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Risk communication on Radioactive Substances in Food

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Introduction

After the accident at Fukushima Daiichi nuclear power plant on 11th Mar. 2011 (3/11)

- *Strong Public concern about health effects of radioactive substances in food*
- *Time has passed with concerns remaining (with questions unanswered)*

A symbol of the concern?

Even after eight years, sales of agricultural products from Fukushima are still restricted.

... Slightly handled at major retailers. Low price range

... Fukushima is an agricultural area rich in fruits, vegetables, rice and livestock products.

Role of experts

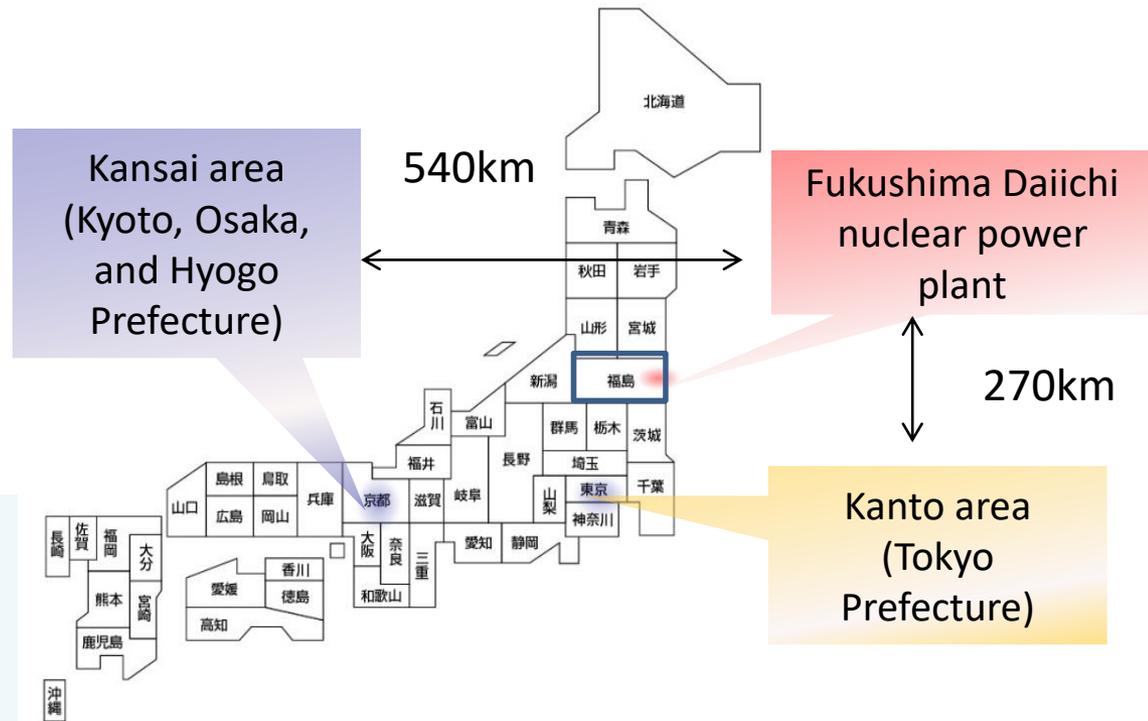
- Identifying the status of public risk perception and knowledge
- Providing opportunities for risk communication responding to their status
... However, risk communication is extremely difficult and has not been successful

To discuss what is the basis of the strong public concern

- Psychological and subjective public risk estimation
- Public knowledge limited by an environment of restricted information

To discuss what risk communication would be effective?

The location of the disaster-stricken area, Fukushima, and our research survey area on citizen's risk perception



Evaluation of accumulated exposure dose

Tokyo : 0.52mSv/2011

Kyoto : 0.25mSv/2011

A pilot for European route : 2mSv/y

Source: Estimated by a radiobiologist when preparing for risk communication (2011, August).

Measures for Primary production

- Planting restriction
- Measures for reduce migration radioactive substances

Decontamination of farmland



- Inspection of radioactive substances

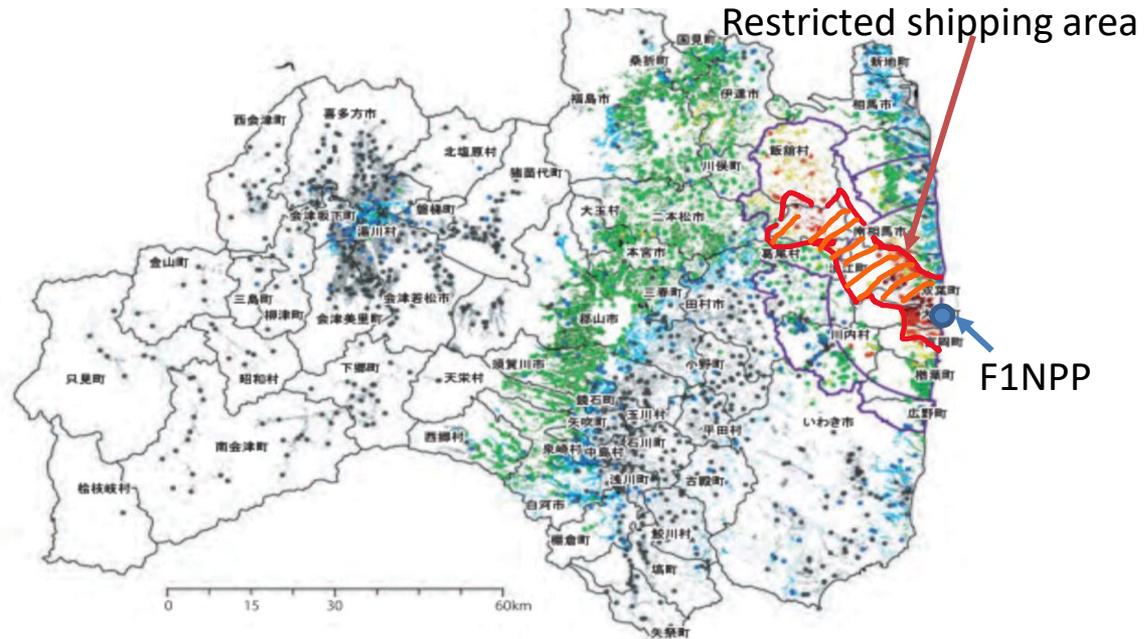
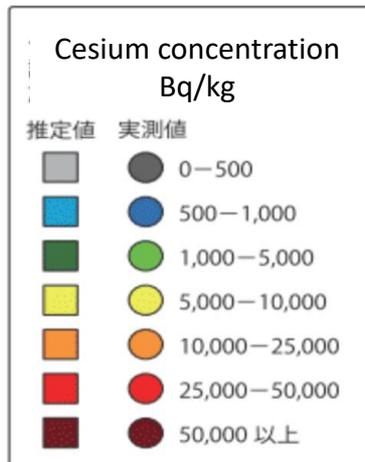


- Shipping restriction (in the case of standard value exceeded)

* Annual dose 1mSV: Based on Codex standard

Cesium test result: Ratio above standard value			
	17 prefectures	Fukushima	number of samples
2011	0.7	2.3	80,889
2012	0.1	0.5	185,294
2014	0.001	0.01	203,097
2016	0.001	0	221,558
2018	0	0.000	217,223

Cesium concentration distribution in farmland soil in Fukushima Prefecture



Note: The estimated values are calculated with reference to the measurement results of air dose by aircraft and include certain errors. Agricultural soil samples were taken to a depth of 15 cm from the ground surface (agitation by plowing and considering the depth of roots of crops).

What is the status of public risk estimation?

The significant gap between experts and the public

: regarding risk assessment approaches, particularly the concepts of risk and risk estimation procedures

	Factor of estimation	Estimation procedures	
Experts	A function of the probability of an adverse health effect and the severity of the effects	Scientific data and processes	Codex Alimentarius commission (2003)
Public	A broad conception of risk that is qualitative and complex	Intuitive and subjective	Slovic (1999)

Elements of public risk conception:

- *"Incorporating considerations such as uncertainty, dread, catastrophic potential, and influencing by emotion and affect"* (Slovic, 1999)
- *"Risk / Hazard Characteristics"* (*"Unknown"* and *"Fearfulness"* : 8 observation variables)
 - : Fischhoff et al. (1978), Slovic et al. (1980)
- *"Interference with nature"*
 - : Sjöberg (2002)
- *"Trust" and "knowledge"*
 - : Sjöberg (2001) , Frewer et al. (1996), Siegrist (2000), etc.
- *"Benefits"*
 - : Siegrist (2000)
- *"Affect" or "Affective images"*
 - : Slovic et al., (1991) ,Slovic (1999), Leiserowitz (2005), Keller et al., (2012) , etc.

→ *To identify factors affecting perceived risk of radioactive substances in food*

	Factor of estimation	Estimation procedures	
Public	Replacing target factors with easy-to-estimate factors	Accessible events and clues such as association ; intuitive	Stanovich KE and West RF. (2000), Kahneman (2011)

The dual process theory on information processing
the system 1 (experiential system) associative, holistic, automatic
the system 2 (analytic system) analytic, controlled
(Stanovich and West, 2000; Slovic et al., 2004; Kahneman 2012)

Hypothesis about citizen's risk estimation for radioactive substances in food

- Lack of hard-to-assess factors: *Probabilistic events of risk*
 - *random health effect*
 - *reducing the probability of contamination by regulatory measures*

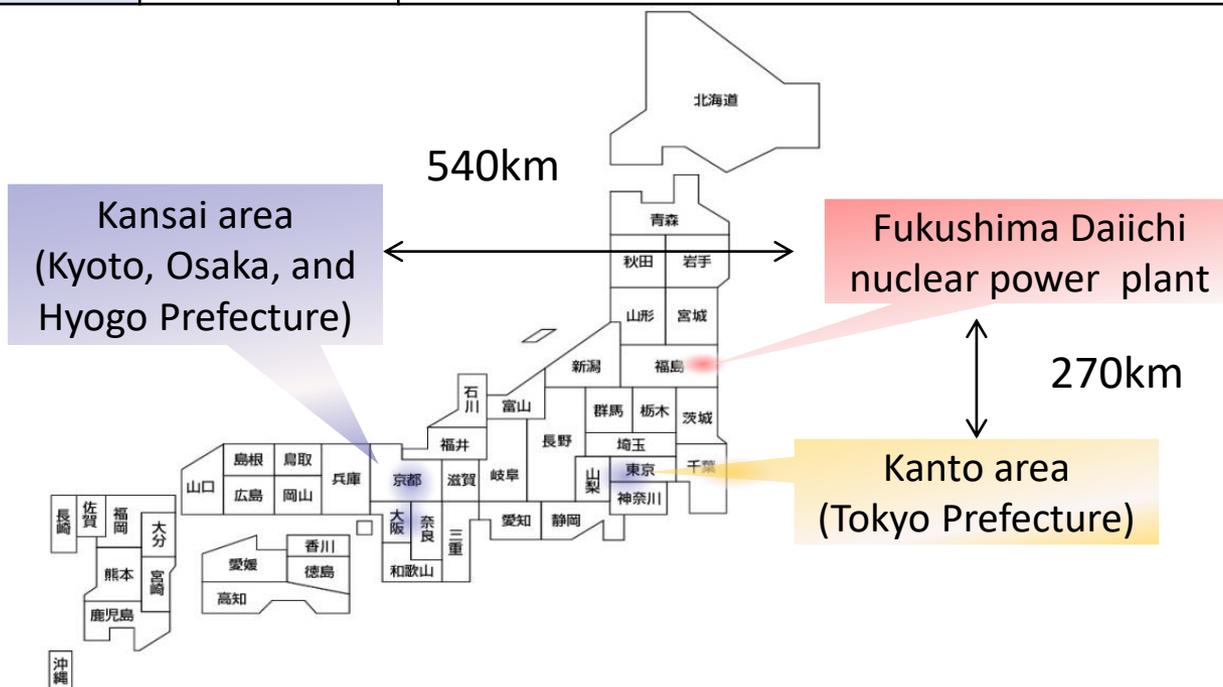
- Replacing with easy-to-estimate factors :
 - *Using association as clues*
 - *Replacing with deterministic effects*

- A lack of knowledge about information they couldn't obtain. → Furthering of the above

Structure of public risk perception about the health effects of radioactive substances in food

Survey 1: To identify factors (latent variables) affecting public risk estimation:
Risk of health effects of radioactive substances released by Fukushima incident

Survey		Subjects	Date
Survey 1	Internet survey	Women aged from 30 to 49 who have school children ...living in <u>Kanto area</u> and <u>Kansai area</u> Sample number : 1,110	May , June, 2012



Magnitude of Perceived Risk and Risk Adjustment

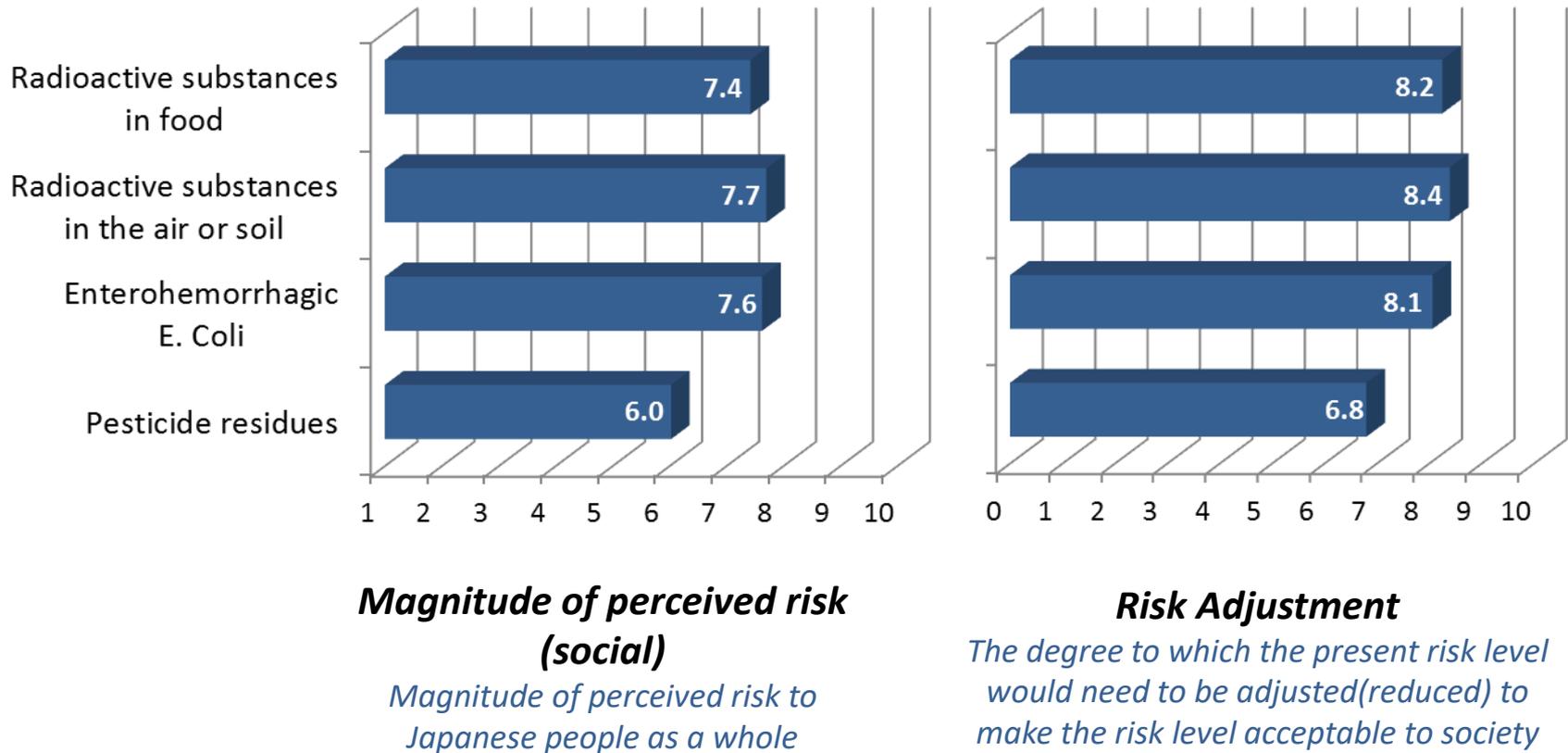


Figure Mean ratings of magnitude of perceived risks and risk adjustment

Source: Data from an internet survey (May-June, 2011) with women aged 30-49 years who had school children (N=1110).

Knowledge Level

The health effects under low dose exposure and the rationale of regulation:

The rationale of regulation:

not generally known to the public due to *lack of those information environments*

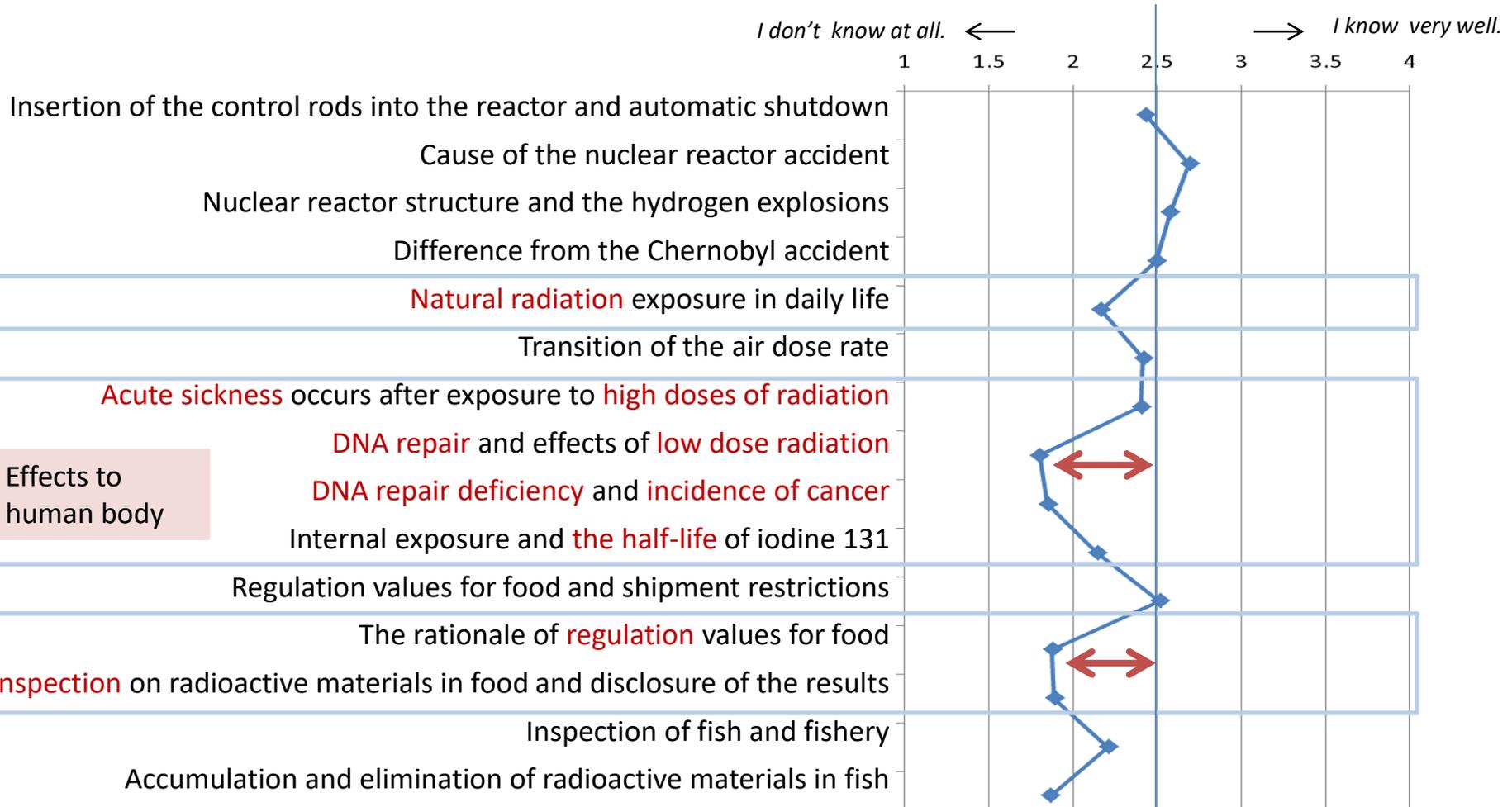


Figure Mean Ratings of Knowledge Level: Internet Survey

Note: The rating scale is: 1 (I don't know anything about this), 2 (I know a little), 3 (I have a general idea), 4 (I know a lot about this)
 Source: Data from an internet survey (May–June, 2011) with women aged 30–49 years who had school children (N=1236).

Cognitive Level of Factors Expected Affecting Risk Perception: Health Effects of Radioactive Substances in Food

Weakness : Radiation dose by Fukushima incident– the effects relation (dose –response)

Strength : horrifying images

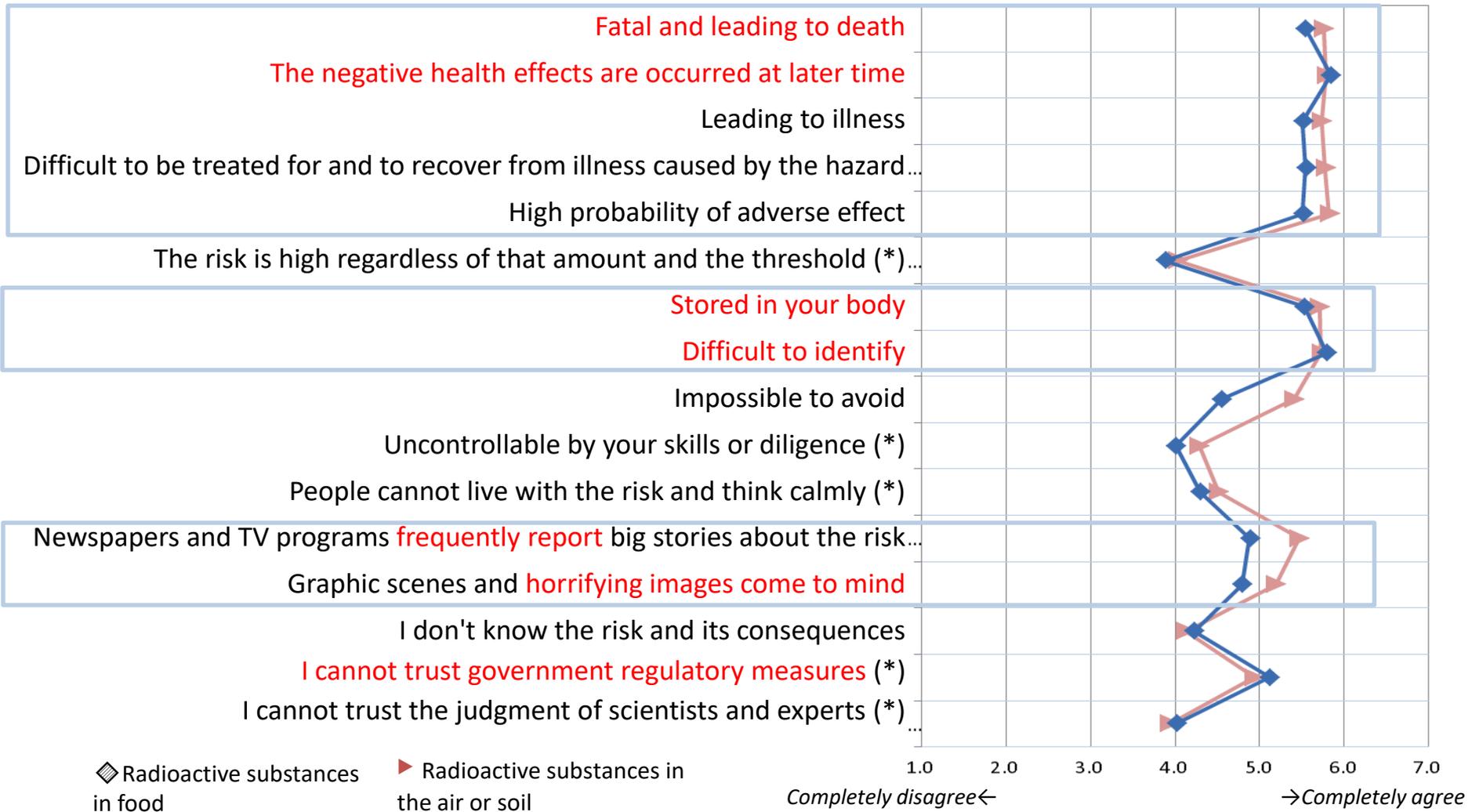
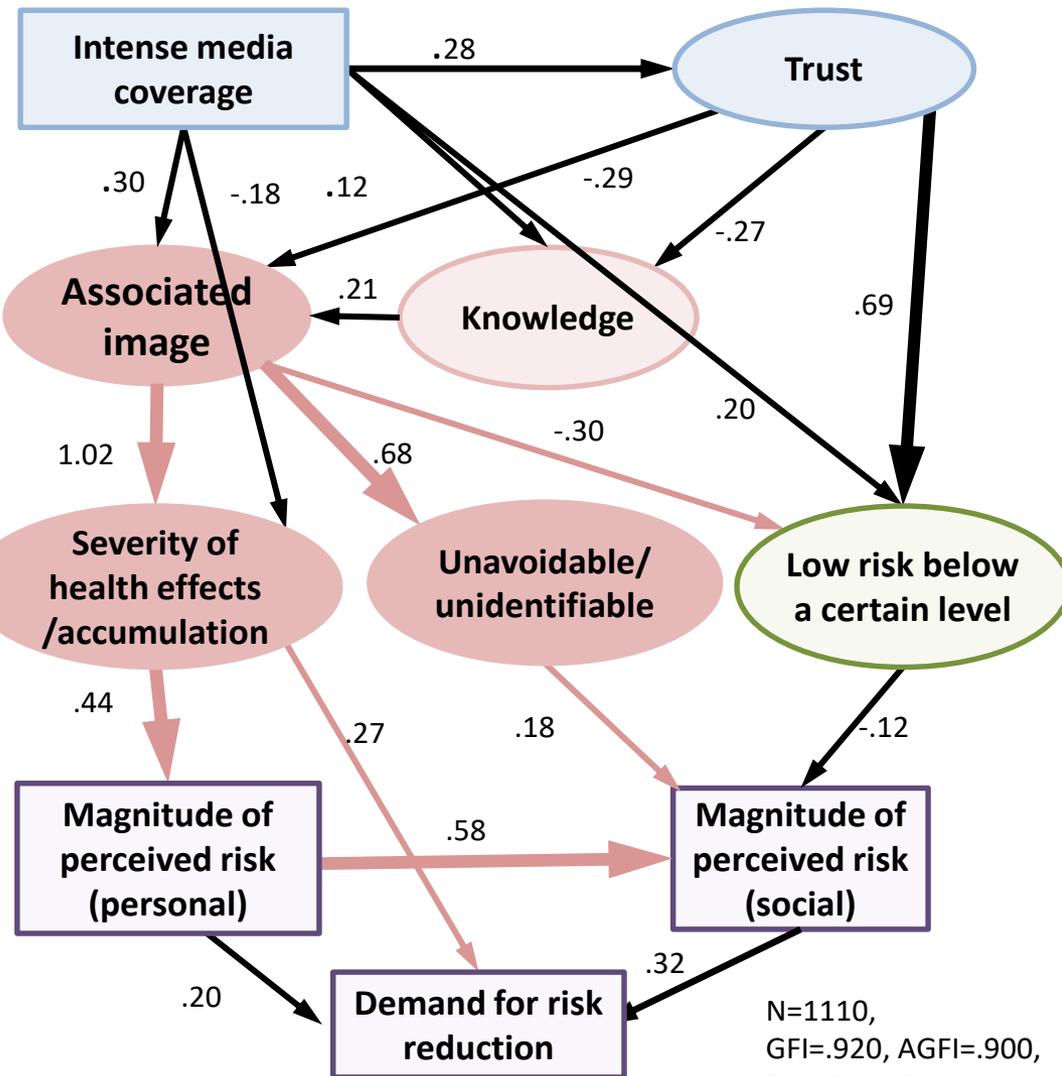


Figure Mean ratings of risk/hazard characteristics

Source: Data from an internet survey (May- June 2011) with women aged 30-49 years who had school children (N=1110).

Factors (latent variables) and its causal chain affecting the level of perceived risk of Radioactive Substances in Food



Key Points

Knowledge

...had no significant effect on the risk/hazard characteristics.

Trust

...had a strong effect on 'low risk below a certain level', which little effect on perceived risk.

Associated image

...The perceived risks were determined mainly by "associated image" and 'severity health effects/accumulation'.

...While, that were not based on media information alone.

...What are the origins?

N=1110,
GFI=.920, AGFI=.900,
RMSEA=.059

Method: Structural Equation Modeling

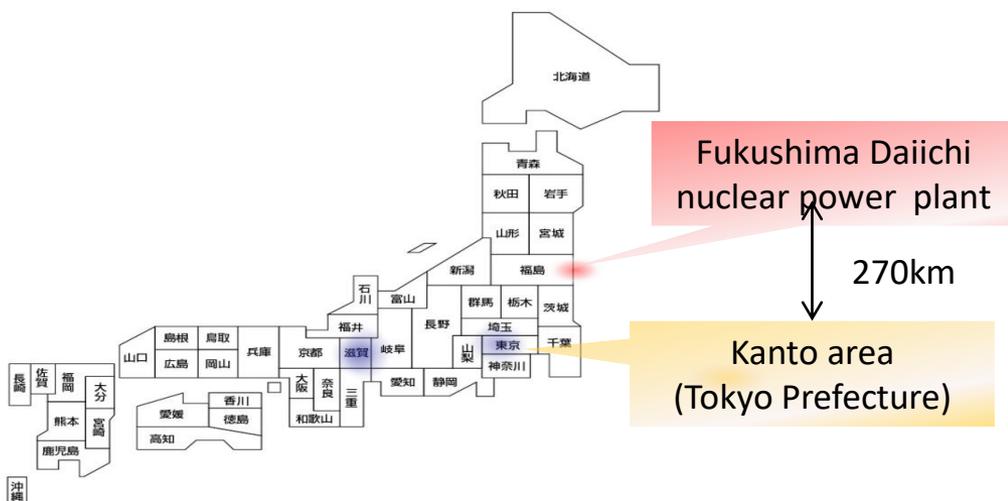
Data: Data from an internet questionnaire survey (May-June 2011) with women aged 30–49 years who had school children .

Figure A Structural Model of Risk Perception of Radioactive Substances in Food

Images and its origins of Health Effects of Radioactive Substance

Survey 2: To identify Images and its origins of Health Effects of Radioactive Substance

Survey		Subjects	Date
Survey 2	Focus group interview	Women aged from 30 to 49 who have school children ...living in Tokyo and Ciba Sample number : $4 \times 1, 6 \times 3 = 22$	February, March, 2014



The participants were asked : to prepare pictures that were presented their images :to describe about it and from what and when they got it.

1. 'Invisible fear' (n=7)

The risk is surrounding us / be not discernible to the eye, accumulated in an invisible space



2. 'Fear of the unpredictable' (n=5)

Not to know when and what effect is given

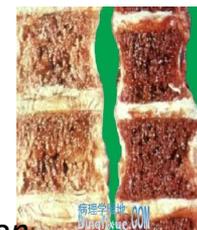
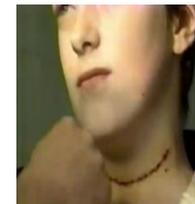


dark tunnel

4. 'Serious health damage' (n=12)

'Health damage: human'

cancer/leukemia



genetic mutation

3. 'Spreading and accumulating' (n=5)

pervading in the air, falling down on plants, eat without realizing, time passes
accumulate in plants and animals, accumulated in the body,



5. 'Heightened fear and despair' (n=5)

abnormal phenomenon Hopelessness, get ill body and soul nothing is possible in ruins



6. 'Safety' (n=1)

Inspection, safety food



'-plants and animals'



deformity



ecology abnormality

Figure 4 Image of health effects of radioactive substance in food: Japanese participants

Source: Data from the Focus group interview with women aged 30-49 years who had school children (N=22).

Origin of the Images of health effects of Radioactive Substance

- The roots of their images were *mainly visual information* , especially on the fear.
 ...Especially from *the comic dealing with the atomic bombings*
 ...Mostly accessed during *elementary-school years*, few after 3.11.
- Only few from textual information, and which was accessed adult years

Table 1 Origin of Images directly related to radioactive substances

Images	Comic	Time	Video pictures	Time	Phots	Time	Textual informaiton	Time	Reading and hear	Time
Invisible dread (Difficult to identify)	Atomic bomb/many dead bodies Atomic bomb/maggot-infested body	E.S. Coll								
Spreading and accumulation			Red spots in cows (TV)	Post-3.11	Deformed butterflies	Post-3.11	Contamination of pasta (news) Black rain (novel)	Coll Coll		
Dread not to know when and what kind of influence is given (Delayed effects)	Atomic bomb/people whose skins were hideously burned	E.S.	Atomic bomb/ maggot-infested body (film) Nuclear accident at Chernobyl (TV) Red spots in cows (TV)	E.S. E.S. Post-	Deformed butterflies	Post-3.11	Effects on children after the nuclear accident at Chernobyl	J.H.	Talk of a fellow mom who supports children from Chernobyl	Post-3.11
Health effects /Cancer Leukemia Deformity (Cause of disease)	Atomic bomb/many dead bodies Atomic bomb/many dead bodies/fear caused by seeing bone Atomic bomb/running around burnt ruins to escape	E.S. E.S. E.S.	Nuclear accident at Chernobyl (TV)	E.S.	Nuclear accident at Chernobyl Atomic bomb/dead mothers holding baby	E.S. Post-3.11	Effects on children after the nuclear accident at Chernobyl	J.H.	Talk of a fellow mom who supports children from Chernobyl	Post-3.11
Maximized dread	Atomic bomb/people whose skins were hideously burned	E.S.	Explosion of nuclear reactor building	Post-3.11	Photos of burned people in Hiroshima Peace Memorial Museum	J.H.				
		7		6		5		4		2

Note: E.S.:Elementary-school years, J.H.:Junior high school days, Coll.:College days

- The things that are not related directly with radioactive substances (such as Tsunami, horror movies, the fear felt at dive and abortion) are also the roots of their images.
 - ... caused by video pictures and experiences.
 - ... mostly were accessed at adult years.

Table 2 Origin of Images not directly related to radioactive substances

	Video pictures	Time	Phots	Time	Experience	Time	Reading and hearing	Time
Invisible dread (Difficult to identify)			Earthquake cloud	Post-3.11	Earthquake Fear experience at diving	E.S. Coll		
Spreading and accumulation	Separating operation of Viet and Duc Nguyen (news) Tsunami War (documentary) Hollywood horror movie	J.H. Post-3.11 E.S. Coll			Earthquake Fear experience at diving	E.S. Coll	When got a warning on scarred lung due to smoking	Coll
Dread not to know when and what kind of influence is given	Tsunami	Post-3.11						
Health effects/ Cancer·eukemia·Deformity (Cause of disease)	Huge cuttlefishes/ Running around to escape from tsunami	Post-3.11 Post-3.11			Abortion caoused by fetal disorder	Pre-3.11	When got a warning on scarred lung due to smoking	Coll
Maximized dread	War (documentary) Separating operation of Viet and Duc Nguyen (news) Hollywood horror movie People escaping from tsunami	E.S. J.H. Coll Post-3.11						
	11		1		5		2	

Note: E.S.:Elementary-school years, J.H.:Junior high school days, Coll.:College days

How is that in France?

Survey 2-2: To identify Images and its origins of Health Effects of Radioactive Substance

Survey		Subjects	Date
Survey 2	Focus group interview	Women aged from 30 to 49 who have school children ...living in Toulouse and Paris (Group 3: June 14, 2016) Sample number : $6 \times 2, 7 \times 1 = 19$	June 9, June 13, 14, 2016

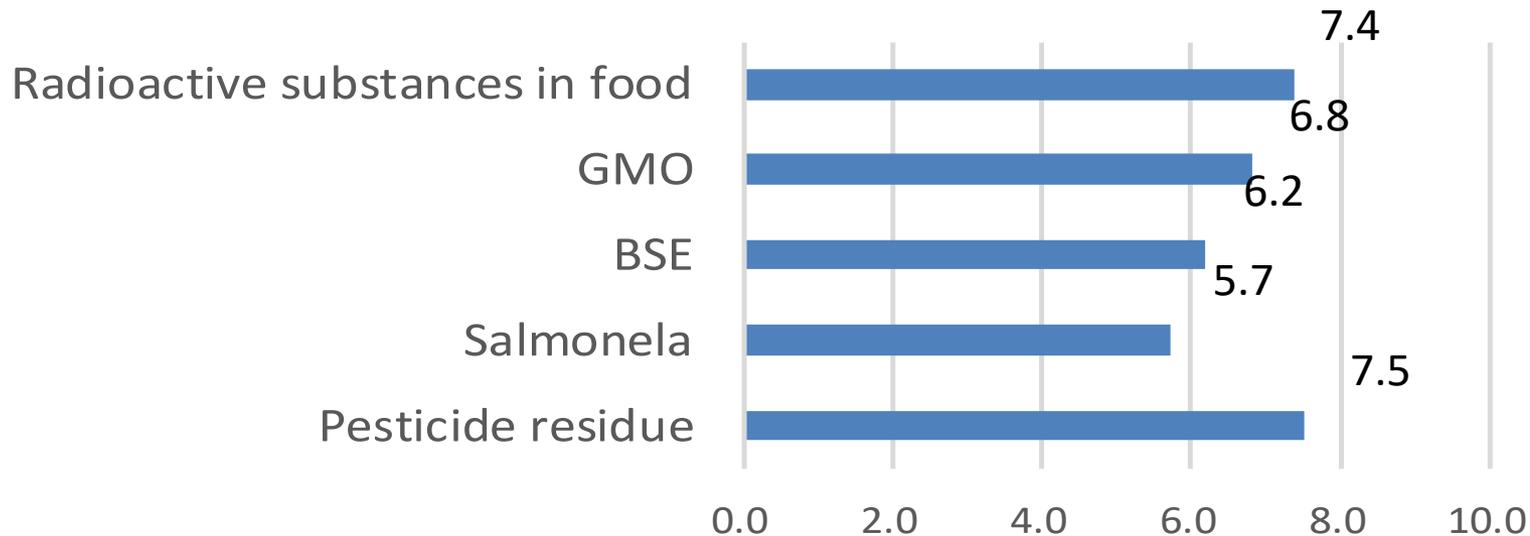


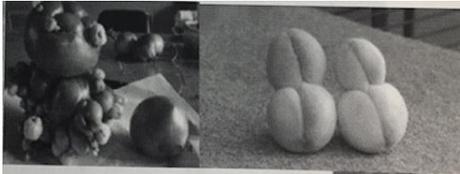
Figure 5 Perceived Magnitude of risks in France

Note: Respondents were given an explanation that “risk is usually defined as the probability (degree of possibility of occurrence) of an adverse health effect and the severity of the effect by a hazard in food.”

Source: Data from the focus group interview with women aged 30–49 years who had school children (N=19). 17

1. "Fear of the Invisible" (n=1)

Radioactive effects on chromosomes



2. "Fear of the Unpredictable" (n=0)

3. "Spreading and Accumulation" (n=5)

Spreading from nuclear power



Pollution



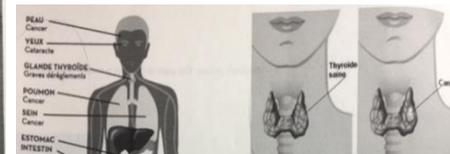
Accumulation in the body



4. Severity of Health Effects (n=15)

1) Humans (n=11)

Deformities, cancer

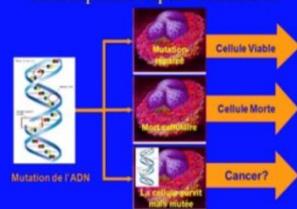


Skin problems, hair loss



2) DNA, Gene, Chromosome humans/plants/animals (n=4)

Conséquences après irradiation



Mechanism for cancer onset

5. "Heightened Dread and Despair" (n=1)



Irrational fear

6. "Safety" (n=0)

Figure 5 Image of health effects of radioactive substance in food: French participants

Source: Data from the Focus group interview with women aged 30–49 years who had school children (n=21).

Table 2 Origins of Image of health effect of RS

Media type	When	Description	Image type	N=
Personal experience	Elementary	Visit near the nuclear power plant	Health effects Spreading	2
Hearsay	Elementary	From parents about CB	(Nuclear risk)	1
	Recent	From habitants near CB From mother about CB and FK	Severe health effects (Nuclear risk in food)	2
School education	Elementary	Victims in HR , atomic bomb	(Nuclear risk on health)	1
	Junior high school	HR atomic bomb, and CB Marie curie, atomic bomb in HR Nuclear risk in history and geography HR and NG atomic bombs	(Nuclear risk) Severe health effects (Nuclear risk) Severe health effects	4
	High school	HR and NG atomic bombs HR and NG in history and geography WWII	Heal. Eff. & Spreading (Nuclear risk) Heal. Eff. & Fear	3
	Childhood	Nuclear risk in some report/image CB	(Nuclear risk) (Nuclear risk)	2
Movie	Highschool	A film about the malformed victims in HR	(Nuclear risk on health)	1
Documentary	Childhood	Atomic bomb in HR	(Nuclear risk on health)	1
	Recent	Nuclear accident in CB	(Nuclear risk in food)	1
TV	Childhood	Nuclear accident in CB	(Nuclear risk on spread.)	1
Image	Elementary	Atomic bomb and victims in HR	(Nuclear risk on health)	1
	Childhood	Deformed child Some image during the class	(Nuclear risk on health) (Nuclear risk)	2
Report	Childhood	Some report during the class	(Nuclear risk)	1

Note: () = Images that were not explicitly mentioned but implied. Hiroshima (HR), Chernobyl (CB), NG (Nagasaki)

Summary :

Characteristics of citizen's risk estimation (why do they estimated high range?) of the health effects of radioactive materials

Lack of "knowledge":

- *The health effects under low dose exposure*
- *The rationale of regulation:*

Weakness of recognition:

- *Radiation dose by Fukushima incident– the effects relation (dose –response)*

Strength of recognition :

- *horrifying images*

Compensating lack of "knowledge"

by "trust" in previous study (Siegrist 2000)

by "*association*" in this case (as suggested by Slovic et al., 2004; Kahneman 2012)

..... *the serious image of past events (Hiroshima, Nagasaki and Chernobyl)*

It is likely that In public risk assessments, the probabilistic events of risk (dose-response, and risk reduction due to regulatory actions) are replaced and estimated by those image (deterministic effects in the past events).

What risk communication would be effective?

According to **elaboration likelihood model** (Petty and Cacioppo 1980)

Attitude change....

Attitudes formed by peripheral routes (emotional processing, intuitive processing based on peripheral information) are unlikely to change depending on central routes (processing based on logical information).

People want systematic information, but communication based on scientific information is expected to be difficult.



Study 1 The interactive risk communication model and results of its experiment

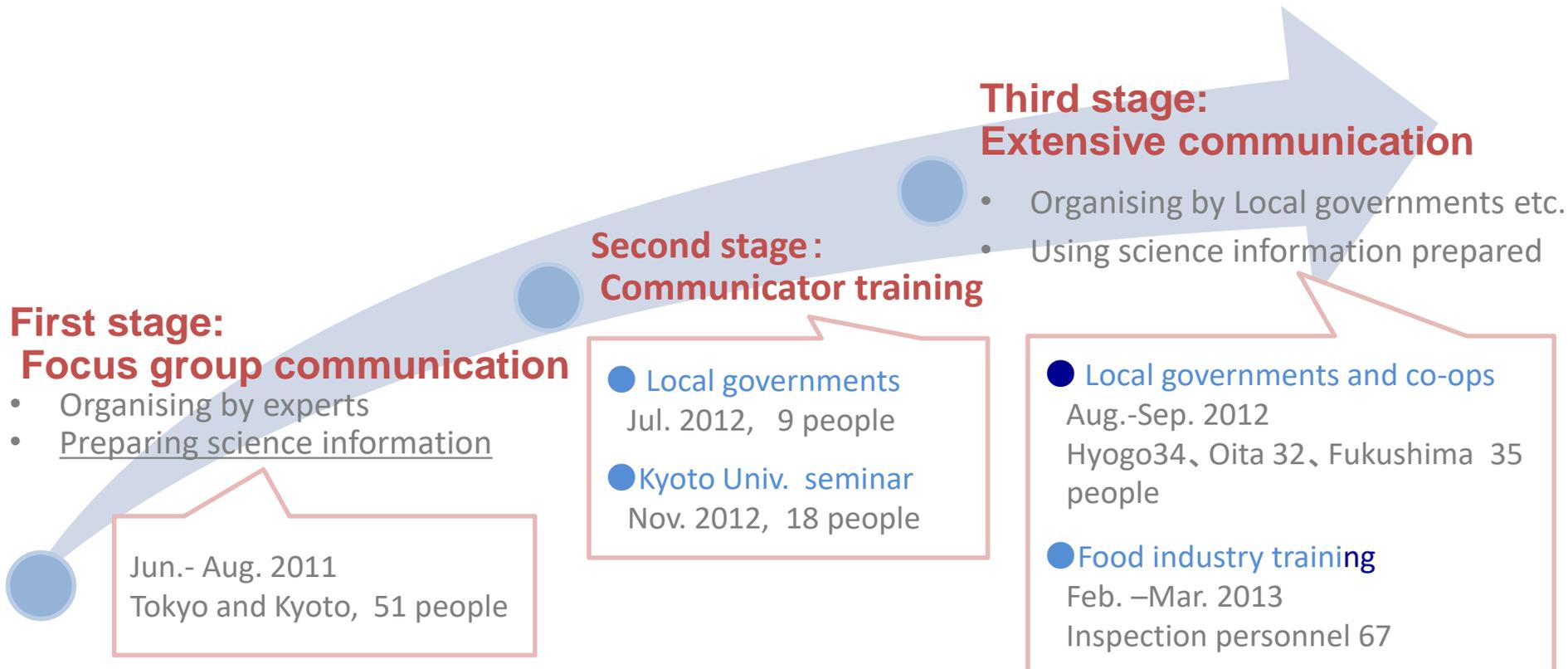
: Interactive and effective, but time consuming

Study 2 Experiment of one-way information provision

: Time-saving and convenient, but the effect is unknown in one direction

Study 1

Development and experiment of interactive risk communication model

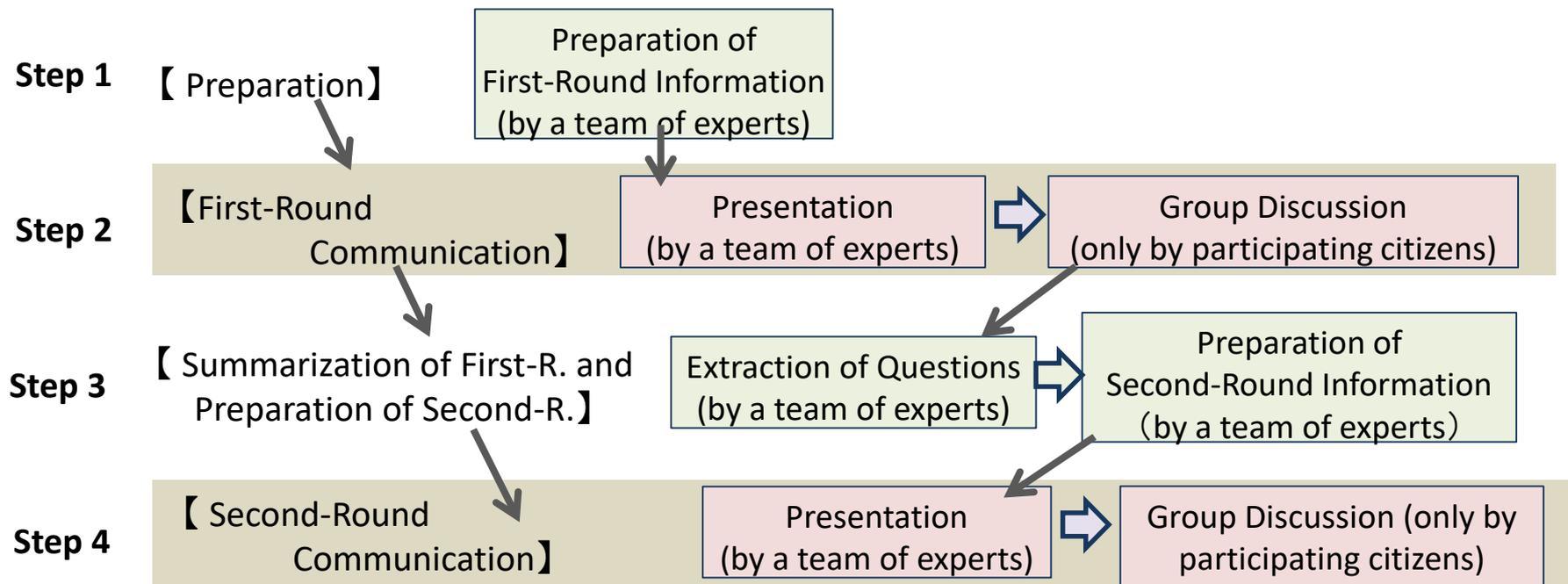


- Niiyama, Y. Kito, Y., Kudo, H., and Matsuo K.: An Interactive Risk Communication Model based on Horizontal Discussion by Citizen and Examination of it through Focus Group Communication: Elaborate Information Processing on Health Effects by Radioactive Substances in Food, *Journal of Food System*; 21(4), March 2015, pp267-285

Interactive Communication Model consisting of four steps

Key points

- Conducting **two continuous discussions**
 - ... in the form of **horizontal discussion only by citizens**:
Facilitators and experts do not join to avoid persuasion and ensure fully citizens own elaborate examination of information
 - ... **presenting questions** about scientific information provided
- **Providing scientific information in response to the questions** by experts' team for the second-round discussion



Scientific Information in the First-round Communication

Information: 34 pages
Presentation: 20 min.
Group discussion: 30 min.

1. The accident at Fukushima Daiichi nuclear power plant

- Functions of nuclear reactor
- The background of hydrogen explosion

2. Effect Mechanism of radioactive substances on the human body

1) Radiation in everyday life

- Radiation received from the natural world
- Radiation exposure from medical exams and procedures

2) Variety and disposition of radiation

3) Effects of radiation on the human body

- Deterministic effect and stochastic effect of radiation
- Threshold for deterministic effect / acute disorder
- Radiation-induced DNA damage and DNA repair
- Stochastic effect and increase of cancer death rate

3. Regulatory standards

- The rationale of regulation standards
- Physical half-life, biological half-life and radiation dose estimate

Participants' Questions in the First-round Group Discussion and Scientific Information in the Second-round Communication

The nuclear accident

Prospect for restoration from the nuclear reactor accident

Effects on health

1. What kind of data is the evaluation of health effects based on ? Do we have a sufficiently amount of data ?

2. Aren't there delayed effects ?

3. What is accumulation and health effects of continuous radiation exposure

4. Actual total radiation exposure

5. What we know from the experience of atomic bombing of Hiroshima and Nagasaki, as well as the effect of the Chernobyl nuclear power plant accident, and how they differ from the Fukushima

Stochastic effect: increase in cases of cancer, genetic effects
With detailed data

Comparison with past cases
With detailed data and numerical values

Measures

1. Inspection system and methods

2. Medical care system and possibilities for treatment

3. Advice for daily life

Knowledge Level : Pre- and Post-communication

The unknown matters were supplemented.

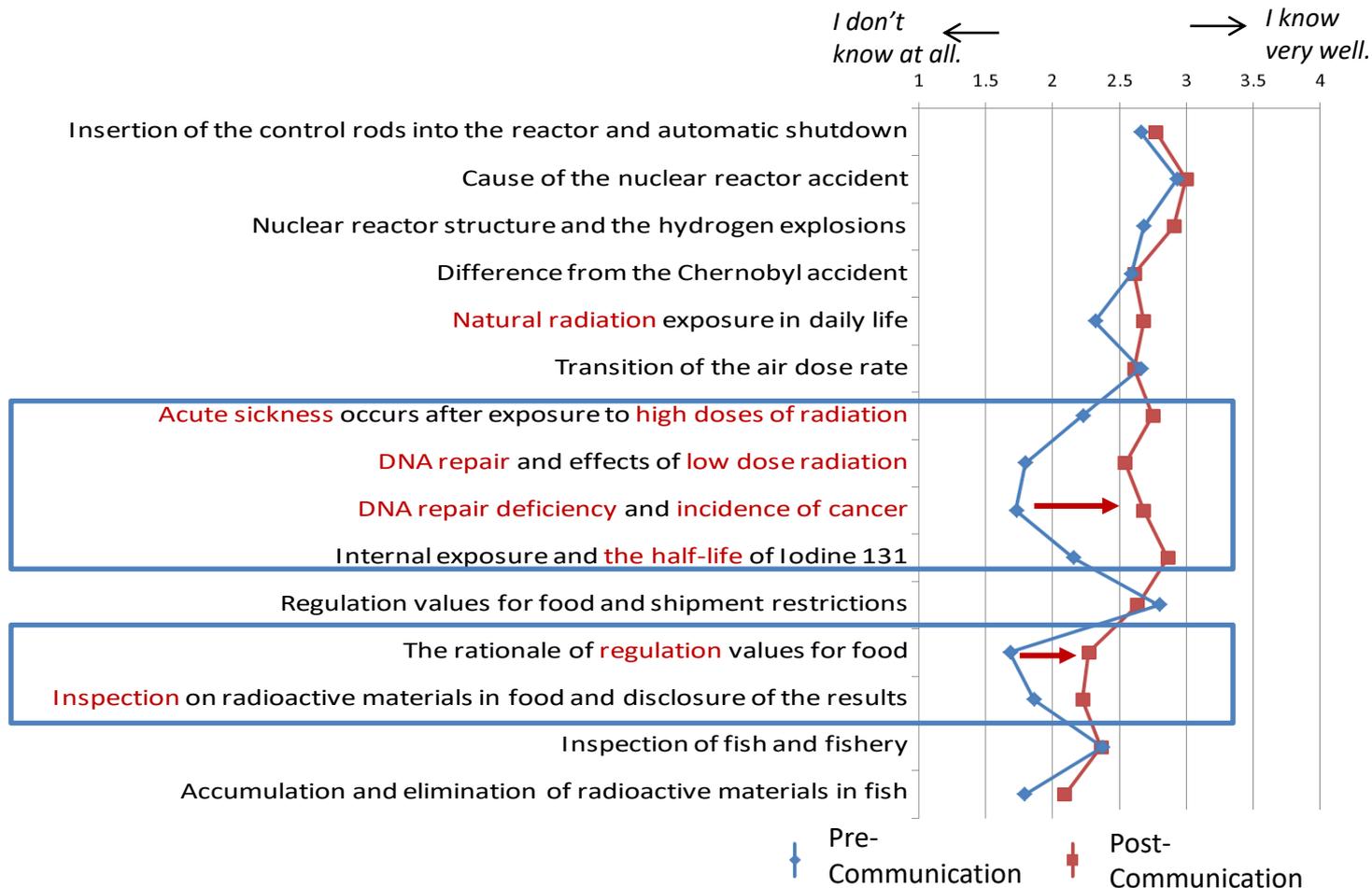


Figure Mean ratings of knowledge levels

Source: Questionnaire surveys of subjects who attended both sessions (10 males and 21 females in Kanto, 13 females in Kansai)
Scales of the items marked with asterisks are converted into the ones which have negative meanings in order to compare with other items.

Rating of risk characteristics: Pre- and Post-communication

Strong recognitions of the serious impacts were somewhat moderate

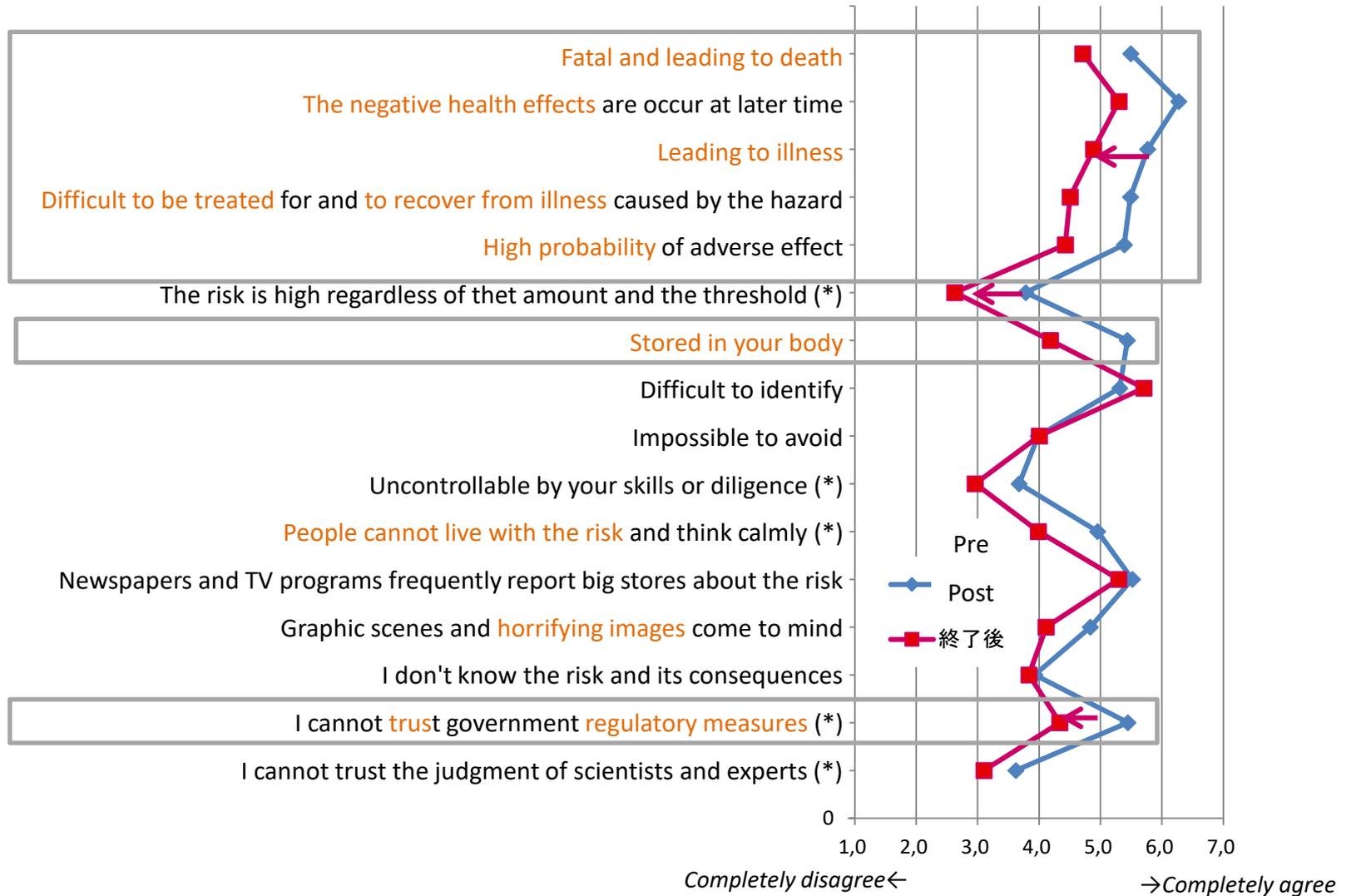


Figure Mean ratings of risk/hazard characteristics

Source: Questionnaire surveys of subjects who attended both sessions (10 males and 21 females in Kanto, 13 females in Kansai)

Scales of the items marked with asterisks are converted into the ones which have negative meanings in order to compare with other items.

Magnitude of Perceived Risks: Pre- and Post-Communication

Change in risk perception

However, the need to allow for differences in people's perception

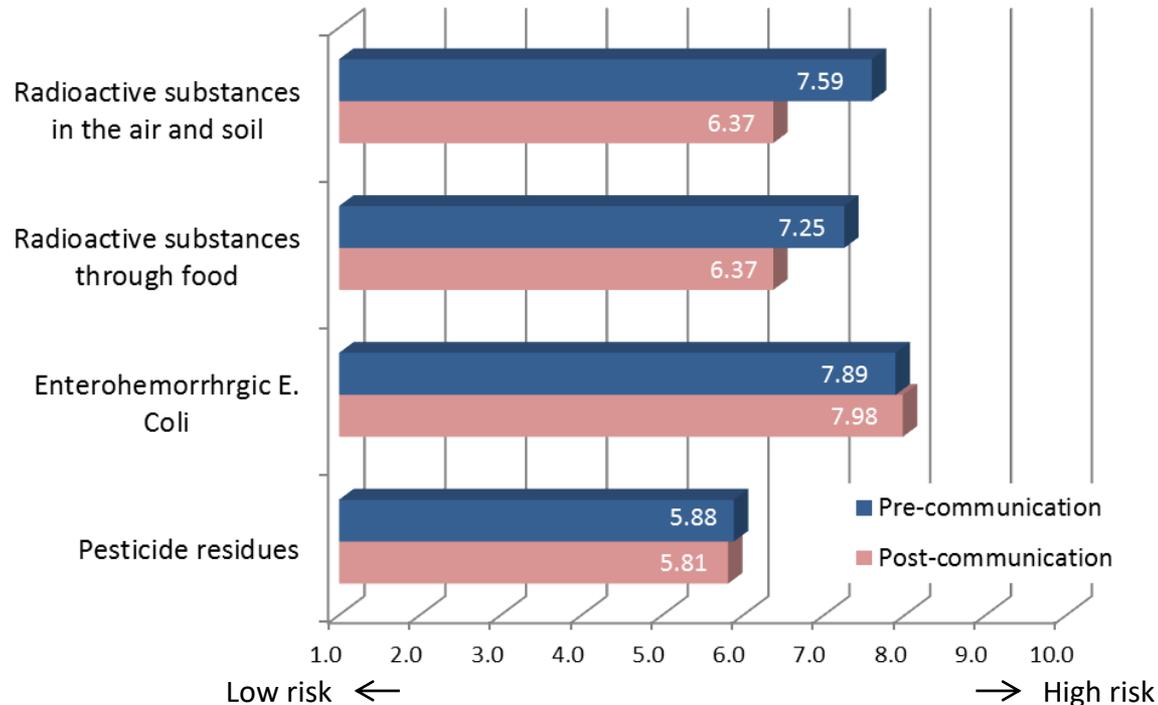


Figure 8 Change in Mean Rating of Magnitude of Perceived Risk: Pre- and Post-communication

Table Number of participants whose perceived risk scores have risen / decreased

	Number of participants					total
	<i>have decreased</i>		<i>no change</i>	<i>have risen</i>		
	<-3	-1, -2	0	+1, +2	+3<	
Radioactive substances through food	9	15	7	8	4	43
Radioactive substances in the air and soil	12	15	8	5	3	43

Study 2

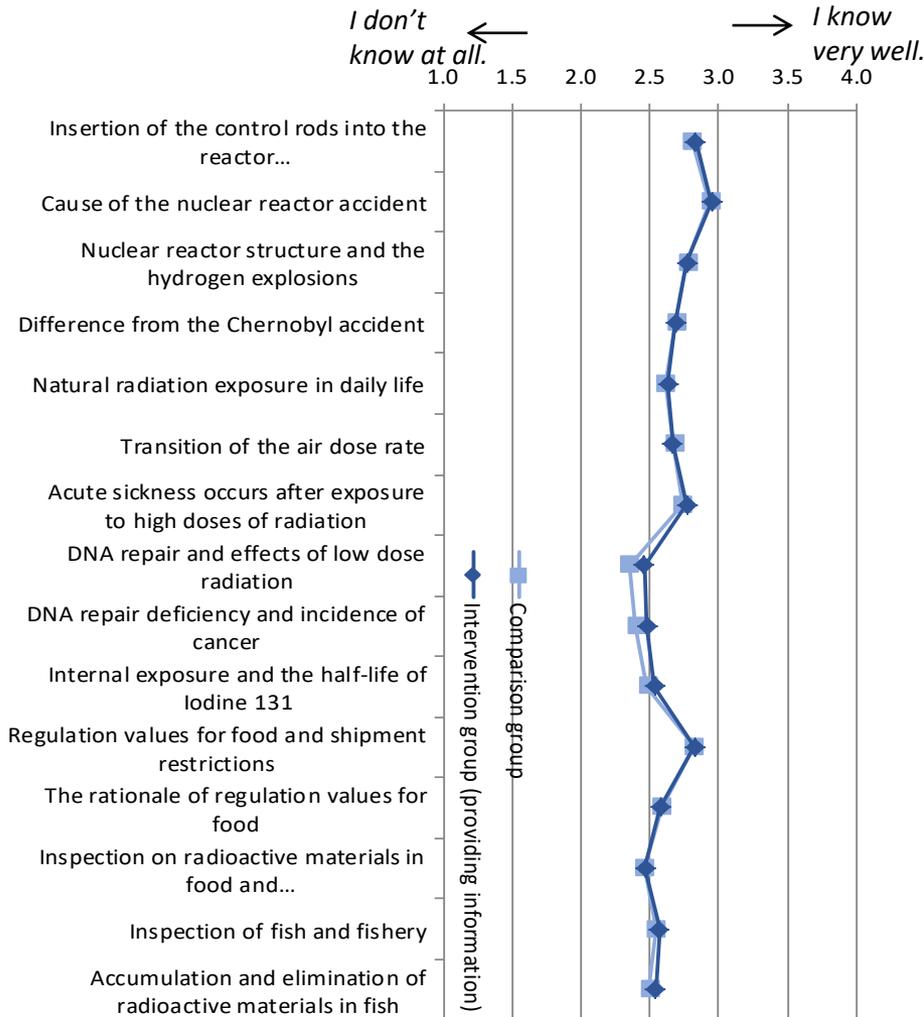
Experiment of one-way information provision

We conducted

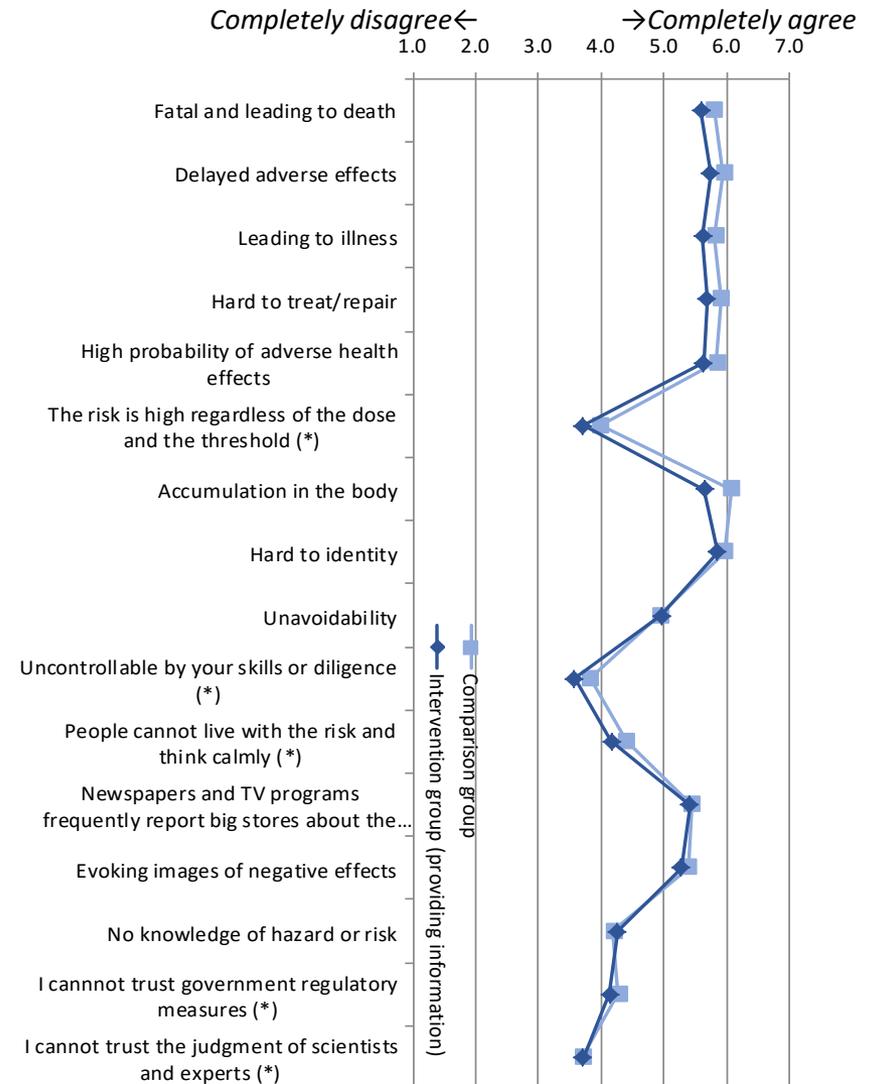
- The online Experiment of one-way information provision in Japan in May–June 2014
→ little change was observed.
- The online choice experiment survey in Kiki and Kanto areas, Japan in March 2016
→ A further negative effect on the choice was observed.

B: the public information by website

Knowledge Level: Intervention Group (providing information) and Comparison Group



Knowledge Level: Intervention Group (providing information) and Comparison Group



Source: Data from an internet survey (May–June, 2014) with women aged 30–49 years who had school children (N=823 × 2).

Study 2

Experiment of one-way information provision

We conducted

- The online Experiment of one-way information provision in Japan in May–June 2014
→ little change was observed.
- The online choice experiment survey in Kinki and Kanto areas, Japan in March 2016
→ A further negative effect on the choice was observed.

Experimental design

2. Choice Experiments

To verify the respondent's reaction to 3 items

	<p>Rice A (5 kg)</p>  <p>Year 2015</p>	<p>Rice B (5 kg)</p>  <p>Year 2015</p>	<p>Rice C (5 kg)</p>  <p>Year 2015 --</p>	<p>Rice D (5 kg)</p>  <p>Year 2015</p>	<p>Do Not Buy Any Rice</p>
Product Origin	Fukushima	Hokkaido	Chiba	Aizu	
Radioactive Inspection Result	Below the Safe Standard			Below a Half of the Safe Standard	
Price per 5kg (Tax included)	JPY 2300	JPY 2200	JPY 2010	JPY 2110	

8 choice tasks per respondent.

Average WTP (Willingness to pay) for rice with the inspection Label

Consumer behavior is divided into three categories.

WTP JPY per 5kg	Product origin				
	Fukushima	Aizu	Chiba	Hokkaido	Niigata
Ordinary	1,989	2,154	2,145	2,370	2,618
<i>95% CI</i>	[1755, 2222]	[1935, 2373]	[1923, 2368]	[2153, 2587]	[2787, 3215]
No Tolerance	177	934	987	2,215	2,502
<i>95% CI</i>	[-1062, 1416]	[127, 1741]	[249, 1725]	[1630, 2800]	[2639, 3875]
Stigma	-234	498	452	2,107	2,780
<i>95% CI</i>	[-2662, 2194]	[-1527, 2523]	[-1568, 2473]	[734, 3480]	[2065, 4989]
Actual Mkt Price	1,922	1,922	1,652	1,836	2,138
	Only ordinary buy	Only ordinary buy	Only ordinary buy	Buy	Buy

Average WTP for rice by Information Types 1

Ordinary Consumers

The providing information had the opposite effects for Fukushima rice.

(JPY / 5kg)	Fukushima	Aizu	Chiba	Hokkaido	Niigata
Control (no information)	2,426	2,583	2,439	2,694	3,050
95%CI	[1910, 2941]	[2093, 3073]	[1912, 2965]	[2211, 3178]	[2694, 3050]
Placebo	1,684	1,991	1,848	2,238	2,419
95%CI	[1024, 2344]	[1412, 2569]	[1258, 2439]	[1643, 2833]	[2001, 2837]
Info. Natural radiation	2,107	2,352	2,227	2,553	2,848
95%CI	[1538, 2677]	[1835, 2870]	[1660, 2794]	[2015, 3092]	[2491, 3205]
+Half life	1,839	2,074	2,074	2,288	2,491
95%CI	[1362, 2316]	[1625, 2524]	[1617, 2532]	[1846, 2731]	[2183, 2798]
+DNA repair	1,960	2,070	1,997	2,360	2,522
95%CI	[1381, 2539]	[1521, 2619]	[1443, 2551]	[1820, 2899]	[2149, 2895]

Average WTP for rice by Information Types 2

Consumers with No Tolerance

The providing information had not let to change in the attitude of not-buying Fukushima rice.

(JPY / 5kg)	Fukushima	Aizu	Chiba	Hokkaido	Niigata
Control (no information)	-383	855	184	1,870	1,875
95%CI	[-3023, 2257]	[-465, 2175]	[-1378, 1745]	[755, 2984]	[1096, 2654]
Placebo	-669	538	354	1,548	2,149
95%CI	[-2752, 1414]	[-873, 1949]	[-1039, 1748]	[524, 2572]	[1432, 2865]
Info. Natural radiation	613	1,007	823	2,166	2,605
95%CI	[-1075, 2302]	[-394, 2407]	[-653, 2299]	[1085, 3247]	[1831, 3378]
+ Half life	-30	804	885	2,201	2,649
95%CI	[-2347, 2287]	[-1082, 2690]	[-904, 2673]	[669, 3733]	[1673, 3624]
+DNA repair	583	1,125	1,096	2,058	2,140
95%CI	[-702, 1869]	[68, 2181]	[101, 2091]	[1130, 2986]	[1537, 2744]

Conclusion

Characteristics of Public risk estimation of health effects of radioactive substances in food:

- Likely to rely on intuitive information processing
- To avoid estimating likelihood of effects (including reduction by regulatory measures)
- To use easily accessible cues such as associations of deterministic effects.
- To promote them due to lack of scientific knowledge (lack of scientific information)

Required elements for *interactive risk communication* in emergency :

- To provide information that responds to citizens' questions and sufficiently detailed data that allow them to closely examine and to judge the situation by themselves.
- To provide a stage for discussion that enables people to elaborate scientific information independently by themselves in their own style.

Further research is needed on the methods of one-way information provision.

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