46th Nuclear and Radiation Studies Board
US National Academy of Science, Engineering and Medicine

Proposing a Simple Radiation Scale for the Public:

RAIN (Radiation Index)

May 16 (Friday) 2025

Gyuseong Cho (KAIST)
Jong Hyun Kim (KAIST/EPRI, retired)
Kun-Woo Cho (KAIST/KINS/ICRP)
Tae Soon Park (KRISS/ICRM, retired)
Keon Wook Kang (SNU/ICRP)

Contents

1. **Introduction (motivation)**
2. **How RAIN formulated?**
3. **A public survey on RAIN**
4. **Summary & plans for going forward**

Part 1

Radiation

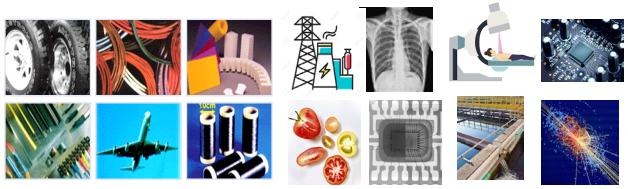
Benefits

Essential to all forms of life on Earth (Sunlight-NIR)

Useful in many activities; industry, agriculture environmental protection, science research, etc.

Critical role in medicine (in diagnostics & therapy)

Many more ---



Harms

Health risks:
cancer,
& genetic mutations,
burns, etc.

What actually matters is the amount of exposure!

However…

Radiophobia

An irrational, excessive and unnecessary **fear of radiation**

🡐 In most cases, it is greatly exaggerated compared to the **actual risk.**

Root Causes of the Public Radiophobia

1) **Radiation** itself is **invisible**, untouchable, undetectable by human senses, yet it is **ubiquitous**. (‘*the background radiation*’) ➔ inducing unfounded fear like a ghost

2) **Mass media**’s natural tendency is to **sensationalize** the accidents such as the Chernobyl and Fukushima.
➔ unfairly **demonizing** radiation to the public

3) **The public** has **little experience** with radiation and has **limited opportunity** to learn about radiation **in daily life**.

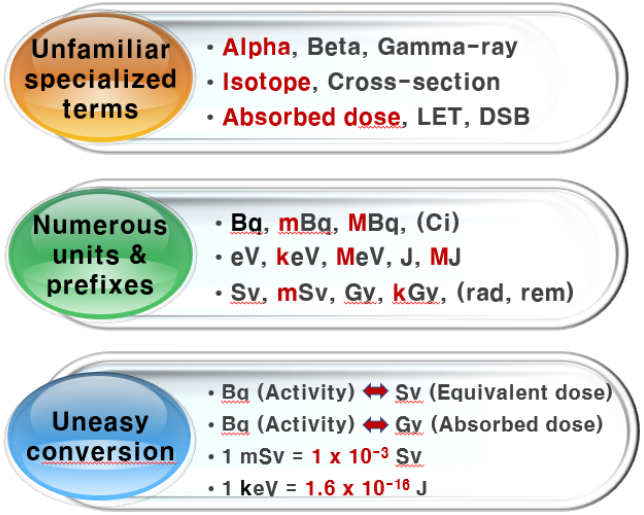
4) **More importantly, …**

Jargon in Radiation Science

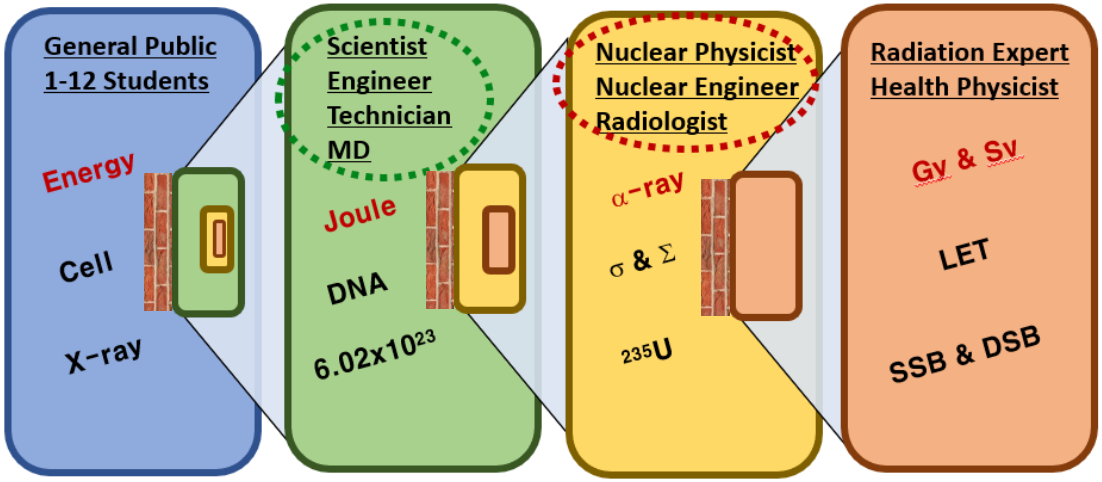
- Unfamiliar, confusing and difficult for the public.
  ➔ It breeds discomfort and distrust ➔ **contribute to radiophobia**
- **A significant barrier to effective communication** with the public.

➢ Even scientists and engineers, without a background in **radiation science,** often find the terminology challenging and unfamiliar.

Jargon of Radiation



Multiple layers of Knowledge Barriers

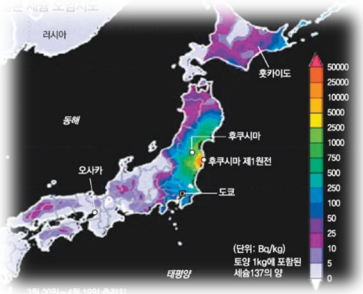


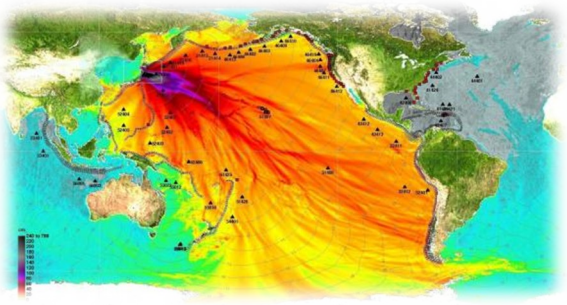
Why RAIN proposed?

- Following the Fukushima accident, **many misguided policies & decisions** were made in Japan, Korea and around the world due to public radiophobia, misinformation and disinformation.

- Over time, we have come to realize educating every member of the public to fully understand the technical terms of radiation impossible. ➔ This has prompted us **to reconsider how** such information should be communicated.

- Our sincere and sole **aim** is **to help ease the public fear** of the radiation by providing a simple communication tool.





Part 2

How RAIN formulated?

1) Strategic guidelines

✓It should serve as a **simple alternative** to **complex scientific jargon** for the public in everyday conversations.

- It should be **easy to remember** ➔ **"Radiation Index"** ➔ **"RAIN"**

✓Just as the **Richter scale** quantifies the **magnitude** of an earthquake, **RAIN** should reflect

- the **impact or health risk of** a certain **radiological event** on members of the public who may have been exposed.

➢ **Thus, it should be intuitively understood without a background in science. But it should be measurable or calculable scientifically.**

2) Technical guidelines

✓Use **the total accumulated effective dose, D (mSv)** for the event.

- Use the ratio of D to a reference baseline of **0.01 *mSv*** 'IAEA Exemption and clearance level'

✓Use a **dimensionless** and **logarithmic** format,

- similarly to **the Richter scale** for the earthquakes, dB for sound, or pH for acidity etc.
- **RAIN** value ranges from 0 and 10
- Allow only up to one decimal place (for RAIN > 1.0)

➢ **Thus, RAIN has precisely one-to-one correspondence with a scientific unit (mSV), effectively complementing the scientific unit.**

Definition of RAIN

$$RAIN = \mathrm{Log}_{10}(1 + D/D_0)$$

where

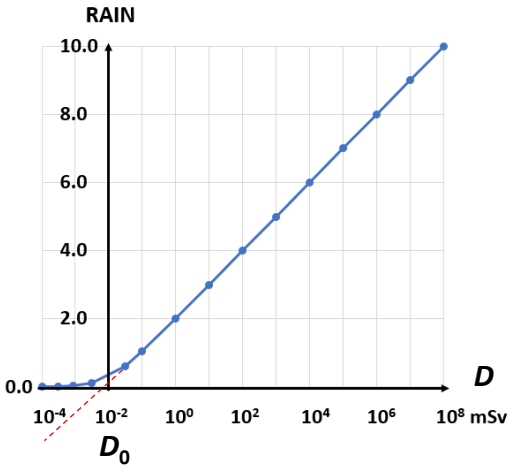
D_0 : the Reference Dose approved by IAEA (= 0.01 *mSv*)

D : the total effective dose from an event [*mSv*]

Examples of conversion

mSv	RAIN
0.1	1
1	2
10	3
100	4
1,000	5
10,000	6

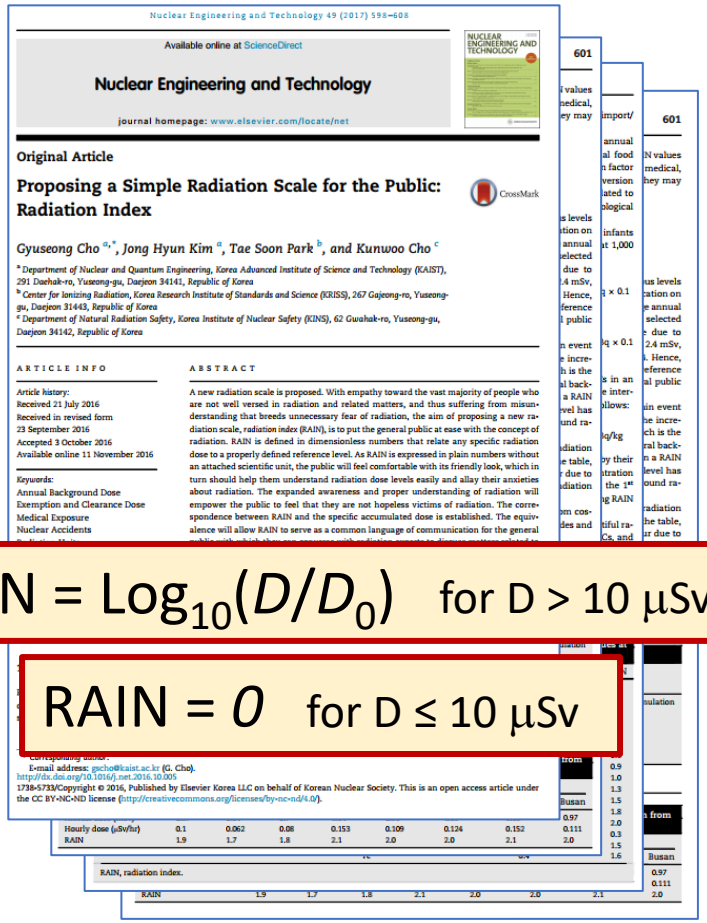
※ **Adding 1** inside the log prevents **the RAIN function** from becoming negative in low doses and makes it start at 0 and increase smoothly with dose.



Nuclear Engineering and Technology *49* **2017**

G. Cho, J. H. Kim, T. S. Park, and K. W. Cho

598 ~ 608 (11 pages)


Nuclear Engineering and Technology 49 (2017) 598–608

Available online at ScienceDirect

Nuclear Engineering and Technology

journal homepage: www.elsevier.com/locate/net

Original Article

Proposing a Simple Radiation Scale for the Public: Radiation Index

Gyuseong Cho [a,], Jong Hyun Kim [a], Tae Soon Park [b], and Kunwoo Cho [c]*

[a] Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea
[b] Center for Ionizing Radiation, Korea Research Institute of Standards and Science (KRISS), 267 Gajeong-ro, Yuseong-gu, Daejeon 31443, Republic of Korea
[c] Department of Natural Radiation Safety, Korea Institute of Nuclear Safety (KINS), 62 Gwahak-ro, Yuseong-gu, Daejeon 34142, Republic of Korea

ARTICLE INFO

Article history:
Received 21 July 2016
Received in revised form
23 September 2016
Accepted 3 October 2016
Available online 11 November 2016

Keywords:
Annual Background Dose
Exemption and Clearance Dose
Medical Exposure
Nuclear Accidents

ABSTRACT

A new radiation scale is proposed. With empathy toward the vast majority of people who are not well versed in radiation and related matters, and thus suffering from misunderstanding that breeds unnecessary fear of radiation, the aim of proposing a new radiation scale, radiation index (RAIN), is to put the general public at ease with the concept of radiation. RAIN is defined in dimensionless numbers that relate any specific radiation dose to a properly defined reference level. As RAIN is expressed in plain numbers without an attached scientific unit, the public will feel comfortable with its friendly look, which in turn should help them understand radiation dose levels easily and allay their anxieties about radiation. The expanded awareness and proper understanding of radiation will empower the public to feel that they are not hopeless victims of radiation. The correspondence between RAIN and the specific accumulated dose is established. The equivalence will allow RAIN to serve as a common language of communication for the general

Hourly dose (μSv/hr) 0.1 0.062 0.08 0.153 0.109 0.124 0.152 0.111
RAIN 1.9 1.7 1.8 2.1 2.0 2.0 2.1 2.0

RAIN, radiation index.

RAIN 1.9 1.7 1.8 2.1 2.0 2.0 2.1

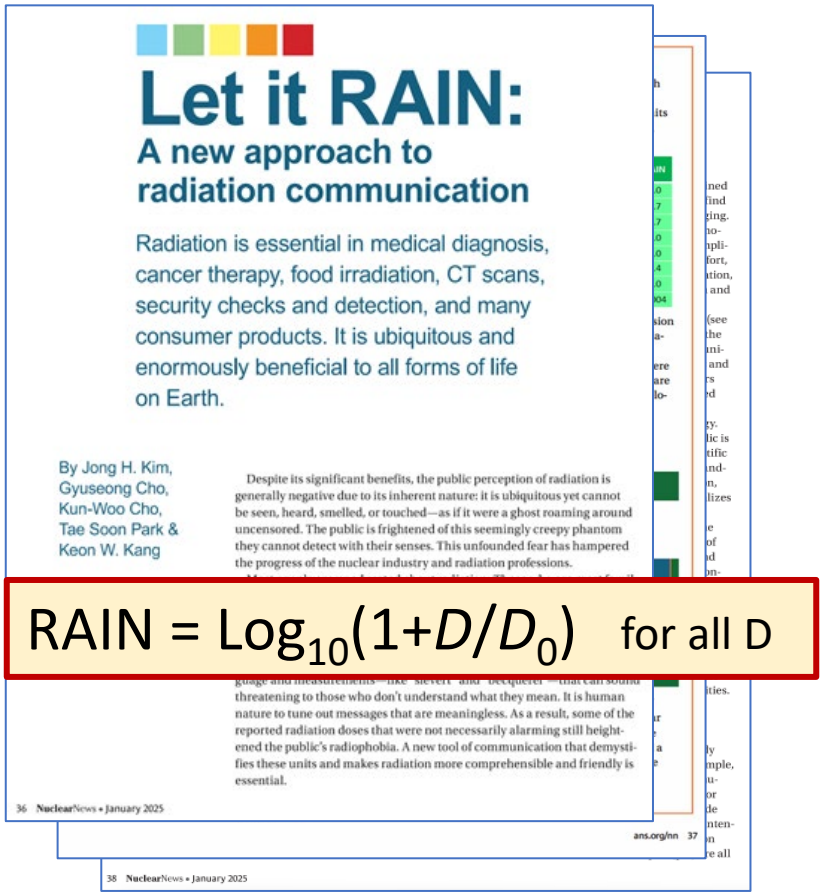
$$RAIN = \mathrm{Log}_{10}(D/D_0) \quad \text{for } D > 10\ \mu Sv$$

$$RAIN = 0 \quad \text{for } D \le 10\ \mu Sv$$

NuclearNews • January 2025

J. H. Kim, G. Cho, K. W. Cho, T. S. Park, and K. W. Kang

36 ~ 42 (7 pages)


Let it RAIN:

A new approach to radiation communication

Radiation is essential in medical diagnosis, cancer therapy, food irradiation, CT scans, security checks and detection, and many consumer products. It is ubiquitous and enormously beneficial to all forms of life on Earth.

By Jong H. Kim, Gyuseong Cho, Kun-Woo Cho, Tae Soon Park & Keon W. Kang

Despite its significant benefits, the public perception of radiation is generally negative due to its inherent nature: it is ubiquitous yet cannot be seen, heard, smelled, or touched—as if it were a ghost roaming around uncensored. The public is frightened of this seemingly creepy phantom they cannot detect with their senses. This unfounded fear has hampered the progress of the nuclear industry and radiation professions.

threatening to those who don't understand what they mean. It is human nature to tune out messages that are meaningless. As a result, some of the reported radiation doses that were not necessarily alarming still heightened the public's radiophobia. A new tool of communication that demystifies these units and makes radiation more comprehensible and friendly is essential.

36 NuclearNews • January 2025

ans.org/nn 37

38 NuclearNews • January 2025

$$RAIN = \mathrm{Log}_{10}(1+D/D_0) \quad \text{for all D}$$

Examples & Color-coded 5 Zones

D	RAIN	Health effect	Ex. Case & Thresholds of health effect	Zone
10,000 Sv	9.0	Immediate Death	Food irradiation limit for sterilization (10 kGy)*	**Serious (RAIN > 5.5)**
50 Sv	6.7		Radiation cancer therapy dose (locally at cancer cells 50 Gy)**	
10 Sv	6.0	95% death in 2 weeks, skin transplant	In Chernobyl, 1 death , Central Nerv Syndrome	
5 Sv	5.7	High fever, bone marrow, LD50/60: 50% die in 2 months	In Chernobyl, 28 death among 130 workers > 1 Sv	
3 Sv	**5.5**	Shiver, sterility	**Threshold of Mortality , 90% treatable**	
2 Sv	5.3	Fever, diarrhea, hair loss , severe leukopenia	**No death risk**	**Alarm (4.7 < RAIN < 5.5)**
1 Sv	5.0	Mild headache, nausea and vomiting, cataract	Threshold of Gastrointestinal Syndrome	
500 mSv	**4.7**	No subjective symptoms, decrease of blood cells	**Threshold of ARS (hematopoietic Syndrome)**	
250 mSv	4.4	Threshold for blood cell change	Hiroshima A-bomb survivors	**Vigilance (4.0 < RAIN < 4.7)**
100 mSv	**4.0**	Threshold for long term effect	**Threshold of CRS (additional cancer risk (0.5%))**	
10 mSv	3.0	No health effect	CT or PET scan	**Breeze (2.4 < RAIN < 4.0)**
2.4 mSv	**2.4**		**World's annual average natural dose**	
1 mSv	2.0	No health effect	Dose limit for general public by ICRP	**Serene (RAIN < 2.4)**
0.3 mSv	1.5		Self-dose by K-40	
0.1 mSv	1.0		Chest X-ray/a round trip of long distance	
0.1 μSv	0.004		One banana/a cup of coffee	

Part 4

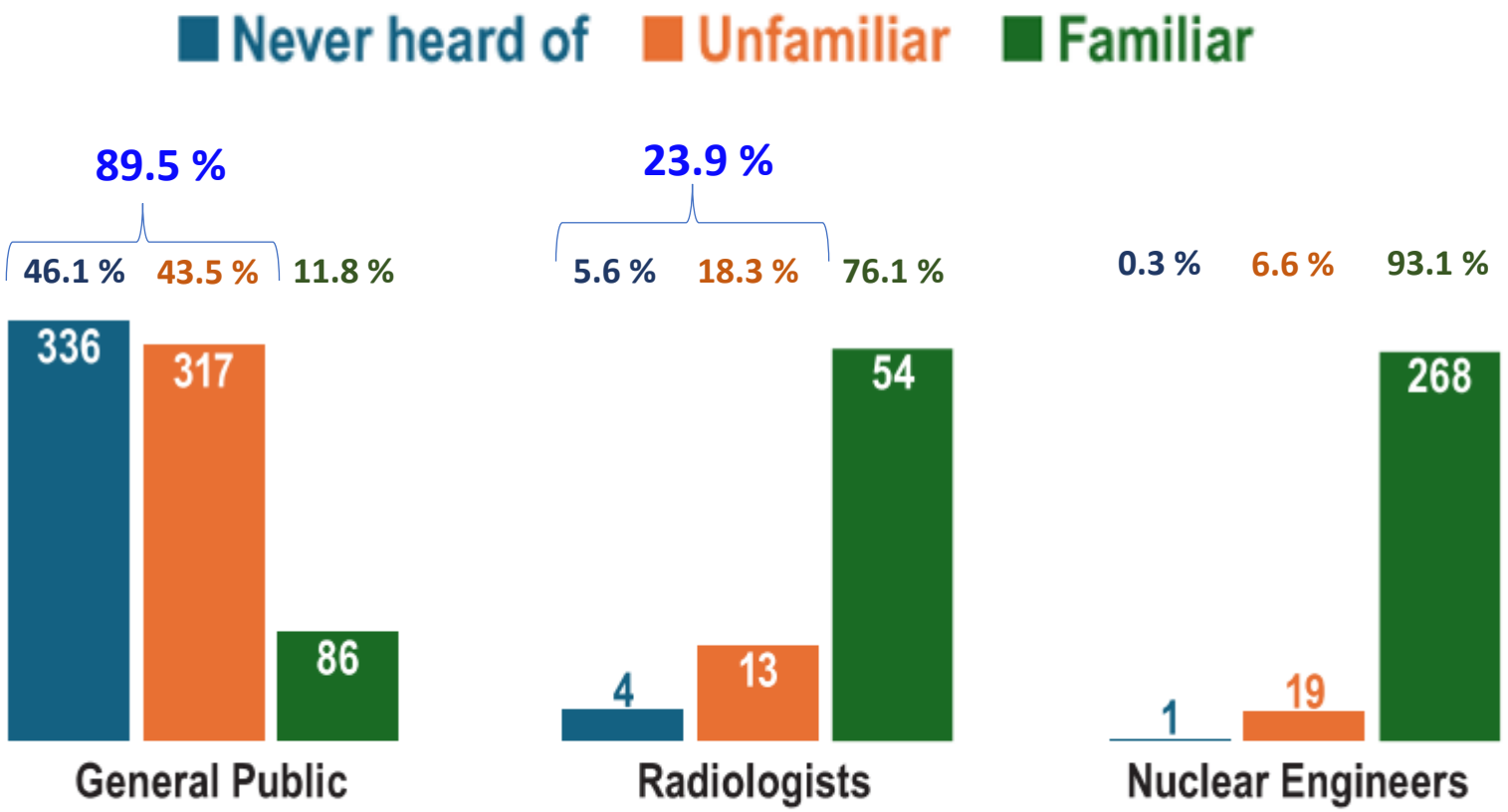
A public survey on RAIN in Korea

- Purpose : Verify usefulness of RAIN
- Survey period : May 2 ~ June 30, 2023
- Respondents : **1,098** Koreans (3 groups: GP, R, NE)
- At a 95% confidence level, the margin of errors : ±3%

Table. Demographics of survey participants

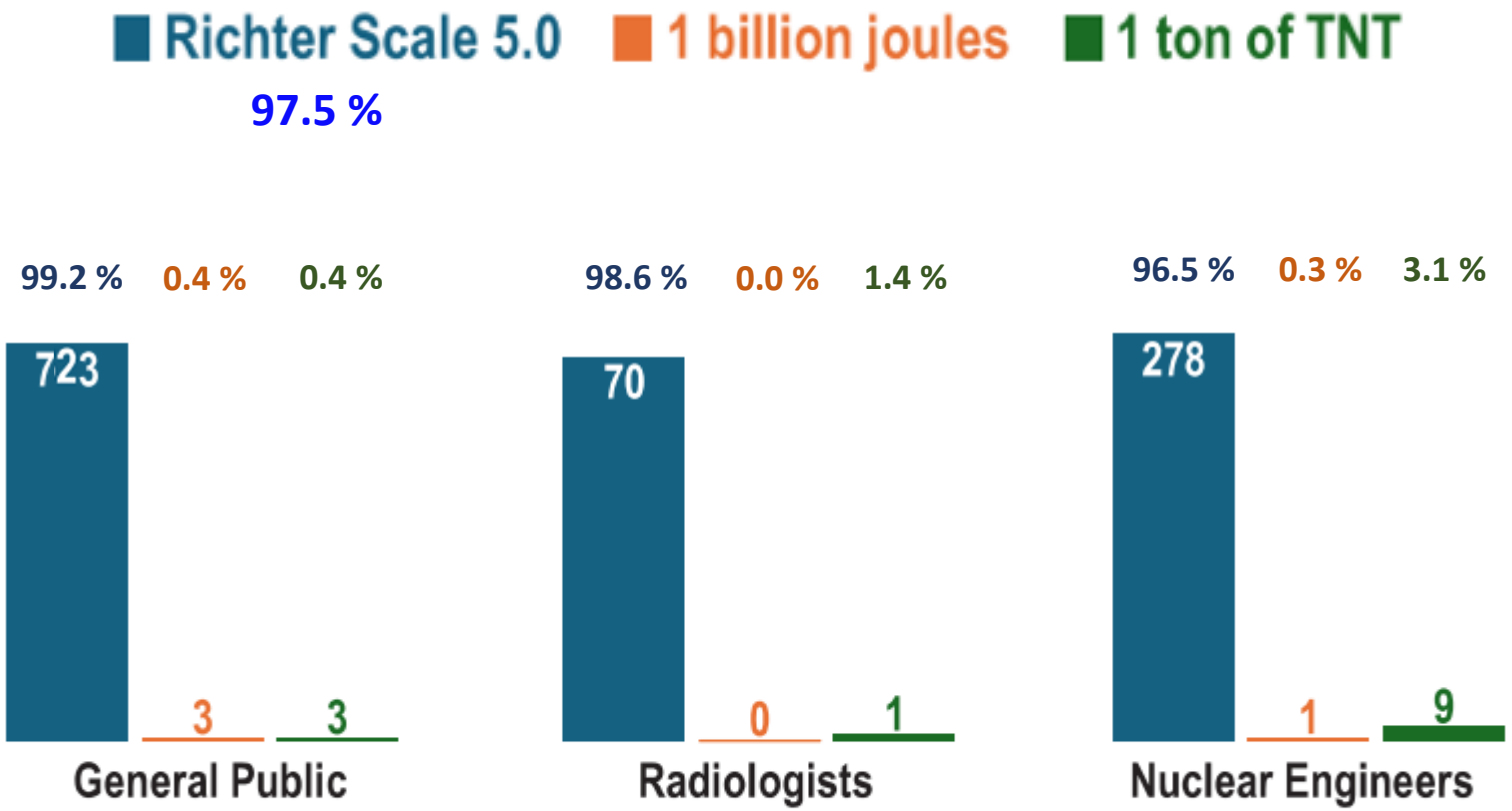
	General public	Radiologist (MD)	Nuclear Engineers	Total	%
Male	468	59	268	795	72.4
Female	271	12	20	303	27.6
Total	739	71	288	1,098	100
%	67.3	6.5	26.2	100	

Question 1: How familiar are you with the units of radiation dose such as mSv and μSv?



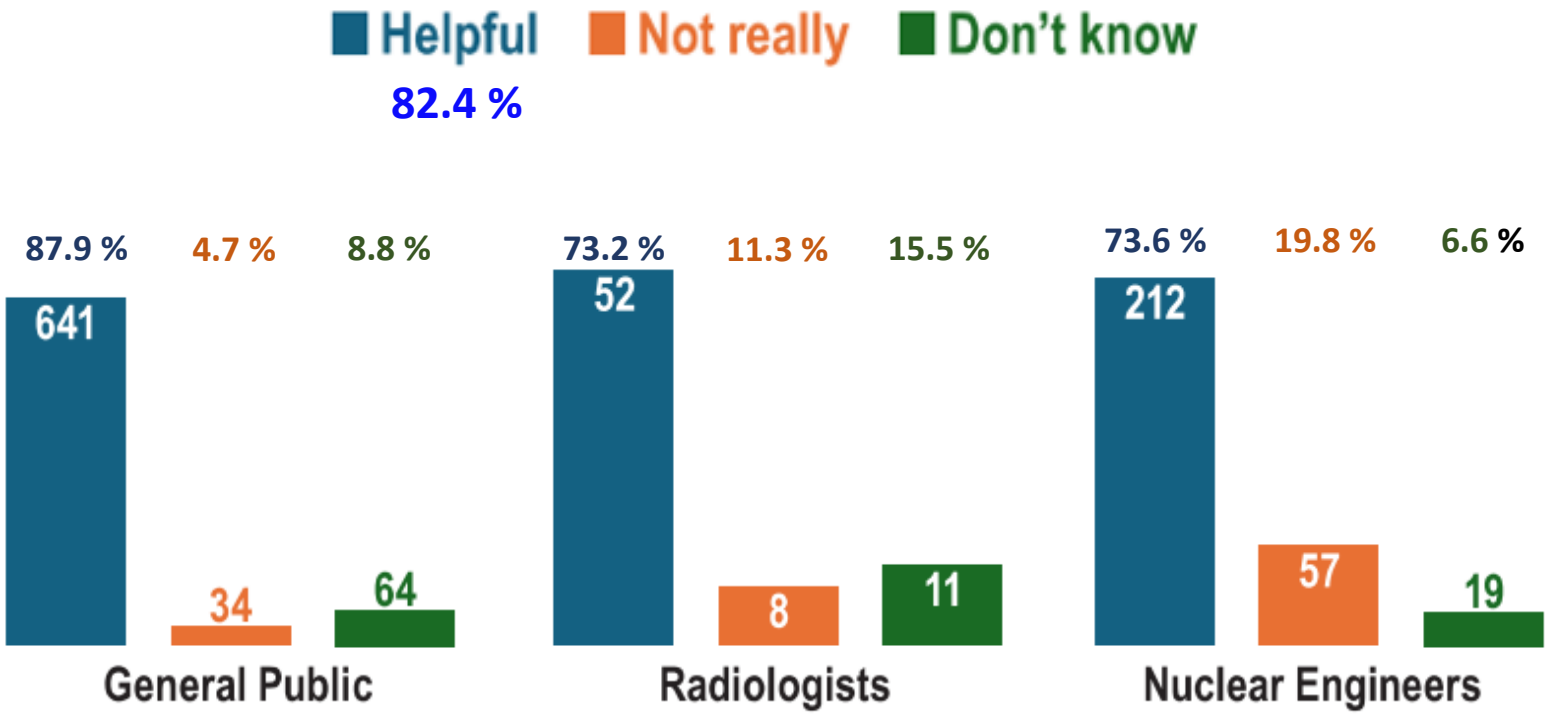
Only a small fraction of the general public is familiar with the scientific units of radiation dose, while radiologists and nuclear engineers are mostly familiar with the units.

Question 2: Which of the following three ways for expressing an earthquake magnitude are you most familiar with?



The vast majority of respondents are familiar with the dimensionless Richter scale of earthquake magnitude, compared with the dimensioned scientific units.

Question 3: If mSv is expressed in a dimensionless plain number called a radiation index (RAIN), similar to the dimensionless Richter scale, will it help you understand the radiation dose level better?



The majority of respondents from the general public, in addition to nearly three-quarters of radiologists and nuclear engineers, believe that expressing radiation dose using a dimensionless scale like RAIN would increase understanding.

Part 4

Summary and plans for going forward

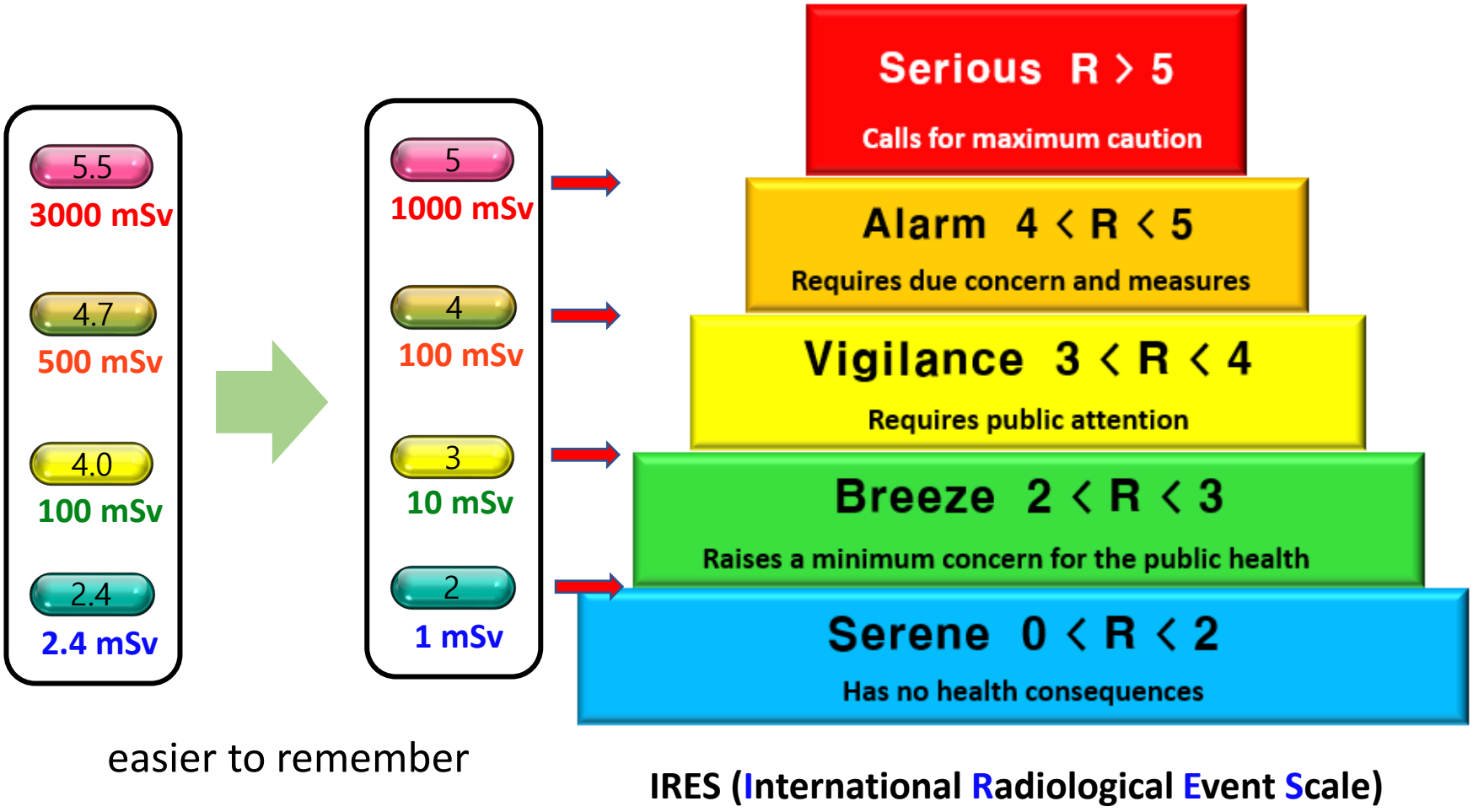
✓In order to help ease the public radiophobia, we proposed **RAIN** as a tool for better communication on radiation, and we also proposed 5 zones with color codes

$$\text{RAIN} = \text{Log}_{10}(1 + D/D_0)$$

✓We invite any constructive suggestion to improve.

- *For example*) Is **appropriate** to divide into 5 zones?
  - Option 4 may be more commonly used and option 3 may be simpler.
  - The 5 **zone names (**Serene, Breeze, Vigilance, Alarm, Serious**) &** Color**?**
  - The **zone boundary values** (2.4, 4.0, 4.7, 5.5) are difficult to remember.

Modification of Z.B. RAIN values



easier to remember

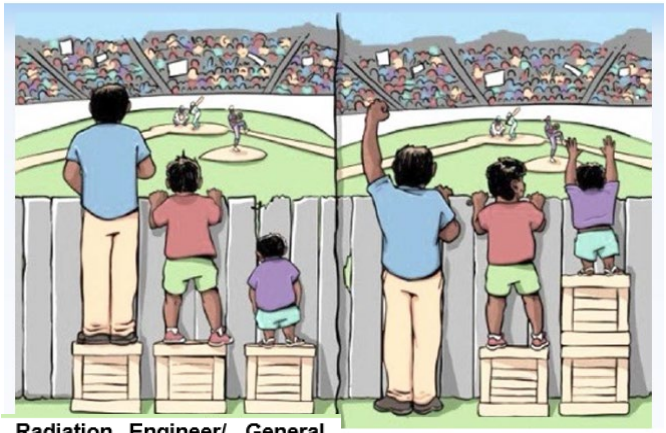
IRES (International Radiological Event Scale)

Plans for going forward (Continued)

✓**Recommendations from the OECD/NEA workshop (2019)**

1) **Get consensus** from the experts & int'l communities
   - ➢through conferences, workshops, and special events.
   - We may propose to IAEA for an official Tech Doc.

2) **Publicize broadly** to the general public ?
   - ➢through News paper, TV broadcast, YouTube®, Classrooms
   - Which body could finance its publicity ?



Thank you for inviting us !

Jong H. Kim, retired from KAIST and EPRI, is a fellow of ANS, NURETH, and ASME, as well as a foreign member of the National Academy of Engineering of Korea.

Gyuseong Cho, professor at KAIST, is a renowned expert in radiation detection, imaging, and medical radiation devices who has served as president of the Korean Society of Radiation Industry.

Kun-Woo Cho, a specialist in radiation regulation, safety, and protection at the Korean Institute of Nuclear Safety, has served on the International Commission on Radiological Protection and as a national representative to the U.N. Scientific Committee on the Effects of Radiation.

Tae Soon Park, retired from the Korea Research Institute of Standards and Science, is currently a research fellow at Dukin Co.

Keon W. Kang is a professor at Seoul National University, head of the Center for Entrepreneurship and Innovation, chair of the Asian Regional Cooperative Council for Nuclear Medicine, and president of the Korean Society of Nuclear Medicine.

KAIST KINS KRISS SNU