보건학 석사 학위논문

A Randomized Study on the Effectiveness of the Geo-visualized Health Information of Air Pollution

무작위 배정을 이용한 미세먼지 건강영향 정보 지도시각화 효과 평가

2019 년 8 월

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ABSTRACT

A Randomized Study for the Effectiveness on the Geo-visualized Health Information of Air pollution

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From 2013, as the articles about the risk of air pollution have been flooded, the concerns on the health risk of air pollution have been increasing. As rises the worrying, the importance of the government's risk communication arises, too. In this study, we identified the effectiveness of visualized health information on air pollution, which is well-known as an effective way of communication to efficient communication.

It is Randomized study with 179 participants. It is 2 × 3 study design with two steps: first is the availability of the information about health information, second is model: text, infographic, tailored. We analyzed the outcome with two-way ordinal analysis with CLM.

In usefulness, ease, motivation to search for information, the severity of the risk, and motivation for taking action of prevention, there is a significant difference by models. In the severity of the risk, perception of the risk, and the motivation for taking action of prevention, there is a significant difference by the availability of health information. However, there is no interaction effect by model and availability of health information in all questions.

Through the scores of the usefulness of information, ease of information, motivation to search for the information, the severity of the risk, perception of the risk, and motivation for taking action of prevention, this study explored to find out the effectiveness of the geo-visualized health information of air pollution, also, the effectiveness of the availability of health information. This explorative study has a strength of randomized comparison and tried to minimize the biases (e.g., allocation, confounding), but there is a limitation of internal validity. Also, this study has a limitation in objectives because of using the questionnaire. The questionnaire is a subjective measuring tool, so there is a need to study in an objective approach like eye-tracking. Through this study, we could identify that it is the more visualized or tailored (personalized) or including the health information, it is more effective in risk communication. If using the visualized or the tailored (personalized) method to risk communication, then communicate more efficient in usefulness, motivating to search for information, risk severity, motivating for taking action of prevention. If using the health information in risk communication, then the severity of the risk, the perception of the risk, and the motivation for taking action of prevention are increasing. However, for improving the literacy of health information, details of visualization or personalization methods, and the way of providing the health information (for example, using the plain words) are needs more discussion to apply in practice.

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Keywords: Geo-visualisation, Risk communication, Air pollution, Particulate matter, Health information, Literacy, Infographic, Communication

Student Number: 2016-29733

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Ⅰ. Introduction

1. Background

The International Agency for Research on Cancer (IARC), under the World Health Organization (WHO) in 2013, has recommended that particulate matter in air pollutants is classified as a primary matter causing cancer. Respectively. Particulate matter, particles with a particle diameter of 10 μm or less as PM_{10}, has been reported to be significantly associated with the risk of respiratory diseases and cardiovascular events such as asthma, ischemic heart disease, arrhythmia, and myocardial infarction (Hyun-Joo, B. (2016)). The increased concentration of air pollution causes blurred vision and discomfort, as well as serious diseases such as conjunctivitis, sinusitis, otitis media, bronchitis, asthma, and chronic obstructive disease. (Jang, A.-S. (2014)). Long-term exposure to air pollution has been found to cause harmful effects on humans such as respiratory and cardiovascular diseases and immunity. Social concerns have increased, and media reports have increased rapidly since the second half of 2013 (Kim, Y. et al. (2016)). In recent years, air pollution has become the new greatest threat to the health of people living in Korea. In 2016, the Korea Institute for Health and Social Affairs surveyed 3,000 adults and found that people who answered the risk of air pollution is

the most urgent problem was the highest among public health issues. Also, we can see the air pollution became a very important factor in daily life by the weather forecast, even though the concentration of air pollution is now much lower than that of the past in the long term trend.

Risks are sized objectively based on the likelihood of occurrence and the severity of the consequences (Haimes, Y. Y. (2009)). However, the risk is important not only because it is an object that exists outside of the society or culture in which they live, but because it is constituted subjectively (Slovic, P. (2016)). If risk communication fails to provide the public with the reliable information that the public wants, and fails to gain an understanding of public and consensus on the core message, it will underestimate or overestimate the risk, impede proper risk decisions, confusing, and undermining confidence in the experts who provide risk information. According to Ahn, S. (2016) 'Assessment of health impact of air pollution using big data and estimation of damage cost (Ⅱ)', at least 55% and 75% of the total, respectively responded the best way to reduce air pollution expose on an individual basis is to have accurate information about air pollution and action plans to be taken at high concentrations. However, only 15.6% of respondents think that they are fully informed about the information on air pollution and their impact

on health. Also, 11.7% of respondents think that they are sufficiently provided with information that adverse health effects can be caused by air pollution (Ahn, S. (2016)). To solve this problem, it is necessary to construct a risk communication strategy to accurately recognize the air pollution issue and take appropriate action (Yungwook, K. et al. (2017)). However, the prevalence due to air pollution is now expressed as "10% increase in the prevalence of acute pulmonary disease when $PM_{2.5}$ concentration is 36 to 50 $\mu g/m^3$, and 10% increase in chronic asthma when 51 to 80 $\mu g/m^3$". It is difficult for the general public to see how the disease causes much health effects. Communication should be made through more specific and sensible risk comparisons (Kim, Y. et al. (2016)).

Human beings mainly rely on the vision to recognize, think, and act on information. Human beings tend to think of data and information only in language or numerology in the form of pictures or images in mind, and this is called visualization. Visualization of information can amplify cognitive abilities. It also helps users to understand information intuitively and efficiently for their purpose by classifying, arranging, and organizing large and diverse data in a specific format and visualizing and conveying them as meaningful information to the user. Effective

visualization data can help people learn and understand information more easily, as appropriate visualization representations can improve their perception of information (Zuo, Y., & Kim, H. (2014)). Spatial information visualization is defined as 'a method to facilitate spatial information comparison, pattern recognition, change detection, and information awareness by creating a visual system' (Kim, M.-Y. (2012)). Although there are several models related to the calculation of air pollution-related mortality rates, research on the mapping of cardiovascular or respiratory mortality information related to air pollution has not been actively conducted not only in Korea but also in overseas. Charts and box plots are often used as methods for expressing trends in mortality and air pollution, but there are few cases of mapping of air pollution or mortality rates. In particular, domestic studies on epidemiological mapping have been lacking, and studies on spatial distribution characteristics or maps have not been comparatively found. Efforts should be made to visualize mapping both contamination and mortality rates (calculated mortality rates) (Roh, Y.-h. (2017)).

2. Geo-visualization of Health Information of Air Pollution

1) Canada's AQHI

Table 1 Key Features of Canada's AQHI

Produced year	2005
Providing Air pollution composition	O_3, $PM_{2.5}$, PM_{10}, NO_2
Classification of Health impact	Four classes
	Low (1~3), Moderate (4~6), High (7~10), Very high (10+)
Location of station	General station
Predicted value (Today, Tomorrow)	Maximum predicted value
Hourly AQHI	Available
Concentration by component	Not available
Servicing the past AQHI	Not available, but next 18 hours
Geo-visualized form	Not available
Target population	At risk, General population
Mobile app service	Available

The Canadian Ministry of the Environment produced the AQHI (Air Quality Health Index) data in 2005 and provided online AQHI map (http://www.airhealth.ca). The purpose of the Canadian AQHI map was as follows.

(1) Helps to understand the health effects of ambient air quality.

(2) Protecting from air pollution by limiting or controlling short-term exposure.

(3) To inform vulnerable groups and the general public of the risk of air pollution and to protect them from air pollution.

The following are the contents delivered by Canada AQHI.

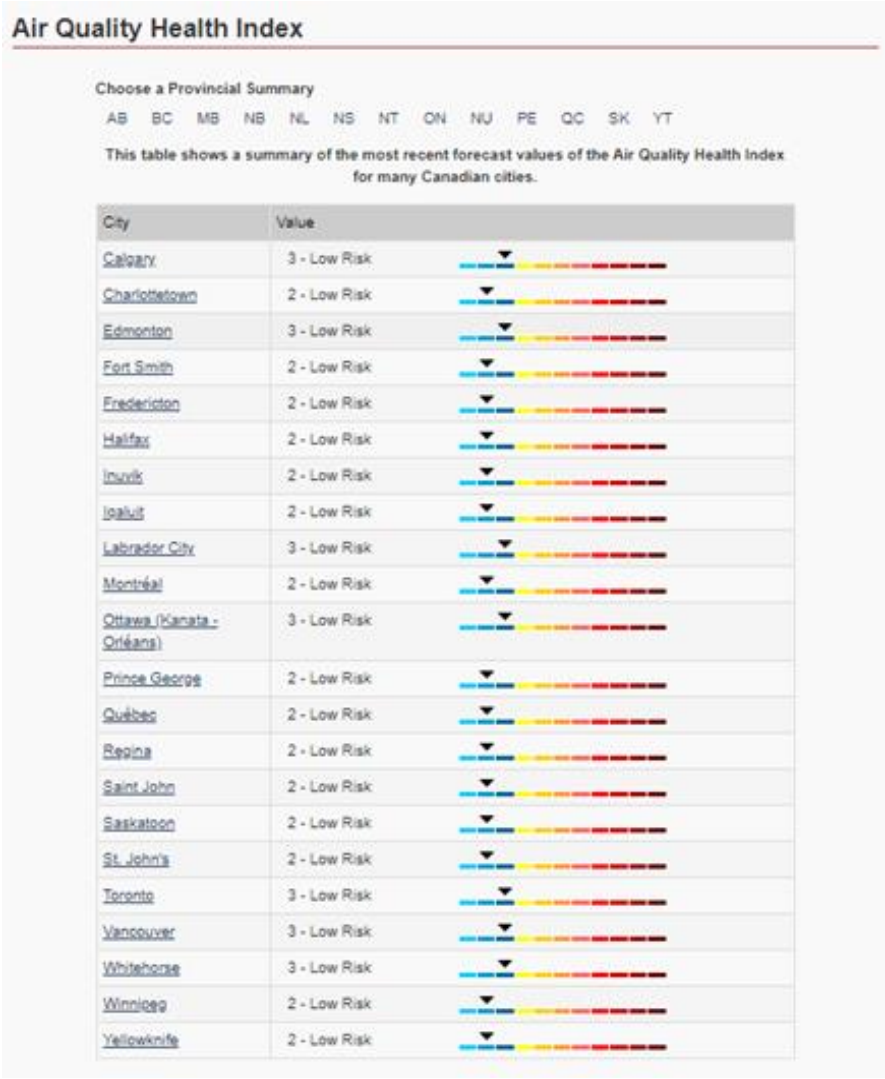
(1) Health risk (1~10+, low~very high) attribute to air quality (O_3, $PM_{2.5}$, PM_{10}, NO_2)

(2) Customized health messages to a vulnerable group

(3) AQHI value and current / tomorrow maximum predicted the value of AQHI

AQHI's most recent forecasts and hazards across the entire Canadian area are shown in a colored bar with bars in the summarized form (Figure 1). Figure 2 is the detail page of the selected area when selecting the area

of interest listed in alphabetical order. AQHI value and predicted AQHI value can be confirmed in detail area page. It also tells who the risk group is, and presents health advice to each of the public and the risk group and communicates the action to take.



Air Quality Health Index

Choose a Provincial Summary

AB BC MB NB NL NS NT ON NU PE QC SK YT

This table shows a summary of the most recent forecast values of the Air Quality Health Index for many Canadian cities.

City	Value
Calgary	3 - Low Risk
Charlottetown	2 - Low Risk
Edmonton	3 - Low Risk
Fort Smith	2 - Low Risk
Fredericton	2 - Low Risk
Halifax	2 - Low Risk
Inuvik	2 - Low Risk
Iqaluit	2 - Low Risk
Labrador City	3 - Low Risk
Montréal	2 - Low Risk
Ottawa (Kanata - Orléans)	3 - Low Risk
Prince George	2 - Low Risk
Québec	2 - Low Risk
Regina	2 - Low Risk
Saint John	2 - Low Risk
Saskatoon	2 - Low Risk
St. John's	2 - Low Risk
Toronto	3 - Low Risk
Vancouver	3 - Low Risk
Whitehorse	3 - Low Risk
Winnipeg	2 - Low Risk
Yellowknife	2 - Low Risk

Figure 1 Example of Canada's AQHI

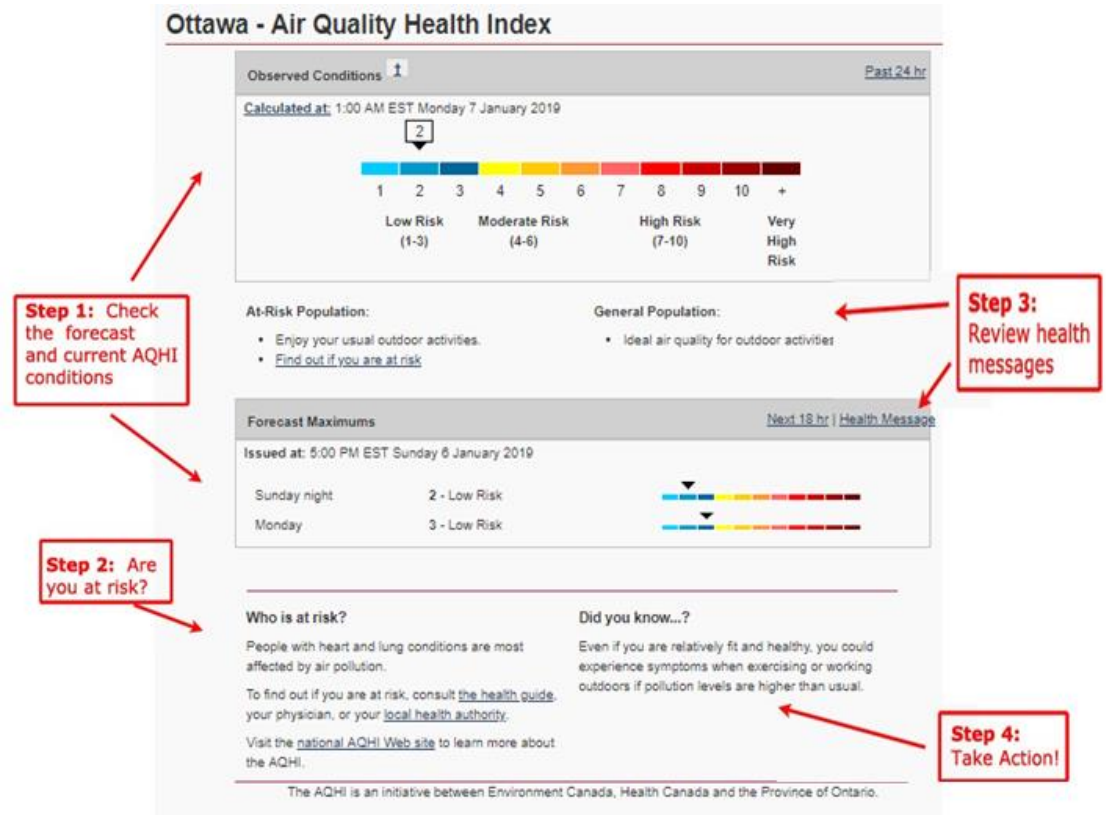


Figure 2 Detailed Regional page of Canada's AQHI

2) Hongkong's AQHI

Table 2 Key Features of Hongkong's AQHI

Produced year	2013
Providing Air pollution composition	O_3, $PM_{2.5}$, PM_{10}, NO_2, SO_2
Classification of Health impact	Five classes
	Low (1~3), Moderate (4~6), High (7), Very high (8~10), Serious (10+)
Location of station	General station, Roadside station, Suspended
Predicted value (Today, Tomorrow)	Minimum/Maximum predicted value
Hourly AQHI	Available
Concentration by component	Available
Servicing the past AQHI	Available, in the past 24 hours
Geo-visualized form	Available
Target population	At risk, Outdoor worker, General population
Mobile app services	Available

The Ministry of Environment of Hong Kong has produced AQHI maps since 2013 (http://www.aqhi.gov.hk/en.html). Hong Kong' purpose of the AQHI map is as follows:

(1) Provide timely and useful air pollution information.

(2) Provide short-term health risks and health protection measures of air pollution.

(3) Take prior action to the occurrence of severe air pollution.

Hong Kong AQHI delivers the following information.

(1) Cumulative health effect risk (1 ~ 10 +, low to severe) due to 3-hour moving average concentration of air quality (O_3, $PM_{2.5}$, PM_{10}, NO_2, SO_2)

(2) Health advice tailored to vulnerable groups, outdoor workers, and the general public

(3) AQHI value by current time, tomorrow predicted value range

Figure 3 is the main page of Hong Kong AQHI. Figure 3 shows the AQHI value and the health risk level in the general area and roadside

observatories of Hong Kong, as shown. When the mouse is over the area with a circle on the map on the main page, a box showing detailed information of the selected area appears in Figure 4. Click the 'Concentration' / 'AQHI' tab in the box (Figure 4_②) to move to the page where you can see the dust concentration / AQHI for the past 24 hours (Figure 6, 7). The table on the right side of Figure 3 is the same as Figure 5 and lists cities in Hong Kong alphabetically. AQHI's most recent forecasts and risks for all Hong Kong regions are summarized in Figure 5. In Figure 5, ③, the day is divided into 12 hours, showing the health risks according to the degree of PM observations in the general area and the roadside. Also, the degree of risk was visualized by adding color and emulsion according to the size of AQHI. Figure 5 also shows the data of the monitoring station of the selected area (users can select the interesting area among listed in ④ of Figure 5) (Figure 8). Press ⑤ and ⑥ in Figure 5 to move to Figures 6 and 7, respectively, to see the AQHI value and predicted AQHI value for the last 24 hours in the selected area.

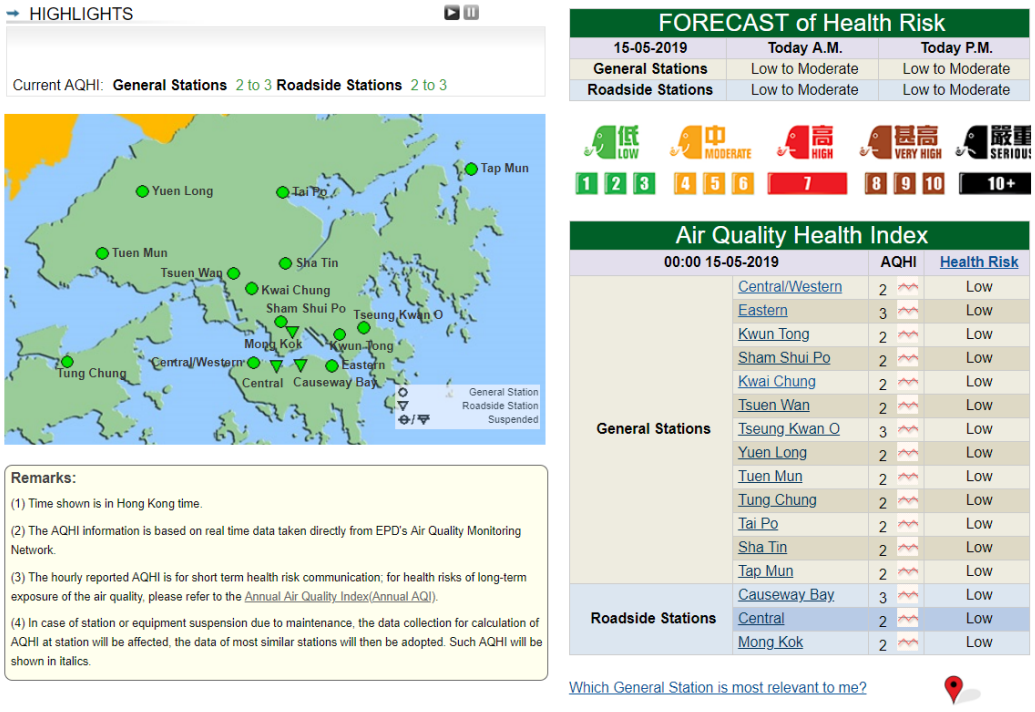


Figure 3 Main page of Hongkong's AQHI

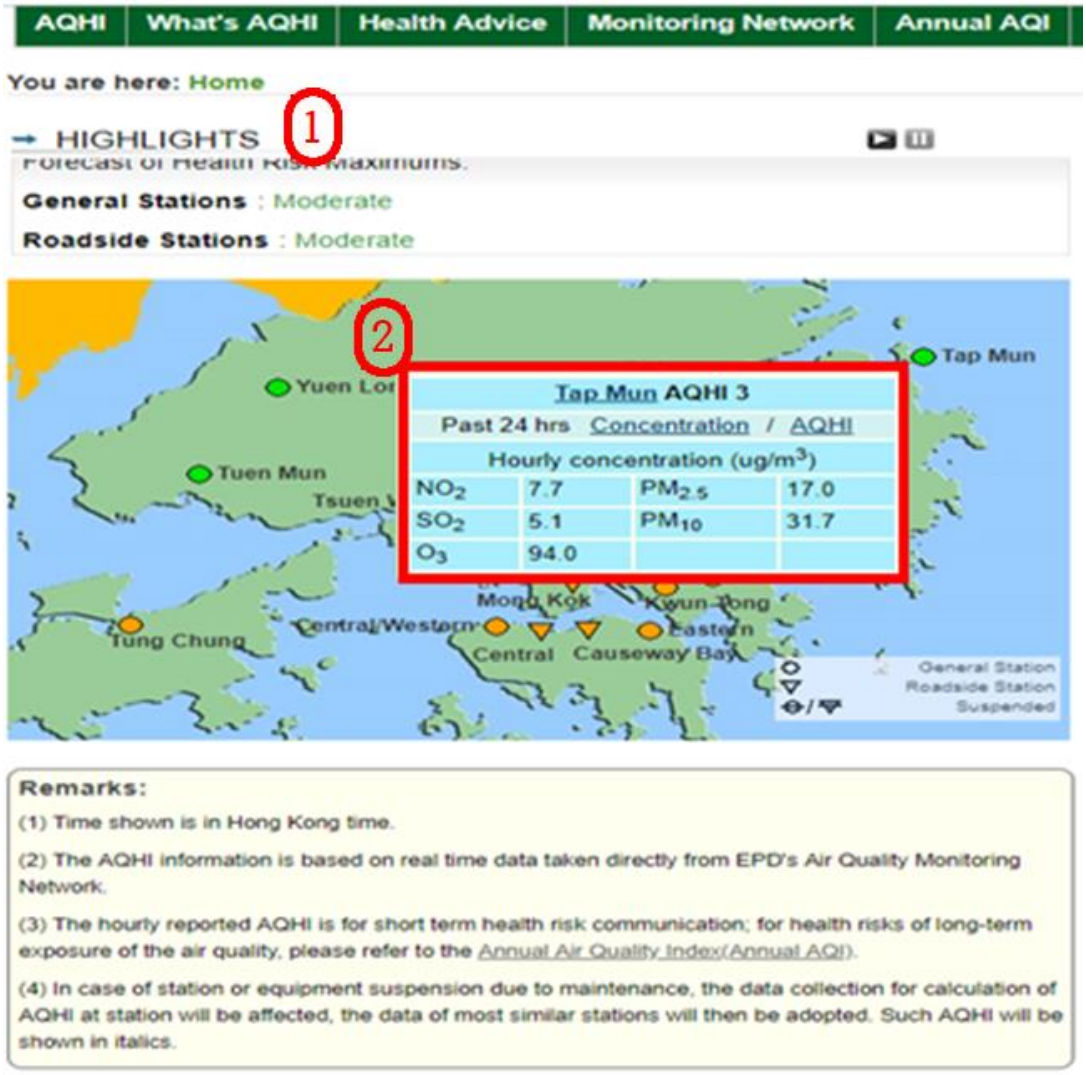
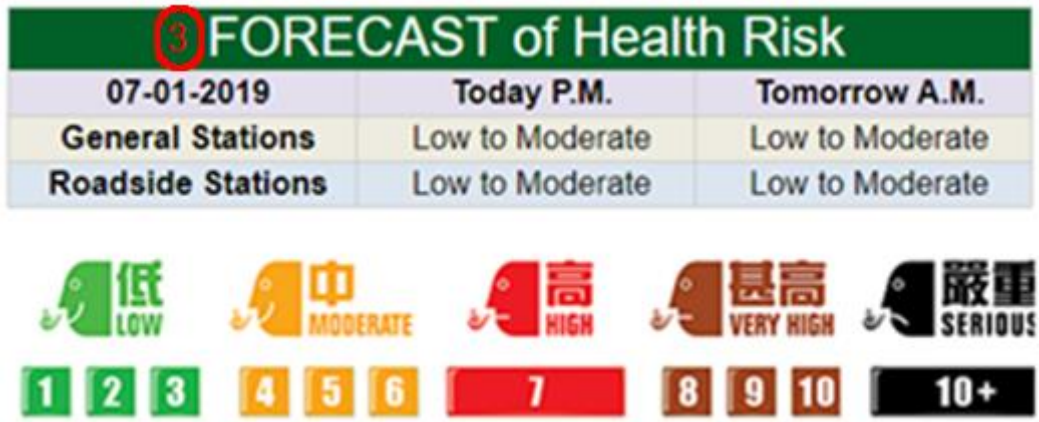


Figure 4 Map on the Main page of Hongkong's AQHI



3 FORECAST of Health Risk		
07-01-2019	Today P.M.	Tomorrow A.M.
General Stations	Low to Moderate	Low to Moderate
Roadside Stations	Low to Moderate	Low to Moderate

低 LOW 1 2 3 | 中 MODERATE 4 5 6 | 高 HIGH 7 | 甚高 VERY HIGH 8 9 10 | 嚴重 SERIOUS 10+

Air Quality Health Index				
13:00 07-01-2019			AQHI	Health Risk
General Stations	4	Central/Western	3	Low 6
		Eastern	3	Low
		Kwun Tong	3	Low
		Sham Shui Po	3	Low
		Kwai Chung	3	Low
		Tsuen Wan	3	Low
		Tseung Kwan O	3	Low
		Yuen Long	3	Low
		Tuen Mun	3	Low
		Tung Chung	3	Low
		Tai Po	3	Low
		Sha Tin	3	Low
		Tap Mun	3	Low
Roadside Stations		Causeway Bay	4	Moderate
		Central	4	Moderate
		Mong Kok	4	Moderate

Figure 5 Table on the Main page of Hongkong's AQHI

Past 24 Hours Pollutant Concentration Summary

General Stations

- Central/Western
- Eastern
- Kwun Tong
- Sham Shui Po
- Kwai Chung
- Tsuen Wan
- Tseung Kwan O
- Yuen Long
- Tuen Mun
- Tung Chung
- Tai Po
- Sha Tin
- Tap Mun

Roadside Stations

- Causeway Bay
- Central
- Mong Kok

Central/Western

Date Time	NO_2	O_3	SO_2	CO	PM_{10}	$PM_{2.5}$
2019-05-15 00:00	39.9	15.1	2.8	-	9.8	7.7
2019-05-14 23:00	37.3	18.4	3.1	-	11.1	8.2
2019-05-14 22:00	38.1	17.1	2.4	-	7.9	6.3
2019-05-14 21:00	21.6	27.6	2.1	-	7.6	3.5
2019-05-14 20:00	40.3	13.6	2.7	-	7.9	4.9
2019-05-14 19:00	17.8	32.5	1.9	-	11.0	7.9
2019-05-14 18:00	42.4	18.6	5.5	-	18.2	9.9
2019-05-14 17:00	37.3	23.2	8.4	-	12.2	9.5
2019-05-14 16:00	23.7	45.4	3.6	-	15.0	10.1
2019-05-14 15:00	33.7	45.4	2.4	-	15.1	10.3
2019-05-14 14:00	29.8	42.7	2.4	-	-	-
2019-05-14 13:00	42.4	26.8	3.1	-	-	-
2019-05-14 12:00	57.1	12.4	5.2	-	-	-
2019-05-14 11:00	54.8	11.2	5.2	-	21.7	15.9
2019-05-14 10:00	58.2	7.5	6.0	-	19.0	15.5
2019-05-14 09:00	48.4	17.3	3.7	-	23.5	20.7
2019-05-14 08:00	37.6	26.2	3.3	-	24.4	20.6
2019-05-14 07:00	27.0	30.7	2.6	-	29.1	23.2
2019-05-14 06:00	18.6	38.4	2.5	-	32.0	24.9
2019-05-14 05:00	19.4	41.0	2.4	-	39.5	26.8
2019-05-14 04:00	19.8	44.3	2.5	-	41.8	27.5
2019-05-14 03:00	21.7	45.9	2.5	-	41.4	27.0
2019-05-14 02:00	21.7	49.6	2.6	-	46.2	30.2
2019-05-14 01:00	39.7	37.4	2.8	-	42.5	28.7

Remarks:

(1) Time shown is in Hong Kong time.

(2) NO_2 - nitrogen dioxide, O_3 - ozone,
SO_2 - sulphur dioxide, CO - carbon monoxide,
PM_{10} - respirable suspended particulates,
$PM_{2.5}$ - fine suspended particulates

(3) Concentration shown is in $\mu g/m^3$.

(4) The pollutant concentration is based on real time data taken directly from EPD's Air Quality Monitoring Network.

Figure 6 Selected Region's Concentrations of Air Pollution in the past 24 hours on Hongkong's AQHI

Past 24 Hours AQHI Summary

General Stations

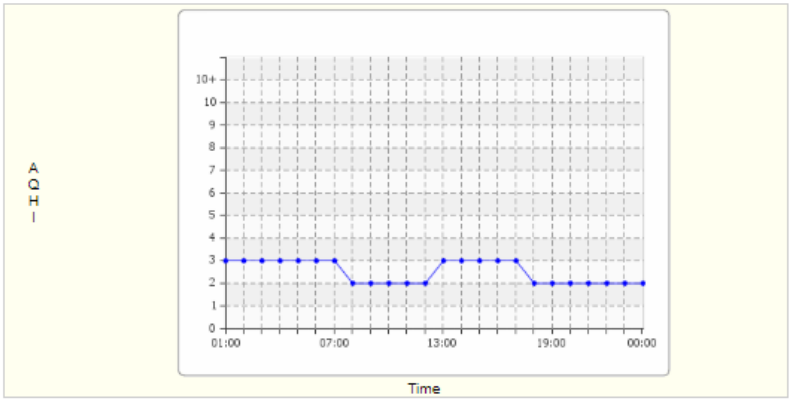
- Central/Western
- Eastern
- Kwun Tong
- Sham Shui Po
- Kwai Chung
- Tsuen Wan
- Tseung Kwan O
- Yuen Long
- Tuen Mun
- Tung Chung
- Tai Po
- Sha Tin
- Tap Mun

Roadside Stations

- Causeway Bay
- Central
- Mong Kok

Chart Index

Central/Western



Date Time	AQHI
2019-05-15 00:00	2
2019-05-14 23:00	2
2019-05-14 22:00	2
2019-05-14 21:00	2
2019-05-14 20:00	2
2019-05-14 19:00	2
2019-05-14 18:00	2
2019-05-14 17:00	3
2019-05-14 16:00	3
2019-05-14 15:00	3
2019-05-14 14:00	3
2019-05-14 13:00	3
2019-05-14 12:00	2
2019-05-14 11:00	2
2019-05-14 10:00	2
2019-05-14 09:00	2
2019-05-14 08:00	2
2019-05-14 07:00	3
2019-05-14 06:00	3
2019-05-14 05:00	3
2019-05-14 04:00	3
2019-05-14 03:00	3
2019-05-14 02:00	3
2019-05-14 01:00	3

Remarks:

(1) Time shown is in Hong Kong time.

(2) The AQHI information is based on real time data taken directly from EPD's Air Quality Monitoring Network.

Figure 7 Selected Region's AQHI of Air Pollution in the past 24 hours on Hongkong's AQHI

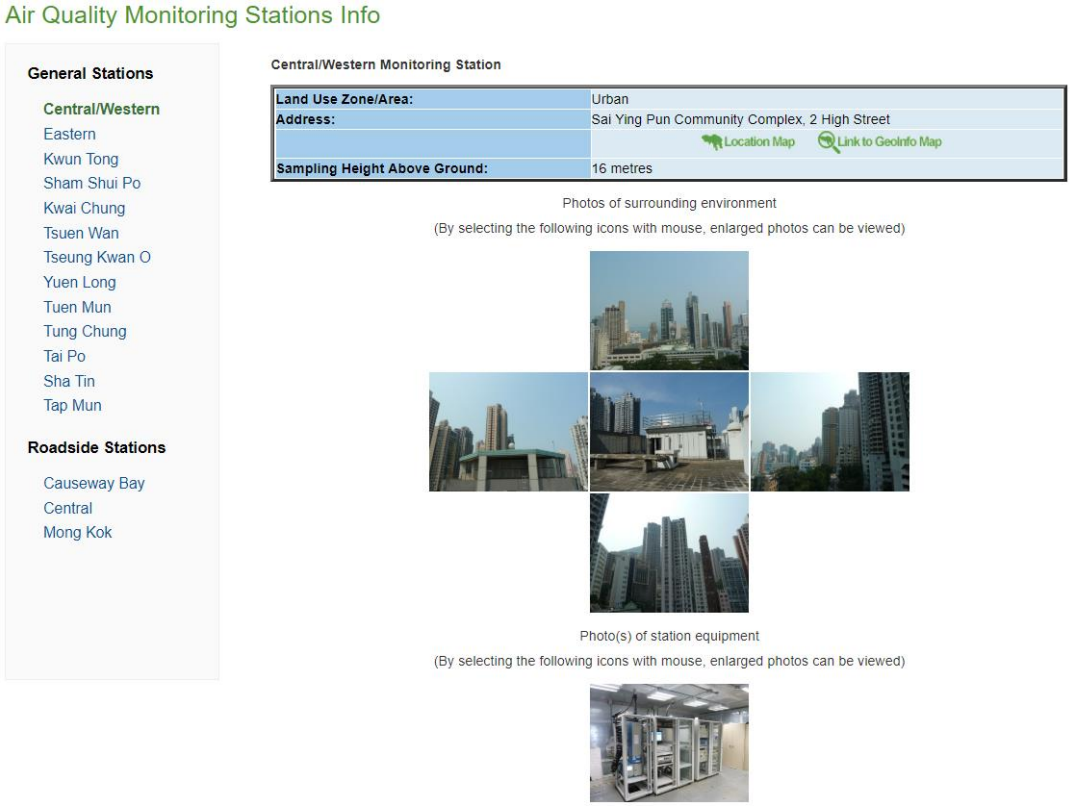


Figure 8 Air Quality Monitoring Station Info of the selected region on Hongkong's AQHI

3) Korea's AQHI

Korea's air pollution visualization has two characteristics. The first is that visualization services provided by public enterprises (Figure 9) are not as effective as the visualization provided by private companies (Figure 10). Secondly, the quality of air pollution is shown as 'good' or 'bad.' It is focused on showing the quality of air as it is. Private companies have designed to be more straightforward (Figure 10). Both visualizations, however, show unprocessed data to users, such as air pollution concentrations and air pollution concentration trends. Although the data itself is simple, it does not know what kind of action to take and what kind of damages are caused by air pollution. Unlike the case of Canada and Hong Kong, in both cases in Korea do not provide information on health effects due to air pollution. It is necessary to make an effort to visualize and provide information on health effects due to air pollution in Korea.

Figure 9 Visualized Air Quality map provided by Public Enterprises

(Airkorea)

대기오염정보

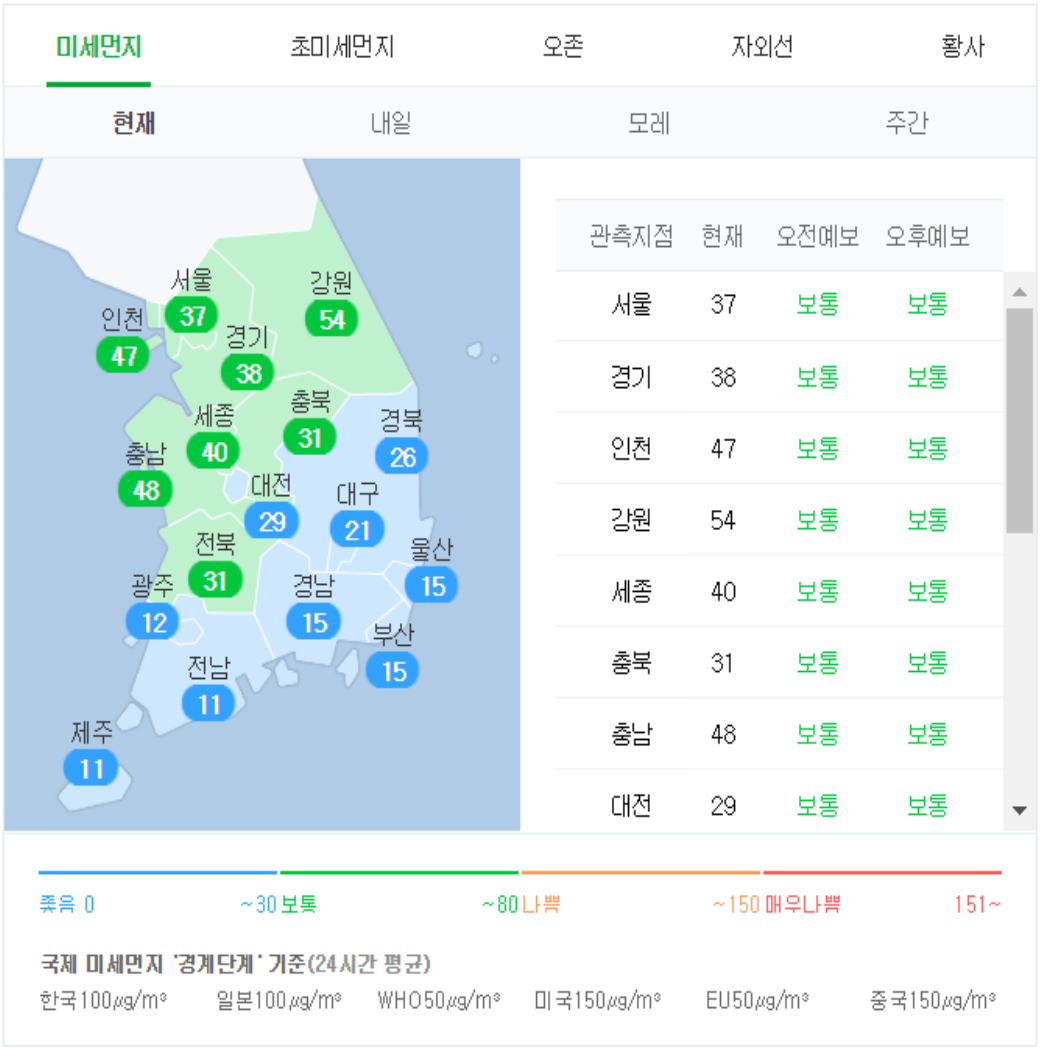


Figure 10 Visualized Air Quality map provided by a private company (NAVER)

3. Literature Review

1) The strategy of searching the literature

(1) PICO-SD

- Problem: Effectiveness of Geo-visualized Health risk
- Intervention: All types of intervention
- Comparison: All types of comparison
- Outcomes: All types of changes in cognitive, behavior, knowledge, etc.
- Time: No time limits
- Study Design: Observational study, RCT (Randomized Controlled Trial/CT (Clinical Trial)

(2) Searching Database

We conducted a systematic review based on the electronic Database. To getting enough literature, focus on the worldwide database for searching. The used databases are PubMed, EMBASE, PsycINFO. There is no limit to the time in the past, but used the literature only published before the time in searching the literature.

(3) Search term

The used search term bases on 'Does pictorial health information improve health behaviors and other outcomes? A systematic review protocol'. To fit into this subject, modified the base search term as below:

(graphic or visual* or infographic) and (literacy or health literacy or communication or risk) and (health information or health) and (map OR mapping OR geographic OR geo*) and "air pollution"

It is divided into five parts to focus on our interesting subjects.

(4) Inclusion and Exclusion criteria

We included the literature of dealing the all types of changes in cognitive, behavior, knowledge, etc. as an outcome. However, we excluded the rest of subjects like a tool of the map, neurological outcome, etc. Also, we excluded the report of methodology or case studies like qualitative studies.

2) The procedure for Selecting Literature

Collected the literature from the online databases, and selected the literature using the inclusion/exclusion criteria. Fifty-three records are identified through database searching in total (PubMed: 17, EMBASE:

35, PsycINFO: 1). 10 records are deleted for duplication. In screening, 43 records are screened, but 36 records are deleted for the unrelated subject. Seven articles assessed for eligibility, but the four are excluded for these reasons; 1. Not about our intervention or outcome (e.g., Burden of diseases), 2. Case report, 3. Methodology research. The included qualitative literature was 3 in total.

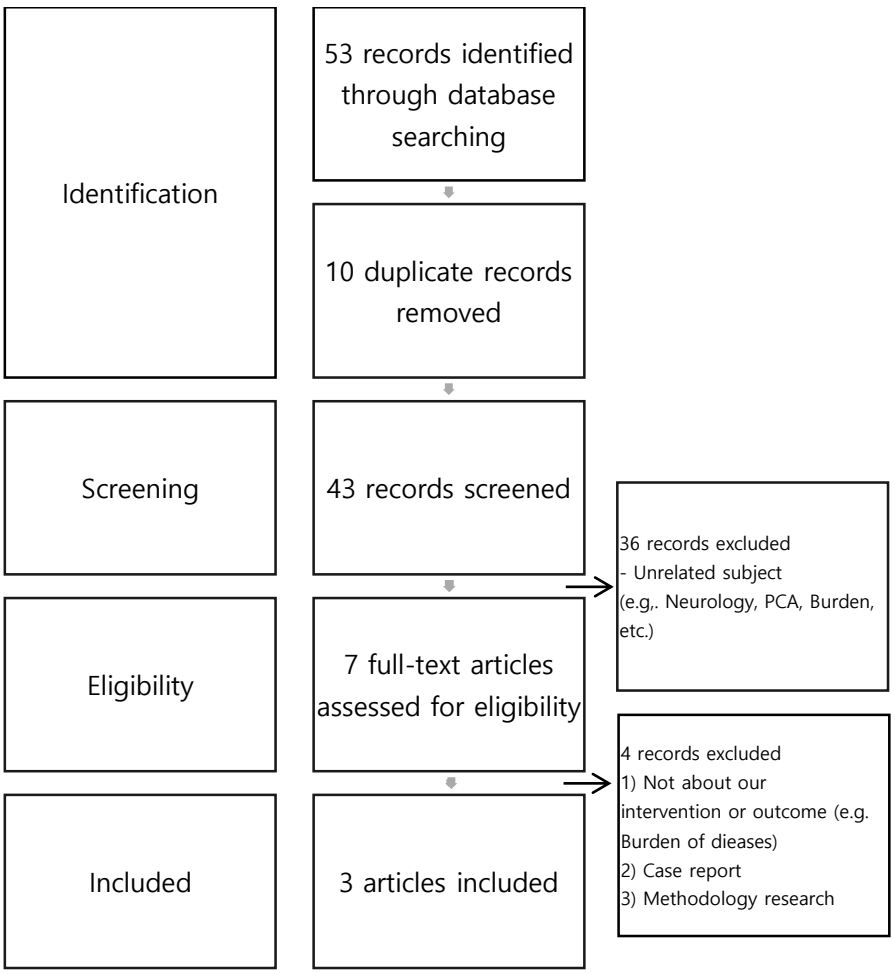


Figure 11 Flow diagram of Literature Review

3) Analysis of the literature

For accurate analysis, make a table for included literature. It has the structure of the study, population, intervention, and results of each.

4) Result of Literature Review

In Severtson, D. J. (2015), comparing the maps by four cancer risk levels and three types of dichotomous features(appearance of map contours, number of colors, how risk was express in the legend) of the map(factorial 4 × 2 × 2 × 2 study). Analyzed participants are 826; they are undergraduate students at the University of Wisconsin-Madison). They are randomly allocated to 32 maps. Through this study, we can identify the certainty of the visual feature was judged as less adequate but met both communication goals and addressed numeracy barriers. Also, expressing relative risk using words in communication arose uncertainty and addressed numeracy barriers but was judged as highly inadequate.

In Shendell, D. G. et al. (2007), School-based intervention is conducted by the flag system to inform the quality of air. From this study, they could improve the quality of life by visualizing the risk of air pollution by the flag system.

Study of Wong, C. et al. (2019) is cross-over(comparing pre-post of intervention) and conducted in two different age group. High-school youth are trained about traffic-related air pollution and how to use its air pollution map of Chinatown as an intervention. Adults are trained to how to interpret the map from the participated youth. In result, youth's pollution knowledge increased and conversation with parents significantly. Adults have increases in pollution knowledge, attitudes toward environmental issues, and self-efficacy in using maps.

From the literature review, we can find some studies to identifying the effectiveness of visualization of risk. However, there are no reports of effectiveness between texted risk and visualized risk. So, we can expect to identify the effectiveness of geo-visualized risk comparing texted risk. Moreover, the effectiveness of a tailored geo-visualized risk could be compared.

Table 3 Summary of findings from the literature review

ID Author (Year)	Journal	Type of study	Participants	№ of participants	Intervention	Results
Severtson, D. J. (2015)	Journal of Science communication	Randomized Controlled Trial	3,300 undergraduate students at the University of Wisconsin-Madison (UW-Madison)	826	2 × 2 × 2 × 4 study : 32 study maps, four cancer risk levels*Map features (uncertain vs. certain) were (a) appearance of map contours (unfocused vs. focused); (b) number of colors (one vs. three); and (c) how risk was expressed in the legend (verbal and relative without evaluative labels vs. a numerical simple frequency with evaluative labels)	The certainty of the visual feature was judged as less adequate but met both communication goals and addressed numeracy barriers. Also, expressing relative risk using words in communication arose uncertainty and addressed numeracy barriers but was judged as highly inadequate.

Shendell, D. G., et al. (2007)	Journal of Environmental Health	Panel study (Winter, 2004 – Spring, 2006)	The San Joaquin Valley agricultural region of Central California comprises urban and rural communities in nine counties	Over 36 public school districts, 402 public schools, 22 private schools, and 22 other locations	The school-based flag system based on the Air Quality Index	Reducing the exposure of outdoor environmental asthma triggers, local health, and help improve the quality of life.
Wong, C. et al. (2019)	Journal of Health Communication	Cross-over design	Two different age group(high-school youth in an after-school program at a Chinatown service agency, two subgroups of adults: working-age adults are attending ESL classes at a Chinatown agency, ("ESL adult students"), and adults ("community meeting attendees") recruited from the Chinatown community.	82 (High school students: 9, Adult(ESL Adult Student: 21, Community Meeting Attendees: 52))	Training high-school youth in their junior and senior years ("high school youth" or "youth") about traffic-related air pollution and how to use our Air Pollution Map of Chinatown, adults about how to interpret the map	Youth have an increase in knowledge of pollution, conversation with parents. Adult participants demonstrated statistically significant improvements in all three domains (pollution knowledge, attitudes toward environmental issues, and self-efficacy in using maps)

4. Objectives and Hypothesis

In health risk communication, one of the many challenges to communicate with the public is the difficulty in expressing information in an easily comprehensible form (Jessica S. Ancker et al., (2006)). In 'Teaching patients with low literacy skills (Cecilia C. Doak et al., (1985))', those with low literacy skills can not read the health information. Not only vocabulary limitation, often they can not understand the illustrations and medical pictures used in health-care materials. Health literacy is based on the concept of literacy; it is reasonable to assume that individuals with limited literacy also have limited health literacy. In aspects of delivering risk communication, literacy of data also has a significant role. Health information that is hard to read may remain inaccessible to low health literacy people (Mcinnes, Nicholas, Haglund, Bo JA., (2011)). In 'Quick Guide to Health Literacy (USDHHS, (2006)), considering the following questions when develop and deliver health information; 'Is the information appropriate for the users?', 'Is the information easy to use?' 'Are you speaking clearly and listening carefully?'. So we use the questions about ease and usefulness to an estimate the literacy of data. According to Convello, Vincent T. et al., (1988), there are four major types as a measure of the effectiveness of

risk communication programs; Information and Education, behavior change and protective action, disaster warnings and emergency information, and joint problem solving and conflict resolution. As aspect of the delivery of risk communication, informing and educating people about risks and risk assessment, in general, is effective and recommended. So, we attempted to identify the differences in the effectiveness of giving health information or not.

Cecilia C. Doak et al., (1985) stated directions to meeting the special needs of poor readers; concentrate on the main message, reduce the amount of reading in the text, provide visual cues and interaction, provide motivation. They recommend the visualization method for poor readers. According to Doris Dransch, et al., (2010), one of the tasks in map-mediated risk communication to the public is creating visualization with a personal view; create personalized maps, customize information. Effective visualization of information can amplify cognitive abilities. It also helps users to understand information intuitively and efficiently for their purpose by classifying, arranging, and organizing large and diverse data in a particular format and visualizing and conveying them as information meaningful to the user. Effective visualization data can help people learn and understand information more easily, as appropriate

visualization representations can improve their perception of information (Zuo, Y., & Kim, H. (2014)). Spatial information visualization is defined as 'a method to facilitate spatial information comparison, pattern recognition, change detection, and information awareness by creating a visual system' (Kim, M.-Y. (2012)). Maps can play a decisive role in risk communication because of the strong spatiotemporal component of natural hazards. However, the application and design of maps to the public has not been investigated comprehensively in risk communication (Dransch, Doris, et al., (2010)). In this study, we attempted to compare the effectiveness of providing types of information. Also, we tried to identify the existence of an interaction between the availability of health information and providing types of information additionally.

In this study, the effectiveness of risk communication with visualization of the risk which attributes to air pollution using the Korean data (concentration of air pollution in the city, county level and cause of death data) has been evaluated. This can be used to compare the effectiveness of each providing forms of information and effectiveness of providing health information in the effectiveness of risk communication aspect. In terms of information recognition, effective information providing models such as text, infographic, and tailored models can be selected. Also, it is

expected that the risk of perception and action will be changed by providing information about the concentration of air pollution and health effect in the aspect of risk perception and coping practice.

In this study, Text model is defined as written health information by Barry Margarete M et al., (2012). Infographics, enhancing our understanding, is a method of visually communicating (McCrorie, AD et al., (2016)). The infographic model in this study using the definition of "larger graphic design that combines data visualizations, illustration, text, and images together into a format that tells a complete story" by Parrish, Candace P (2016). Especially we used graphic design mediating the map for this study. Tailoring is defined as any of several methods for creating communications individualized for their receivers underlying the expectation that this individualization will lead to larger intended effects of these communications(Hawkins, Robert P., et al. (2008)). Tailoring aims to enhance the relevance of the information presented and thus to produce more significant desired changes in response to the communication. This study using the meaning of tailoring as 'tailored communication' that produces a message matched to the needs and preferences of individuals. In Tailored model, the first showing page of information is tailored by collected interesting location of respondents.

The following hypotheses were established to evaluate the effectiveness of efficient visualization of health risk of air pollution and to evaluate the effectiveness of visualized data on the communication of risk information.

Hypothesis 1. H_0: There is no difference in the result value according to the information providing type.

Hypothesis 2. H_0: There is no difference in the results according to whether health information is provided or not.

Hypothesis 3. H_0: There is no significant interaction effect depending on the type of information provided and whether or not health information is provided.

Outcome: Usefulness, Ease, Motivation to search for information, Severity, Risk perception, Motivation for taking action of prevention.

Ⅱ. Method

1. Participants

1) Participants

In this exploratory study, we attempted to find out the effect of risk communication with the map of health risk attribute to air pollution and improvement before applying to a larger population. So limited the participants to the member of Seoul National University. However, to ensure that the sample is representative, the sample was collected by posting recruitment of research participants, focusing on places where a variety of people gathered, such as a student hall or a library, and their surroundings. Those who want to participate in the study could participate through the QR code and the online link of the recruitment inquiry in the school or online. The questionnaire proceeds with a PC, tablet PC, and mobile device of participants to increase the respondent's convenience.

2) Sample size

The reference for calculating the sample size was referred to as the 'Sample Size Considerations for Multiple Comparison Procedures in ANOVA (2006)'.

There is a similar study to refer to the sample size. The average value of the three visualization versions to understand the effective metaphor component comprehension was 3.44, and the standard deviation was 0.51. The appropriate number of sample size in the literature is 165 and 55 per group (Zuo, Y., & Kim, H. (2014)).

2. Study Design

1) Study design

The study had been designed as an experiment with random allocation using a form of questionnaire to find out how to effectively communicate risk due to air pollution. The experiment used the data of map visualized risk information (air pollution concentration ($PM_{2.5}$), health effect information (excess mortality)). All study participants receive two sets of data (Step 1: do not contain health information, and Step 2: contain health information). Each data is composed of text, infographic, and tailoring, and defined as Text, Infographic, and Tailored models according to each form. This research design is a 2 × 3 design according to health information (Step 1, 2) and given data's form (Text, Infographic, Tailored) with random allocation in the types of model (Figure 12).

Research participants are randomly assigned to three models (Text, Infographic, Tailored) by the computer when they access the questionnaire page through the link of the mail. No personally identifiable information is included except for e-mail collection for duplicate participation and granting an ID. Because this is an online questionnaire that scoring the usefulness, degree of easy understanding, the perception of the given data, etc. of the given data, so no part directly

harms the participants. Also, at randomization, participants were assigned to each model as 1: 1: 1 as possible and randomly assigned by a computer. Since researchers do not know what model they are assigned to, it is blinding (masking) study that can minimize the harm that the probability of identifying someone.

The period for the recruitment of research participants and the questionnaire period was from October 24, 2018, to November 20, 2018, for one month, but could end earlier than planned when the number of planned participants reaches early. However, since the number of research participants could not be limited in real-time, so it could be more recruitment of participants than planned. The researcher did not change the part of the rest (for example, study design, etc.).

This study was conducted under IRB approval (IRB No. 1809/001-006) and complied with research ethics.

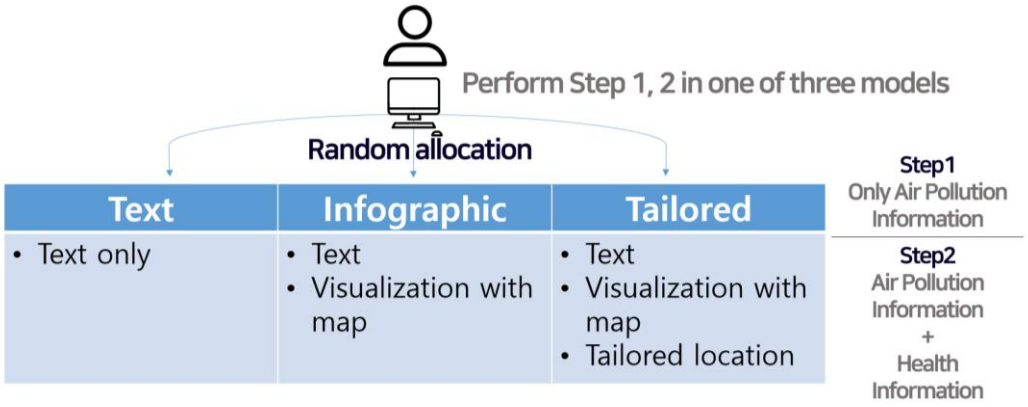
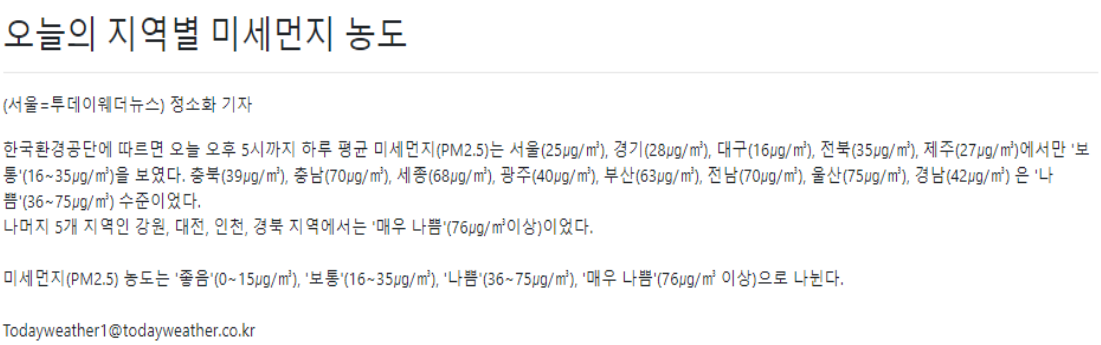


Figure 12 Study design and summary of the used intervention

2) Intervention

This study design is a randomized trial of 2×3 design according to health information (Step 1,2) and the data format (Text, Infographic, Tailored). The summary of the used intervention is in figure 12. Below is a detailed description of the interventions used.

The text model provided information in the form of the actual article contents with text only (Figure 13, 14).



오늘의 지역별 미세먼지 농도

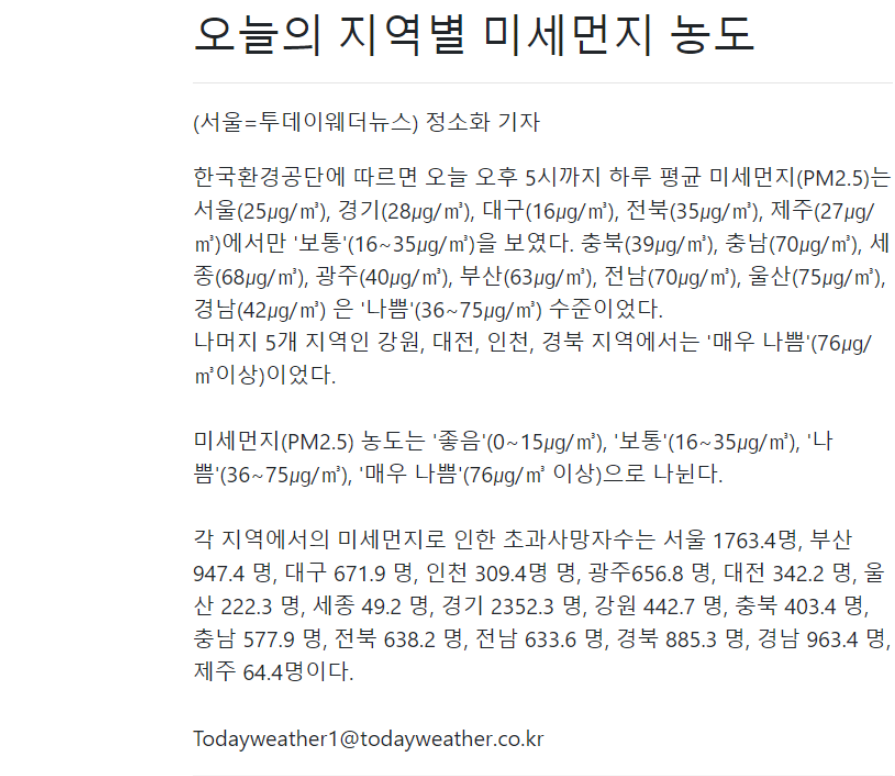
(서울=투데이웨더뉴스) 정소화 기자

한국환경공단에 따르면 오늘 오후 5시까지 하루 평균 미세먼지(PM2.5)는 서울(25㎍/㎥), 경기(28㎍/㎥), 대구(16㎍/㎥), 전북(35㎍/㎥), 제주(27㎍/㎥)에서만 '보통'(16~35㎍/㎥)을 보였다. 충북(39㎍/㎥), 충남(70㎍/㎥), 세종(68㎍/㎥), 광주(40㎍/㎥), 부산(63㎍/㎥), 전남(70㎍/㎥), 울산(75㎍/㎥), 경남(42㎍/㎥) 은 '나쁨'(36~75㎍/㎥) 수준이었다.
나머지 5개 지역인 강원, 대전, 인천, 경북 지역에서는 '매우 나쁨'(76㎍/㎥이상)이었다.

미세먼지(PM2.5) 농도는 '좋음'(0~15㎍/㎥), '보통'(16~35㎍/㎥), '나쁨'(36~75㎍/㎥), '매우 나쁨'(76㎍/㎥ 이상)으로 나뉜다.

Todayweather1@todayweather.co.kr

Figure 13 Example (without Health information (Step 1)) of the Text model



오늘의 지역별 미세먼지 농도

(서울=투데이웨더뉴스) 정소화 기자

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나머지 5개 지역인 강원, 대전, 인천, 경북 지역에서는 '매우 나쁨'(76㎍/㎥이상)이었다.

미세먼지(PM2.5) 농도는 '좋음'(0~15㎍/㎥), '보통'(16~35㎍/㎥), '나쁨'(36~75㎍/㎥), '매우 나쁨'(76㎍/㎥ 이상)으로 나뉜다.

각 지역에서의 미세먼지로 인한 초과사망자수는 서울 1763.4명, 부산 947.4 명, 대구 671.9 명, 인천 309.4명 명, 광주656.8 명, 대전 342.2 명, 울산 222.3 명, 세종 49.2 명, 경기 2352.3 명, 강원 442.7 명, 충북 403.4 명, 충남 577.9 명, 전북 638.2 명, 전남 633.6 명, 경북 885.3 명, 경남 963.4 명, 제주 64.4명이다.

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Figure 14 Example (with Health information (Step 2)) of the Text model

The infographic model is showing the map of Korea with the degree of air pollution concentration or the number of excess deaths (Figure 15, 16). When the participants enter the page, the shown page is a map of Korea, colored according to the concentration of air pollution or the number of excess deaths by city, county level. In step 1 (Figure 15, 17), color-coded as very bad to good indicates the state criteria of concentration of air pollution divided by national standards. In step 2 (Figure 16, 18), the number of excess deaths is added in step 1. According to the concentration of air pollution and the number of excess deaths, it shows the degree of good to very bad, and the color of letters and the color of tooltip's frame is changed by the degree of good to very bad. Considering that the Standard Deviation (SD) of the data is 588.5, the number of excess deaths was set to a legend of 600 persons. Also, the research participant who is provided health information can select the area they want to view freely. In selecting the region, the information of the selected area name and given information by the model is shown in the upper left tooltip. In Step 1, showing the concentration of air pollution only, but the number of excess deaths is added in Step 2 (Figure 17, 18).

지역별 하루 평균 $PM_{2.5}$

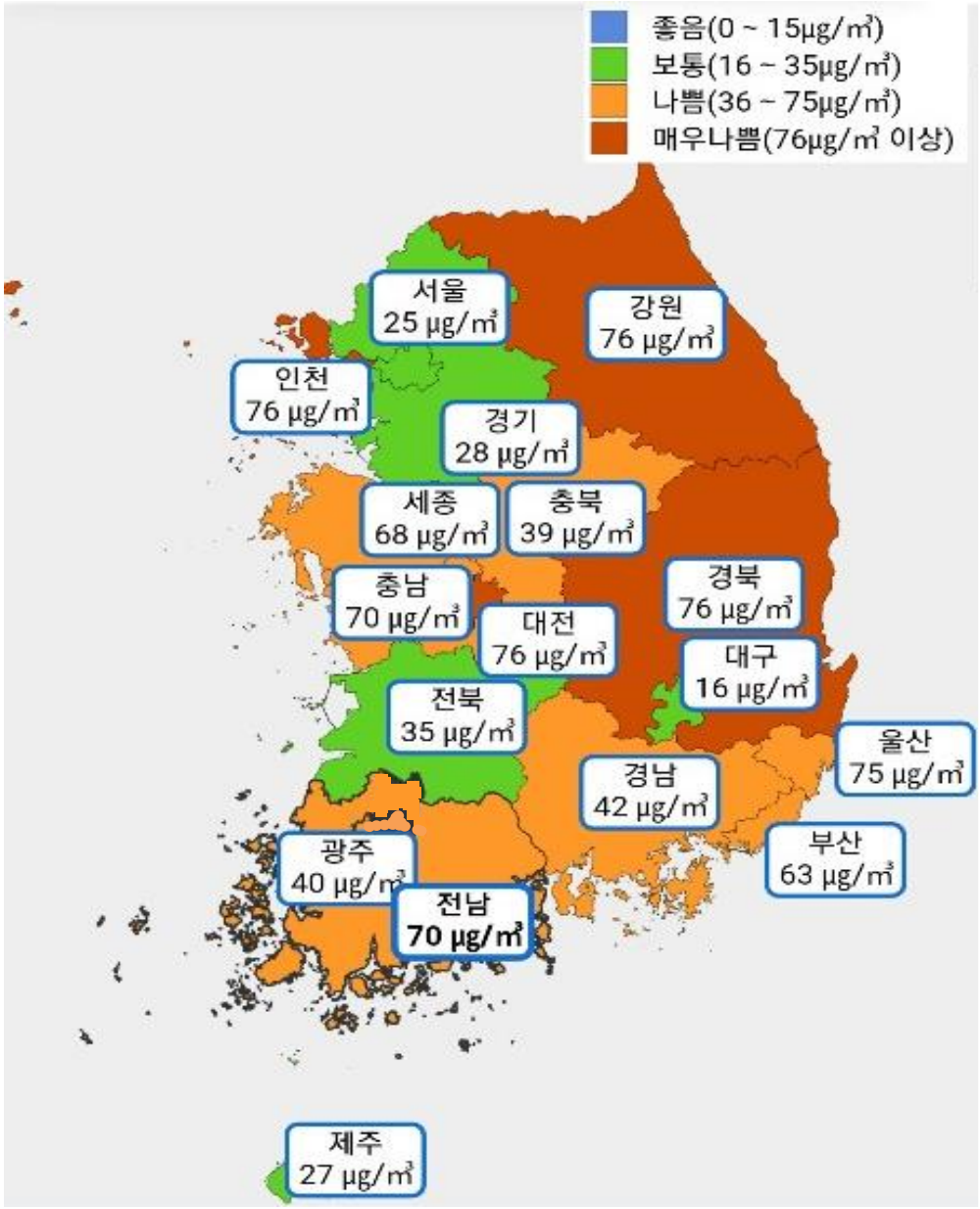


Figure 15 Example (without Health information (Step 1)) of the Infographic model

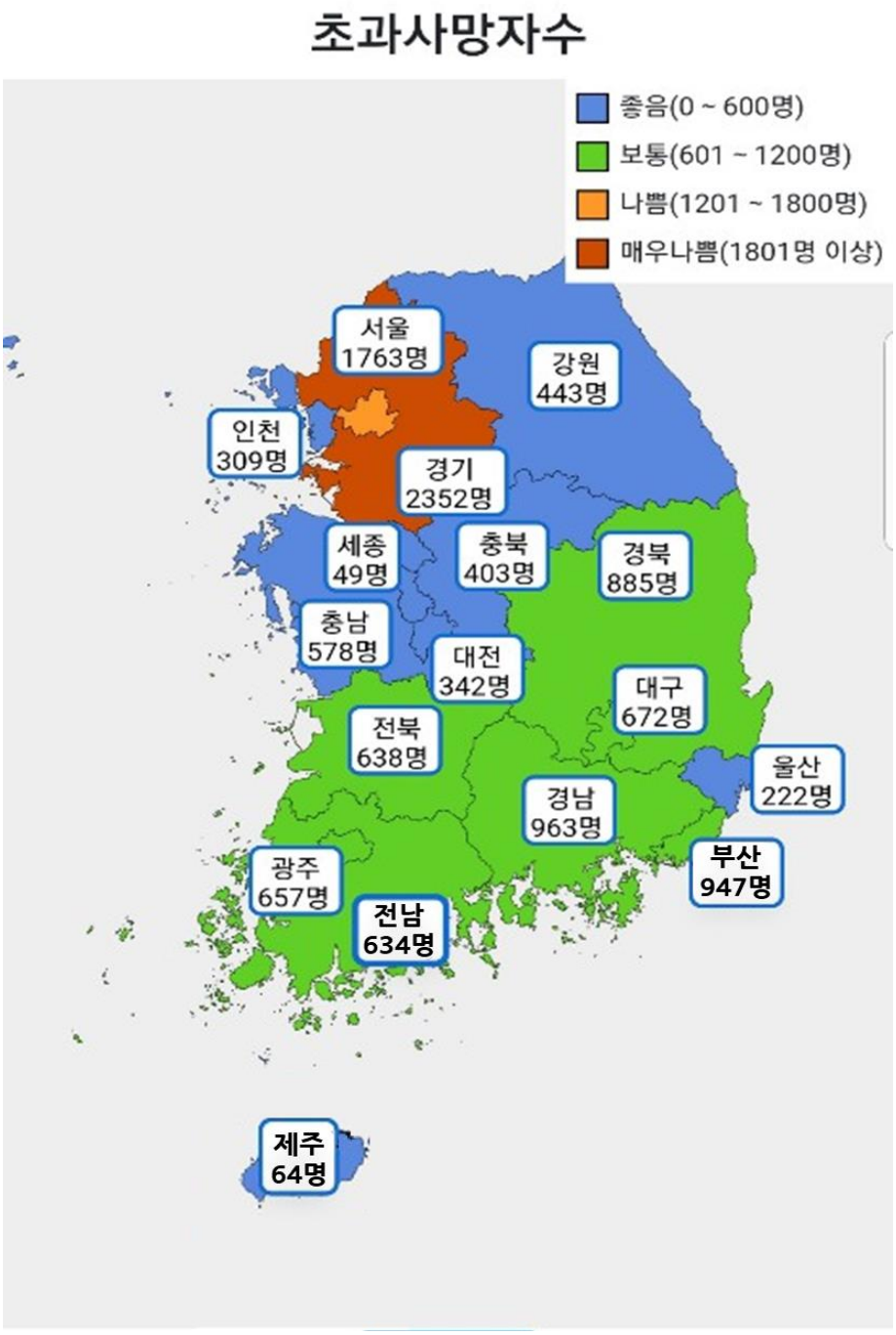


Figure 16 Example (with Health information (Step 2)) of the Infographic model

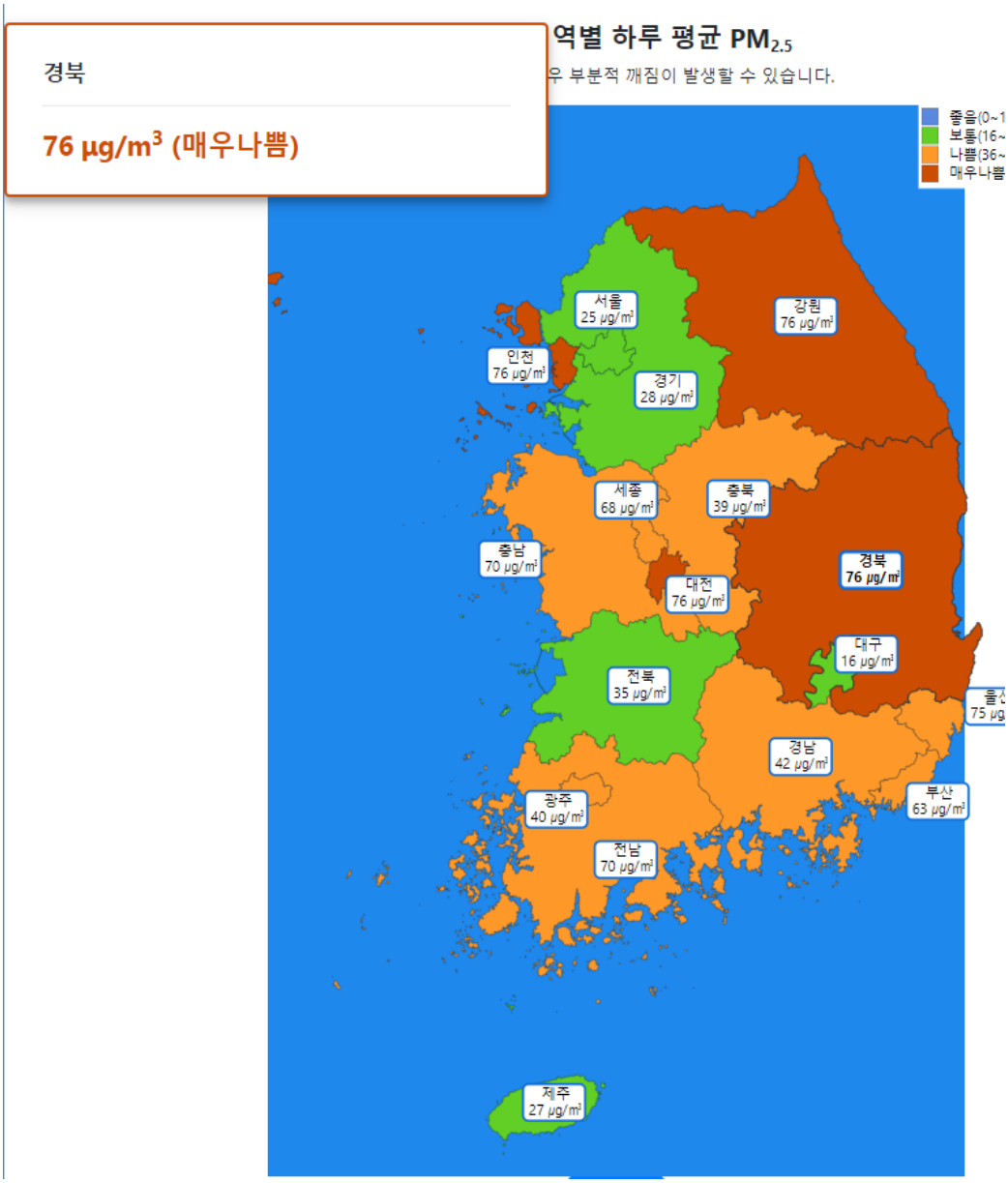


Figure 17 Example (without Health information (Step 1)) of the Infographic model

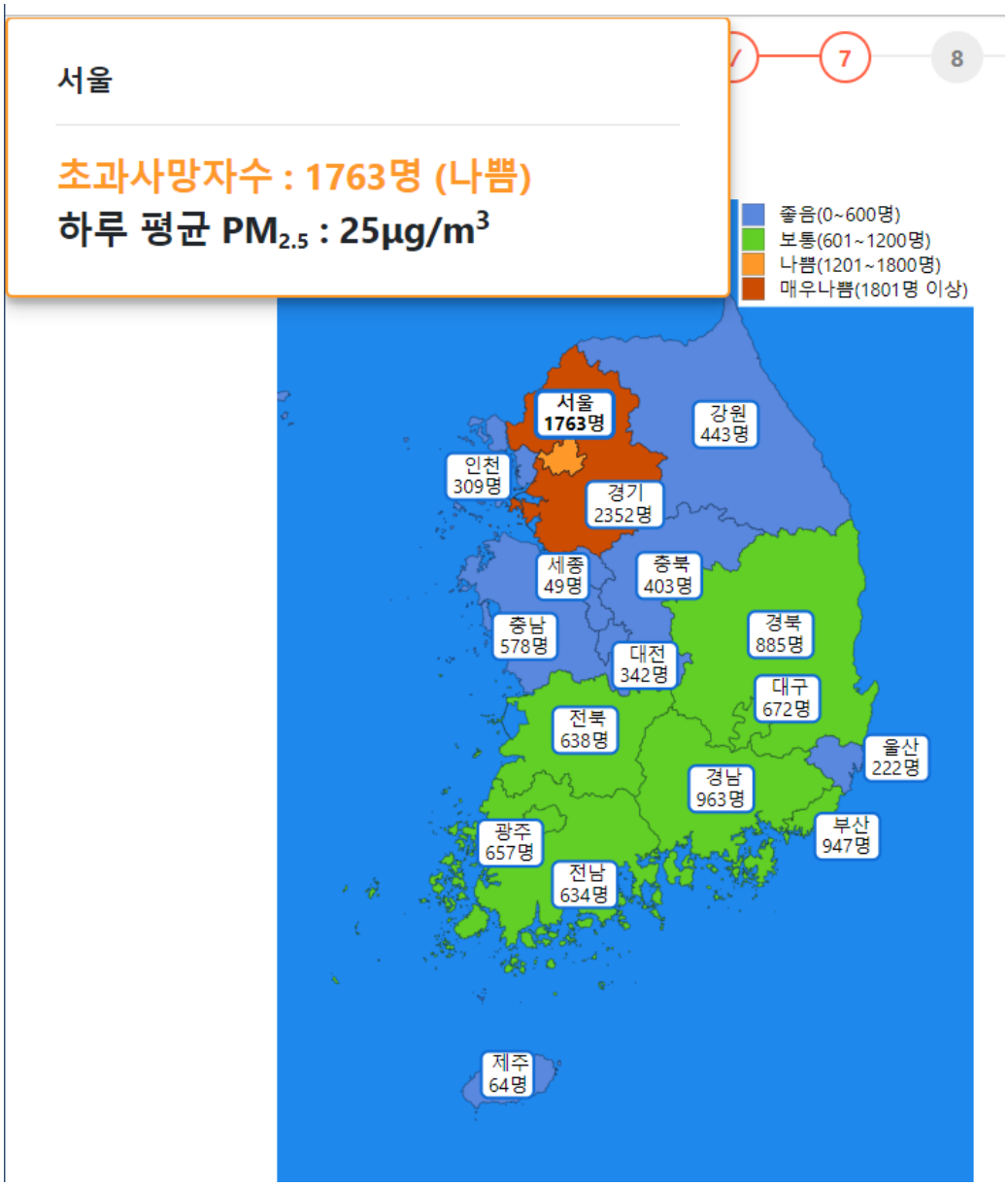


Figure 18 Example (with Health information (Step 2)) of the Infographic model

The tailored model is based on the design of the infographic model, but the research participants saw the enlarged area of selected as an interesting area in the previous questionnaire and are provided the information of the area on the tooltip with priority (Figure 19, 20). Participants can freely click on another area to check the information in that area.

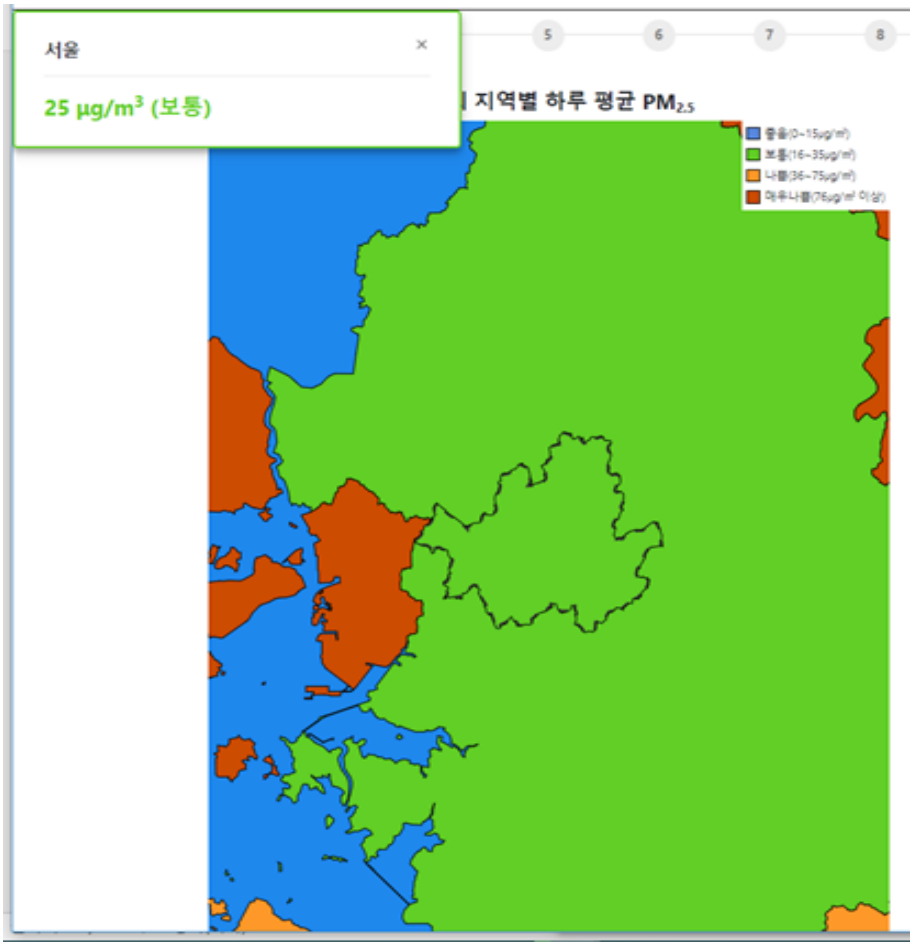


Figure 19 Example (without Health information (Step 1)) of Tailored model

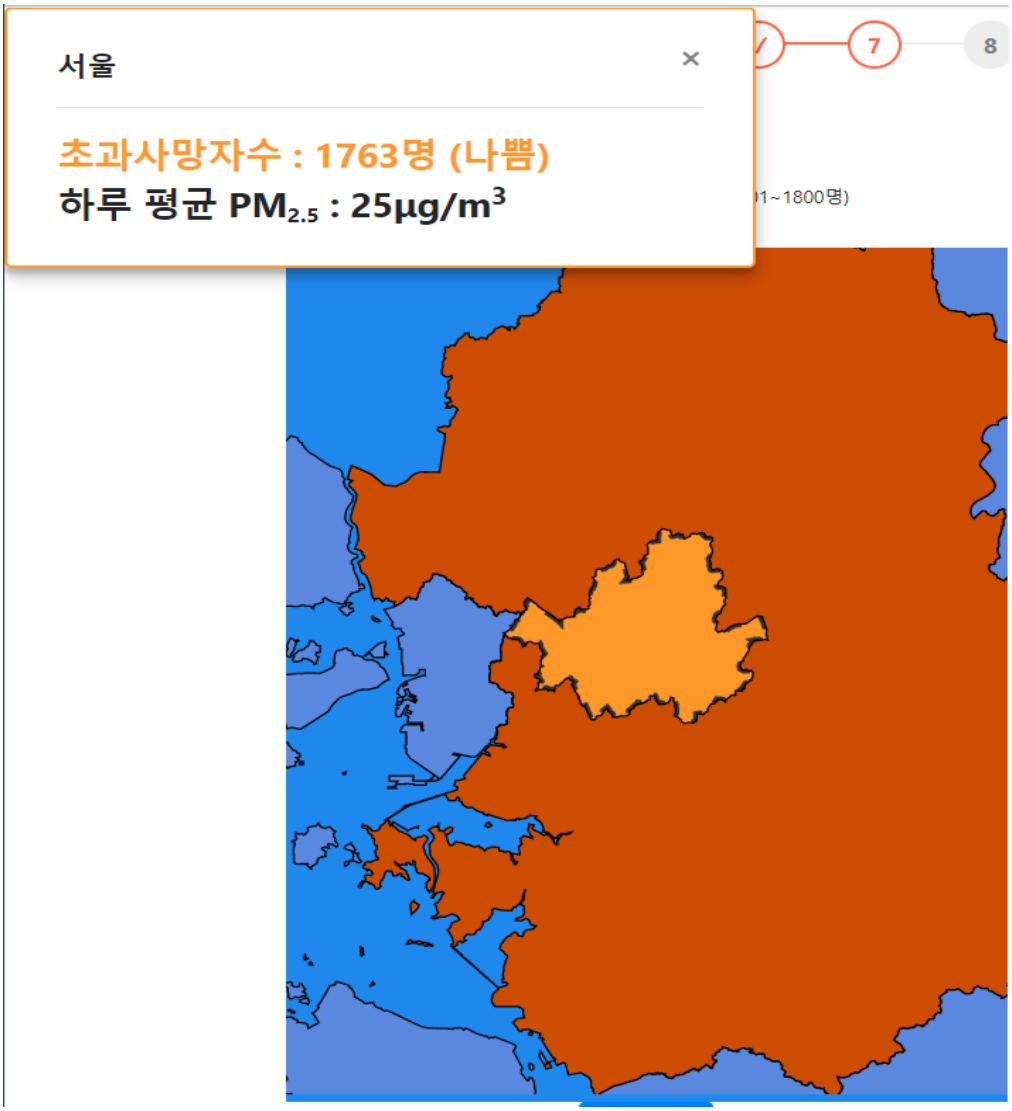


Figure 20 Example (with Health information (Step 2)) of Tailored model

3) Used data

The risk of mortality due to air pollution used in this study is part of the results of Han, C. et al., (2018). Name of cities and provinces, Concentration of $PM_{2.5}$ at the year 2015, Population census data of the year 2015(age over 25) and a total number of deaths attributable to $PM_{2.5}$ by cities and provinces have been used for the study (Appendix 1). Using data had been produced for evaluating the spatial and temporal trends of the health burden attributable to $PM_{2.5}$ in the metropolitan cities and provinces of Korea. It had used modeled $PM_{2.5}$ concentration data for the basic administrative levels (the cities and the provinces of Korea). Corresponding annual population census data for each level, and the age and cause-specific mortality data. They had applied cause-specific integrated exposure-response functions to calculate the premature mortality attributable to ambient $PM_{2.5}$ for some disease endpoints (ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), lung cancer (LC), and cerebrovascular disease (stroke)) for the year 2015. Also, they had assessed the temporal trends of the health burden from 2006 to 2015. In 2015, the annual average $PM_{2.5}$ concentration for Korea was 24.4 $\mu g/m^3$, and 11,924 premature deaths were attributable to $PM_{2.5}$ exposure. It simulated preventable premature

deaths means that if reducing the annual mean values of $PM_{2.5}$ to 10 $\mu g/m^3$, about 8,539 premature deaths can be preventable. There was spatial variation in the burden of mortality attributable to $PM_{2.5}$ across the sub-national regions of Korea.

4) Process of questionnaire

The flow of the completed questionnaire is in Figure 21. Full questionnaire sheets, including a description of research and consents, are in Appendix 2.

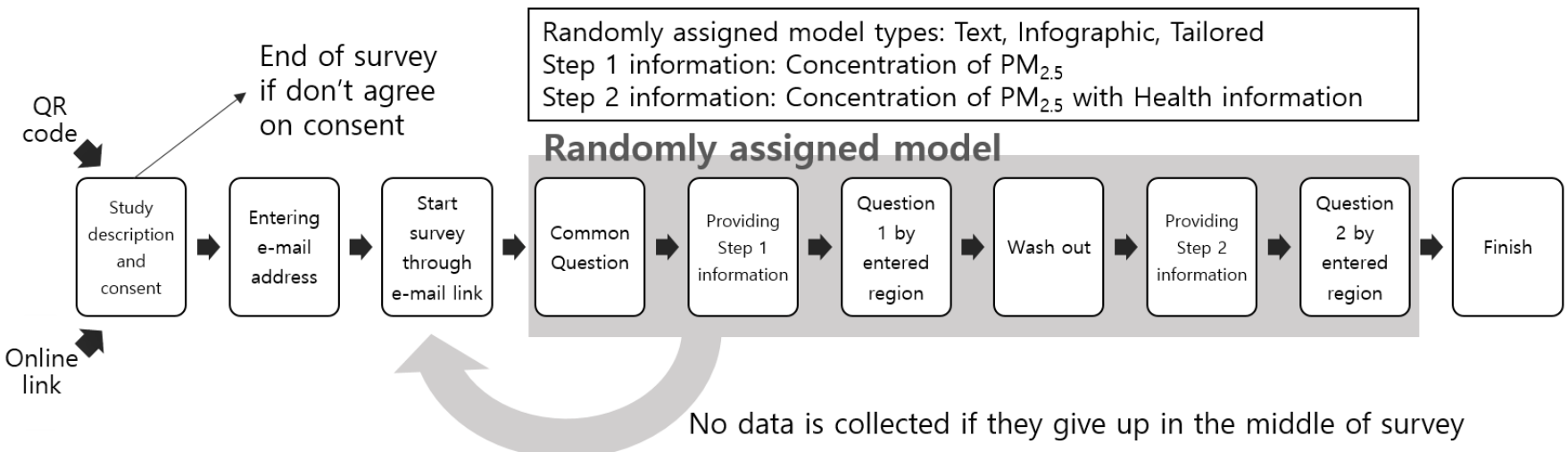


Figure 21 Process of Questionnaire

(1) Through QR codes or online links, interested people in research flow to below notice page before the questionnaire (Figure 22).

Figure 22 Entering page through the QR code or online link

(2) Before starting the questionnaire, describe the research, and make consent for participation. After then, insert the e-mail address of Seoul National University to prevent the duplication and limit the participants as the member of Seoul National University (Figure 23, 24).

Figure 23 Description of study

Figure 24 Consent to participate in research

(3) The participants can start the main questionnaire through the link on e-mail which entered e-mail address. In e-mail, there is a link to join the questionnaire, a description of research, and consent for the preserve(Figure 25).

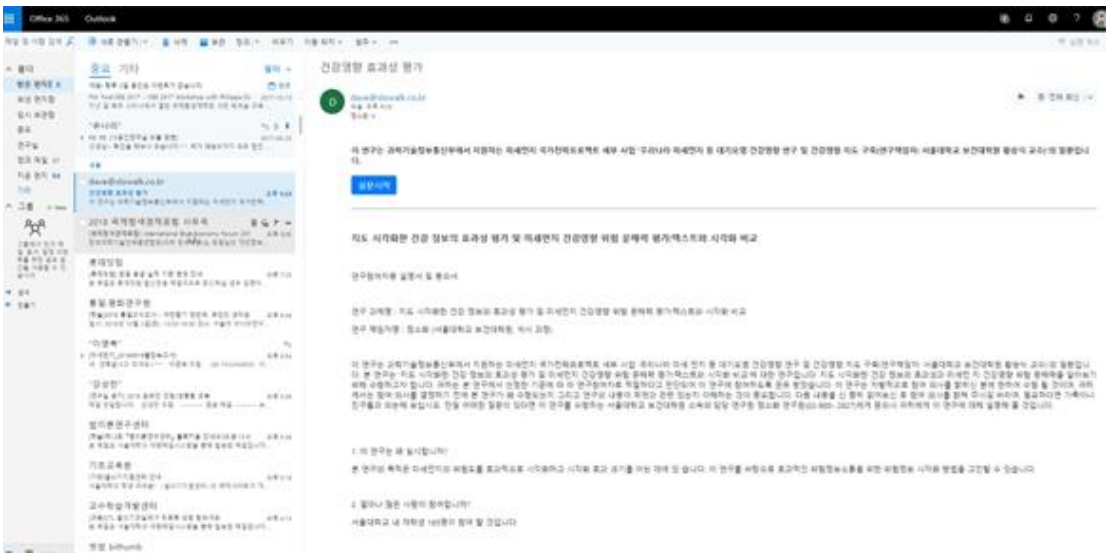


Figure 25 Step to check SNU member through e-mail

(4) The main questionnaire consists of three parts. The first, it is a common questionnaire (basic personal information). The second is the questionnaire after giving information (without health information) by model. The last is the questionnaire after giving information (with health information) by model. The questions except for the first, contains recall, the usefulness of given information, ease, motivation to search for information, the severity of risk due to air pollution, the possibility of

health risk due to air pollution within five years, motivation for practicing guidelines of air pollution.

It makes to forget the previous information by placing the wash-out page between Step 1, 2. During wash-out, playing the eye-catching music video of the idol (playing 3' 40'' on average) to the end in force. Also, it announced that 'You should return to the beginning of the questionnaire if you turn off the window or go back while watching the music video.'. Participants need to watch the entire music video before proceeding to the next step (Step 2) (Figure 26).

Figure 26 Wash-out page (playing idol Music video)

3. Outcomes

The outcome of the questionnaire consists of two parts; 1) common questionnaire part, 2) questionnaire by model and select region. Part 1 (common questionnaire) contains questions about basic personal information. Part 2 (questionnaire by model and select region) is dealing with the questions about the given information of each model. In part 2, it has two steps having a difference in providing health information. For knowing the effect of the difference in providing health information, questions about the number of excess deaths are added in step 2, comparing with step 1.

1) Common questionnaire (Basic personal information)

This questionnaire asks 16 questions (including sub-questions) about age, sex, interesting region, belonged college, marriage, having children under six years old, health state, having functional disability or activity limitation, having medical services within 2 weeks, smoking, risk, and air pollution. These used the questionnaires of 'Survey of household chemical products risk (2018)', 'Korea National Health and Nutrition Examination Survey (KNHANES)).' The questions about literacy·health

literacy·numeracy are using the form of 'The role of numeracy in understanding the benefit of screening mammography (Lina, (1997))' and fit into this study considering the expert's comments.

2) Questionnaire by model and select region (main outcomes)

The main analysis domains are the usefulness of information, easy understanding, motivation to search for information, risk severity, risk perception, motivation for taking action of prevention of each model, and step. Each question consists of a 5 point Likert scale. Questions took the form of 'Survey of household chemical products risk (2018)' and change the contents for this research, and an expert examined it.

(1) Usefulness of information

The 'usefulness' means helpful in understanding and communicating how the system works or helpful in identifying hazards given specific hazard identification and analysis (Gyuchan Thomas Jun., (2010)). Its answer is collected as 'Very useless' (1)~'Very useful' (5) in 5 scores Likert.

(2) Ease of information

Ease of information can be measured by readability, assessing how easy the information the text is to read (Biddinika, Muhammad Kunta, et al. 2016). It asks as 'how easy to understand the information?' in 5 scores Likert (Very difficult (1) ~ Very easy (5)).

(3) Motivation to search for information

Motivation to search for information is an aggressive attempt to acquire risk-related information beyond habitual or routine media use (Tam, L. et al., (2014)). This question is five scores Likert (No motivation at all (1)~Very motivated (5)) of asking 'How more you motivated to search for information about air pollution after seen the given information?'

(4) Severity

The seriousness of the negative consequences of a certain behavior (de Hoog, N. et al. (2007)). This measured by the question as 'After seen the given information, could you know the severity of risk due to air pollution more?' with five scores Likert (I could not know at all (1)~Very, I could (5)).

(5) Risk perception

Risk perception means the estimation of the likelihood of harm to oneself or others (Tam, L. et al. (2014)). It is the result of the question as asking 'After seen the given information, comparing with your age group, the possibility of health risk due to air pollution within five years?' in 5 scores Likert (Very low (1)~Very high (5)).

(6) The motivation for taking action of prevention

There is a view motivation for taking action of prevention as the likelihood that an individual will pursue and continue a specific program of behavior change (Sussman, Steve., et al. (2004)). It is the result of the question asking 'Are you motivated to try the guidelines of air pollution after seeing the given information?' in five scores Likert (Not motivated at all (1)~Very motivated (5)).

4. Statistical methods

No personally identifiable information is included except for e-mail collection for duplicate participation and granting an ID. Because this is an online questionnaire that scoring the usefulness, degree of easy understanding, the perception of the given data, etc. of the given data. Therefore, we conducted all analysis after the recruitment and questionnaire of the research participants without the interim analysis.

First, we analyze the demographic characteristics of participants in total and by model through descriptive statistics.

The main data analysis method is the two-way ordinal regression with CLM(Cumulative Link Model), and identify the effectiveness of providing health information, delivering method of information in each. Also, the interaction effect of two factors. The tool used in R (R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.). The model assumed in the analysis is as follows.

$$y = \beta_1(\text{provision of health information}) + \beta_2(\text{delivery method of information}) + \beta_3(\text{provision health information} \cdot \text{delivery method of information})$$

We used the 'cld' function in the 'lsmeans' package of R to verify the significance of the assumption. Also, with Tukey-adjusted comparison, we could confirm the difference between the groups.

If there are many categories of ordinal variables, analysis by treating them as one continuous variable will facilitate interpretation along with dimension reduction (Chung, S.-S. et al., (2004)). However, the acquired data in this study is ordinal, so it requires to analyze in the ordinal analysis or loss of power (Alan Agresti (2013)). So, analyses the ordinal data with linear regression treating as numeric for sensitivity analysis.

In this study, we used the two-way ordinal regression with CLM and ordered logit regression method for another sensitivity analysis. We used these methods to find the interaction between model and other variables, and the difference between the distribution of Likert score by variable's score. For this analysis, we used the 'cld' function in the 'lsmeans' package and 'oglmx' function in the 'oglmx' package of R.

Ⅲ. Results

1. Characteristics of Participants

1) Recruitment of Participants

The recruitment and questionnaire period are from October 24, 2018, to October 30, 2018, for a total of 7 days. The recruitment of study participants had terminated early by achieving the calculated minimum sample size of the study. However, since the number of research participants could not be limited in real time, research participants had been recruited more than the number of the planned, and the rest (research design, etc.) had not changed. The total number of participants who completed the questionnaire was 181, which was 16 more than 165 participants. The final analysis included 179 subjects (Text: 60, Infographic: 59, Tailored: 60). Two subjects had been excluded from the study; one is excluded for missing due to coding error and the other one as a coding error and uncertain response (Figure 27).

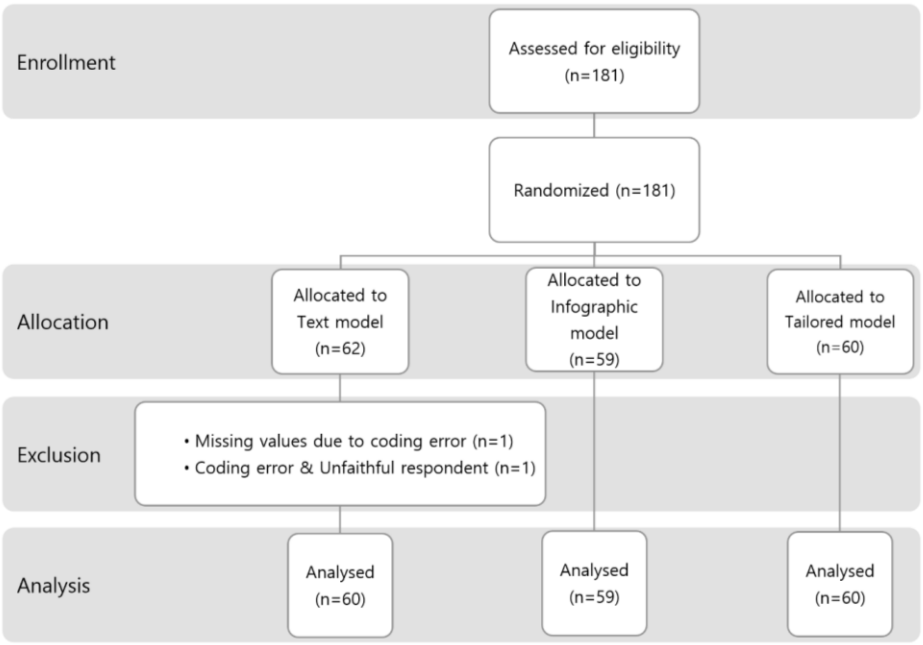


Figure 27 Flow diagram of the progress through the phases

2) Characteristics of Participants

Table 4 Demographic characteristics and health condition of participants

		Total	%	Text	%	Infographic	%	Tailored	%
	Total	179		60	33.5	59	33.0	60	33.5
Gender	Men	76	42.5	22	29.0	30	39.5	24	31.6
	Women	103	57.5	38	36.9	29	28.2	36	35.0
Age	Mean	24.8		24.5		25.0		24.9	
	SD	3.7		3.2		4.2		3.6	
Interesting region[1]	Seoul metropolitan	165	92.2	58	35.2	53	32.1	54	32.7
	Non-Seoul metropolitan	14	7.8	2	14.3	6	42.9	6	42.9
Belonged college[2]	Arts & Physical Education	7	3.9	2	28.6	2	28.6	3	42.9
	Education	11	6.2	5	45.5	4	36.4	2	18.2
	Engineering	36	20.1	12	33.3	10	27.8	14	38.9
	Humanities	19	10.6	5	26.3	8	42.1	6	31.6
	Medicine & Pharmacy	28	15.6	8	28.6	9	32.1	11	39.3
	Natural Sciences	44	24.6	15	34.1	15	34.1	14	31.8
	Social Sciences	34	19.0	13	38.2	11	32.4	10	29.4
Marriage	Married [3]	9	6.2	1	11.1	6	66.7	2	22.2
	Single	170	95.0	59	34.7	53	31.2	58	34.1
Children under 6	No children	171	95.5	59	34.5	55	32.2	57	33.3
	Only school children	6	3.4	1	16.7	2	33.3	3	50.0
	Children under 6	2	1.1	0	0.0	2	100.0	0	0.0

Table 4 Demographic Characteristics and health condition of participants (continued)

		Total	%	Text	%	Infographic	%	Tailored	%
	Total	179		60	33.5	59	33.0	60	33.5
Smoking	Sometimes	4	2.2	1	25.0	1	25.0	2	50.0
	Smoking in past but no smoking now[4]	8	4.5	1	12.5	3	37.5	4	50.0
	Never smoked	161	89.9	57	35.4	51	31.7	53	32.9
	Smoking everyday	6	3.4	1	16.7	4	66.7	1	16.7
Usual health condition	Mean	3.8		3.8		3.8		3.8	
	SD	0.8		0.9		0.6		0.9	
Functional disability/ Activity limitation	No	172	96.1	57	33.1	58	33.7	57	33.1
	Yes	7	3.9	3	42.9	1	14.3	3	42.9

1. Seoul metropolitan: Seoul, Gyeonggi, Incheon, Non-Seoul metropolitan: All metropolitan cities or provinces of Korea except Seoul metropolitan

2. Arts & Physical Education: Art, Music/ Education: Education/ Engineering: Engineering, Graduate School of Convergence Science and Technology/ Humanities: Humanities, Liberal Studies, Graduate School of Business/ Medicine & Pharmacy: Medicine, Nursing, Pharmacy, Graduate School of Dentistry, Graduate School of Medicine, Graduate School of Public Health/ Natural Science: Agriculture and Life Sciences, Graduate School of Environmental Studies, Graduate School of International Agricultural Technology, Human Ecology, Veterinary Medicine/ Social Science: Business Administration, Social Science, Graduate School of International, Graduate School of Law, Graduate School of Public Administration.

3. Married: Married including factual marriage

4. Smoking in the past but no smoking now: Smoking in the past but no smoking now, also in future

Table 4 shows the demographic characteristics and health condition of the participants. A total number of participants to analysis is 179. Each number of participants to the analysis in the Text, the Infographic, the

Tailored model is 60 (33.5%), 59 (33.0%), 60 (33.5%). The number of participants to an analysis by the model as similar, and its ratio is nearly 1:1:1.

A total number of analyzed participants of men is 76 (42.5%) and of women is 103 (57.5%). Each number of analyzed participants of men in Text, Infographic, Tailored model is 22 (29.0%), 30 (39.5%), 24 (31.6%), and women is 38 (36.9%), 29 (28.2%), 36 (35.0%). There were more women than men in total, the Text, and the Tailored. Also, the ratio of sex is nearly 1:1.5 as men: women, except for Infographic. In the Infographic, there were more men than women.

The mean (SD (Standard Deviation)) of the age of total is 24.8 (3.7) years old. The mean (SD) age of each model (Text, Infographic, Tailored) is 24.5 (3.2), 25 (4.2), 24.9 (3.6) in each. The age pattern of each is not that different.

Seoul metropolitan has operationally grouped Seoul and its surrounding metropolitans (Gyeonggi, Incheon). Non-Seoul metropolitan is the regions which are not the Seoul metropolitan (listed in Appendix 1). In total, most of the participants (165 people, 92.2%) picked the Seoul metropolitan. 35.2% (58 people), 32.1% (53 people), 32.7% (54 people) of respondents of Seoul metropolitan was in each model (Text,

Infographic, Tailored). Non-Seoul metropolitan is selected for 7.8% (14 people) in total. Of who selected Non-Seoul metropolitan, 14.3% (2 people) was Text, and six people (42.9%) was left two models (Infographic, Tailored) for each. In all, most of the participants selected the Seoul metropolitan. Nearly over 90%, not only in total but also in each model's participants.

Belonged college has operationally categorized as Arts & Physical Education, Education, Engineering, Humanities, Medicine & Pharmacy, Natural Sciences, Social Sciences based on 'Major Category Book' published by KEDI (Korean Educational Development Institute). College of Education, College of Art and College of Music are grouped as Arts & Physical Education is 3.9% of total participants (7 people), and 28.6% (2 people), 28.6% (2 people), 42.9% (3 people) of Arts & Physical Education was in each model. Education is 6.2% (11 people) in total, 45.5% (5 people)of Education was in Text, 36.4% (4 people) of Education was in Infographic, and 18.2% (2 people) of Education was in Tailored. College of Engineering and Graduate School of Convergence Science and Technology are grouped as Engineering. Engineering was the second of the most common. 20.1%(36 people) in total, 33.3%(12 people) of Engineering was in Text, 27.8%(10 people) of Engineering was in

Infographic, and 38.9% (14 people) of Engineering was in Tailored. Humanities, Liberal Studies and Graduate School of Business are bind as Humanities. A portion of Humanities in total is 10.6% (19 people), and 26.3% (5 people) of Humanities was in Text, 42.1% (8 people) was in Infographic, and 31.6% (6 people) was in Tailored. Medicine, Nursing, Pharmacy, Graduate School of Dentistry, Graduate School of Medicine and Graduate School of Public Health categorized as Medicine & Pharmacy. Total percentage of Medicine & Pharmacy is 15.6% (28 people), and 28.6% (8 people) of Medicine & Pharmacy was in Text. In Infographic, it is 32.1% (9 people). In Tailored, it is 39.3% (11 people). Natural Science grouped with Agriculture and Life Sciences, Graduate School of Environmental Studies, Graduate School of International Agricultural Technology, Human Ecology, and Veterinary Medicine. Natural Sciences took parts as 24.6% (44 people) in total. Its 34.1% (15 people) was Text model's participants, 34.1% (15 people) of Infographic and 31.8% (14 people) of Tailored. Natural Sciences is the most common in whole. Social Science is composed of Business Administration, Social Science, Graduate School of International, Graduate School of Law and Graduate School of Public Administration. Social Sciences is the third common. It is 19.0% (34 people) in total participants, 38.2% (13 people)

of Social Sciences was in Text, 32.4% (11 people) in Infographic and 29.4% (10 people) in Tailored.

Respondents of Married, including factual marriage, are 6.2% (9 people) in total. 11.1% (1 person) of them was in Text, 66.7% (6 people) in Infographic and 22.2% (2 people) in Tailored. However, respondents of single are 95.0% (170 people) in total, 34.7% (59 people) of them was in Text, 31.2% (53 people) was in Infographic, and 34.1% (58 people) was in Tailored. The single overwhelmed the Married in total and models. In married, respondent's proportion of each model is different in little, but not in a single.

Question about having children under six years old, 95.5% (171 people) respondents of total answered having no children. 34.5% (59 people) of them was in Text, 32.2% (55 people) was in Infographic, and 33.3% (57 people) was in Tailored. Answered as only school children is 3.4% (6 people) of the total. 16.7% (1 person), 33.3% (2 people), 50% (3 people) of them was in each model. The left 1.1% (2 people) of the total answered as having children under six years old who was in Infographic. Most of total and models, answered as 'No children' and its proportion to each model is not that different, but not in other answers ('Only school children,' 'Children under 6').

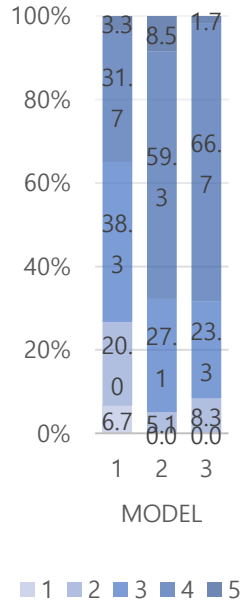
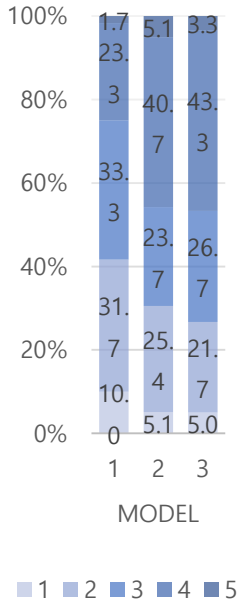
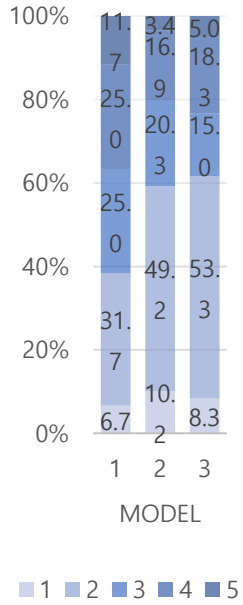
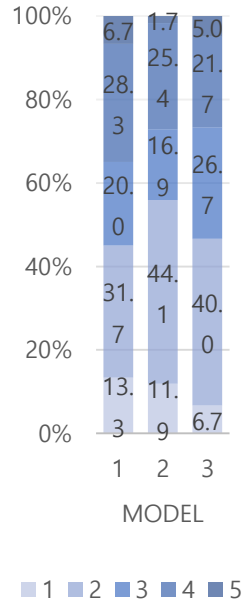
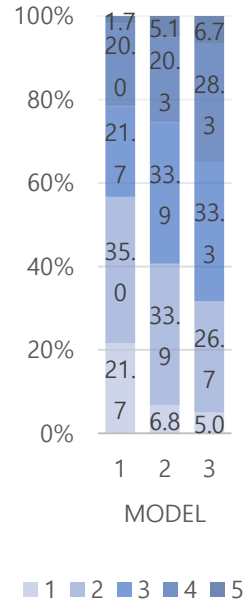
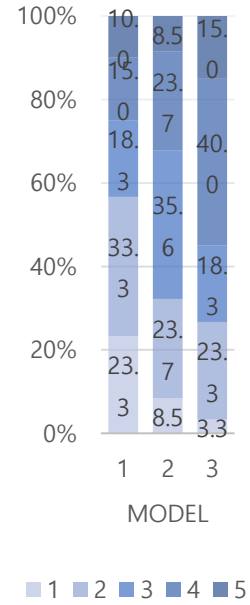
In the question of the status of smoking, 'smoking sometimes' took 2.2% (4 people) of the total. 25% (1 person) of them in Text and Infographic for each and 50% of them were in Tailored. Answered as 'Smoking in pas but no smoking now (also in future)' was 4.5% (8 people) of the total, and 12.5% (1 person), 37.5% (3 people), 50% (4 people) of them was in each model. The most common answer was 'Never smoked' was 89.9% (161 people) of the total. 35.4% (57 people) of them was in Text, 31.7% (51 people) was in Infographic, and 32.9% (53 people) was in Tailored. The last answer, 'Smoking every day', took 3.4% (6 people) of the total. 16.7% (1 person) of the last answer had assigned to Text, 66.7% (4 people) to Infographic, and 16.7% (1 person) to Tailored.

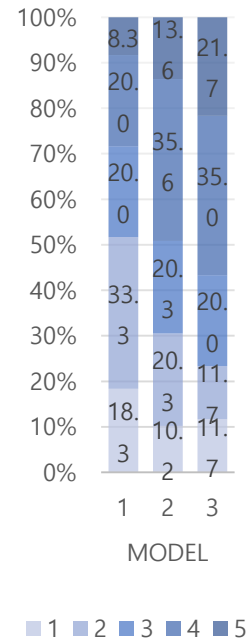
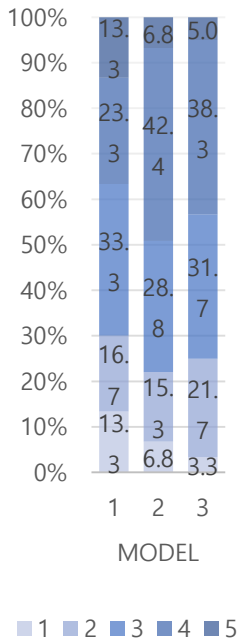
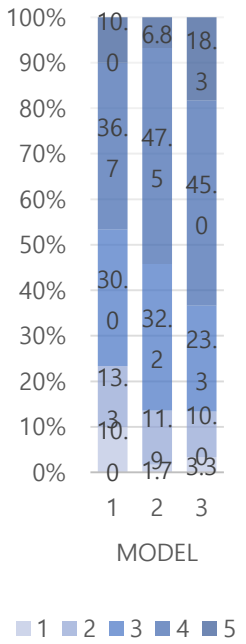
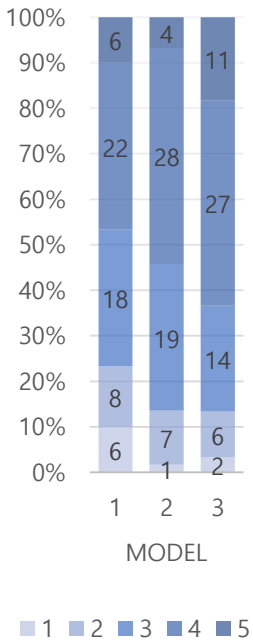
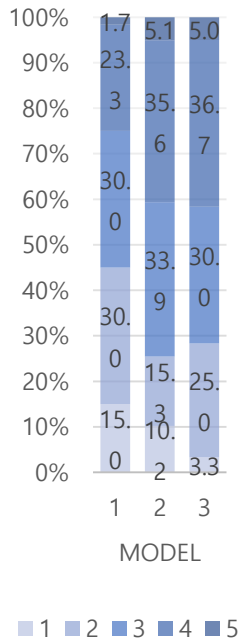
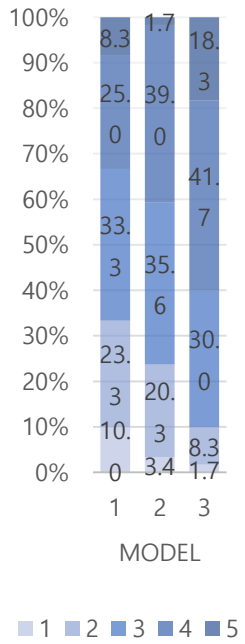
Mean score (SD) of 'Usual health condition' is 3.8 (0.8) in total. 3.8 (0.9) in Text, 3.8 (0.6) in Infographic and 3.8 (0.9) in Tailored.

Answering the functional disability or activity limitation, as 'No' was 96.1% (172 people) of the total, 33.1% (57 people) was in Text, 33.7% (58 people) was in Infographic, and 33.1% (57 people) was in Tailored. As 'Yes' was 3.9% (7 people) of the total. 42.9% (3 people), 14.3% (1 person), 42.9% (3 people) of 'Yes' was in each model.

2. Distributions (%) of the score in each question by model and availability of health information

Table 5 Distributions(%) of the score in each question by model and availability of health information

Q1. Usefulness		Q2. Ease		Q3. Motivation to search for information	
Health information		Health information		Health information	
0	1	0	1	0	1
					
Number of participants in each Model: 1 (Text): 60/ 2 (Infographic): 59/ 3 (Tailored): 60					

Q4. Risk severity		Q5. Risk perception		Q6. Motivation for taking action of prevention	
Health information		Health information		Health information	
0	1	0	1	0	1
					

Number of participants in each Model: 1 (Text): 60/ 2 (Infographic): 59/ 3 (Tailored): 60

Table 5 is showing the visualized distributions (%) of the score in each question by model and availability of health information. The summary table of Likert score by the availability of health information and model in each question is in Appendix 4. In most of the questions without health information, the more people are in the high score from the Text model to a Tailored model except the question about usefulness, ease, and motivation for taking action of prevention; it seems like the score is descending in the question of ease, and the distribution of score in usefulness, and motivation for taking action of prevention is not that different between models (it seems like the text's score is less than the other, but between the left is not that different). With health information, there is a similar trend like most of the questions without health information but not in the questions asking ease and risk severity; distribution of score is not that different between models in the question of ease and risk severity without health information (it seems like the Text's score is less than the other, but between the left is not that different).

3. Results of Randomized Comparision

Table 6 Result of two-way ordinal regression with CLM

			Chisq (Df)	Pr (>Chisq)
Q1	Usefulness	Model	23.5 (2)	<0.001
		Health	17.5 (1)	<0.001
		Model:Health	1.0 (2)	0.6
Q2	Ease	Model	6.5 (2)	0.04
		Health	0.1 (1)	0.8
		Model:Health	2.2 (2)	0.3
Q3	Motivation to search for information	Model	6.5 (2)	0.04
		Health	0.1 (1)	0.8
		Model:Health	2.2 (2)	0.3
Q4	Risk severity	Model	18.1 (2)	<0.001
		Health	94.2 (1)	<0.001
		Model:Health	0.9 (2)	0.6
Q5	Risk perception	Model	4.1 (2)	0.1
		Health	6.1 (1)	0.01
		Model:Health	1.7 (2)	0.4
Q6	Motivation for taking action of prevention	Model	18.5 (2)	<0.001
		Health	7.0 (1)	0.008
		Model:Health	3.6 (2)	0.2

The main result of the analysis is two-way ordinal regression with CLM is shown in Table 6. The analysis' confidence level was α=0.05.

In the effect of giving different model, it is significantly having difference among models in all questions except 'Risk perception (Q5)'. 'Usefulness (Q1)', 'Risk severity (Q4)' and 'Motivation for taking action of prevention (Q6)' are significant (p-value<0.001). 'Ease (Q2)' and 'Motivation to search for information (Q3)' are also significant (p-value=0.04).

The effect depends on whether health information provided significantly has a difference in 'Usefulness (Q1)', 'Risk severity (Q4)', 'Risk perception (Q5)' and 'Motivation for taking action of prevention (Q6)'. There is significantly having a difference in 'Usefulness (Q1)' and 'Risk severity (Q4)' in p-value<0.001 level. 'Motivation for taking action of prevention (Q6)' is also significantly having difference (p-value<0.001).

Interaction of model and availability of health information is not significant in all questions.

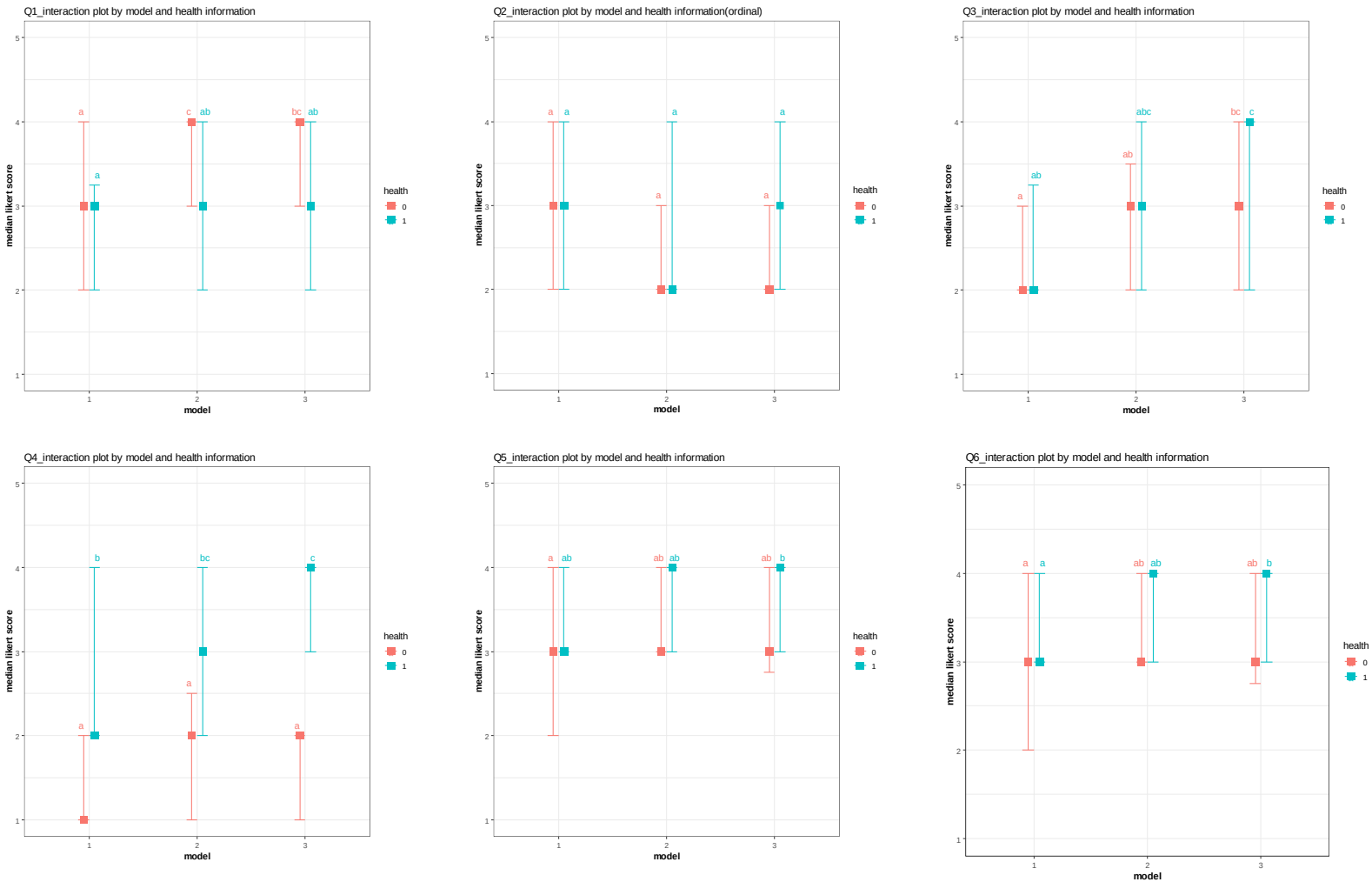


Figure 28 (Ordinal) Interaction plot by model and health information in each question

Figure 28 shows the interaction plot by the model (1: Text, 2: Infographic, 3: Tailored) and health information in ordinal data for each question. If bars are sharing a letter above the error bar, then they are not significantly having a difference. The post-hoc tests' confidence level set as α=0.05, using Tukey-adjusted.

In Question 1, Text model without health information group have difference with the Infographic model without health information and Tailored model without health information. Infographic model without health information and Tailored model without health information (median: 4) are more useful than Text model without health information (median: 3). Also, Text model with health information has a difference with left two models without health information. Even without health information, Infographic, or Tailored model (median: 4) is significantly more useful than Text model with health information (median: 3). However, the Infographic model and Tailored model with health information (median: 3) is less useful than the one without health information (median: 4) significantly.

In Question 2, all bars are sharing the same letter. So there are no significant differences.

In Question 3, Text model without health information group have

difference with Tailored model whether giving health information. A Tailored model with/without health information (median: 4/3) makes more motivation to search for information than Text model without health information (median: 2). Also, Text model with health information (median: 2) is having difference and less motivated to search for information with Tailored, including health information model (median: 4). Infographic model without health information (median: 3) is also having a difference with Tailored model with health information (median: 4), and it is less make searching information than the last. Whether providing the health information, the Tailored model makes to search for more information than Text model without health information. A Tailored model with health information is motivating to seeking information more than Text model, whether giving the health information in the text model.

In Question 4, giving the data with health information is more increase the severity of risk than any model without health information significantly. Without health information (median 1~2) in all of the model is not that effective than the one with health information (median: 2~4). Also, Text model with health information has a significant difference comparing with Tailored model with health information.

Tailored one (median: 4) is more increase the severity of risk than the Text one (median 2).

In Question 5, most of the bars are sharing the same letter. However, Text model with no health information has a difference with Tailored model with health information significantly. The Tailored model with health information (median: 4) make perceiving the risk increase than the Text with no health information (median: 3).

In Question 6, Tailored with health information is more motivating to take action of prevention (median: 4) than Text model with/without health information (median: 3) significantly.

4. Sensitivity analysis

1) Result of two-way linear regression

Table 7 Result of two-way linear regression

			F value (Df)	Pr(>F)
Q1	Usefulness	Model	13.2 (2)	<0.001
		Health	20.5 (1)	<0.001
		Model:Health	0.6 (2)	0.5
		Residuals	(352)	
Q2	Ease	Model	3.4 (2)	0.03
		Health	0.0 (1)	0.8
		Model:Health	1.1 (2)	0.3
		Residuals	(352)	
Q3	Motivation to search for information	Model	13.1 (2)	<0.001
		Health	3.2 (1)	0.1
		Model:Health	0.4 (2)	0.7
		Residuals	(352)	
Q4	Risk severity	Model	8.6 (2)	<0.001
		Health	123.9 (1)	<0.001
		Model:Health	1.1 (2)	0.3
		Residuals	(352)	
Q5	Risk perception	Model	2.3 (2)	0.1
		Health	6.0 (1)	0.01
		Model:Health	0.7 (2)	0.5
		Residuals	(352)	
Q6	Motivation for taking action of prevention	Model	10.1 (2)	<0.001
		Health	7.8 (1)	0.006
		Model:Health	1.6 (2)	0.2
		Residuals	(352)	

The answer to each question is in ordinal, so analyze the data with the ordinal method. Sometimes, ordinal data are considered as numeric, so compare the result of the ordinal way with numeric. Distribution and summary of Likert score by health and model in each question are added in Appendix 4 to available the comparing the value of each way as median and mean (Histogram of distribution of Likert is in Appendix 3).

Table 7 shows the result of two-way linear regression in each question. In the effect of giving different model, there are differences between ordinal and numeric. In ordinal, the p-value of Question 3 is. 0.04, but p-value is under the 0.001 in numeric.

The effect depends on whether health information provided also have a difference in Question 3. The p-value of the ordinal way was 0.8, but 0.1 in numeric.

Interaction of model and availability of health information is not significant in all questions and method of analyze.

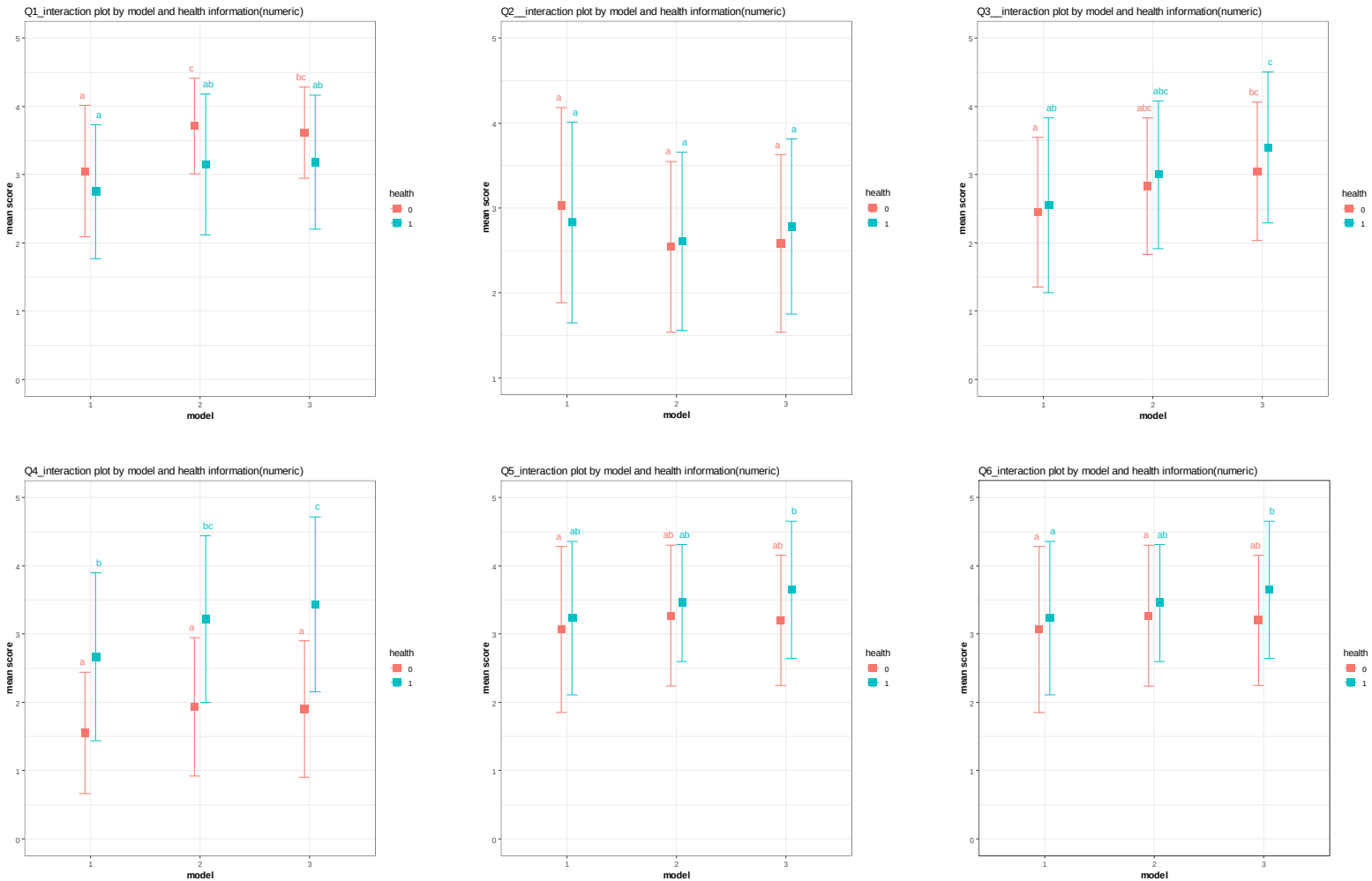


Figure 29 (Numeric) Interaction plot by model and health information in each question

Figure 29 shows the interaction plot by model and health information in numeric data for each question using Tukey–adjusted and set α =0.05.

Most of all, the most significant difference between ordinal and numeric is the pattern of the plot. The pattern of the plot shows like there are no effects of difference of model or difference of health information in visible. Most of all boxes have a parallel in health information. Also, all error bar is overlapped with each other.

In Question 3, there is another difference between ordinal and numeric. Question 3's Infographic model without health has a significant difference with Tailored model with health information in ordinal but not in numeric.

There are little differences between analyzing in ordinal and in numeric, as see above. So, it is essential to analyze the data with the proper method.

2) Summary of analysis with other variables

Table 8 Summary of analysis with other variables

	Q1. Usefulness		Q2. Ease		Q3. Motivation to search for information		Q4. Risk severity		Q5. Risk perception		Q6. Motivation for taking action of prevention	
	Interaction with model	Difference between models	Interaction with model	Difference between models	Interaction with model	Difference between models	Interaction with model	Difference between models	Interaction with model	Difference between models	Interaction with model	Difference between models
Risk-taking	0.1		0.01	M1(0.02)	0.009	M3(0.01736)	0.3		0.1		0.1	
Risk perception	0.02		<0.001	M1(0.003) M2(0.03) M3(0.04)	0.09		0.4		0.007	M1(0.04) M3(0.001)	0.005	M1(0.007) M3(0.02)
Risk severity	0.5		0.3		0.3		0.04		0.6	M2(0.007)	0.4	M1(0.04)
Literacy	0.8		0.4	M1(0.02)	0.5		-		0.3	M3(0.05)	0.7	
Risk perception of air pollution	0.1		-		0.002	M1(0.002)	0.04	M1(0.04)	-	M2(0.002) M3(<0.001)	-	M2(0.02) M3(0.01)
Understanding the harms from air pollution	0.5		0.8		-		-		0.7	M3(0.008)	-	M3(0.01)
Understanding the air pollution	0.05	M1(0.01)	0.6	M2(0.03)	0.009	M1(<0.001) M2(0.04)	-		-		-	

Frequency of searching information of air pollution	0.003	M1(0.007) M2(0.05)	0.3	M2(0.04)	0.06	M1(0.005) M2(0.001)	0.5		0.7		0.2	
Frequency of taking action of prevention	0.1		0.3	M2(0.05)	0.2	M1(0.01)	0.9		0.1	M3(0.03)	0.1	
Personal effectiveness of taking action of prevention	0.1	M1(0.004) M3(0.001)	0.2		–		1.0		0.2		–	
Ease of usual information about air pollution	0.8	M1(0.009) M3(0.01)	0.7		–		0.7		0.2	M3(0.03)	–	M1(0.02)
Enough of the usual information about air pollution	0.1	M3(0.02)	0.7		0.04	M2(0.03) M3(0.002)	0.1		0.2		0.04	M2(0.008) M3(0.008)
Health literacy	0.6		0.5		0.4		0.07	M1(0.05)	1.0		0.1	
Numeracy	0.4		0.3		0.9		0.9		0.2	M3(0.05)	0.07	

Table 8 shows the summary of analysis with other variables about risk / literacy·health literacy·numeracy /air pollution in personal question part. However, some of the variables are combined with relevant questions; risk-taking, risk perception, risk severity, literacy, numeracy. Their score is the mean score of relevantly combined.

Interactions between model and variables are calculated using the two-way ordinal regression with CLM in α=0.05. Especially, risk perception variable has interaction with model in most of the questions; usefulness, ease, risk perception, motivation for taking action of prevention.

Findings using ordered logit regression (α=0.05) supports that models have differences between them, especially in risk perception variable. In a question about ease, distribution of Likert score by risk perception score has differences in all models. It means ease of information is perceived differently by the level of risk perception of each person.

Ⅵ. Discussion

This study explored to find out the effectiveness of the geo-visualized health information of air pollution in randomized comparison by models and providing health information. Findings supported that visualized information provision having differences in usefulness, ease, motivation to search for information, the severity of the risk, motivation for taking action of prevention. Also, the effect depends on whether health information having differences significantly in usefulness, severity, risk perception, and motivation for taking action of prevention. However, there is no interaction effect found by the model and availability of health information in all questions. In usefulness, the Infographic and Tailored with no health information is more useful than the Text without health information. However, the Infographic and Tailored with health is less useful than the Text without health information. In, motivation to search for information, the Tailored with health information makes more motivated to search for information than the Infographic with health information and the Text (no matter with giving health information). Also, Tailored without health information is more motivating than the Text without health information. In risk severity, all models with health information make the risk more severe than the ones without health

information except Tailored with health information and Text with health information. Comparing the ones with health information, the Tailored makes it more severe than the text one significantly. At the risk perception, Tailored with health information makes more perceive the risk in personal than the Text without health information. At last, motivation for taking action of prevention, the Tailored with health information is more motivating to take action of prevention than the Text (whether providing health information or not). From sensitivity analysis, ease of the information is differently perceived by the level of risk perception of the individual.

These findings are supported by previous studies. In Shendell, D. G. et al. (2007), visualizing the air quality index (AQI) by flag program help increase awareness, knowledge, and behavior changes reducing environmental exposures. In Wong, C. et al. (2019), self-efficacy, and attitude towards environmental issues had been increased significantly after the training of using the tailored and interactive air pollution map.

According to the previous study, giving the information influence to increase the efficacy in Caress, A. L. (2003).. This supports some of our results that the availability of health information is effective in follows; usefulness, risk perception. However, in ease, which is not statistically

significant in our study, is significantly effective in McPherson, C. J., et al. (2001). This can be explained in Severtson, D. J. et al. (2013), risk expression can influence the ambiguity. It says the numeric risk expression is less threatening the message than a verbal-relative expression for some reasons. It can explain the finding of this study that giving health information which expressed in excessive mortality is less useful than not giving.

While the interaction between different models and the availability of health information is not effective in this study, we could not find the evidence from the previous studies of studying the same interaction. The interaction effect is also influenced by each factor, so the expression of health information may affect the result of the interaction. So, more studies are needed to identify the interaction between different models and the availability of health information. However, in sensitivity analysis, the interaction between the model and some variables are detected. In a question about ease of information, all model is significantly having differences in the distribution of Likert score of ease by risk perception level.

This study has a strength of randomized comparison. It is strong at confounding bias. By randomized allocation, we could minimize the

allocation bias. Also, to minimize the likelihood of differential intervention, we use the blinding (masking). This study has limitations. We tried to minimize the selection bias by collecting people as various as possible. However, it is a school-based exploratory study, so it is hard to generalize comparing with the Census. However, through sensitivity analysis, we could find a consistent (robust) result in most of the outcomes. Post-hoc tests can lead to a multiple comparison problem. However, in questions about usefulness, risk severity, and motivation for taking action of prevention, a p-value of the model using two-way ordinal regression is small enough to overcome the multiple comparison problem. This study used the reliable tools for the questionnaire for each domain. However, it had not validated the whole questionnaire. This study may have a limitation of internal validity. However, we tried to minimize the internal validity by an expert had inspected the questionnaire. We also have another limitation of using a questionnaire approach. The questionnaire is a subjective measuring tool, so there is a need to study in an objective approach like eye-tracking.

People are thinking the most urgent problem to solve is the air pollution (The ministry of environment & The ministry of culture, sports and tourism., (2018)); it took 48.7%, and it is over twice the second one

(climate change, 24%). However, the satisfaction of sufficient information about air pollution is low as 15.6%. The satisfaction of sufficient health information on air pollution is also low as 11.7% (Soeun Ahn et al., 2016). Also, the confidence in the information from the government is low as 3.52 (mean) of 7. So, it is important to communicate properly. The visualization is well known as an effective way to communicate, but there is no evidence of proofing the effectiveness of visualizing health information on a map (Roh, Y.-h. (2017)). Findings from this study are supporting that the visualizing the information on air pollution is effective in some outcomes; usefulness, motivation to search for information, risk severity, and motivation for taking action of prevention, and this could be applied to the practice as the risk communication. If using the visualized or personalized method to risk communication, then communicate more efficient in usefulness, motivating to search for information, the severity of the risk, and motivating for taking action of prevention. Other findings from this study are supporting that the availability of health information is effective in risk severity, risk perception, and motivation for taking action of prevention. However, there need more details, such as how to visualize the information or make personalize or express the risk/health

information (for example, using the plain words) to improve the literacy of health information.

Ⅶ. Conclusion

We conducted this study to identify the effectiveness of the geo-visualized health information of air pollution using randomized allocation. Also, the effect of giving information on health. Findings supported that visualized information provision is effective in usefulness, motivation to search for information, the severity of the risk, and motivation for taking action of prevention. Also, the effect depends on the availability of health information is significantly in severity, risk perception, and motivation for taking action of prevention. This exploratory study has a strength of conducting randomized allocation and tried to minimize the biases (e.g., allocation, confounding), but may have a limitation of the internal validity. We also have another limitation of using a questionnaire approach. The questionnaire is a subjective measuring tool, so there is a need to study in an objective approach like eye-tracking. Through this study, we could identify the more visualized or tailored; it is more effective to risk communication. However, the way of providing health information needs to be studied more. If using the visualized or tailored (personalized) method to risk communication, then communicate more efficient in usefulness, ease, motivating to search for information, severity, motivating for taking action of prevention.

However, details of visualization or personalization method and expression of risk/health information (for example, using the plain words) are needs more discussion to apply in practice to improve the literacy of health information.

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Ⅸ. Appendix

1. Using data

Extracted from (Han, C. et al., 2018)

	Cities & Provinces	Population (Person)	$PM_{2.5}$ ($\mu g/m^3$)	Number of deaths[1] (person)
Seoul metropolitan	Seoul	7189442	24.2	1763.4
	Gyeonggi	8571943	25	2352.3
	Incheon	2045392	27.6	309.4
Non-Seoul metropolitan	Busan	2557993	25.9	947.4
	Daegu	1769795	24.9	671.9
	Gwangju	1028181	24.1	656.8
	Daejeon	1060749	27.2	342.2
	Ulsan	809987	24.6	222.3
	Sejong	134303	27.7	49.2
	Gangwon	1104304	20.6	442.7
	Chungbuk	966579	26.4	403.4
	Chungnam	1471674	25.8	577.9
	Jeollabuk	1313542	29.1	638.2
	Jeollanam	1323030	22.4	633.6
	Gyeongbuk	1960926	21.6	885.3
	Gyeongnam	2364910	25	963.4
	Jeju	418612	13.6	64.4

1. Number of deaths : Number of deaths attributable to $PM_{2.5}$

2. Full Questionnaire Sheets

지도 시각화한 건강 정보의 효과성 평가 및 미세먼지 건강영향 위험 문해력 평가:텍스트와 시각화 비교

연구참여자용 설명서 및 동의서

연구 과제명 : 지도 시각화한 건강 정보의 효과성 평가 및 미세먼지 건강영향 위험 문해력 평가:텍스트와 시각화 비교
연구 책임자명 : ***(서울대학교 보건대학원)

이 연구는 과학기술정보통신부에서 지원하는 미세먼지 국가전략프로젝트 세부 사업 '우리나라 미세먼지 등 대기오염 건강영향 연구 및 건강영향 지도 구축(연구책임자: 서울대학교 보건대학원 황승식 교수)'의 일환입니다. 본 연구는 '지도 시각화한 건강 정보의 효과성 평가 및 미세먼지 건강영향 위험 문해력 평가:텍스트와 시각화 비교'에 대한 연구입니다. 지도 시각화한 건강 정보의 효과성과 미세먼지 건강영향 위험 문해력을 알아보기 위해 수행하고자 합니다. 귀하는 본 연구에서 선정한 기준에 따라 연구참여자로 적절하다고 판단되어 이 연구에 참여하도록 권유 받았습니다. 이 연구는 자발적으로 참여 의사를 밝히신 분에 한하여 수행 될 것이며, 귀하께서는 참여 의사를 결정하기 전에 본 연구가 왜 수행되는지 그리고 연구의 내용이 무엇과 관련 있는지 이해하는 것이 중요합니다. 다음 내용을 신중히 읽어보신 후 참여 의사를 밝혀 주시길 바라며, 필요하다면 가족이나 친구들과 의논해 보십시오. 만일 어떠한 질문이 있다면 이 연구를 수행하는 서울대학교 보건대학원 소속의 담당 연구원 ***(02-880-****)에게 문의시 귀하에게 이 연구에 대해 설명해 줄 것입니다.

1. 이 연구는 왜 실시합니까?

본 연구의 목적은 미세먼지의 위험도를 효과적으로 시각화하고 시각화 효과 크기를 아는 데에 있습니다. 이 연구를 바탕으로 효과적인 위험정보소통을 위한 위험정보 시각화 방법을 고안할 수 있습니다.

2. 얼마나 많은 사람이 참여합니까?

서울대학교 내 재학생 165명이 참여 할 것입니다.

3. 만일 연구에 참여하면 어떤 과정이 진행됩니까?

만일 귀하가 참여의사를 밝혀주시면 다음과 같은 과정이 진행될 것입니다. 연구 참여시, 온라인 상에서 PC 또는 모바일 기기를 이용한 1회의 인터넷 설문 조사가 이루어지기 전 귀하는 먼저 이메일을 주소를 입력하시고 입력한 이메일을 통해 본 설문조사를 수행할 수 있는 링크를 받게됩니다. 링크를 통해 접속 시 개인의 인구학적 특징 및 성향과 건강상태를 묻는 17문항, 위험인식 관련 15문항, 선호하는 정보 유형과 제공 방식, 건강 정보에 대한 관심도 등에 대한 7문항, 미세먼지 관련 14문항, 문해력 관련 4문항을 작성합니다. 그 후 제공된 미세먼지 정보 페이지를 보신 후 시각화된 건강정보 혹은 글로 작성된 건강정보에 대한 내용과 인지 정도, 동기부여 등에 대한 문항을 포함한 설문 8문항을 작성합니다. 다음으로 5분 이내의 뮤직비디오를 본 후 건강 정보가 포함된 미세먼지 관련 정보 페이지를 보신 후 앞과 같은 설문 10문항을 수행하게 됩니다.

귀하는 평균 15분, 최대 20분이 소요되는 온라인 설문 조사를 수행하게 될 것입니다.

4. 연구 참여 기간은 얼마나 됩니까?

설문조사 총 1회를 수행하며 평균 15분, 최대 20분이 소요될 것입니다.

5. 참여 도중 그만두어도 됩니까?

예, 귀하는 언제든지 어떠한 불이익 없이 참여 도중에 그만 둘 수 있습니다. 만일 귀하가 연구에 참여하는 것을 그만두고 싶다면 담당 연구원이나 연구 책임자에게 즉시 말씀해 주십시오. 또한 온라인 설문 작성 시 창을 닫으시면 이전에 작성된 내용은 수집되지 않습니다.

6. 부작용이나 위험요소는 없습니까?

몇몇 질문은 개인적인 요소를 물을 수도 있습니다. 이럴 경우 귀하는 언제든지 조사를 중단 할 수 있습니다. 만일 연구 참여 도중 발생할 수 있는 부작용이나 위험 요소에 대한 질문이 있으면 담당 연구원에게 즉시 문의해 주십시오.

7. 이 연구에 참여시 참여자에게 이득이 있습니까?

귀하가 이 연구에 참여하는데 있어서 직접적인 이득은 없습니다. 그러나 귀하가 제공하는 정보는 '효과적인 위험정보소통을 위한 위험정보 시각화와 시각화 효과성 평가'에 도움이 될 것입니다.

8. 만일 이 연구에 참여하지 않는다면 불이익이 있습니까?

귀하는 본 연구에 참여하지 않을 자유가 있습니다. 또한, 귀하가 본 연구에 참여하지 않아도 귀하의 수업 또는 성적을 포함한 어떠한 불이익도 없습니다.

9. 연구에서 얻은 모든 개인 정보의 비밀은 보장됩니까?

개인정보관리책임자는 서울대학교의 ***(02-880-****)입니다. 본 연구에서 수집되는 개인정보는 귀하의 성별, 나이, E-mail주소입니다. 수집된 개인정보는 개인 식별, 중복참여 여부와 학내 구성원 식별 및 상품 제공을 위해 수집됩니다. 수집된 개인 정보는 연구책임자에게만 접근이 허락됩니다. 본 연구에서 얻어진 개인정보 및 연구결과는 코드화된 인식 번호를 부여하여 관리되며 E-mail 주소는 연구 종료 시점을 기준으로 1년 후 폐기됩니다. 수집된 설문지는 코드화되어 외장하드에 저장 후 비관계자의 접근이 불가한 실험실에 보관될 것입니다. 동의서는 관련 법령에 따라 3년을 보관한 후 폐기할 예정이며, 연구자료의 경우는 서울대학교 연구윤리 지침에 따라 가능한 영구 보관할 예정입니다. 저희는 이 연구를 통해 얻은 모든 개인 정보의 비밀 보장을 위해 최선을 다할 것입니다. 이 연구에서 얻어진 개인 정보가 학회지나 학회에 공개 될 때 귀하의 이름과 다른 개인 정보는 사용되지 않을 것입니다. 그러나 만일 법이 요구하면 귀하의 개인정보는 제공될 수도 있습니다. 또한 모니터 요원, 점검 요원, 생명윤리위원회는 연구참여자의 개인 정보에 대한 비밀 보장을 침해하지 않고 관련규정이 정하는 범위 안에서 본 연구의 실시 절차와 자료의 신뢰성을 검증하기 위해 연구 결과를 직접 열람할 수 있습니다. 귀하가 본 동의서에 서명하는 것은, 이러한 사항에 대하여 사전에 알고 있었으며 이를 허용한다는 동의로 간주될 것입니다.

10. 이 연구에 참가하면 댓가가 지급됩니까?

귀하의 연구 참여시 감사의 뜻으로 4000원 가량의 음료 기프티콘이 제공되며 추첨을 통해 5명에게 1만원 문화 상품권 기프티콘을, 3명에게 3만원 문화 상품권 기프티콘을, 1명에게 5만원 문화 상품권 기프티콘이 증정됩니다.

11. 연구에 대한 문의는 어떻게 해야 됩니까?

본 연구에 대해 질문이 있거나 연구 중간에 문제가 생길 시 다음 연구 담당자에게 연락하십시오.

이름: ***　　전화번호: 02-880-****

만일 어느 때라도 연구참여자로서 귀하의 권리에 대한 질문이 있다면 다음의 서울대학교 생명윤

리위원회에 연락하십시오.

서울대학교 생명윤리위원회(SNUIRB) 전화번호: 02-880-5153

동 의 서

연구 과제명 : 지도 시각화한 건강 정보의 효과성 평가 및 미세먼지 건강영향 위험 문해력 평가:텍스트와 시각화 비교

연구 책임자명 : *(서울대학교 보건대학원)**

1. 나는 이 설명서를 읽었으며 문의 사항에 대해 담당 연구원에 연락하여 이에 대하여 의논하였습니다.
2. 나는 위험과 이득에 관하여 읽었으며 나의 질문에 만족할 만한 답변을 얻었습니다.
3. 나는 이 연구에 참여하는 것에 대하여 자발적으로 동의합니다.
4. 나는 이 연구에서 얻어진 나에 대한 정보를 현행 법률과 생명윤리위원회 규정이 허용하는 범위 내에서 연구자가 수집하고 처리하는 데 동의합니다.
5. 나는 담당 연구자나 위임 받은 대리인이 연구를 진행하거나 결과 관리를 하는 경우와 법률이 규정한 국가 기관 및 서울대학교 생명윤리위원회가 실태 조사를 하는 경우에는 비밀로 유지되는 나의 개인 신상 정보를 확인하는 것에 동의합니다.
6. 나는 언제라도 이 연구의 참여를 철회할 수 있고 이러한 결정이 나에게 어떠한 해도 되지 않을 것이라는 것을 압니다.
7. 나의 동의는 동의받는 연구원이 연구 참여가 끝날 때까지 이 동의서를 대신 보관하는 것에 동의합니다.

동의서 내용을 숙지하였으며 연구에 참여하시겠습니까?

1. 동의
2. 동의하지 않음(설문 종료)

사용하시는 서울대학교 SNU메일주소는 무엇입니까?

개인 식별과 중복 참여를 막기 위해 SNU계정을 수집합니다. 서울대학교 SNU메일 계정 입력 하신 후 SNU계정의 메일 함을 확인하시어 설문을 진행해주십시오. 예: example@snu.ac.kr

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문1. 귀하의 올해 만 나이는 몇 세입니까?
숫자만 입력해주세요. (두 자리 숫자로 제한)

_____

문2. 성별은 무엇입니까?
1. 남자 2. 여자

문3. 현재 소속 대학/대학원은 어느 곳입니까?
1. 인문대학 2. 사회과학대학 3. 자연과학대학 4. 경영대학 5. 공과대학 6. 농업생명과학대학 7. 미술대학 8. 사범대학 9. 생활과학대학 10. 수의과대학 11. 약학대학 12. 음악대학 13. 자유전공학부 14. 치과대학 15. 보건대학원 16. 행정대학원 17. 환경대학원 18. 국제대학원 19. 경영전문대학원 20. 법학전문대학원 21. 융합과학기술대학원 22. 간호대학 23. 의과대학 24. 치의학대학원 25. 의학대학원 26. 국제농업기술대학원

문4. 혼인 상태는 어떻게 되십니까?
1. 미혼 2. 기혼(사실혼 포함) 3. 사별 4. 이혼 5. 별거

문5. 귀하의 가정에는 미취학 자녀(만 6세 이하)가 있습니까?
1. 예 2. 아니오. 취학 자녀만 있습니다. 3. 아니오. 자녀가 없습니다.

문6. 평소 귀하의 건강상태는 어떠합니까?

	1	2	3	4	5	
매우 나쁘다	○	○	○	○	○	매우 좋다

문7. 현재 건강상의 문제나 신체 혹은 정신적 장애로 일상생활 및 사회활동에 제한을 받고 계십니까?
1. 예 →문8로
2. 아니오 →문9로

문8. 일상 활동에 제한을 가져온 이유는 무엇입니까?(복수응답)
1. 골절, 관절부상 2. 기타 손상 3. 관절염, 류마티즘 4. 심장질환 5. 호흡문제, 폐질환, 천식 6. 뇌

졸중 7. 당뇨병 8. 고혈압 9. 등, 목의 문제 10. 암 11. 치아 및 구강질환 12. 시력문제 13. 청각문제 14. 치매 15. 우울/불안/정서상 문제 16. 정신지체 17. 비만 18. 노령 19. 신부전 20. 어지럼증 21. 위장장애 22. 무릎, 다리통증(관절염 제외) 23. 두통 24. 기타(_____)

문9. 최근 2주 동안 입원을 하지않고, 병의원(치과 포함)이나 보건소, 한의원에서 치료를 받은 적이 있습니까?

1. 예 →9-1. 최근 2주 동안 입원을 하지 않고, 병의원(치과 포함)이나 보건소, 한의원에서 치료를 몇 번 받았습니까? ____회
2. 아니오

문10. 현재 담배를 피우고 계십니까?

1. 피운 적 없음
2. 현재 매일 피움 →10-1. 하루 평균 흡연량 ____개비
3. 가끔 피움 →10-2. 1)최근 1개월간 흡연일수 _____일
   2)흡연하는 날 하루평균 흡연량 ____개비
4. 과거에는 피웠으나 현재 피우지 않음(앞으로도 계속 금연)

   →10-3. 1)흡연중단 시기 _____년 _____월
   (현재까지 금연한 지 1개월 미만일 경우 빈칸으로)
   2)과거 하루평균 흡연량 ____개비

문11. 귀하는 일반적으로 위험을 피하기보다는 위험을 감수하는 편입니까?

	1	2	3	4	5	
전혀 그렇지 않다	○	○	○	○	○	매우 그렇다

문12. 급하게 이동 중인 상황에서 교차로를 건널 때, 신호등의 신호가 바뀌기 직전이라면 귀하는 멈추지 않고 지나가는 편입니까?

	1	2	3	4	5	
전혀 그렇지 않다	○	○	○	○	○	매우 그렇다

문13. 귀하는 알코올이 건강에 다소 나쁜 영향을 미친다고 할지라도 기분 전환, 친목 유지, 사회생활 등 음주로 인한 이익을 추구하시겠습니까?

	1	2	3	4	5	
전혀 그렇지 않다	○	○	○	○	○	매우 그렇다

문14-문19. 향후 5년 이내, 다음의 각 항목으로 인한 위험이 발생할 가능성은 어느 정도라고 생각하십니까?

항목	전혀 높지 않다				매우 높다
문14. 신종감염병(예: 메르스)					
문15. 방사능 누출(예: 원전 사고)					
문16. 자연재해(예: 포항지진)					
문17. 사회적 재난(예: 세월호 참사)					
문18. 생활화학제품 안전사고(예: 가습기살균제 사건)					
문19. 환경화학물질 노출(예: 미세먼지로 인한 건강문제)					

문20-문25. 위의 위험이 발생하였을 때, 그 심각성은 각각 어느 정도일 것이라고 생각하십니까?

항목	전혀 심각하지 않다				매우 심각하다
문20. 신종감염병(예: 메르스)					
문21. 방사능 누출(예: 원전 사고)					
문22. 자연재해(예: 포항지진)					
문23. 사회적 재난(예: 세월호 참사)					
문24. 생활화학제품 안전사고(예: 가습기살균제 사건)					
문25. 환경화학물질 노출(예: 미세먼지로 인한 건강문제)					

문26. 가장 선호하는 정보 유형은 어떤 것입니까?

1. 텍스트 형태 2. 시각화 형태 3. 텍스트와 시각화 혼합 형태

문27. 가장 선호하는 정보 제공 방식은 어떤 것입니까?

1. 단방향(예: 일반적인 신문기사 혹은 대중 매체 등)

2. 양방향(예: SNS, 블로그, 소셜커머스 등)
3. 맞춤형(예: 페이스북 광고, 유튜브 추천 영상, 음악 어플의 추천 음악 등)

문28. 맞춤형 정보를 어떻게 생각하십니까?
(예: 페이스북 광고, 유튜브 추천 영상, 음악 어플의 추천 음악 등)

	1	2	3	4	5	
매우 부정적이다.	○	○	○	○	○	매우 긍정적이다.

문29. 건강정보 관련 맞춤형 정보를 어떻게 생각하십니까?
(예: 개인 맞춤형 운동 처방, 맞춤형 보건교육 등)

	1	2	3	4	5	
매우 부정적이다.	○	○	○	○	○	매우 긍정적이다.

문30-문31. 귀하는 다음의 설명에 동의하십니까? 각 항목에 대해 귀하의 생각과 가장 가까운 답을 선택해주십시오.

항목	아니다, 쉽게 이해할 수 있다.				그렇다, 이해하기 어렵다.
문30. 나는 '과학 전문용어'로 이루어진 건강 정보를 이해하는 것이 어렵다.					
문31. 나는 '숫자'로 이루어진 건강 정보를 이해하는 것이 어렵다.					

문32. 귀하는 건강 정보를 주로 어디에서 접하십니까? 가장 많이 접하는 종류 한 가지만 선택해주십시오.

1. 방송매체(TV, 라디오 등)
2. 인쇄매체(신문, 잡지 등)
3. 인터넷 포털사이트(다음, 네이버, 구글 등)
4. 개인 블로그나 SNS(트위터, 페이스북 등)
5. 가족, 친구 등 지인
6. 유튜브
7. 기타(_____)

8. 없음

문33. 귀하와 비슷한 나이대의 사람들과 비교하였을 때, 향후 5년 이내 귀하가 미세먼지로 인해 입을 건강 피해는 어느 정도라고 생각하십니까?

	1	2	3	4	5	
전혀 없다	○	○	○	○	○	매우 심각하다

문34. 미세먼지로 인한 건강 피해에 대해 알고 계십니까?

	1	2	3	4	5	
전혀 모른다	○	○	○	○	○	매우 잘 알고있다

문35. 귀하는 2017년 9월 정부가 발표한 '미세먼지 관리 종합대책'에 대해 얼마나 알고 계십니까?

	1	2	3	4	5	
전혀 모른다	○	○	○	○	○	매우 잘 알고있다

문36. 귀하는 환경부에서 발표한 '미세먼지 국민행동요령'에 대해 얼마나 알고 계십니까?

	1	2	3	4	5	
전혀 모른다	○	○	○	○	○	매우 잘 알고 있다

문37. 귀하는 2005년 12월부터 환경부에서 제공 중인 전국 실시간 대기 오염도 공개 홈페이지 '에어코리아'에 대해 알고 계십니까?

	1	2	3	4	5	
전혀 모른다	○	○	○	○	○	매우 잘 알고 있다

문38. 미세먼지 위험으로 인한 문제 해결의 책임은 누구에게 있다고 생각하십니까?

	1	2	3	4	5	
개인	○	○	○	○	○	국가

문39. 미세먼지 관련 정보를 얼마나 자주 찾아보십니까?

	1	2	3	4	5	
전혀 찾아보지 않는다	○	○	○	○	○	매일 찾아본다.

문40. 아래 '미세먼지 국민행동요령' 중 가장 많이 실천하는 행동은 무엇입니까?

1. 외출 자제
2. 보건용 마스크 착용
3. 외출 후 깨끗이 씻기
4. 대기오염 유발행위 자제
5. 대기오염 심한 곳 피하고 활동량 줄이기
6. 환기, 실내 물청소 등 실내 공기질 관리
7. 물과 비타민 C가 풍부한 과일이나 야채 섭취

문41. 앞서 선택한 미세먼지 행동 요령을 얼마나 자주 실천하십니까?

	1	2	3	4	5	
일주일 중 하루 실천	○	○	○	○	○	일주일 중 5일 이상 실천

문42. 귀하는 '미세먼지 국민행동요령'을 읽고 실천하는 것이 미세먼지로부터의 건강 위험을 막는 효과적인 방법이라고 생각하십니까?

	1	2	3	4	5	
전혀 효과적이지 않다	○	○	○	○	○	매우 효과적이다

문43. 귀하가 접했던 미세먼지 관련 정보는 이해하기 쉬웠습니까?

	1	2	3	4	5	
매우 쉬웠다	○	○	○	○	○	매우 어려웠다

문44. 귀하는 정부가 제공한 미세먼지에 대한 정보를 얼마나 신뢰하십니까?

	1	2	3	4	5	
전혀 믿지않는다	○	○	○	○	○	완전히 믿는다

문45. 귀하는 어떤 미세먼지 정보에 관심이 있습니까? 두 가지만 선택해주십시오.(중복선택, 2가지)

1. 구성성분
2. 건강영향
3. 주요 배출원
4. 국민행동요령
5. 관심 지역 농도
6. 기타(_____)

문46. 귀하는 미세먼지에 대해 궁금했던 정보를 충분히 얻을 수 있었습니까?

	1	2	3	4	5	
전혀 그렇지 않다	○	○	○	○	○	매우 그렇다

문47. 미세먼지로 인한 건강 정보가 제시됩니다. 제시된 건강정보를 가장 올바르게 설명한 것은 어느 것이라고 생각하십니까?

질병관리본부에 따르면, 미세먼지(PM2.5) 농도가 10㎍/㎥ 증가할 때마다 폐암 발생률이 9% 증가하는 것으로 나타났다. 보기 중 올바른 설명은 무엇입니까?

1. 내가 살고있는 지역에 미세먼지(PM2.5) 농도가 10㎍/㎥ 증가하면 내가 살고있는 지역의 새로 폐암 발생자가 100명당 9명이 더 생긴다.
2. 내가 살고있는 지역에 미세먼지(PM2.5) 농도가 10㎍/㎥ 증가하면 내가 폐암에 걸릴 확률이 9% 늘어난다.
3. 내가 살고있는 지역에 미세먼지(PM2.5) 농도가 10㎍/㎥ 감소하면 폐암 사망자 100명당 9명 줄

일 수 있다.
4. 내가 살고있는 지역에 미세먼지(PM2.5) 농도가 10㎍/㎥ 감소하면 내가 폐암에 걸릴 확률이 9% 줄어든다.

문48. 1%는 1,000번 중 몇 번입니까? 숫자만 입력해주십시오.

_____

문49. 1,000번 중 1번은 몇 %입니까? %기호를 제외한 숫자만 입력해주십시오.

_____

문50. 동전을 1,000번 던지면 앞면이 몇 번쯤 나오겠습니까? 예상되는 하나의 숫자만 써주십시오.

_____

문51. 가장 관심있는 지역은 어느 지역입니까? 한 곳만 선택해주십시오.
1. 서울 2. 대전 3. 경기 4. 강원 5. 대구 6. 인천 7. 충북 8. 충남 9. 전북 10. 세종 11. 경북 12. 광주 13. 부산 14. 전남 15. 울산 16. 경남 17. 제주

**************************모델 별 정보 제공_TEXT1, MIXED1, INTERACTIVE1**************************

==========모델 및 지역 별 설문_TEXT1, MIXED1, INTERACTIVE1==========

문1. 제공된 정보에서 (관심 지역)의 하루 평균 PM2.5농도는 어땠습니까?
1. 좋음 2. 보통 3. 나쁨 4. 매우 나쁨

문2. 제공된 정보에서 (관심 지역 외 지역)의 하루 평균 PM2.5농도는 어땠습니까?
1. 좋음 2. 보통 3. 나쁨 4. 매우 나쁨

문3. 제공된 정보는 유용하였습니까?

	1	2	3	4	5	
전혀 그렇지 않다	○	○	○	○	○	매우 그렇다

문4. 제공된 미세먼지 정보는 이해하기에 쉬웠습니까?

	1	2	3	4	5	
매우 쉬웠다	○	○	○	○	○	매우 어려웠다

문5. 제공된 정보를 본 후 미세먼지 정보를 얼마나 더 많이 찾아보시겠습니까?

	1	2	3	4	5	
전혀 변하지 않을 것이다	○	○	○	○	○	매우 많이 찾아볼 것이다

문6. 제공된 정보를 본 후 향후 5년 이내 미세먼지로 발생하는 위험의 심각성을 잘 알 수 있었습니까?

	1	2	3	4	5	
전혀 모르겠다	○	○	○	○	○	매우 잘 알겠다

문7. 제공된 정보를 본 후 귀하와 비슷한 나이대의 사람들과 비교하였을 때, 향후 5년 이내 미세먼지 건강 위험이 귀하에게 피해를 초래할 가능성은 얼마나 더 증가할 것이라 생각하십니까?

	1	2	3	4	5	
전혀 변하지않을 것이다	○	○	○	○	○	매우 많이 피해를 입을 것이다

문8. 제공된 정보를 본 후 미세먼지 대처 방법을 얼마나 더 자주 실천하시겠습니까?

	1	2	3	4	5	
전혀 변하지 않을 것이다	○	○	○	○	○	매우 많이 실천할 것이다

**********WASH OUT**********
**********동영상 시청**********

**********모델 별 정보 제공_TEXT2, MIXED2, INTERACTIVE2**********

==========모델 및 지역 별 설문_TEXT2, MIXED2, INTERACTIVE2==========

문1. 제공된 정보에서 (관심 지역)의 하루 평균 PM2.5농도는 어땠습니까?

1. 좋음 2. 보통 3. 나쁨 4. 매우 나쁨

문2. 제공된 정보에서 (관심 지역 외 지역)의 하루 평균 PM2.5농도는 어땠습니까?

1. 좋음 2. 보통 3. 나쁨 4. 매우 나쁨

문3. 제공된 정보에서 (관심 지역)의 미세먼지로 인한 초과 사망자수는 몇 명입니까?

1. A명 2. B명 3. C명 4. D명

문4. 제공된 정보에서 (관심 지역 외 지역)의 미세먼지로 인한 초과 사망자수는 몇 명입니까?

1. E명 2. F명 3. G명 4. H명

문5. 제공된 정보는 유용하였습니까?

	1	2	3	4	5	
전혀 그렇지 않다	○	○	○	○	○	매우 그렇다

문6. 제공된 미세먼지 관련 정보는 이해하기에 어려웠습니까, 쉬웠습니까?

	1	2	3	4	5	
매우 쉬웠다	○	○	○	○	○	매우 어려웠다

문7. 제공된 정보를 본 후 미세먼지와 관련한 정보를 얼마나 더 많이 찾아보시겠습니까?

	1	2	3	4	5	
전혀 변하지 않을 것이다	○	○	○	○	○	매우 많이 찾아볼 것이다

문8. 제공된 정보를 본 후 미세먼지로 인한 위험의 심각성을 더 잘 알 수 있었습니까?

	1	2	3	4	5	
전혀 모르겠다	○	○	○	○	○	매우 잘 알겠다

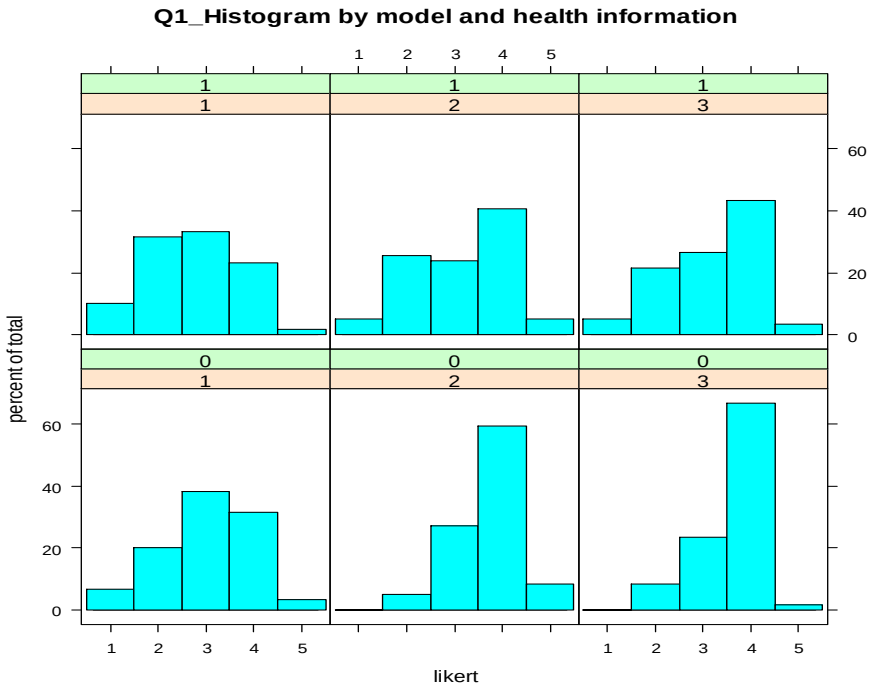
문9. 제공된 정보를 본 후 귀하와 동일한 연령대의 사람들과 비교하였을 때, 향후 5년 이내 미세먼지로 인한 건강 위험이 귀하에게 피해를 초래할 가능성은 얼마나 더 증가할 것이라 생각하십니까?

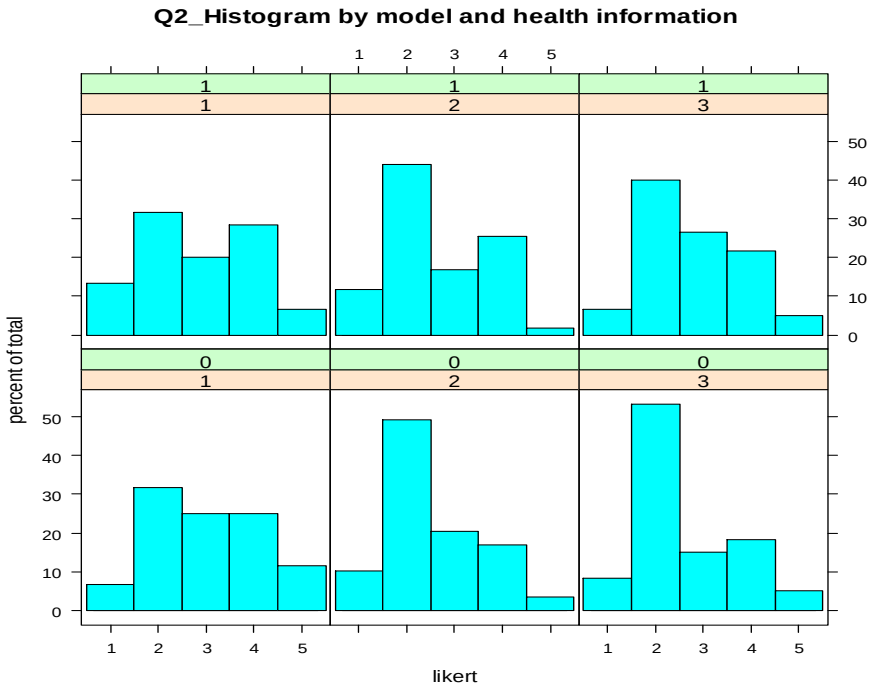
	1	2	3	4	5	
전혀 변하지않을 것이다	○	○	○	○	○	매우 많이 피해를 입을 것이다

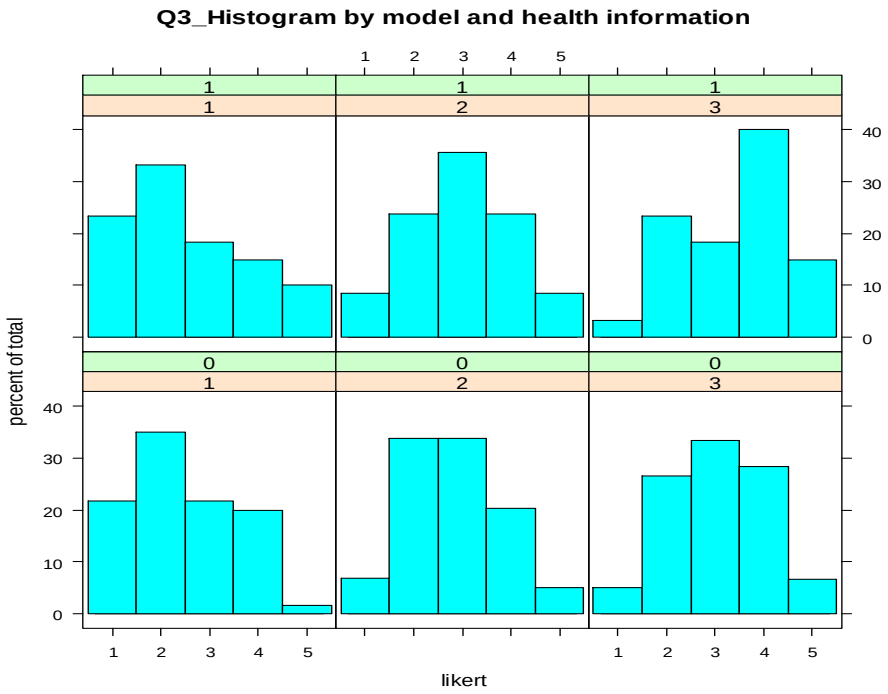
문10. 제공된 정보를 본 후 미세먼지 대처 방법을 얼마나 더 자주 실천하시겠습니까?

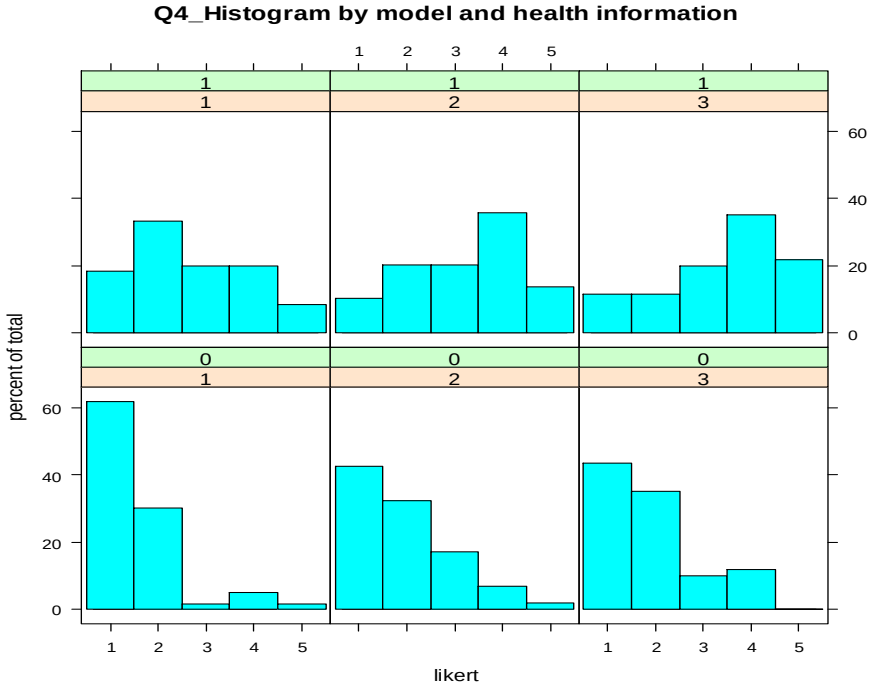
	1	2	3	4	5	
전혀 변하지 않을 것이다	○	○	○	○	○	매우 많이 실천할 것이다

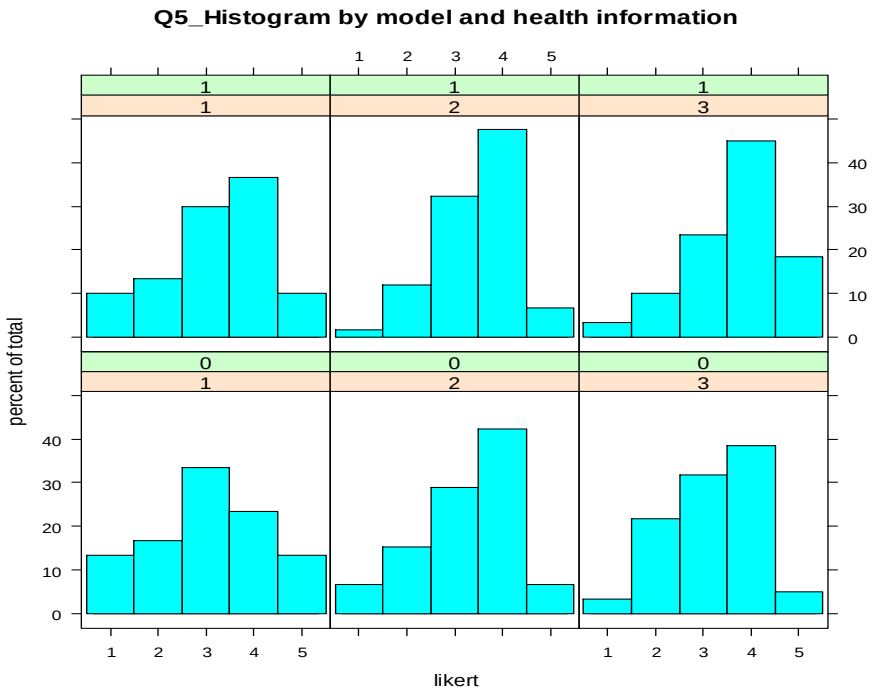
3. Histogram by model and health information in each Question

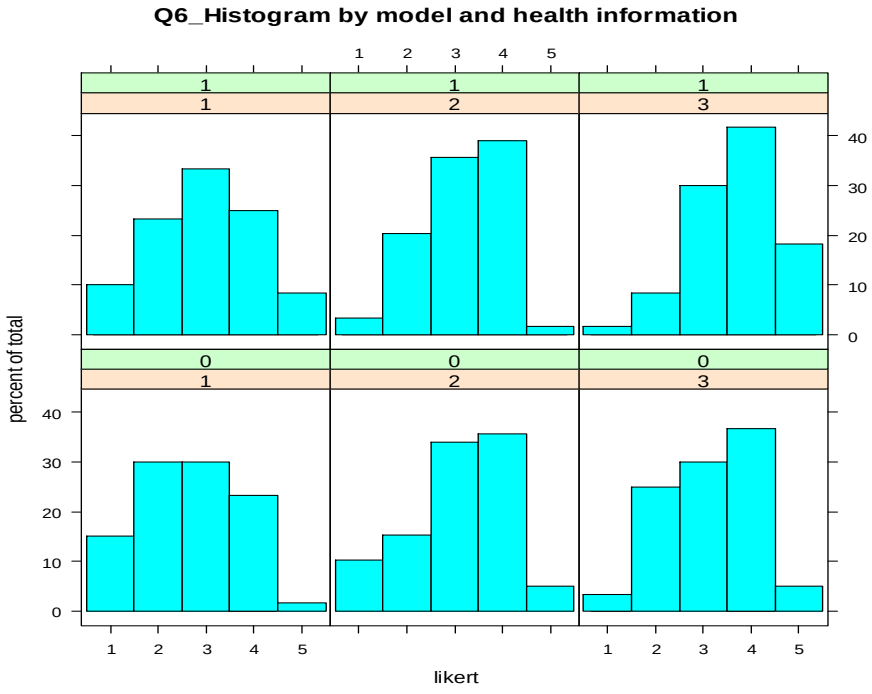





Q3_Histogram by model and health information
1 2 3 4 5
1 1 1
1 2 3
0 0 0
1 2 3
percent of total
likert


Q4_Histogram by model and health information
1 2 3 4 5
1 1 1
1 2 3
0 0 0
1 2 3
percent of total
likert


Q5_Histogram by model and health information
1 1 1
1 2 3
0 0 0
1 2 3
percent of total
likert


Q6_Histogram by model and health information
1 1 1
1 2 3
0 0 0
1 2 3
percent of total
likert

4. Summary of Likert score by Health and Model in each Question

				Likert										Summary					
		Health	Model	1	%	2	%	3	%	4	%	5	%	n	Q1	median	Q3	mean	SD
Q1	Usefulness	0	1	4	6.7	12	20.0	23	38.3	19	31.7	2	3.3	60	2	3	4	3.1	1.0
			2	0	0.0	3	5.1	16	27.1	35	59.3	5	8.5	59	3	4	4	3.7	0.7
			3	0	0.0	5	8.3	14	23.3	40	66.7	1	1.7	60	3	4	4	3.6	0.7
		1	1	6	10.0	19	31.7	20	33.3	14	23.3	1	1.7	60	2	3	3.3	2.8	1.0
			2	3	5.1	15	25.4	14	23.7	24	40.7	3	5.1	59	2	3	4	3.2	1.0
			3	3	5.0	13	21.7	16	26.7	26	43.3	2	3.3	60	2	3	4	3.2	1.0
Q2	Ease	0	1	4	6.7	19	31.7	15	25.0	15	25	7	11.7	60	2	3	4	3.0	1.2
			2	6	10.2	29	49.2	12	20.3	10	17.0	2	3.4	59	2	2	3	2.5	1.0
			3	5	8.3	32	53.3	9	15.0	11	18.3	3	5	60	2	2	3	2.6	1.1
		1	1	8	13.3	19	31.7	12	20.0	17	28.3	4	6.7	60	2	3	4	2.8	1.2
			2	7	11.9	26	44.1	10	17.0	15	25.4	1	1.7	59	2	2	4	2.6	1.1
			3	4	6.7	24	40	16	26.7	13	21.7	3	5	60	2	3	4	2.8	1.0
Q3	Motivation to search for information	0	1	13	21.7	21	35.0	13	21.7	12	20.0	1	1.7	60	2	2	3	2.5	1.1
			2	4	6.8	20	34.0	20	34.0	12	20.3	3	5.1	59	2	3	3.5	2.8	1.0
			3	3	5.0	16	26.7	20	33.3	17	28.3	4	6.7	60	2	3	4	3.1	1.0
		1	1	14	23.3	20	33.3	11	18.3	9	15.0	6	10.0	60	2	2	3.3	2.6	1.3
			2	5	8.5	14	23.7	21	35.6	14	23.7	5	8.5	59	2	3	4	3.0	1.1
			3	2	3.3	14	23.3	11	18.3	24	40.0	9	15.0	60	2	4	4	3.4	1.1

Summary of Likert score by Health and Model in each Question (continued)

				Likert										Summary					
		Health	Model	1	%	2	%	3	%	4	%	5	%	n	Q1	Median	Q3	Mean	SD
Q4	Severity	0	1	37	61.7	18	30.0	1	1.7	3	5.0	1	1.7	60	1	1	2	1.6	0.9
			2	25	42.4	19	32.2	10	17.0	4	6.8	1	1.7	59	1	2	2.5	1.9	1.0
			3	26	43.3	21	35.0	6	10.0	7	11.7	0	0.0	60	1	2	2	1.9	1.0
		1	1	11	18.3	20	33.3	12	20.0	12	20.0	5	8.3	60	2	2	4	2.7	1.2
			2	6	10.2	12	20.3	12	20.3	21	35.6	8	13.6	59	2	3	4	3.2	1.2
			3	7	11.7	7	11.7	12	20.0	21	35.0	13	21.7	60	3	4	4	3.4	1.3
Q5	Risk perception	0	1	8	13.3	10	16.7	20	33.3	14	23.3	8	13.3	60	2	3	4	3.1	1.2
			2	4	6.8	9	15.3	17	28.8	25	42.4	4	6.8	59	3	3	4	3.2	1.0
			3	2	3.3	13	21.7	19	31.7	23	38.3	3	5.0	60	2.8	3	4	3.2	1.0
		1	1	6	10.0	8	13.3	18	30.0	22	36.7	6	10.0	60	3	3	4	3.2	1.1
			2	1	1.7	7	11.9	19	32.2	28	47.5	4	6.8	59	3	4	4	3.5	0.9
			3	2	3.3	6	10.0	14	23.3	27	45.0	11	18.3	60	3	4	4	3.7	1.0
Q6	Motivation for taking action of prevention	0	1	9	15.0	18	30.0	18	30.0	14	23.3	1	1.7	60	2	3	4	3.1	1.2
			2	6	10.2	9	15.3	20	33.9	21	35.6	3	5.1	59	3	3	4	3.3	1.0
			3	2	3.3	15	25.0	18	30.0	22	36.7	3	5.0	60	2.8	3	4	3.2	1.0
		1	1	6	10.0	14	23.3	20	33.3	15	25.0	5	8.3	60	3	3	4	3.2	1.1
			2	2	3.4	12	20.3	21	35.6	23	39.0	1	1.7	59	3	4	4	3.5	0.9
			3	1	1.7	5	8.3	18	30.0	25	41.7	11	18.3	60	3	4	4	3.7	1.0

5. CONSORT checklist

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	Cover page
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	Abstract
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	1
	2b	Specific objectives or hypotheses	28
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	35
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	36

Participants	4a	Eligibility criteria for participants	33
	4b	Settings and locations where the data were collected	33
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	35
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	53
	6b	Any changes to trial outcomes after the trial commenced, with reasons	-
Sample size	7a	How sample size was determined	33
	7b	When applicable, explanation of any interim analyses and stopping guidelines	33, 59
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	35
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	35
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	35

Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	35
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	35
	11b	If relevant, description of the similarity of interventions	31, 37~52
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	57
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	58
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	59, 66~76
	13b	For each group, losses and exclusions after randomisation, together with reasons	59
Recruitment	14a	Dates defining the periods of recruitment and follow-up	59
	14b	Why the trial ended or was stopped	59

Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	59
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	59
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	118
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	-
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	77~83
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	35
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	86~87
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	86
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and	86~87

		considering other relevant evidence	
Other information			
Registration	23	Registration number and name of trial registry	-
Protocol	24	Where the full trial protocol can be accessed, if available	48
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	127

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

요약(국문초록)

무작위 배정을 이용한 미세먼지 건강영향 정보 지도시각화 효과 평가

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2013년부터 대기오염 위험에 관한 기사가 쏟아지기 시작했으며 대기 오염의 건강 위험에 대한 우려 또한 증가하였다. 시민들의 우려가 증가하면서 정부의 위험 커뮤니케이션의 중요성이 부각되었다. 본 연구에서는 효과적인 위험 소통을 위한 효율적인 의사 소통 수단으로 잘 알려진 시각화에 초점을 맞추어 위험 소통 측면에서 대기 오염으로 인한 건강 정보의 시각화 효과를 확인하고자 한다.

179 명이 참여한 2×3 형태의 무작위 배정 연구이다. 건강 정보 제공 여부와 텍스트, 인포그래픽, 맞춤형 3 가지 모델에 따른 결과(정보의 유용성, 쉬운이해정도, 정보탐색 동기 정도, 대처 실천 정도, 위험 심각성 인지 정도, 주관적 위험 인지 정도)를 확인할 것이다. 순위형 자료를 이용한 2 요인 분석방법(two-way ordinal analysis)으로 분석하였다.

정보의 유용성, 쉬운이해정도, 정보탐색 동기 정도, 대처 실천 정도, 주관적 위험 인지 정도에서 모델별로 유의한 차이가 나타났다. 유용성, 심각성, 위험 심각성인지, 예방 동기 측면에서, 건강 정보 제공에 따라 모델별로 유의한 차이가 있었다. 하지만, 모델과 건강 정보 제공 유무에 따른 인터렉션 효과는 나타나지 않았다.

본 연구는 정보의 유용성, 쉬운이해정도, 정보탐색 동기정도, 대처실천정도, 위험심각성 인지, 주관적 위험인지 정도에 대한 응답을 통해 대기오염으로인한 건강정보를 지도시각화한 효과를 확인하였다. 또한 건강 정보 제공 유무에 따른 효과를 확인하였다. 본 연구는 무작위배정의 강점을 가지고 있지만, 실험적 연구이기 대문에 내적 타당성의 한계가 있다. 또한 주관적 측정방법인 설문 연구를 수행하여 객관적 측정 지표가 아니라는 한계가 있으므로 시선추적(eye-tracking)과 같은 객관적인 측정방법을 사용한 연구가 필요하다. 하지만, 본 연구를 통해 시각화 또는 맞춤형 자료일수록, 건강정보를 포함할수록 위험소통에 효과적임을 알 수 있었다. 위험소통시 정보전달에 시각화와 맞춤화를 사용한다면 유용성, 정보탐색 동기정도, 위험 심각성 인지, 대처실천 동기 정도를 효과적으로 높일 수 있을 것이다. 또한 위험소통에 건강 정보를 포함한다면, 위험에 대한 심각성, 위험 인지, 대처 실천 정도가 증가할 것이다. 하지만, 더욱 효과적인 건강정보의 리터러시 향상 측면에서, 상세한 시각화, 맞춤화 방법과 건강 정보 표현, 제공 방법에 대한 논의가 필요하다.

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주요어: 지도시각화, 위험소통, 대기오염, 미세먼지, 건강 정보, 리터러시, 인포그래픽, 커뮤니케이션

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