Download the app on your **smartphone** or **tablet**

Or access the following **web page**:

https://responseware.turningtechnologies.**eu**/responseware/

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medphys2018

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Risk
and radiations

Pr **François Bochud**
Lausanne University Hospital

Learning objectives

- Briefly explain the **effects of radiation** on **human health**
- Be able to **compare** in the day to day life **acute** and **chronic risks**
- Understand some **psychological aspects** of **risk perception** and how **ethics** could help find solutions
- Understand the complexity of **communicating about** radiation **risk**

Risk and radiation

1. Effects of ionizing radiations

dose

tissue reactions

(deterministic effects)

skin burn
organ/tissue dysfunction

only at high dose

absorbed dose
unit: gray [Gy]

typically above 500 mGy

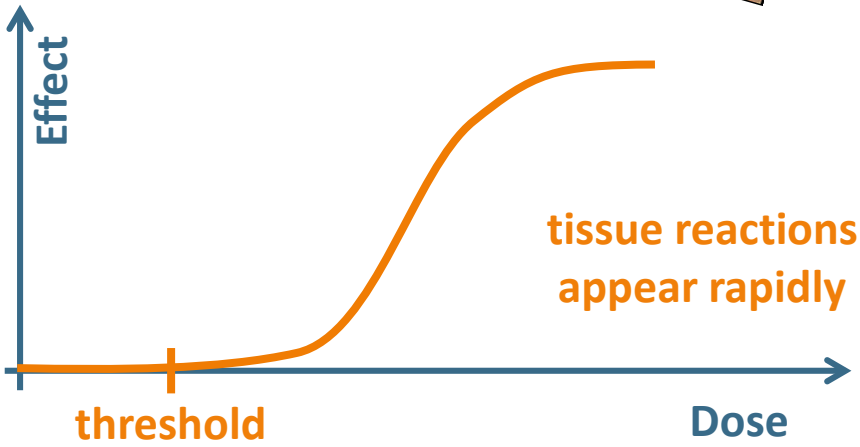
stochastic effects

cancer
heredity

already at low dose

effective dose
unit: sievert [Sv]

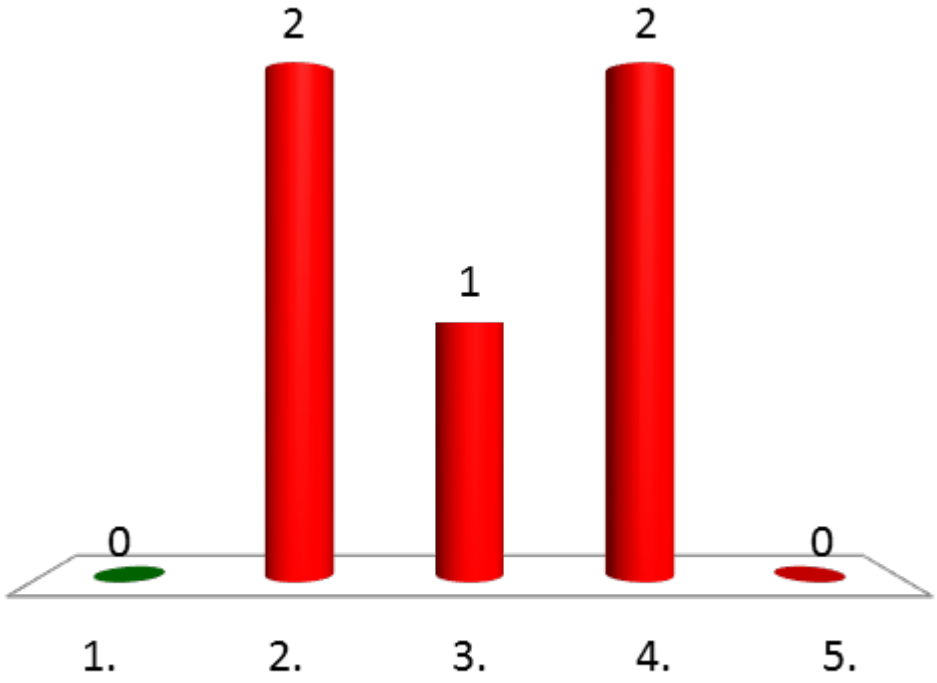
0


Effect
tissue reactions
appear rapidly
threshold
Dose

How do we define the threshold of tissue reaction?

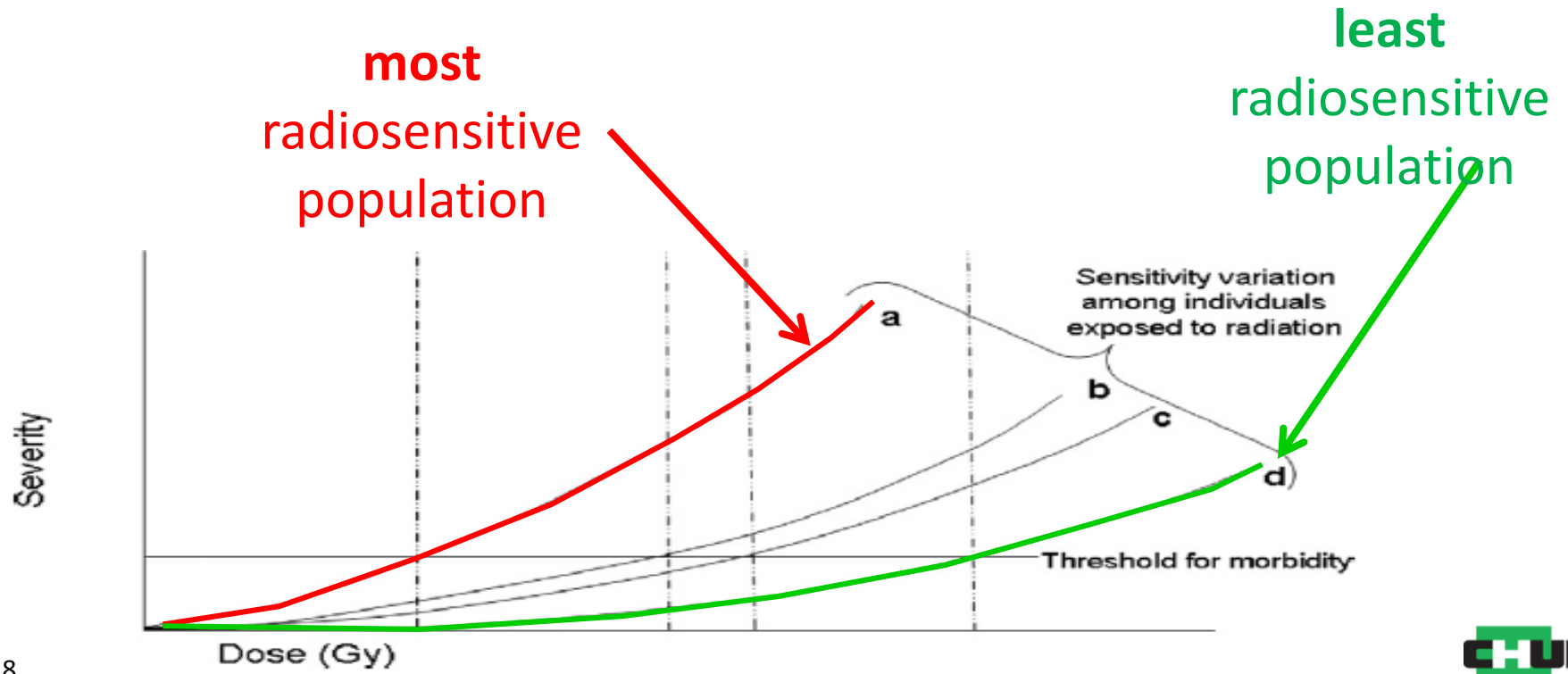
*(in terms of **proportion of the population showing the effect**)*

1. 1%
2. 5%
3. 10%
4. 50%
5. 90%



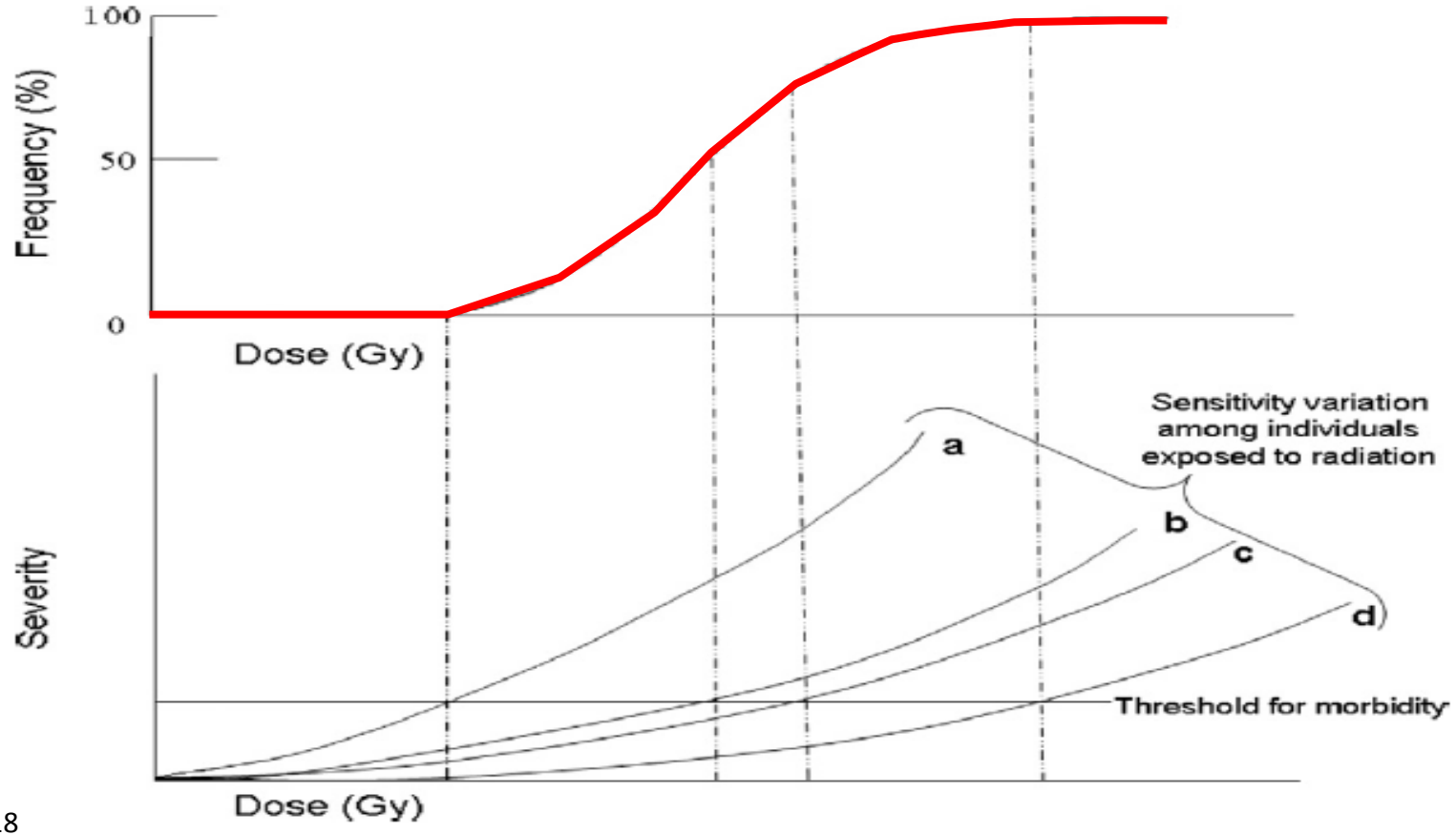
5 sur 5

Tissue reactions *(aka deterministic effect)*

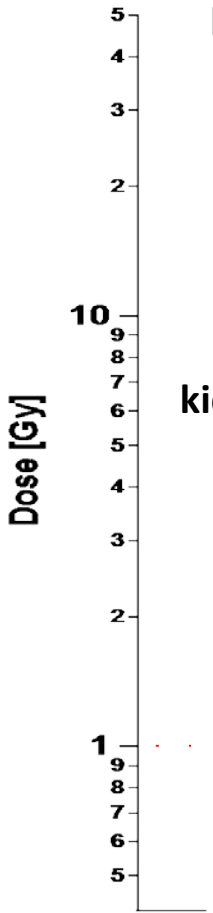


ICRP-118

Tissue reactions *(aka deterministic effect)*



ICRP-118



bladder (50 Gy)

adult **bone** (50 Gy)

brain myelite (50 Gy)

bone growth (20 Gy)

kidney (20 Gy)

lethal **whole body** 1-3 months (10-14 Gy)

kidney acute (6-7 Gy)

GI acute (6 Gy)

lungs acute (6.5 Gy)

lethal **whole body** 1 week (4-8 Gy)

sterility F acute (2.5-6 Gy)

sterility M acute (3.5-6 Gy)

brain growth (1-2 Gy)

lethal **whole body** acute (1 Gy)

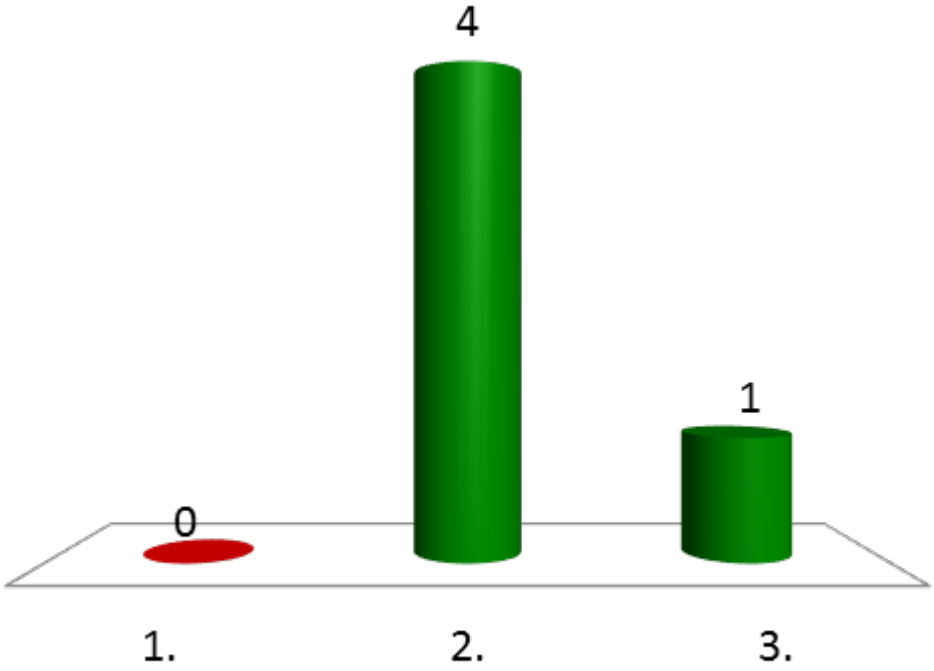
CV (0.5 Gy)

cataract (0.5 Gy)

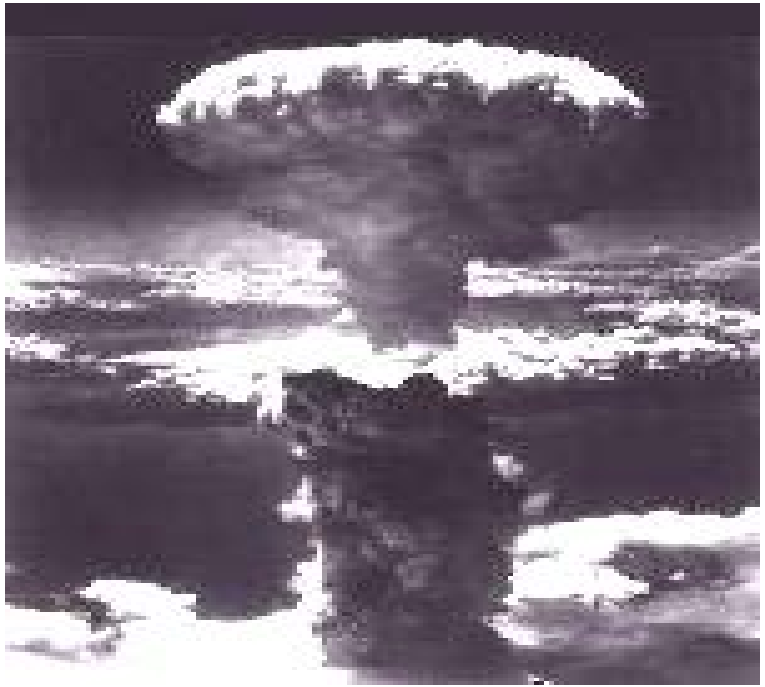
very young **brain** (>0.1 Gy)

Does the risk to develop a **radiation-induced cancer** have a **threshold**?

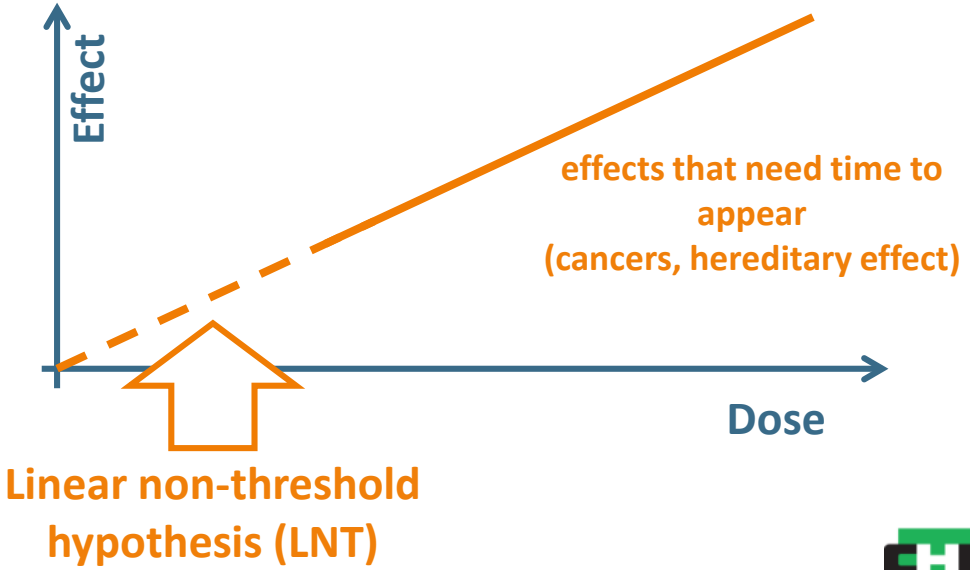
1. Yes, below a given dose, the **risk is zero**
2. No, whatever the dose, **there is a risk**
3. **Nobody** really **knows** for sure



5 sur 5



A lot of information thanks to the survivors of **Hiroshima et Nagasaki**



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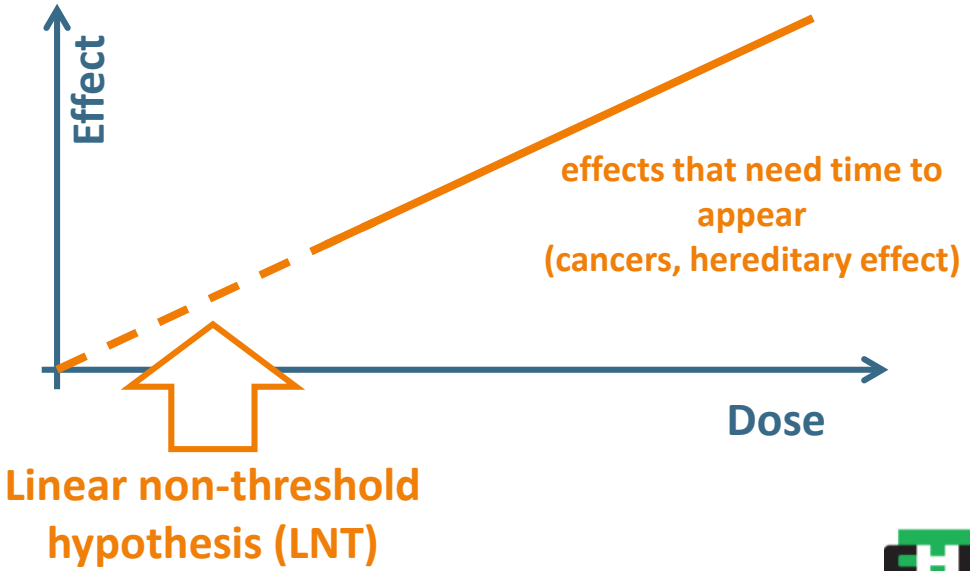
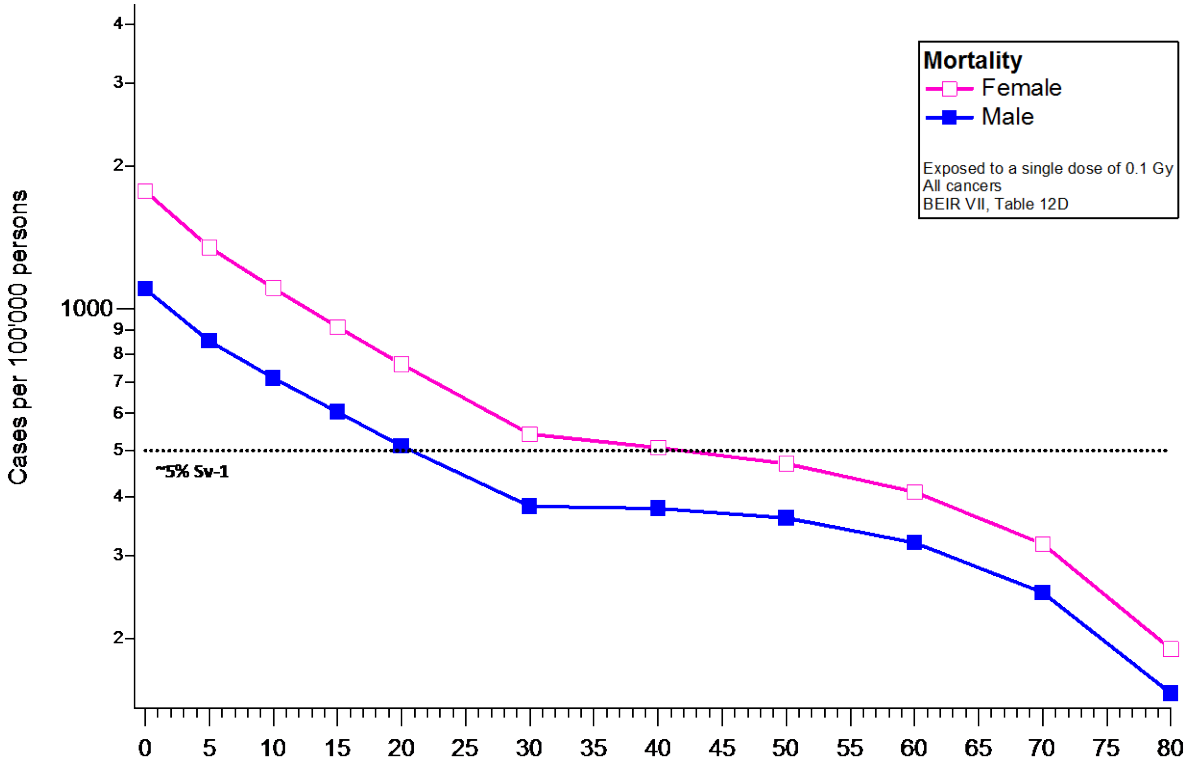


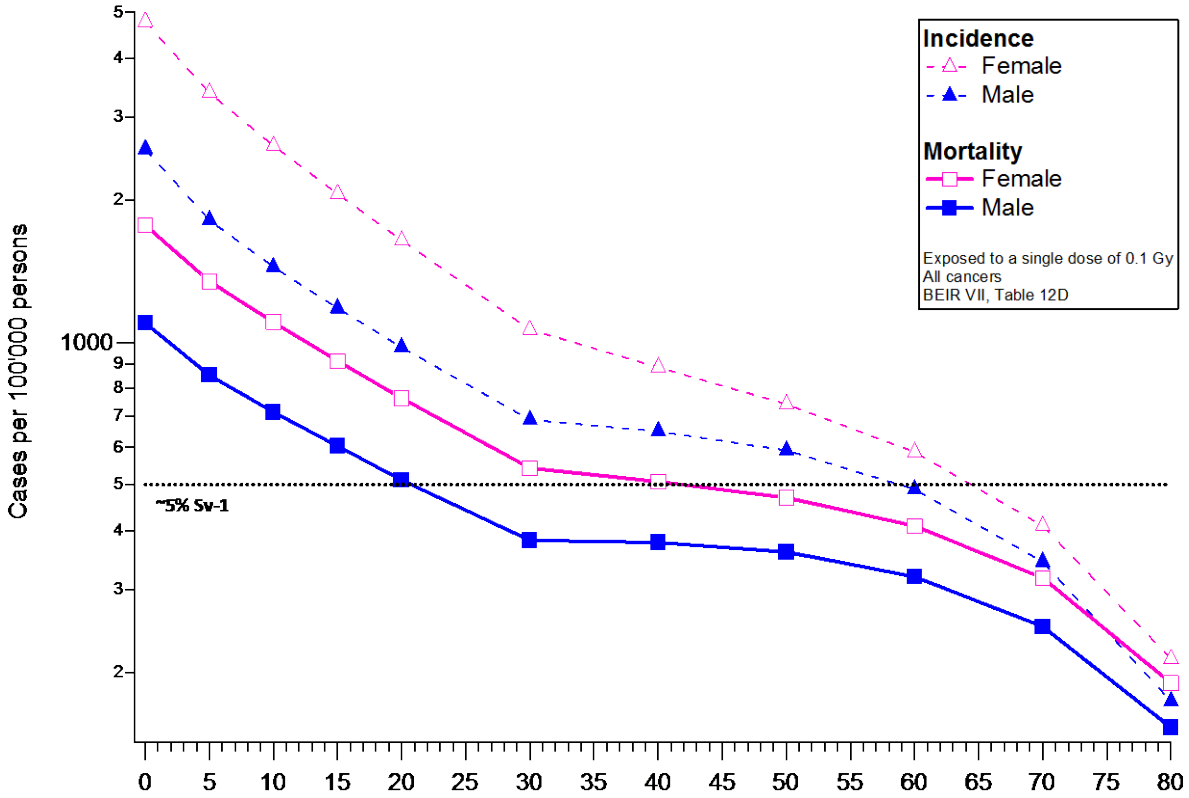
Probability to develop a **cancer** after a **effective dose** = **100 mSv**

(energy uniformly distributed within the body)



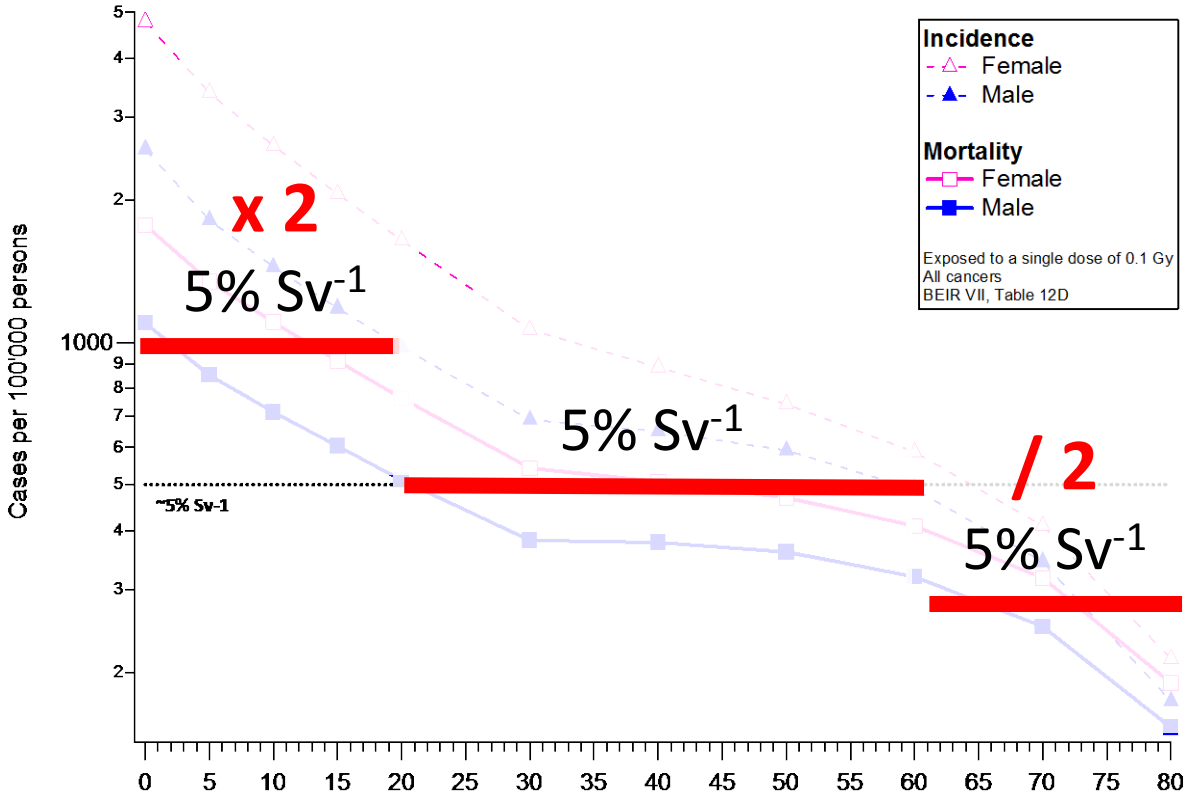
BEIR-7

Probability to develop a **cancer** after a **effective dose** = **100 mSv**



BEIR-7

Effective dose is a **good approximation** of possible **stochastic risk**



BEIR-7

Exercise: what is the probability
to **die from cancer** after receiving an effective dose (E) of **20 mSv**?

(for a 25 year old person)

Exercise: what is the probability
to **die from cancer** after receiving an effective dose (E) of **20 mSv**?

(for a 25 year old person)

solution

risk factor: $r = 5\%\ Sv^{-1} = 0.05\ Sv^{-1}$

$E = 20\ mSv = 0.02\ Sv$

Risk: $R = r\ E = 0.05 \times 0.02 = 0.001 = \mathbf{10^{-3}}$

Risk and radiation

2.

How do we justify limits?

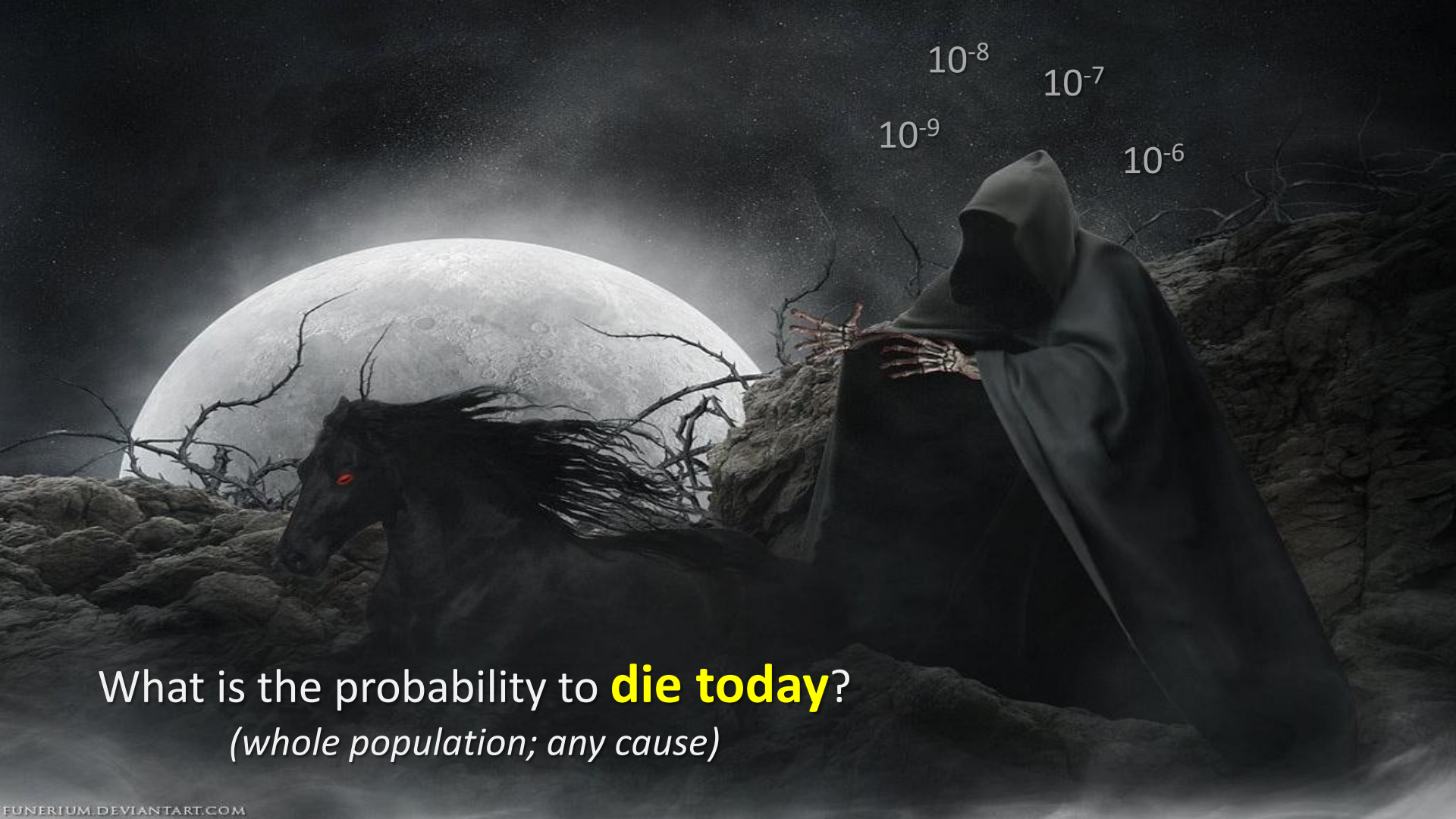
An effective dose **E =** 

mSv

is the annual **dose limit** for professionals


Limits are **not** borders between **SAFE** and **DANGEROUS**

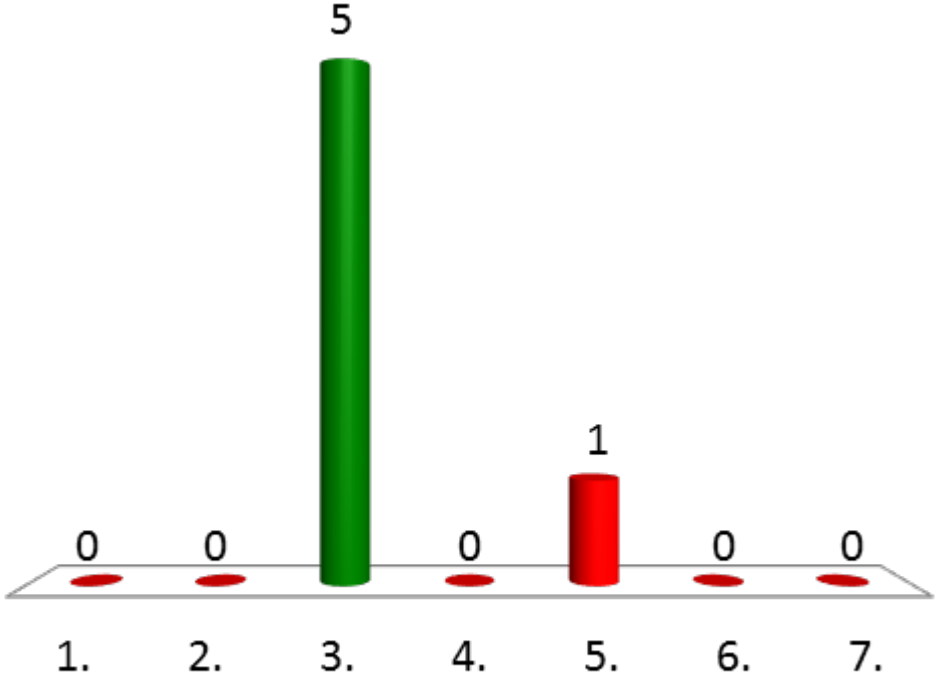

public
1 mSv/year
approximately
natural background
(ICRP-103)
workers
20 mSv/year
risk of 10^{-3}
(ICRP-103)
Risk unacceptable
Limits are not borders between SAFE and DANGEROUS
Risk tolerable
http://www.denaligrizzlybear.com/


10^{-8}
10^{-7}
10^{-9}
10^{-6}
What is the probability to **die today**?
(whole population; any cause)
FUNERIUM.DEVIANTART.COM

What is the probability to die today?

(all causes combined, in a developed country)

1. 20×10^{-8}
2. 20×10^{-7}
3. 20×10^{-6}
4. 20×10^{-5}
5. 20×10^{-4}
6. 20×10^{-3}
7. 20×10^{-2}



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Probability to die per day

(all causes ; whole population)

Context	Time period	N deaths	N population	10^{-6}	Reference
England and Wales	2012	499,331	56,567,000	**24** per day	ONS Deaths Table 5.
Canada	2011	242,074	33,476,688	**20** per day	Statistics Canada
US	2010	2,468,435	308,500,000	**22** per day	CDC Deaths Table 18.

about **20×10^{-6}** per day

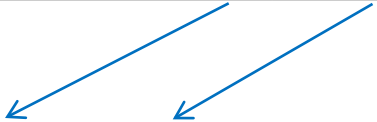
https://en.wikipedia.org/wiki/Micromort

In Switzerland

Nombre de décès et taux de mortalité standardisés par classes d'âge pour 100'000 habitants

selon les causes de décès principales, par sexe, 2013

Cause de décès	Nombre de décès 2013		Taux de mortalité 2013	
	Hommes	Femmes	Hommes	Femmes
Toutes les causes de décès	31257	33704	555.0	371.0

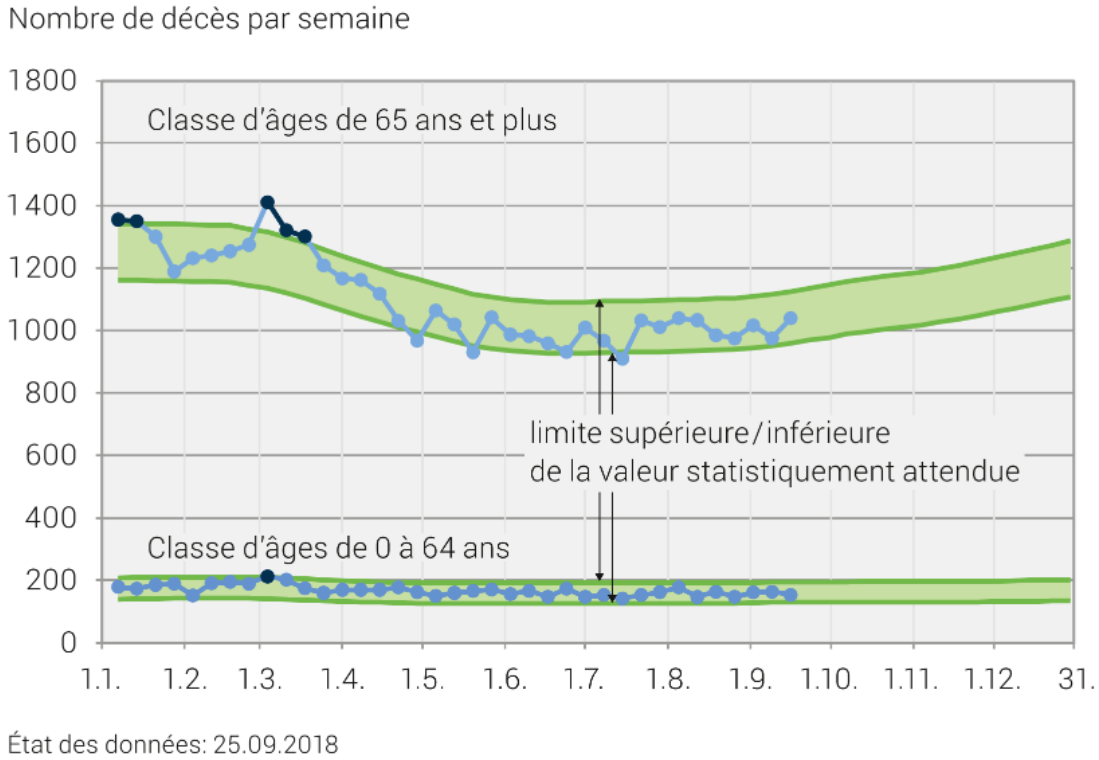


31 257 + 33 704 = **64 961 death in 2013**

$$\frac{64961}{8 \cdot 10^{6} \cdot 365} = 22.2 \cdot 10^{-6}$$ deaths per day per inhabitant

http://www.bfs.admin.ch/bfs/portal/fr/index/themen/14/02/04/key/01.html#parsys_84305

Today statistics in Switzerland

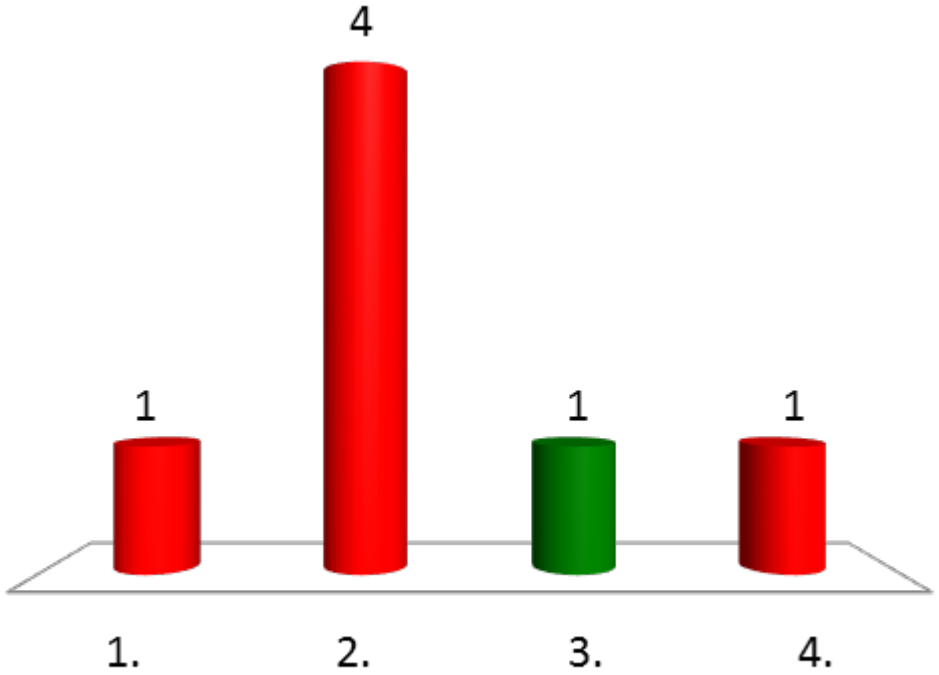


https://www.bfs.admin.ch/bfs/fr/home/statistiques/sante/etat-sante/mortalite-causes-deces.html

What is the probability to die today?

(of a non-natural cause, in a developed country)

1. 1×10^{-8}
2. 1×10^{-7}
3. 1×10^{-6}
4. 1×10^{-5}



7 sur 7

Probability to die per day

(non-natural causes ; whole population)

Death from	Context	Time period	N deaths	N population	10^{-6}	Reference
Non-natural cause	England and Wales	2012	17,462	56,567,000	**0.8** per day	ONS Deaths Table 5.19.
Non-natural cause *(excluding suicide)*	England and Wales	2012	12,955	56,567,000	**0.6** per day	ONS Suicides
Non-natural cause	US	2010	180,000	308,500,000	**1.6** per day	CDC Deaths Table 18
Non-natural cause *(excluding suicide)*	US	2010	142,000	308,500,000	**1.3** per day	CDC Deaths Table 18.

The probability to die from a non-natural cause in the general population is about **1×10^{-6}** per day

https://en.wikipedia.org/wiki/Micromort

Number of deaths in Switzerland *(2013)*

Cause de décès	Nombre de décès 2013		Taux de mortalité 2013	
	Hommes	Femmes	Hommes	Femmes
Toutes les causes de décès	31257	33704	555.0	371.0
Maladies infectieuses	352	415	6.4	4.8
Tumeurs malignes	9200	7475	167.0	107.0
Gros intestin	584	583	10.3	7.4
Poumons	1960	1208	36.5	19.4
Sein	5	1329	0.1	20.0
Diabète sucré	615	700	10.6	6.8
Démence	1797	4110	28.5	34.5
Appareil circulatoire	9719	11793	164.0	109.0
Cardiopathies, toutes formes	7663	8984	130.0	81.3
Cardiopathies ischémiques	4097	3628	69.9	33.4
Maladies cérébro-vasculaires	1465	2238	24.3	21.5
Appareil respiratoire, toute formes	2167	1949	36.4	20.4
Cirrhose du foie alcoolique	319	121	6.5	2.3
Accidents et morts violentes	2177	1642	44.0	21.0
Accidents, toutes formes	1312	1285	25.3	13.7
Suicides	786	284	16.9	6.0

1312 + 1285
= **2597** people

$$\frac{2597}{8 \cdot 10^6 \cdot 365} = 0.89 \cdot 10^{-6}$$

deaths per day per inhabitant

http://www.bfs.admin.ch/bfs/portal/fr/index/themen/14/02/04/key/01.html#parsys_84305

The probability to die from an accident in the general population is about 10^{-6} per day

10^{-6} is 1 MicroMort

10^{-3} (**20 mSv/y**) = 1000 MicroMort/y

In radiation protection,

3 MicroMort/day is **unacceptable**

R.A. Howard, Intl. J. of Technology Assessment in Health Care, 1989, 5, 357-370

Which **risk** do I **tolerate** when I climb during the winter season?

20-30 deaths per year in Switzerland
8 million inhabitants

$$\text{risk} = \frac{30}{365 \times 8'000'000} = 0.01 \times 10^{-6}$$

0.01 MicroMort/day

Risk of dying in an avalanche [MicroMort/day]

15

10

5

0

outdoor population

(**4.9** MicroMort)

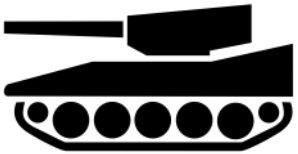
men (**7.0** MicroMort)

(**2.0** MicroMort)

ski (**11.0** MicroMort)

(**2.1** MicroMort)

MicroMort is useful for events with **immediate** effect



It allows us to **evaluate now**

a risk that could (or not) **materialize now**

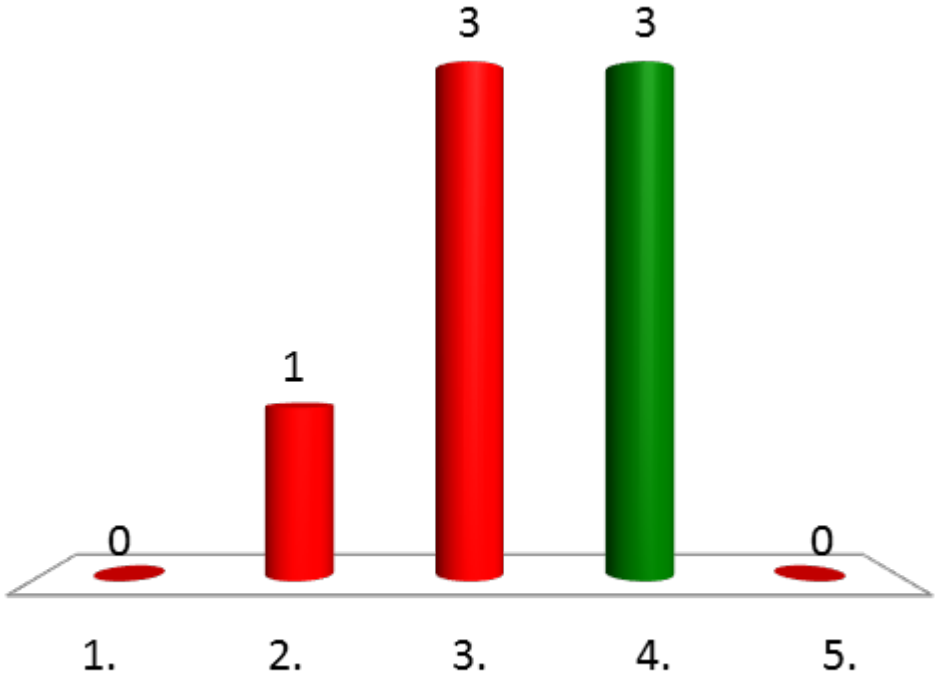
not adequate
for **stochastic risk**

For **delayed risks**, we need to project ourselves into the future

*(and there is **no reset button**, once the risk has been taken)*

How many half-hours of life can you expect when you enter adulthood?

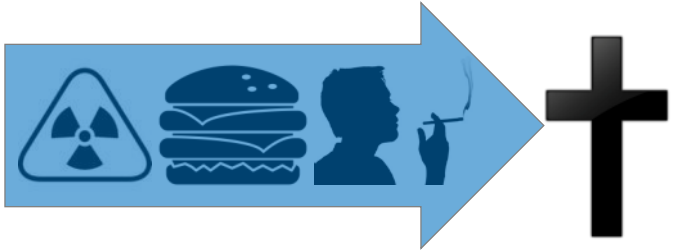
1. 1 000
2. 10 000
3. 100 000
4. 1 000 000
5. 10 000 000



7 sur 7

30 minutes = **1 MicroLife**

Entering adulthood
1 million half-hours to use



M. Blastland and D. Spiegelhalter, The Norm Chronicles, Stories and Numbers About Danger, Profile Books, 2013

Long-term risk

can be understood **now**
as changing
the pace of time

smoking **15-24 cigarettes uses 10** additional **MicroLives**
(at the end of the day, you actually used 58 MicroLives)

doing a **20 min exercise gives** you **2** additional **MicroLives**
(at the end of the day, you actually used 46 MicroLives)

https://en.wikipedia.org/wiki/Microlife

Exercise

compute the average time loss
for an effective dose of 20 mSv

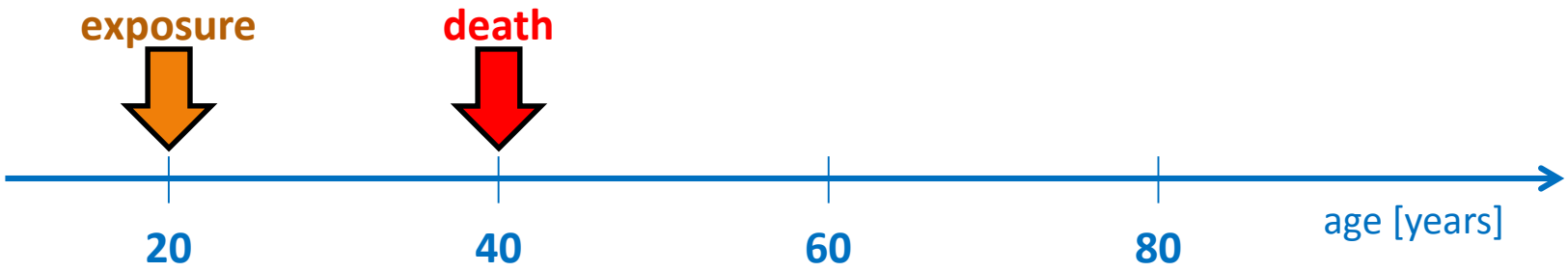
Simplistic hypotheses

Risk to die: **5% Sv^{-1}**

Latency: L=**20 years** *(assume that those who will die, will do it exactly at this time)*

Life expectancy: **80 years**

Possible expositions **between e=20 and e=60** years old



Exercise (solution)

compute the average of time loss for an effective dose of 20 mSv

Simplistic hypotheses

Risk to die: **5% Sv^{-1}**

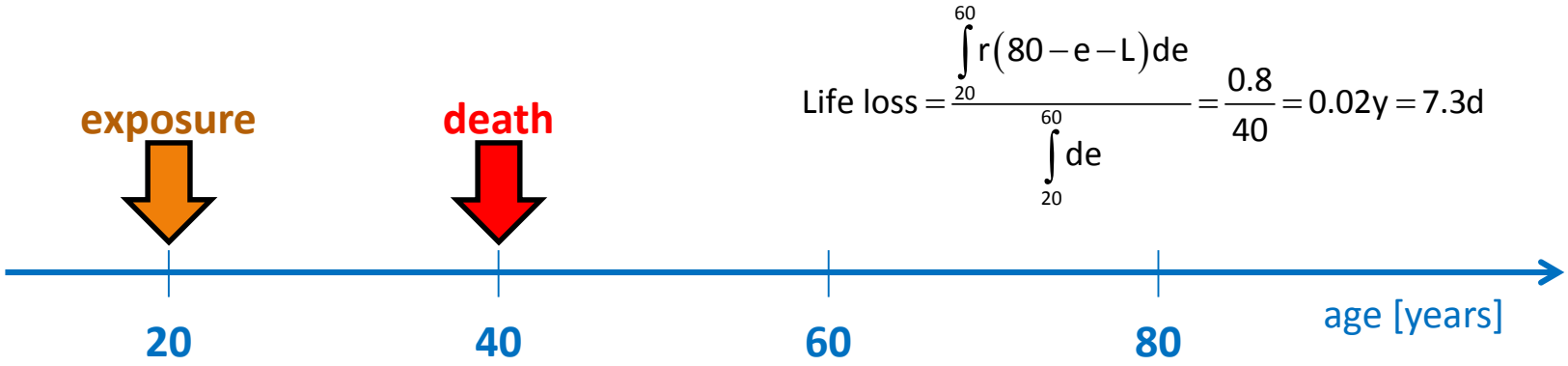
Latency: L=**20 years** *(assume that those who will die, will do it exactly at this time)*

Life expectancy: **80 years**

Possible expositions **between e=20 and e=60** years old

risk to die: **r =** 0.02 x 0.05 = **1/1000**

life loss if exposed **at 20 y.o.**: r x (80-40) = 40/1000 = 0.04 years = **14.6 days**



$$\text{Life loss} = \frac{\int_{20}^{60} r(80 - e - L)\,de}{\int_{20}^{60} de} = \frac{0.8}{40} = 0.02y = 7.3d$$

Exposure	E [mSv]	Average loss in life expectancy	MicroLives
Annual occupational limit	20	7 days	400
Whole body CT scan	10	3 days	150
Fukushima prefecture	1 – 10	10h – 3d	20 - 150
Fukushima Town Hall in the two weeks following accident	0.1	1 h	2
Flight from London to New-York	0.07	37 min	1
Chest X-ray	0.02	11 min	0.5

M. Blastland and D. Spiegelhalter, The Norm Chronicles, Stories and Numbers About Danger, Profile Books, 2013

Risk and radiation

3.

How ethics can help to decide what is acceptable

The role of **genetic differences** in determining **individual sensitivity**

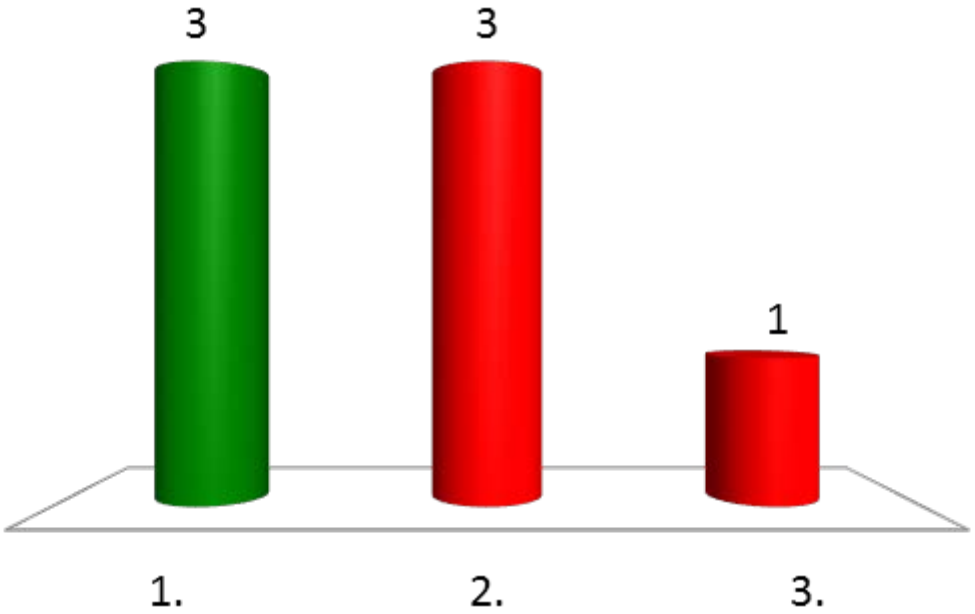
genetic differences has the potential to significantly influence radiological protection…

…so do **life style** characteristics *(e.g. smoking)*

Should we **exclude** workers in a nuclear power plant if they smoke **tobacco**?

(risk is potentially 25 times higher than the non-smoking population)

1. Yes, exclude
2. No, they can work
3. Don't know

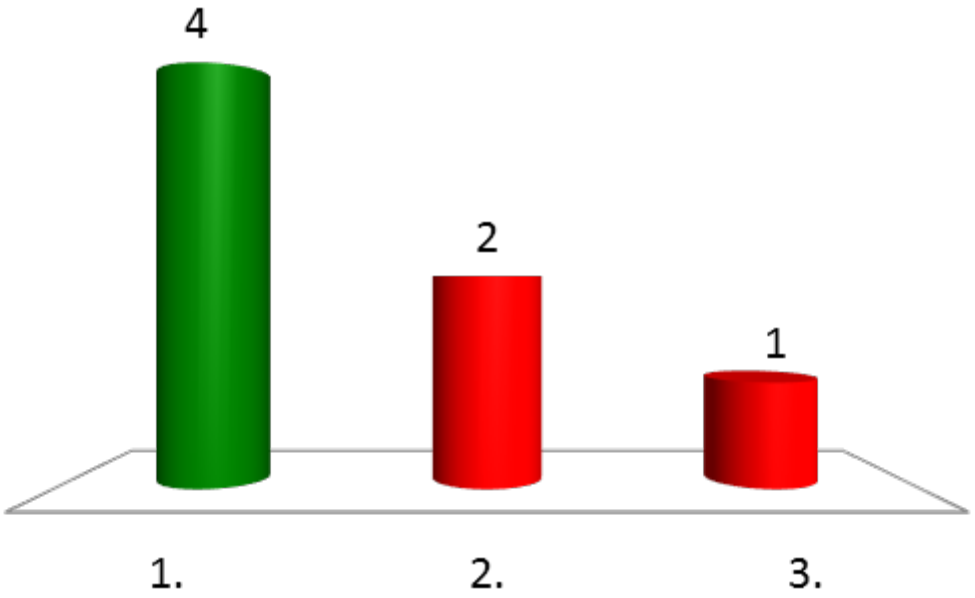


7 sur 7

Should we **exclude** a worker in a nuclear power plant if they have **high risk gene** for developing **leukemia**?

(risk is potentially 25 times higher than the "normal" population)

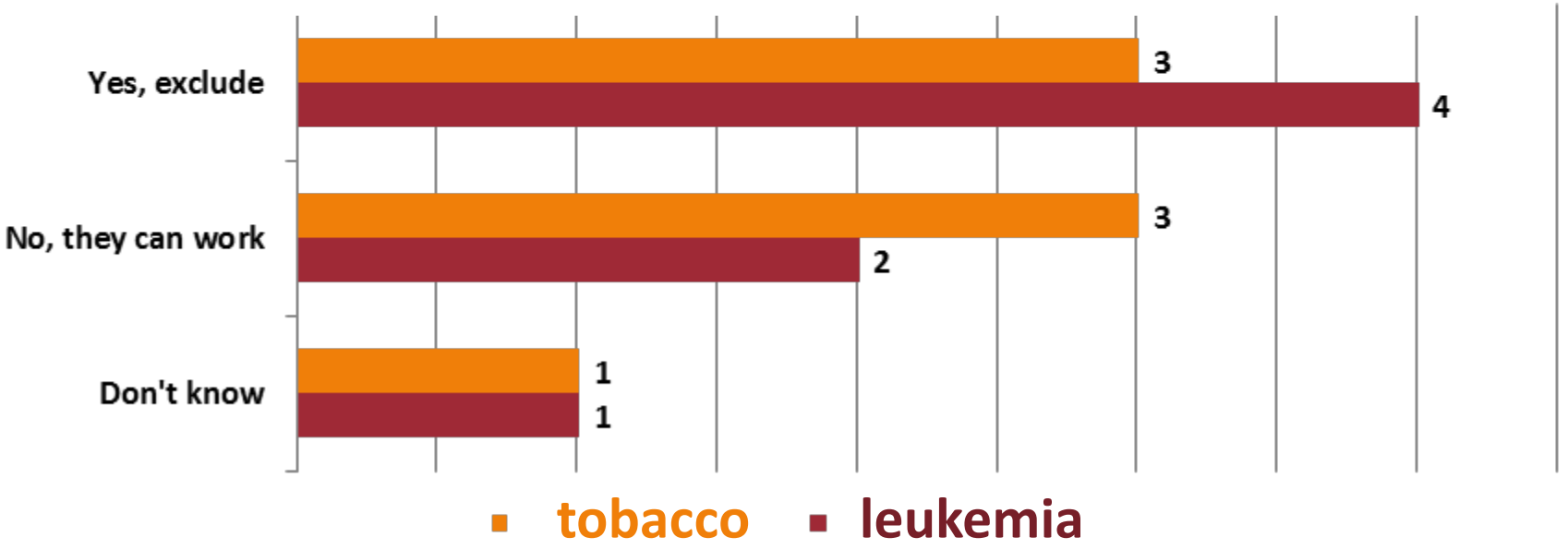
1. Yes, exclude
2. No, they can work
3. Don't know



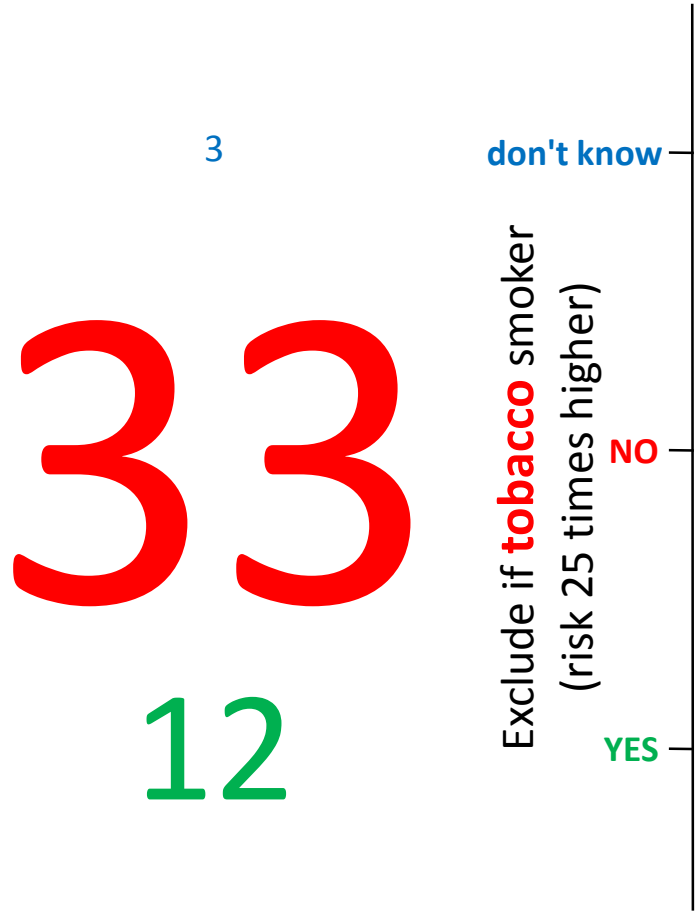
7 sur 7

Should we **exclude** workers
if they are **particularly at risk**?

- because of their **behavior** (tobacco)
- because of their **genes** (leukemia)



What kind of **worker** should we **exclude** from exposure situations?



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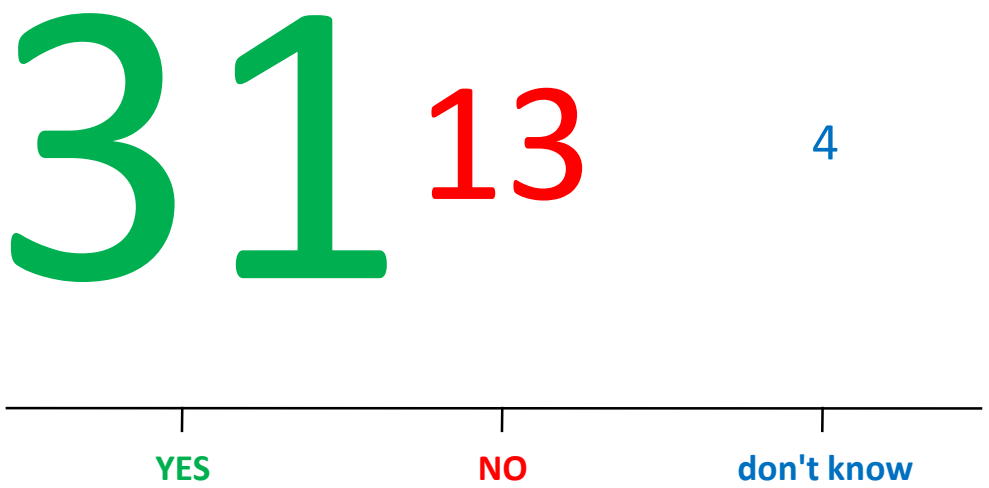
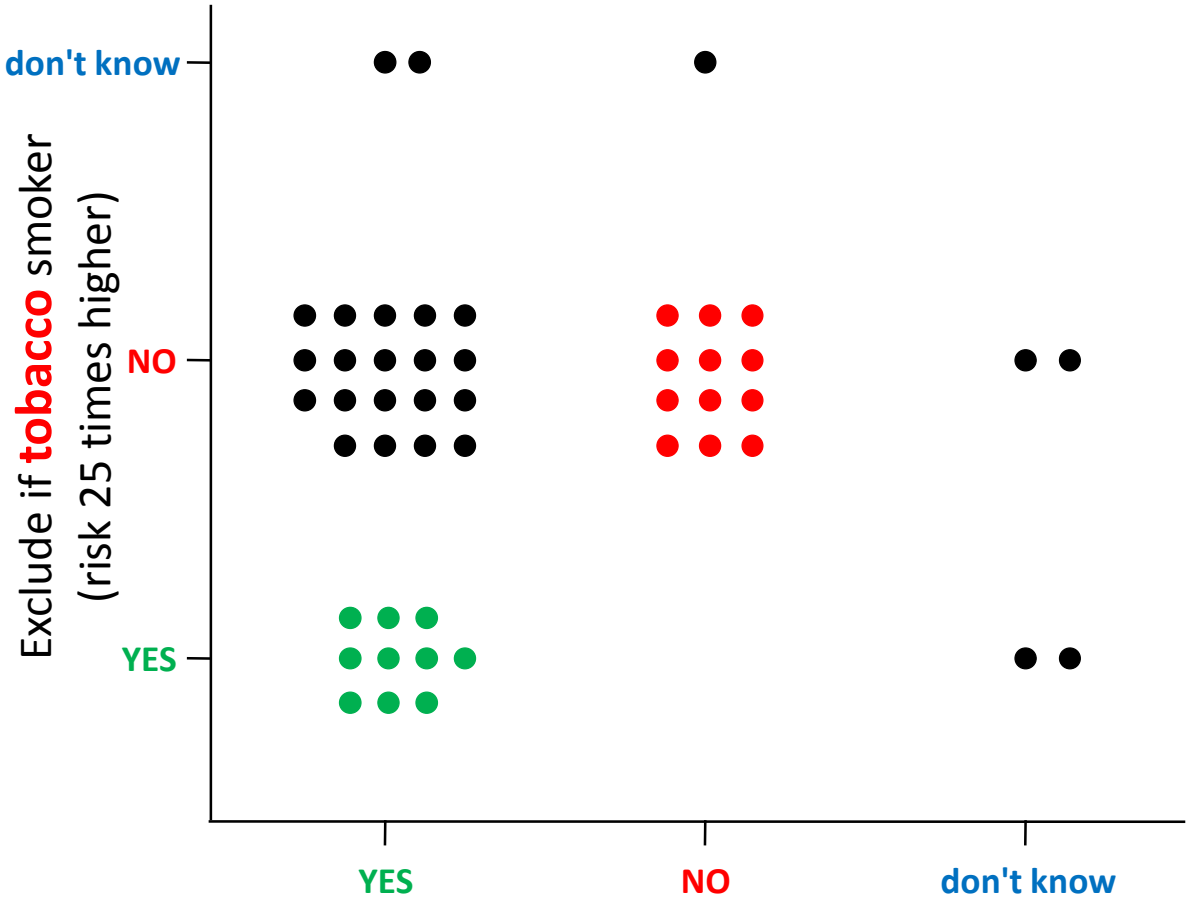


Exclude if **leukemia** risk is 25 times higher



Exclude if **leukemia** risk is 25 times higher

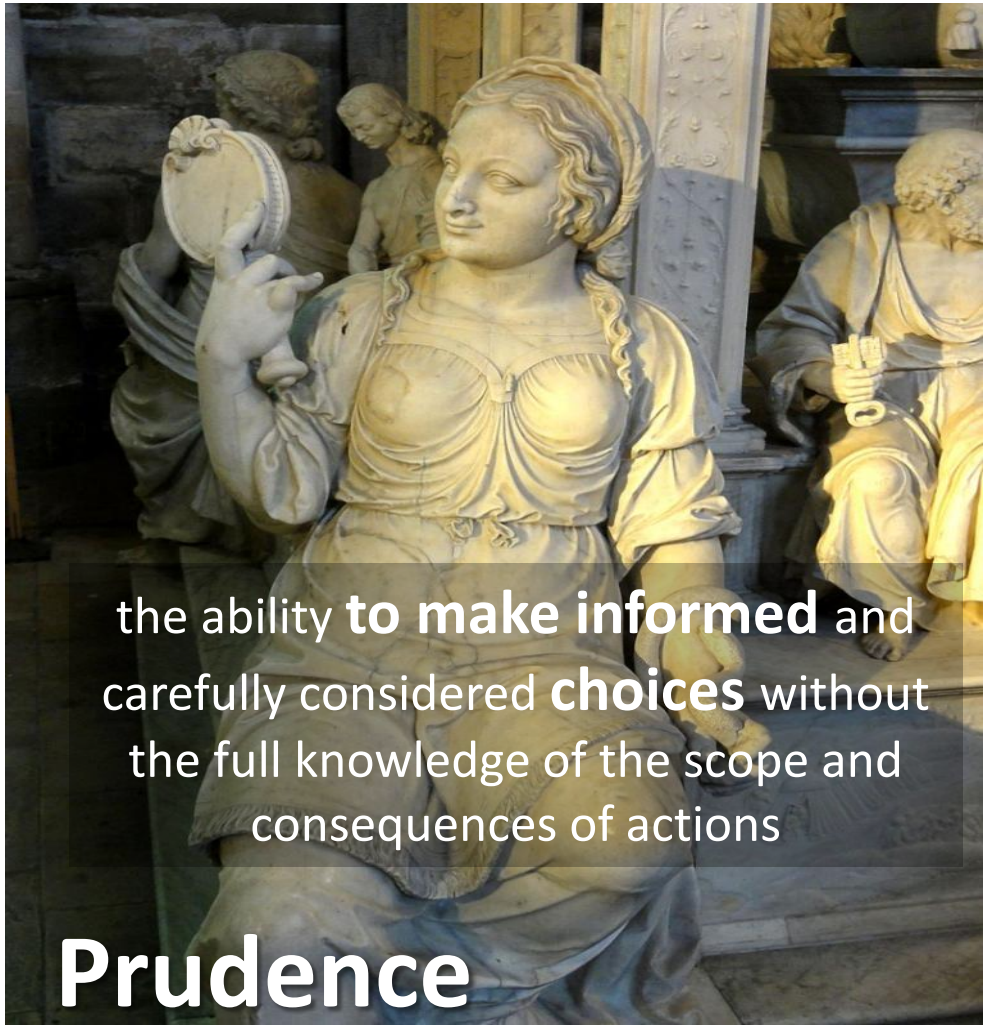
Ethics in radiation protection

has been introduced to help us to **make choices**


Beneficence
(and non-maleficence)

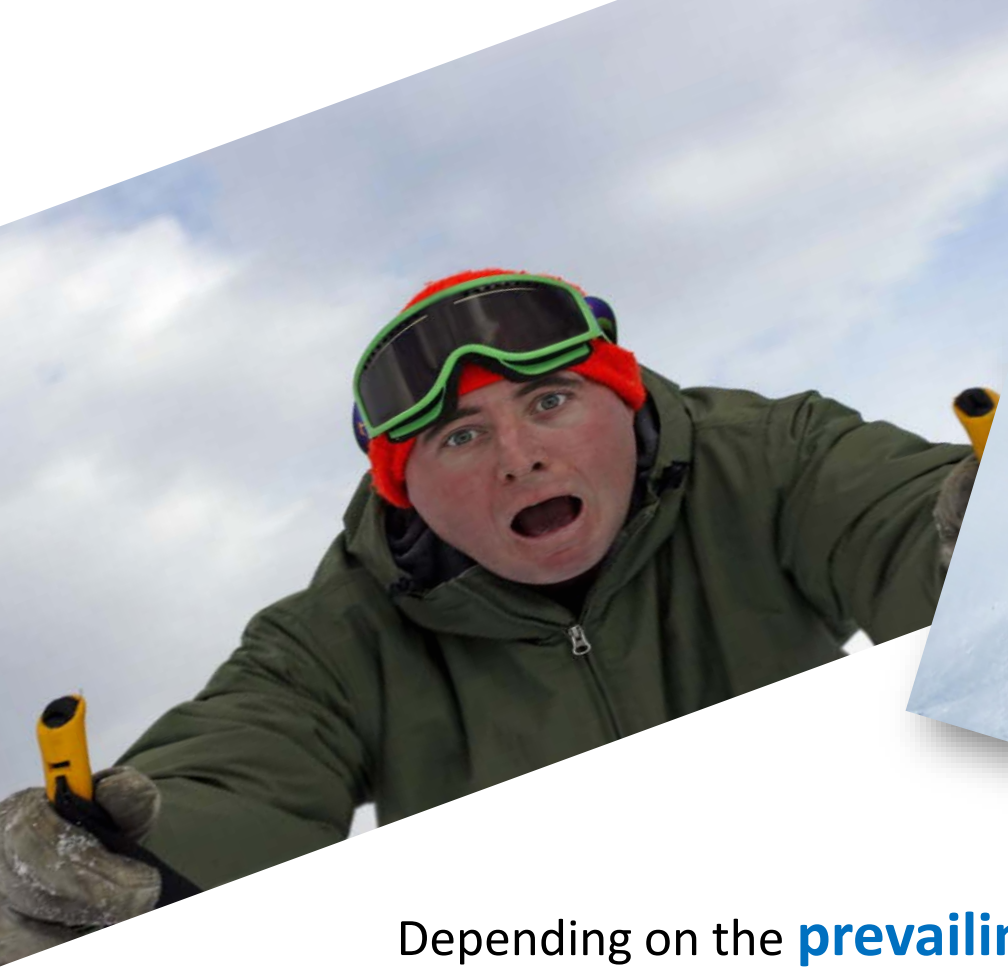
over
cautiousness

cowardice



over
confidence

recklessness



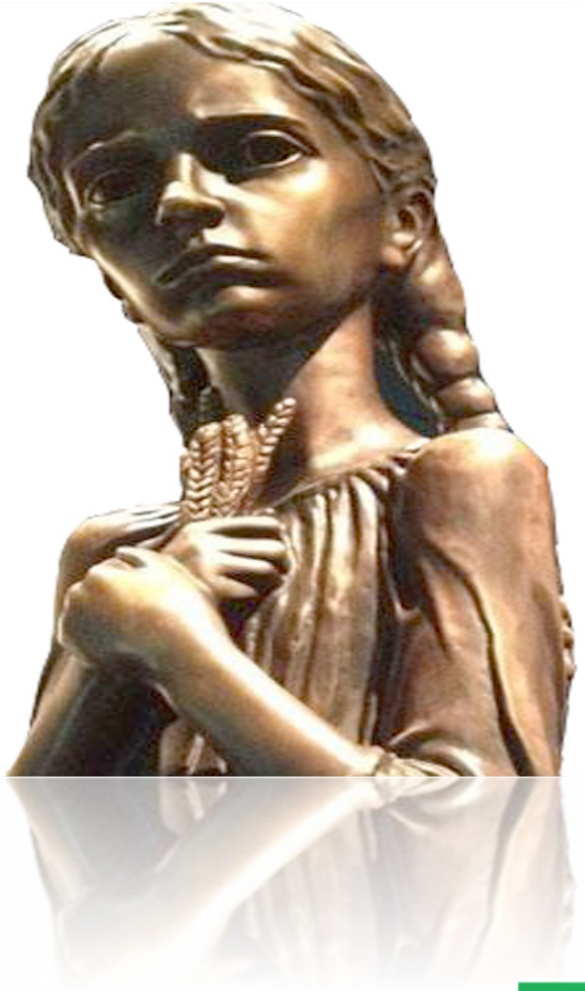
Depending on the **prevailing circumstances**,

both may (or may not) act **with prudence**

Justice

Dignity

Every **human being**
deserves **unconditional respect**,
whatever their age, gender, mental or physical health, religion, social condition or ethnic origin



https://humanrights.ca/blog/story-holodomor-canadian-museum-human-rights

Example 1

Should we forbid a **female surgeon** to work with **fluoroscopy** as soon as she's **pregnant**?

1. Yes, exclude
2. No, she can choose
3. No, she should work
4. Don't know

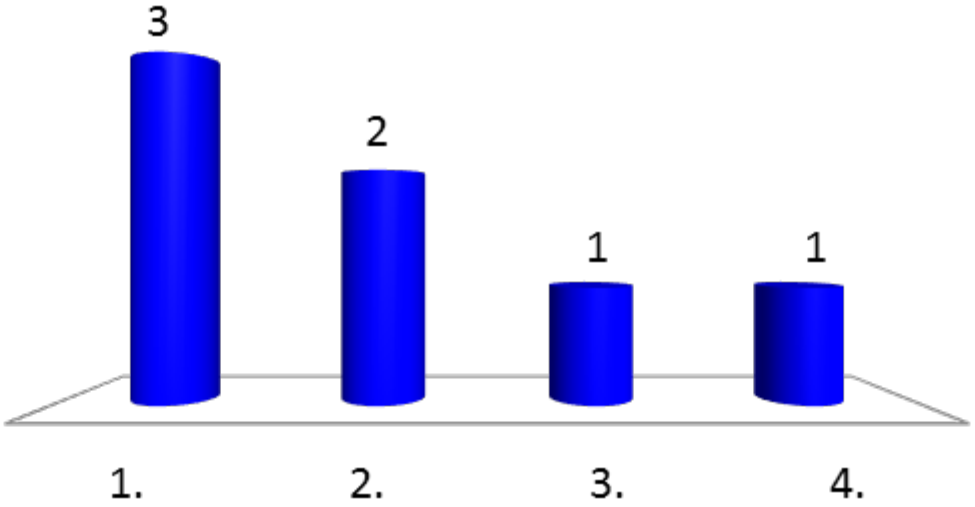
7 sur 7


Example 1
Should we **forbid** a **female surgeon** to work with **fluoroscopy** as soon as she's pregnant?
beneficence/non-maleficence
more good than harm for the radiologist or for the fetus?
prudence
doses to the fetus almost guaranteed to be < 1mSv
justice
comparable with other risks?
(bus driver, cleaner)
if anything happens at birth, even with the most unlikely link with radiation, there will be a doubt
dignity
no more autonomy for the radiologist

Example 1

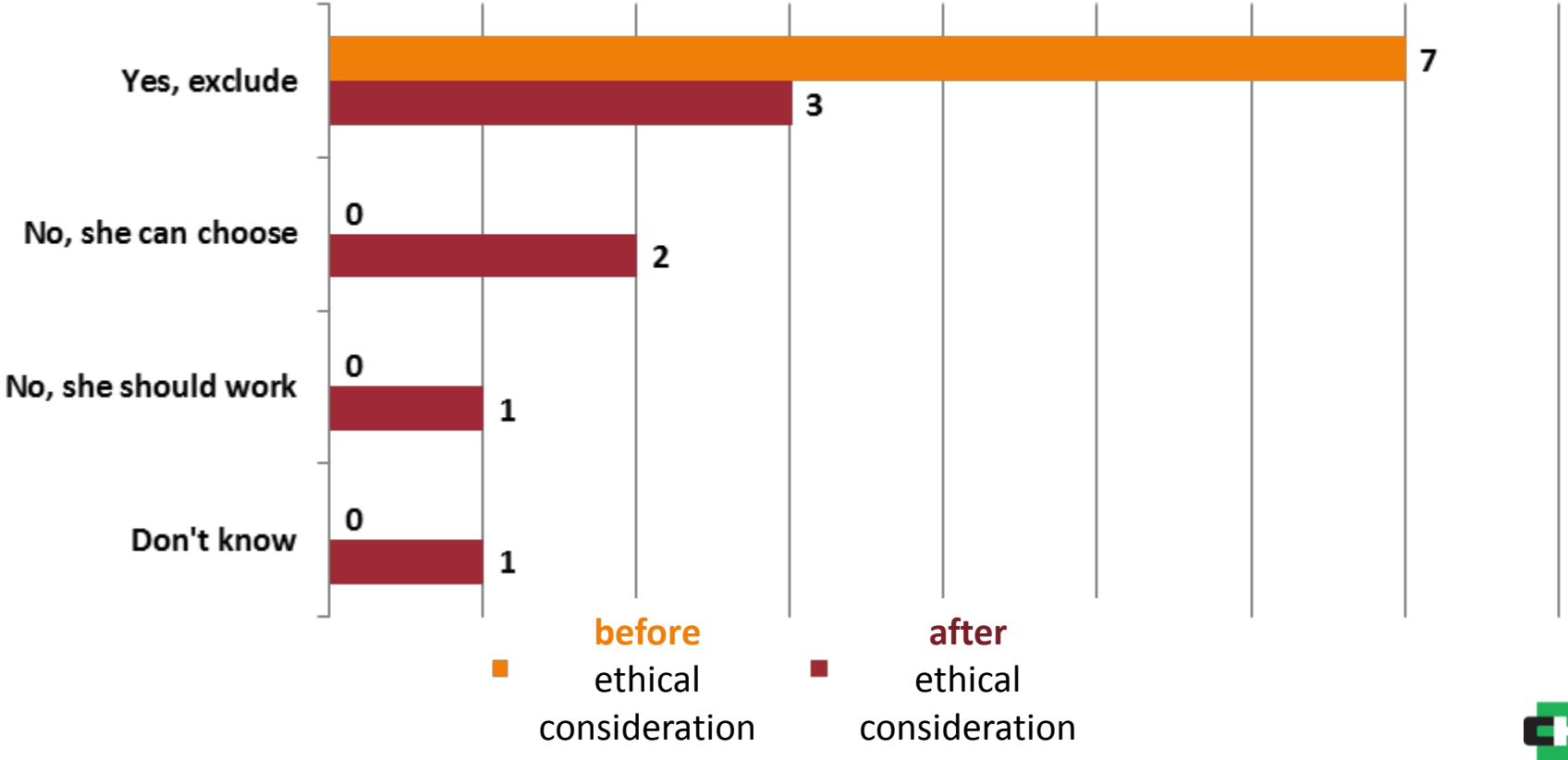
Should we forbid a **female surgeon** to work with **fluoroscopy** as soon as she's **pregnant**?

1. Yes, exclude
2. No, she can choose
3. No, she should work
4. Don't know



7 sur 8

Should we forbid a female surgeon to work with fluoroscopy as soon as she's pregnant?

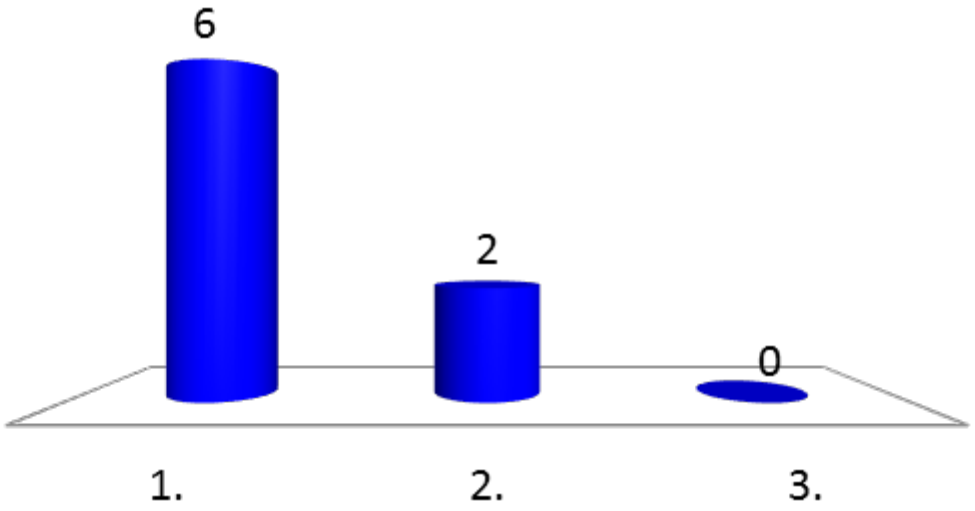


Example 2

Should we set up a **lung cancer screening** program for **smokers**?

(after 55 years old, 1 low-dose CT yearly, could save 3 people out of 1000)

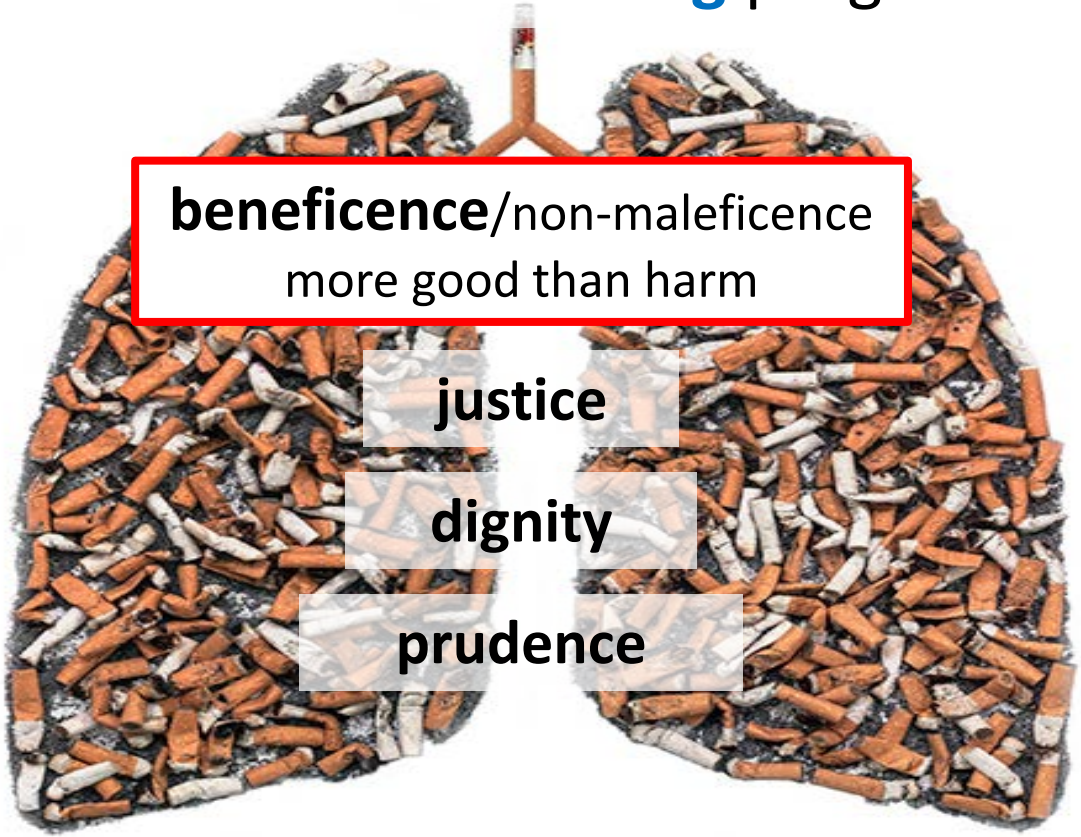
1. Yes
2. No
3. Don't know



8 sur 10

Example 2

Should we set up a **lung cancer screening** program for **smokers**?



beneficence/non-maleficence
more good than harm

justice

dignity

prudence

Example 2

National Lung Screening trial **NLST-study**

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 AUGUST 4, 2011 VOL. 365 NO. 5

Reduced Lung-Cancer Mortality with Low-Dose Computed Tomographic Screening

The National Lung Screening Trial Research Team*

ABSTRACT

BACKGROUND

The aggressive and heterogeneous nature of lung cancer has thwarted efforts to reduce mortality from this cancer through the use of screening. The advent of low-dose helical computed tomography (CT) altered the landscape of lung-cancer screening, with studies indicating that low-dose CT detects many tumors at early stages. The National Lung Screening Trial (NLST) was conducted to determine whether screening with low-dose CT could reduce mortality from lung cancer.

METHODS

From August 2002 through April 2004, a total of 53,454 persons at high risk for lung cancer and deaths from lung cancer that occurred through December 31, 2009. Participants were randomly assigned to undergo three annual screenings with either low-dose CT (26,722 participants) or standard chest radiography (26,732). Data were collected on cases of

RESULTS

The rate of adherence to screening was more than 90%. The rate of positive screening tests was 24.2% with low-dose CT and 6.9% with radiography over all three rounds. A total of 96.4% of the positive screening results in the low-dose CT group and 94.5% in the radiography group were false positive results. The incidence of lung cancer was 645 cases per 100,000 person-years (1060 cancers) in the low-dose CT group, as compared with 572 cases per 100,000 person-years (941 cancers) in the radiography group (rate ratio, 1.13; 95% confidence interval [CI], 1.03 to 1.23). There were 247 deaths from lung cancer per 100,000 person-years in the low-dose CT group and 309 deaths per 100,000 person-years in the radiography group, representing a relative reduction in mortality from lung cancer with low-dose CT screening of 20.0% (95% CI, 6.8 to 26.7; P=0.004). The rate of death from any cause was reduced in the low-dose CT group, as compared with the radiography group, by 6.7% (95% CI, 1.2 to 13.6; P=0.02).

CONCLUSIONS

Screening with the use of low-dose CT reduces mortality from lung cancer. (Funded by the National Cancer Institute; National Lung Screening Trial ClinicalTrials.gov number, NCT00047385.)

The members of the writing team (who are listed in the Appendix) assume responsibility for the integrity of the article. Address reprint requests to Dr. Christine D. Berg at the Early Detection Research Group, Division of Cancer Prevention, National Cancer Institute, 6130 Executive Blvd., Suite 3112, Bethesda, MD 20892-7346, or at bergc@mail.nih.gov.

*A complete list of members of the National Lung Screening Trial research team is provided in the Supplementary Appendix, available at NEJM.org.

This article (10.1056/NEJMoa1102873) was published on June 29, 2011, at NEJM.org.

N Engl J Med 2011;365:395-409.

New England Journal of Medicine 365:395 (2011)

Example 2

Should we set up a **lung cancer screening** program for **smokers**?

National Lung Screening trial **NLST-study**

53,454 current or former **heavy smokers**

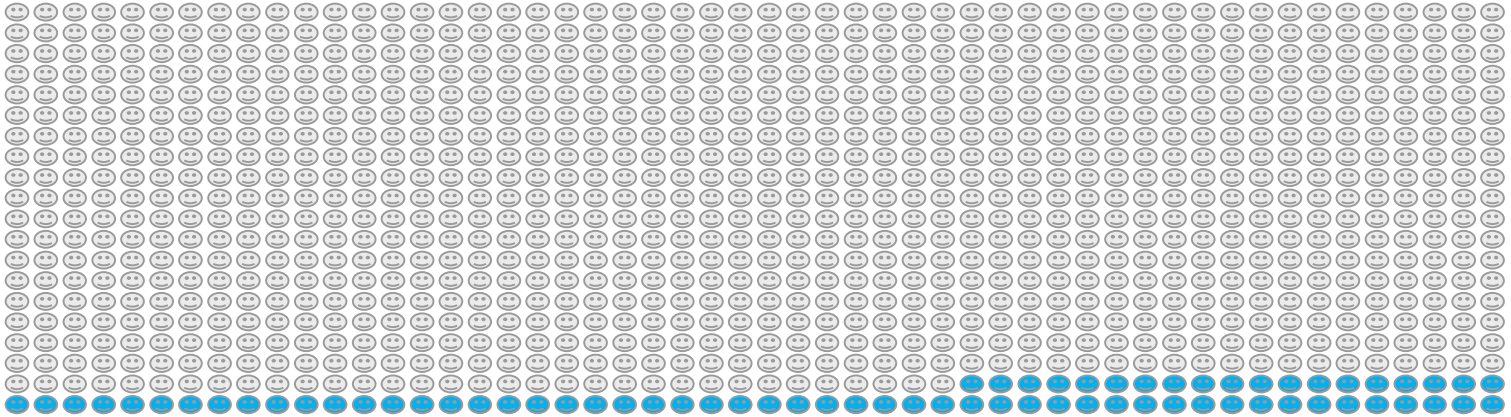
(30+ pack-year; half current/half former) **ages 55 to 74**

(highly motivated and primarily urban group)

randomized trial

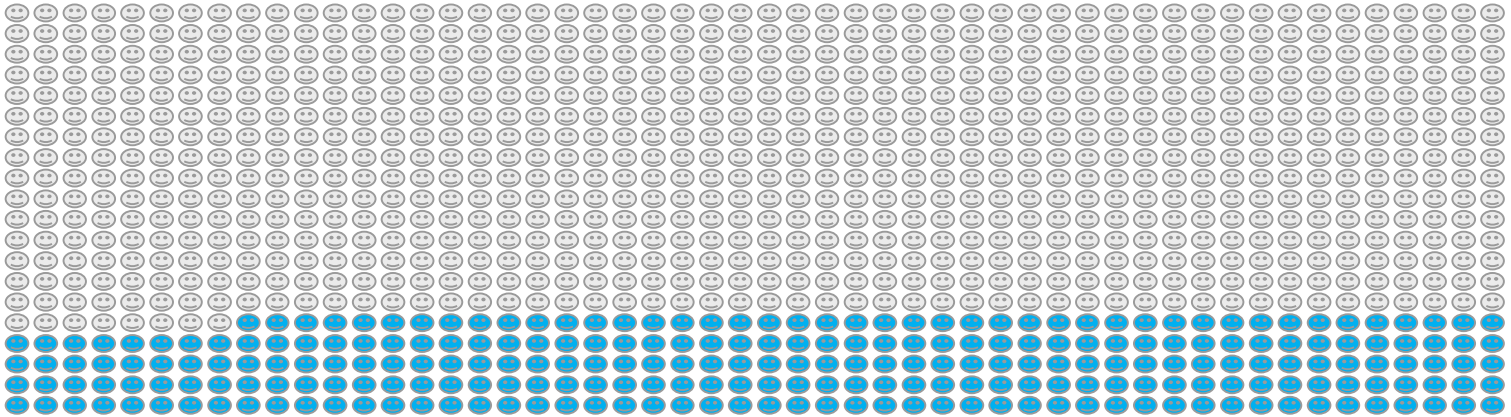
low-dose chest CT	chest radiograph
(E=1.5 mSv)	*(E=0.03 mSv)*
once a year	once a year
(over 3 years)	*(over 3 years)*

chest x-ray



69 +

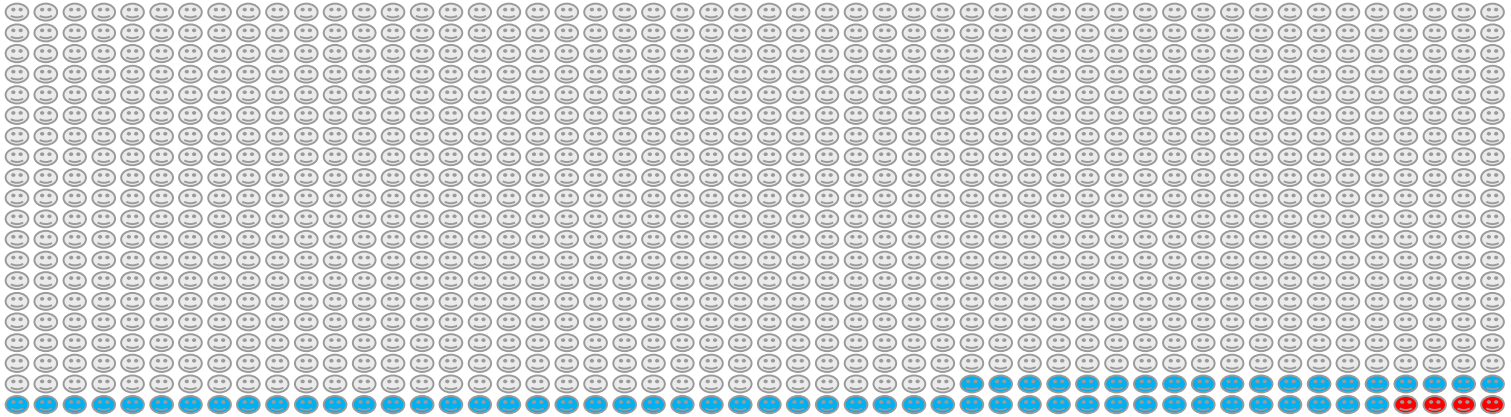
low-dose CT



242+

New England Journal of Medicine 365:395 (2011)

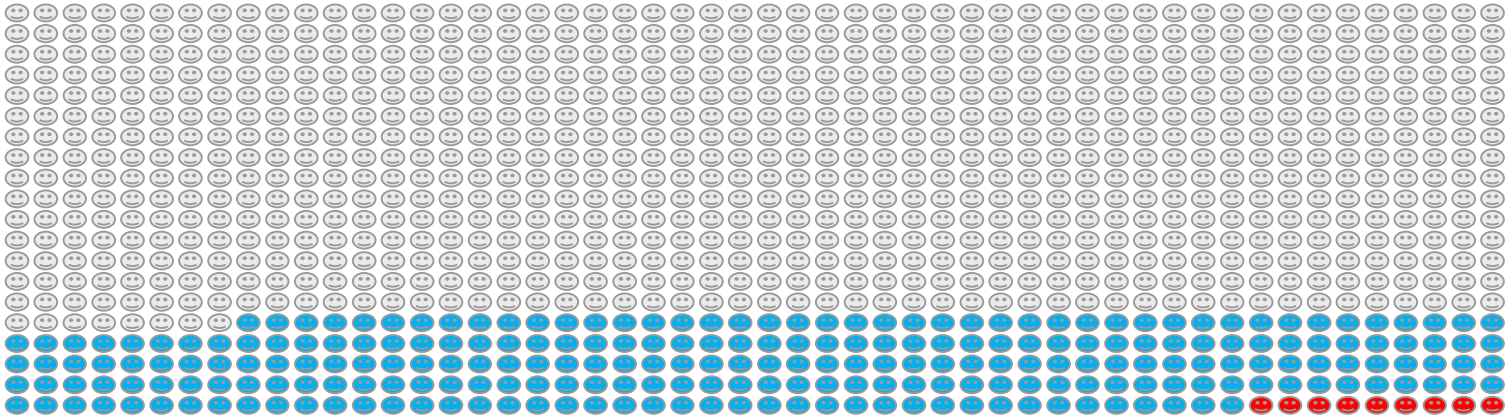
chest x-ray



4 TP

(5.5%)

low-dose CT



9 TP

(3.6%)

TP: true positive

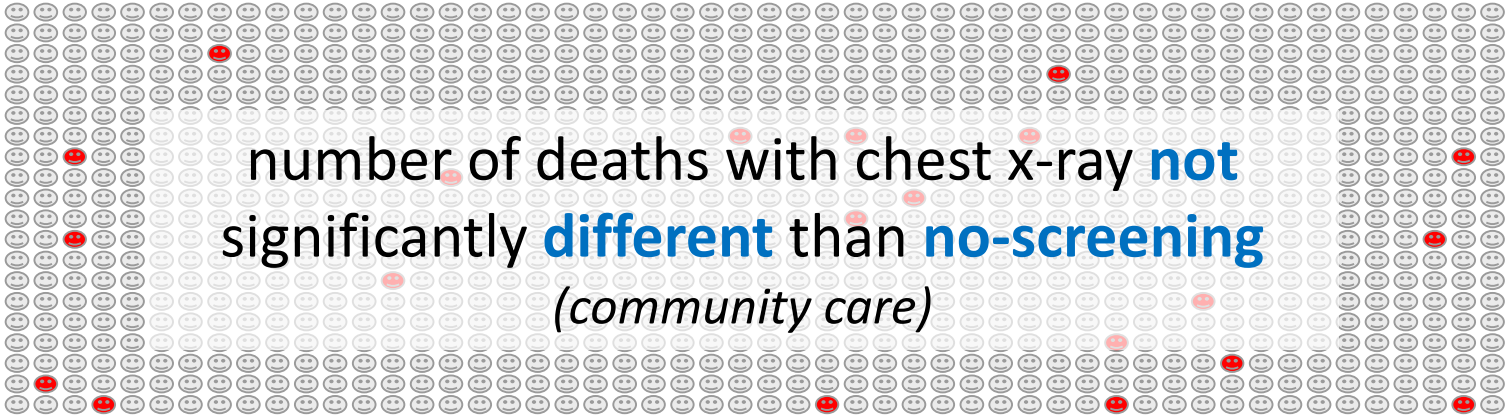
New England Journal of Medicine 365:395 (2011)

	Total chest x-ray	Total CT
Total positive tests	5043 (100.0)	18,146 (100.0)
Lung cancer confirmed	279 (5.5)	649 (3.6)
Lung cancer not confirmed†	4764 (94.5)	17,497 (96.4)
Positive screening results with complete diagnostic follow-up information	4953 (100.0)	17,702 (100.0)
Any diagnostic follow-up	4211 (85.0)	12,757 (72.1)
Clinical procedure	2795 (56.4)	10,430 (58.9)
Imaging examination	3884 (78.4)	10,246 (57.9)
Chest radiography	1613 (32.6)	2,547 (14.4)
Chest CT	3003 (60.6)	8,807 (49.8)
FDG PET or FDG PET–CT	397 (8.0)	1,471 (8.3)
Percutaneous cytologic examination or biopsy	172 (3.5)	322 (1.8)
Transthoracic	141 (2.8)	254 (1.4)
Extrathoracic	39 (0.8)	80 (0.5)
Bronchoscopy	225 (4.5)	671 (3.8)
With neither biopsy nor cytologic testing	96 (1.9)	320 (1.8)
With biopsy or cytologic testing	150 (3.0)	391 (2.2)
Surgical procedure	239 (4.8)	713 (4.0)
Mediastinoscopy or mediastinotomy	55 (1.1)	117 (0.7)
Thoracoscopy	53 (1.1)	234 (1.3)
Thoracotomy	184 (3.7)	509 (2.9)
Other procedures	122 (2.5)	327 (1.8)

many medical procedures performed on all **positive cases**

New England Journal of Medicine 365:395 (2011)

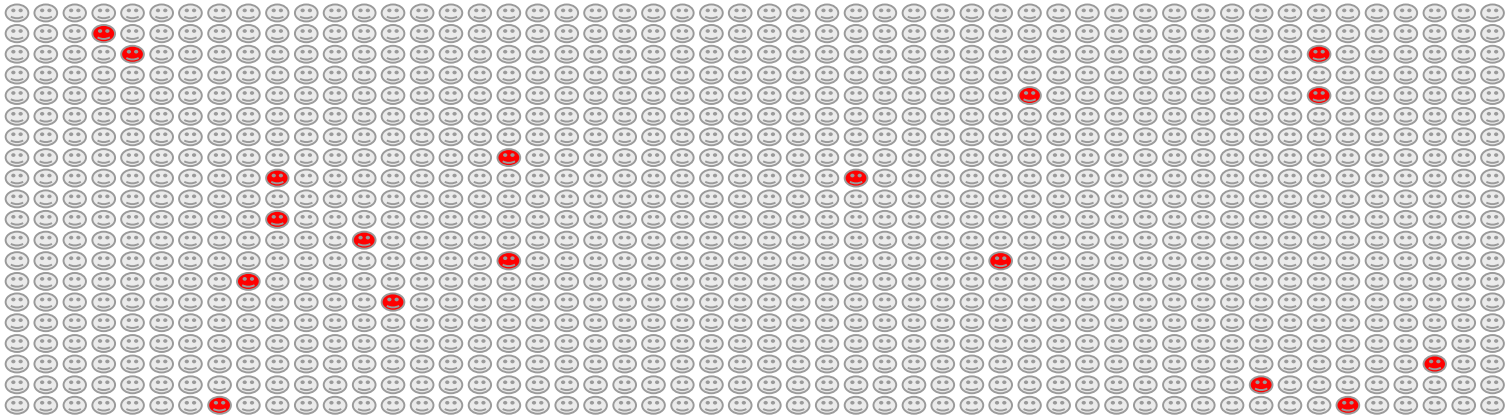
chest x-ray



20.7 †

3 deaths avoided with CT *(15 to 20 percent lower risk of dying from lung cancer)*

low-dose CT



17.6 †

New England Journal of Medicine 365:395 (2011)

3 deaths avoided with CT *(15 to 20 percent lower risk of dying from lung cancer)*

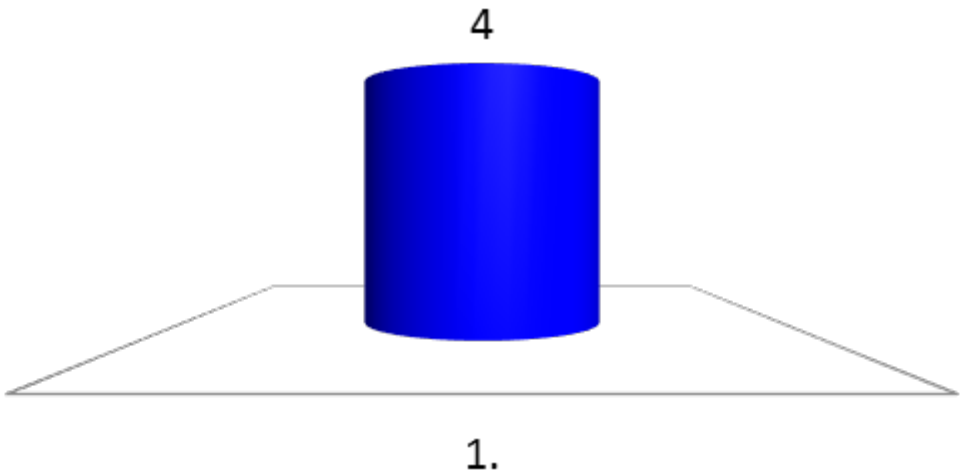
Exercise

According to LNT, what would be
the **number of additional deaths**
induced by the **low dose CT** on a population of 1000 people?

Exercise: According to LNT, what would be the **number of additional deaths** induced by the **low dose CT** on a population of 1000 people?

(3 x 1.5 mSv)

1. I'm finished



4 sur 10

beneficence/non-maleficence
more good than harm

for avoiding **3 deaths**
(per 1,000 screened)

radiation protection perspective

3 x 1.5 mSv *(collective dose 4.5 Sv)*
risk according to LNT *(≈2%/Sv)*: **0.1 additional** (potential) **death**

medical perspective

NLST performed
on **favorable cohort**
with **top quality** medical **staff**
(especially for surgical resection)

> 95% false positive *(follow-up procedure costly and invasive)*
Not all lung cancers found with screening will be early stage
Performance may increase with more than three rounds
Screening programs may **discourage smoker to quit**

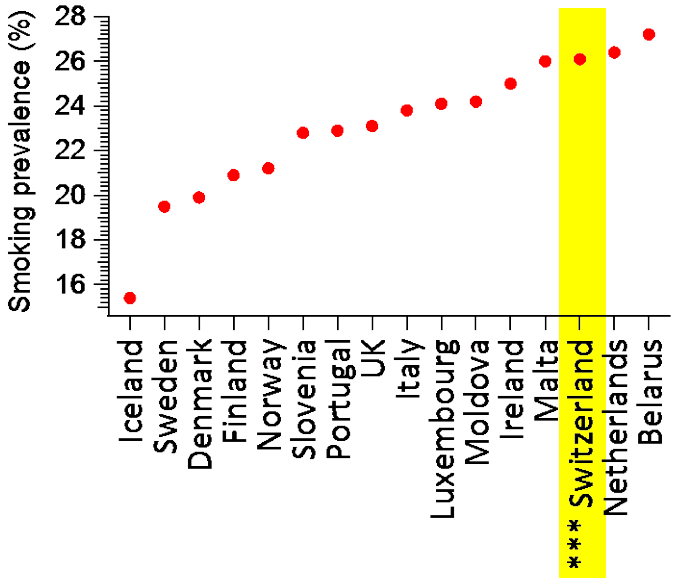
political perspective

program costly

(CT-screening; additional tests;
loss of productivity of the patients; …)

Switzerland may **learn from nearby countries**

(prevention is cheaper)



Example 2

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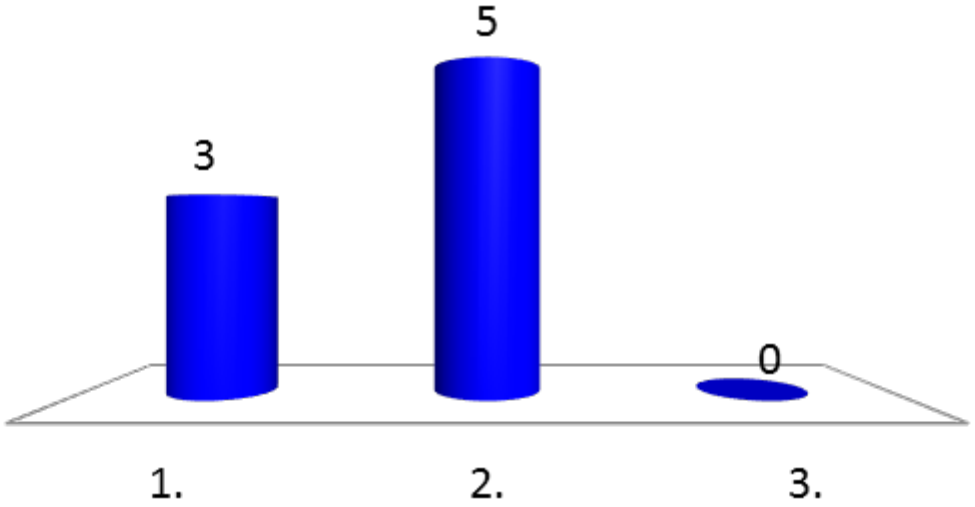
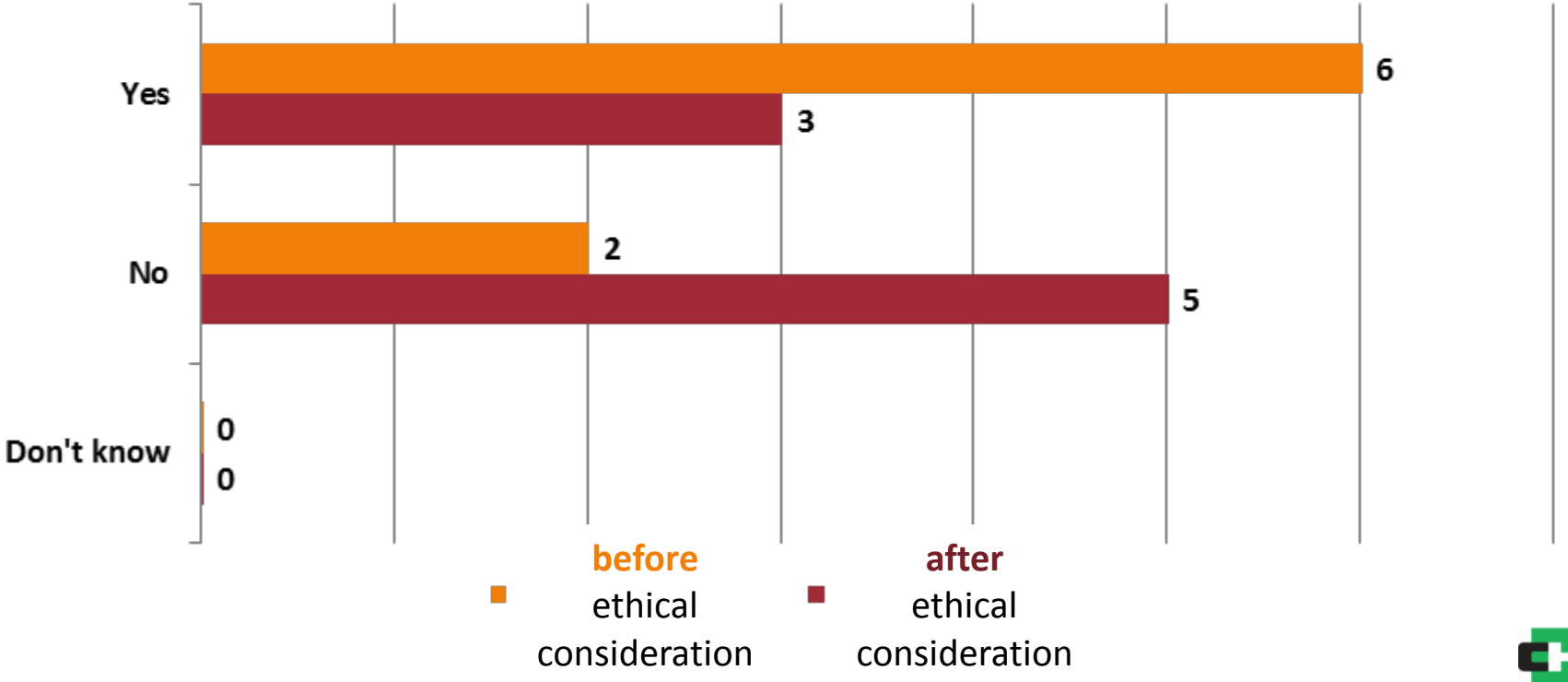


8 sur 11

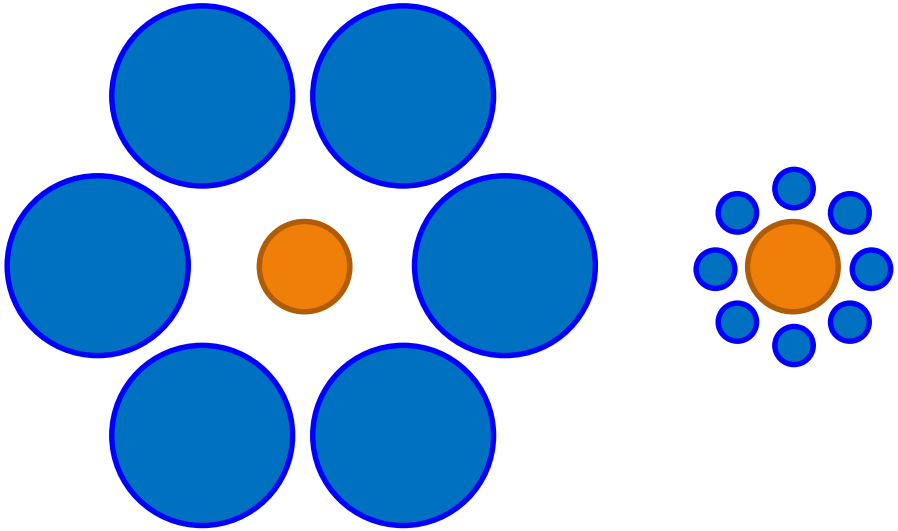
Should we set up a lung cancer screening program for smokers?(after 55 years old, 1 low-dose CT yearly, could save 3 people out of 1000)



Risk and radiation

4.

Perception is reality!



Our **attitude toward risk**
depends on **how it is framed**

Pandemic in a country 600 people concerned

Preferred

A
200 saved

B
all saved 1/3
nobody saved 2/3

C
400 die

Preferred

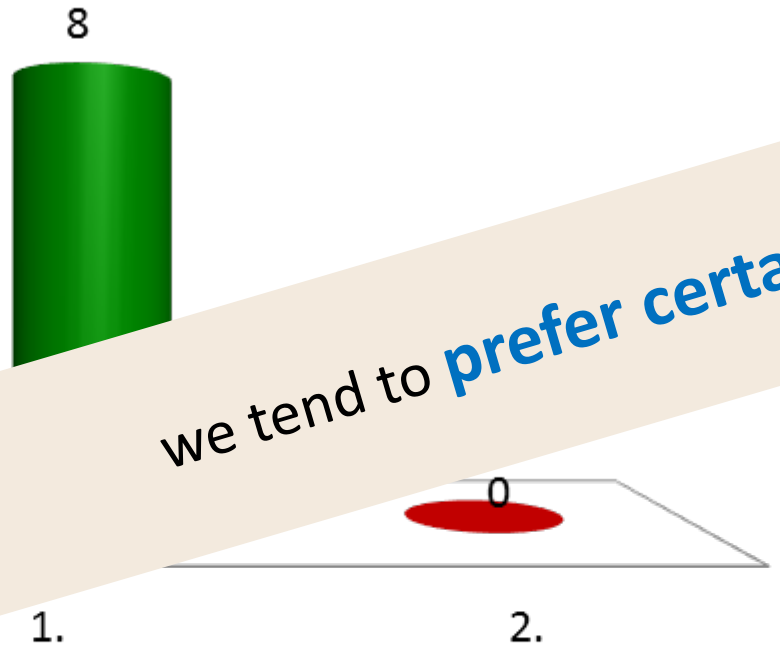
D
Nobody dies 1/3
All die 2/3

Tversky & Kahneman, The framing of decisions and the psychology of choice, Env Impact Tech Ass, and Risk Ana (1985)

What do you prefer?

(imagine that you won a contest)

1. **Win** 3000 $ *(certain)*
2. **Win** 4000 $ *(probability 80%)*



Faced with a **gain**

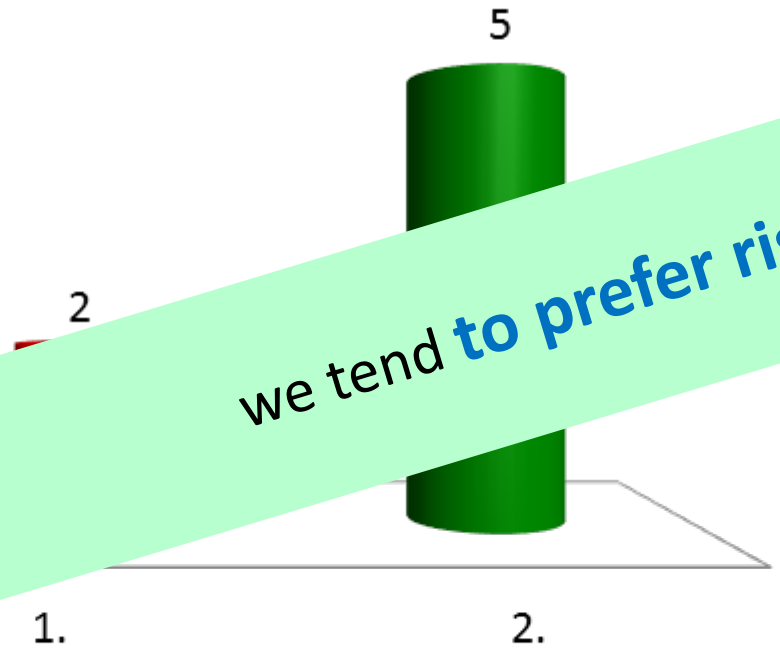
we tend to **prefer certainty**

8 sur 1

What do you prefer

(imagine that you have to pay a fine)

1. **Pay** 3000 $
   (certain)
2. **Pay** 4000 $
   (probability 80%)

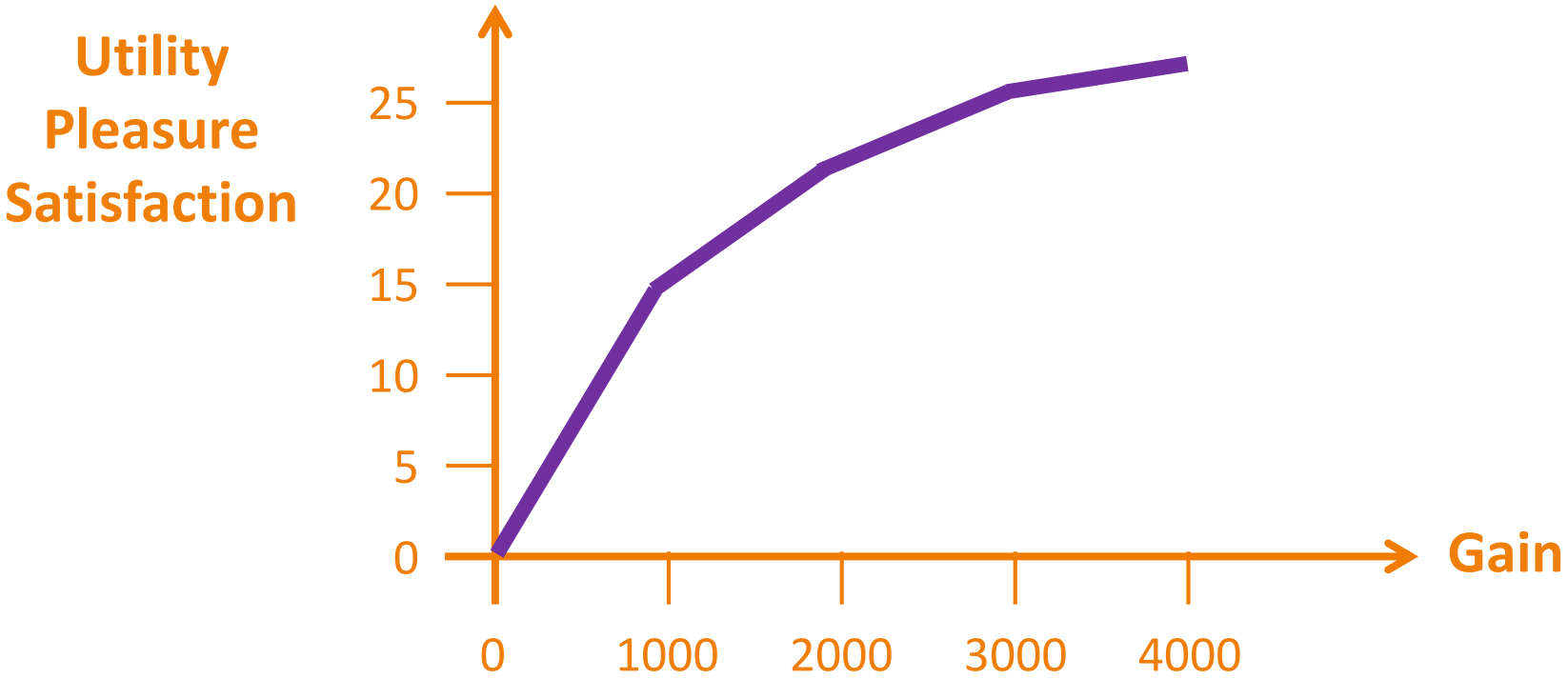


Faced with a **loss**

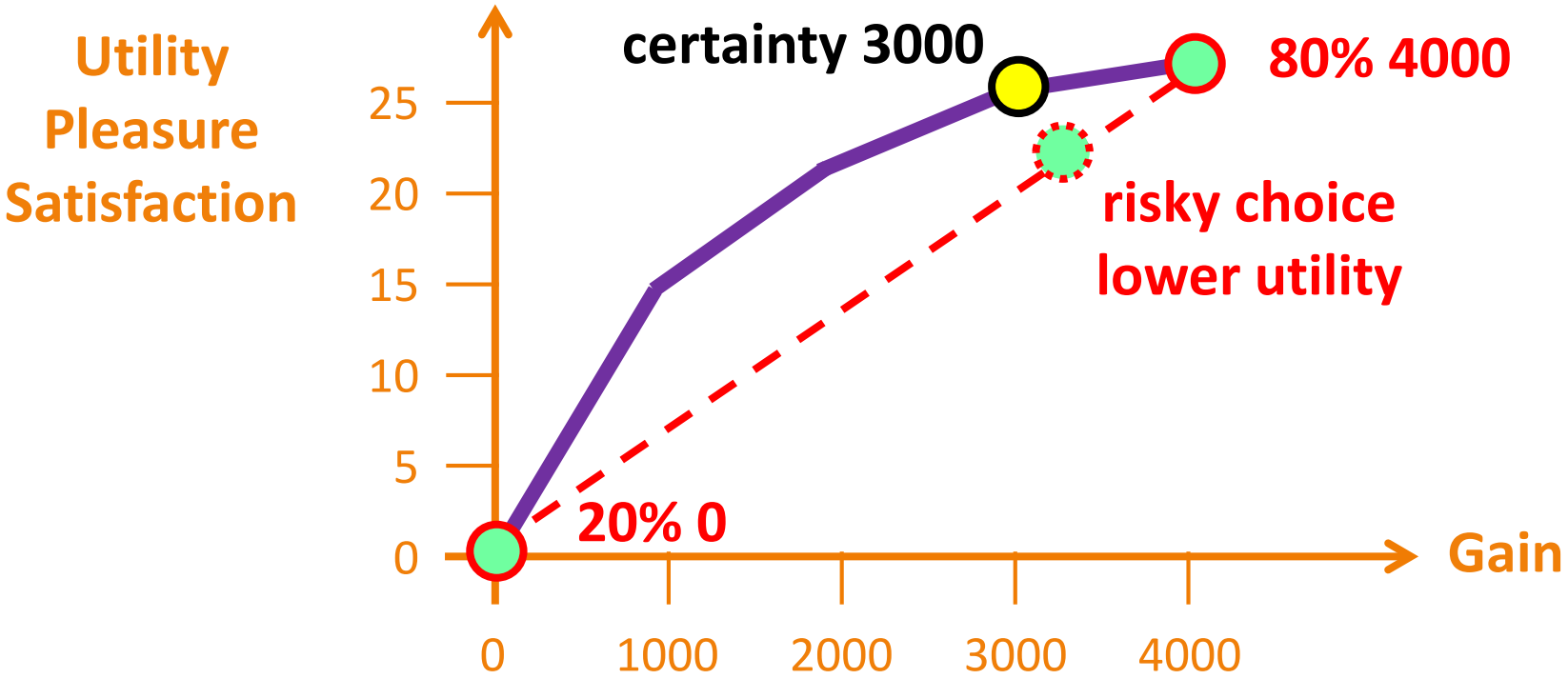
we tend **to prefer risk**

7 sur 1

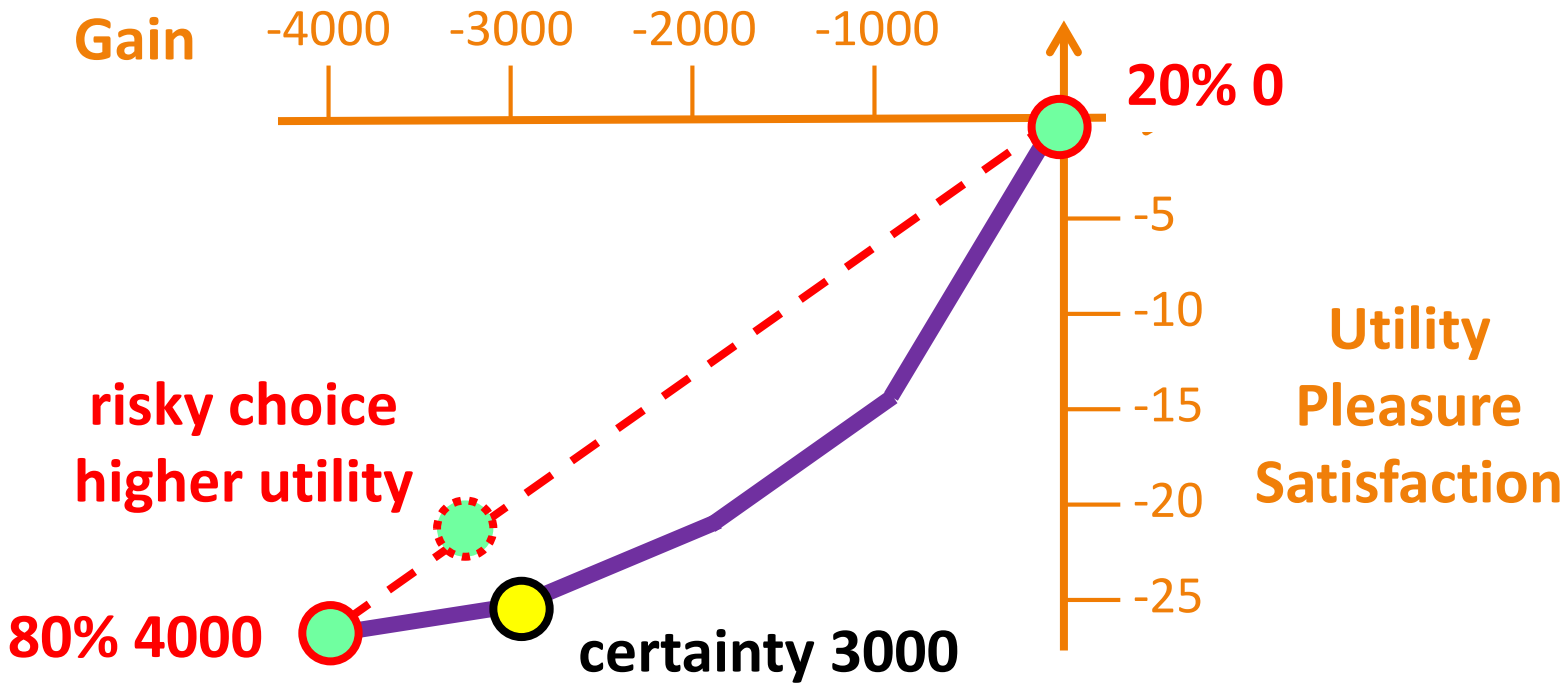
Faced with a **gain** we tend to **prefer certainty**

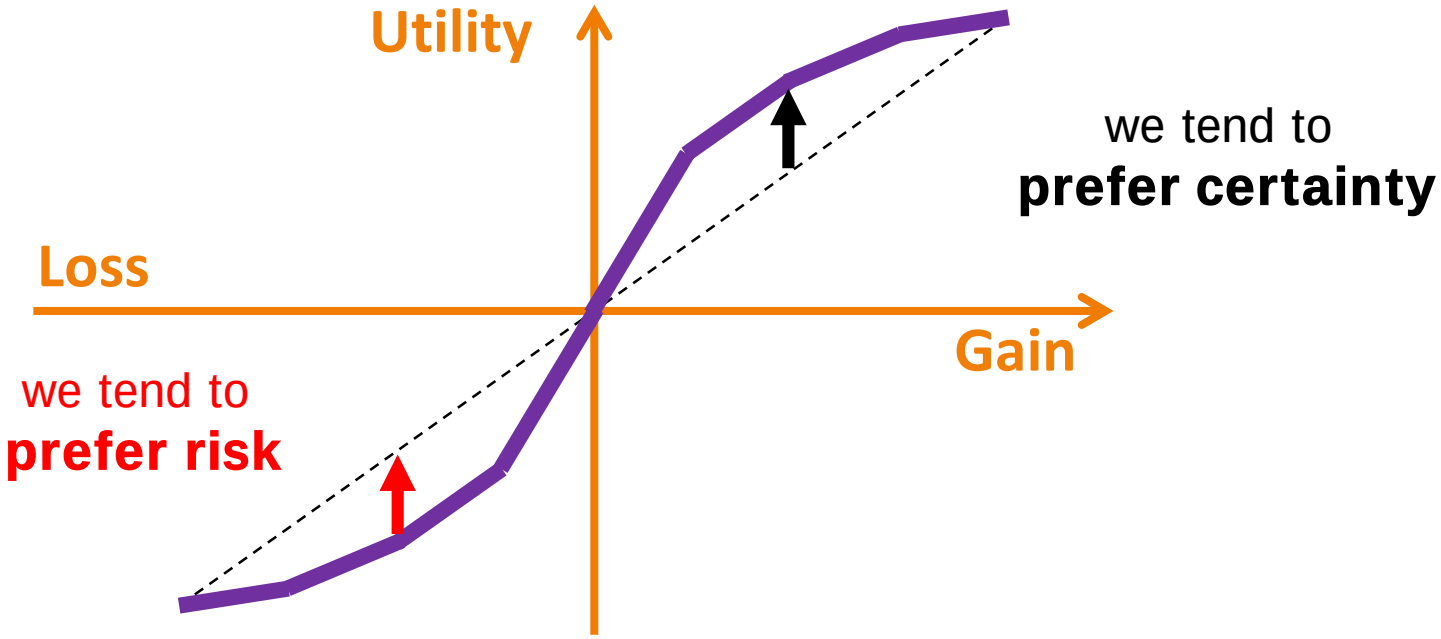


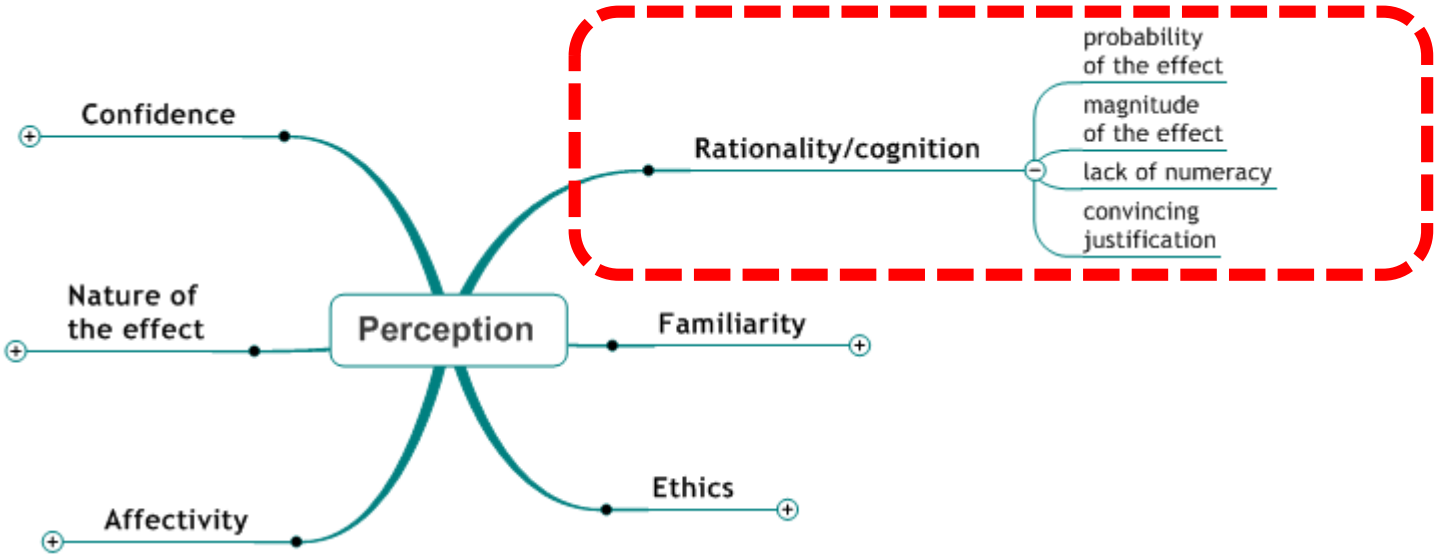
Faced with a **gain** we tend to **prefer certainty**



Faced with a **loss** we tend **to prefer risk**



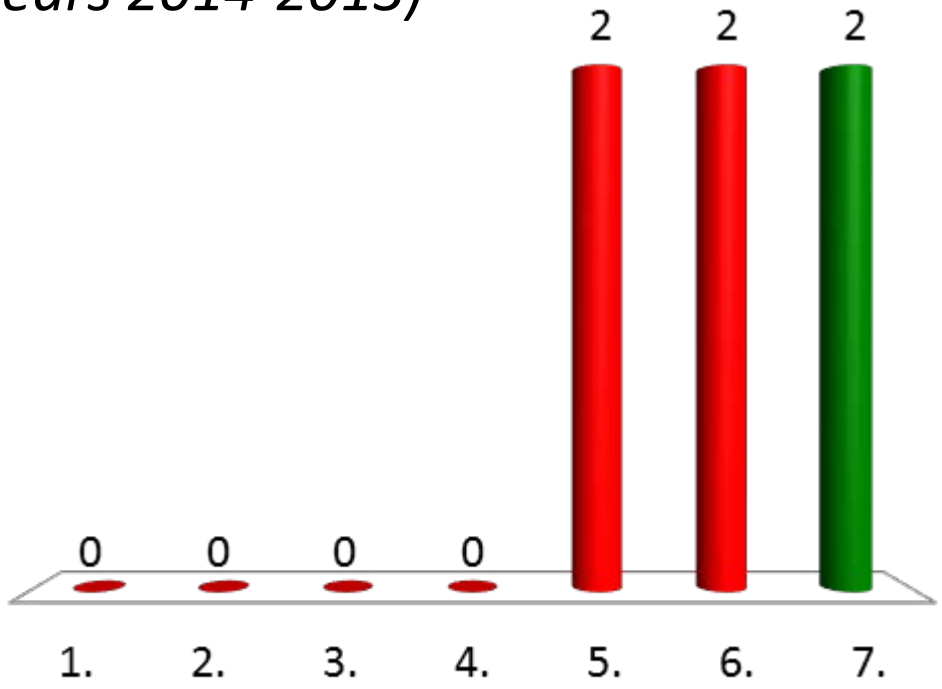

Utility
Loss
Gain
we tend to
prefer certainty
we tend to
prefer risk


Perception
Confidence
Nature of the effect
Affectivity
Rationality/cognition
probability of the effect
magnitude of the effect
lack of numeracy
convincing justification
Familiarity
Ethics

The probability of dying of "normal gun violence" is higher than of dying of a terror attack

(in the USA; years 2014-2013)

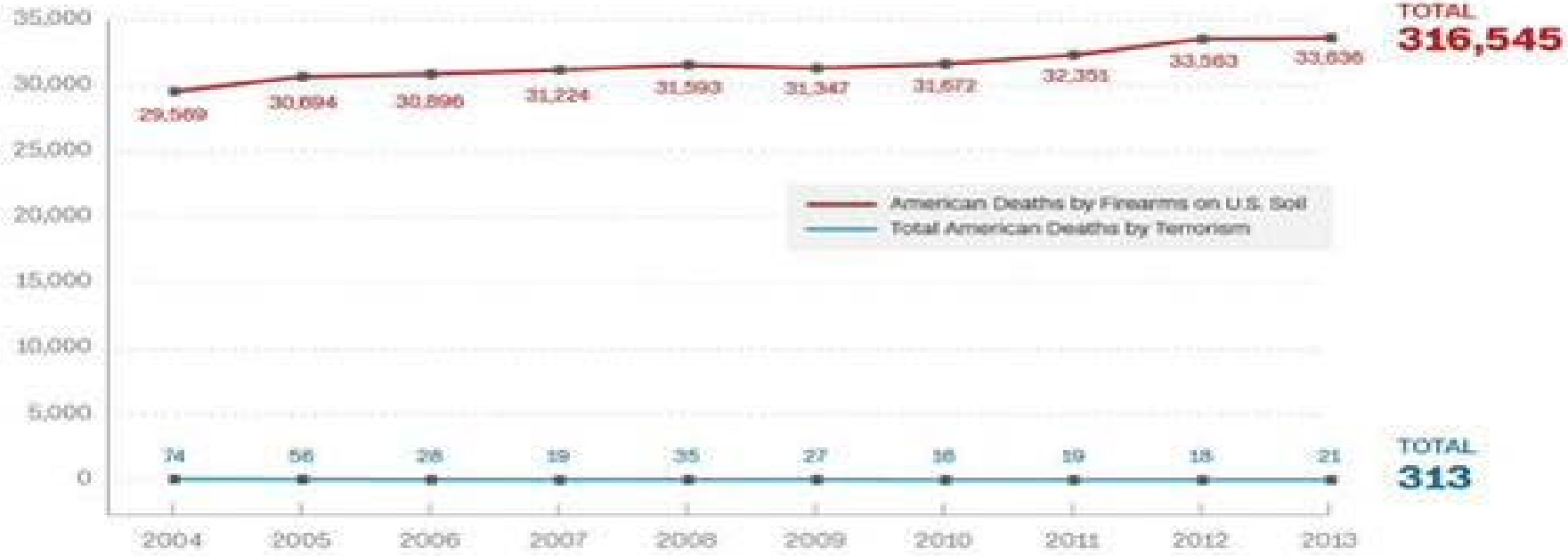
1. wrong, **1000** times smaller
2. wrong, **100** times smaller
3. wrong, **10** times smaller
4. wrong, it is the **same**
5. true, **10** times higher
6. true, **100** times higher
7. true, **1000** times higher



6 sur 11

NUMBER OF AMERICANS DEATHS CAUSED BY TERRORISM VS. GUN VIOLENCE

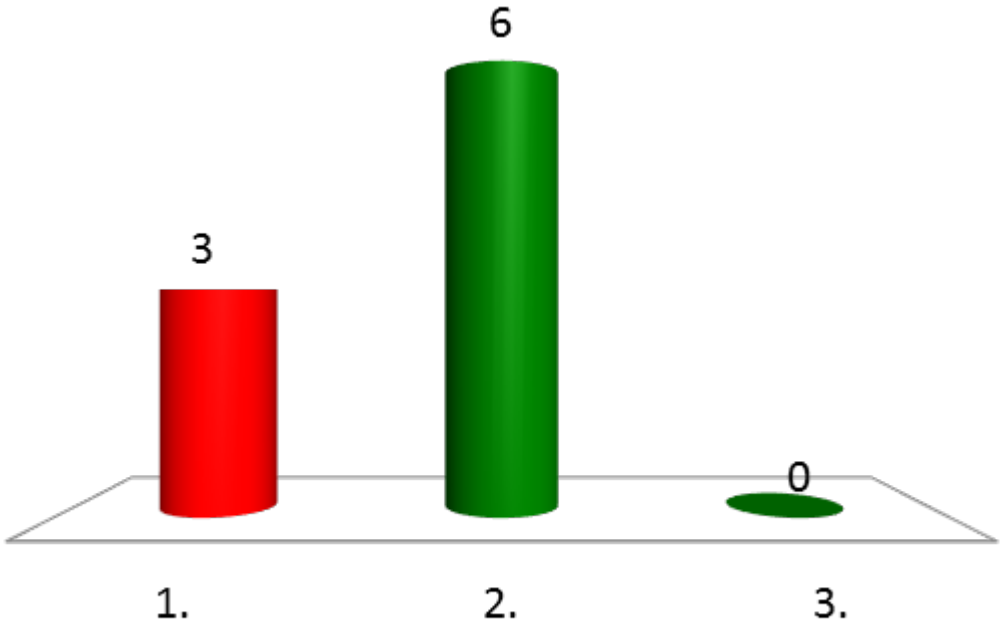
For every American killed by terrorism in the U.S. and around the world, more than 1,000 were killed by firearms inside the U.S. during the most recent decade for which comparative data is available.



Source: Centers for Disease Control and Prevention, U.S. State Department

When **you** make a decision about risk, what is usually the decisive parameter?

1. Facts
2. Emotional and cultural predispositions
3. I don't know



8 sur 11

A common belief among scientists is that people who seem to them to hold **views inconsistent with the evidence** simply **need enlightening with the facts**

Kahan *and colleagues* (Yale University)
questioned **1'800 Americans** about **nanotechnology**

Their **original views** generally only
hardened the more they learned

This suggests that our visceral and emotional response determines how risky we think about risk

M. Blastland and D. Spiegelhalter, The Norm Chronicles, Stories and Numbers About Danger, Profile Books, 2013

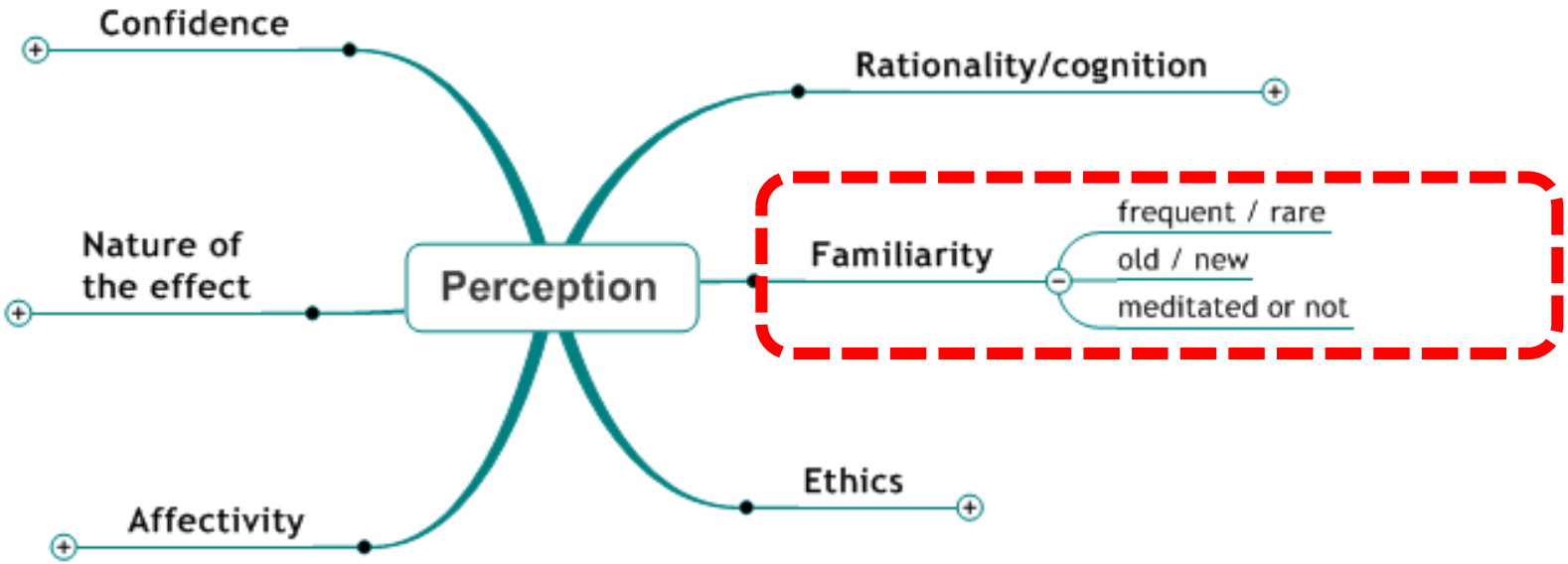
Scientists and other educated people are **not immune**!

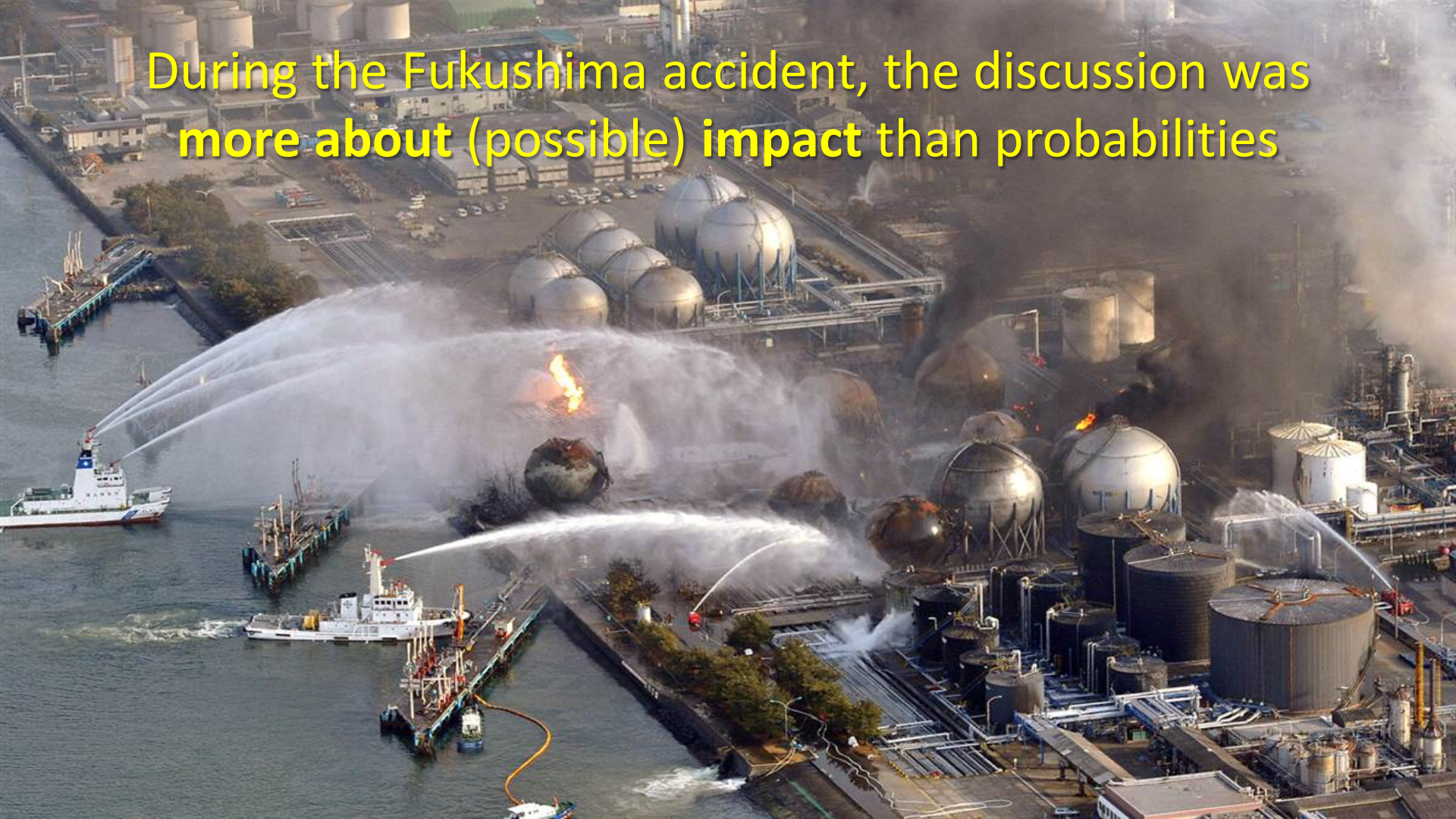
We tend to assimilate new knowledge in a manner that confirms our emotional and culture predispositions.

In other words,

we filter the facts to suit our beliefs and instincts

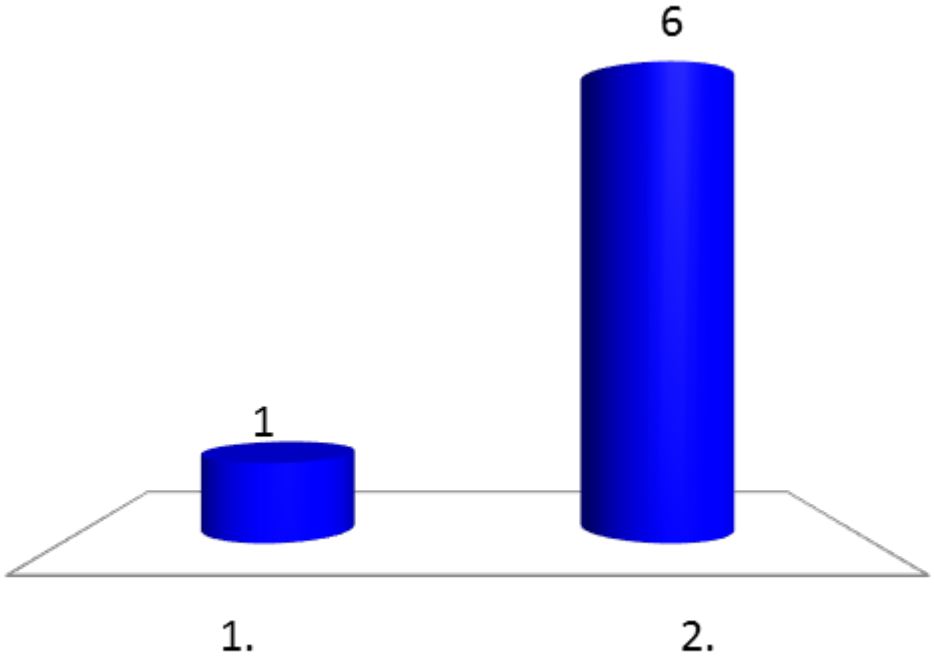
M. Blastland and D. Spiegelhalter, The Norm Chronicles, Stories and Numbers About Danger, Profile Books, 2013


Confidence
Rationality/cognition
Nature of the effect
Perception
Familiarity
frequent / rare
old / new
meditated or not
Ethics
Affectivity


During the Fukushima accident, the discussion was
more about (possible) **impact** than probabilities

For a given cost, which action do you choose?

1. Transform the Gotthard tunnel in order **to avoid a large accident**
2. Mark all Swiss roads with fluorescent painting in order to **reduce many small accidents**



7 sur 11

Acceptation of "objective risk"

We give much **more weight** to **large impacts events**;
even if they are **not frequent**

31 deaths in the London underground fire on 18.11.1987

- The government invested **300 M£** to reduce the risk of **another fire in the underground**
- The same amount could have paid **smoke detectors** in all British homes
  - **Each year**, **500 people are killed** by fires in Britain
  - A large part could be saved by installing smoke detectors

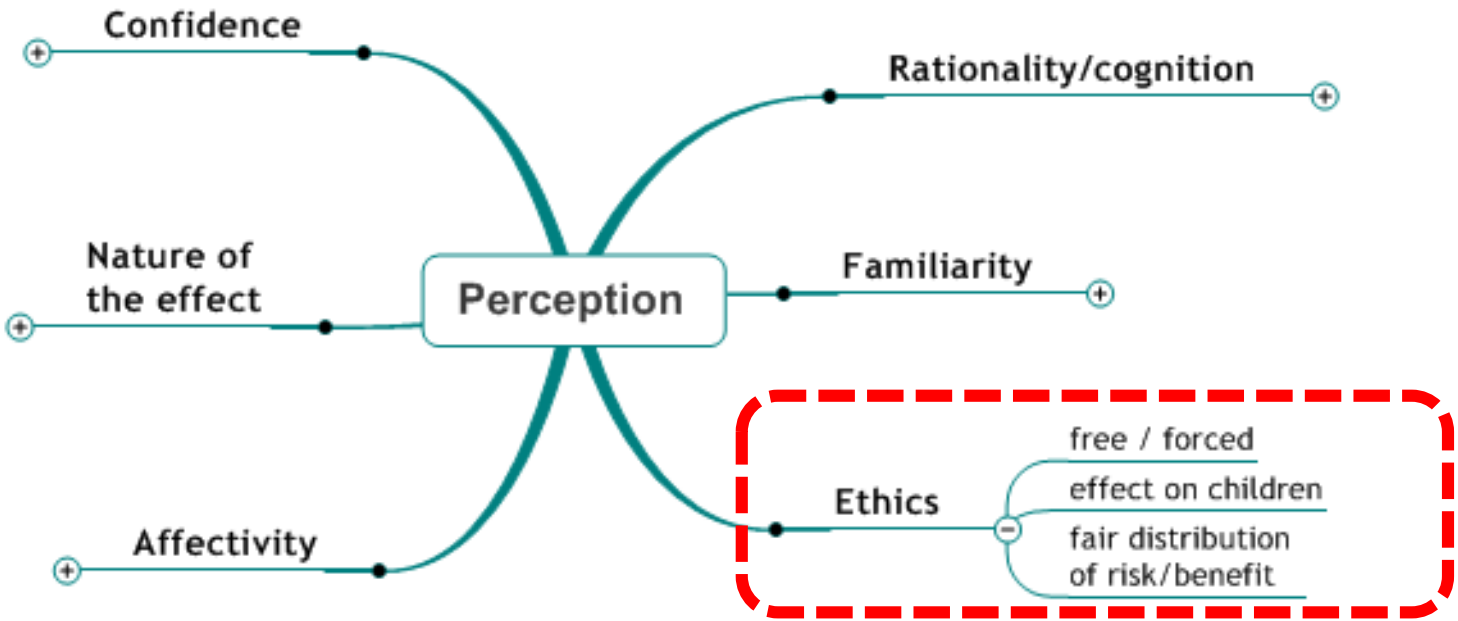
The Economist, 11 Sept 2003

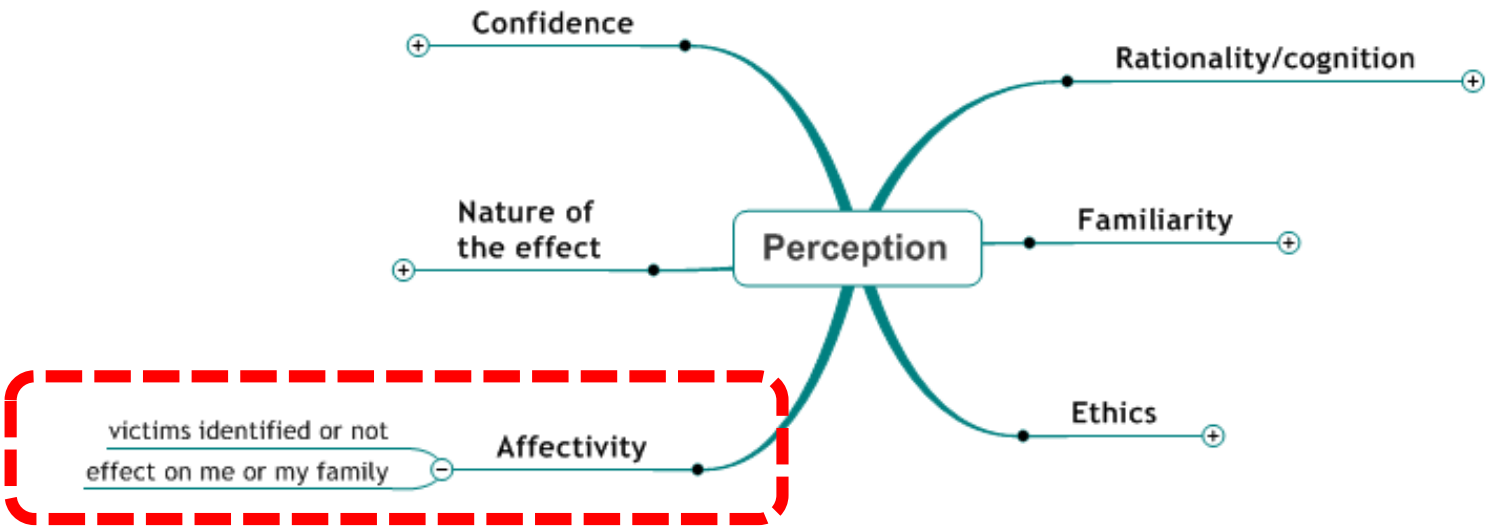
COST OF A YEAR OF LIFE SAVED BY VARIOUS INTERVENTIONS

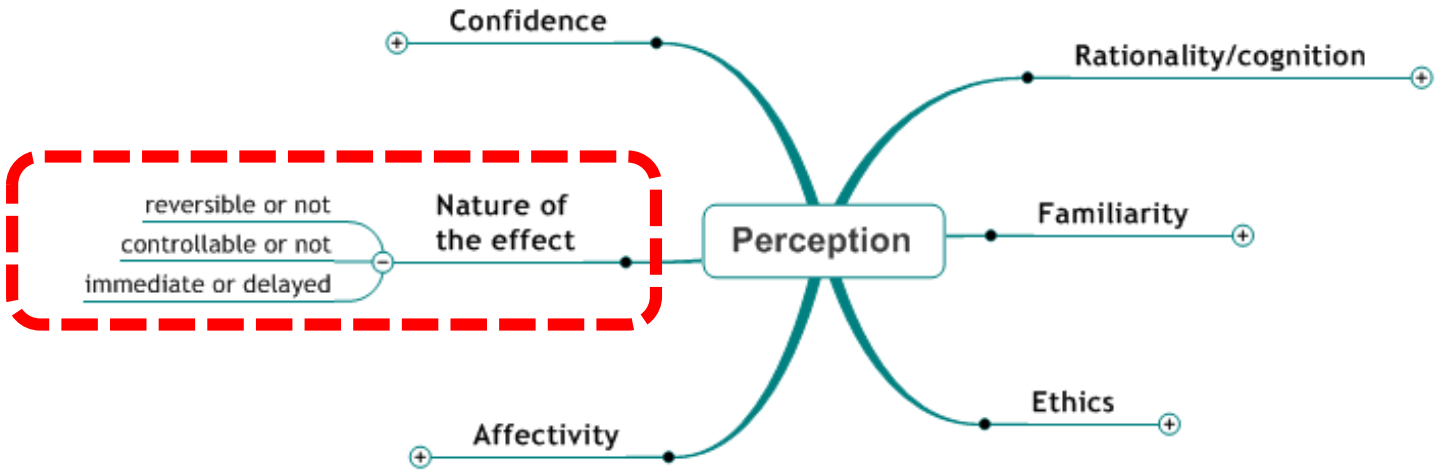
Flu shots	$500
Water chlorination	$4,000
Pneumonia vaccinations	$12,000
Breast cancer screening	$17,000
All medical interventions	$19,000
Construction safety rules	$38,000
All transportation interventions	$56,000
Highway improvement	$60,000
Home radon control	$141,000
Asbestos controls	$1.9 million
All toxin controls	$2.8 million
Arsenic emission controls	$6.0 million
Radiation controls	$10.0 million

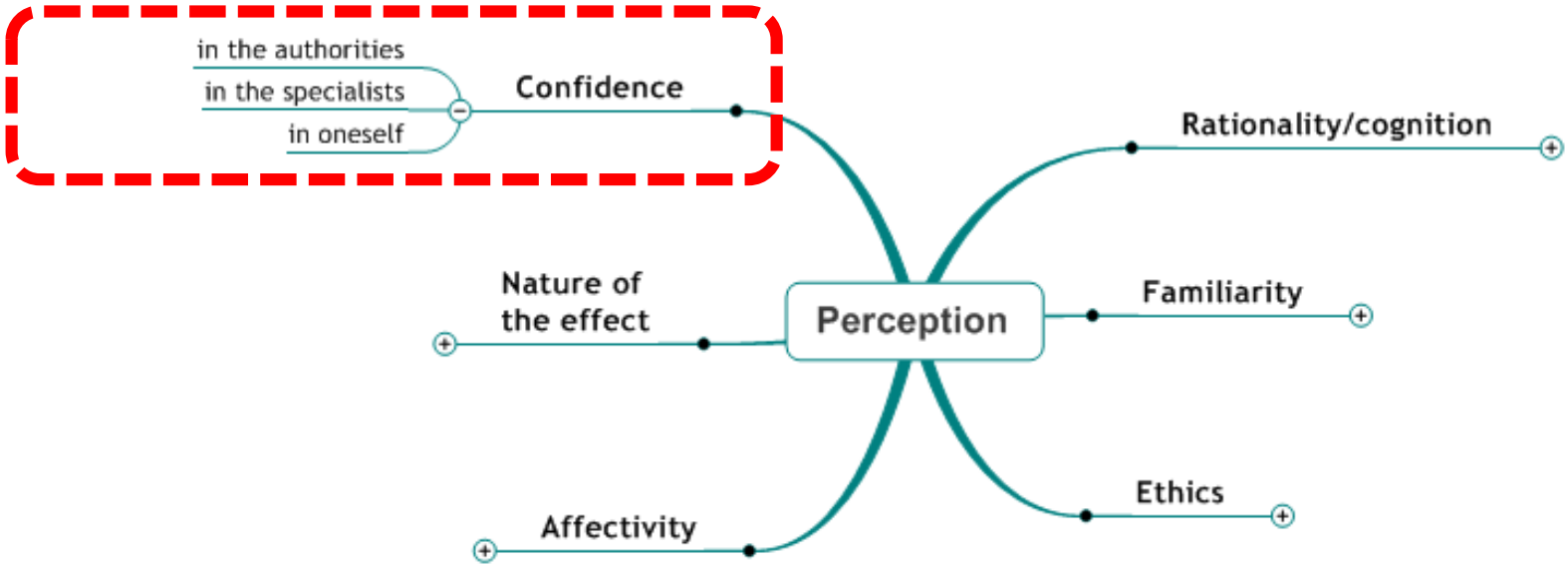
SOURCE: Adapted from T. O. Tengs et al., "Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness," *Risk Analysis*, 15:369-90 (1995).

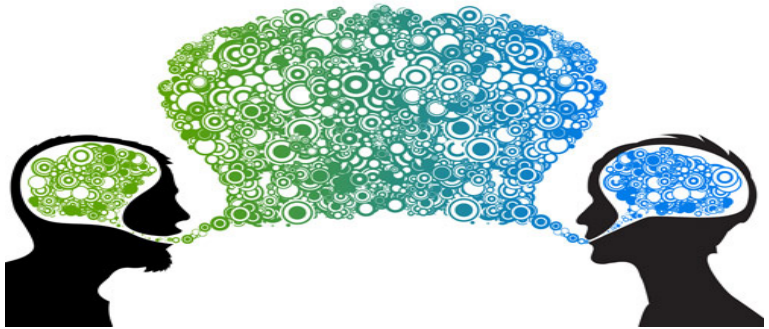
Howard Kunreuther and Paul Slovic, Annals of the American Academy of Political and Social Science, Vol. 545, Challenges in Risk Assessment and Risk Management. (May, 1996), pp. 116-125


Confidence
Rationality/cognition
Nature of
the effect
Perception
Familiarity
Ethics
free / forced
effect on children
fair distribution
of risk/benefit
Affectivity


Confidence
Rationality/cognition
Nature of the effect
Perception
Familiarity
Ethics
victims identified or not
effect on me or my family
Affectivity


Confidence
Rationality/cognition
reversible or not
controllable or not
immediate or delayed
Nature of the effect
Perception
Familiarity
Ethics
Affectivity


in the authorities
in the specialists
in oneself
Confidence
Rationality/cognition
Nature of the effect
Perception
Familiarity
Ethics
Affectivity



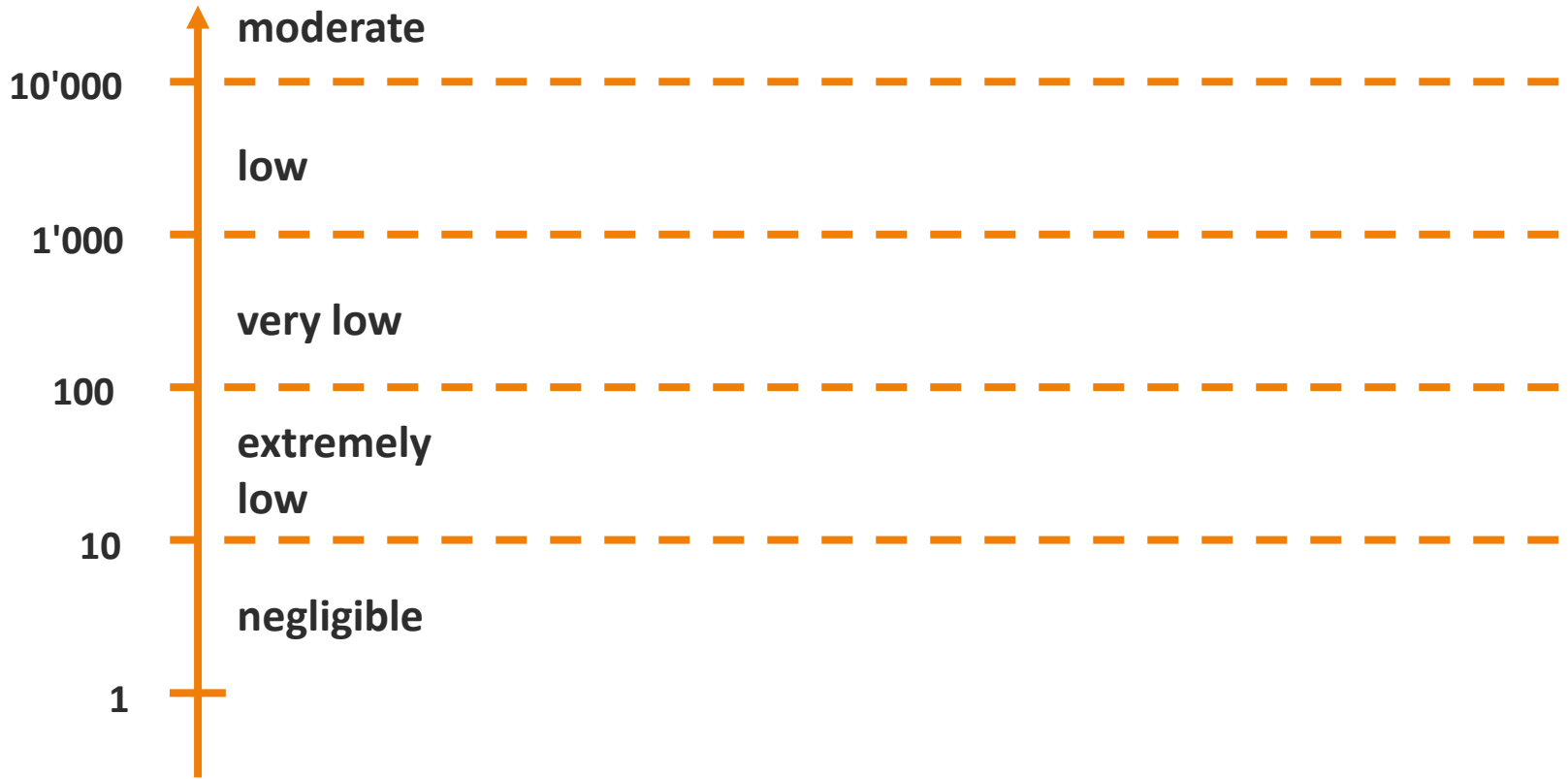
Risk and radiation

5. Communication of risk in medicine

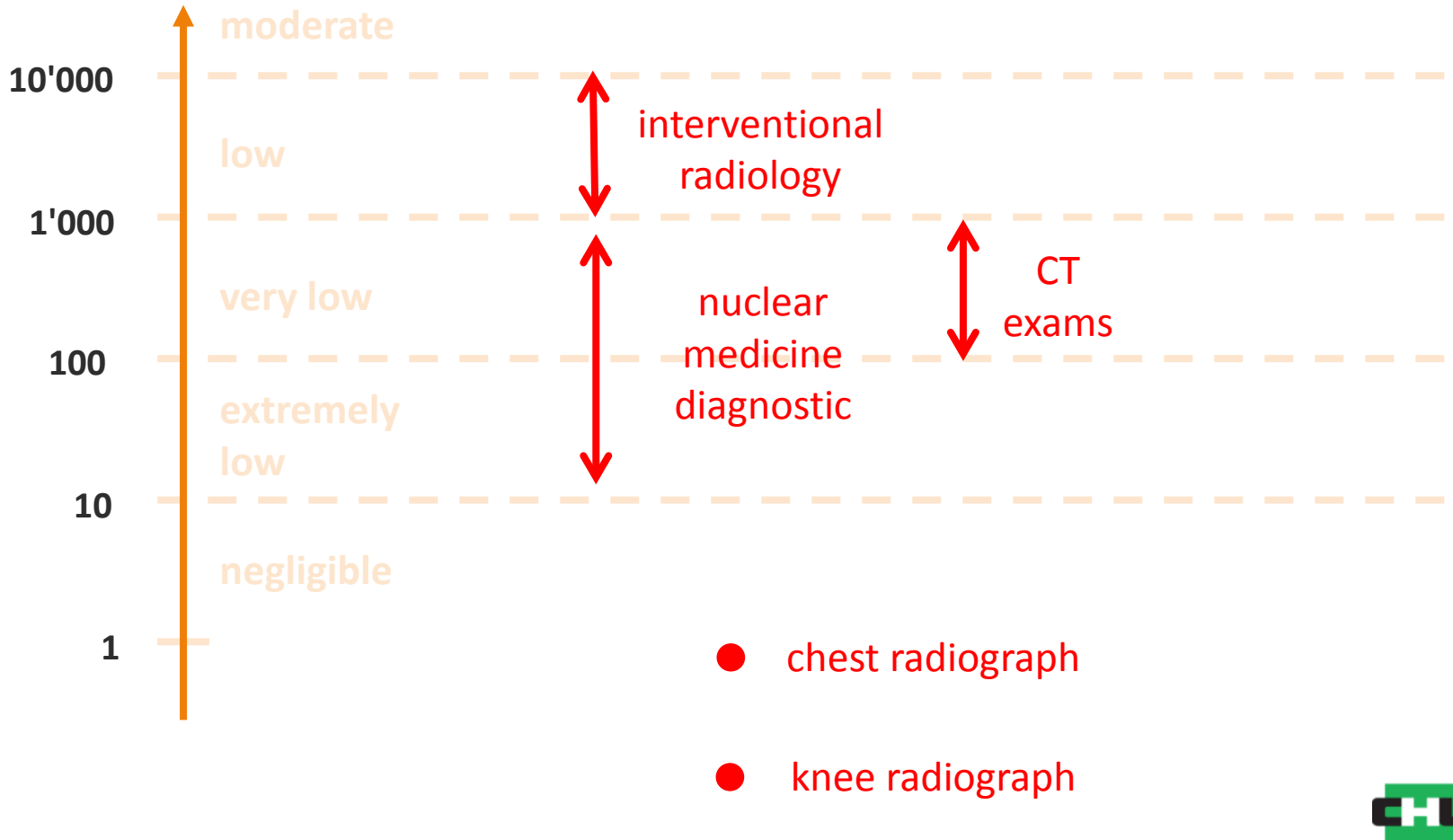
Communicating the **numerical** rational **risk**

Ratio *(e.g. 10^{-5})*	nobody has any cue *(what is riskier 10^{-4} or 10^{-5}?)*	effect **now**
MicroMort	10^{-6} linked to one "normal day" scale intuitive and easy to grasp	
Natural background	most people don't even know about natural radiation	effect **delayed**
MicroLife	put radiation risk into "normal life" scale intuitive and easy to grasp	

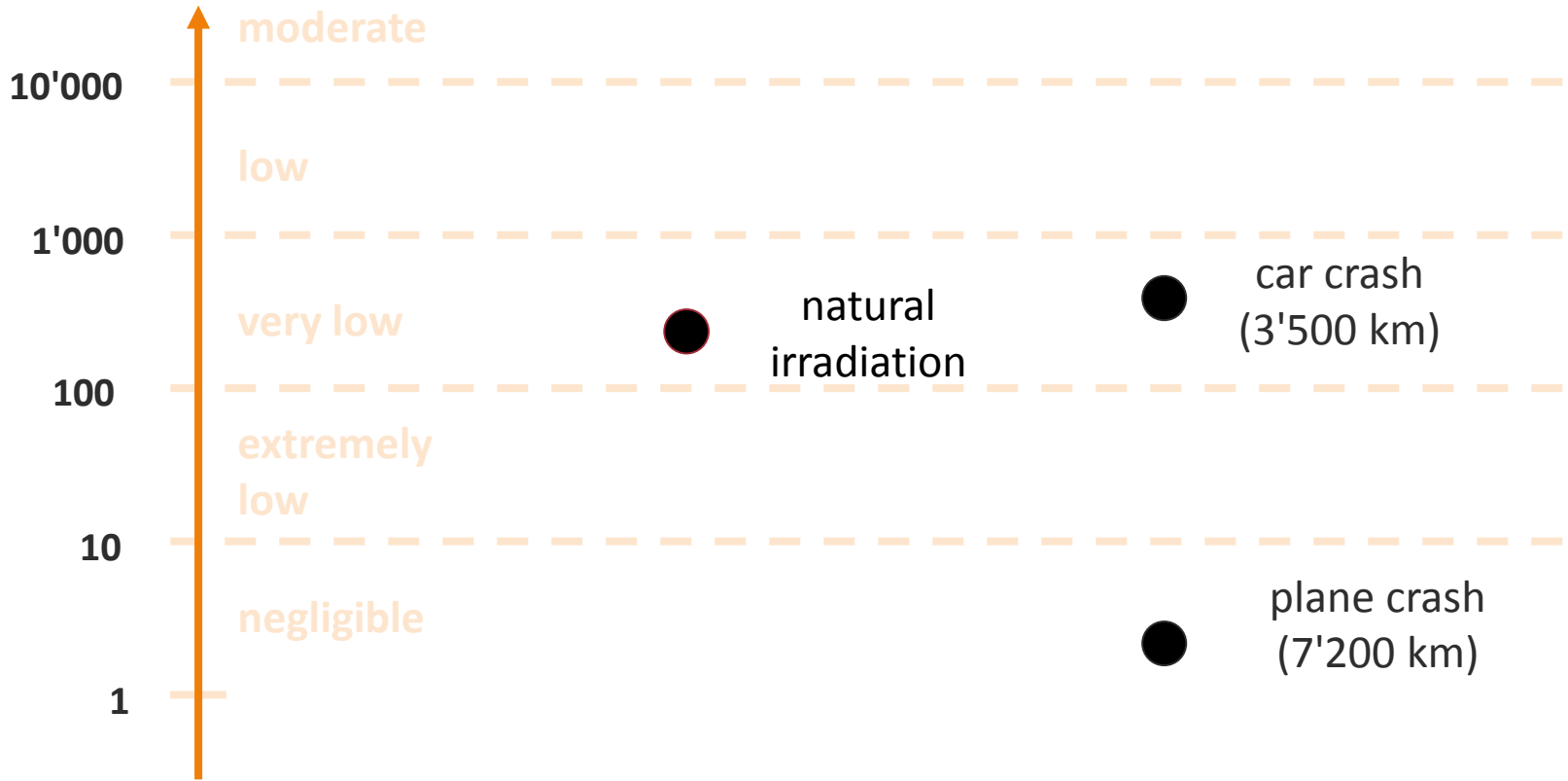
MicroMort


moderate
10'000
low
1'000
very low
100
extremely
low
10
negligible
1

MicroMort


moderate
10'000
low
1'000
very low
100
extremely low
10
negligible
1
interventional radiology
nuclear medicine diagnostic
CT exams
chest radiograph
knee radiograph

MicroMort


moderate
10'000
low
1'000
very low
100
extremely low
10
negligible
1
natural irradiation
car crash (3'500 km)
plane crash (7'200 km)

Alternative way to explain the medical **risk to a patient** ???

$$D = D_\gamma + 10\, D_n$$

- D < 5 mGy
- 5 mGy < D < 0.1 Gy
- 0.1 Gy < D < 0.5 Gy
- 0.5 Gy < D < 1.0 Gy
- D > 1 Gy
- unknown dose

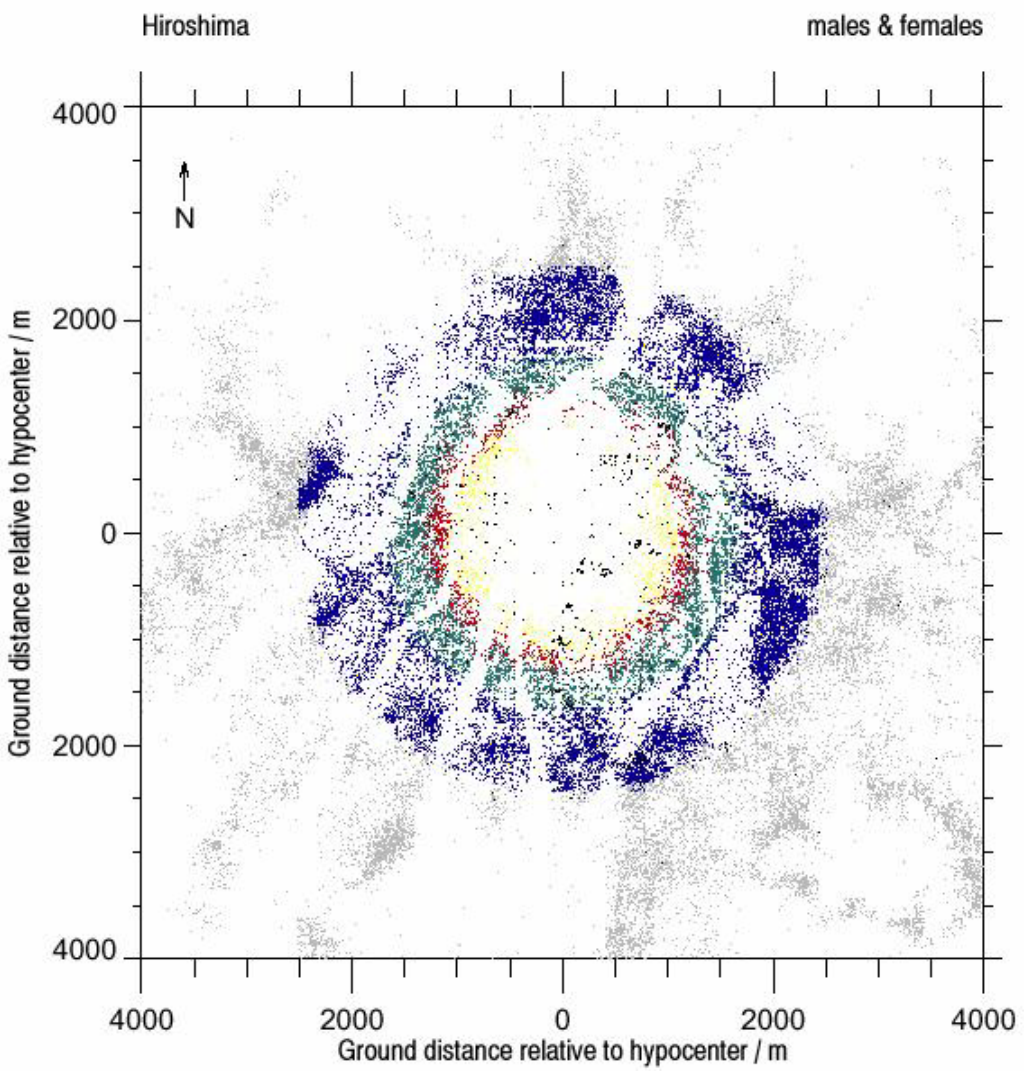


Figure: Linda Walsh, KSR 23.03.2017

Alternative way to explain the medical **risk to a patient** ???

Definitively a **bad idea!**

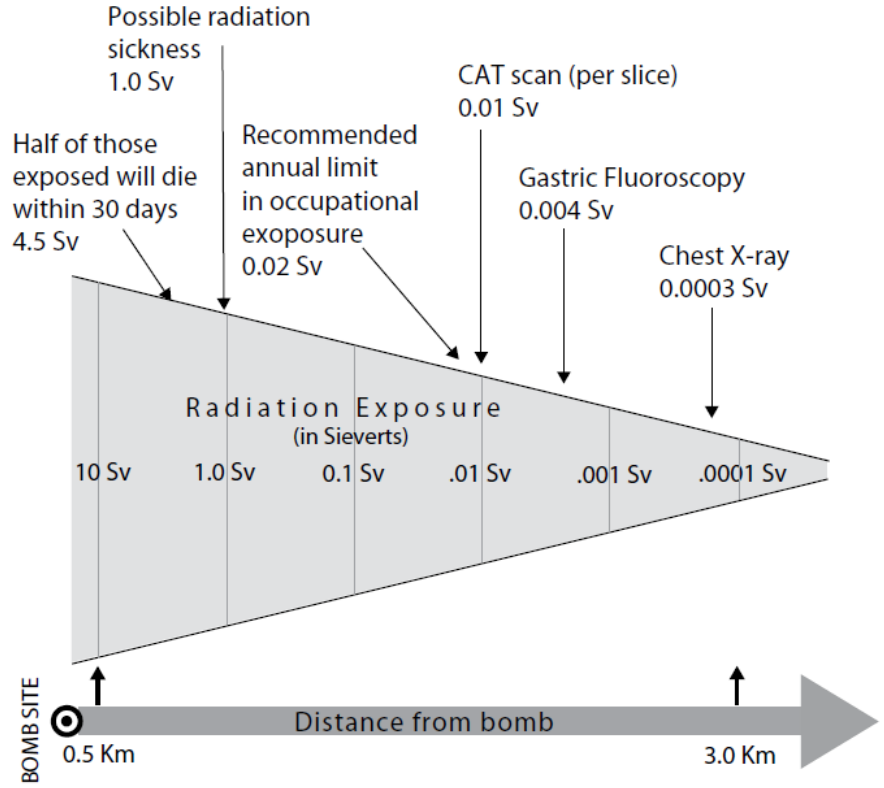


Figure 1. The chart shows the approximate radiation exposure (in Sieverts) in relation to a person's distance from the bombsite and provides a comparison with other radiation exposures.

National Academy of Science, 2003

Learning objectives

- Briefly explain the **effects of radiation** on **human health**
- Be able to **compare** in the day to day life **acute** and **chronic risks**
- Understand some **psychological aspects** of **risk perception** and how **ethics** could help find solutions
- Understand the complexity of **communicating about** radiation **risk**