Predicting PM2.5 reduction behavior among college students: The role of beliefs and descriptive norms

Seona Park, Hyun Suk Kim and Sun-Jin Yun

*Department of Environmental Planning, Graduate School of Environmental Studies, Seoul, Republic of Korea; †Department of Communication, College of Social Sciences, Seoul National University, Seoul, Republic of Korea

Understanding how psychological factors affect individual intentions is essential to designing a better communication campaign that promotes sustainable transport. This empirical study investigates the roles of beliefs and descriptive norms on behavior that would reduce particulate matter (PM2.5). We proposed public bikeshare usage as a way college students could help reduce PM 2.5 and analyzed cognitive factors affecting public bikeshare usage intentions through partial least squares structural equation modeling (PLS-SEM). The analysis results show that attitude, self-efficacy, and descriptive norms had a significant effect on behavioral intention; among these, descriptive norms had the greatest effect. Beliefs about personal benefits also had a positive effect on attitudes and descriptive norms; in contrast, beliefs about social benefits did not have a significant effect. Based on the findings, we suggest foregrounding the personal benefits and making effective normative appeals to overcome the difficulty of following the practice.

1. Introduction

Particulate matter (PM2.5) is a carcinogenic air pollutant that has recently emerged on the critical environmental agenda in Asia (Shi et al., 2017, 2019). PM2.5 has been a major social and environmental concern in South Korea since 2013 (Y. Kim et al., 2015). According to a 2018 national survey, 92.3% of Koreans thought the density of PM2.5 had increased significantly during the previous 10 years, and 94.7% thought the damage from PM2.5 was more severe in Korea than in other advanced countries (Joo et al., 2018). According to the annual national environmental awareness survey, PM2.5 has been the most severe environmental issue since 2018, moving ahead of natural resource depletion and garbage problems (Jeon et al., 2020).

As PM2.5 became an urgent issue in Asian countries, legal and civic approaches followed. Following people’s worries about PM2.5, the South Korean national legislature enacted a special law on reducing and managing PM2.5 and established the Special Countermeasures Committee on PM2.5, a public–private joint review board. Subsequently, the Framework Act on Disaster Safety Management was amended to include PM2.5 as a social disaster in March 2019. In addition to these policy responses, civic practices to reduce PM2.5 were emphasized. In South Korea, most local governments, including the Seoul metropolitan government, suggest cycling in the city as a primary effort to reduce PM2.5.

Sociopsychological approaches have also been used to predict individuals’ PM2.5 reduction behavior in China, which is geographically adjacent to the Korean peninsula (Shi et al., 2017, 2019; Xu et al., 2020). However, there has been a continuing gap between individuals’ perceptions and their behavior. Previous studies asked respondents about their general intention to reduce PM2.5 (Ru et al., 2019; Shi et al., 2017; Xu et al., 2020) or about multiple actions such as using public transport; reducing heat; and having less barbecue, fireworks, and smoking (Shi et al., 2019). This led to inconsistency between intention and behavior (Xu et al., 2020) and to overestimating the impact of moral norms (Ru et al., 2019). To get more practical and effective results, researchers should both reflect and create public demand for action (Cox, 2013). It is crucial to select actions that are easy to perform and to identify target groups (Steg & Vlek, 2009). Actions and messages used in communication campaigns should consider the social context (Hornik & Yanovitzky, 2003) in order to translate the public’s passive support for clean air into an active demand for action.

In the context of South Korea, using public bikeshare can be a promising communication campaign.
message against PM2.5. Riding a bike is already well-known as a sustainable means of transportation that allows citizens to reduce air pollutants and greenhouse gases every day (UNEP, 2020). The difficulty in explaining riding intention, however, arises from the physical environment and conditions around each individual (Passafaro et al., 2014). In other words, riding a bike itself is less accessible than indoor ecofriendly behaviors. Using a public bikeshare system is one way to overcome one of the barriers to cycling. While types of public bicycles vary by cities, Seoul’s public bicycle, Ttareungi, is characterized by low usage fees and flexible use. Citizens can purchase a pass for 0.80 USD for an hour or for 26.60 USD for an hour of riding every day for a year. Anyone can borrow and return anywhere and there is no need to worry about the start and end points of the trip. Prior research about citizen participation on reducing PM2.5 has already suggested riding Ttareungi as a visible behavior (Park, 2018).

This study pays attention to college students as a targeted group. Undergraduate students are open to sustainable efforts because they are forming their own beliefs (Whitley et al., 2018). College students start to act green in their everyday lives and project their attitudes and values into their future careers (Ma et al., 2020). What people learn and think in college is more influential than formal education during middle and secondary school (Hsu, 2009). Universities are required to be socially responsible, so they are paying more and more attention to educating individuals about sustainability (Meyer, 2016). Meanwhile, targeting college students is not very biased within the national context. First, the results can substantially cover Ttareungi users because more than half of such users are in their 20s. Second, 71.5% of students who graduate from high school enter college in Korea (Ministry of Education, 2021), so college students are a good sample for explaining people in their 20s. Therefore, we looked into the characteristics of a sample of college students.

This study explores Korean college students’ behavioral intention to ride a shared bike to reduce PM2.5. The research asks two research questions. First, how do attitudes, norms, and perceived behavioral control affect the use of a public bikeshare system to reduce PM2.5? Second, how do detailed beliefs affect theoretical cognitive factors? This study focuses on the influence of descriptive norms (how often and how many others ride public bikes) and behavioral beliefs on personal and social benefits. It explores the conditions under which a communication campaign on air pollutants can effectively function.

2. Literature review and research model

2.1. The IMBP and the role of descriptive norm

The integrative model of behavioral prediction (IMBP; Fishbein & Ajzen, 2010) is a theoretical framework that explains individual behavioral intentions. According to IMBP, attitude toward the behavior, perceived norms, and perceived behavioral control (self-efficacy) are the factors that best explain individual behavioral intentions (Fishbein & Cappella, 2006). The relative importance of these three psychological constructs varies with the behavior and the subjects. A reasoned-action approach has been implemented in previous studies on intention to reduce PM2.5 (Xu et al., 2020), predicting behavior against PM2.5 (Yang & Wu, 2021), and riding a bicycle to reduce PM2.5 (Shi et al., 2019).

2.1.1. Attitude and beliefs

Attitude, behavioral beliefs, and behavioral intention are theoretical constructs used to predict behavior. They are distinct constructs and impact each other in a B-A-I hierarchy (Ajzen, 1991). Attitude is one’s positive or negative evaluation of a recommended behavior; attitudes are determined by one’s accessible behavioral beliefs. Behavioral beliefs refer to the perceived positive or negative consequences of engaging in a behavior and people’s evaluation of these beliefs. Behavioral intention is considered an independent variable since persuasive communication matters voluntary actions and actions derive from behavioral intention. The intention is defined as the readiness of a person to act on recommended behavior (O’Keefe, 2016: 98–100). Based on the strong theoretical background, the following hypothesis is posited:

H1: Students’ attitude toward PM2.5 reduction behavior is positively related to their intention to engage in PM2.5 reduction behavior.

A belief list that fits with the interested behavior should be established to measure behavioral belief because presumably only a few of the possible behavioral beliefs influence attitudes. Behavioral beliefs pay attention to the expected consequence, which could be either private or social (Ajzen, 2015). For example, a behavioral consequence may be good for the environment but not always good for oneself. The differences among beliefs can be measured at the belief level layer.
(Y. D. Kim et al., 2021). It is necessary to specify types of beliefs into research, depending on the research design. Here we establish two subscales of personal and social beliefs, depending on the specific benefit types from bikesharing, and posit the following hypotheses:

**H2a**: Students’ personal beliefs about PM2.5 reduction behavior are positively related to their attitude toward PM2.5 reduction behavior.

**H2b**: Students’ social beliefs about PM2.5 reduction behavior are positively related to their attitude toward PM2.5 reduction behavior.

### 2.1.2. Perceived norms

**Perceived norms** or **subjective norms** refer to “perceived social pressure to perform or not to perform a given behavior” (Fishbein & Ajzen, 2010, 130p). The focus theory of normative conduct categorizes perceived norms into injunctive norms and descriptive norms (R. Cialdini, 2012; Cialdini et al., 1991; Fishbein & Ajzen, 2010, 151p; Hagger & Chatzisarantis, 2005). **Injunctive norms**, which are generally defined as imposing responsibility toward a thing approved in a culture, consider whether people who are important to me can say “should” to me. **Descriptive norms** (DN) are information about the typical behavior in a certain culture. In other words, DN are an individual’s perception of the number of people who are engaged in a certain behavior (R. B. Cialdini, 2003; Cialdini et al., 1991). Injunctive norms are based on an understanding of the ethical rules of the society, while descriptive norms are only based on perceptions of other people’s actual behavior.

Some prior research on reducing PM2.5 behavior has shown that subjective norms have the largest effect on behavioral intention (Shi et al., 2019; Xu et al., 2020), but those works did not distinguish descriptive norms from injunctive norms. Descriptive norms attract attention in environmental message development because they can directly affect behavioral intention without interfering with the process of message evaluation (Cialdini et al., 2006; Griskevicius et al., 2008; Hain, 2014; Nolan et al., 2008). Descriptive norms on reducing PM2.5 are empirically separate from social norms and moral norms and have a significant effect on behavioral intention. Moreover, specific perception can be the antecedent variable not only for attitude but also for social norms (Xu et al., 2020). This evidence leads to these hypotheses:

**H3**: Students’ descriptive norms about PM2.5 reduction behavior are positively related to their attitude toward PM2.5 reduction behavior.

**H4a**: Students’ personal beliefs about PM2.5 reduction behavior are positively related to their attitude toward PM2.5 reduction behavior.

**H4b**: Students’ social beliefs about PM2.5 reduction behavior are positively related to their attitude toward PM2.5 reduction behavior.

### 2.1.3. Perceived behavioral control

Last, perceived behavioral control (PBC) or self-efficacy is how difficult it is to engage in actual behavior. This ease or difficulty assessment is a vital determinant of an actor’s decision to engage in a given behavior (Ajzen, 1991; Fishbein & Ajzen, 2010). PBC does not directly result in behavioral intention, but it can be used as a moderator or considered a condition of behavioral intention. The importance of PBC may vary with the subject of behavioral intention in the analysis. Because this research measures the PBC of public bicycling, it is important to investigate relevant factors, such as previous behavior, sex, and age, along with the direct measure of PBC. For example, perceptions of road safety affect perceived behavioral control and behavioral intention to ride bicycles in a city (Fishman et al., 2012; Passafaro et al., 2014; Yu et al., 2018). Therefore, we hypothesize:

**H5**: Students’ perceived behavioral control over PM2.5 reduction behavior is positively related to their attitude toward PM2.5 reduction behavior.

### 2.2 Sharing a bike as a pro-environmental behavior

Bikeshare has penetrated across the globe, generation by generation, since it began in Amsterdam in 1965 (Shaheen et al., 2010). Seoul’s public bicycle system started in 2015, although it was not the first one introduced in Korea. Several times, it has been voted as Seoul’s best policy in annual public surveys conducted by the Seoul government. As of 31 January 2021, there were 2,154 rental sites and 2.78 million members; the usage in 2020 was 23 million, which is twice as large as the Seoul population (Seoul-Metropolitan-city, 2021). Seoul public bicycles use a docked bikesharing service. Users are able to know the location of nearby bicycle kiosks and the number of available bicycles, and they are able to rent and return one wherever they want through a radio-frequency identification (RFID) card or a quick response (QR) code. Seoul is gradually improving the inherent problem of sharing services by
redistributing the bicycles according to daily demand, analyzing the accumulated data, repairing old bicycles, and managing old bicycles based on voluntary trouble reports from users.

Bicycle commuting is healthy but dangerous, so various factors can affect bicycle riding behavioral intention (Fishman et al., 2012; Passafaro et al., 2014). Perceived physical and environmental factors—such as perceived evaluative factors in IMBP, traffic safety, crime safety, street connectivity, and street aesthetics—can affect bicycle riding intention. In particular, previous behavior can affect attitude, perceived behavioral control, behavioral intention, and behavior (Zhang et al., 2019). This evaluative and physical influence applies to public bicycles as well. Using a public bicycle is cheaper than purchasing one, but the sign-up process is a barrier, as is the facility problem, such as docking station locations (Fishman et al., 2012). Regional context should be well understood before measuring the behavioral intention of public bicycle riding in places where a facility is installed.

Studies for developing persuasive messages using descriptive norms (i.e., what is done) have drawn special attention in the field of designing environmental protection messaging (R. B. Cialdini, 2003; Cialdini et al., 2006). Gao et al. (2017) identified the effectiveness of descriptive norms at inducing energy-saving behavior. However, the effect of descriptive norms on public cycling is not well understood. According to one qualitative study (Fishman et al., 2012), the best way to promote public bicycles is to show other people using them. This practical effect of descriptive norms may result from the fact that descriptive norms increase self-efficacy. The study samples in this research were taken from an age group that can easily ride bicycles so it could more accurately assess whether the descriptive norm did influence public bicycle usage.

Descriptive norms address whether one expects other people to engage in a specific behavior. If the other people are ones I trust and tend to comply with, their influence is strengthened. Said differently, the reference group is important and may affect the resulting descriptive norm (Mertens & Schultz, 2021). Parents, teachers (professors), and friends were used in previous bicycle recommendation research (Passafaro et al., 2014).

2.3. Research model

We adopted the IMBP as a theoretical framework for our empirical investigation of Korean undergraduate students’ intention to PM2.5 reduction behavior. It is imperative that research figure out which factor leads to improvement based on the exact understanding of the case. Therefore, one must investigate detailed behavioral beliefs among the IM BP factors and contemplate other factors that are likely to have an influence. Focus group interviews were conducted, and target behavior and related beliefs were set through a participatory workshop.

Based on the literature review, we hypothesize that the main determinants of the IMBP (attitudes, descriptive norms, and perceived behavioral control) would have a positive effect on behavioral intention to use a public bikeshare system.

Next, we hypothesize that beliefs related to the advantages of public bicycle riding would have a positive effect on attitudes and descriptive norms. These beliefs are divided into two categories: what benefits society and what benefits the individual. We predict that both kinds of beliefs will affect behavioral intention through attitudes and descriptive norms.

This model is presented in Figure 1. This model is useful in an intervention design because it allows us to understand not only the role of the three cognitive factors based on the reasoned action theories but also the role of beliefs, which are antecedents of the three cognitive factors.

3. Method

3.1. Pilot study

IMBP research on message intervention follows the process of defining the behavior concisely, defining the population, developing measures, eliciting survey responses, conducting a pilot study, and measuring other idiosyncratic factors (Fishbein & Ajzen, 2010, p. 449). We conducted a workshop on young people’s perceptions and understanding of PM to choose which of the available actions to reduce PM would be used as the pilot study (Park, 2018). In the workshop preparation phase, various problems related to PM reduction behavior were identified through group interviews with 25 undergraduate students. In the workshop phase, eight undergraduate students and graduate students in the Seoul metropolitan area were invited (M = 25 years old, SD = 4.2). Workshop participants were provided various information about PM2.5 and reduction methods during four sessions. They determined through discussion that Seoul’s public bicycle policy was the most appealing of the PM2.5 reduction methods.

Based on this, we set riding a Seoul public bike as the recommended behavior. The workshop result was able to be used for the basic material on attitude, descriptive norms, and behavioral intention because discussion of PM2.5 and public bicycles was abundant. The survey questionnaires were prepared based on the result of the workshop. These are summarized in Figure 2.
3.2. Measurement

For each variable’s measurement items, we used the standard questionnaire that Fishbein and Ajzen suggested (Fishbein & Ajzen, 2010: 449). Attitude items directly measured positive or negative evaluation of riding a public bike with four bipolar options (good–bad, unpleasant–pleasant, harmful–beneficial, interesting–boring). To measure descriptive norms, we used three items with three different referents: Seoul citizens, my close friends, and someone like me. To measure perceived behavioral control, we used two items. To measure behavioral intention, we used three items.

For behavioral beliefs, which we assumed operate as preceding factors, a list of six potential outcomes was presented to assess students’ beliefs about the consequences of riding a public bike. Among the six behavioral beliefs, three were about personal consequences (time saving, physical fitness, effective workout) and three were about social or ecological consequences (ease traffic congestion, improve the natural environment, reduce PM2.5). All items used a 7-point Likert scale. Last, we asked for demographic information about experience with riding a public bike; experience of having seen a shared bike; and gender, grade, and academic major to control the results (Appendix A). The appropriateness and comprehensibility of the questionnaire were reviewed by 12
graduate students who were majoring in environmental studies, and the translation of the questionnaire was double-checked by a native English-speaking communication researcher. The full list of questions is reported in Appendix A.

### 3.2. Sample and procedure

Using GPower 3.1, we conducted a sample size estimation considering a medium effect size = .15 with an alpha = .05, power = .95, and $p = .05$. The minimum sample size was calculated as $N = 119$ to execute $F$ tests for linear multiple regression of one partial least squares structural equation modeling (PLS-SEM) model. A total of 250 students were recruited on one Korean university campus to participate in a paper-and-pencil questionnaire about public bikes as pro-environmental behavior. The recruitment process was followed by a preapproved IRB process. We randomly selected 30 classes that had more than 10 students to conduct the survey, with permission from the instructors. Students voluntarily participated in the survey. All 250 students participated in the survey and there was no missing data.

The survey questions were the same, but four different explanatory messages were randomly provided to the participants as the manipulation to create variance (O’Keefe, 2003). The four messages were based on established facts. The first message only included the contents of Seoul’s official public bicycle webpage. The second message added a news article stating that people should use public bicycles because they could reduce PM2.5. The number of people using public bicycles was added in the third message. Finally, the fourth message included an examplar (Zillmann, 2006) of a worker using a public bicycle.

Among the 250 participants, 141 were men and 109 were women; the grade level was evenly distributed. The four different messages were evenly distributed as well. Twenty-two participants had never seen a public bicycle, but 91.2% of participants had experienced public bicycles at least indirectly. Twenty-five participants had purchased a season ticket; 79 participants had purchased a one-time ticket, and 145 participants had not ridden the public bicycle (see Table 1).

The standard deviations of the measured constructs were between 0.998 and 1.622, which is relatively small on a 7-point scale. The average of all measured constructs was 5.11, which reflects the participants’ tendency to give a high score. Most of the constructs correlated with each other, but the correlation between strength of social belief (SB) and other constructs was relatively low (see Table 2).

| Measure         | Items | N   | %   |
|-----------------|-------|-----|-----|
| Gender          | male  | 141 | 56.4%|
|                 | female | 109 | 43.6%|
| Grade           | 1st   | 54  | 21.6%|
|                 | 2nd   | 53  | 21.2%|
|                 | 3rd   | 49  | 19.6%|
|                 | 4th   | 65  | 26.0%|
|                 | Over the 4th | 29 | 11.6%|
| Having seen a public bike | Yes | 228 | 91.2%|
|                 | No    | 22  | 8.8% |
| Having ridden a public bike | Season ticket* | 26 | 10.4%|
|                 | One-time ticket | 79 | 31.6%|
|                 | None  | 145 | 58.0%|
| Message treatment | No Message | 60 | 24.0%|
|                 | Message 1 | 60 | 24.0%|
|                 | Message 2 | 71  | 28.4%|
|                 | Message 3 | 59  | 23.6%|
| Total           |       | 250 | 100.0%|

Note: * Season ticket: 7-day, 30-day, 180-day, 365-day pass

| Table 1. Demographics of study participants (N = 250) |
|---------------------------------|-------|-----|-----|
| Construct                      | M (SD)| INT | PBC | ATT | DN | PB | SB |
| INT               | 4.52(1.43) | 1   |     |     |     |    |
| PBC               | 5.88(1.08) | .393***| 1   |     |     |    |
| ATT               | 5.35(0.06) | .521**| 362**| 1   |     |    |
| DN                | 4.30(1.14) | .658**| .238**| .435**| 1  |
| PB                | 5.27(0.96) | .486**| .239**| .408**| .501**| 1  |
| SB                | 4.90(1.33) | .254**| 0.026| .188**| .299**| .387**| 1  |

Note: ** p < .01; * p < .05; N = 250. Abbreviations: INT (behavioral intention), PBC (perceived behavioral control), ATT (attitude), DN (descriptive norms), PB (strength of personal belief), SB (strength of social belief)

The homogeneity of data was investigated by conducting a $t$ test. We investigated whether the average of each construct (ATT, DN, EFF, INT, PB, SB) varied along with the sample characteristics summarized in Table 1. Riding experience had a significant and positive effect on five constructs (ATT, DN, EFF, INT, PB), but the other characteristics showed no significant effect. In short, this sample was rather homogenous, except for experience riding a public bike.

### 3.4. Data analysis

PLS-SEM was applied for the analysis. PLS can derive a model with a relatively small sample size, and it is reliable with a minimum 150–200 sample size (Garson, 2016). The hypotheses of the conceptual model were tested based on empirical data by means of structural equation modeling using partial least squares (PLS) with the support of SmartPLS 3.0 (Ringle et al., 2015). The PLS-SEM approach is recommended when the measurement model has several latent variables that are measured with fewer items than recommended in the covariance based structural equation modelling (CB-SEM) approach. Further, PLS-SEM’s ability to handle
single-item constructs without model identification problems (Hair et al., 2011) lends flexibility to data analysis.

Our structural model was relatively simple. We hypothesized that the intention to ride a public bike would be predicted by the key IMBP constructs (attitudes, PBC, and descriptive norms) and that attitude and descriptive norms would be predicted by behavioral beliefs. Past behavior (i.e. the experience of using a one-time ticket, a season ticket, or none of them) and gender were considered control variables in the PLS-SEM model, but they did not have meaningful effects on analysis results. Therefore, these variables were not added for control purposes.

The results of the path model were used to reveal important factors that influence the intention to ride a public bike. To assess the measurement model and structural model, several criteria were used:

(1) Measurement model (Outer model evaluation)
   • Internal consistency reliability: (1) Composite reliability (CR) higher than 0.70 and (2) The size of the standardized loadings > 0.70 (recommended; Hair et al., 2011)
   • Convergent validity: Average variance extracted (AVE) higher than 0.5 (Hair et al., 2011)
   • Discriminant validity: The value of the Heterotrait-Monotrait Ratio (HTMT) smaller than 0.90 (Henseler et al., 2015)

(2) Structural model (Inner model evaluation)
   • Model evaluation: R-Squared ($R^2$) values of 0.75, 0.50, or 0.25 for endogenous latent variables as substantial, moderate, and weak effects (Hair et al., 2011)
   • Predictive relevance: $Q^2 > 0$ for predictive validity (Hair et al., 2011)
   • Explanatory power: (1) $R^2$ small = 0.02, $R^2$ medium = 0.13, $R^2$ large = 0.26 (Cohen, 1992) and (2) $f^2$ (strength of each predictor variable in explaining endogenous variables): 0.02, 0.15, and 0.35 for the significant independent variables represent weak, moderate, and substantial effects (Chin, 1998)
   • Hypothesis testing: t-test values near 1.65, 1.96, and 2.58 were considered with significance levels of 0.10, 0.05, and 0.01, respectively (Hair et al., 2011)

### 4. Results

#### 4.1. Measurement model

A preliminary PLS-SEM analysis was conducted to verify the reliability and validity of the measurement models. The measurement model exhibited satisfactory internal consistency reliability, convergent validity, and discriminant validity, which are the prerequisites for assessing the study’s path model (AVE > 0.626, CR > 0.832, HTMT < .764) (see Table 3). All factor loadings of items were acceptable (higher than .7), except the first SB item (S11) ($\lambda = 0.66$) and the first DN item (D31) ($\lambda = 0.683$). Because all items in the construct variables in the conceptual model showed sufficient levels of statistical quality, no item was discarded from the later analyses.

#### 4.2. Structural model

Coefficient of determination ($R^2$), Effect size ($f^2$), and Predictive relevance (Q). This model explained 58% of the total variance in behavioral intentions, which can be interpreted as a moderate result (Hair et al., 2011). The tested models have predictive relevance because $Q^2$ was greater than 0. There is no collinearity problem among predictor variables, with all VIF values < 1.4. In the model tested, based on the observed effect size ($f^2$), DN had a substantial explanatory power on INT, and ATT and PBC had a moderate explanatory power on INT. While PB’s explanatory powers on both ATT and

### Table 3. The result of internal consistency reliability, convergent validity, and discriminant validity (max. iteration 300)

| Construct | Composite reliability | AVE | ATT | DN | INT | PBC | PB | SB |
|-----------|-----------------------|-----|-----|----|-----|-----|----|----|
| ATT       | 0.922                 | 0.747|     |    |     |     |    |    |
| DN        | 0.857                 | 0.669| 0.522|    |     |     |    |    |
| INT       | 0.956                 | 0.878| 0.577| 0.764|    |     |    |    |
| PBC       | 0.848                 | 0.739| 0.461| 0.32| 0.489|     |    |    |
| PB        | 0.832                 | 0.626| 0.43 | 0.487| 0.41| 0.318|    |    |
| SB        | 0.919                 | 0.79 | 0.214| 0.367| 0.28| 0.087| 0.416|    |

Note: Abbreviations: INT (behavioral intention), PBC (perceived behavioral control), ATT (attitude), DN (descriptive norms), PB (strength of personal belief), SB (strength of social belief)

### Table 4. The result of inner model (structural model) analysis (bootstrapping 5,000 in sample)

| Constructs | $R^2$-Squared ($R^2$) | Adj. $R^2$ | Effect size ($f^2$) | $Q^2$ predictive validity | VIF |
|------------|----------------------|------------|---------------------|--------------------------|-----|
| ATT        | 0.17                 | 0.163      | 0.062               | 0.123                    | 1.397|
| DN         | 0.26                 | 0.254      | 0.546               | 0.163                    | 1.28 |
| INT        | 0.58                 | 0.575      | 0.013 (on ATT)      | 0.498                    | 1.206|
| PBC        | 0.162 (on ATT)       | 0.231 (on DN) |                |                          | 1.183|
| PB         | 0.001 (on ATT)       | 0.017 (on DN) |                |                          | 1.183|

Note: Abbreviations: INT (behavioral intention), PBC (perceived behavioral control), ATT (attitude), DN (descriptive norms), PB (strength of personal belief), SB (strength of social belief)
Table 5. Path model results of direct effects (significance)

| Relationship (seven hypotheses) | Original sample (O) | Standard error (STDEV) | t statistics (O/STDEV) | p-value | Confidence interval |
|--------------------------------|---------------------|------------------------|------------------------|---------|---------------------|
| ATT → INT (H1)                | 0.191               | 0.188                  | 3.184                  | .001    | 0.067               | 0.3                  |
| DN → INT (H3)                | 0.542               | 0.544                  | 11.039                 | .000    | 0.447               | 0.638                |
| PBC → INT (H5)               | 0.228               | 0.23                   | 4.367                  | .000    | 0.125               | 0.333                |
| PB → ATT (H2a)               | 0.399               | 0.404                  | 4.613                  | .000    | 0.218               | 0.564                |
| SB → ATT (H2b)               | 0.031               | 0.033                  | 0.439                  | .661    | −0.102              | 0.178                |
| PB → DN (H4a)                | 0.45                | 0.453                  | 7.251                  | .000    | 0.323               | 0.567                |
| SB → DN (H4b)                | 0.121               | 0.122                  | 1.758                  | .079    | −0.015              | 0.253                |

Note: Significant relationships bolded. Abbreviations: INT (behavioral intention), PBC (perceived behavioral control), ATT (attitude), DN (descriptive norms), PB (strength of personal belief), SB (strength of social belief)

DN were moderate, SB did not show a significant effect size (see Table 4).

4.3. Path model results

Path coefficients (β) of direct effect. Among the model constructs, DN had the largest effect (β = .542, p < .001) on intention and was significant. The effects of ATT (β = .191, p = .001) and PBC (β = .228, p < .001) on INT were also significant. Path coefficients of PB on ATT (β = .399, p < .001) and PB on DN (β = .450, p < .001) were both significant. See Table 5.

Path coefficients (β) of indirect effect. There was a significant indirect effect of PB on INT (β = .244, p < .001), which was mediated by ATT (β = .076, p = .007) and DN (β = .244, p < .001) (see Table 6 and Figure 3). Table 6 provides details of the path model results, showing standardized path coefficients and confidence intervals for the latent variables that predict intention to ride a public bike.

Table 6. Path model results of indirect effects (significance)

| Relationship (seven hypotheses) | Original sample (O) | Standard error (STDEV) | t statistics (O/STDEV) | p-value | Confidence interval |
|--------------------------------|---------------------|------------------------|------------------------|---------|---------------------|
| PB → DN → INT                 | 0.244               | 0.041                  | 6.009                  | .000    | 0.166               | 0.328                |
| PB → ATT → INT                | 0.076               | 0.028                  | 2.681                  | .007    | 0.025               | 0.134                |
| PB → DN → INT                 | 0.066               | 0.038                  | 1.703                  | .089    | −0.008              | 0.144                |
| PB → ATT → INT                | 0.006               | 0.014                  | 0.415                  | .678    | −0.019              | 0.039                |

Note: Significant relationships bolded. Abbreviations: INT (behavioral intention), ATT (attitude), DN (descriptive norms), PB (strength of personal belief), SB (strength of social belief)

Thus, five of the seven hypotheses tested in our study can be considered valid for our sample. ATT, PBC, and DN explained INT at a significance level of .001. PB had significant effects on ATT and DN, and it had indirect effects on INT at a significance level of .01. SB had no significant effects on ATT, DN, and INT. In terms of indirect effects, PB had a significant effect on INT through each of DN and ATT. In contrast, SB had no significant effect on INT through either DN or ATT.

5. Discussion and implications

This study used the IMBP model to analyze the behavioral intention to use a public bikeshare to reduce PM2.5. As confirmed in many studies, DN, ATT, and PBC—the main variables of the IMBP model—were found to sufficiently explain behavioral intentions. The predictive success of descriptive norms in the context of the IMBP has considerable theoretical value.

Although other influential variables from the IMBP theory were included, DN directly explained over 50% of intention. In a meta-analysis of studies dealing with DN, its influence on INT was significantly greater among the younger group, such as children and students, including undergraduates (Rivis & Sheeran, 2003). Because this sample targeted undergraduate students, the tendency for peers to be influenced by group acceptance was greater. However, this explanation may not be sufficient. The magnitude of the DN explaining the INT in this study (54.2%) is larger than the average explanatory power of the DN (46%) suggested by Rivis and Sheeran (2003). Moreover, the behaviors with a strong influence on DN-INT in their meta-study were those with more obvious peer effects, such as drug use and drinking.

Thus, we suggest an additional explanation: the proposed action was new and easy. The PM2.5 reduction message was unfamiliar to them. The influence of those around an individual can be more significant for judging new behaviors. An individual tries to reduce negative consequences and considers joining in the behavior by referring to the people around them. When the recommended behavior is perceived as easy, a peer effect intuitively proceeds and is more likely to affect a person (Wolske et al., 2020). In contrast to previous research conducted at U.S. colleges, which reported that bike sharing was rated as the most difficult environmental behavior (Meyer, 2016), the mean value of PBC in this study was 5.88. Taken together, the huge power of DN can be explained by their young age, unfamiliarity of the message, and easiness to follow.

Two other predictor variables significantly affected behavioral intention and are worthy of discussion. The
relationship between ATT and INT has already been found in many ecofriendly behaviors (Abrahamse et al., 2005; Klöckner, 2013; Shi et al., 2017). Despite its robustness, ATT had the smallest effect size among the three predictors in this study. In other words, attitude was not the best predictor of behavioral intentions in public bike sharing. On the other hand, PBC had a large effect on INT. As mentioned in the introduction, cycling requires more physical effort than other behaviors. The results show that perceived behavioral control can have a significant impact on intention to engage in environmental behaviors that require physical activity. In sum, the two variables’ impact reconfirm that it is necessary to identify specific and unique predictors when trying to predict new behavioral intentions (Simmons & Fielding, 2019).

Another strong point in this study is that we separately analyzed the beliefs of different dimensions (i.e., PB and SB). PB affected both ATT and DN, and it affected INT via both ATT and DN. In other words, belief that the behavior would bring useful results to me not only made my attitude more positive but also led to the idea that people around me would ride a lot. This mechanism ultimately had a significant positive effect on individual behavioral intentions.

On the other hand, it was found that SB did not affect other factors. A belief in bringing good results to society could not explain the degree of behavioral intention. Interestingly, SB had a lower mean and greater variance than PB, which was measured in the same scale. For participants, riding a public bicycle would undoubtedly benefit them (PB), but it was not likely to be environmentally helpful (SB). Our pilot study contributes to explaining the weak power of SB. College students confronted counter arguments because most Korean university students use public transportation daily. One of the pilot study participants asked, “Will it be of any help to the environment if I ride a bicycle instead of a bus?” Also, young people were doubtful that their actions alone would contribute to reducing pollutants. Overall, Korean college students were not sensitive to the environmental effects of ecofriendly transportation, given the lack of much environmental education on air pollutants. Therefore, emphasizing only the social benefit of bike-sharing would not be a good strategy for the young generation. According to the overall results, the message would be most effective when it suggests personal benefit and descriptive norms together.

**6. Conclusions**

This study tried to show how to deal with new environmental action messages. Existing studies have mainly studied classic environmental behaviors such as turning off lights, separating trash, and conserving water. As the environmental crisis deepens, new campaigns such as reducing meat consumption and eliminating spam emails to
reduce the digital carbon footprint have been devised to slow climate change. However, because the causes of environmental problems permeate society, it is difficult for laypeople to readily understand them without updated environmental education. Among Koreans, 89.6% believe that PM2.5 comes from abroad, which is very much an exaggeration. Therefore, the participants lacked confidence in this campaign when they were faced with voluntary PM2.5 reduction actions. This study result emphasizes the role of DN ("Others do . . . ") for environmental behaviors when IN ("Others think you should . . . ") is not clear. Environmental communicators must find an effective way to fight counter arguments in the future.

We draw several policy implications for encouraging more ecofriendly actions:

- Salient behavior should be drawn through a participatory workshop. We need to brainstorm ways to address environmental risks and identify environmentally conducive actions that are convincing.
- Beliefs must be provided in as much detail as we can. In particular, it is better to specify how the recommended behavior can help the person, society, and the ecosystem. This goes a long way in improving their attitude.
- Use the peer effect. When people are not confident that doing a specific behavior will be of personal and social benefit, they see what the people around them do. In that respect, DN can be used strategically to design new campaigns (Shi et al., 2017). Here is the legacy of the nudge, meaning natural intervention to make people choose alternatives properly (Thaler & Sunstein, 2008). As a practical strategy for maximizing the peer effect, it is possible to manipulate the message and organize an action group or campaigners to lead the target group so ecofriendly behavior can be accepted naturally. This study is a good example of the need to understand the characteristics of the target group before designing a nudge.

6.1. Future research directions

Our results are different from prior research on reducing PM2.5 behavior (Shi et al., 2017, 2019; Xu et al., 2020) because we adopted a more specific research questionnaire while targeting a specific policy target group. This led to more realistic results than a random survey of the overall population. Since we provided slightly different messages to students only to create a variance, there was no statistical outcome by message manipulation (no significant difference was found in PLS-MGA, ANOVA, or ANCOVA). Therefore, future research should create message treatment with impact when researcher wants to apply the implication from this study results for real message effect research.

While collecting the data, we did not invite participants to a laboratory; rather, we searched for people and collected data in the places where they were (mainly classrooms in colleges). This is meaningful because the data were measured in everyday life. On the other hand, there is a possibility of contaminating data from heterogeneous environments. It would be challenging to even say that the results were representative of all college students because only one university was the site.

Future studies need to consider how to increase the accuracy of measurements for environmental campaign research. A study in health communication suggests detailed behavioral guidelines such as "exercise to the extent of shortness of breath 2–3 times a day for 30 minutes" (Fishbein & Ajzen, 2010, p. 453). The IMBP researchers also suggest describing recommended behaviors in as much detail as possible. However, no prior studies recommended how and how much to ride a public bicycle in Seoul. Suggesting it as commuter transportation was considered, but the results would be difficult to interpret because college students traveled various distances between school and home, in times ranging from several minutes to 2 hours. Future studies should improve the measurement of recommended behavior to increase reliability and control the relevant attributes of the sample.

Acknowledgements

This work was supported by the National Research Foundation of Korea [grant numbers NRF-2017S1A3A2067220] and Environmental Planning Institute, Seoul National University.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the National Research Foundation of Korea [NRF-2017S1A3A2067220].
Notes on contributors

Seona Park Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft.

Hyun Suk Kim Conceptualization, Methodology, Validation, Writing – review & editing.

Sun-Jin Yun Funding acquisition, Methodology, Resources, Supervision, Writing – review & editing.

ORCID

Seona Park http://orcid.org/0000-0003-1696-5571
Hyun Suk Kim http://orcid.org/0000-0001-9803-314X

Data Availability Statement

Data for this article can be accessed https://doi.org/10.6084/m9.figshare.19103180

References

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology, 25(3), 273–291. https://doi.org/10.1016/j.jenvp.2005.08.002

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2015). Consumer attitudes and behavior: The theory of planned behavior applied to food consumption decisions. Italian Review of Agricultural Economics, 70(2), 121–138. https://doi.org/10.13128/REA-18003

Chin, W. W. (1998). Commentary: Issues and opinion on structural equation modeling. MIS Quarterly, 22(1), vii–xvi. https://www.jstor.org/stable/249674

Cialdini, R. B., Kallgren, C. A., & Reno, R. R. (1991). A focus theory of normative conduct: A theoretical refinement and reevaluation of the role of norms in human behavior. In Advances in experimental social psychology (Vol. 24, Academic Press, pp. 201–234).

Cialdini, R. B. (2003). Crafting normative messages to protect the environment. Current Directions in Psychological Science, 12(4), 105–109. https://doi.org/10.1111/1467-8721.01242

Cialdini, R. B., Demaine, L. J., Sagarin, B. J., Barrett, D. W., Rhoads, K., & Winter, P. L. (2006). Managing social norms for persuasive impact. Social Influence, 1(1), 3–15. https://doi.org/10.1080/15534510500181459

Cialdini, R. (2012). The Focus Theory of Normative Conduct. In A. W. K. P. A. M. Van Lange & E. T. Higgins (Eds.), Handbook of Theories of Social Psychology (pp. 295–312). Sage.

Cohen, J. (1992). A power primer. Psychological Bulletin, 112(1), 155. https://doi.org/10.1037/0033-2909.112.1.155

Cox, R. (2013). Environmental communication and the public sphere. Sage.

Fishbein, M., & Cappella, J. N. (2006). The role of theory in developing effective health communications. Journal of Communication, 56(suppl_1), S1–S17. https://doi.org/10.1111/j.1460-2466.2006.00280.x

Fishbein, M., & Ajzen, I. (2010). Predicting and Changing Behavior: The Reasoned Action Approach. Taylor and Francis. https://books.google.co.kr/books?id=zDd5AgAAQBAJ

Fishman, E., Washington, S., & Haworth, N. (2012). Barriers and facilitators to public bicycle scheme use: A qualitative approach. Transportation Research Part F: Traffic Psychology and Behaviour, 15(6), 686–698. https://doi.org/10.1016/j.trf.2012.08.002

Gao, L., Wang, S., Li, J., & Li, H. (2017). Application of the extended theory of planned behavior to understand individual’s energy saving behavior in workplaces. Resources, Conservation and Recycling, 127, 107–113. https://doi.org/10.1016/j.resconrec.2017.08.030

Garson, G. D. (2016). Partial Least Squares (PLS-SEM). Statistical Associates Publishing.

Griskevicius, V., Cialdini, R. B., & Goldstein, N. J. (2008). Social norms: An underestimated and underemployed lever for managing climate change. International Journal of Sustainability Communication, 3, 5–13.

Hagger, M. S., & Chatzisarantis, N. L. (2005). First- and higher-order models of attitudes, normative influence, and perceived behavioural control in the theory of planned behaviour. British Journal of Social Psychology, 44(4), 513–535. https://doi.org/10.1348/014466604X16219

Hain, Margit. (2014). Development and implementation of effective pro-environmental campaigns: Psychological strategies and case study. Maastricht University Journal of Sustainability Studies, 2, 3. https://openjournals.maastrichtuniversity.nl/SustainabilityStudies/article/view/64

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. Journal of Marketing Theory and Practice, 19(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Hornik, R. C., & Yanovitzky, I. (2003). Using Theory to Design Evaluations of Communication Campaigns: The Case of the National Youth Anti-Drug Media Campaign. Communication Theory: CT: a Journal of the International Communication Association, 13(2), 204–224. https://doi.org/10.1111/j.1468-2885.2003.tb00289.x

Hsu, S. J. (2009). Significant life experiences affect environmental action: A confirmation study in eastern Taiwan. Environmental Education Research, 15(4), 497–517. https://doi.org/10.1080/13504620903076973

Jeon, H.-C., Lee, H.-L., Kim, H.-N. (2020). 2019 National Environmental Awareness Survey. KEI FOCUS, 63, 2288–9043.

Joo, H.-S., Shin, D.-W., Choi, K.-C., Kim, O.-S., Choi, J.-W. (2018). Study on Integrated Management Strategies for PM (Particulate Matter). Korea Environment Institute.

Kim, Y., Lee, H., Jang, Y., & Lee, H. (2015). How does media construct particulate matter risks?: A news frame and source analysis on particulate matter risks. Korean Journal of Journalism and Communication Studies, 59(2), 35.
Kim, Y. D., Nam, C., & LaPlaca, A. M. (2021). Marketing and communicating sustainability through college athletics: The effects of pro-environmental initiatives on the belief-attitude-intention hierarchy. *Journal of Marketing for Higher Education*, 1–21. https://doi.org/10.1080/08841241.2021.192897

Klöckner, C. A. (2013). A comprehensive model of the psychology of environmental behaviour—A meta-analysis. *Global Environmental Change*, 23(5), 1028–1038. https://doi.org/10.1016/j.gloenvcha.2013.05.014

Korean Educational Development Institute. (2021). *Basic Education Statistics*. Ministry of Education.

Ma, Y., Men, J., & Cui, W. (2020). Does environmental education matter? Evidence from provincial higher education institutions in China. *Sustainability*, 12(16), 6338. https://doi.org/10.3390/su12166338

Mertens, S. N., & Schultz, P. W. (2021). Referent group specificity: Optimizing normative feedback to increase residential recycling. *Journal of Environmental Psychology*, 73, 101541. https://doi.org/10.1016/j.jenvp.2020.101541

Meyer, A. (2016). Heterogeneity in the preferences and pro-environmental behavior of college students: The effects of years on campus, demographics, and external factors. *Journal of Cleaner Production*, 112, 3351–3363. https://doi.org/10.1016/j.jclepro.2015.10.133

Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2008). Normative social influence is underdetected. *Personality and Social Psychology Bulletin*, 34(7), 913–923. https://doi.org/10.1177/0146167208316691

O’Keefe, D. J. (2003). Message properties, mediating states, and manipulation checks: Claims, evidence, and data analysis in experimental persuasive message effects research. *Communication Theory*, 13(3), 251–274. https://doi.org/10.1111/j.1468-2885.2003.tb00292.x

O’Keefe, D. J. (2016). *Reasoned Action Theory, Persuasion: Theory and research* (3rd ed.) Sage.

Park, S. (2018). '10 Promise of Citizen Practice for reducing PM2.5' Improvement Plan for Youth Participation. Small Research Good Seoul, Issue. S Institute.

Passafaro, P., Rimano, A., Piccini, M. P., Metastasio, R., Gambardella, V., Gullace, G., & Lettieri, C. (2014). The bicycle and the city: Desires and emotions versus attitudes, habits and norms. *Journal of Environmental Psychology*, 38, 76–83. https://doi.org/10.1016/j.jenvp.2013.12.011

Ringle, C. M., Wende, S., & Becker, J.-M. (2015). *SmartPLS 3*. Bönningstedt: http://www.smartpls.com

Rivis, A., & Sheeran, P. (2003). Descriptive norms as an additional predictor in the theory of planned behaviour: A meta-analysis. *Current Psychology*, 22(3), 218–233. https://doi.org/10.1007/s12144-003-1018-2

Ru, X., Qin, H., & Wang, S. (2019). Young people’s behaviour intentions towards reducing PM2.5 in China: Extending the theory of planned behaviour. *Resources, Conservation and Recycling*, 141, 99–108. https://doi.org/10.1016/j.resconrec.2018.10.019

Seoul bike policy team. (2021). *Seoul surpassed 23 million cases of ‘Tareungi’ last year… Enlightened Transportation in the Corona Era*. Seoul-Metropolitan-city.

Shaheen, S. A., Guzman, S., & Zhang, H. (2010). Bikesharing in Europe, the Americas, and Asia: Past, Present, and Future. *Transportation Research Record*, 2143(1), 159–167. https://doi.org/10.3141/2143-20

Shi, H., Fan, J., & Zhao, D. (2017). Predicting household PM2.5-reduction behavior in Chinese urban areas: An integrative model of theory of planned behavior and norm activation theory. *Journal of Cleaner Production*, 145, 64–73. https://doi.org/10.1016/j.jclepro.2016.12.169

Shi, H., Wang, S., & Guo, S. (2019). Predicting the impacts of psychological factors and policy factors on individual’s PM2.5 reduction behavior: An empirical study in China. *Journal of Cleaner Production*, 241, 118416. https://doi.org/10.1016/j.jclepro.2019.118416

Simmons, E. C., & Fielding, K. S. (2019). Psychological predictors of fishing and waste management intentions in Indonesian coastal communities. *Journal of Environmental Psychology*, 65, 101324. https://doi.org/10.1016/j.jenvp.2019.101324

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, 29(3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving Decisions About Health, Wealth, and Happiness*. Yale University Press.

UNEP (2020). Investing in people who walk and cycle: Share the Road Programme Annual Report 2019.

Whitley, C. T., Takahashi, B., Zwickle, A., Besley, J. C., & Lertrprratchya, A. P. (2018). Sustainability behaviors among college students: An application of the VBN theory. *Environmental Education Research*, 24(2), 245–262. https://doi.org/10.1080/13504622.2016.1250151

Wolske, K. S., Gillingham, K. T., & Schultz, P. (2020). Peer influence on household energy behaviours. *Nature Energy*, 5(3), 202–212. https://doi.org/10.1038/s41560-019-0541-9

Xu, Z., Shan, J., Li, J., & Zhang, W. (2020). Extending the theory of planned behavior to predict public participation behavior in air pollution control: Beijing, China. *Journal of Environmental Planning and Management*, 63(4), 669–688. https://doi.org/10.1080/09640568.2019.1603821

Yang, Q., & Wu, S. (2021). How social media exposure to health information influences Chinese people’s health protective behavior during air pollution: A theory of planned behavior perspective. *Health Communication*, 36(3), 324–333. https://doi.org/10.1080/10410236.2019.1692486

Yu, Y., Yi, W., Feng, Y., & Liu, J. (2018). Understanding the intention to use commercial bike-sharing systems: An integration of TAM and TPB. *Proceedings of the 51st Hawaii International Conference on System Sciences*.

Zhang, C.-Q., Zhang, R., Gan, Y., Li, D., & Rhodes, R. E. (2019). Predicting transport-related cycling in Chinese employees using an integration of perceived physical environment and social cognitive factors. *Transportation Research Part F: Traffic Psychology and Behaviour*, 64, 424–439. https://doi.org/10.1016/j.trf.2019.06.003

Zillmann, D. (2006). Exemplification effects in the promotion of safety and health. *Journal of Communication*, 56(suppl_1), S221–S237. https://doi.org/10.1111/j.1460-2466.2006.00291.x
Appendix A. Measurement Items (all used a 7-point Likert scale)

Behavioral belief on personal aspect
PB1. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi will save time.
PB2. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi will enhance my physical fitness.
PB3. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi will be an effective workout.

Behavioral belief on social aspect
SB1. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi will ease traffic congestion.
SB2. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi will improve the natural environment.
SB3. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi will reduce PM2.5.

Descriptive norm
DN1. When the concentration of PM2.5 exceeds air quality standards, Seoul citizens will ride a Ttareungi.
DN2. When the concentration of PM2.5 exceeds air quality standards, my close friends will ride a Ttareungi.
DN3. When the concentration of PM2.5 exceeds air quality standards, people like me will ride a Ttareungi.

Attitude toward Behavior
ATT1. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi is good/bad.
ATT2. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi is unpleasant/pleasant.
ATT3. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi is harmful/beneficial.
ATT4. When the concentration of PM2.5 exceeds air quality standards, my riding a Ttareungi is interesting/boring.

Perceived control behavior
PBC1. If I really wanted to, I could ride a Ttareungi.
PBC2: My riding a Ttareungi is under my control.

Behavioral intention
INT1. I intend to ride a Ttareungi
INT2. I will ride a Ttareungi.
INT3. I plan to ride a Ttareungi.

Demographic Questions
(1) Gender: male, female
(2) Grade: 1, 2, 3, 4, 5+
(3) Major: Humanities and social science, Science and Engineering, Arts and Physical Education, Others
(4) I know how to ride a bike: Yes, No
(5) I’ve seen a Seoul public bike system before: Yes, No

I’ve used a Seoul public bike system before: Yes (season ticket), Yes (One-time ticket), No