What is common between sweets, buildings and sunscreens?

On the risk assessment and regulation of chemicals in Europe

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28.04.2021

TiO_2 - Titania

Physical properties of TiO_2

- White inorganic compound
- Occurs naturally as a solid
- Insoluble in water, even in its particle form
- Extremely high melting point of 1,843ºC and boiling point of 2,972ºC
- Refractive index (ability to scatter UV light) very high >>> diamond
- Photocatalytic activity under UV light

=> Resistant, extra-white, bright, protective, aesthetic, very promising

https://tdma.info/uses-of-titanium-dioxide/

https://www.youtube.com/watch?v=7ObnoGtDi0Q&t=93s/

What is titanium dioxide?

- White inorganic compound
- As a white pigment, TiO_2 is one of the most important raw materials for paints and coatings
- As a photocatalyst, titanium dioxide can be added to paints, cements, windows and tiles in order to decompose environmental pollutants.
- Beyond paints, catalytic coatings, plastics, paper, pharmaceuticals and sunscreen, some lesser-known applications include packaging, commercial printing inks, cosmetics, toothpastes, and food (E171)

What do we know regarding TiO_2 safety ?

Tous Images Vidéos Actualités Maps ⋮ Plus Paramètres Outils

Environ 8 110 000 résultats (0,73 secondes)

Titanium dioxide (TiO_2) is considered as an inert and **safe** material and has been used in many applications **for** decades. ... Although TiO_2 is permitted as an additive (E171) in food and pharmaceutical products **we do** not have reliable data **on** its absorption, distribution, excretion and toxicity **on** oral exposure.

https://www.ncbi.nlm.nih.gov › articles › PMC3423755

Titanium dioxide in our everyday life; is it safe? - NCBI - NIH

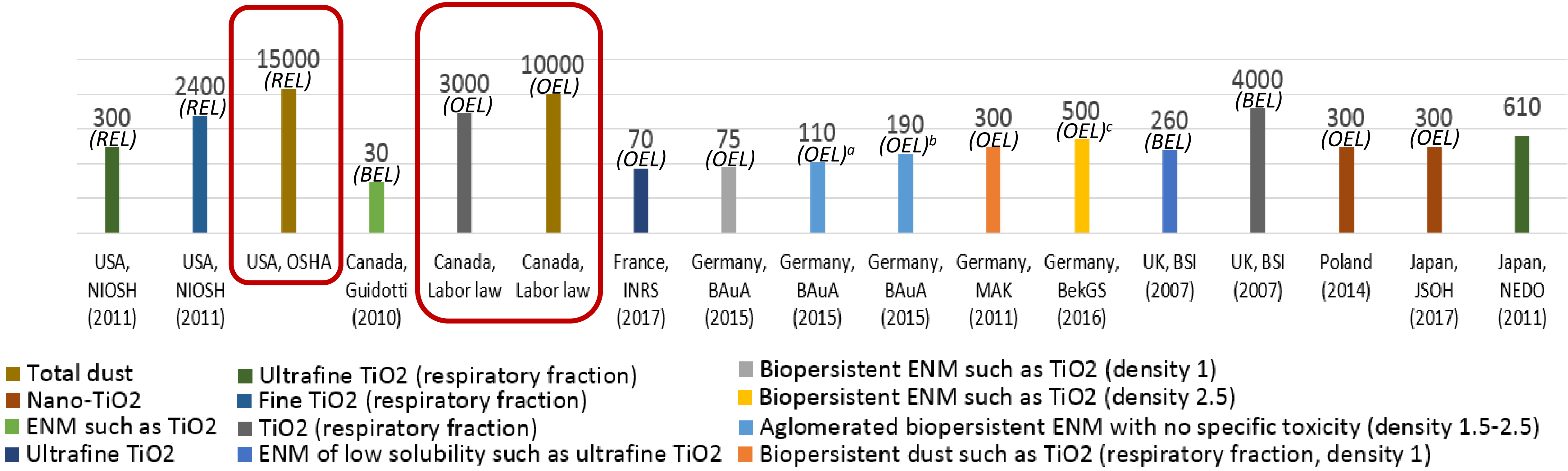
Conclusions

Until relevant toxicological and human exposure data that would enable reliable risk assessment are obtained, TiO_2 nanoparticles should be used with great care.

Radiol Oncol. 2011 Dec; 45(4): 227–247.
Published online 2011 Nov 16. doi: 10.2478/v10019-011-0037-0

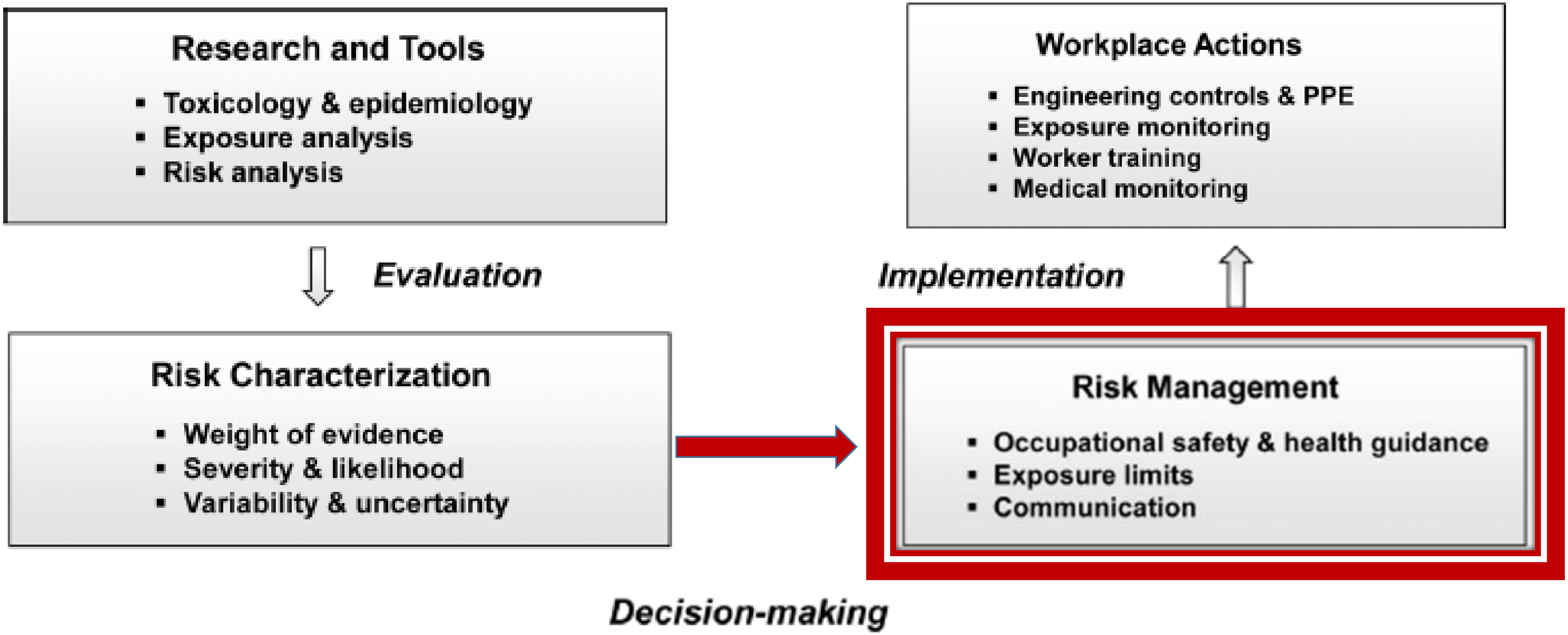
What do we know regarding TiO_2 safety ?

- Currently available Occupational Exposure Limits (OEL) in µg/m3

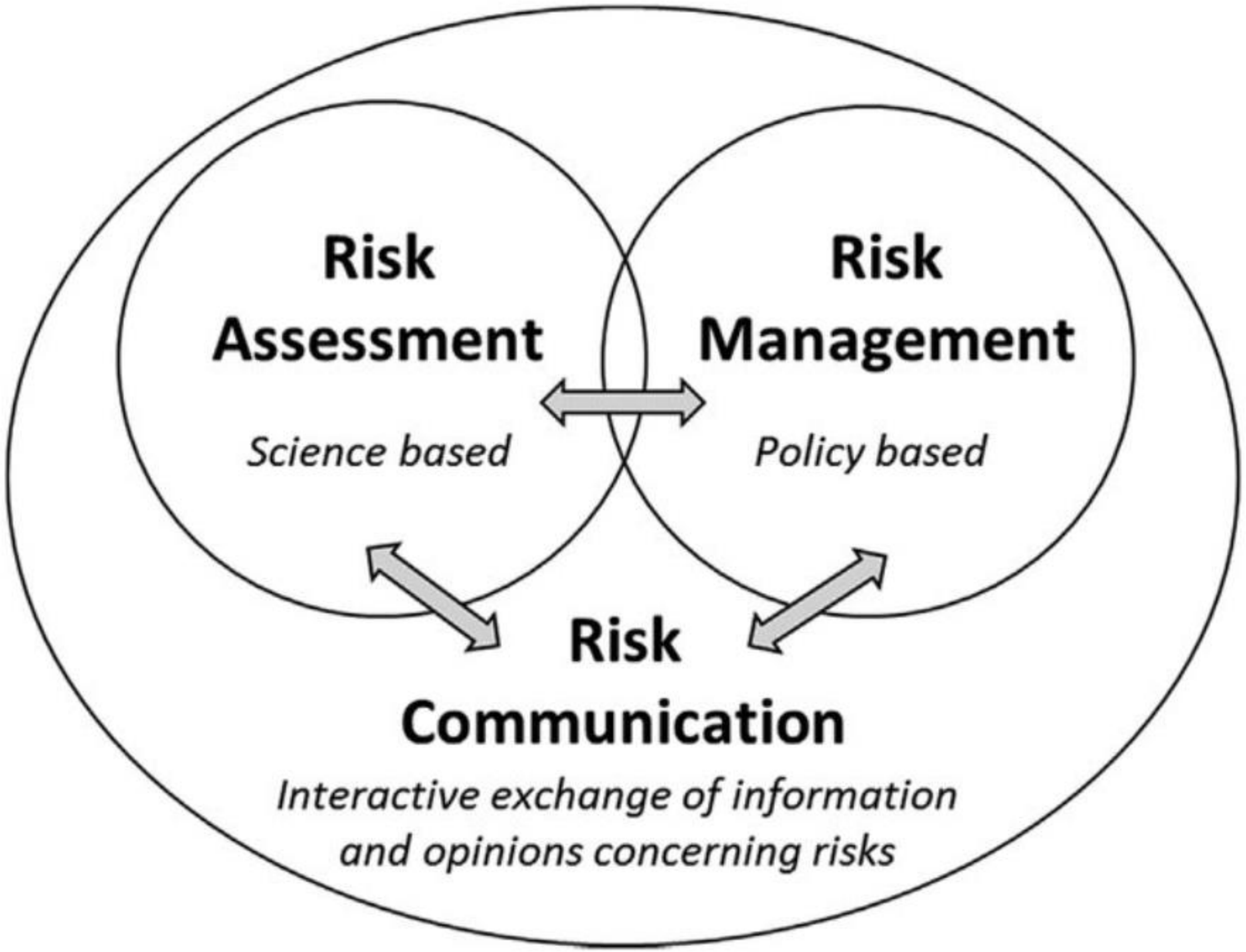


Abbreviations: REL, recommended exposure limit; PEL, permissible exposure limit; BEL, benchmark exposure level; OEL[a], OEL for cancer risk 1/5000; OEL[b], OEL for cancer risk 1/2000 ; OEL[c], regulatory OEL, OEL PL[d], 15y period limited OEL; ENM, engineered nanomaterials

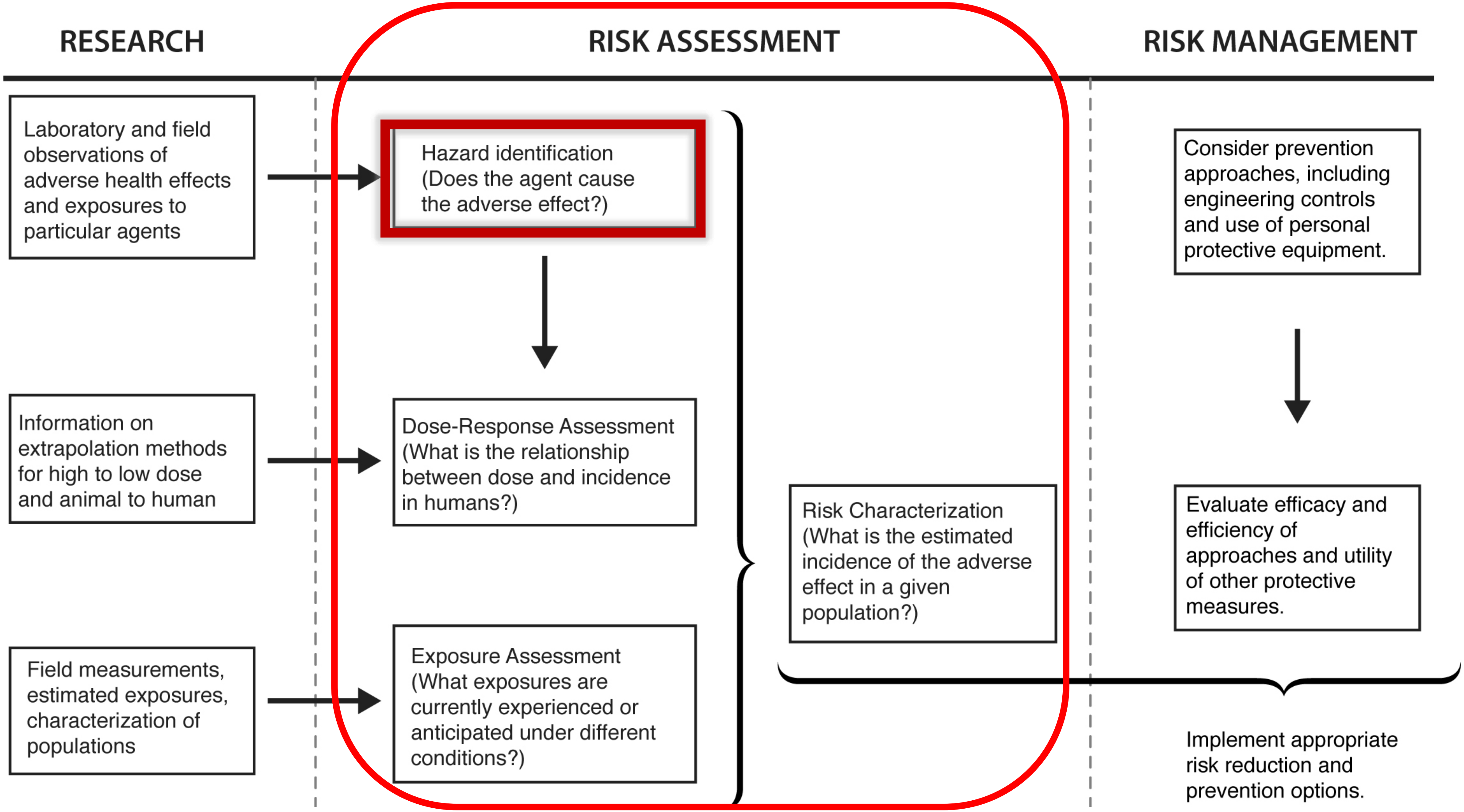
NIOSH framework of Risk Assessment & Risk Management



WHO risk analysis framework



US NRC Risk Assessment/Risk Management framework



Hazard identification

- **Slowly soluble particles not otherwise regulated or classified** (TWA of total suspended particles or dusts)

- **Case report Yamadori *et al*. (1986**) reported a papillary adenocarcinoma of the lung and titanium dioxide-associated pneumoconiosis in a male titanium dioxide packer with 13 years of potential dust exposure and a 40-year history of tobacco smoking.

- **1st assessment IARC Monographs** on the Evaluation of Carcinogenic Risks to Humans Volume 47 **(IARC, 1989)** => Not classifiable as to its carcinogenicity to humans (**group 3**)

IARC Classification framework

<table>
<tr><th rowspan="2">EVIDENCE IN HUMANS</th><th colspan="4">EVIDENCE IN EXPERIMENTAL ANIMALS</th></tr>
<tr><th>Sufficient</th><th>Limited</th><th>Inadequate</th><th>ESLC</th></tr>
<tr><td>Sufficient</td><td colspan="4">Group 1 (carcinogenic to humans)</td></tr>
<tr><td>Limited</td><td>Group 2A (probably carcinogenic)</td><td colspan="3">Group 2B (possibly carcinogenic)
(exceptionally, Group 2A)</td></tr>
<tr><td>Inadequate</td><td>Group 2B (possibly carcinogenic)</td><td colspan="3">Group 3 (not classifiable)</td></tr>
<tr><td>ESLC</td><td colspan="3"></td><td>Group 4</td></tr>
</table>

ESLC: Evidence suggesting lack of carcinogenicity

IARC evaluation Framework for human data

Cancer in humans — Preamble Part B, Section 6(a)	Cancer in experimental animals	Mechanistic and other relevant data

Sufficient evidence	Causal relationship has been established Chance, bias, and confounding could be ruled out with reasonable confidence
Limited evidence	Causal interpretation is credible Chance, bias, or confounding could not be ruled out
Inadequate evidence	Studies permit no conclusion about a causal association
Evidence suggesting lack of carcinogenicity	Several adequate studies covering the full range of exposure levels are mutually consistent in not showing a positive association at any observed level of exposure Conclusion is limited to cancer sites and conditions studied

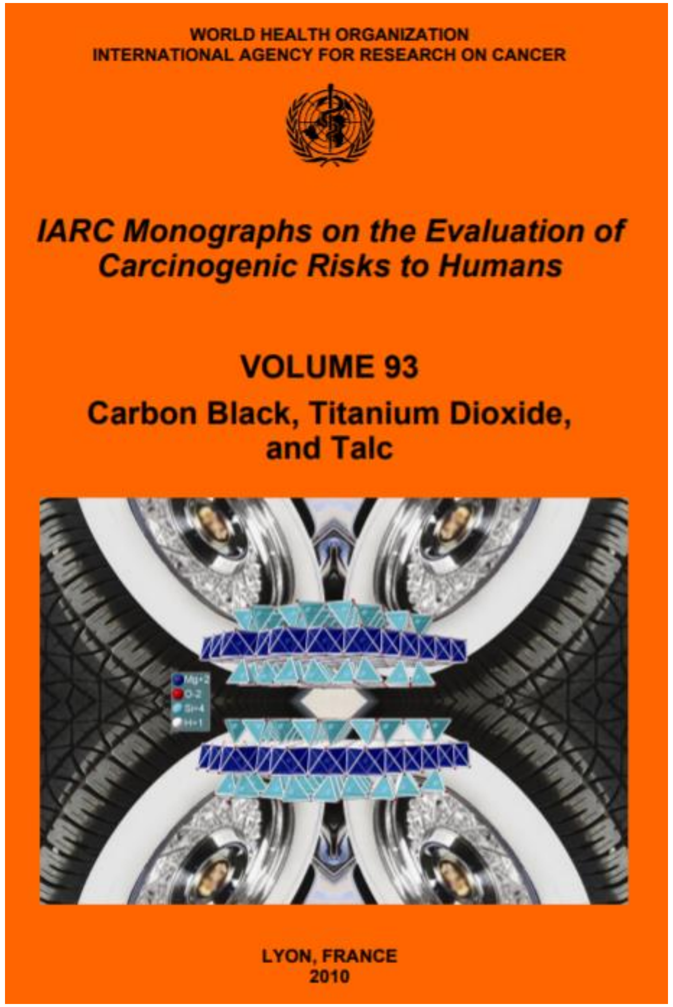
Hazard identification

- 2nd **assessment in <u>2006</u>** Volume 93 **(IARC, 2010**) => Possibly carcinogenic to humans **(Group 2B)**
  - There is *inadequate evidence* in humans for the carcinogenicity of titanium dioxide.
  - There is *sufficient evidence* in experimental animals for the carcinogenicity of titanium dioxide

Human carcinogenicity data

- Chen & Fayerweather (1988); Fayerweather *et al*. (1992), USA
- Fryzek *et al.* (2003), USA
- Boffetta *et al.* (2004), 6 EU countries

«***All the studies had methodological limitations***. *…None of the studies was designed to assess the impact of particle size (fine or ultrafine) or the potential effect of the coating compounds on the risk for lung cancer.”*



And what happened since ?

In the USA, *NIOSH Current Intelligence Bulletin (April 2011)*

- Quantitative risk assessments for fine and ultrafine TiO_2
  - ➢ Hazard identification in humans

Lung cancer mortality

Europe SMR (95% CI) *Boffetta et al (2001)*

	Finland	France	Germany	Italy	Norway	UK
Males **1.23** **(1.10-1.38)** **Females** 0.8 (0.02-4.09)	0.76 (0.39-1.32)	**1.42** (0.99-1.96)	**1.51** **(1.26-1.79)**	0.97 (0.50-1.69)	0.79 (0.21-2.02)	**1.09** (0.90-1.31)

Amérique du nord

US SMR (95% CI)

Fryzek et al (2003)	*Chen & Frayerweather (2003)*	*Ellis et al (2010)*	*Ellis et al (2013)*
1.00 (0.80-1.30)	0.52 (??-??)	0.90 (0.75-1.05) 1.02 (0.84-1.22)	0.98 (0.78-1.21) **1.35 (1.07-1.66)**[a] **1.15** (0.94-1.39) **1.68 (1.32-2.11)**[a]

Canada OR (95% CI)

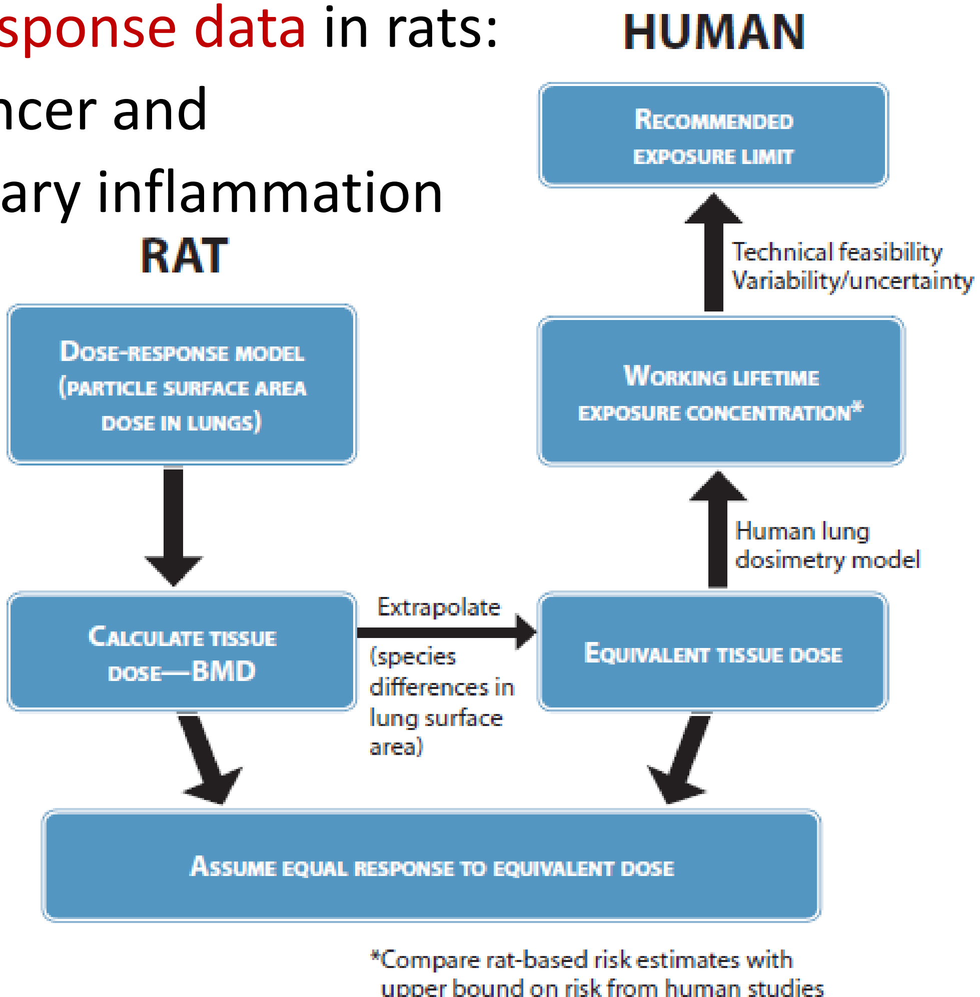
Boffetta et al (2001)
Ramanakumar et al (2008)

Study I	Study II	Pooled
1.1 (0.7-2.0)[a] 1.2 (0.8-1.09)[b]	**M** 1.0 (0.7-2.1) **F** 0.5 (0.1-3.4)	**1.0 (0.8-1.5)**[c]

And what happened since ?

In the USA, *NIOSH Current Intelligence Bulletin (April 2011)*

- Quantitative risk assessments
  - ➢ Dose-response data in rats: lung cancer and pulmonary inflammation



NIOSH recommends exposure limits of 2.4 mg/m^3 for fine TiO_2 and 0.3 mg/m^3 for ultrafine (including engineered nanoscale) TiO_2, as time-weighted average (TWA) concentrations for up to 10 hours per day during a 40-hour work week. NIOSH has determined that ultrafine TiO_2 is a potential occupational carcinogen but that there are insufficient data at this time to classify fine TiO_2 as a potential occupational carcinogen. However, as a precautionary step, NIOSH used all of the animal tumor response data when conducting dose-response modeling and determining separate RELs for ultrafine and fine TiO_2. These recommendations represent levels that over a working lifetime are estimated to reduce risks of lung cancer to below 1 in 1,000. NIOSH realizes that knowledge about the health effects of nanomaterials is an evolving area of science. Therefore, NIOSH intends to continue dialogue with the scientific community and will consider any comments about nano-size titanium dioxide for future updates of this document. (Send comments to nioshdocket@cdc.gov.)

NIOSH urges employers to disseminate this information to workers and customers and requests that professional and trade associations and labor organizations inform their members about the hazards of occupational exposure to respirable TiO_2.

OSHA® Occupational Safety and Health Administration

U.S. Department of Labor

www.osha.gov (800) 321-OSHA (6742)

DTSEM FS-3634 04/2013

And what happened since ?

In the EU

TiO2 = poorly soluble,
low-toxicity particles

ECHA
EUROPEAN CHEMICALS AGENCY

REACH Regulation aims to improve the protection of human health and the environment from the risks that can be posed by chemicals.

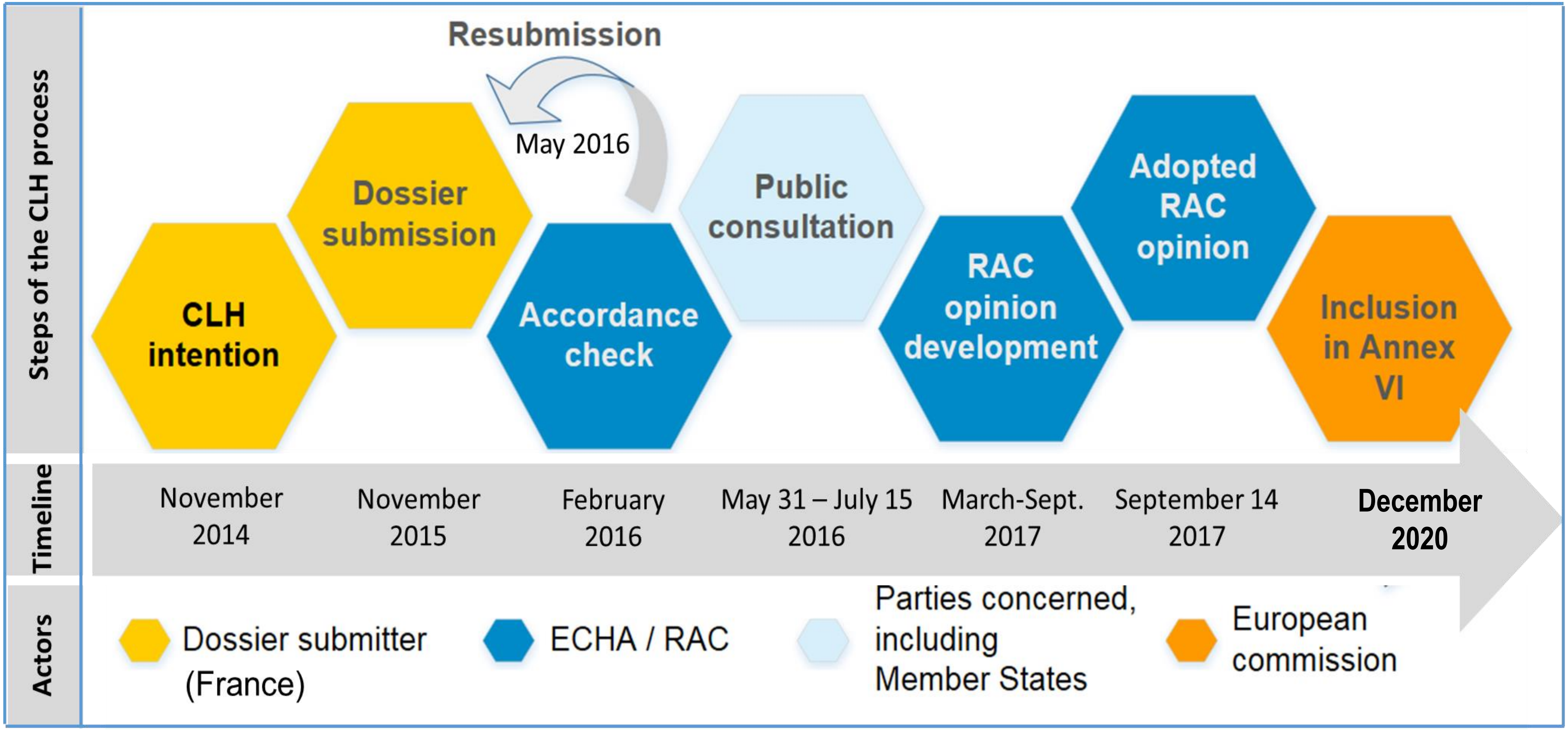
The **CLP** Regulation ensures that the hazards presented by chemicals are clearly communicated to workers and consumers in the EU through classification and labelling of chemicals.

The **Chemical Agents Directive (CAD)** and the **Carcinogens and Mutagens Directive (CMD)** provide a framework for setting occupational exposure limits, forming an integral part of the EU's mechanism for protecting the health of workers.

EU CLP Regulation (*Classification, Labelling and Packaging of chemicals)*

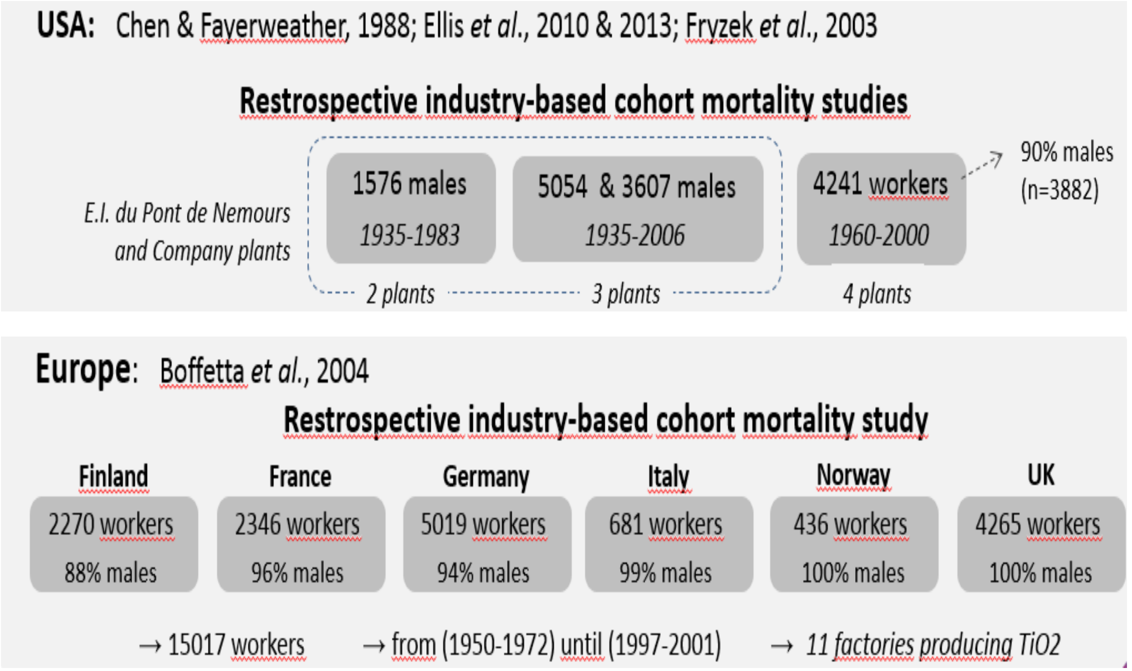
- The identified hazards must be communicated to other actors in the supply chain, including consumers (via a label and a safety data sheet)
- The objective is to alert stakeholders to the presence of a danger and the need to manage the associated risks
- The CLP classification affects other EU laws such as the Workers Directive (CMD 2004/37 / EC), which sets binding OELs and BLVs
- Revision in the frame of the CLH procedure

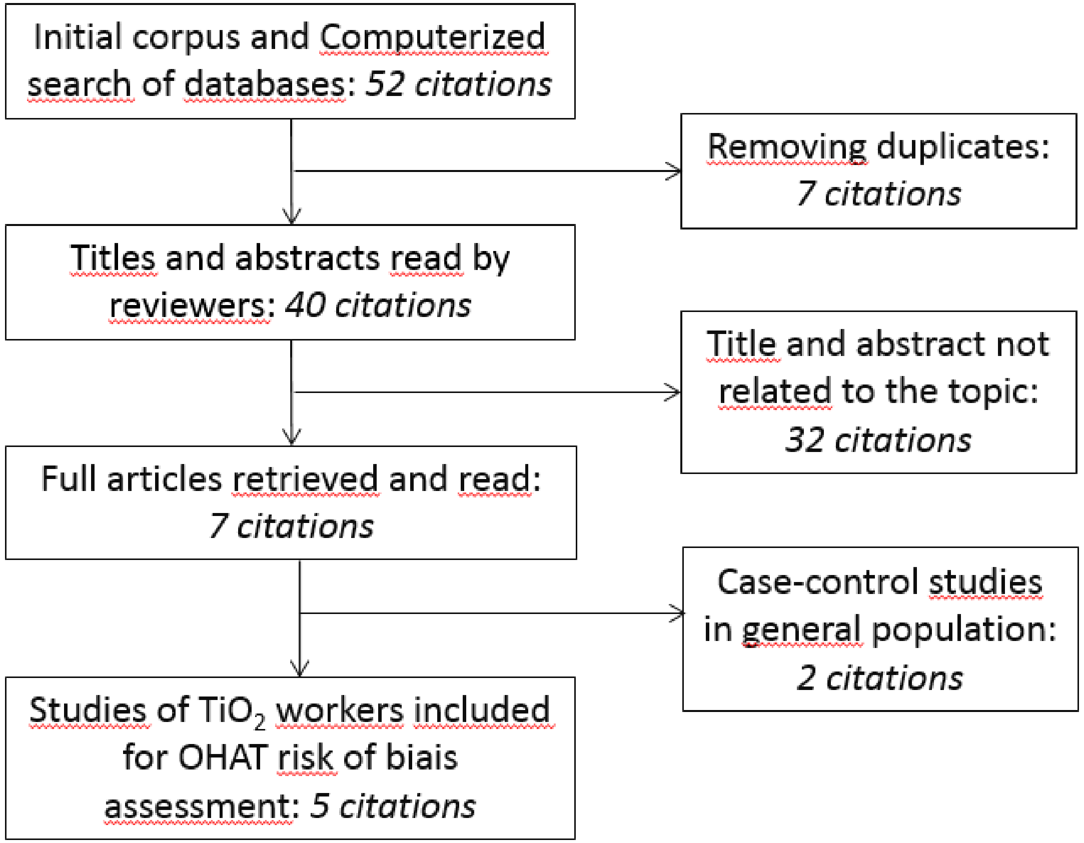
CLH procedure for CLP regulation revision



Approach followed by France (ANSES) for TiO2

- Systematic review of TiO2 production worker cohorts
- Critical assessment of bias using the OHAT method and gradation of the level of evidence





ANSES = The French Agency for Food, Environmental and Occupational Health & Safety

Cancer Causes and Control **15**: 697–706, 2004.

Mortality among workers employed in the titanium dioxide production industry in Europe*

Paolo Boffetta[1,2,3], Anne Soutar[4], John W. Cherrie[4,5], Fredrik Granath[2], Aage Andersen[6], Ahti Anttila[7], Maria Blettner[8], Valerie Gaborieau[1], Stefanie J. Klug[8], Sverre Langard[9], Daniele Luce[10], Franco Merletti[11], Brian Miller[4], Dario Mirabelli[11], Eero Pukkala[7], Hans-Olov Adami[1] & Elisabete Weiderpass[1,2,*]

Abstract

Objectives: To assess the risk of lung cancer mortality related to occupational exposure to titanium dioxide (TiO_2).
Methods: A mortality follow-up study of 15,017 workers (14,331 men) employed in 11 factories producing TiO_2 in Europe. Exposure to TiO_2 dust was reconstructed for each occupational title; exposure estimates were linked with the occupational history. Observed mortality was compared with national rates, and internal comparisons were based on multivariate Cox regression analysis.
Results: The cohort contributed 371,067 person-years of observation (3.3% were lost to follow-up and 0.7% emigrated). 2652 cohort members died during the follow-up, yielding standardized mortality ratios (SMRs) of 0.87 (95% confidence interval [CI] 0.83–0.90) among men and 0.58 (95% CI 0.40–0.82) among women. Among men, the SMR of lung cancer was significantly increased (1.23, 95% CI 1.10–1.38); however, mortality from lung cancer did not increase with duration of employment or estimated cumulative exposure to TiO_2 dust. Data on smoking were available for over one third of cohort members. In three countries, the prevalence of smokers was higher among cohort members compared to the national populations.
Conclusions: The results of the study do not suggest a carcinogenic effect of TiO_2 dust on the human lung.

Key words: titanium dioxide, mortality, lung cancer, occupation.

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Table 4. Standardized mortality ratios of selected causes by country

Cause of death		Country					
		Finland	France	Germany[a]	Italy	Norway	UK
All causes	Obs/Exp	224/276.1	305/313.8	1015/1131.7	89/99.8	84/96.0	902/1102.4
	SMR	0.81	0.97	0.90	0.89	0.87	0.82
	95% CI	0.71–0.92	0.87–1.09	0.84–0.95	0.72–1.10	0.70–1.08	0.77–0.87
All malignant neoplasms	Obs/Exp	34/51.2	125/103.3	319.5/298.3	28/37.1	21/23.6	279/312.9
	SMR	0.66	1.21	1.07	0.75	0.89	0.89
	95% CI	0.46–0.93	1.01–1.44	0.96–1.20	0.50–1.09	0.55–1.36	0.79–1.00
Lung cancer	Obs/Exp	12/15.8	36/25.4	128.5/84.8	12/12.4	4/5.0	114/104.7
	SMR	0.76	1.42	1.51	0.97	0.79	1.09
	95% CI	0.39–1.32	0.99–1.96	1.26–1.79	0.50–1.69	0.21–2.02	0.90–1.31

SMR, standardized mortality ratio; CI, confidence interval.
[a] Observed deaths are not integer values (except for all causes of death) because of correction factors for missing causes of deaths.

Table 5. Standardized mortality ratios of lung cancer by duration of employment and time since first employment

Healthy worker survivor effect (HWSE)

Years of employment		Years since first employment 1–10	10.01–20	20.01–30	30.01 +	Total
1–5	Obs/Exp	7.0/7.1	12.1/9.7	40.9/16.6	17.8/15	77.7/48.4
	SMR	0.99	1.24	2.47	1.19	1.61
	95% CI	0.4–2.03	0.64–2.15	1.78–3.36	0.71–1.90	1.27–2.01
5.01–10	Obs/Exp	9.0/9.2	10.1/7.7	11.2/9.7	3.2/7.2	33.5/33.7
	SMR	0.98	1.31	1.15	0.44	0.99
	95% CI	0.45–1.86	0.62–2.4	0.57–2.03	0.09–1.22	0.67–1.37
10.01–15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34.4/35.1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.98
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.67–1.35
15.01–20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45.4/38.3
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.18
	95% CI	–	0.47–1.51	0.85–2.11	0.64–2.30	0.85–1.56
20.01 +	Obs/Exp	–	–	38.8/34.7	76.7/57.8	115.5/92.5
	SMR	–	–	1.12	1.33	1.25
	95% CI	–	–	0.80–1.54	1.05–1.67	1.03–1.49
Total	Obs/Exp	16.0/16.3	53.2/50.9	120.6/88.0	116.6/93.9	306.5/248.3
	SMR	0.98	1.05	1.37	1.25	1.23
	95% CI	0.56–1.59	0.78–1.37	1.14–1.64	1.04–1.50	1.10–1.38

SMR, standardized mortality ratio; CI, confidence interval.
[a] Observed deaths are not integer values because of correction factors for missing causes of deaths.

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Table 6. Relative risk of mortality from lung cancer and non–malignant respiratory diseases for estimated cumulative exposure to respirable TiO_2 dust

Selective reporting bias

Conflict of interest

Cumulative exposure (mg/			
Lung cancer			
0–0.73			
0.73–3.43			
3.44–13.19	52	1.03	0.69–1.55
13.20 +	53	0.89	0.58–1.35
Linear trend, *p*–value		0.5	
Non-malignant respiratory diseases			
0–0.8	40	1.00	Ref.
0.9–3.8	39	1.23	0.76–1.99
3.9–16.1	40	0.91	0.56–1.49
16.2+	39	1.12	0.67–1.86
Linear trend, *p*–value		0.6	

Results of Cox regression analysis.

CLP Expertise conclusion

- Given the methodological bias in dose-response assessment and a statistically significant increase in lung cancer mortality reported in two publications, France has established that **human data are not sufficient to conclude that there is no carcinogenic effect in humans** and cannot contradict the carcinogenic effects observed in rats
- Need to re-analyze existing data and / or a meta-analysis

ECHA RAC decision

- Classification as a **category 2 carcinogen (suspected human carcinogen) by inhalation for TiO2 in all its forms**
- Inclusion in Annex VI of the CLP Regulation

And then…

- Industrial repost

ANNEX 2 - COMMENTS AND RESPONSE TO COMMENTS ON CLH PROPOSAL ON TITANIUM DIOXIDE

COMMENTS AND RESPONSE TO COMMENTS ON CLH: PROPOSAL AND JUSTIFICATION

Date	Country	Organisation	Type of Organisation	Comment number
15.07.2016	Belgium	EuPC (European Plastics Converters	BehalfOfAnOrganisation	5

Comment received

…pigment, brightener or opacifier in most plastics … stability important for outdoor applications. … O2 substance. The … ostat 2014). The … gnitude the whole … € including polymer … nverting sector.

Date	Country	Organisation	Type of Organisation	Comment number
15.07.2016	Belgium			

Comment received

Cerame-Unie, the Europe… including bricks & roof tile… table & decorative ware, t… accounts for more than 2…

No cases of pulmonary fib… of Dupont "Epidemiologic… Dec;30(12):937-42 gave … TiO_2 as a carcinogen cat. … the classification, which w… by France.

Date	Country	Organisation	Type of Organisation	Comment number
15.07.2016	United Kingdom		BehalfOfAnOrganisation	17

Comment received

This business employs 187 people in Europe. We manufacture wallcoverings. Titanium Dioxide is an important component of our products and it is great concern to us if this material were to be classed as a carcinogen. We have used TiO_2 within our products for over fifty years and during this time we have followed all statutory requirements for dust control and we are unaware of any health issues experienced by our employees through exposure to TiO_2 in the workplace. The prospect that we may have to label our rolls of wallpaper as containing a carcinogen will potentially cause customers to stop buying our products due to misplaced concerns about a hazard when the potential for exposure to that hazard is very low.
Substitution of TiO_2 for other materials would not be economic and will raise the cost of products at a time when the whole of Europe does not need any further inflationary pressures. This proposed re-classification if adopted will decimate the DIY industry in Europe

… anisation	Comment number
… rganisation	10

… problems. … product containing more … 50i. This means almost … r if ist dusty or not. … n amount of TiO_2 will get in… st…

As ist allready written, there is no evidence, that any product containing TiO_2 has caused cancer. Not a single case is known.
And the costumers using products containing TiO_2 will not come in a situation like mice in a TiO_2 dust filled air. TiO_2 is bound in liquids and pastes, there is simply no TiO_2 dust.
Because of this and the fact that there is no sufficient replacement for TiO_2 at the time we support any position which does not has to lable products containing TiO_2 in liquid or pasty form

https://echa.europa.eu/documents/10162/13626/clh_comments_titanium_dioxide_en.pdf

ACHA RAC response

Attachment to the responses to comments on the CLH repo

received during public consultation

514 comments have been received as a result of the public consult
from 5 Member-States (Germany, Sweden, Finland, Netherlan
individuals and the remaining from organizations. Among them:

- 176 are related to identity and scope of the dossier (in pa matrix),
- 338 are related to carcinogenicity (human and/or animal da
- 67 are related to hazard endpoints other than carcinogenicit
- 226 are related to exposure and risk assessment,
- 294 are related to economic impact of the proposed classifi

https://echa.europa.eu/documents/10162/7c2e76

RAC response to comments on carcinogenicity (human data)

RAC independently assessed all the epidemiological studies available up to now, including four studies initially not assessed by DS, but mentioned during PC (Ellis *et al*., 2010, Ellis *et al*., 2013, Hext *et al*., 2005 and Thompson *et al*., 2016). RAC agreed with the general assessment made by Thompson *et al*. that epidemiological data support a moderate level of confidence for the human evidence and therefore can be used for carcinogenicity risk evaluation. RAC considers that human data do not consistently suggest an association between occupational exposure to TiO2 and risk for lung cancer as far as no specific TiO2 micro and nano particle sizes and/or specific physical forms are regarded. However, one cohort study by Boffetta *et al*. (2004) deals specifically with the respirable fraction of TiO2 dust (calculated from total dust) and suggests that there is no clear dose – response relationship expressed as RR for lung cancer; generally we do not have sufficient amount of relevant studies. In addition, Boffetta *et al*. (2004) indicated in their paper and Hext *et al*. (2005) repeated in their summary paper that the investigated TiO2 concentrations in the occupational environment generally could be too low to cause lung cancer. Therefore RAC concludes that the animal carcinogenicity studies cannot be overruled.

And finally…

https://echa.europa.eu/fr/substance-information/-/substanceinfo/100.033.327

Titanium dioxide

Regulatory process names 5 Translated names 22 CAS names 1 IUPAC names 29 Trade names 176 Other identifiers 135

BP OBL

Substance identity

EC / List no.: 236-675-5

CAS no.: 13463-67-7

Mol. formula: O2Ti

Hazard classification & labelling

Warning! According to the **harmonised classification and labelling** (ATP14) approved by the European Union, this substance is suspected of causing cancer.

EU classification of CMR substances	
Category	**Criteria**
Cat. 1 A	known to have CMR potential for humans, based largely on human evidence
Cat. 1 B	presumed to have CMR potential for humans, based largely on experimental animal data
Cat. 2	suspected to have CMR potential for humans

Properties of concern

C Suspected to be Carcinogenic

Nanomaterial form

Substance is known to be on the EEA market in nanomaterial form.

Important to know

- Substance included in the Community Rolling Action Plan (CoRAP).

Re-analysis of the French data from Boffetta et al (2004)

Type of TiO2 exposure variable	Observed lung cancer	Model 1*		Model 2*		Model 3*	
Binary exposed Vs non-exposed	14	3.75	[0.79-17.9]	4.34	[0.85-22.15]	3.77	[0.79-17.95]
Categorical annual average exposure Vs non-exposed							
]0-0.3] mg/m^3	7	4.04	[0.79-20.63]	5.94	[1.07-32.99]	4.15	[0.81-21.21]
[0.3-2.4] mg/m^3	3	1.68	[0.26-10.93]	1.64	[0.24-11.11]	1.64	[0.25-10.67]
>2.4 mg/m^3	4	28.28	[4.57-175.15]	12.97	[1.86-90.74]	27.33	[4.35-171.84]
Continuous annual average exposure (mg/m3)	16	2.10	[1.37-3.22]	1.70	[1.03-2.79]	2.07	[1.34-3.20]
Continuous cumulative exposure (mg/m3-year), 0 lag	16	1.02	[0.97-1.06]	-	-	1.02	[0.97-1.06]**
5-year lag	9	1.02	[0.98-1.07]	-	-	1.02	[0.98-1.07]**
10-year lag	5	1.03	[0.99-1.08]	-	-	1.03	[0.98-1.08]**
15-year lag	1	1.04	[0.98-1.11]	-	-	1.04	[0.98-1.11]**

Hazard ratios and associated 95%-confidence intervals are adjusted for calendar period in Model 1; for calendar period and exposure duration in Model 2;
for calendar period, exposure duration and smoking status in Model 3, except for cumulative exposure variable ** adjusted only for calendar period and smoking status in Model 3

Guseva Canu I et al. Lung cancer mortality in the French cohort of titanium dioxide workers: some aetiological insights. Occup Environ Med 2020;**77**:795–7
Tomenson JA. Letter commentary on: lung cancer mortality in the French cohort of titanium dioxide workers: some aetiological insights. Occup Environ Med 2021;**78**
Guseva Canu I et al. Letter: Response to Tomenson's letter on 'Lung cancer mortality in the French cohort of titanium dioxide workers: some aetiological insights' Occup Environ Med 2021;78

Re-analysis of the EU data

International Agency for Research on Cancer

World Health Organization

Research Project

Reana**ly**sis of **Ti**O2 human data (**RealyTi**)

As part of the CLP classification dossier on titanium dioxide, the available epidemiological data were evaluated (ANSES, 2017). Three occupational cohorts were identified: two American cohorts (Ellis et al., 2013, Fryzek et al., 2003) and a

Main conclusions

- Association between cumulative exposure and lung cancer mortality, after correction of the HWSE
- Exposure reduction corresponds to a significant reduction in the number of lung cancer deaths
- The safety of NIOSH REL (2.4 mg / m3) seems questionable

Essential Public Health Operations

- EPHO**3**: Health protection (environmental, occupational, food safety etc.)
- EPHO**10**: Advancing public health research to inform policy & practice

Statistiques

La population active suisse est championne en Europe

A fin 2018, la population active (15-64 ans) participant au marché du travail en Suisse a augmenté à 84,2%, contre 81,3% en 2010, juste derrière l'Islande avec 88,7%.

https://www.24heures.ch/economie/population-active-suisse-championne-europe/story/10701185

Essential Public Health Operations

- EPHO**3**: Health protection (environmental, occupational, food safety etc.)
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ORIGINAL ARTICLE

Healthy worker, healthy citizen: the place of occupational health within public health research in Switzerland

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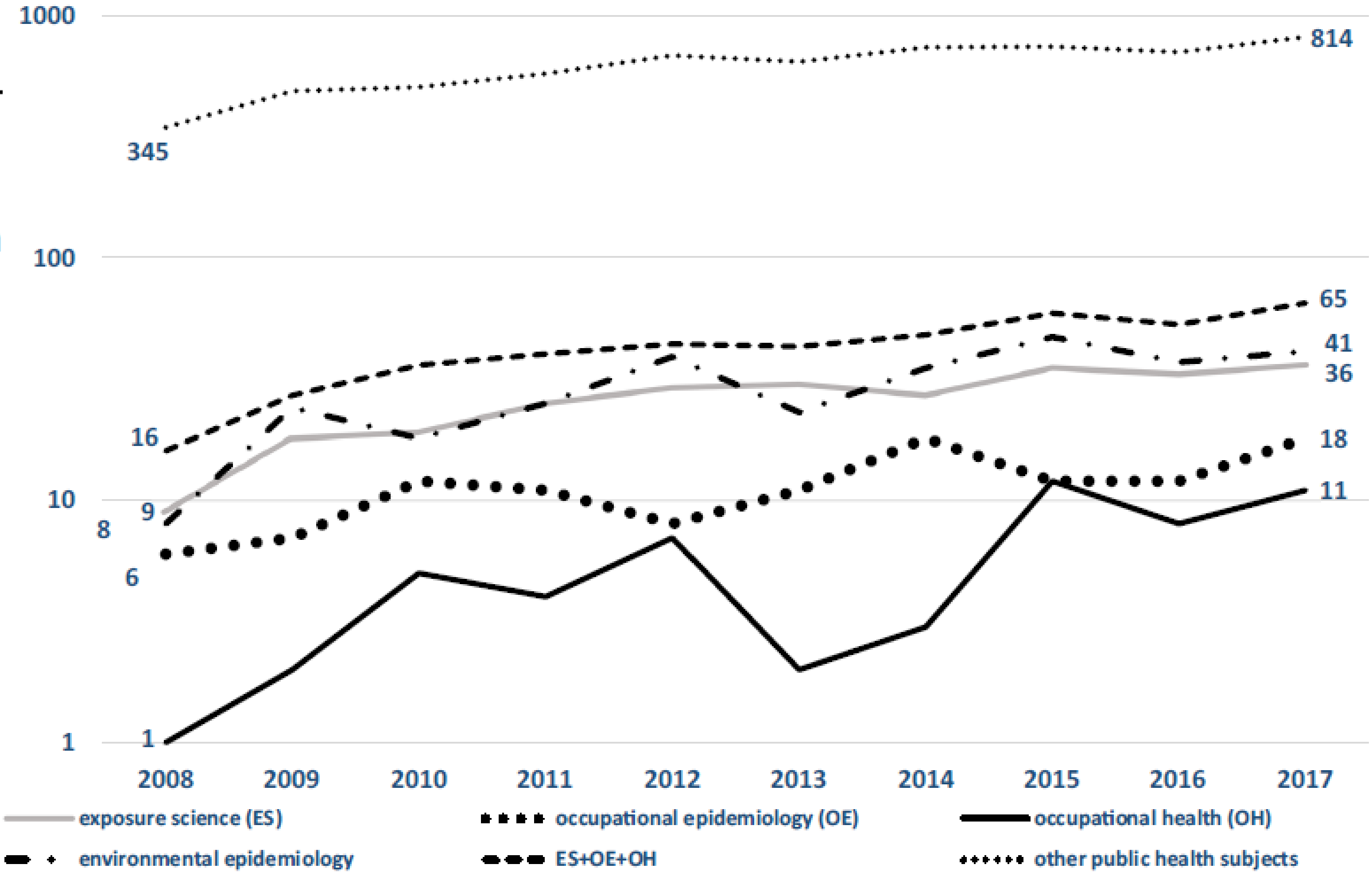

Fig. 1 Evolution of the number of yearly publications in public health, occupational health and its related disciplines, and environmental epidemiology in the six selected Swiss public health institutions in Switzerland, 2008–2017

Thank you for your attention !

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