ORIGINAL RESEARCH

Interactive survey of consumer awareness of nanotechnologies and nanoparticles in consumer products in South Korea

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Background: The purpose of our study was to understand consumers' risk awareness and need for relevant information about nanotechnology and nanoparticles contained in products currently being sold in Korea.

Methods: One thousand and seven adult consumers (aged 20–50 years) were randomly selected from all over South Korea between November 1 and 9, 2010. We surveyed the origin and degree of their concern and their need for information and education regarding nanomaterials.

Results: Analysis of the survey results showed no significant differences in responses by sex, age, and level of education, but significant differences were found in responses based on average monthly household income. Our research showed that consumers have vague expectations for and positive image of nanotechnology and nanoproducts but do not clearly understand what they are. In addition, we found that preparing and disseminating information to consumers is required in order to provide correct information about nanotechnology to the public.

Conclusion: A communication system should be established among the multiple stakeholders involved with nanomaterials to address consumer expectations and concerns. Further, a safety evaluation system must be set up, the results of which should be processed by a reliable expert group so they can be disseminated to the public.

Keywords: questionnaire survey, nanomaterials, consumer characteristics, household income

Introduction

The importance of science–society interaction, which has focused on public response to and perception of emerging technologies, has recently increased; public engagement in science policy also has been emphasized. Related to this concept, early in the 21st century, researchers in the UK developed the term "upstream engagement" and promoted it in the UK Royal Society's report on nanotechnologies.[1] According to upstream engagement, the public should understand nanotechnology and participate in decisions regarding its development and the application of its research. Therefore, a survey of public acceptance and understanding of nanotechnology, which is one of the emerging technologies, is needed.

Nanoparticles (NPs) are commonly defined as materials designed and produced to have structural features with at least one dimension of 1–100 nanometers.[2] Such particles typically possess structure-dependent properties such as chemical, mechanical, electronic, optical, magnetic, and biological properties that make them desirable for commercial and medical applications.[3,4] The US National Nanotechnology Initiative defines nanotechnology as "The understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications."[5] For the last several years, the implementation of nanotechnology has grown rapidly and

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Table I Respondent characteristics

Classification	Frequency	Percentage (%)	Valid percent (%)	Cumulative percent (%)
Sex				
Male	505	50.1	50.1	50.1
Female	502	49.9	49.9	100.0
Total	1,007	100.0	100.0	
Age (years)				
11–30	331	32.9	32.9	32.9
31–50	406	40.3	40.3	73.2
>50	270	26.8	26.8	100.0
Total	1,007	100.0	100.0	
Education level				
Enrolled in or graduated from middle or high school	601	59.7	59.7	59.7
Enrolled in or graduated from university or graduate school	406	40.3	40.3	100.0
Total	1,007	100.0	100.0	
Average monthly household income				
Less than $3,000	364	36.1	36.1	36.1
More than $3,000 but less than $5,000	481	47.8	47.8	83.9
More than $5,000	162	16.1	16.1	100.0
Total	1,007	100.0	100.0	

now includes a variety of consumer applications.[6] For example, nanotechnology has been commercially used in health and fitness products such as cosmetics, clothing, personal care, sporting goods, and sunscreen. Also, NPs are expected to be applied to the medical field in diagnosis, imaging, and drug delivery.[7] Although the field of nanotechnology has been rapidly expanding with the continuous development of nanomaterial-based consumer products, their industrial, human risk, and toxicity mechanisms are not completely understood. Thus, the public may feel vague anxiety about nanotechnology because of its unknown effects on human health and the environment.

A number of studies have examined public perception of nanotechnology in the US and Europe, focusing on public attitudes toward nanotechnology. These previous studies showed that the public knew little about nanotechnology and seemed to have few pessimistic views about the field.[1,8,9] However, a study to assess public perceptions of nanotechnology has never been performed in Korea. Therefore, we conducted a national survey to evaluate consumer awareness and concern about nanotechnology, nanomaterials, and nanoproducts. Moreover, this study represents the first questionnaire survey analysis to be conducted by a nongovernmental organization in Korea. This analysis was performed using data from 1,007 randomly selected consumers nationwide. The objectives of this survey were 1) to understand consumers' risk awareness regarding nanotechnology, nanomaterials, and nanoproducts; 2) to understand the consumers' need for appropriate information about nanomaterials and nanoproducts based on consumer characteristics; and 3) to understand consumer needs for developing appropriate communication about the risks of nanoproducts such as functional food, medicine, medical supplies, and cosmetics.

Table 2 Differences in consumer awareness of nanotechnology, nanomaterials, and nanoproducts

Household income	Very	Most	Not very	Do not know well	P-value
≤$3,000					
n (%)	4 (28.6)	54 (29.3)	259 (36.6)	47 (46.1)	<0.01
$3,000–$5,000					
n (%)	3 (21.4)	92 (50.0)	342 (48.4)	44 (43.1)	
≥$5,000					
n (%)	7 (50.0)	38 (20.7)	106 (15.0)	11 (10.8)	
Total					
n (%)	14 (100.0)	184 (100.0)	707 (100.0)	102 (100.0)	

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

In the present study, we examined consumer awareness of nanotechnology, their concerns and expectations for various nanoproducts, and the need for information and education regarding nanotechnology and nanomaterials. In particular, we examined differences in consumer awareness of nanotechnology according to characteristics such as sex, age, level of education, and average monthly household income. The results of this study will be helpful for identifying and targeting consumers unfamiliar with nanotechnology, and for the development of related education and risk communication.

Material and methods
Survey outline
Survey subjects
For the present study, 1,007 adults aged 20–50 years were randomly selected from all over South Korea between November 1 and November 9, 2010. The sample was carefully balanced with regard to sex, religion, residence, age, education, marital status, profession, and income. Participant characteristics are shown in Table 1. The expected error rate was 95% and the confidence interval was ±3.09%.

Survey methods
We used a field survey method consisting of a structured questionnaire and a one-to-one interview survey. The questionnaire was divided into six sections comprising about 19 different questions. Using this questionnaire, we asked consumers to describe their degree of awareness, concern, and expectations about nanotechnology and their need for information and education about the subject. Finally, we used a proportional quota sampling method.

Statistical analysis
Frequencies and chi-square tests were determined for each characteristic, with subjects compared by sex, age, education, and income. One-way ANOVA analyses and two independent sample *t*-tests were performed to evaluate the significance of differences in means. All analyses were performed with SPSS Statistics version 19.0 (IBM Corporation, Armonk, NY, USA).

Results
Differences in consumer awareness by characteristics
To assess differences in consumer awareness according to their characteristics, we analyzed responses based on sex, age, education level, and average monthly household income. Analysis of the results showed no significant difference in

Table 3 Routes for acquisition of information on nanotechnology, nanomaterials, and nanoproducts by household income

Household income	International organization	Central government	Local government	Enterprise	Consumer organization	Environmental organization	Teacher, professor	Research institutions	Professions	Media	People (eg, friends)	Other
≤$3,000 n (%)	16 (17.8)	50 (21.4)	12 (15.0)	25 (26.9)	29 (17.2)	43 (23.1)	50 (25.6)	20 (32.8)	26 (21.8)	222 (45.7)	87 (36.0)	13 (37.1)
$3,000–$5,000 n (%)	54 (60.0)	133 (56.8)	46 (57.5)	46 (49.5)	102 (60.4)	109 (58.6)	100 (51.3)	32 (52.5)	70 (58.8)	194 (39.9)	112 (46.3)	15 (42.9)
≥$5,000 n (%)	20 (22.2)	51 (21.8)	22 (27.5)	22 (23.7)	38 (22.5)	34 (18.3)	45 (23.1)	9 (14.8)	23 (19.3)	70 (14.4)	43 (17.8)	7 (20.0)
Total n (%)	90 (100.0)	234 (100.0)	80 (100.0)	93 (100.0)	169 (100.0)	186 (100.0)	195 (100.0)	61 (100.0)	119 (100.0)	486 (100.0)	242 (100.0)	35 (100.0)

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

responses according to sex, age, or education level (data not shown). However, there were significant differences in responses based on average monthly household income.

Differences in consumer awareness by household income

Respondents were classified into three groups according to their average monthly household incomes: group 1, less than 3,000 US dollars per month ($\leq$\$3,000); group 2, between 3,000 and 5,000 US dollars (\$3,000–\$5,000); and group 3, more than 5,000 US dollars ($\geq$\$5,000).

Awareness of nanotechnology and NPs

Our survey of consumers' awareness of nanotechnology and NPs revealed that 70.2% "do not know well" and 10.1% "do not know at all" (data not shown), indicating that most respondents knew little about nanotechnology and NPs. However, there were statistically significant differences regarding nanotechnology, nanomaterials, and nanoproducts awareness among the three groups by household income ($P<0.01$). Of those surveyed, 46.1% in group 1 and 43.1% in group 2 answered "do not know well", and 28.6% in group 1 and 21.4% in group 2 answered "know very well". However, in group 3, only 10.8% answered "do not know well" and 50.0% answered "know very well" (Table 2).

To determine the route of consumer awareness regarding nanotechnology and NPs, we asked participants which of the following groups they trusted to provide them with information: international organizations, the central government, corporations, consumer and environmental organizations, teachers and professors, research institutes, experts, the media, people, and other. The analysis revealed that "media" was the highest, followed by "people", "the central government", and "teachers and professors", regardless of household income. The frequency of respondents who choose "the media" was highest in group 1 (45.7%), and "the central government" was highest in group 2 (56.8%) among the three groups, but there were no statistically significant differences (Table 3).

Awareness of nanomaterial-related concepts

We asked participants about their awareness of nanomaterial-related concepts focused on their safety for humans and the environment (Table 4). Regardless of household income, the majority of people reported positive feelings about nanotechnology: "nano is safe for the human body" (54.2%), "nano is not harmful for the human body" (52.2%), and "nano could not have a negative effect on the environment" (47.7%).

Table 4 Difference in consumer awareness of nano-related concepts

Related fact	Household income	Very	Most	Not very	Not at all	Do not know well	*P*-value
Safe for the human body	$\leq$\$3,000						
	n (%)	35 (18.8)	120 (33.6)	82 (41.2)	12 (42.9)	115 (49.6)	<0.001
	\$3,000–\$5,000						
	n (%)	105 (56.5)	176 (49.3)	102 (21.3)	12 (42.9)	84 (36.2)	
	$\geq$\$5,000						
	n (%)	46 (24.7)	61 (17.1)	15 (7.5)	4 (14.3)	33 (14.2)	
	Total						
	n (%)	186 (100.0)	357 (100.0)	199 (100.0)	28 (100.0)	232 (100.0)	
Harmful to the human body	$\leq$\$3,000						
	n (%)	15 (55.6)	58 (30.7)	139 (33.6)	25 (22.9)	127 (48.3)	
	\$3,000–\$5,000						
	n (%)	8 (29.6)	114 (60.3)	206 (49.8)	49 (45.0)	102 (38.8)	
	$\geq$\$5,000						
	n (%)	4 (14.8)	17 (9.0)	69 (16.7)	35 (32.1)	34 (12.9)	
	Total						
	n (%)	27 (100.0)	189 (100.0)	414 (100.0)	109 (100.0)	263 (100.0)	
Negative effect on the environment	$\leq$\$3,000						
	n (%)	12 (44.4)	88 (41.7)	123 (34.6)	25 (20.7)	116 (40.8)	
	\$3,000–\$5,000						
	n (%)	10 (37.0)	109 (51.7)	187 (52.5)	60 (49.6)	110 (38.7)	
	$\geq$\$5,000						
	n (%)	5 (18.5)	14 (6.6)	46 (12.9)	36 (29.8)	58 (20.4)	
	Total						
	n (%)	27 (100.0)	211 (100.0)	356 (100.0)	121 (100.0)	284 (100.0)	

Notes: Household income means average monthly household income; $\leq$\$3,000 means less than or equal to 3,000 US dollars; \$3,000–\$5,000 means more than 3,000 but less than 5,000 US dollars; $\geq$\$5,000 means greater than or equal to 5,000 US dollars.

Table 5 Degree of concern about nanotechnology-applied and nanomaterial-containing products

Related fact	Household income	Very	Most	Not very	Not at all	Do not know well	*P*-value
Food	≤$3,000						
	n (%)	48 (50.5)	153 (40.7)	78 (30.1)	25 (16.3)	60 (50.0)	<0.001
	$3,000–$5,000						
	n (%)	35 (36.8)	200 (53.2)	118 (45.6)	84 (54.9)	42 (35.0)	
	≥$5,000						
	n (%)	12 (12.6)	23 (6.1)	63 (24.3)	44 (28.8)	18 (15.0)	
	Total						
	n (%)	95 (100.0)	376 (100.0)	259 (100.0)	153 (100.0)	120 (100.0)	
Health-functional food	≤$3,000						
	n (%)	54 (50.5)	125 (48.3)	100 (27.8)	21 (16.5)	64 (42.7)	
	$3,000–$5,000						
	n (%)	40 (37.4)	115 (44.4)	203 (56.4)	68 (53.5)	53 (35.3)	
	≥$5,000						
	n (%)	13 (12.1)	19 (7.3)	57 (15.8)	38 (29.9)	33 (22.0)	
	Total						
	n (%)	107 (100.0)	259 (100.0)	360 (100.0)	127 (100.0)	150 (100.0)	
Medicine and medical supplies	≤$3,000						
	n (%)	49 (47.1)	124 (43.1)	109 (33.5)	25 (18.7)	57 (37.5)	
	$3,000–$5,000						
	n (%)	44 (42.3)	138 (47.9)	157 (48.3)	71 (53.0)	69 (45.4)	
	≥$5,000						
	n (%)	11 (10.6)	26 (9.0)	59 (18.2)	38 (28.4)	26 (17.1)	
	Total						
	n (%)	104 (100.0)	288 (100.0)	325 (100.0)	134 (100.0)	152 (100.0)	
Functional cosmetics	≤$3,000						
	n (%)	34 (38.2)	130 (43.5)	111 (34.2)	31 (24.8)	58 (35.4)	
	$3,000–$5,000						
	n (%)	52 (58.4)	48 (49.5)	137 (42.2)	64 (51.2)	77 (47.0)	
	≥$5,000						
	n (%)	3 (3.4)	21 (7.0)	77 (23.7)	30 (24.0)	29 (17.7)	
	Total						
	n (%)	89 (100.0)	299 (100.0)	325 (100.0)	125 (100.0)	164 (100.0)	
Hair products	≤$3,000						
	n (%)	47 (44.3)	117 (44.0)	106 (34.1)	31 (22.8)	63 (34.4)	
	$3,000–$5,000						
	n (%)	56 (52.8)	131 (49.2)	141 (45.3)	64 (47.1)	86 (47.0)	
	≥$5,000						
	n (%)	3 (2.8)	18 (6.8)	64 (20.6)	41 (30.1)	34 (18.6)	
	Total						
	n (%)	106 (100.0)	266 (100.0)	311 (100.0)	136 (100.0)	183 (100.0)	
Food containers	≤$3,000						
	n (%)	50 (42.7)	129 (41.6)	90 (39.0)	29 (21.0)	66 (31.9)	
	$3,000–$5,000						
	n (%)	55 (47.0)	158 (51.0)	102 (44.2)	70 (50.7)	94 (45.4)	
	≥$5,000						
	n (%)	12 (10.3)	23 (7.4)	39 (16.9)	39 (28.3)	47 (22.7)	
	Total						
	n (%)	117 (100.0)	310 (100.0)	231 (100.0)	138 (100.0)	207 (100.0)	
Sanitary aids	≤$3,000						
	n (%)	34 (50.0)	131 (42.3)	111 (36.5)	26 (22.4)	62 (30.5)	
	$3,000–$5,000						
	n (%)	29 (42.6)	154 (49.7)	142 (46.7)	56 (48.3)	97 (47.8)	
	≥$5,000						
	n (%)	5 (7.4)	25 (8.1)	51 (16.8)	34 (29.3)	44 (21.7)	
	Total						
	n (%)	68 (100.0)	310 (100.0)	304 (100.0)	116 (100.0)	203 (100.0)	

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

Table 6 Degree of the need for relevant information regarding nanotechnology, nanomaterials, or nanoproducts

Household income	Yes	No	*P*-value
≤$3,000			
n (%)	174 (29.2)	190 (46.1)	<0.0001
$3,000–$5,000			
n (%)	298 (50.1)	183 (44.4)	
≥$5,000			
n (%)	123 (20.7)	39 (9.5)	
Total			
n (%)	595 (100.0)	412 (100.0)	

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

As shown in Table 4, the results for the question regarding "nanomaterials are safe for the human body" showed that more than half of the respondents who answered "very" belonged to group 2 (56.5%) ($P<0.001$), 18.8% were from group 1, and 24.7% were from group 3. The results for the question concerning "nanomaterials could be not harmful for the human body" indicated that the majority of the respondents (55.6%) who answered "very" belonged to group 1, with 29.6% from group 2, and 14.8% from group 3 ($P<0.001$). The results for the question regarding "nanomaterials could have a negative effect on the environment" showed that approximately 20.7% of the respondents in group 1 answered "not at all". Also, the percentages of the respondents in groups 2 and 3 who answered "not at all" were 40.6% and 29.8%, respectively ($P<0.001$).

Degree of concern regarding applied nanotechnology and nanomaterial-containing products' safety for humans

We asked about respondents' concerns regarding the safety of applied nanotechnology and nanomaterial-containing products such as food, health-functional food, medicine/medical supplies, functional cosmetics, hair products, food containers, and

sanitary aids (Table 5). Our results showed that the degree of concern about food, health-functional food, and medicine/medical supplies was the highest in group 1, and that of functional cosmetics, hair products, food containers, and sanitary aids was the highest in group 2 among the three groups. Also, the degree of concern about all products was the lowest in group 3 among these three groups. For example, the result of the question about "degree of concern about food safety for humans" showed that the percentages of respondents who answered "very" were 50.5% in group 1, 36.8% in group 2, and 12.6% in group 3 ($P<0.001$). Similarly, the percentage of respondents indicating "very" with regard to their "degree of concern about health-functional foods" was 50.5% in group 1, 37.4% in group 2, and 12.1% in group 3 ($P<0.001$). Of those who answered "very" about their "degree of concern about functional cosmetics", more than half were in group 2 (58.4%) and only 3.4% were in group 3 ($P<0.001$).

Degree of the need for relevant information regarding nanotechnology, nanomaterials, or nanoproducts

Of the respondents who agreed that "they do need relevant information about nano", 50.1% were in group 2. However, the percentage of the respondents in group 1 who answered that "they do not need relevant information about nano" was 46.1%, which was the highest among the three groups ($P<0.001$) (Table 6).

There were no statistically significant differences in responses to the question about "nano-relevant expected routes for nano information" among the three groups, which included seminar lectures, printouts, internet homepages, video, and others (Table 7). Also, there were no significant differences among the three groups in their responses to the question about "types of information needed about nano," (eg, concept, effects, benefits and functions, performance, and types) (Table 8).

Table 7 Difference in consumers' expected routes to gain information about nanotechnology, nanomaterials, or nanoproducts

Household income	Seminar lecture	Print out	Internet homepage	Video	Others
≤$3,000					
n (%)	45 (24.3)	59 (25.9)	90 (28.4)	26 (32.5)	14 (26.9)
$3,000–$5,000					
n (%)	101 (54.6)	124 (54.4)	152 (47.9)	36 (45.0)	27 (51.9)
≥$5,000					
n (%)	39 (21.1)	45 (19.7)	75 (23.7)	18 (22.5)	11 (21.2)
Total					
n (%)	185 (100.0)	228 (100.0)	317 (100.0)	80 (100.0)	52 (100.0)

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

Degree of need for education and promotion regarding nanotechnology, nanomaterials, or nanoproducts

The results for the question about "social consent is required about the safety of nanomaterials" showed that the percentage of respondents who replied "very" was highest in group 1 (48.7%) while the response "mostly" was highest in group 2 (49.4%) among the three groups ($P<0.001$). Also, 40.5% of respondents in group 1 answered "mostly", while 36.0% in group 2 answered "very" (Table 9). Related to social consent about nano, about 70% of respondents answered that "nano education and promotion are needed". Specifically, the degree of need for education and promotion was higher in groups 1 (38.0%) and 2 (44.6%) than group 3 (17.4%) ($P<0.05$) (Table 10). For education and promotion, most respondents, regardless of income, chose the central government and the media as suitable channels for nano education and promotion. The evaluation of the appropriateness of suitable channels showed that about 40% of respondents who chose the central government and the media belonged to group 1 (39.5% and 40.5%, respectively) and group 2 (47.0% and 41.7%, respectively) ($P<0.001$). However, the frequency of respondents who chose the central government and the media was lower in group 3 compared to groups 1 and 2 ($P<0.001$) (Table 11).

Discussion

With the rapid development of nanotechnology and the growing market for applied nanotechnology products, this study aimed to investigate consumers' awareness of and concerns regarding nanotechnology, and to verify consumers' need for education and promotion of nanomaterials and nanoproducts. Therefore, we conducted a nationwide survey of 1,007 randomly selected consumers in November 2010 and analyzed the data according to characteristics including age, sex, education level, and average monthly household income.

We found that most consumers in Korea did not clearly understand nanotechnology, nanomaterials, and nanoproducts. For example, 80.3% of respondents indicated that they "did not know at all" or "did not know well"; only 1.4% of respondents indicated that "they know very well". Although consumers had less understanding of nanotechnology, they did have a positive image of the field. More than half of respondents thought that nano is good and safe for the body and is not harmful to the environment. Similarly, in the US, a number of studies showed that the majority of the public had a small amount of knowledge and a positive perception of nanotechnology.[1,9,10] Cobb and Macoubrie reported that most US consumers had a positive view of nanotechnology, even though they had limited knowledge about it.[1] However, in Europe, the public possessed not only little knowledge, but were also less optimistic about and supportive of nanotechnology.[8,11] In 2010, the Eurobarometer survey showed that 40% of respondents answered that they did not have any knowledge of nanotechnology, and 20% had a negative and unconcerned attitude toward it.[12]

When we analyzed the results based on respondent characteristics, we found statistically significant differences in responses according to average monthly household income, but no differences according to sex, age, and education level. Our study showed that consumers with low household income also had low awareness of nanotechnology but were significantly more likely to have a positive view of it ($P<0.001$). For example, the majority of respondents who answered that nanomaterials are safe and not harmful for the human body belonged to groups 2 and 1, respectively. Approximately 70% of respondents who thought that nanomaterials could not have a negative effect on the environment were in groups 1 and 2. Ironically, even though the consumers in groups 1 and 2 had positive attitudes regarding nanotechnology, the degree of concern about the safety of nanotechnology-applied and nanomaterial-containing products was higher in groups 1 and 2 than

Table 8 Difference in type of necessary information about nanotechnology, nanomaterials, or nanoproducts

Household income	Concept	Effects	Benefits and functions	Types	Others
≤$3,000					
n (%)	43 (22.1)	124 (35.2)	93 (32.7)	44 (23.5)	0 (0.0)
$3,000–$5,000					
n (%)	97 (49.7)	173 (49.1)	133 (46.8)	104 (55.6)	1 (25.0)
≥$5,000					
n (%)	55 (28.2)	55 (15.6)	58 (20.4)	39 (20.9)	3 (75.0)
Total					
n (%)	195 (100.0)	352 (100.0)	284 (100.0)	187 (100.0)	4 (100.0)

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

Table 9 Degree of the need for social consent regarding nanotechnology or nanomaterials

Household income	Very	Most	Not very	Not at all	Do not know well	P-value
≤$3,000						
n (%)	111 (48.7)	137 (40.5)	52 (24.9)	14 (19.2)	50 (32.7)	<0.001
$3,000–$5,000						
n (%)	82 (36.0)	167 (49.4)	126 (60.3)	36 (49.3)	67 (43.8)	
≥$5,000						
n (%)	35 (15.4)	34 (10.1)	31 (14.8)	23 (31.5)	36 (23.5)	
Total						
n (%)	228 (100.0)	338 (100.0)	209 (100.0)	73 (100.0)	153 (100.0)	

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

in group 3. We found that respondents in group 1 were highly concerned about the food safety, health-functional foods, and medicine/medical supplies containing nanomaterials while respondents in group 2 were highly concerned about the safety of functional cosmetics, hair products, and food containers. However, the degree of concern in group 3 was lower than that in groups 1 and 2 for all questions about nanoproducts. Our observations suggest that consumers with low household income not only have a vague anxiety for nanotechnologies and nanoproducts but also have vague expectations because they did not clearly understand them. Consistent with our findings, Currall et al reported that members of the public who consider nanotechnology beneficial also tend to believe that it has risks; therefore, they concluded that perceptions of the risks and benefits of nanotechnology are correlated.[13] In addition, the findings of a previous study on perceptions of nanotechnology that focused on differences according to public characteristics reported that people tended to judge the risks and benefits of nanotechnology based on their social position and cultural experiences.[14]

As with other emerging technologies, it can be beneficial to build public consensus and education to relieve public anxiety regarding nanotechnology. We showed that most

Table 10 Degree of the need for education and promotion about nanotechnology or nanoproducts

Household income	Yes	No	P-value
≤$3,000			
n (%)	269 (38.0)	40 (36.0)	<0.05
$3,000–$5,000			
n (%)	316 (44.6)	59 (53.2)	
≥$5,000			
n (%)	123 (17.4)	12 (10.8)	
Total			
n (%)	595 (100.0)	412 (100.0)	

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

respondents wanted relevant information and social consent about the safety of nanotechnology and nanomaterials. Similarly, Burri and Bellucci reported that most participants in their survey conducted in Switzerland wanted more information and better communication regarding nanoscience and its applications.[15] In addition, our results showed that low-income consumers needed more education and promotion regarding nanotechnology, nanomaterials, or nanoproducts than consumers with higher incomes. Also, they had more confidence in the central government and the media as suitable channels for nanoeducation and promotion than others such as international organizations, corporations, consumer organizations, and research institutes.

Based on these results, we speculate that accurate information about the risks of nanomaterials is required, despite a lack of scientific evidence of their effects on the human body. Therefore, safety- and risk-evaluation systems should be developed for nanomaterials and their results processed by a reliable, expert group. This group has included people who have experience and are experts in the field of nanotechnology, such as research institutes, universities, government, industry, and nongovernmental organizations.[16] Finally, the results could be disseminated through an official organization trusted by the public. A recent study demonstrated that public perception of nanotechnology has tended to diverge according to expert opinion.[17] In addition, Vandermoere et al reported that public awareness of nanoscience was related to views on science, technology, and nature.[18] Similarly, other previous studies demonstrated the positive relation between scientific knowledge and public attitude to technology.[19,20] Thus, people with occupations related in nanotechnology should be actively participating in risk-evaluation and communication, which can help consumers to more easily make judgments of nanotechnology and its applied products. Moreover, when a communication system is established, active participation from the stakeholder to include consum-

Table 11 Differences in consumers recognition of the suitable channels for nano education and promotion

Household income	International organization	Central government	Local government	Enterprise	Consumer organization	Environmental organization	Teacher, professor	Research institutions	Professionals (eg, scientists)	Media	People (eg, friends)	Other
≤$3,000												
n (%)	56 (42.7)	79 (39.5)	9 (22.0)	14 (21.5)	5 (45.9)	27 (28.1)	8 (26.7)	20 (33.9)	30 (42.3)	66 (40.5)	3 (13.6)	1 (6.7)
$3,000–$5,000												
n (%)	49 (37.4)	94 (47.0)	26 (63.4)	36 (55.4)	49 (44.1)	61 (63.5)	18 (60.0)	26 (44.1)	30 (42.3)	68 (41.7)	15 (68.2)	7 (46.7)
≥$5,000												
n (%)	26 (19.8)	27 (13.5)	6 (14.6)	15 (23.1)	11 (9.9)	8 (8.3)	4 (13.3)	13 (22.0)	11 (15.5)	29 (17.8)	4 (18.2)	7 (46.7)
Total												
n (%)	131 (100.0)	200 (100.0)	41 (100.0)	65 (100.0)	111 (100.0)	96 (100.0)	30 (100.0)	59 (100.0)	71 (100.0)	163 (100.0)	22 (100.0)	15 (100.0)

Notes: Household income means average monthly household income; ≤$3,000 means less than or equal to 3,000 US dollars; $3,000–$5,000 means more than 3,000 but less than 5,000 US dollars; ≥$5,000 means greater than or equal to 5,000 US dollars.

ers will be important to provide the necessary information that is imperative for raising awareness of nanotechnology. The public requires more direct communication, which emphasizes disputing, experiencing, and making thoughtful decisions. Through communication between consumers, producers, and experts, it is important to educate the public and thereby reduce consumer anxiety toward nanorelated products.

Conclusion

For the first time in Korea, the present study examined the relationship between consumer characteristics and their awareness of nanotechnology, nanomaterials, and nanoproducts. We found that consumers with low monthly household incomes had low awareness of nanotechnology, but high anxiety and expectations for nanotechnology and nanoproducts. In addition, these consumers believed they needed to receive relevant information about nanotechnology through education and promotion, as they did not have sufficient knowledge of nanotechnology and nanoproducts. Therefore, a communication system should be established for vulnerable consumers to address their expectations and concerns.

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Disclosure

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