



# The Effect of COVID-19–Related Lifestyle Changes on Depression

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**Objective** This study aimed to identify the effect of coronavirus disease (COVID-19)–related lifestyle changes on depression.

**Methods** This secondary data analysis study included 229,269 adults from a community health survey conducted in the South Korea in 2020. Data were collected using a structured questionnaire about participants' lifestyle changes related to COVID-19 and the Patient Health Questionnaire-9. The data were analyzed using a complex sample independent t-test, analysis of variance, Pearson's correlation coefficient, and multiple regression analysis.

**Results** The mean age of the participants was 48.76; 49.6% were male, and 50.4% were female. The multiple regression showed that depression increased due to COVID-19–related lifestyle changes (physical activity, sleep duration, consumption of convenience foods, alcohol consumption, smoking, and use of public transportation). The explanatory power was 27.3%, and the model was suitable (Wald  $F=63.75$ ,  $p<0.001$ ).

**Conclusion** This study identified the effect of COVID-19–related lifestyle changes on depression, and the results have implications for future depression-relieving interventions.

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**Keywords** COVID-19; Depression; Life style; Population health.

## INTRODUCTION

The coronavirus disease (COVID-19) pandemic triggered one of the most significant mental health crises of our time. To mitigate the impact of the pandemic, governments have responded with intervention strategies to contain the spread of COVID-19, including social (i.e., physical) distancing and self-isolation measures, that have had a profound impact on the activities that constitute individuals' normal lives worldwide.<sup>1</sup> These policies have affected every aspect of individuals' daily lives as well as the economic, social, environmental, and health systems that support societies' well-being.<sup>2</sup> For example, as the economic situation worsened, individuals' job security and working hours decreased. Similarly, as the opportunities for social interaction decreased, individuals' feelings of loneliness and social isolation increased.<sup>3</sup> These and other

lifestyle changes have resulted in negative mental, physical, and social effects during the pandemic response period, and may continue through the recovery period.<sup>4</sup> Studies show that COVID-19–related lifestyle changes act as stressors in the short- and long-term, with far-reaching consequences for individuals' physical and psychological well-being.<sup>5</sup> For example, the prolonged stress of the pandemic has caused many individuals to modify their eating habits and eat both unhealthier and more, with diets skewed towards fats and carbohydrates and increased caloric intake. Such changes are accompanied by future health risks, including the increased incidence of obesity and chronic diseases including diabetes and heart disease.<sup>6</sup> Other negative behaviors, such as decreased physical activity and sleep disturbances, have been exacerbated by psychological problems including panic, anxiety, depression, schizophrenia, and acute stress disorder.<sup>7-9</sup> The pressures of the pandemic and the resultant restrictions have also intensified illness anxiety disorder, anger issues, alcohol and tobacco abuse, divorce rates, and factors related to the risk of suicide.<sup>10</sup> From an epidemiological point of view, although social (i.e., physical) distancing and self-isolation measures may have been considered effective in reducing infectivity, emerging research indicates that these restrictive interventions have caused lifestyle changes associated with reduced physical ac-

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tivity and productivity; poor nutritional habits; feelings of loneliness, depression, anxiety, and stress; and panic disorder.<sup>11</sup> Such urgent problems require governments and other stakeholders develop policies to prevent, manage, and mitigate these physical and mental health impacts during both the pandemic response and recovery periods.

Among psychological problems, numerous studies have reported an increase in the prevalence of depressive symptoms during the COVID-19 pandemic. According to researchers, more than 48% of Koreans have experienced COVID-19–related symptoms of depression, and among them 52.2% were in their 50s when they experienced these symptoms.<sup>12</sup> Researchers have also reported that pandemic–related depression appears to have shown gender differences, with the greatest increases among women and young people.<sup>13</sup> To minimize the risk of a further increase in the prevalence of psychological problems among the population, policy makers and stakeholders should provide mental health services that deliver healthcare and social support to individuals who have been adversely affected by COVID-19–related depression. Studies of the effects of COVID-19 on depression in individuals are fragmentary,<sup>10</sup> and few studies have focused on the effects of COVID-19–related participant characteristics—including demographic characteristics, health status, and the degree of individuals’ lifestyle change—on depression. This study aimed to identify the degree of COVID-19–related lifestyle changes in adults and analyze the effects of these factors on depression from an integrated perspective. Our study’s findings have implications for policy strategies and medical practices that may reduce depression during future health crises.

This study’s objectives were as follows. First, we investigated the effect of COVID-19–related lifestyle changes on depression and the degree of depression. Second, we investigated the differences in depression according to the characteristics of participants and COVID-19–related lifestyle changes. Third, we analyzed the effects of participants’ characteristics and COVID-19–related lifestyle changes on depression.

## METHODS

### Research design

This secondary data analysis study identified and analyzed the effects of COVID-19–related lifestyle disruptions on depression using raw data from the Korean Community Health Survey (KCHS) conducted in 2020.

### Participants

#### Data collection

For the analysis of this study, 2020 data from the KCHS

were used. The participants were selected from 253 community health centers (CHCs) and households utilizing a systematic sampling method among adults over 19 years old. Approximately 900 people per CHC were surveyed. The total sample size surveyed for all 253 CHCs was 229,269. The Korean Disease Control and Prevention Agency completed the development and sampling of questionnaires, guidelines, and training materials for investigators. Data were collected through direct interviews using a laptop equipped using CAPI offline data collection software (IdWeb srl, Città di Castello, Italy) for computer-assisted personal interviewing. Data were collected between August 16–October 31, 2020, and data from the 229,269 participants who responded to the survey were used for the final analysis.

### Ethics statement

All survey participants provided informed consents prior to data collection. This study was a secondary analysis of the data of subjects who had participated in a community health survey. Logical errors and outliers were removed from the original data, and personal information was converted to private information in accordance with the 2011 South Korean Personal Information Protection Act (Act No. 10465). Identifiable personal information was deleted, and separated from data that are open to the public. Approval from the Institutional Review Board of Jeonbuk National University was exempted (IRB No. 2021-08-014-001).

### Measurements

#### Demographic characteristics

According to the KCHS,<sup>14</sup> demographic characteristics included age, gender, marital status, educational level, employment status, monthly household income, and receipt of South Korean National Basic Livelihood Security System benefits. The subjective health status and level of stress of participants were identified as health status. Subjective health status was measured using the question, “When you think about yourself, how do you feel about your health?” with responses ranging from 1 (very bad), 2 (bad), 3 (average), 4 (good), to 5 (very good), with higher scores indicating perceived better health. Level of stress was assessed using the question, “How much stress do you feel in your everyday life?” with responses ranging from 4 (very much), 3 (a lot), 2 (a little bit), to 1 (none at all), with higher scores indicating perceived higher levels of stress.

#### COVID-19–related lifestyle changes

In this study, we investigated lifestyle changes related to physical activity; sleep duration; consumption of convenience

foods and beverages with added sugar; food delivery; alcohol consumption and smoking; number of social meetings with family, friends, and neighbors; and use of public transportation. The answer to the question, “What level of change have you experienced in your daily routine since the COVID-19 outbreak?” measured COVID-19-related lifestyle changes in general. Answers indicating an increase, no change, or a decrease were used in our analysis.

### Depression

Depression was analyzed using the diagnostic score of the self-administered Patient Health Questionnaire-9 (PHQ-9), widely used as a symptom tracking tool to measure depression severity in individuals.<sup>15</sup> The questionnaire comprises nine items. The participants indicated the extent of their agreement or disagreement with each item, and each of the nine items was rated on a scale ranging from 0 (not at all) to 3 (nearly every day). The degree of agreement was calculated as a sum of the scores. Thus, the score can range from 0 to 27 (i.e., 27 represents the highest level of depression, and 0 represents the lowest level of depression). At the time of development and in this study, the Cronbach's coefficient alpha of the PHQ-9 was 0.84 and 0.80, respectively.

### Statistical analysis

IBM SPSS Statistics Version 21.0 (IBM Corp., Armonk, NY, USA) was used for data analysis, and the differences and relationships in depression according to participants' characteristics and COVID-19-related lifestyle changes were analyzed using an independent t-test, analysis of variance, and Pearson's correlation coefficient. Multiple regression analysis was performed to identify the factors affecting depression according to COVID-19-related lifestyle changes. Considering that the Community Health Survey data is a complex sample design, individual weights were applied to estimate the population.

## RESULTS

### Participants' characteristics

The study sample consisted of 229,269 participants. The mean age of the participants was 48.76 years, among which 49.6% were male, and 63.2% were married. The mean scores of subjective health status, level of stress, and depression severity were 3.54, 2.09, and 2.04, respectively (Table 1).

### COVID-19-related lifestyle changes

COVID-19-related lifestyle changes included a decrease in physical activity up to 52.6%; change in sleep duration 21.4%; change in consumption of convenience foods or beverages

with added sugar 35.6% and change in consumption of delivered foods 53.4%; change in alcohol consumption 52.2% and change in smoking 28.6%; number of social meetings decreased by 89.6%; and use of public transportation decreased by 63.6% (Table 1).

### Differences in depression according to participants characteristics

The differences in depression according to participants' characteristics were significantly statistically higher for females ( $t=-41.72$ ,  $p<0.001$ ); unmarried status ( $t=26.39$ ,  $p<0.001$ ); educational level below university ( $t=20.22$ ,  $p<0.001$ ); unemployed status ( $t=28.12$ ,  $p<0.001$ ); monthly income less than 3.5 million KRW ( $t=31.37$ ,  $p<0.001$ ); receipt of South Korean National Basic Livelihood Security System benefits ( $t=-27.13$ ,  $p<0.001$ ); and depression scores. Correlation analysis revealed a statistically significant positive correlation between depression and age ( $r=0.04$ ,  $p<0.001$ ) and stress ( $r=0.37$ ,  $p<0.001$ ). Additionally, subjective health status ( $r=-0.31$ ,  $p<0.001$ ) confirmed that the negative correlation was statistically significant. COVID-19-related lifestyle changes including physical activity ( $F=486.90$ ,  $p<0.001$ ); sleep duration ( $F=1203.01$ ,  $p<0.001$ ); consumption of convenience foods ( $F=402.53$ ,  $p<0.001$ ) and consumption of delivered foods ( $F=274.69$ ,  $p<0.001$ ); alcohol consumption ( $F=268.73$ ,  $p<0.001$ ) and smoking ( $F=212.66$ ,  $p<0.001$ ); number of social meetings ( $F=7.65$ ,  $p<0.001$ ); and use of public transportation ( $F=20.99$ ,  $p<0.001$ ) were significantly different from the depression score (Table 2).

### Analysis of Factors Affecting Depression

With regard to participants' characteristics, depression increased in the case of females ( $B=0.46$ ,  $p<0.001$ ); unmarried status ( $B=0.23$ ,  $p=0.002$ ); educational level below university ( $B=0.14$ ,  $p=0.028$ ); unemployed status ( $B=0.10$ ,  $p=0.004$ ); monthly income of less than 3.5 million KRW ( $B=0.26$ ,  $p<0.001$ ); receipt of South Korean National Basic Livelihood Security System benefits ( $B=0.92$ ,  $p<0.001$ ); and increased stress ( $B=1.45$ ,  $p<0.001$ ). In addition, depression decreased with age ( $B=-0.01$ ,  $p<0.001$ ) and subjective health status ( $B=-0.67$ ,  $p<0.001$ ). For lifestyle changes, depression increased with increased ( $B=0.41$ ,  $p=0.018$ ) and decreased physical activity ( $B=0.13$ ,  $p=0.029$ ); decreased sleep duration ( $B=0.59$ ,  $p<0.001$ ); increased ( $B=0.25$ ,  $p=0.009$ ) and decreased consumption of convenience foods ( $B=0.21$ ,  $p=0.040$ ); increased ( $B=1.07$ ,  $p<0.001$ ) and decreased alcohol consumption ( $B=0.26$ ,  $p<0.001$ ), and increased smoking ( $B=0.80$ ,  $p<0.001$ ). Depression decreased with smoking reduction ( $B=-0.27$ ,  $p<0.001$ ) and the use of public transportation ( $B=-0.27$ ,  $p<0.001$ ). The explanatory power was 27.3% and the model was suitable (Wald  $F=63.75$ ,  $p<0.001$ ) (Table 3).

## DISCUSSION

In this study, a decrease in physical activity; an increase in sleep duration, consumption of convenience foods, and con-

sumption of delivered foods; a decrease in alcohol consumption and smoking; a decrease in the number of social meetings; and a decrease in the use of public transportation were confirmed to be due to COVID-19-related lifestyle changes.

**Table 1.** General characteristics of participants and COVID-19 related lifestyle change (N=229,269)

		Categories	Value
General characteristic	Age (yr)		48.76±0.05
	Sex	Male	49.6
		Female	50.4
	Marital status	Married	63.2
		Unmarried	36.8
	Education	≥University	50.8
		<University	49.2
	Employment	Yes	61.9
		No	38.1
	Monthly household income (10,000 won)*	<350	48.6
≥350		51.4	
National Basic Livelihood Security recipients	Yes	3.4	
	No	96.6	
Health status	Subjective health status		3.54±0.01
	Stress score		2.09±0.01
COVID-19 related lifestyle change	Physical activity	Increase	6.0
		Same	41.3
		Decrease	52.6
	Sleep duration	Increase	12.0
		Same	78.6
		Decrease	9.4
	Consumption of convenience food	Increase	23.8
		Same	64.4
		Decrease	11.8
	Food delivery	Increase	43.6
		Same	46.6
		Decrease	9.8
	Alcohol consumption	Increase	6.9
		Same	47.8
		Decrease	45.3
	Smoking	Increase	8.9
		Same	71.4
		Decrease	19.7
	Number of social meeting	Increase	0.3
		Same	10.1
Decrease		89.6	
Use of public transportation	Increase	1.4	
	Same	34.9	
	Decrease	63.6	
Depression score		2.04±0.01	

Values are presented as the mean±standard error or weighted %. \*Korean 1,000 won: 8.57 USD. COVID-19, coronavirus disease

These findings are in accordance with those from previous studies that demonstrated that owing to the spread of COVID-19 and the effects of social (i.e., physical) distancing, individuals demonstrated a decrease in physical activity; an in-

crease in sleep duration; an increase in the consumption of convenience foods (including delivered foods); a decrease in the number of social meetings; and a decrease in the use of public transportation.<sup>16-19</sup> These lifestyle changes can have far-

**Table 2.** Depression by characteristics of participants (N=229,269)

		Categories	Mean±SE	t/F/r	p
General characteristics	Age (yr)			0.04	<0.001
	Sex	Male	1.71±0.01	-41.72	<0.001
		Female	2.36±0.01		
	Marital status	Married	1.86±0.01	26.39	<0.001
		Unmarried	2.35±0.02		
	Education	≥University	1.87±0.01	20.22	<0.001
		<University	2.21±0.01		
	Employment	Yes	1.85±0.01	28.12	<0.001
		No	2.35±0.02		
	Monthly household income (10,000 won)*	<350	2.38±0.02	31.37	<0.001
≥350		1.74±0.01			
National Basic Livelihood Security recipients	Yes	4.00±0.07	-27.13	<0.001	
	No	1.97±0.01			
Health status	Subjective health status			-0.31	<0.001
	Stress score			0.37	<0.001
COVID-19 related lifestyle change	Physical activity	Increase	1.95±0.03	486.90	<0.001
		Same	1.71±0.01		
		Decrease	2.25±0.01		
	Sleep duration	Increase	2.35±0.03	1203.01	<0.001
		Same	1.81±0.01		
		Decrease	3.59±0.04		
	Consumption of convenience food	Increase	2.55±0.03	402.53	<0.001
		Same	1.82±0.01		
		Decrease	2.10±0.03		
	Food delivery	Increase	2.25±0.02	274.69	<0.001
		Same	1.76±0.01		
		Decrease	2.03±0.03		
	Alcohol consumption	Increase	3.15±0.06	268.73	<0.001
		Same	1.82±0.01		
		Decrease	1.91±0.02		
	Smoking	Increase	3.74±0.09	212.66	<0.001
		Same	1.93±0.02		
		Decrease	1.90±0.04		
	Number of social meeting	Increase	2.73±0.20	7.65	<0.001
		Same	2.02±0.03		
Decrease		1.99±0.01			
Use of public transportation	Increase	2.85±0.11	20.99	<0.001	
	Same	2.14±0.02			
	Decrease	2.10±0.02			

\*Korean 1,000 won: 8.57 USD. SE, standard error

**Table 3.** The influencing factors on depression

		Categories	B	SE	t	p
General characteristics	Age (yr)		-0.01	0.002	-4.89	<0.001
	Sex	Male	0.00		9.62	<0.001
		Female	0.46	0.048		
	Marital status	Married	0.00		3.17	0.002
		Unmarried	0.23	0.073		
	Education	≥University	0.00		2.20	0.028
		<University	0.14	0.063		
	Employment	Yes	0.00		2.89	0.004
		No	0.10	0.035		
	Monthly household income (10,000 won)*	<350	0.26	0.066	3.88	<0.001
≥350		0.00				
National Basic Livelihood Security recipients	Yes	0.92	0.189	4.84	<0.001	
	No	0.00				
Health status	Subjective health status		-0.67	0.044	-15.23	<0.001
	Stress score		1.45	0.048	30.45	<0.001
Daily life changes	Physical activity	Increase	0.41	0.173	2.37	0.018
		Same	0.00			
		Decrease	0.13	0.059	2.18	0.029
	Sleep duration	Increase	0.08	0.100	0.83	0.405
		Same	0.00			
		Decrease	0.59	0.143	4.12	<0.001
	Consumption of convenience food	Increase	0.25	0.094	2.62	0.009
		Same	0.00			
		Decrease	0.21	0.105	2.05	0.040
	Food delivery	Increase	0.04	0.082	0.48	0.632
		Same	0.00			
		Decrease	0.10	0.125	0.82	0.410
	Alcohol consumption	Increase	1.07	0.201	5.32	<0.001
		Same	0.00			
		Decrease	0.26	0.065	3.98	<0.001
	Smoking	Increase	0.80	0.172	4.62	<0.001
		Same	0.00			
		Decrease	-0.27	0.071	-3.75	<0.001
Number of social meeting	Increase	0.73	0.549	1.33	0.184	
	Same	0.00				
	Decrease	0.07	0.081	0.83	0.405	
Use of public transportation	Increase	0.16	0.281	0.58	0.563	
	Same	0.00				
	Decrease	-0.27	0.065	-4.24	<0.001	

R<sup>2</sup>=0.273, Wald F=63.75, p<0.001

\*Korean 1,000 won: 8.57 USD. SE, standard error

reaching consequences for individuals' physical and psychological well-being. For example, researchers have confirmed that obesity and metabolic diseases have increased during the pandemic due to the implementation of restrictive distancing measures to contain the spread of COVID-19.<sup>6</sup> It will be vital for the mental and physical health of the population to maintain healthy lifestyles and effective social relationships throughout the COVID-19 pandemic response and recovery periods.

To facilitate the maintenance of a healthy lifestyle in the current non-face-to-face environment, the healthcare and wellness industries have made considerable advances in the development of e-health programs and in the field of wearable technologies designed to help users maintain healthy habits such as increasing their levels of physical activity,<sup>20</sup> boosting their immune systems, and following balanced diets.<sup>21</sup> Hence, we suggest that governments and other stakeholders develop policies and programs that promote and support healthy lifestyles during both the pandemic response and recovery periods.

In this study, we confirmed the depression score of the participants of 2.04 points. This finding was slightly higher than those from previous study that found the depression score of Korean adults of 1.36 points.<sup>22</sup> By referring to the study of Bae et al.,<sup>22</sup> which was conducted before the onset of the COVID-19 outbreak, we can indirectly confirm that COVID-19 is a risk factor for increased depression. Hence, we suggest that governments and other stakeholders develop policies to assess, manage, and monitor the mental health impacts of depression during both the pandemic response and recovery periods.<sup>12</sup>

This study investigated the factors affecting depression by examining indicators such as participant characteristics and COVID-19-related lifestyle changes. We found that depression was higher in females; unmarried adults; individuals with low educational levels and low household income; and recipients of the South Korean national public assistance and social insurance program. These findings are in accordance with those of previous study that found a relationship between low socioeconomic status and high levels of depression.<sup>18</sup> Researchers have also posited that there is an underlying relationship between gender and the impact of the COVID-19 pandemic on mental health. Studies have found that women reported worse symptoms of depression after the onset of the COVID-19 outbreak, appear to have been worse affected by the consequences of the pandemic, were more sensitive to psychological influences, experienced higher levels of stress, and had increased levels of depression.<sup>23</sup> In the response and recovery to future infectious disease crises, we suggest that governments and other stakeholders address existing health inequalities and develop and implement targeted healthcare

services for women. For women and other vulnerable or marginalized populations, new technologies such as mobile health—the practice of medicine and public health supported by mobile devices—offer novel possibilities for the accessible and efficient delivery of healthcare. We suggest that governments and stakeholders actively propose policies for the institutional support of these initiatives.<sup>24</sup>

In this study confirmed that subjective health status and stress affect depression. A previous study reported that subjective health status significantly affected depression,<sup>25</sup> and we argue that this requires further investigation of the relationship between subjective health status and depression in various environments. Additionally, a significant number of participants reported high levels of stress during COVID-19, which affects depression.<sup>26</sup> Advanced mobile health programs and wearable healthcare technologies, such as trackers and sensors, can support individuals' self-efficacy and facilitate the monitoring of their emotional state. We suggest that governments and other stakeholders support advances in mobile health programs and technologies that can provide accessible and efficient delivery of healthcare.

In this study, the effecting factors of COVID-19-related lifestyle changes on depression included physical activity; sleep duration; consumption of convenience foods; alcohol consumption; smoking; and the use of public transportation. Regarding physical activity in the context of the COVID-19 pandemic response period, depression increased in groups with both increased and decreased physical activity. The results of this study related to physical activities can be viewed as unique to the special infectious disease situation of the COVID-19 pandemic. We suggest that governments develop policies and specific guidelines to mitigate the lack of physical activity resulting from restrictive social (i.e., physical) distancing measures implemented to contain the spread of COVID-19.<sup>11</sup> The limited social and physical environment of a fitness center is likely to have a negative psychological effect on users,<sup>27</sup> with increased risk of infection in such a confined space during physical activity. This study's findings of an increase in depression with increased physical activity is in accordance with those of a Japanese study which demonstrated that certain types of physical activity, such as manual labor and competitive sports activities, may have a negative effect on mental health.<sup>28</sup> The establishment and enforcement of restrictive social (i.e., physical) distancing rules to contain the spread of COVID-19 can be seen as a factor that further increases symptoms of depression in individuals,<sup>11</sup> in contrast to findings that inactive individuals with decreased physical activity who did not increase their daily physical activity experienced increased symptoms of depression. Further research is needed to determine the changes in the prevalence and severity of

depression according to the increase or decrease in physical activity level and type.

COVID-19 has had a significant impact on a person's general sleep dysfunctions, and the prevalence of sleep disorders increased when governments responded to the pandemic with restrictive societal interventions—known as lockdowns—to mitigate the impact of the crisis and contain the spread of COVID-19. Researchers have posited that COVID-19–related lifestyle disruptions are potential factors for sleep disturbances.<sup>29</sup> Studies have shown the decrease of individuals' sleep duration results in the increase of the overall feeling of fatigue, which increases the symptoms of depression. We suggest that healthcare providers conduct environmental education by assessing, monitoring, and managing individuals' sleep processes and habits to prevent and mitigate sleep dysfunctions during future health crises.

Our study found that both an increase and decrease in consumption of convenience foods demonstrated an effect on depression—the symptoms of depression further increased when the consumption of convenience foods increased. This can be considered another result of the COVID-19 pandemic—increased consumption of convenience foods may increase depression, as social norms reinforce the perception that the consumption of these foods is unhealthy. Conversely, it is thought that depression has increased because of the possibility of exposure to infectious diseases in restaurants rather than the consumption of convenience foods indoors in the COVID-19 pandemic response and recovery period.

We found that both increased and decreased consumption of alcohol had an effect on depression—an increase in alcohol consumption resulted in an increase in depression. These findings are in accordance with those of a previous study,<sup>30</sup> which reported that depression increases in the high-risk drinking group (i.e., individuals who consume alcoholic beverages almost every day). Conversely, other researchers have posited that depression increases when alcohol intake is insufficient,<sup>31</sup> as a causal relationship has not been confirmed, we argue that this area requires further investigation. Generally, medical experts argue that alcohol can exacerbate symptoms of depression, and thus recommend that depression management strategies focus on alcohol consumption management.

In this study, both an increase and decrease in smoking had an effect on depression—an increase in smoking resulted in a further increase in depression. We posit that reduced smoking may also reduce the incidence of depression. These findings are in accordance with those of previous studies<sup>30</sup> which demonstrated that current smoking is a risk factor for depression, and that current smoking status and increased smoking further increase depression. There is also a study result of smoking as a means to cope with these feelings of stress or

depression.<sup>32</sup> Hence, we argue that further investigation of the causal relationship between depression and the increase or decrease in smoking is necessary.

In the present study, a decrease in the use of public transportation resulted in a decrease in depression. These findings are in accordance with those of a previous study,<sup>33</sup> which demonstrated that when the use of public transportation decreased, contact with nearby people decreased thereby lowering the risk of infection, and depression could be reduced by this reduction in the possibility of infection. As an alternative to public transportation, active movement (e.g., walking and cycling) may result in a range of societal benefits including increased social (i.e., physical distancing) and the resultant reduction in the risk of infection.<sup>33</sup> We suggest that governments and stakeholders study the relationship between public transportation and depression, and develop and promote policies for active movement.

The limitations of this study are as follows. We identified respondents about COVID-19–related lifestyle changes. The answer to the question, “What level of change have you experienced in your daily routine since the COVID-19 outbreak?” measured COVID-19–related lifestyle changes in general. The respondents indicated an increase, no change, or a decrease, and we used these answers in our analysis. In future studies, researchers should use a structured questionnaire about specific health-related lifestyles. Nevertheless, this study is meaningful because it identified overall COVID-19–related lifestyle changes, depression, and influencing factors through a large-scale data analysis.

Based on the results of this study, according to the changes in daily life due to COVID-19–related lifestyle changes, government policy makers and other stakeholders will require a multidisciplinary approach and strategy to promote individuals' healthy lifestyle and depression reduction. Additionally, we suggest that healthcare providers implement and monitor these strategies to ultimately create a healthier environment for our society.

The results of our analysis revealed that COVID-19–related infection control and safety intervention strategies caused lifestyle changes and depression. Based on the results of this study, we suggest that governments and other stakeholders develop and implement improved response and recovery social support and related public healthcare policy initiatives to manage and mitigate lifestyle changes and other factors that affect depression in future health crises. We suggest that government policymakers and other stakeholders contribute to these initiatives by developing strategies and support measures to reduce depression, for example, by developing a customized manual that considers various demographic and sociological characteristics.



## Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

## Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

## Author Contributions

Conceptualization: all authors. Data curation: Eun Gyeong Kim, Ju-Hee Nho. Formal analysis: Eun Gyeong Kim, Ju-Hee Nho. Investigation: Eun Gyeong Kim, Ju-Hee Nho. Methodology: all authors. Project administration: Eun Gyeong Kim. Visualization: all authors. Writing—original draft: all authors. Writing—review & editing: all authors.

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