



Associations Between Compliance With Non-pharmaceutical Interventions and Social-distancing Policies in Korea During the COVID-19 Pandemic

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Objectives: This study explored changes in individuals' behavior in response to social distancing (SD) levels and the "no gatherings of more than 5 people" (NGM5) rule in Korea during the coronavirus disease 2019 (COVID-19) pandemic.

Methods: Using survey data from the COVID-19 Behavior Tracker, exploratory factor analysis extracted 3 preventive factors: maintenance of personal hygiene, avoiding going out, and avoiding meeting people. Each factor was used as a dependent variable. The chi-square test was used to compare differences in distributions between categorical variables, while binary logistic regression was performed to identify factors associated with high compliance with measures to prevent transmission.

Results: In men, all 3 factors were significantly associated with lower compliance. Younger age groups were associated with lower compliance with maintenance of personal hygiene and avoiding meeting people. Employment status was significantly associated with avoiding going out and avoiding meeting people. Residence in the capital area was significantly associated with higher compliance with personal hygiene and avoiding venturing out. Increasing SD levels were associated with personal hygiene, avoiding going out, and avoiding meeting people. The NGM5 policy was not significantly associated with compliance.

Conclusions: SD levels, gender, age, employment status, and region had explanatory power for compliance with non-pharmaceutical interventions (NPIs). Strengthening social campaigns to inspire voluntary compliance with NPIs, especially focused on men, younger people, full-time workers, and residents of the capital area is recommended. Simultaneously, efforts need to be made to segment SD measures into substrategies with detailed guidance at each level.

Key words: COVID-19, Physical distance, Population characteristics, Public health systems research, Republic of Korea

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INTRODUCTION

Human and economic losses from coronavirus disease 2019 (COVID-19) since 2019 have been substantial; as of May 2, 2021, 222 countries and international territories have reported over 152 million cases and over 3.2 million deaths from COVID-19 [1]. During this period, 122 000 cases and 1800 deaths have been reported in Korea. Other countries that took countermeasures too late or indecisively had to implement rigorous lockdowns in the early phase of the pandemic. Conversely, Korea quickly organized intensive mass testing and contact tracing and did

not impose a complete lockdown [2,3]. Instead, the Korea Disease Control and Prevention Agency (KDCA; formerly Korea Centers for Disease Control and Prevention) promptly introduced non-pharmaceutical interventions (NPIs) such as hand-washing, covering the mouth with sleeves when coughing, avoiding touching the eyes or nose with unwashed hands, wearing masks, and not visiting crowded places [4]. In addition, starting in June 2020, the KDCA enforced a social distancing (SD) system consisting of 5 levels (levels 1, 1.5, 2, 2.5, and 3) containing differentiated preventive measures in each level.

The KDCA adjusted the grading of levels based on the characteristics and intensity of newly confirmed cases. When the second wave of the pandemic began, the KDCA upgraded the SD level of the capital area to level 2 (on August 16, 2020) and strengthened level 2 (on August 26, 2020) for mitigation. It subsequently downscaled the level to 1 (on October 12, 2020) after the end of the second wave. During the third wave, the SD level of the capital area was increased gradually to level 1.5 (on November 19, 2020), level 2 (on November 24, 2020), and level 2.5 (on December 8, 2020). The December 8, 2020, increase was coupled with a simultaneous increase in SD to level 2 in non-capital areas. Nonetheless, the third wave was not sufficiently controlled and new cases surged to over 1000 per day in late December 2020. Therefore, the KDCA enacted the “no gatherings of more than 5 people” (NGM5) policy, prohibiting private gatherings of more than 5 people, irrespective of region. When the number of 7-day moving average cases declined to under 400 by January 26, 2021, the KDCA downscaled the SD level to 2 for the capital area and 1.5 for non-capital areas [4].

The adjustment in SD policies was evaluated as being effective in controlling the number of new cases in Korea and other countries [5-9]. However, fluctuations in the number of new confirmed cases might be a result of a combination of elements, such as public compliance with NPIs, the management of high-risk facilities (e.g., care centers and hospitals), quarantine protocols, seasonal effects, and vaccination. Furthermore, the success of SD measures thoroughly depends on people’s voluntary participation [10,11]. Previous studies also emphasized the importance of guiding people’s behaviors to prevent and control the spread of COVID-19 [12,13]. Therefore, the effectiveness of SD policies should be assessed by judging changes in individuals’ compliance, rather than based on the number of new confirmed cases. Nonetheless, limited data are available regarding how individuals’ behavior has changed in re-

sponse to SD levels or the implementation of NGM5 over the past year.

Therefore, this study examined the association between compliance with NPIs and SD policies (i.e., SD levels and NGM5) in Korea with repeatedly and representatively surveyed data. This study also investigated how socio-demographic characteristics (e.g., gender, age, generation, employment status, and area of residence) determined compliance with NPIs. Its findings and outcomes are expected to provide basic data for planning viable policies with the goal of overcoming COVID-19.

METHODS

Data

Publicly available data from the Imperial College London’s YouGov COVID-19 Behavior Tracker Data Hub were used for this study. These data were made accessible for academic research purposes on the GitHub webpage [14]. The Centre for Health Policy of the Institute of Global Health Innovation took charge of collecting and releasing related reports.

Surveys in Korea have been conducted to assess subjective well-being [15], perception of danger [16] and life changes [17] in the context of the COVID-19 pandemic. The data in this research were also suitable for assessing people’s compliance with NPIs, given that the data were collected between April 2020 and April 2021, repeatedly (24 times) using the same questions for compliance with NPIs. Since the survey was regularly conducted over the past year, it is believed that the data from the survey could shed light on changes in behavior according to SD levels in Korea. Prior studies have also evaluated the strength of the accumulated data from Imperial College London [18-21].

A total of 13 300 individuals responded to this survey. Although the data were collected over 1 year, these were cross-sectional data, as the survey did not follow the same set of people weekly. The responses were collected considering demographic characteristics (e.g., gender, age, and region). The data contained numerous questions related to COVID-19: wearing a face mask, contact tracing, diagnosis of health conditions, lifestyle, perceptions of vaccination, and compliance with NPIs.

Variables

The items used to explain compliance with NPIs comprised questions on behavioral patterns 7 days prior to responding to

the survey, for example, “How often have you taken the following measures to protect yourself or others from COVID-19?” Of 20 items, 16 were utilized since 4 were not mentioned since January 2021. The answers to each of the items were coded as follows: 1 = always, 2 = frequently, 3 = sometimes, 4 = rarely, 5 = not at all. However, we inversely coded answers to ensure that higher compliance was assigned a higher numerical value. The factors representing compliance with NPIs were analyzed using exploratory factor analysis. The Kaiser-Meyer-Olkin test yielded a value of 0.930, and the Bartlett’s test of sphericity was significant ($p < 0.001$). Among the 16 items used, 5 were eliminated because they had a low factor loading (< 0.5) (Supplemental Material 1).

The results of the rotated principal component analysis were summarized as the following 3 factors: (1) Personal hygiene (5 items): wearing a face mask outside home, washing one’s hands with soap and water, using hand sanitizer, covering one’s nose and mouth when sneezing and coughing, and avoiding crowded areas. (2) Avoiding going out (3 items): avoiding going out in general, avoiding working outside one’s home, and avoiding going to shops. (3) Avoiding meeting people (3 items): avoiding small social gatherings (of no more than 2 people), avoiding medium-sized social gatherings (of 3 to 10 people), and avoiding large social gatherings (of more than 10 people).

To calculate the values for each factor, the value of the component items was averaged and modified into a binary category. If the value was above the average value of all the responses, it was marked as high (= 1); if it was below average, it was marked as low (= 0). These values were used as dependent variables for the chi-square test and binary logistic regression analysis. The second factor had 9331 participant records because its component item (9) “avoided working outside your home,” was not relevant to unemployed participants. Therefore, the item did not apply to them.

We generated the variable of SD level and merged the corresponding SD level into each response in accordance with the date and region of respondents. NGM5 was enforced on December 23, 2020 in the capital area. Subsequently, it was extended to non-capital areas on January 4, 2021. The NGM5 variable was coded into a binary response. Information on SD level adjustment and the commencement date of NGM5 was gathered from the webpage of the KDCA [22]. A variable named “region” was provided in the format of province names and re-categorized into 2 categories—the capital area (i.e., Seoul Metropolitan City, Gyeonggi Province, and Incheon Metropoli-

tan City) and non-capital areas (i.e., elsewhere)—reflecting the dichotomization used by the KDCA for SD levels.

Statistical Analysis

In order to extract dependent variables, exploratory factor analysis was conducted. The chi-square test was used to compare differences in distributions between categorical variables, while binary logistic regression was performed to identify factors associated with a high extent of compliance with NPIs. Associations were quantified using odds ratios (ORs) with 95% confidence intervals (CIs). All statistical analyses were conducted using IBM SPSS version 24.0 (IBM Corp., Armonk, NY, USA).

Ethics Statement

This study does not have an institutional review board approval number since it uses secondary data.

RESULTS

Table 1 shows the general characteristics of 13 300 participants according to the 3 preventive factors. The mean age of participants was 43.20 ± 14.26 years (range, 18 to 99). Participants included 7149 men (53.8%), 7741 full-time workers (58.2%), and 7086 residents of the capital area (53.3%). Furthermore, 4919 (37.0%) participants responded during SD stage 1, 1289 (9.7%) participants during stage 1.5, 5608 (42.2%) participants during stage 2, and 1484 (11.2%) participants during stage 2.5, while 8829 participants responded before the enactment of NGM5. All variables, except “region,” in the “avoiding meeting people” factor, showed significant differences between high and low compliance.

Table 2 summarizes the associations of the 3 preventive factors and socio-demographic characteristics with and SD policies. Among men, all 3 factors (personal hygiene, avoiding going out, and avoiding meeting people) were significantly associated with decreased compliance (I: OR, 0.66; 95% CI, 0.61 to 0.71; II: OR, 0.90; 95% CI, 0.82 to 0.98; III: OR, 0.77; 95% CI, 0.71 to 0.83). Younger age groups were significantly associated with lower compliance with maintenance of personal hygiene (50-59: OR, 0.75; 95% CI, 0.66 to 0.86; 40-49: OR, 0.77; 95% CI, 0.67 to 0.88; 30-39: OR, 0.72; 95% CI, 0.63 to 0.83, <30: OR, 0.63; 95% CI, 0.55 to 0.72), and avoiding meeting people (50-59: OR, 0.88; 95% CI, 0.77 to 1.00; 30-39: OR, 0.85; 95% CI, 0.75 to 0.97, <30: OR, 0.68; 95% CI, 0.59 to 0.77). However, compliance with avoiding going out was significantly more common

Table 1. Distribution of socio-demographic characteristics and SD policies according to compliance with preventive measures

Characteristics	(I) Personal hygiene				(II) Avoiding going out				(III) Avoiding meeting other people			
	Total (n = 13 300)	High (n = 8072)	Low (n = 5228)	p-value	Total (n = 9333)	High (n = 5082)	Low (n = 4251)	p-value	Total (n = 13 300)	High (n = 7656)	Low (n = 5644)	p-value
Gender												
Women	6151	4046 (65.8)	2105 (34.2)	<0.001	3762	2153 (57.2)	1609 (42.8)	<0.001	6151	3764 (61.2)	2387 (38.8)	<0.001
Men	7149	4026 (56.3)	3123 (43.7)		5571	2929 (52.6)	2642 (47.4)		7149	3892 (54.4)	3257 (45.6)	
Age (y)												
≥ 60	1926	1283 (66.6)	643 (33.4)	<0.001	1129	619 (54.8)	510 (45.2)	<0.001	1926	1187 (61.6)	739 (38.4)	<0.001
50-59	2806	1699 (60.5)	1107 (39.5)		2160	1110 (51.4)	1050 (48.6)		2806	1659 (59.1)	1147 (40.9)	
40-49	2981	1827 (61.3)	1154 (38.7)		2322	1218 (52.5)	1104 (47.5)		2981	1766 (59.2)	1215 (40.8)	
30-39	2727	1633 (59.9)	1094 (40.1)		2221	1229 (55.3)	992 (44.7)		2727	1581 (58.0)	1146 (42.0)	
<30	2860	1630 (57.0)	1230 (43.0)		1501	906 (60.4)	595 (39.6)		2860	1463 (51.2)	1397 (48.8)	
Employment status												
Full-time	7741	4624 (59.7)	3117 (40.3)	0.023	7741	4038 (52.2)	3703 (47.8)	<0.001	7741	4423 (57.1)	3318 (42.9)	<0.001
Part-time	1592	977 (61.4)	615 (38.6)		1592	1044 (65.6)	548 (34.4)		1592	930 (58.4)	662 (41.6)	
Unemployed or not working	2067	1274 (61.6)	793 (38.4)		-	-	-		2067	1243 (60.1)	824 (39.9)	
Student	691	408 (59.0)	283 (41.0)		-	-	-		691	329 (47.6)	362 (52.4)	
Retired	644	423 (65.7)	221 (34.3)		-	-	-		644	388 (60.2)	256 (39.8)	
Region												
Non-capital areas	6214	3637 (58.5)	2577 (41.5)	<0.001	4140	2179 (52.6)	1961 (47.4)	0.002	6214	3523 (56.7)	2691 (43.3)	0.057
Capital area	7086	4435 (62.6)	2651 (37.4)		5193	2903 (55.9)	2290 (44.1)		7086	4133 (58.3)	2953 (41.7)	
SD stage												
Level 1	4919	2800 (56.9)	2119 (43.1)	<0.001	3485	1753 (50.3)	1732 (49.7)	<0.001	4919	2554 (51.9)	2365 (48.1)	<0.001
Level 1.5	1289	828 (64.2)	461 (35.8)		856	483 (56.4)	373 (43.6)		1289	772 (59.9)	517 (40.1)	
Level 2	5608	3436 (61.3)	2172 (38.7)		3907	2186 (56.0)	1721 (44.0)		5608	3369 (60.1)	2239 (39.9)	
Level 2.5	1484	1008 (67.9)	476 (32.1)		1085	660 (60.8)	425 (39.2)		1484	961 (64.8)	523 (35.2)	
NGM5												
Not enforced	8829	5175 (58.6)	3654 (41.4)	<0.001	6200	3258 (52.5)	2942 (47.5)	<0.001	8829	4890 (55.4)	3939 (44.6)	<0.001
Enforced	4471	2897 (64.8)	1574 (35.2)		3133	1824 (58.2)	1309 (41.8)		4471	2766 (61.9)	1705 (38.1)	

Values are presented as number (%).

SD, social distancing; NGM5, no gatherings of more than 5 people.

Table 2. Associations of socio-demographic characteristics and SD policies with compliance with 3 preventive measures in Korea

Characteristics	(I) Personal hygiene	p-value	(II) Avoiding going out	p-value	(III) Avoiding meeting	p-value
Gender						
Women	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Men	0.66 (0.61, 0.71)	<0.001	0.90 (0.82, 0.98)	0.012	0.77 (0.71, 0.83)	<0.001
Age (y)						
≥60	1.00 (reference)		1.00 (reference)		1.00 (reference)	
50-59	0.75 (0.66, 0.86)	<0.001	0.90 (0.78, 1.04)	0.167	0.88 (0.77, 1.00)	0.049
40-49	0.77 (0.67, 0.88)	<0.001	0.95 (0.83, 1.10)	0.521	0.90 (0.79, 1.03)	0.115
30-39	0.72 (0.63, 0.83)	<0.001	1.06 (0.92, 1.23)	0.423	0.85 (0.75, 0.97)	0.016
<30	0.63 (0.55, 0.72)	<0.001	1.20 (1.02, 1.41)	0.025	0.68 (0.59, 0.77)	<0.001
Employment status						
Full-time	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Part-time	1.01 (0.90, 1.13)	0.863	1.68 (1.49, 1.88)	<0.001	1.04 (0.93, 1.16)	0.526
Unemployed or not working	0.98 (0.88, 1.09)	0.730	-		1.08 (0.97, 1.20)	0.145
Student	1.12 (0.94, 1.34)	0.212	-		0.83 (0.70, 0.99)	0.040
Retired	1.06 (0.88, 1.27)	0.556	-		1.00 (0.84, 1.20)	0.980
Region						
Non-capital areas	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Capital area	1.20 (1.11, 1.30)	<0.001	1.14 (1.04, 1.25)	0.005	1.02 (0.95, 1.11)	0.558
SD stage						
Level 1	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Level 1.5	1.29 (1.09, 1.54)	0.003	1.23 (1.01, 1.50)	0.039	1.22 (1.03, 1.45)	0.020
Level 2	1.15 (1.05, 1.25)	0.003	1.22 (1.10, 1.35)	<0.001	1.34 (1.22, 1.46)	<0.001
Level 2.5	1.35 (1.17, 1.56)	<0.001	1.35 (1.15, 1.60)	<0.001	1.57 (1.35, 1.81)	<0.001
NGM5						
Not enforced	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Enforced	1.10 (0.99, 1.22)	0.063	1.11 (0.98, 1.24)	0.092	1.08 (0.98, 1.20)	0.123

Values are presented as odds ratio (95% confidence interval).
SD, social distancing; NGM5, no gatherings of more than 5 people.

among respondents under the age of 30 years than among those over 60 years (<30: OR, 1.20; 95% CI, 1.02 to 1.41).

Employment status was significantly associated with avoiding going out (part-time workers: OR, 1.68; 95% CI, 1.49 to 1.88) and negatively associated with avoiding meeting people (students: OR, 0.83; 95% CI, 0.70 to 0.99). In addition, residence in the capital area was significantly associated with higher compliance with personal hygiene (OR, 1.20; 95% CI, 1.11 to 1.30) and avoiding going out (OR, 1.14; 95% CI, 1.04 to 1.25).

As for the policy effects, increasing SD stages were positively associated with maintenance of personal hygiene (level 1.5: OR, 1.29; 95% CI, 1.09 to 1.54; level 2: OR, 1.15; 95% CI, 1.05 to 1.25; level 2.5: OR, 1.35; 95% CI, 1.17 to 1.56), avoiding going out (level 1.5: OR, 1.23; 95% CI, 1.01 to 1.50; level 2: OR, 1.22; 95% CI, 1.10 to 1.35; level 2.5: OR, 1.35; 95% CI, 1.15 to 1.60),

and avoiding meeting other people (level 1.5: OR, 1.22; 95% CI, 1.03 to 1.45; level 2: OR, 1.34; 95% CI, 1.22 to 1.46; level 2.5: OR, 1.57; 95% CI, 1.35 to 1.81), respectively. However, the NGM5 policy was not significantly associated with the extent of compliance with anti-infection measures pertaining to COVID-19.

Figure 1 shows forest plots for the associations of socio-demographic variables and government policies with the 3 compliance factors. The x-axis represents the OR, which is plotted on a logarithmic scale.

DISCUSSION

This study researched associations between compliance with NPI and SD policies in Korea during the COVID-19 pandemic.

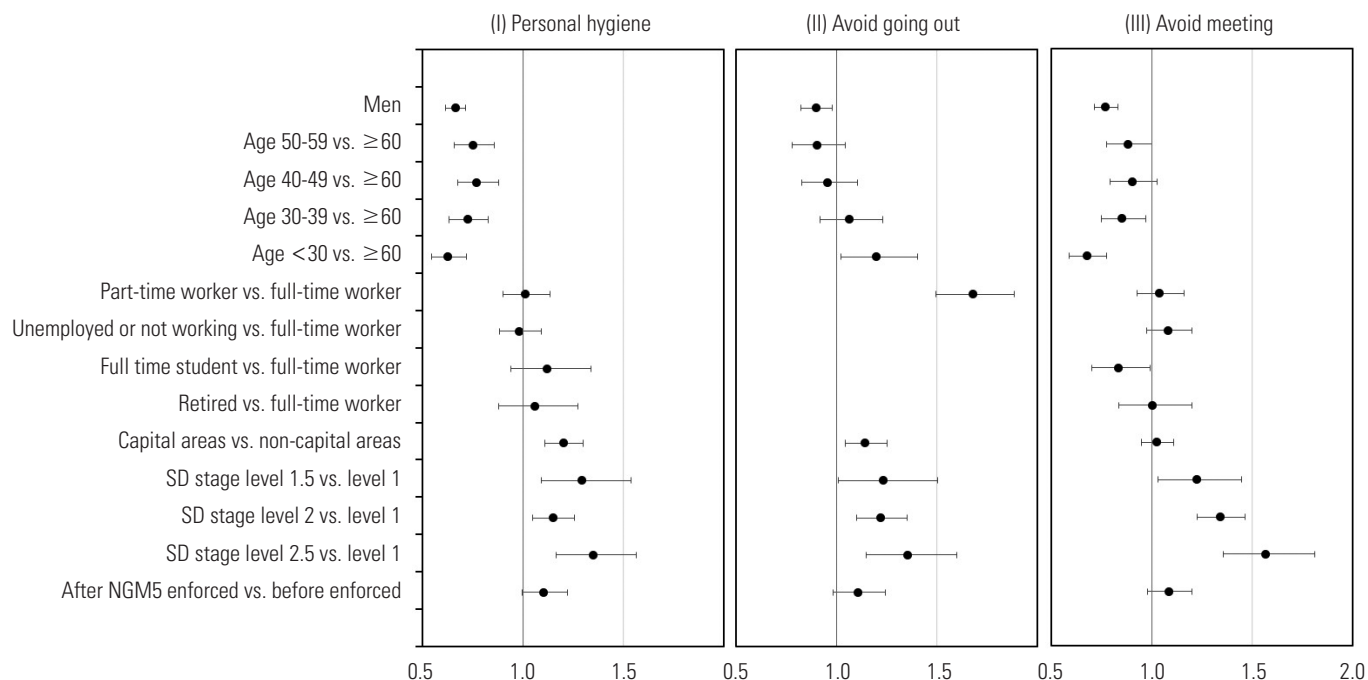


Figure 1. Forest plots showing the associations of the 3 preventive factors with socio-demographic characteristics and SD policies in Korea. SD, social distancing; NGM5, no gatherings of more than 5 people.

All 3 preventive factors—(I) maintenance of personal hygiene, (II) avoiding going out, and (III) avoiding meeting people—were associated with SD levels. The magnitude of these associations was greater in level 2.5 than in levels 1 and 1.5. In particular, the probability of compliance with avoiding meeting people was 57% higher in level 2.5 than in level 1. The reason for this may be the imposition of intensive preventive measures such as prohibiting gatherings at various facilities and limitations or restrictions of opening hours in level 2.5.

Conversely, the enactment of the NGM5 policy was not significantly associated with compliance toward preventive factors, including avoiding meeting people. This can be explained by the fact that people did not cancel gatherings to comply with the NGM5 policy. Instead, people kept gathering while complying with gathering-size guidelines (i.e., under 5 people) each time they met. This interpretation is supported by an announcement from the KDCA stating that the rate of infection from individual contacts had increased to 46% as of May 18, 2021—the highest this year [20]. Another possible explanation is that the standard of implementation in multiple-purpose facilities may not have been rigorous. The KDCA reported that mass infections occurred in bars, sports facilities, karaoke rooms, PC rooms, and public baths through contact with un-

known people.

Among the socio-demographic characteristics, men were more likely to have low compliance with respect to every preventive factor. Significantly, men participants were 34% less likely to belong to the high-compliance group for the “maintenance of personal hygiene” factor than women. The result of a previous study also revealed that young men demonstrated low compliance [23].

The youngest age group (<30 years) was 37% less likely to belong to the high-compliance group for maintenance of personal hygiene and 32% less likely for avoiding meeting, but 20% more likely for avoiding going out. These figures seem to reflect socio-cultural factors. Younger people are familiar with the online environment that enables them to telecommute and engage in contact-free living (e.g. online shopping, food delivery services via mobile applications). Consequently, they have fewer reasons to have to go out as part of their regular routines.

Part-time workers showed distinctly higher odds (68%) than full-time workers for compliance with avoiding going out, meaning that full-time workers more frequently “went out.” Therefore, strategies that help full-time workers to lessen physical contact regarding work need to be considered, including the extension of telecommuting and online meetings,

as well as adjustments of the commute time to avoid overcrowded public transportation.

In addition, students were more likely to have low compliance with avoiding meeting people than full-time workers. Therefore, as prior studies have suggested [24,25], there is a need for social movements promoting telecommuting and strengthening of the online learning system.

Living in the capital area increased participants' chances of belonging to the high-compliance group for maintenance of personal hygiene by 20%, as well as the chances of belonging to the high compliance group for avoiding going out by 14%. This might have been because the KDCA applied an enhanced level of SD in the capital area. Conversely, living in the capital area did not contribute to avoiding meeting people. Therefore, compliance with the measures included in the "avoiding meeting people" factor should be emphasized.

This study has several limitations. Since this study used secondary data, there remains the limitation of a lack of information on confounding factors (e.g., economic status, professions, religion, etc.), as well as potential issues regarding the validity of self-reported data the possibility of recall bias. Further, we assumed the survey data to be cross-sectional. However, the survey continued for a year (April 2020 to April 2021). Therefore, the model may have a limited power of explanation for causal relationships among variables and the time-varying effects of prolonged COVID-19 diffusion. Moreover, the effects of mass media on compliance rates were not fully considered. However, we tried to take account of time-varying effects by including variables such as SD stages, as well as regions where SD stages and the NGM5 policy were applied, since each SD stage corresponds to a definite standard of preventive measures.

SD levels, gender, age, employment status, and region had explanatory power for compliance with NPIs. Strengthening SD campaigns to inspire the public to voluntarily comply with NPIs, with a particular focus on younger, full-time men workers, and residents of the capital area, is recommended. Simultaneously, efforts should be made to segment SD measures into substrategies with detailed guidance at each level.

SUPPLEMENTAL MATERIALS

Supplemental material is available at <https://doi.org/10.3961/jpmph.21.139>.

CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

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AUTHOR CONTRIBUTIONS

Conceptualization: HSJ. Data curation: YSH. Formal analysis: YSH. Funding acquisition: None. Methodology: YSH. Project administration: HSJ. Visualization: YSH. Writing – original draft: YSH. Writing – review & editing: HSJ, YSH.

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