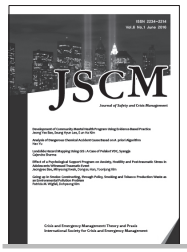

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An Empirical Analysis on Particulate Matter Risk Perception in Korea

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A B S T R A C T

The purpose of this study is to measure public perception of particulate matter. For accomplishing the research goal, we conducted survey and use various kinds of variables, such as severity, effect on health, disease, health problems, influencing factors, policies, and so on. The results of the survey can be summarized as follows. First, the severity of particulate matter was recognized as a serious problem and particulate matter had an adverse effect on their health. Second, with regard to the health problems caused by particulate matter, respiratory diseases accounted for 54.1%, and 42.0% of eye diseases and skin diseases was 30.7%. Third, the introduction of the total pollutant emission system was required to be equipped, especially for industrial complexes. Fourth, a mandatory introduction of a chimney automatic measuring device was required. Fifth, if public transportation is convenient and infrastructure is expanded, people are willing to use public transportation to reduce the occurrence of particulate matter. Sixth, people are willing to participate in a double-shift vehicle system to reduce the occurrence of particulate matter. Eighth, polluters should pay for a budget to implement a particulate matter management system.

Key words: particulate matter, public perception, severity, health, disease, pollutant emission system

Introduction

Particulate matter (PM_{10}, $PM_{2.5}$) among air pollutants is considered to cause more than 3 million premature deaths every year. In particular, Korea's air pollution is severe, with 18,200 deaths annually due to particulate matter. Unless urgent measures are taken, premature mortality and economic damage is expected to be the largest among OECD countries in 2060 (WHO, 2016; OECD, 2016; Oh & Lim, 2019: 47). And air pollution is the fifth highest cause of death worldwide, after high blood pressure, smoking, high blood sugar, and cholesterol. Air pollution is responsible for half of all deaths of acute respiratory tract infections (bronchitis, pneumonia, etc.) in infants under five years of age (Cohen, *et. al.*, 2017). Air pollution causes ischemic heart disease (angina, myocardial infarction), cerebral hemorrhage, chronic obstructive pulmonary disease, asthma and cancer. Among the air pollution, the health effect of $PM_{2.5}$ particulate matter having a particle diameter of 2.5μm or less is the highest. In 2015, 4.2 million people worldwide died of $PM_{2.5}$. This accounts for 7.6% of all deaths (Cohen, *et. al.*, 2017; Hwang

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& Sohn, 2019: 9).

Particulate matter problems have not improved significantly since 2016 despite domestic reduction efforts. Particulate matter occurs in Korea, but it is also flowing into China. At high concentrations, the influence of foreign factors can reach 30-70% depending on the season and weather conditions. Korea is strengthening cooperation with China in establishing joint air quality forecasting and warning systems, coordinating high-density emergency reduction measures, and activating air pollution reduction technology demonstration projects (Park, 2019: 15). Korea strengthened the forecast of particulate matter in March 2018 to the level of developed countries. Restrictions on particulate matter emissions are also being tightened, but they do not provide accurate policies to reduce emissions themselves (Kim & Kim, 2019: 33-34).

It is also pointed out that the attitude of the individual on the matter of particulate matter is important (Lee, *et. al*., 2019: 162-163). Particulate matter is important for national countermeasures, but the attitude of each individual is also important (Cho, *et. al*., 2018). When a person encounters a problem, he or she forms beliefs through values, attitudes, norms, social psychological factors, and media to solve them. These beliefs are expressed by actions (Park & Sung, 2017).

This means that people act on social issues based on their own beliefs. The theory of planned behavior is the most widely used theory in behavioral psychology research to predict human behavior (Ajzen, 1991).

Air pollution due to particulate matter is a representative environmental problem where physical boundaries do not exist. Because the causes are complex, the solution is not clear, and it is not clear whether existing policy alternatives are also appropriate measures. Particulate matter problems are characterized as wicked problems with high uncertainty. Therefore, in order to solve the particulate matter problem, it is necessary to solve the problem of governance that not only the government but also related agencies and citizens participate in the policy process to identify the problem and come up with a solution. The government should create an environment in which various policy actors can participate in solving the problem as a policy manager to solve the problem of particulate matter (Kim & Lee, 2019: 100-101).

Risk perception of particulate matter includes concern, severity, and sensation of particulate matter (Park, *et. al*., 2018). It refers to the degree of perception of an individual's risk of particulate matter. Risk perception is defined as "a subjective judgment that an individual has about the likelihood of a negative event occurring." Even with the same risk, perception of risk can be higher or lower because each person has a different level of perception of the risk (Slovic, 1992). Risk perception tends to change a person's attitudes or interests and affects the execution of decision-making processes and actions (Oliver, 1997). According to Kim, *et. al*.(2016), the group that perceived high risk of particulate matter showed high interest in their health and solution, and high intention to avoid from dangerous situation.

In this context, this study aims to measure the degree of public perception of particulate matter. The variables that measure people's perception of particulate matter are as follows; the severity of particulate matter, the effect of particulate matter on health, the disease most affected by particulate matter, the health problems caused by particulate matter, influencing factors of particulate matter emission, policies to reduce the occurrence of particulate matter, the need to introduce the total amount of pollutant emissions from thermal power plants, mandatory attachment of chimney automatic measuring equipment, effective transportation policy, intention to use public transportation, electric motorcycle introduction, budgetary expansion, organization to solve particulate matters, etc.

Theoretical Background

Particulate Matter and Living Environment Crisis

Particulate matter is also called aerosol, as solid and liquid particles suspended in the atmosphere. Particulate matter is classified into coarse particles larger than 2.5㎛ produced by mechanical processes on the surface and fine particles less than 2.5㎛ produced by physical and chemical processes such as condensation and aggregation (Park, *et. al.*, 2019: 1). Particulate matter in the air is divided into PM10 having a diameter of 10 ㎛ or less and PM2.5 having a size of 2.5㎛ or less according to its size, and are referred to as particulate matter and fine particulate matter. Particulate matter has a variety of chemical properties depending on the source, and also varies depending on weather, regional characteristics, and time changes. Particulate matter discharged to the atmosphere has a smaller diameter, which floats longer in the air, worsening its visual range and affecting the human body. In particular, pulmonary dysfunction, increased respiratory or cardiovascular disease patients, and early death are the main types of health disorders. Longer exposure to PM2.5 than PM10 has been associated with greater health risks, including cardiovascular disease (Kim, *et. al.*, 2019: 61).

The study of the effect of particulate matter on the human body began with the Donora smog incident in Pennsylvania, USA, which occurred from October 27 to October 31, 1948. At that time, about 20 people were killed by smog and 6,000 were hospitalized

for respiratory illness. The days of heavy fog and little air movement lasted for five days. In addition, toxic gas and soot were mixed with the mist, causing smog, causing serious air pollution. Epidemiological investigations were conducted to analyze these causes. Causes of death and disease Particulate matter below 10㎛. Research has shown that particulate matter is more likely to adversely affect healthy people. Since then, the US government has begun to prepare air pollution standards for particulate matter along with air pollution measures (Lee, *et. al.*, 2019: 84).

Let's look at the socio-economic costs of particulate matter. Socioeconomic costs of particulate matter can generally be divided into market and nonmarket costs (OECD, 2016). Market costs include reduced labor productivity due to the impact of particulate matter on the goods or services traded in the market, reduced labor productivity due to reduced labor days, damage to crops, and reduced industrial production such as wholesale and retail trade, and so on. Nonmarket costs can include health effects such as death, aesthetic effects such as worsening visibility, and ecosystem disturbances, with the effect of particulate matter on goods or services not traded in the market (Hwang & Sohn, 2019: 11). In order to calculate the socioeconomic costs of particulate matter, it is necessary to set the scope of analysis such as time and space. After forecasting particulate matter emissions, concentrations, and physical effects within the scope of analysis, the process must monetize the physical effects.

Compared with climate change, there are parts where particulate matter is easier to respond to (Park, 2019: 15-16). First, GHG(greenhouse gas) sources are distributed not only in the combustion process, but also in economic activities such as agriculture, livestock raising, and forest removal. On the other hand, particulate matter is relatively easy to manage due to its relatively limited discharge sources such as coal-fired power plants, aging diesel vehicles, large ships, factory smoke and farm waste. Second, unlike GHGs, particulate matters are limited to emissions and neighboring countries, which can be significantly reduced through domestic reduction policies. It can also respond effectively through information sharing and technology exchange between neighboring countries. Third, in order to respond to climate change, long-term global GHG reduction measures are required, and the improvement effect is also shown for a long time, so it is difficult to realize the direct connection between the response measures and the effects. However, efforts to reduce particulate matter can be carried out regionally and have immediate effects, which makes it easier to implement policies as there is a direct link between response measures and effects.

Defining a living environment that includes particulate matter, 'living environment refers to the environment related to people's daily lives such as air, water, soil, waste, noise and vibration, odor, sunlight, artificial lighting, and chemicals. It is defined in Article 3 of the Framework Act on Environmental Policy. There are also differences in the definition of living environment among scholars. Lee (2010: 5) defines the living environment as ‘the possibility of sunshine, noise, vista, and invasion of privacy related to human daily life or quality of life.' Kwon (2017: 19) defines the living environment as ‘environmental and social environment that has a close influence on human life'. Among the problems and accidents that occur in modern society, unlike traditional national crises such as military security crisis, territorial crisis and disaster, there are factors that threaten the safety of people's living environment. Recently, many incidents threaten the people's living environment due to chemical spills and particulate matter. Crisis that threatens living environment is defined as living environment crisis.

Problems that arise in the modern living environment are dealt with mainly in the medical and engineering fields (Lee, 1993; Song, 2006; Lee, 2016; Hong, *et. al.*, 2017). In addition to this, an approach from Crisisonomy which means crisis & emergency management science, (Lee, 2018: 41-42) is necessary to manage the living environment position that threatens the living environment of the people.

Risk Perception

Risk perception is a helpful indicator for policy makers, and it can also help the public determine the behavior of risk factors. Risk perception can provide an objective way to derive an opinion on risk (Sjöberg, 2000: 1). Risk perception can provide the basis for understanding and predicting the public's response to risk. It helps to support risk analysis and social decision making by bridging the gap between risk perception among the public, technology experts and policy makers. The study of risk perception started in the nuclear debate of the 1960s (Slovic, *et. al.*, 1982: 83).

The diversity and complexity of crisis types has created new perspectives and approaches to managing crisis more effectively. The government found that the dominant part of determining policy priorities and legislative agendas for risk management is that risk perception investigation, as defined by public perception, is subjective and valueable in risk assessment (Slovic, 1997: 22). Because crisis is a social structure, it must be embodied as a policy made in combination with science and judgment, taking into account psychological, social, cultural and political factors. And understanding citizen participation and perception can be seen as a more effective and efficient way for governments to conduct risk management (Slovic, 1997: 22).

Sowby (1965: 879-887) conducted a study on the relationship

between risk perception and communication. Starr (1969: 1232-1238) studied not only the relationship between risk perception, risk acceptance and the resulting economic benefits, but also with the subjective dimension of behavioral change in perception. There are many variables for perceiving and evaluating risk perception, and Sjöberg(2000: 1) discusses prejudice and approaches to cultural theory. Lerner, *et. al*.(2003: 144-150) and Lerner & Keltner(2000: 473-493) study that instinctive feelings such as fear and anger influence perception of risk. Schwarz & Clore (1988: 44-62) also found that experience with risk influences emotional judgment and decision making about risk.

Review of Previous Research

There are various studies on risk perception in Korea. Kim (2018) investigated risk perception centered on victims of disaster areas. Factors affecting risk perception were analyzed into three categories: objective factors (hazards, exposures, and vulnerabilities), subjective factors (fear, familiarity, belief, demographic factors), constructive elements (cultural type, information, communication, government trust, etc.).

Kim (2017) analyzed the effects of risk perception on the hierarchical factors such as occupation, income level and education level among individual characteristics.The results showed that education and class consciousness influenced risk perception. Kim (2018) studied extreme events, policy factors, personal factors, surroundings, characteristics of risk objects, and experiences as variables that influence risk perception.As a result, it was analyzed that extreme events influence risk perception. Kim (2018) conducted a relationship study on risk behavior according to risk perception. The findings indicate that uncertainty about risk perception also affects the corresponding response.

Park (2018) analyzed risk perception through the variables of socioeconomic variables, political orientation, religion and individual beliefs of risk perception. The more socioeconomic vulnerable and the weaker the social trust, the higher the risk perception.

Park (2019) analyzed the effects of demographic sociological factors on risk perception.As a result, risk perception differs according to attribute variables according to personal knowledge, controllability, fear, and familiarity with risk.

Cha (2006) analyzed risk perception rankings using the psychometric paradigm and Khaltar, *et. al*.(2019) conducted a study on the relationship between government trust and risk perception. Jang, *et. al.*(2019) have empirically analyzed the risk perception of citizens by the division factors such as fear and controllability.

Kang & Hong (2019: 191) found that perception of the risk of particulate matter affects the attraction of visitors to tourist attractions. Particulate matter (PM_{10}) variables were found to have a greater effect on attracting visitors to outdoor tourist attractions than indoor tourist attractions.

Woo, *et. al.*(2019: 143) examined the effects of particulate matter on the development of psychological emotions in out-of-home care children. The results showed that particulate matter had a negative effect on the self-efficacy, stigma, depression and anxiety of children outside the home. Restriction of outdoor activities due to particulate matter results in limiting the physical activities that children can interact with others, which is interpreted as having a negative effect on the development of psychological emotions of children.

In studies of risk perception in other countries, studies of risk perception factors and theories (Slovic, 1987; Slovic & Peters, 2006; Slovic, *et. al.*, 1982; Wildavsky & Dake, 1990), risk perception case studies (Deery, 1999; Siegrist, *et. al.*, 2000), and studies of major factors that influence risk perception (Slovic & Weber, 2002; Joffe, 2003; Cohn, *et. al*., 1995).

In general, domestic and international risk perception studies have been conducted by finding factor variables that influence risk perception and arranging policy alternatives and implications. In particular, case studies on the risk factors of living environment that have a great influence on risk perception are actively conducted.

Empirical Analysis

Research Methods: Survey Design and Demographic Variables

This empirical study surveyed 1,500 adult men and women between 20 and 69 years of age from March 25 to 27, 2019 in Seoul, Metropolitan area, and other regions, to find out the status of particulate matter risk perception in Korea. Because disaster has regional characteristics that are limited in time and space by the mechanism of occurrence. The nature of disasters and damage varies from region to region, so the area's ability to respond on-site is very significant (Lee, *et. al*., 2019: 130). The survey was conducted by the Environmental Foundation and Lime (Lotte Members Research Platform). The demographic characteristics of the study subjects are as follows. The genders of the study subjects were 766 males (51.1%) and 734 females (48.9%). In the age group, 305 (20.3%) were in their 30s, 347 (23.1%) were in their 40s, and 341 (22.7%) were in their 50s. Marital status was 930 married

(62.0%) and unmarried 519 (34.6%). The occupational distribution was the highest with 589 general office workers (39.3%) and 206 technical service workers (13.7%). The average monthly household income was 254 (16.9%) for 4 million won-499 million won, and 236 (15.8%) for 5 million won-599 million won.

<Table 1> Demographic characteristics

Classification		Percentage(%)	Frequency(N)
Gender	Male	51.1	766
	Female	48.9	734
	Total	100.0	1,500
Age	20's	18.7	281
	30's	20.3	305
	40's	23.1	347
	50's	22.7	341
	60's	15.1	226
	Total	100.0	1,500
Marriage	Single	34.6	519
	Married	62.0	930
	Other (Divorce, Bereavement, etc)	3.4	51
	Total	100.0	1,500
Job	Student/Graduate Student	4.7	71
	White-collar job	39.3	589
	Technical-service job	13.7	206
	Professional-service job(Doctor/Lawyer, etc)	7.9	118
	Self-employment	9.1	137
	Teacher/Public Official	3.6	54
	Housewife	11.7	175
	Inoccupation	8.0	120
	Other	2.0	30
	Total	100.0	1,500
Child	Having child(ren)	93.7	871
	Childlessness	6.3	59
	Total	100.0	930
Youngest Child Age	Infants(under 6)	18.4	160
	Child(7-10 years old)	11.0	96
	Youth(11-18 years old)	19.2	167
	Adult(over 19 years old)	51.4	448
	Total	100.0	871
Family Economy	Dual-income family	54.0	502
	Single income family	46.0	428
	Total	100.0	930
Average Monthly Household Income	Below 1.99 million won	7.7	116
	2 million won - 2.99 million won or less	15.0	225
	3 million won - 3.99 million won or less	15.3	229
	4 million won - 4.99 million won or less	16.9	254
	5 million won - 5.99 million won or less	15.8	236
	6 million won - 6.99 million won or less	7.9	118
	7 million won - 7.99 million won or less	6.7	101
	8 million won - 8.99 million won or less	6.5	97
	9 million won - 9.99 million won or less	1.9	28
	More than 10 million won	6.4	96
	Total	100.0	1,500

Major Empirical Analysis Result

Severity of Particulate Matter and Its Effect on Health

How do you think the severity of domestic particulate matter? As a result of the survey, the average was 6.28 out of 7 and considered serious. When converted to 100 points, the average was 88.07. The proportion of those who said they were serious was 94.7%, and the proportion of those who said they were not serious was only 0.6%.

How bad do you think particulate matter affects your health? As a result of the survey, the average was 6.09 out of 7(when it was converted into 100 points, the average was 84.86) and was considered serious. Specifically, 94.1% of the respondents answered that they were serious, and only 0.6% of those who answered that they were not serious.

Disease and Health Problem

What disease do you think is most affected by particulate matter? Respiratory diseases (cough, asthma, etc.) accounted for 53.1%, and 27.1% of lung diseases (pneumonia, lung cancer, etc.), and eye diseases (dry eye, conjunctivitis, etc.) was 7.7%.

What health problems do you have due to particulate matter? Respiratory diseases (cough, asthma, etc.) accounted for 54.1%,

<Table 2> Severity of particulate matter and its effect on health

Classification	Severity	Percentage(%)	Classification	Effect on Health	Percentage(%)
Particulate matter severity perception	Not serious at all-①	0	Effect of Particulate Matter on Health	No effect at all-①	0
	②	0.3		②	0.2
	③	0.3		③	0.4
	Average-④	4.8		Average-④	5.3
	⑤	11.7		⑤	18.9
	⑥	31.5		⑥	34.5
	Very Serious-⑦	51.5		Great effect-⑦	40.7
	Sum			Sum	100.0 (1,500)

<Table 3> Disease and health problem

Classification	Answer	Percentage (%)	Region(N)		
			Seoul (589)	Metropolitan area (303)	Other areas (608)
The Disease Most Affected by Particulate Matter	Respiratory diseases (cough, asthma, etc.)	53.1	51.6	53.1	54.4
	Lung diseases (pneumonia, lung cancer, etc.)	27.1	30.2	25.7	24.7
	Eye diseases (dry eye, conjunctivitis, etc.)	7.7	7.8	6.3	8.2
	Skin disorders (skin problems, etc.)	4.9	3.1	6.9	5.6
	Nervous system diseases (stroke, dementia, etc.)	3.1	2.5	3.6	3.3
	Cardiovascular diseases (hypertension, myocardial infarction, etc.)	2.9	3.9	2.3	2.1
	Metabolic diseases (diabetes, obesity, etc.)	.9	.8	1.7	.7
	Other	.5	0.0	.3	1.0
Health Problems Caused by Particulate Matter	Respiratory diseases (cough, asthma, etc.)	54.1	54.0	57.4	52.6
	Eye diseases (dry eye, conjunctivitis, etc.)	42.0	43.3	41.9	40.8
	Skin disorders (skin problems, etc.)	30.7	35.5	30.4	26.2
	Not having a problem	17.2	17.5	15.8	17.6
	Lung diseases (pneumonia, lung cancer, etc.)	11.8	13.6	10.6	10.7
	Cardiovascular diseases (hypertension, myocardial infarction, etc.)	7.5	9.8	5.6	6.1
	Nervous system diseases (stroke, dementia, etc.)	4.9	5.8	3.6	4.6
	Metabolic diseases (diabetes, obesity, etc.)	4.7	5.1	4.6	4.4
	Other	1.5	1.9	1.7	1.2
Sum		100.0 (1,500)			

and 42.0% of eye diseases (dry eye, conjunctivitis, etc.) and skin diseases (skin problems, etc.) Was 30.7%. 11.8% of lung diseases (pneumonia, lung cancer, etc.) and 7.5% of cardiovascular diseases (hypertension, myocardial infarction, etc.).

Particulate Matter Emission and Response Policy

What do you think has the greatest impact on the particulate matter emitted in the country? In Korea, factories and power plants had the highest impact on particulate matter emitted (49.1%) and automobile emissions (38.3%). The aged air-conditioning system and the construction site were 3.5%.

How do you think it is more effective to deal with China with regard to particulate matter? With regard to particulate matter problems, 63.3% of respondents found that it was more effective to find a countermeasure through cooperation with China on how to deal with China. In addition, 36.9% of the respondents demanded a cause identification and resolution through strong pressure on China.

What do you think is the most important policy to reduce the occurrence of particulate matter? In response to the question of what is the most important policy to reduce the occurrence of particulate matter, 36.6% of respondents responded to the cause of foreign emissions, and 30.6% of responded to the reduction of thermal power plants. In addition, automobile emission reduction was 24.7%, and the replacement of aged urban heating with eco-friendly boilers was 7.7%.

Policy Such As Total Pollutant Emission System and Mandatory Installation of Automatic Measurement Equipment for Air Pollutant Stacks

What do you think about the need to introduce a total pollutant emission system for coal-fired power plants? As a result of the survey, the average was 5.87 out of 7 (average 81.16 when converted into 100 points), and it was recognized that the introduction of the total pollutant emission system was necessary. 87.5% of the total respondents answered that the introduction of total pollutant emission system was necessary. On the other hand, the proportion of those who said they did not need was only 1.0%.

What do you think about the need to introduce a total pollutant emission system for industrial complexes (steel, cement, petrochemical, etc.)? As a result of the survey, the average was 5.92 out of 7 (average 82.02 when converted into 100 points), and it was

<Table 4> Particulate matter emission and response policy

Classification	Answer	Percentage (%)	Gender(N)		Age(N)				
			Male (766)	Female (734)	20's (281)	30's (305)	40's (347)	50's (341)	60's (226)
Particulate Matter Emission Factor	Factory and power plant	49.1	53.8	44.1	47.7	48.9	51.9	47.5	49.1
	Car exhaust gas	38.3	35.5	41.1	27.8	37.7	38.3	44.3	42.9
	Aged air conditioning system	3.5	3.1	4.0	4.6	4.3	4.0	2.6	1.8
	Construction site	3.5	3.0	4.1	6.0	3.6	3.5	2.3	2.2
	Smoking	2.1	1.4	2.9	5.0	3.3	.3	1.2	1.3
	Do not know	1.7	1.6	1.9	4.6	1.3	.9	.9	1.3
	Food cooking	1.2	1.0	1.4	2.8	.7	.9	1.2	.4
	Other	.5	.5	.5	1.4	.3	.3	0.0	.9
Cooperation with China on Particulate Matter	Cooperation with China for finding countermeasures to particular matter	63.1	63.3	62.8	50.9	59.7	66.3	69.2	68.6
	Strong pressure on China to identify the cause and find a solution	36.9	36.7	37.2	49.1	40.3	33.7	30.8	31.4
The Most Important Policy to Reduce the Occurrence of Particulate Matter	Responding to Overseas Emission Causes (China Pressure, etc.)	36.6	35.9	37.3	52.0	39.7	33.4	27.6	31.9
	Thermal power plant reduction (Using natural energy, LNG power plant conversion)	30.6	34.6	26.4	23.8	30.5	31.1	31.7	36.7
	Car emissions reduction (Regulation of diesel car, double-shift vehicle system, etc.)	24.7	22.5	27.0	15.3	19.7	27.1	33.1	26.5
	Replace aged urban heating with eco-friendly boilers (condensing / low knox, etc.)	7.7	6.8	8.6	8.9	9.2	7.8	7.3	4.4
	Other	.5	.3	.7	0.0	1.0	.6	.3	.4
Sum		100.0 (1,500)							

recognized that a total amount of pollutant emission for industrial complexes (steel, cement, petrochemical, etc.) was required. 89.1% of the total respondents of the respondents said that it is necessary to introduce the total pollutant emission system for industrial complexes (steel, cement, petrochemical, etc.). In contrast, the proportion of those who said they did not need was only 0.8%.

What do you think about introducing mandatory chimney measurement systems that remotely monitor workplace air pollutants in real time? As a result of the survey, the average was 6.02 out of 7 (average 83.62 when converted into 100 points), and it was recognized that a mandatory introduction of a chimney automatic measuring device that remotely monitors workplace air pollutants is required. 90.9% of the respondents said that it is necessary to introduce a mandatory chimney measurement system that remotely monitors air pollutants in the workplace. On the other hand, only 0.9 percent of respondents said they were not needed.

Traffic Policy to Reduce Particulate Matter

Which of the transportation-related policies regarding particulate matter do you think is effective in reducing particulate matter? Respondents responded that the effective transportation policy to reduce particulate matters was 25.5% for the expansion of electric and hydrogen vehicles, 21.9% for the establishment of infrastructure for spreading public transportation, and 19.8% for the regulation of obsolete diesel vehicles. At the same time, 10.4% of respondents responded to the limited production of diesel cars and 10.4% for the double-shift vehicle system. At the time of the announcement of particulate matter, public transportation cost support was 10.9%.

Are you interested in using public transportation to reduce future particulate matter? As a result, the average was 5.87 out of 7 (average 81.13 when converted to 100 points), indicating that people are willing to use public transportation to reduce the occurrence of particulate matter in the future. Specifically, 85.5% of the respondents answered that it is necessary to use public transportation to reduce the occurrence of particulate matter. And only 2.3 percent of respondents said they were not needed.

Are you willing to use public transportation to reduce the occurrence of particulate matter if it is easier to use public transportation and infrastructure is expanded than it is today? As a result, the average was 5.99 out of 7 (an average of 83.12 when converted

<Table 5> Total pollutant emission system and mandatory installation of automatic measurement equipment

Classification	Answer	Percentage (%)	Gender(N)		Age(N)				
			Male (766)	Female (734)	20's (281)	30's (305)	40's (347)	50's (341)	60's (226)
Necessity of Introducing Total Amount of Pollutant Emission in Thermal Power Plant	Not needed at all - ①	.2	.4	0.0	.4	.3	.3	0.0	0.0
	②	.2	.3	.1	.4	0.0	.3	.3	0.0
	③	.6	.8	.4	2.5	0.0	0.0	.6	0.0
	Average - ④	11.5	11.6	11.3	14.2	11.5	12.1	9.1	10.6
	⑤	20.9	19.3	22.5	21.0	23.0	21.9	16.4	23.0
	⑥	32.3	33.0	31.6	31.3	33.4	30.8	31.4	35.8
	Very necessary - ⑦	34.3	34.6	34.1	30.2	31.8	34.6	42.2	30.5
Necessity of Introducing Total Amount of Pollutant Emission in Industrial Complex	Not needed at all - ①	.3	.5	0.0	.7	.3	.3	0.0	0.0
	②	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	③	.5	.7	.4	1.8	.3	.3	.3	0.0
	Average - ④	10.1	10.1	10.2	12.5	8.2	11.2	8.8	10.2
	⑤	20.3	20.5	20.2	22.4	25.2	20.5	15.0	19.0
	⑥	33.1	32.6	33.5	32.4	32.8	31.4	32.6	37.6
	Very necessary - ⑦	35.7	35.6	35.7	30.2	33.1	36.3	43.6	33.2
Introducing a Mandatory Installation of Automatic Measurement Equipment for Air Pollutant Stacks	Not needed at all - ①	.2	.4	0.0	.7	0.0	.3	0.0	0.0
	②	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	③	.7	.8	.5	1.4	1.0	.3	0.0	.9
	Average - ④	8.3	8.4	8.2	11.7	8.2	7.8	6.2	8.0
	⑤	19.4	20.8	18.0	19.2	22.6	20.5	14.7	20.8
	⑥	30.8	29.2	32.4	31.0	31.8	28.0	33.1	30.1
	Very necessary - ⑦	40.7	40.5	40.9	35.9	36.4	43.2	46.0	40.3
Sum		100.0 (1,500)							

into 100 points). If public transportation is convenient and infrastructure is expanded, it is shown that they are willing to use public transportation to reduce the occurrence of particulate matter. Specifically, 88.5% of respondents said they were willing to use public transportation, and only 1.2% said they did not intend to use public transportation.

What do you think about implementing a double-shift vehicle system to reduce the occurrence of particulate matter? Respondents found 70.7% of those in favor of implementing a double-shift vehicle system to reduce the occurrence of particulate matter and

<Table 6> Traffic policy to reduce particulate matter

Classification	Answer	Percentage (%	Region(N)		
			Seoul (589)	Metropolitan area (303)	Other area (608)
Effective Transport Policy for Particulate Matter	Proliferation of Electric and Hydrogen Cars	25.5	24.4	22.1	28.3
	Establishment of infrastructure for spreading public transportation(Expand subway / bus routes, etc.)	21.9	19.5	22.4	23.8
	Aging diesel car regulation	19.8	20.5	19.1	19.4
	Restriction on production of diesel cars	10.4	12.1	10.9	8.6
	Enforcement of double-shift vehicle system	10.4	10.9	9.9	10.2
	Support for public transportation costs when warning of particulate matter	10.9	11.4	14.5	8.6
	Other	1.1	1.2	1.0	1.2
Willingness to use public transportation to reduce particulate matter	Have no intention at all - ①	.5	.7	.7	.3
	②	.7	1.0	.3	.7
	③	1.0	.3	.7	1.8
	Average - ④	12.2	9.8	11.6	14.8
	⑤	17.5	14.1	20.5	19.4
	⑥	30.7	32.9	27.1	30.3
	Very willing - ⑦	37.3	41.1	39.3	32.7
Willingness to Use Public Transportation When Expanding Public Transportation Convenience and Infrastructure	Have no intention at all - ①	.3	.3	.3	.3
	②	.3	.7	0.0	0.0
	③	.6	.3	.3	1.0
	Average - ④	10.3	9.2	9.2	12.0
	⑤	17.7	14.1	20.1	20.1
	⑥	29.1	29.9	27.7	28.9
	Very willing - ⑦	41.7	45.5	42.2	37.7
Enforcement of the Double-shift Vehicle System	Agree	70.7	74.5	68.3	68.1
	Disagree	29.3	25.5	31.7	31.9
Willingness to Participate in the Enforcement of the Double-shift Vehicle System	Have no intention at all - ①	4.7	3.7	4.3	5.9
	②	3.3	2.2	2.6	4.8
	③	4.7	3.6	7.3	4.4
	Average - ④	17.7	17.5	17.2	18.3
	⑤	15.3	14.9	16.2	15.1
	⑥	23.7	23.8	22.1	24.3
	Very willing - ⑦	30.6	34.3	30.4	27.1
Replace Existing Motorcycle with Electric Motorcycle	Not needed at all - ①	1.5	1.2	1.7	1.6
	②	1.4	1.4	1.0	1.6
	③	2.9	3.4	2.6	2.6
	Average - ④	20.7	18.7	24.4	20.9
	⑤	21.8	19.5	23.1	23.4
	⑥	27.7	30.1	26.1	26.3
	Very necessary - ⑦	23.9	25.8	21.1	23.5
Sum		100.0 (1,500)			

29.3% of those who opposed it.

Are you interested in participating in a double-shift vehicle system to reduce the occurrence of particulate matter? As a result, the average was 5.29 out of 7 (an average of 71.48 when converted to 100 points), indicating that they are willing to participate in a double-shift vehicle system to reduce the occurrence of particulate matter. Specifically, 69.5% of respondents said they were willing to participate in a double-shift vehicle system, and only 12.7% said they would not.

What do you think about replacing an old motorcycle with an electric motorcycle? As a result, the average was 5.39 out of 7 (average 73.16 when converted into 100 points), and it was necessary to replace the existing motorcycle with an electric motorcycle. In order to reduce the occurrence of particulate matter, 73.5% of the respondents said that it was necessary to replace the existing motorcycle with an electric motorcycle, and 5.8% said that it was not needed.

Budget and Organization for Particulate Matter Management

What do you think about how to increase the budget for implementing a particulate matter management system? Respondents reported that 70.7% of respondents said that polluters should pay for a budget to implement a particulate matter management system. On the other hand, 29.3% of the respondents said that particulate matter is a problem for all citizens and should be borne by general tax.

What do you think is the most important organization for solving particulate matter? In order to solve the problem of particulate matter, 70.4% of respondents answered that government is the most important organization, 24.1% said that companies are the most important organization, and 5.5% civic groups.

Conclusion

The purpose of this study is to measure public perception of particulate matter. For accomplishing the research goal, we conducted survey and use various kinds of variables, such as severity of particulate matter, effect of particulate matter on health, disease most affected by particulate matter, health problems, influencing factors of particulate matter emission, policies to reduce the occurrence of particulate matter, and so on.

The main results of the empirical survey on the fact of perception of particulate matter can be summarized as follows.

First, the severity of particulate matter was recognized as an average of 88.07 points, and 94.7% of the total respondents answered that they were serious.

Second, the average score of 84.86 showed that particulate matter had an adverse effect on their health, and 94.1% of the respondents answered that it had an adverse effect.

Third, in response to what diseases are most affected by particulate matter, respiratory diseases (cough, asthma, etc.) accounted for 53.1%, and 27.1% of lung diseases (pneumonia, lung cancer, etc.), and eye diseases (dry eye, conjunctivitis, etc.) was 7.7%.

Fourth, with regard to the health problems caused by particulate matter, respiratory diseases (cough, asthma, etc.) accounted for 54.1%, and 42.0% of eye diseases (dry eye, conjunctivitis, etc.) and skin diseases (skin problems, etc.) was 30.7%. 11.8% of lung

<Table 7> Budget and organization for particulate matter management

Classification	Answer	Percentage (%)	Gender(N)		Average monthly household income(N)		
			Male (766)	Female (734)	Upper (321)	Middle (839)	Lower (340)
Expansion of Particulate Matter Management Budget	Burden to pollutants (eg diesel car users, power plants, companies that emit particulate matter)	70.7	68.9	72.5	68.2	70.8	72.6
	As a matter of the whole nation, it is paid by general tax	29.3	31.1	27.5	31.8	29.2	27.4

Classification	Answer	Percentage (%)	Male (766)	Female (734)	Age(N)				
					20's (281)	30's (305)	40's (347)	50's (341)	60's (226)
The Most Important Organization for Solving Particulate Matter Problems	Government	70.4	73.8	66.9	68.0	68.2	68.6	72.7	75.7
	Company	24.1	20.9	27.4	22.1	24.9	28.5	23.5	19.5
	Civil organization	5.5	5.4	5.7	10.0	6.9	2.9	3.8	4.9
Sum		100.0 (1,500)							

diseases (pneumonia, lung cancer, etc.) and 7.5% of cardiovascular diseases (hypertension, myocardial infarction, etc.).

Fifth, factors that have the greatest impact on particulate matter emissions were highest at factories and power plants (49.1%) and automobile emissions at 38.3%.

Sixth, with regard to particulate matter problems, 63.3% of respondents found that it was more effective to find a countermeasure through cooperation with China on how to deal with China. In addition, 36.9% of the respondents demanded a cause identification and resolution through strong pressure on China.

Seventh, in response to the question of what is the most important policy to reduce the occurrence of particulate matter, 36.6% of respondents responded to the cause of foreign emissions, and 30.6% of responded to the reduction of thermal power plants. In addition, automobile emission reduction was 24.7%, and the replacement of aged urban heating with eco-friendly boilers was 7.7%.

Eighth, it was recognized that the introduction of the total pollutant emission system was necessary. 87.5% of the total respondents answered that the introduction of total pollutant emission system was necessary. On the other hand, the proportion of those who said they did not need was only 1.0%.

Ninth, it was recognized that a total amount of pollutant emission for industrial complexes (steel, cement, petrochemical, etc.) was required. 89.1% of the total respondents said that it is necessary to introduce the total pollutant emission system for industrial complexes (steel, cement, petrochemical, etc.). In contrast, the proportion of those who said they did not need (① + ② + ③) was only 0.8%.

Tenth, it was recognized that a mandatory introduction of a chimney automatic measuring device that remotely monitors workplace air pollutants is required. 90.9% of the respondents said that it is necessary to introduce a mandatory chimney measurement system that remotely monitors air pollutants in the workplace. On the other hand, only 0.9 percent of respondents said they were not needed.

Eleventh, respondents answered that the effective transportation policy to reduce particulate matters was 25.5% for the expansion of electric and hydrogen vehicles, 21.9% for the establishment of infrastructure for spreading public transportation, and 19.8% for the regulation of obsolete diesel vehicles.

Twelfth, people are willing to use public transportation to reduce the occurrence of particulate matter in the future. Specifically, 85.5% of the respondents answered that it is necessary to use public transportation to reduce the occurrence of particulate matter. And only 2.3 percent of respondents said they were not needed.

Thirteenth, if public transportation is convenient and infrastructure is expanded, they are willing to use public transportation to reduce the occurrence of particulate matter. Specifically, 88.5% of respondents said they were willing to use public transportation, and only 1.2% said they did not intend to use public transportation.

Fourteenth, respondents found 70.7% of those in favor of implementing a double-shift vehicle system to reduce the occurrence of particulate matter and 29.3% of those who opposed it.

Fifteenth, people are willing to participate in a double-shift vehicle system to reduce the occurrence of particulate matter. Specifically, 69.5% of respondents said they were willing to participate in a double-shift vehicle system, and only 12.7% said they would not.

Sixteenth, it is necessary to replace the existing motorcycle with an electric motorcycle. In order to reduce the occurrence of particulate matter, 73.5% of the respondents said that it was necessary to replace the existing motorcycle with an electric motorcycle, and 5.8% said that it was not needed.

Seventeenth, 70.7% of respondents reported that polluters should pay for a budget to implement a particulate matter management system. On the other hand, 29.3% of the respondents said that particulate matter is a problem for all citizens nation-wide and should be borne by general tax.

Eighteenth, in order to solve the problem of particulate matter, 70.4% of respondents answered that government is the most important organization, 24.1% said that companies are the most important organization, and 5.5% civic groups.

Based on the empirical analysis, the following key policy implications can be suggested. First, countermeasures to the problem of particulate matter should not only prevent the emission of particulate matter, but also provide health care policies to cure diseases that seriously damage health.. Second, measures must be taken to regulate particulate matter emissions from factories and power plants. Third, it is necessary to prepare effective particulate matter countermeasures through cooperation with China. Fourth, it is necessary to introduce a total amount of particulate matter emissions from industrial complexes, while mandatory attachment of chimney automatic measuring devices that remotely monitors air pollutants in the workplace. Fifth, in order to reduce particulate matter emissions, it is necessary to establish policies such as proliferation of electric and hydrogen vehicles, provision of public transportation infrastructure, and regulation of aged diesel vehicles. Sixth, making a more convenient public transportation system is very important to solve the problem of particulate matter.

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