuting routes between students and parents, as well as between students and school staff, were examined using crude logistic regression models, with students serving as the reference category. The multiple logistic regression analysis was employed to examine the associations between the presence of smoke-free zones along school commuting routes and outcomes comprising negative attitudes toward smoking and SHS exposure both inside the school and along commuting routes. The multiple logistic regression analysis was conducted, with the adjustment of sex, age, education level (for parents and school staff only), regional deprivation index, local smoking rate, and the prevalence of smoke-free zones. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were reported.

Ethical Considerations

All participants provided written informed consent after receiving an explanation of the purpose of the study. The study design was approved by the Institutional Review Board of Korea University (No. KUIRB-2020-0303-01). All procedures were carried out in adherence to the board's ethical standards. For minors, additional written consent was obtained from their legal guardians via home communication letters.

Results

The study included 210 students (50.0% girls), 272 parents (82.7% women), and 137 school staff members (82.5% women), with mean ages of 11.3, 42.9, and 42.3 years, respectively (Table 1). Most of the parents and staff members were college educated (82.7% parents, 92.0% staff) and non-smokers (84.9% parents, 89.8% staff). Students, parents, and school staff under the smoke-free zone policy were 62.4%, 63.2%, and 63.5%, respectively. The proportions of students, parents, and school staff with negative attitudes toward smoking were 68.6%, 63.2%, and 72.3%, respectively (Table 1).

The proportions of students, parents, and school staff who reported experiencing SHS exposure inside the school were 14.3%, 7.7%, and 3.6%, respectively (Table 1 and Figure 2). Students were significantly more likely to be exposed to SHS inside the school compared with parents (OR = 0.50, 95% CI = 0.278–0.905, $p=0.022$) and school staff (OR = 0.23, 95% CI = 0.086–0.601, $p=0.003$). The proportions of students, parents, and school staff who reported experiencing SHS exposure along school commuting routes were 42.9%, 39.7%, and 29.2%, respectively (Table 1 and Figure 2). Students were significantly more likely to be exposed to SHS along school commuting routes compared with school staff (OR = 0.55, 95% CI = 0.348–0.870, $p=0.003$).

No significant associations were found between the presence of a smoke-free zone policy along school commuting routes and attitudes toward smoking among students, parents, or school staff (Table 2). Similarly, the presence of the smoke-free zone policy along school commuting routes was not significantly associated with SHS exposure inside the school across all three groups. However, students covered by a smoke-free zone policy along their commuting route were significantly less likely to be exposed to SHS along the route compared to those not covered (adjusted OR = 0.29, 95%

Table 1 General Characteristics of Participants

	n (%) or Mean (SD)		
	Students (n = 210)	Parents (n = 272)	School Staff (n = 137)
Age, years ^A	11.3 (0.45)	42.9 (5.54)	42.3 (9.72)
Gender ^A			
Men	105 (50.0)	54 (19.9)	24 (17.5)
Women	105 (50.0)	218 (80.1)	113 (82.5)
College-educated ^A			
Yes	–	225 (82.7)	126 (92.0)
No	–	47 (17.3)	11 (8.0)
Smoking status			
Current smoker	–	41 (15.1)	14 (10.2)
Non-smoker	–	231 (84.9)	123 (89.8)
The presence of smoke-free zone policy			
Yes	131 (62.4)	172 (63.2)	87 (63.5)
No	79 (37.6)	100 (36.8)	50 (36.5)
Negative attitudes toward smoking			
Yes	144 (68.6)	172 (63.2)	99 (72.3)
No	66 (31.4)	100 (36.8)	38 (27.7)
SHS exposure inside the school ^A			
Yes	30 (14.3)	21 (7.7)	5 (3.6)
No	180 (85.7)	251 (92.3)	132 (96.4)
SHS exposure along school commuting routes ^A			
Yes	90 (42.9)	108 (39.7)	40 (29.2)
No	120 (57.1)	164 (60.3)	97 (70.8)

Notes: The presence of smoke-free zone policy indicates having designated smoke-free zone along the school commuting route; Negative attitude toward smoking was treated as a dichotomous variable, categorized as negative attitude versus not-negative attitude. ^Astatistically significant difference among the three stakeholder groups.

Abbreviations: SD, standard deviation; SHS, secondhand smoke.

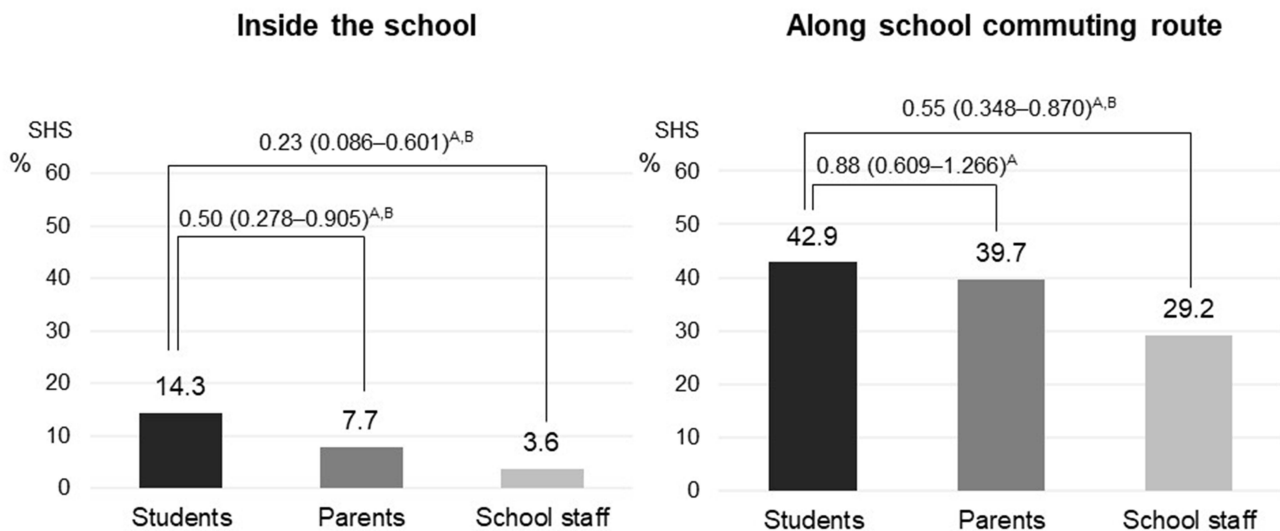


Figure 2 Secondhand smoke exposure (%) inside the school and along school commuting routes. ^Aodds ratio (95% confidence interval), ^B*p* <0.05. **Abbreviations:** OR, odds ratio; CI, confidence interval.

CI = 0.098–0.853, *p* =0.025) (Table 2). In addition, school staff working in areas with the smoke-free zone policy were significantly less likely to report SHS exposure along commuting routes than those without such coverage (adjusted OR = 0.09, 95% CI = 0.008–0.939, *p* =0.044) (Table 2).

Table 2 Association of a Smoke-Free Zone Policy Along School Commuting Routes with Attitudes Toward Smoking and SHS Exposure

	Negative Attitudes Toward Smoking ^A		SHS exposure ^A			
			Inside the School		Along School Commuting Route	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Students (n = 210)						
Smoke-free zone policy ^B (ref. none)	1.21 (0.374–3.936)	0.747	1.28 (0.267–6.156)	0.756	0.29 (0.098–0.853)	0.025
Girls (ref. boys)	1.18 (0.642–2.151)	0.601	0.95 (0.431–2.117)	0.910	1.75 (0.985–3.117)	0.056
Age	0.64 (0.313–1.307)	0.220	1.52 (0.632–3.650)	0.350	0.66 (0.325–1.326)	0.241
Regional deprivation index	0.77 (0.228–2.630)	0.683	1.74 (0.253–11.976)	0.574	3.01 (1.024–8.865)	0.045
Local smoking rate	0.70 (0.146–3.358)	0.657	0.87 (0.083–9.211)	0.910	6.09 (1.395–26.569)	0.016
Prevalence of smoking-free zones	0.99 (0.968–1.007)	0.203	1.01 (0.977–1.035)	0.700	1.03 (1.012–1.050)	0.001
Parents (n = 272)						
Smoke-free zone policy ^B (ref. none)	0.55 (0.231–1.304)	0.174	0.26 (0.040–1.626)	0.148	0.53 (0.224–1.269)	0.155
Women (ref. men)	2.76 (1.425–5.348)	0.003	1.41 (0.371–5.366)	0.613	1.44 (0.734–2.822)	0.290
Age	1.05 (0.993–1.105)	0.092	1.02 (0.907–1.137)	0.793	0.97 (0.922–1.016)	0.188
College-educated (ref. no)	1.88 (0.964–3.667)	0.064	4.45 (0.569–34.786)	0.155	1.12 (0.567–2.201)	0.748
Regional deprivation index	20.94 (0.042–10372.584)	0.337	0.02 (0.000–364.633)	0.420	0.46 (0.001–156.987)	0.793
Local smoking rate	0.45 (0.085–2.425)	0.356	3.02 (0.194–47.080)	0.430	1.33 (0.274–6.458)	0.723
Prevalence of smoking-free zones	1.00 (0.994–1.012)	0.510	1.01 (0.992–1.032)	0.249	1.01 (1.002–1.020)	0.014
School staff (n = 137)						
Smoke-free zone policy ^B (ref. none)	0.84 (0.212–3.284)	0.796	–	–	0.09 (0.008–0.939)	0.044
Women (ref. men)	1.64 (0.610–4.397)	0.327	–	–	0.74 (0.263–2.097)	0.574
Age	1.02 (0.981–1.069)	0.281	–	–	0.96 (0.913–1.002)	0.062
College-educated (ref. no)	2.53 (0.594–10.765)	0.209	–	–	1.25 (0.225–6.933)	0.800
Regional deprivation index	10.25 (0.001–149861.498)	0.634	–	–	1.01 (0.000–16192.138)	0.999
Local smoking rate	0.44 (0.034–5.712)	0.530	–	–	1.20 (0.094–15.464)	0.887
Prevalence of smoking-free zones	1.00 (0.984–1.009)	0.594	–	–	1.04 (1.015–1.065)	0.002

Notes: Negative attitude toward smoking was treated as a dichotomous variable, categorized as negative attitude versus not-negative attitude. ^AOdds ratio adjusted for gender, age, education level, regional deprivation index, local smoking rate, and prevalence of smoke-free zones. ^Bsmoke-free zone policy along school commuting routes; Bold characters indicate statistically significant findings. (–) indicates data not reported due to the small number of events and unstable model convergence.

Abbreviations: CI, confidence interval; OR, odds ratio; SHS, secondhand smoke; ref., reference group.

Discussion

Of the elementary school students recruited in the present study, 68.6% held negative attitudes toward smoking and 42.9% reported exposure to SHS in school commuting routes. Students and their stakeholders (ie, school staff) who were subject to the policy for smoke-free zones along the school commuting routes were less likely to be exposed to SHS in the commuting routes, compared to those not covered by such a policy. However, the policy was not significantly associated with attitudes toward smoking.

Among the students and their stakeholders, more than 63% exhibited negative attitudes toward smoking. Due to the limited availability of previous research, the degree of negative attitudes toward smoking cannot be directly compared. However, it remains essential to continuously foster negative attitudes toward smoking among children and adolescents. Attitudes and values related to smoking are shaped in part by observational learning, particularly through the behaviors of adults in their living and working environments.⁴ Strengthening these attitudes requires continued collaboration between parents and school staff to reinforce smoking cessation messages consistently across both school and home environments. This collaborative approach, involving students and their stakeholders, may contribute to a more effective reduction in SHS exposure and designation of smoke-free zones in a city. Accordingly, it is imperative that educational institutions prioritize tobacco awareness training not only for students, but also for parents and school staff—groups identified in this study as being least aware of tobacco-related attitudes. Furthermore, education and mentoring provided by school staff or community members who model appropriate attitudes toward smoking may have a beneficial influence on children.

In the present study, the prevalence rates of exposure to SHS among students were 14.3% within schools and 42.9% along school commuting routes; these rates were higher among students compared to school staff. The prevalence of SHS exposure among students, whether inside the school or along commuting routes, reported in previous studies—for instance, 31.9% among Chinese adolescents within schools,³⁰ 37.9% among US children aged 3–11 years in any setting,³¹ and approximately 50% as the global average for SHS exposure across various public settings.⁴ This discrepancy may reflect differences in the extent of smoking policy implementation within school environments. However, the limited number of studies investigating SHS exposure both within and outside educational settings hinders direct comparison and comprehensive understanding.

In the present study, no significant associations were found between the designated smoke-free zone on commuting routes and negative attitudes toward smoking among either students or their stakeholders. This finding is somewhat inconsistent with previous studies involving school-aged children and their stakeholders.³² Previous research has demonstrated that tobacco control policies are often associated with shifts in social norms that support smoke-free environments.³³ This discrepancy across studies may be explained by the possibility that the study participants already exhibited a skewed high level of negative attitudes toward smoking (eg, 68.6% of students), which may have contributed to the non-significant association observed. Nevertheless, schools may be uniquely positioned to promote student awareness of anti-smoking norms and policies by strengthening enforcement efforts, such as monitoring school grounds.³⁴ Based on this premise, even in the absence of significant associations, we support the notion that fostering smoke-free environments—such as through smoke-free zone on the commuting routes—may help children internalize non-smoking norms early on and lower the risk of smoking initiation later in life.²¹

Our findings indicated that the smoke-free zone policy along school commuting routes was significantly associated with students' exposure to SHS both inside the school and along the school commuting routes. School-going students usually spend their waking hours at school.¹⁹ Educational institutions and the domestic environment are ideally positioned to assist young people in avoiding the initiation of nicotine and tobacco use and safeguard them from the adverse effects of SHS exposure. Although this was a cross-sectional study, the finding that a smoke-free policy in school surroundings is effective suggests that a multi-pronged approach of school inside and outside settings is needed to protect children from SHS exposure.

A new guide and toolkit released by the WHO in 2023 contains a step-by-step manual for schools to create nicotine- and tobacco-free campuses; however, it takes a “whole school” approach including school staff, students, parents, and more.¹⁹ For parents, the findings on the association between the smoke-free zone policy and SHS exposure were not statistically significant. However, the results suggested a reduced probability of SHS exposure when smoke-free policies were in place, compared to when such policies were absent. Although the smoke-free zone policy primarily targeted students, it demonstrated the potential to promote smoke-free environments across the broader community. A school is not only a workplace for

students and school staff but also an outdoor space for members of the local community. Strong smoke-free policies in public places, including commuting routes, reduce the visibility and social acceptability of smoking. This can serve as an effective strategy to prevent SHS exposure among both students and community members.^{35,36}

In this context, it falls upon the relevant government departments to reinforce the implementation and supervision of smoke-free policies and enhance training, publicity, and education to achieve a truly 100% smoke-free school. Moreover, it is essential to dedicate significant resources to monitoring and evaluating the impact of these measures to maintain broad public support and identify optimal practices. While the widespread implementation of the WHO FCTC and its guidelines in public places can protect children and communities from SHS exposure, it is difficult to extend smoke-free regulations or laws to extended outdoor school spaces. Therefore, smoke-free schools rely primarily on non-regulatory measures. Health policymakers should implement appropriate strategies, such as educating parents and school staff about the risks of smoking and SHS exposure, and the benefits of smoke-free zones surrounding schools. This approach could motivate individuals to voluntarily prohibit smoking among extended population groups.

Strengths and Limitations

This study demonstrates the feasibility of the designation of smoke-free zones along school commuting routes to improve awareness and reduce SHS exposure. Recent evidence suggests that extending smoke-free policies to private and outdoor settings may be an effective strategy to protect children and communities from harm related to SHS.²⁰ However, the lack of study findings has made it difficult to include this in major health policies adopted by governments.

The present study has several limitations. First, the data was obtained from a cross-sectional survey; therefore, the findings should be interpreted with caution. Second, the children's exposure to SHS was assessed based on self-reporting without any objective measurements, such as the levels of nicotine in the air and biomarkers in the urine or blood; therefore, the results may have been underestimated. Third, the participants in this study resided in a single metropolitan area, specifically Seoul, South Korea, and the sample size was relatively small. Fourth, the majority of parent and school staff respondents were women, which may limit the generalizability of the findings, although gender was adjusted for in the logistic regression models. Therefore, it is essential to conduct further investigations with a more expansive population distribution. Finally, although we adjusted for key community-level covariates such as regional deprivation index, local smoking rate, and prevalence of smoke-free zones in the logistic regression models, the possibility remains that other unmeasured interventions or contextual factors may have influenced the observed associations. To minimize this concern, the analysis was restricted to schools within the same urban setting and time period. Nonetheless, due to the cross-sectional design, causal inferences cannot be drawn, and the potential influence of residual confounding cannot be fully excluded. This limitation should be considered when interpreting the findings.

Conclusions

This study aimed to examine the association between the presence of a smoke-free zone policy along school commuting routes and attitudes toward smoking and SHS exposure among elementary school students, their parents, and school staff in Seoul, South Korea. The findings suggest that the policy may be effective in reducing SHS exposure among students and school staff in commuting areas, although it did not show a significant association with smoking-related attitudes. These results indicate that complementary and sustained educational or community engagement strategies may be needed to support attitude change. Enforcing smoke-free policies in school zones remains a challenge; however, such efforts are necessary to protect children and surrounding communities from the harmful effects of tobacco smoke. As schools are embedded within broader communities, smoke-free zones can have wider public health benefits by reducing SHS exposure among not only students but also parents, school staff, and local residents. Future efforts should focus on evaluating the long-term impact of such policies on behavior change, integrating education-based interventions to influence smoking-related attitudes, and expanding the reach of smoke-free legislation to include broader school environments and their surroundings.

Data Sharing Statement

The data supporting the findings of this study are available from the corresponding author upon request.

Ethics Approval and Informed Consent

All participants provided written informed consent after receiving an explanation of the purpose of the study. The study design was approved by the Institutional Review Board of Korea University (No. KUIRB-2020-0303-01). All procedures were carried out in adherence to the board's ethical standards. For minors, additional written consent was obtained from their legal guardians via home communication letters.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that there is no competing of interests in this work.

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