The history of occupational and environmental exposure to carcinogens

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May 24th 2024 | 3pm - 5pm

Occupational and Environmental cancer

- About 4% of all cancers are due to work exposures, but varies by country. Estimates for environmental exposures are not well developed
- Exposures to well-identified carcinogens are still here!
- Environmental and particularly workplace exposures decline in high-income countries and increase in middle-income countries
- New risks arise, including climate change
- Historically very productive cancer research (with important findings and some failures); boost from exposome research (environment)
- Valid exposure assessment is a key characteristic of studies on occupational & environmental cancer
- Environmental and Occupational cancer prevention is a global problem!

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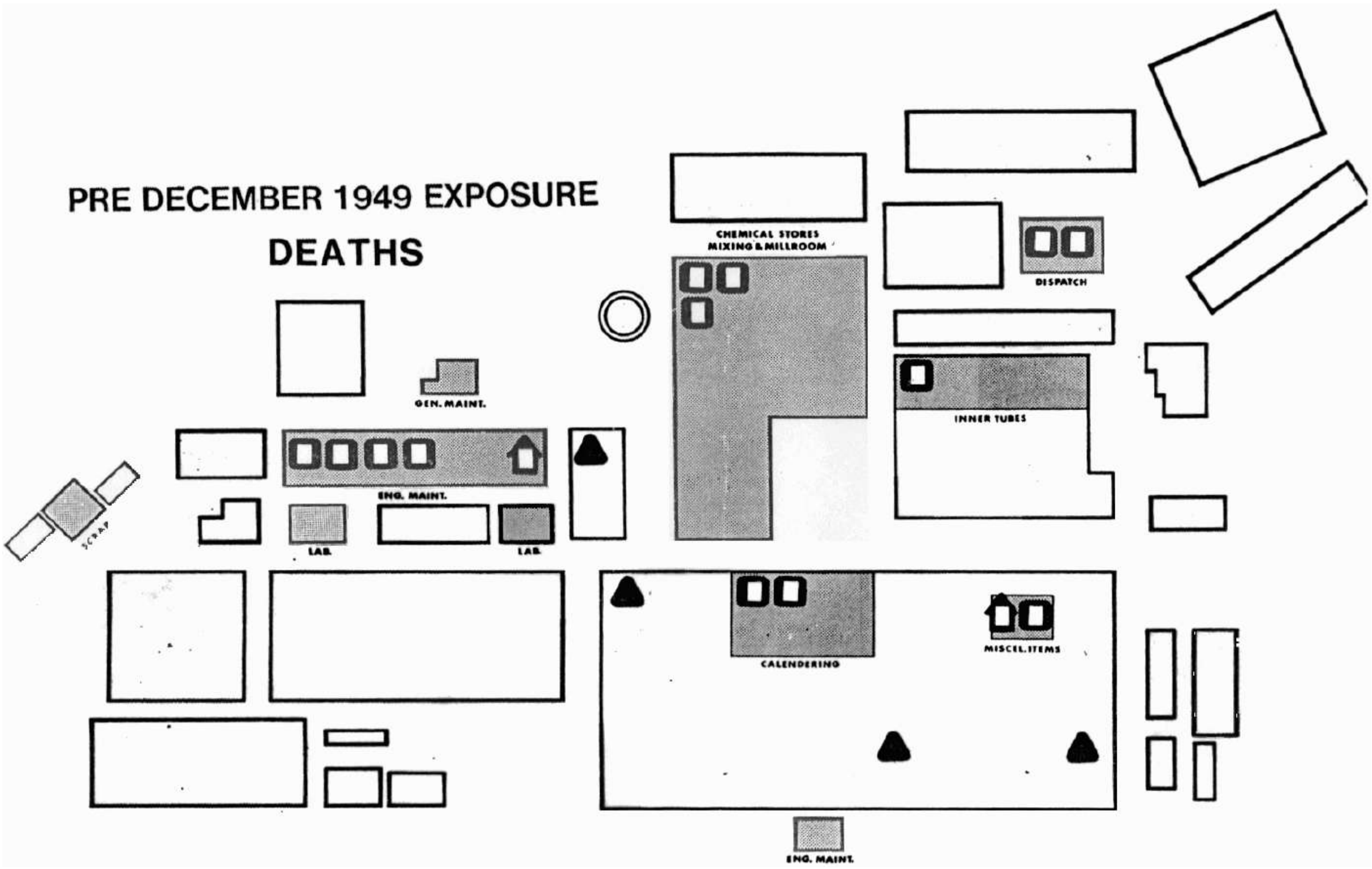


Rubber-Tire Industry "Michelin", England

- We still have working conditions like those in this Michelin factory 70 years ago but today, in most cases, we have to evaluate less pronounced risks

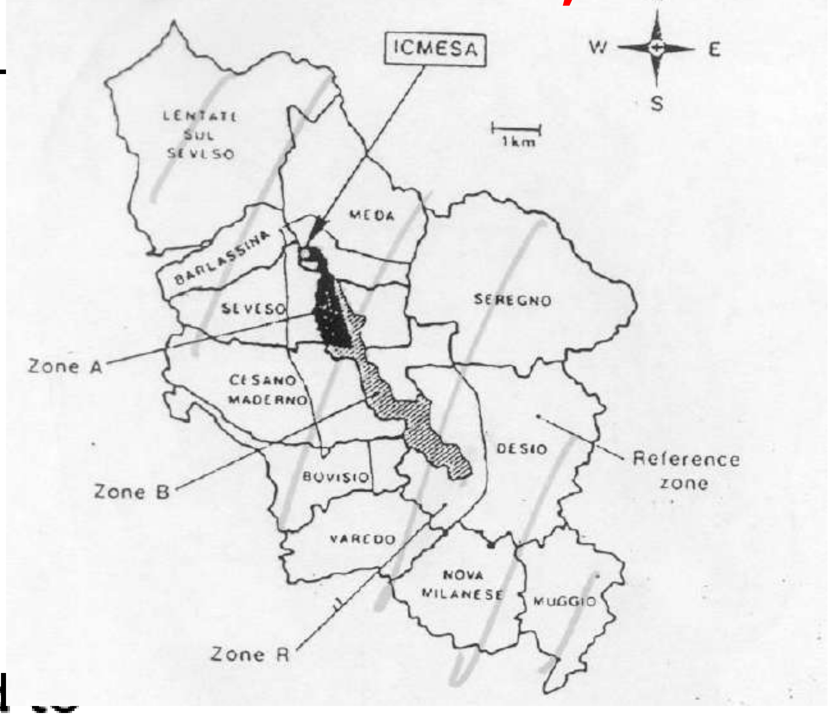
- This makes epidemiological research more complex

THE LANCET

Vol 338 Saturday 26 October 1991

ORIGINAL ARTICLES

Seveso accident, 1976



Cancer mortality in workers exposed chlorophenoxy herbicides and chlorophenols

RODOLFO SARACCI MANOLIS KOGEVINAS PIER-ALBERTO BERTAZZI
BAS H. BUENO DE MESQUITA DAVID COGGON
LOIS M. GREEN TIMO KAUPPINEN KRISTAN A. L'ABBÉ
MARGARETA LITTORIN ELSEBETH LYNGE JOHN D. MATHEWS
MANFRED NEUBERGER JOHN OSMAN NEIL PEARCE
REGINA WINKELMANN

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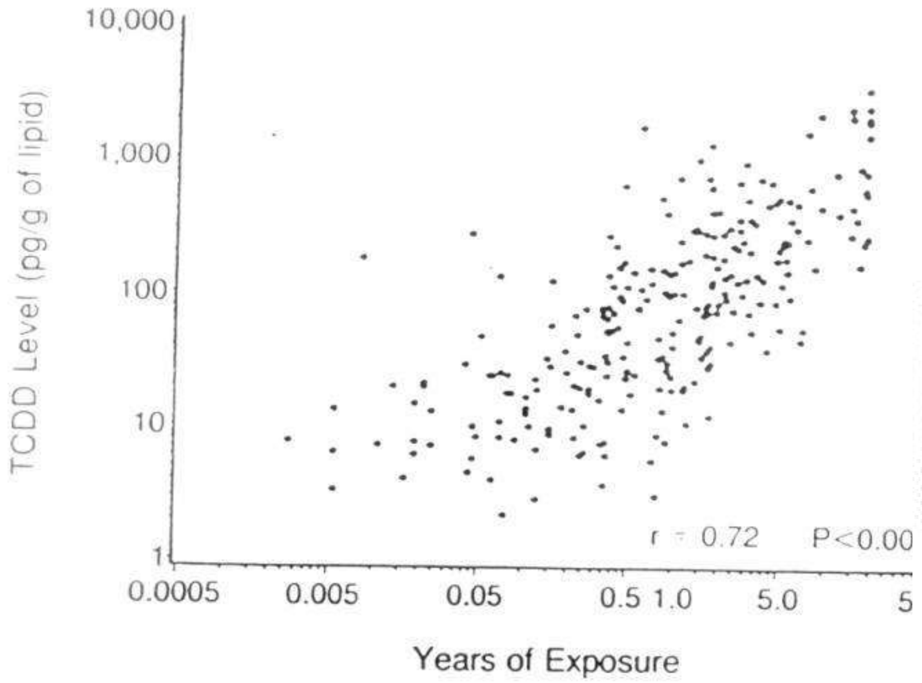
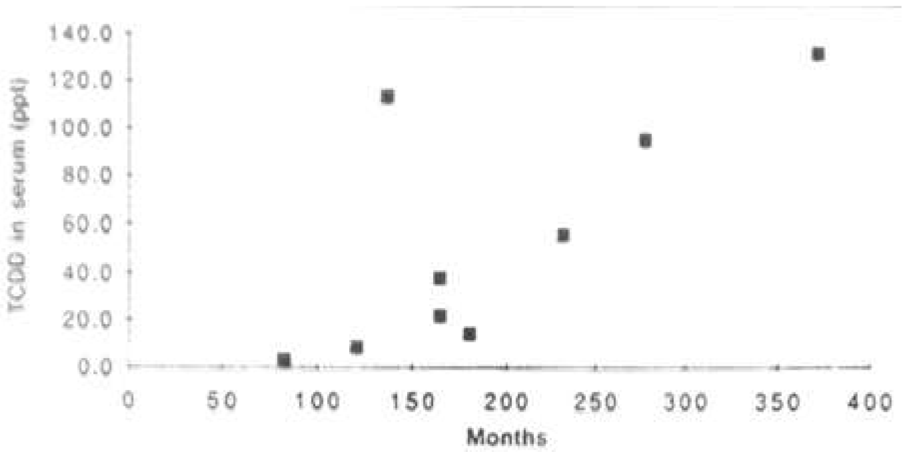
Dioxins research: studies in workers became conclusive only when we provided valid exposure assessment models

Serum levels of TCDD in 253 US workers, according to years of exposure. (Fingerhut et al, NEJM 1991)



Concentration of TCDD in serum of New Zealand applicators in relation to total months spent spraying 2,4,5-T. (Smith et al, JNCI. 1992)



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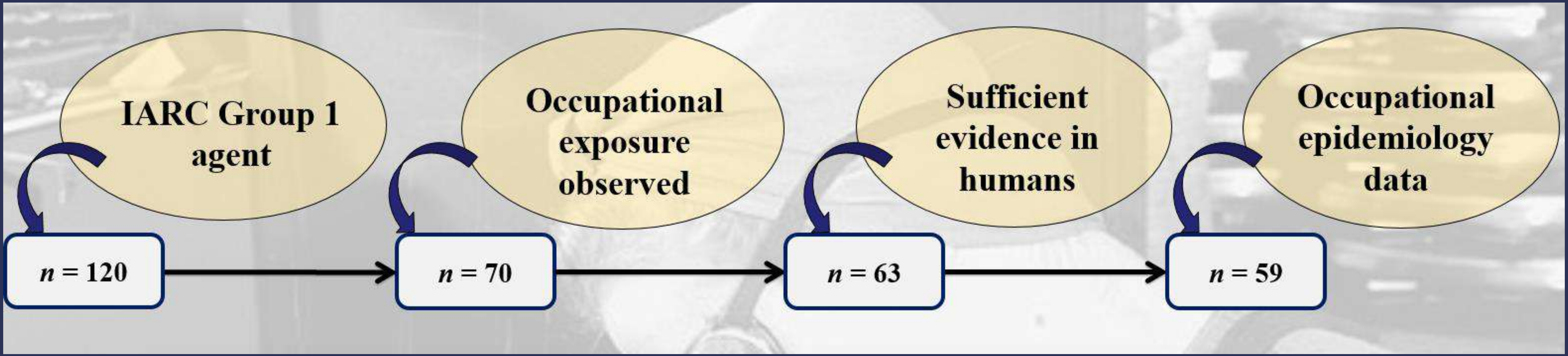
Valid exposure assessment is a key feature for occupational epidemiological studies

Occupational cancer studies crucial for Group 1 identification



Afer Loomis D, Guha N, Hall AL, Straif K (2018). Identifying occupational carcinogens: an update from the IARC Monographs. Occup Environ Med. 75:593-603. PMID:29769352

Slide form Mary K Schubauer-Berigan, IARC

Research in occupational epidemiology has been very important for the identification and regulation of carcinogens

4%

(Doll & Peto 1981)

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4% of all cancers in Italy, both sexes

Incidence 436.242 * 4% = 17.450
Mortality 193.706 * 4% = 7.748

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(incidence data from Global Cancer Observatory, IARC 2022)

4% of all cancers in Italy, both sexes

Incidence 436.242 * 4% = 17.450
Mortality 193.706 * 4% = 7.748

(but is 4% a valid estimate for today?)

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(incidence data from Global Cancer Observatory, IARC 2022)

ORIGINAL RESEARCH

Global and regional burden of cancer in 2016 arising from occupational exposure to selected carcinogens: a systematic analysis for the Global Burden of Disease Study 2016

GBD 2016 Occupational Carcinogens Collaborators

OEM 2020, Tim Driscoll

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Global Burden of Disease (GBD) Occupational Cancer 2016

- There were an estimated 349,000 (269,000 to 427,000) deaths in 2016 due to exposure to occupational carcinogens, representing 3.9% (3.2% to 4.6%) of all cancer deaths
- 79% of deaths in men; 88% were in people between 55 and 79 years old
- Lung cancer 86%, mesothelioma 7.9% and laryngeal cancer 2.1%

but

- major cancers (eg, bladder cancer) were not included; underestimation of the true load

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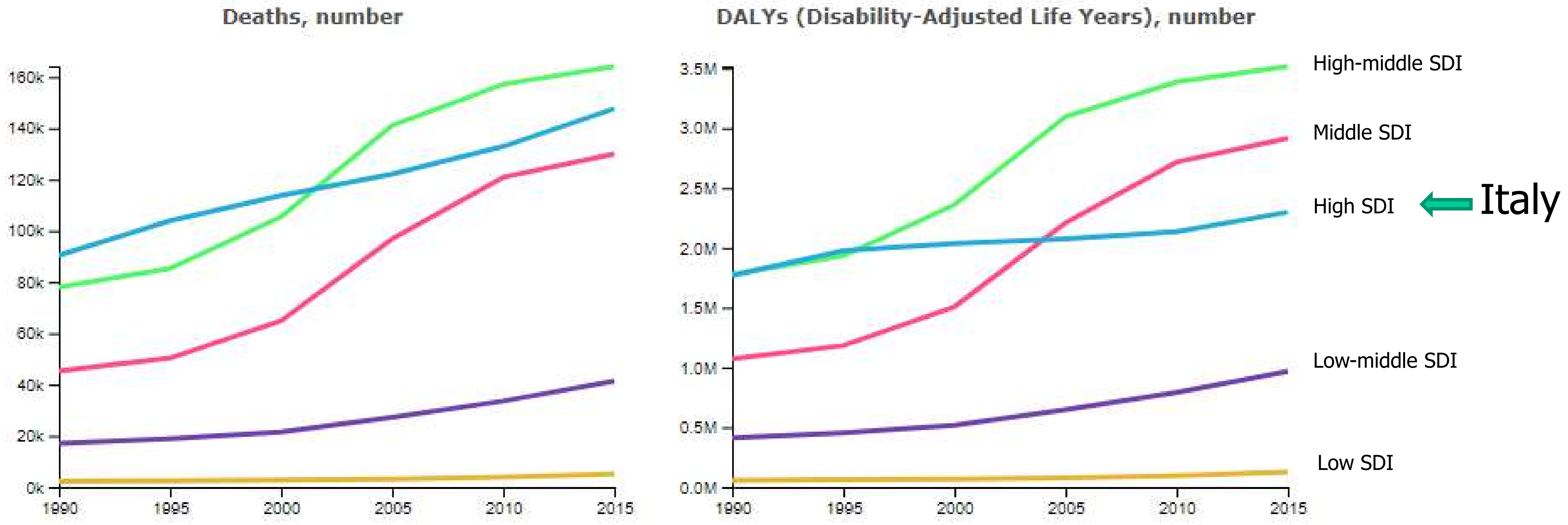
Exposures GBD 2016

- Asbestos was responsible for the largest number of deaths from occupational carcinogens (63%)
- Other important risk factors were passive smoking in the workplace (14%), silica (14%), and diesel engine exhaust (5%)
- High-income countries, largely due to asbestos-related cancers
- In other countries, cancer deaths caused by passive smoking, silica and diesel engine fumes were more prominent

Global Burden of Disease – Deaths and DALYs from occupational carcinogens by Social Development Index (SDI)



(http://ghdx.healthdata.org/gbd-results-tool)

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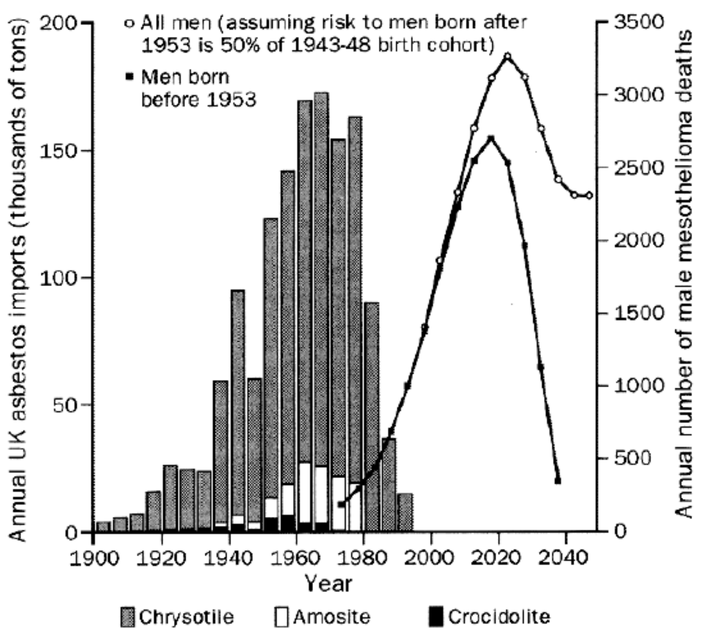
Major Occupational Human carcinogens (Group 1/2A- IARC)

Agent-England	Agent-Catalonia
	UV-solar
	Shift work
haust	Diesel engine exhaust
	Radon
r	Silica
al workers, printing	PAHs
noke	Benzene
	Chromium VI
Dioxins	



Prediction of mortality from mesothelioma in England (J Peto et al., Lancet 1996)

Major Occupational Human carcinogens (Group 1/2A- IARC)

Agent-England	Agent-Catalonia
Asbestos	UV-solar
Silica	Shift work
Diesel engine exhaust	Diesel engine exhaust
Radon	Radon
Work as a painter	Silica
Mineral oils (metal workers, printing industry)	PAHs
Second Hand Smoke	Benzene
Work as a welder	Chromium VI
Dioxins	

These 8 agents constitute 85% of all occupational carcinogens in Catalonia
(from CarexCat, Dept Treball, Mayte Martí)

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The identification of a similar proportion of cancers attributed to work exposures (4%), 40 years after Doll & Peto (1981), may not be as surprising:

- Exposures went down in HICs
- Exposures went up in MICs
- Doll & Peto may have underestimated because there was much less knowledge on occupational cancer at that time

Occupational cancer
Present and future

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Trends in occupational exposure to carcinogens

- Reduction of number of workers exposed through wider changes in production (in Western Europe/N America) and transfer to 3rd world countries

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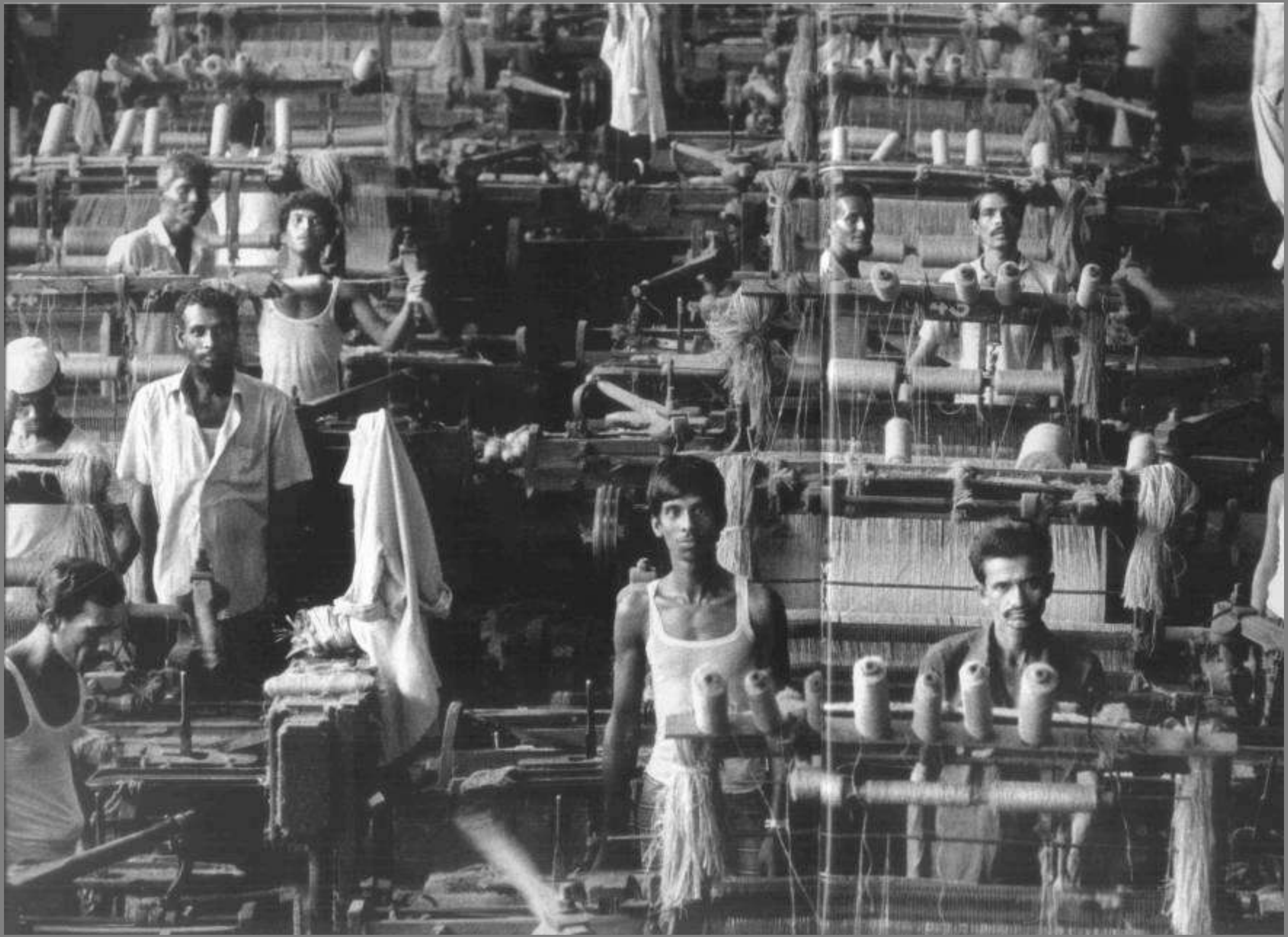
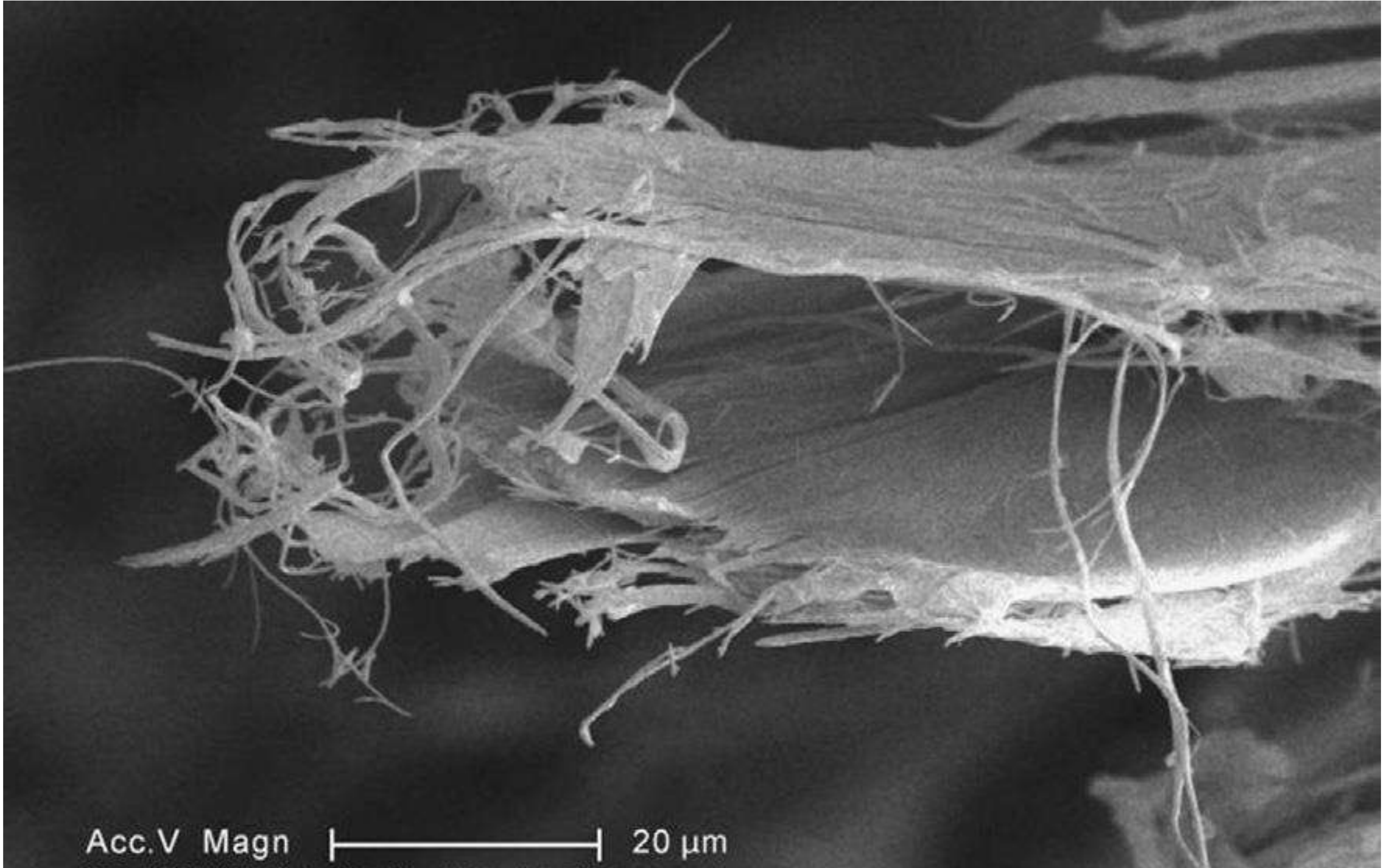
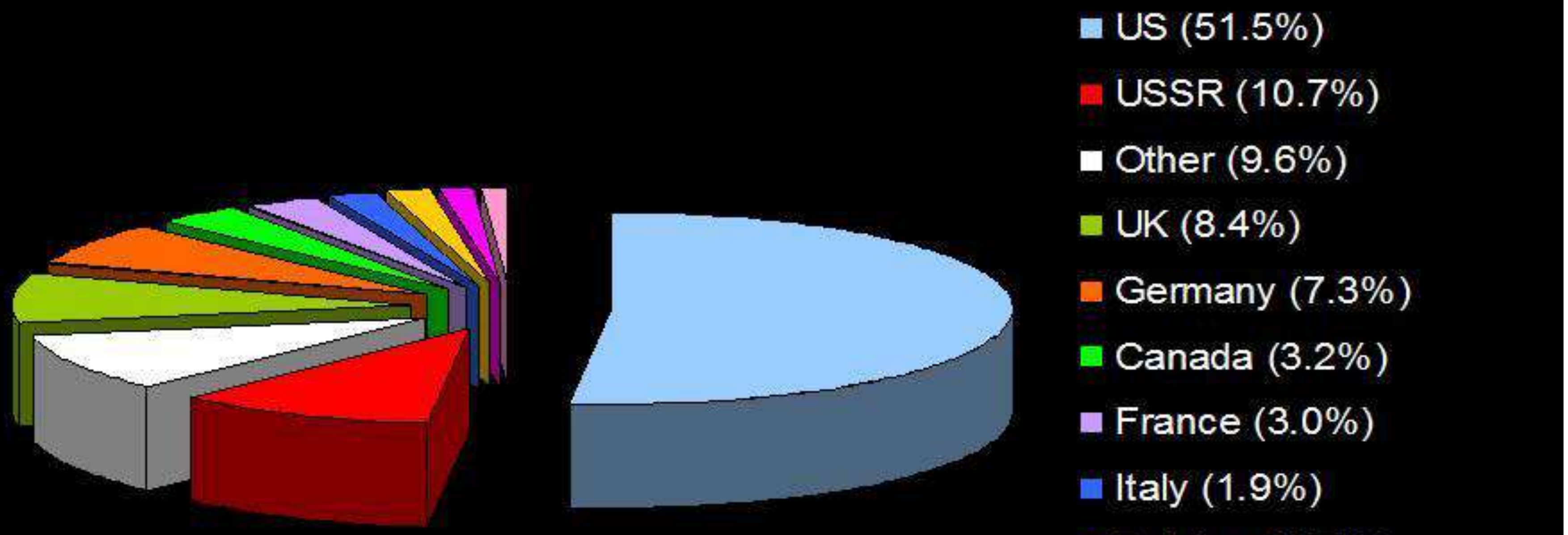


Textiles, Bangladesh
C. Salgado

Ship dismantling
Bangladesh
C. Salgado


Acc.V Magn
20 µm

Global Asbestos Fiber Consumption, 1950

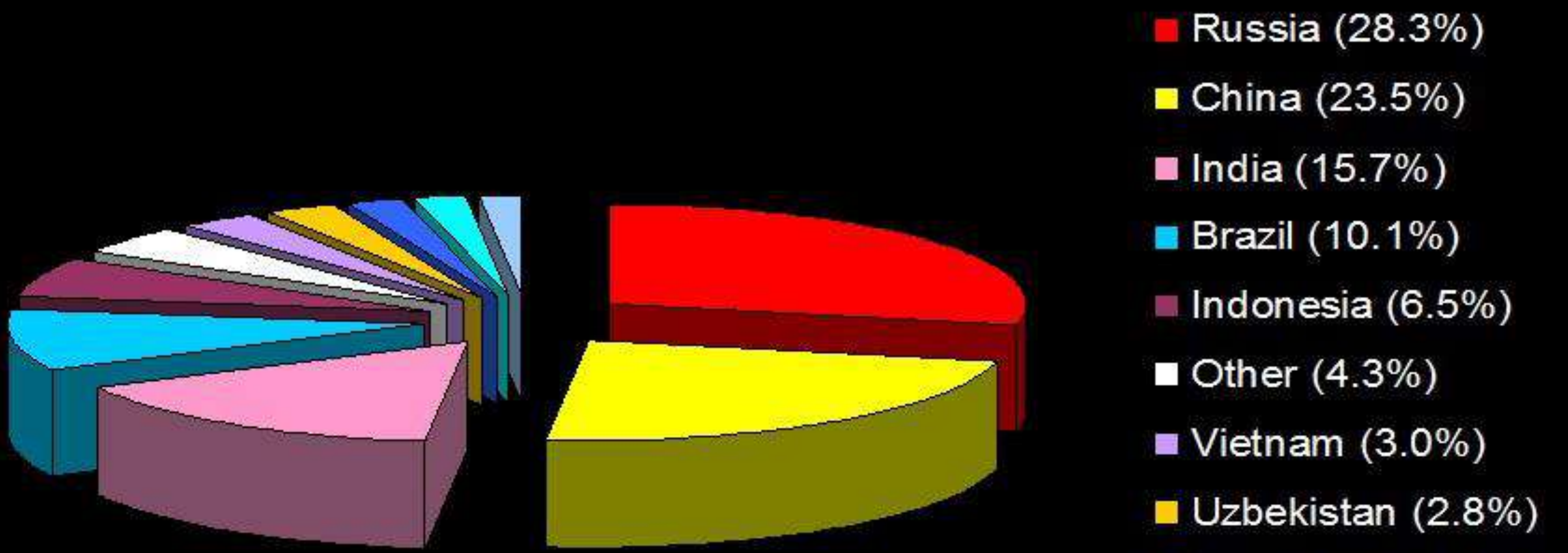


Notes:

- Based on USGS data on apparent asbestos consumption.
- Figure for Germany is the combined percentage for East and West Germany.
- Belgium, above refers to Belgium and Luxembourg.
- Other: around 40 smaller consumers listed by the USGS.

Compiled by: International Ban Asbestos Secretariat

Global Asbestos Fiber Consumption, 2015



Notes:

- Total consumption: ~2,027,000 tonnes
- Based on 2015 USGS data on apparent asbestos consumption.

Compiled by: International Ban Asbestos Secretariat

Trends in occupational exposure to carcinogens

- Reduction of number of workers exposed through wider changes in production (in Western Europe/N America) and transfer to 3rd world countries

- More efficient control of exposure to known carcinogens in High Income Countries through elimination, substitution, and specific and general measures of hygiene and security

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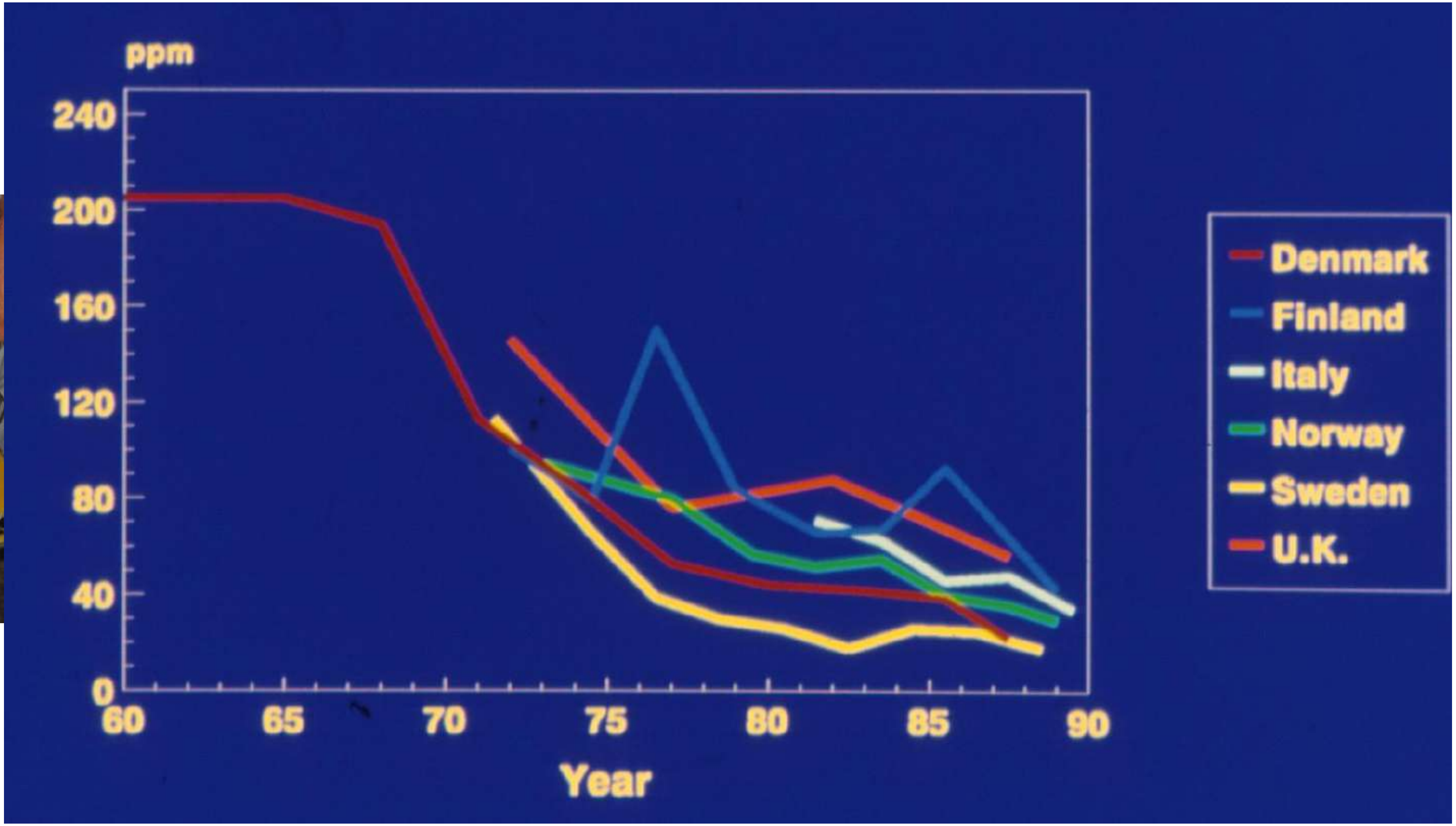
Exposure to styrene among workers (laminators) in the reinforced plastics industry, 1960-1990

Workplace near Bologna



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Interventions to Reduce Exposures in the Workplace 1960-2019 (n=146)

	1960–2019	
Number of articles	**146**	
	n	%
TYPES OF EXPOSURE		
Chemical	114	78.1
Biological	30	20.5
Both chemical and biological	2	1.4
STUDY LOCATION[a]		
LIC	3	2.1
LMIC	10	6.8
UMIC	12	8.2
HIC	111	76.0
Not reported	10	6.9

60% of included interventions were considered to be effective or successful

Ohlander, FrontPH 2020

Sensible best practice advice can be used to address exposures that are excessively high

Further reducing exposures will require more sophisticated evidence-based interventions to ensure that trends in declining exposures and negative health impacts continue and occur globally

It is important to apply properly designed occupational intervention studies that allow evaluating the effectiveness of the intervention to further expand the evidence on cost-effective interventions

Trends in occupational exposure to carcinogens

- Reduction of number of workers exposed through wider changes in production (in Western Europe/N America) and transfer to 3rd world countries

- More efficient control of exposure to known carcinogens in High Income Countries through elimination, substitution, and specific and general measures of hygiene and security

- Introduction of new materials and technologies that could be associated with increased risks, or changes in work conditions and employment patterns that could have a direct or indirect association with cancer

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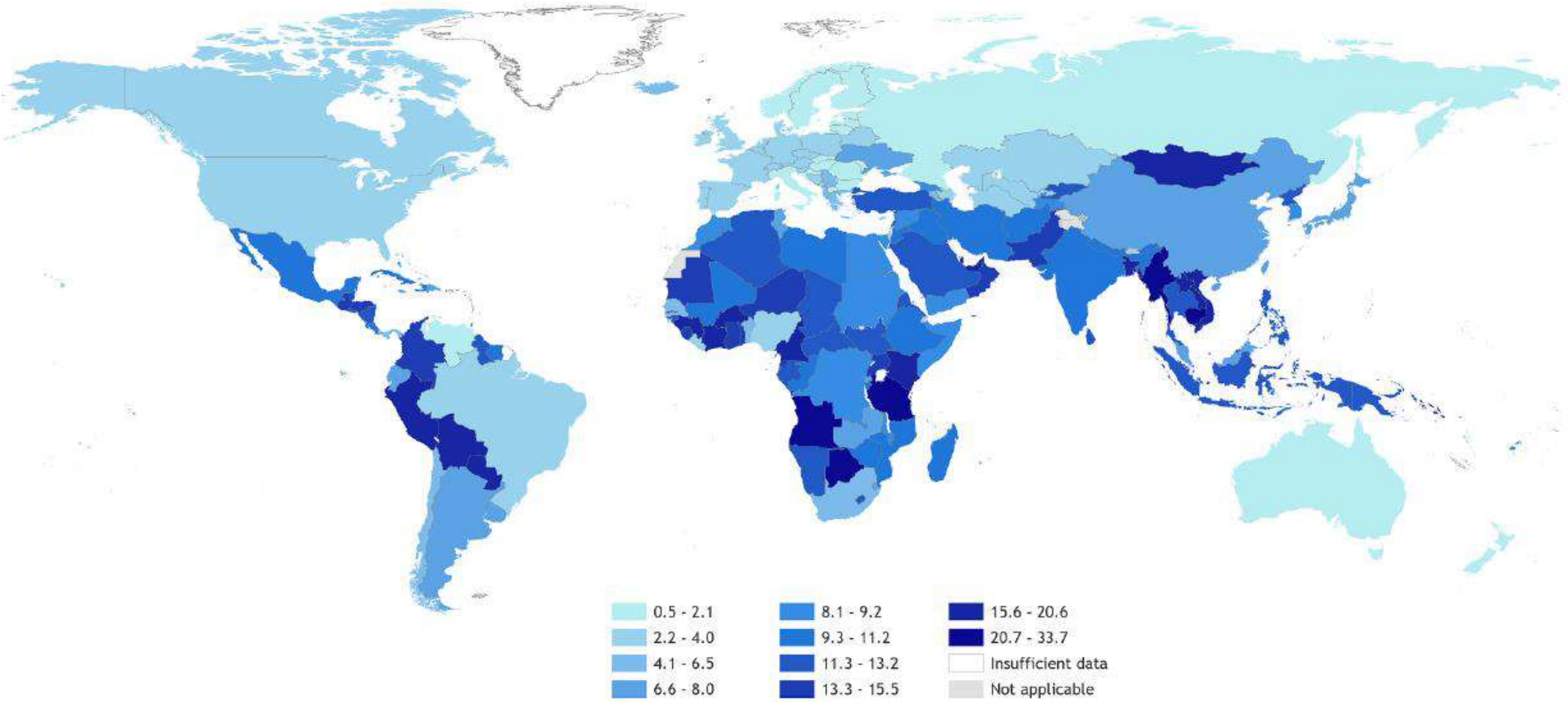
OPEN
24 HOURS

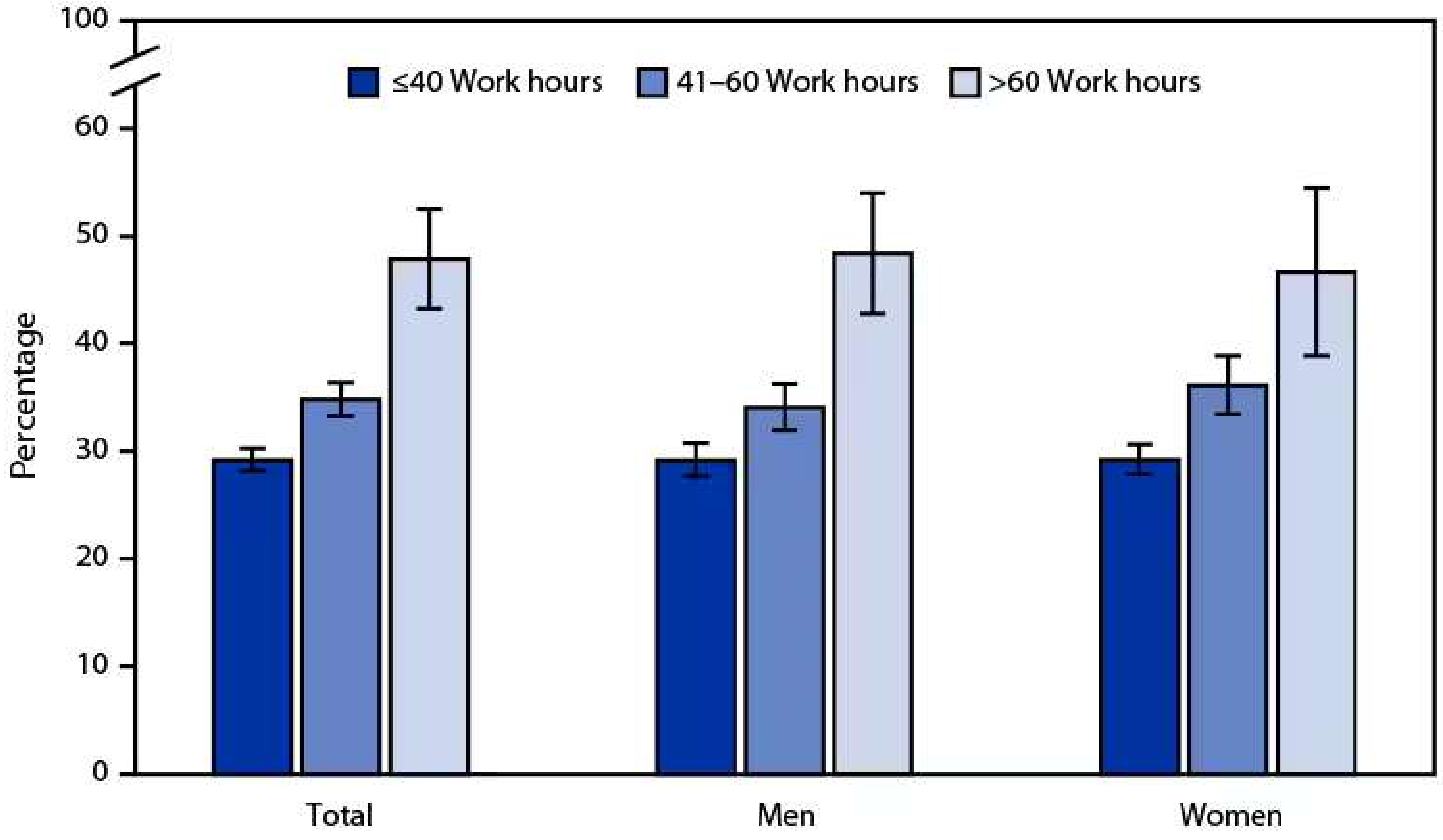
Working Time

Proportion (%) of population exposed to long working hours (≥55 hours/week), 2016, 194 countries



Pega, EnvInt,

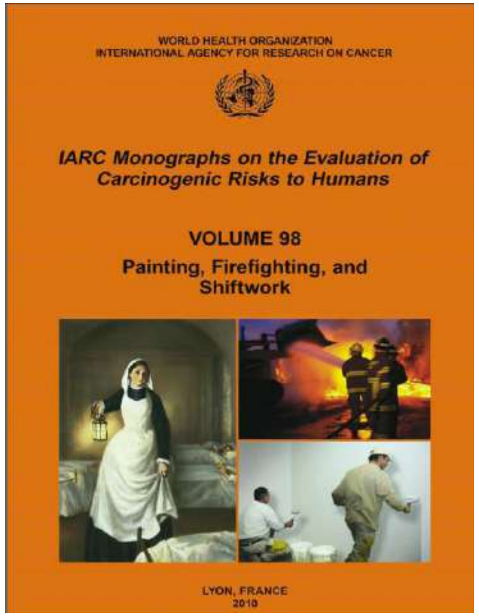
Percentage of Employed Adults Aged ≥18 Years Who Slept <7 Hours per 24-Hour Period, by Sex and Number of Work Hours per Week — United States, 2022



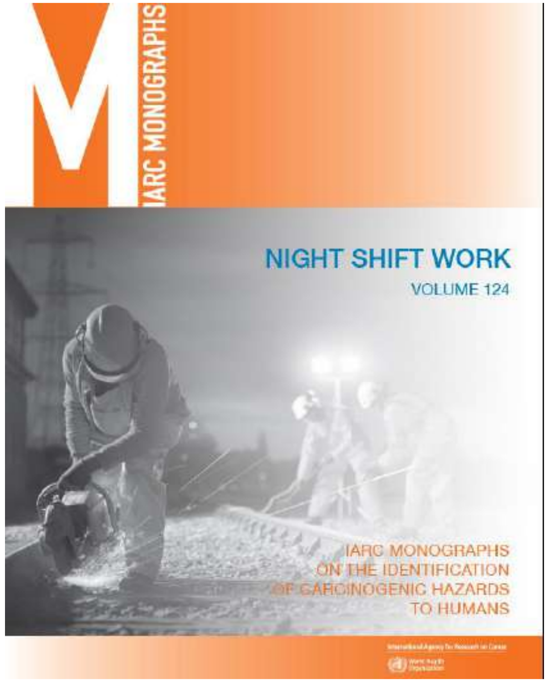
MMWR Morb Mortal Wkly Rep 2024;

Carcinogenicity of shift work

- ***Sufficient*** evidence from animal studies
- ***Limited*** evidence from epidemiological studies
- ***Strong evidence*** in experimental systems, based on findings consistent with immunosuppression, chronic inflammation, and cell proliferation but ***Not strong*** evidence from mechanistic studies in humans.



2019: “Night shift work is probably carcinogenic to humans” (Group 2A)
Breast, Prostate, Colorectal



IARC Monographs Vol 98, 2010; Vol 124 2019

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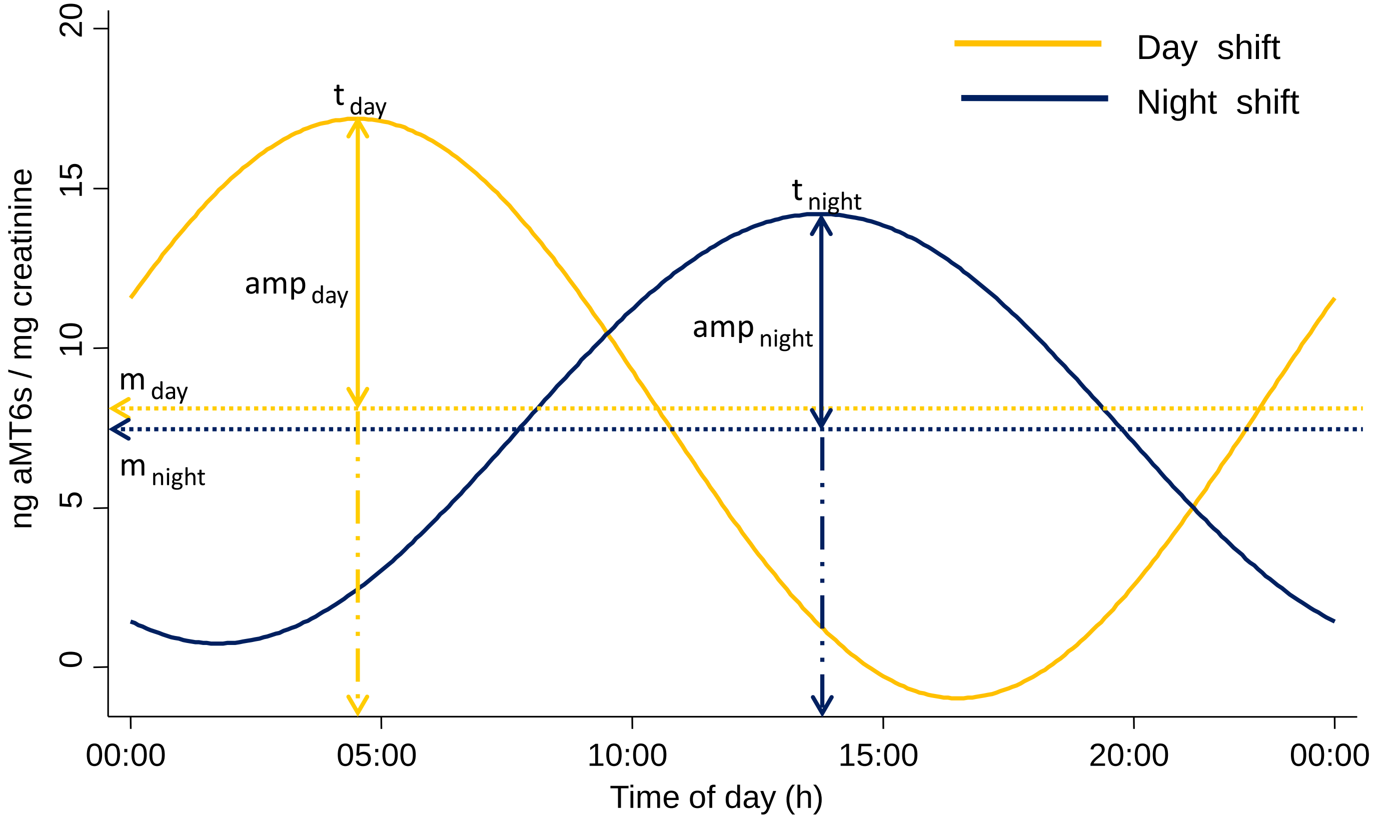
In Catalonia night-shift work is the second most prevalent exposure associated with cancer
(n=136.000 workers, *from CarexCat*)

Credit Cristina Calderer


Imatge: www.counselheal.com

Melatonin in end of 3 weeks night shift and end of 3 weeks day shift. Cosinor model – 50 subjects Hormonit study



(Barbara Harding, SJWEH 2022)

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Contrary to what is usually assumed, the best evidence on night shift an cancer comes from case-control studies. The evaluation of Exposure in most cohort studies is crude.

Night shift work & breast cancer in 5 population based case-control studies

Australia, Canada, France, Germany, and Spain; 6093 breast cancer cases and 6933 population controls

	Ever night shift	
All	1.12	[1.00-1.25]
Premenopausal	1.26	[1.06-1.51]
Postmenopausal	1.04	[0.90-1.19]
	More than 3nights/wk	
All	1.26	[0.97-1.63]
Premenopausal	1.80	[1.20-2.71]
Postmenopausal	0.92	[0.65-1.31]

(Emilie Cordina-Duverger, EJE 2018)

Night shift work and prostate cancer risk.
MCC-Spain (cases n=1095, population controls 1388)

Ever night shift	OR=1.14 (95%CI 0.9-1.4)

Intensity related night-shift exposure

Duration (>28yrs)	OR=1.38 (95%CI 1.1-1.8)
Cumulative nights (>2857)	OR=1.30 (95%CI 1.0-1.7)

(Kyriaki Papantoniou, IJC 2015)

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Association Between Night-Shift Work and Risk of Overall Prostate Cancer, PROtEuS study, Montreal, Quebec, Canada, 2005–2012

Night-Shift Work Metric	OR[a]	95% CI
Never engaged in night-shift work	1.00	Referent
Ever engaged in night-shift work	1.07	0.92, 1.26
Cumulative duration of night-shift work, years		
≤4.00	1.10	0.84, 1.44
4.01–11.00	1.01	0.76, 1.34
11.01–21.00	1.17	0.86, 1.59
>21.00	1.04	0.77, 1.38
P for trend	0.61	

(Barul C, 2019)

Climate change

- Changing working environments
  - Heat stress
- Changing exposure patterns
  - Allergens
  - Agricultural practice - pesticides

HERA
Health Environment Research Agenda

Key enabling technologies, the Green Deal

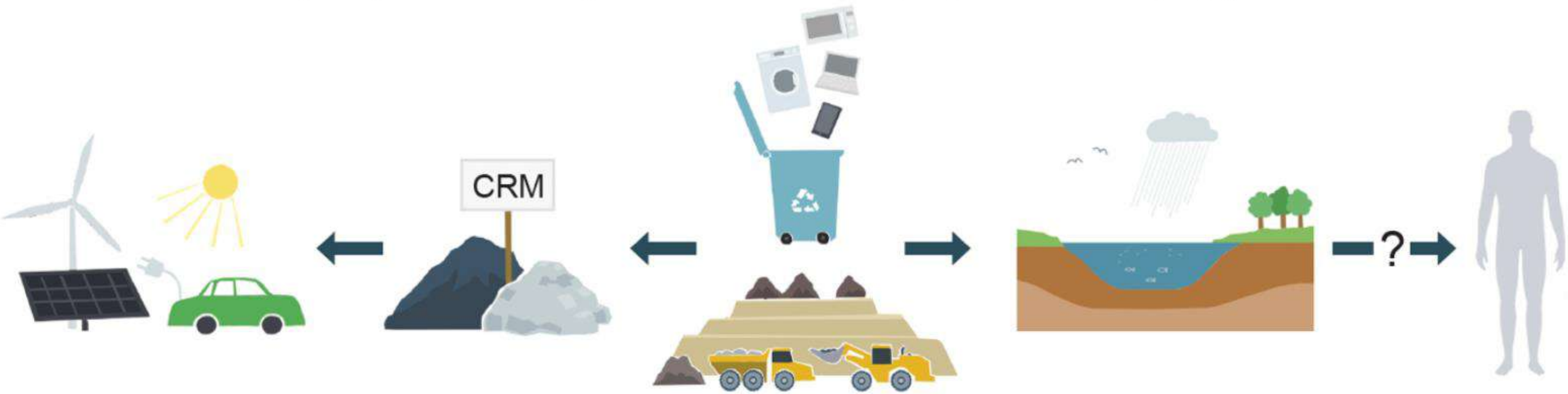
Key enabling technologies and the European Green Deal, are rapidly transforming the European economy, production systems, and labour market.

New materials are introduced and mitigation measures, e.g. circular economy, result in **new exposures**.

Knowledge gaps. Research on new solutions should integrate risk assessment with implementation of sustainable technologies (e.g. green chemistry).

HERA
Health Environment Research Agenda

Effects of hazardous materials from the green energy transition and the circular economy on human health



Cobalt mining
DR Congo

eWaste
Ghana

Pesticides and cancer: one of the failures of Occupational cancer research

A very small number of pesticides are classified as human carcinogens (Group 1) by the IARC, and some, for example Lindane, are not currently used

Why are so few pesticides classified as human carcinogens by IARC/WHO?

The lack of convincing evidence for pesticides shows the difficulties in assessing the carcinogenicity of many chemical agents in human populations, and the lack of research in large parts of the world where exposures are high

Review

ehp Environmental Health Perspectives

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP9934.

Health Effects of Pesticide Exposure in Latin American and the Caribbean Populations: A Scoping Review

Liliana A. Zúñiga-Venegas,[1†] Carly Hyland,[2,3*†] María Teresa Muñoz-Quezada,[4†] Lesliam Quirós-Alcalá,[5,6†] Mariana Butinof,[7†] Rafael Buralli,[8†] Andres Cardenas,[2] Ricardo A. Fernandez,[9] Claudia Foerster,[10] Nelson Gouveia,[11] Juan P. Gutiérrez Jara,[1] Boris A. Lucero,[4] María Pía Muñoz,[12] Muriel Ramírez-Santana,[13] Anna R. Smith,[2] Noemi Tirado,[14] Berna van Wendel de Joode,[15] Gloria M. Calaf,[16,17†] Alexis J. Handal,[18†] Agnes Soares da Silva,[19†] Sandra Cortés,[20†] and Ana M. Mora[2,15†]*

- Se identificaron 233 publicaciones de 16 países que cumplieron con los criterios de inclusión.
- Genotoxicidad, problemas neuroconductuales, efectos placentarios y teratogenicidad, cáncer, función tiroidea, efectos reproductivos, resultados del nacimiento y crecimiento infantil, y otros
- La mayoría de los estudios publicados se realizaron en Brasil (37 %, n= 88) y México (20 %, n= 46)

The evolution of research in Occupational cancer

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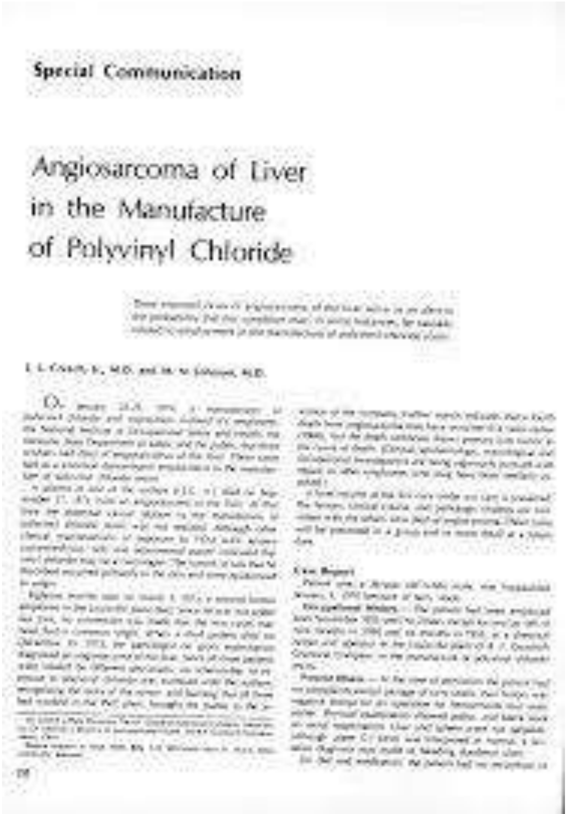
Phases in occupational cancer research

- ***The case-series phase***

Creech JL Jr, Johnson MN. Angiosarcoma of liver in the manufacture of polyvinyl chloride *(J Occup Med. 1974; 16: 150-1)*


Special Communication

Angiosarcoma of Liver in the Manufacture of Polyvinyl Chloride

Between September 1967 and December 1973, 4 cases of angiosarcoma of the liver were diagnosed among men employed in the polyvinyl chloride polymerization section of a B.F. Goodrich plant near Louisville, Kentucky. Angiosarcoma of the liver is an exceedingly rare tumor. It is estimated that only about 25 such cases occur each year in the United States

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Phases in occupational cancer research

- ***The case-series phase***
- ***SMR study phase*** (high risks, fairly simple designs)

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Principal evidence leading to the identification of occupational carcinogens (Group 1 IARC)

Carcinogen	Case Reports	Case-Control	Cohort Retrospective	Cohort Prospective	Mechanistic Data
Aminobiphenyl			x		
Aromatic amines	x		x		
Arsenic	x		x		
Asbestos			x		
Benzene	x	x	x		
Benzidine		x	x		
Beryllium			x		
Cadmium			x		
Chloromethyl ethers				x	
Chromium			x		
Dioxin			x		x
Erionite	x				
Ethylene oxide			x		x
Mustard gas			x		
Nickel					x
Pitch, Tar, Sorts	x				
Radon		x			
Silica					x
Talc	x			x	
Vinyl chloride	x				
Wood dust		x	x		x

Slide by Paolo Vineis

Phases in occupational cancer research

- ***The case-series phase***
- ***SMR study phase*** (high risks, fairly simple designs)
- ***Advanced exposure assessment phase*** (development of advanced methods for exposure assessment in cohort and case-control studies)

Siemiatycki J, Richardson L, Gérin M, Goldberg M, Dewar R, Désy M, Campbell S, Wacholder S. *Associations between several sites of cancer and nine organic dusts: results from an hypothesis-generating case-control study in Montreal, 1979-1983*. Am J Epidemiol. 1986; 123: 235-49.

Trish Stewart, Mustafa Dosemeci (NCI), Hans Kromhout (UU) and many others

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Ana, carrying the 63 occupational modular questionnaires. EPICURO study (Spanish bladder Cancer Study)

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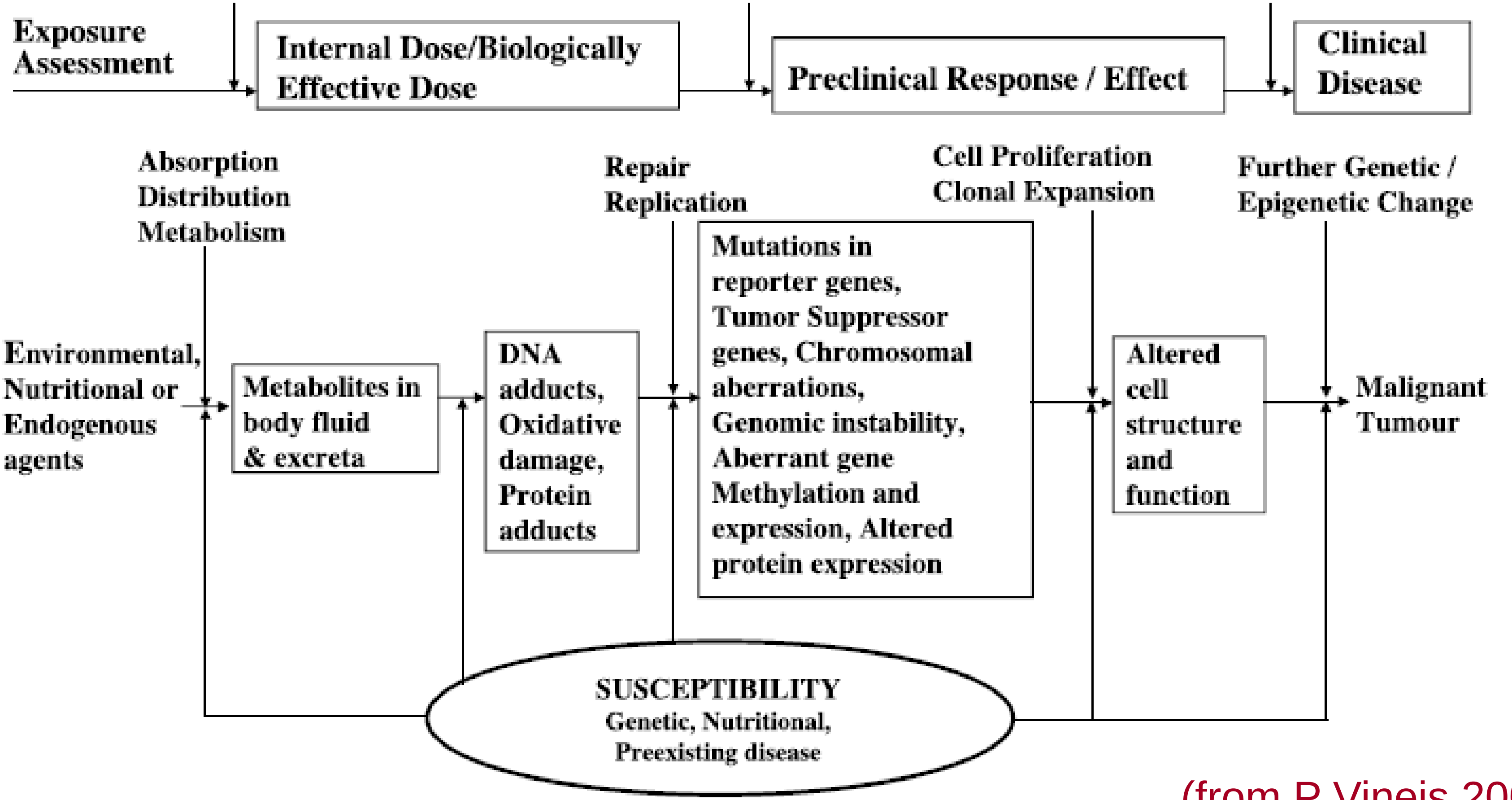
Phases in occupational cancer research

- ***The case-series phase***
- ***SMR study phase*** (high risks, fairly simple designs)
- ***Advanced exposure assessment phase*** (development of advanced methods for exposure assessment in cohort and case-control studies)
- ***Molecular epidemiology phase*** (incorporation of molecular and omic techniques)

Epidemiology

Exposure → Disease and public health action

Molecular epidemiology



(from P Vineis 2007)

Use of mechanistic data – the case of ethylene oxide (IARC 1994)

5.5 Evaluation[1]

There is *limited evidence* in humans for the carcinogenicity of ethylene oxide.

There is *sufficient evidence* in experimental animals for the carcinogenicity of ethylene oxide.

In making the overall evaluation, the Working Group took into consideration the following supporting evidence. Ethylene oxide is a directly acting alkylating agent that:

(i) induces a sensitive, persistent dose-related increase in the frequency of chromosomal aberrations and sister chromatid exchange in peripheral lymphocytes and micronuclei in bone-marrow cells of exposed workers;

(ii) has been associated with malignancies of the lymphatic and haematopoietic system in both humans and experimental animals;

(iii) induces a dose-related increase in the frequency of haemoglobin adducts in exposed humans and dose-related increases in the numbers of adducts in both DNA and haemoglobin in exposed rodents;

(iv) induces gene mutations and heritable translocations in germ cells of exposed rodents; and

(v) is a powerful mutagen and clastogen at all phylogenetic levels.

Overall evaluation

Ethylene oxide *is carcinogenic to humans (Group 1).*

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Phases in occupational cancer research

- ***The case-series phase***
- ***SMR study phase*** (high risks, fairly simple designs)
- ***Advanced exposure assessment phase*** (development of advanced methods for exposure assessment in cohort and case-control studies)
- ***Molecular epidemiology phase*** (incorporation of molecular and omic techniques)
- ***Newer trends: exposome*** *(external and internal and pathways)**; pooled analyses** (sharing of data)**; record linkage** (big data)**; emphasis on cohort studies*** (with exceptions); **new approaches to *causal inference***

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The Exposome

G E

Recognizing the disparity in current knowledge between genes and environmental exposures, Chris Wild (2005) defined the "exposome" representing *all environmental exposures (including those from diet, lifestyle, and endogenous sources) from conception onwards,* as a quantity of critical interest to disease etiology.

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Features of the Exposome

1. Holistic – many exposures
2. Life-course – dynamic
3. New tools / technology
4. Integrate biological responses (“internal exposome”)
5. Untargeted discovery

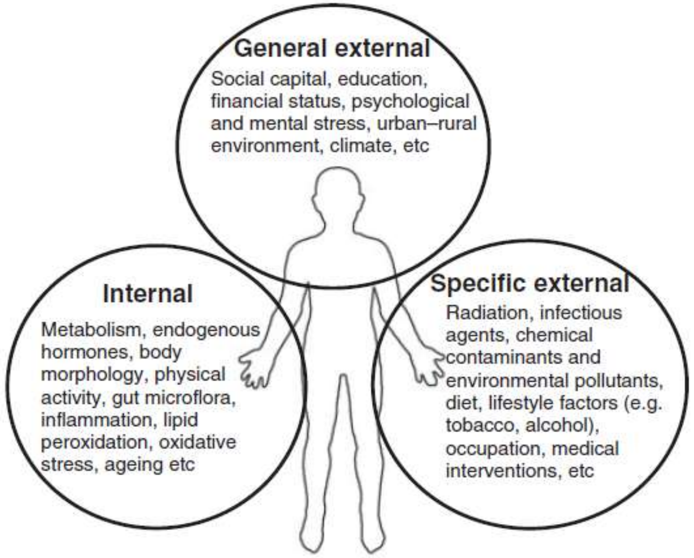
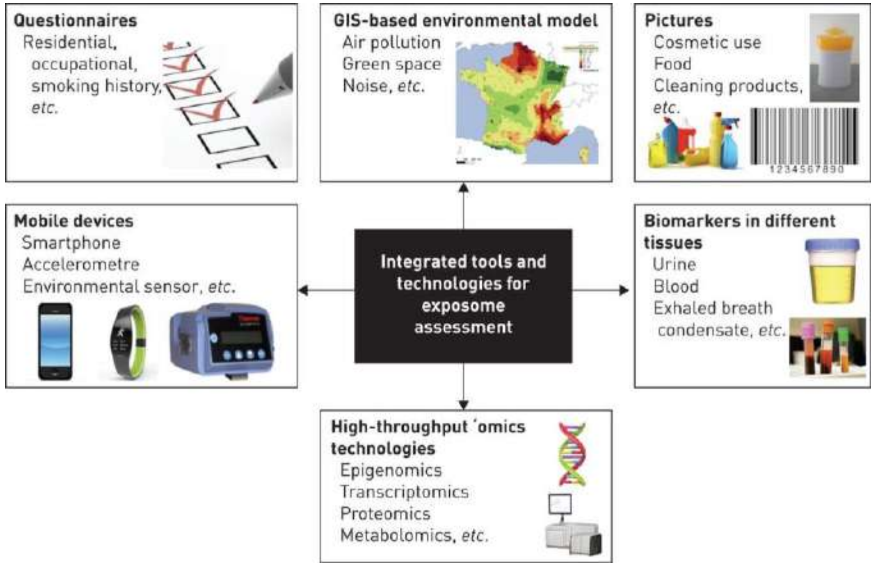
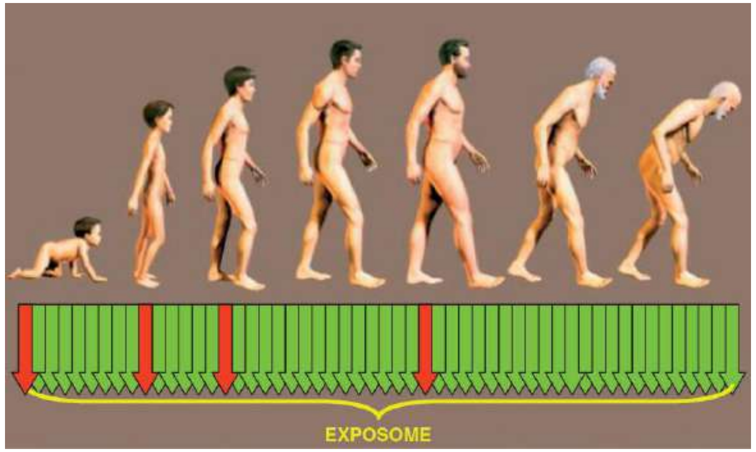


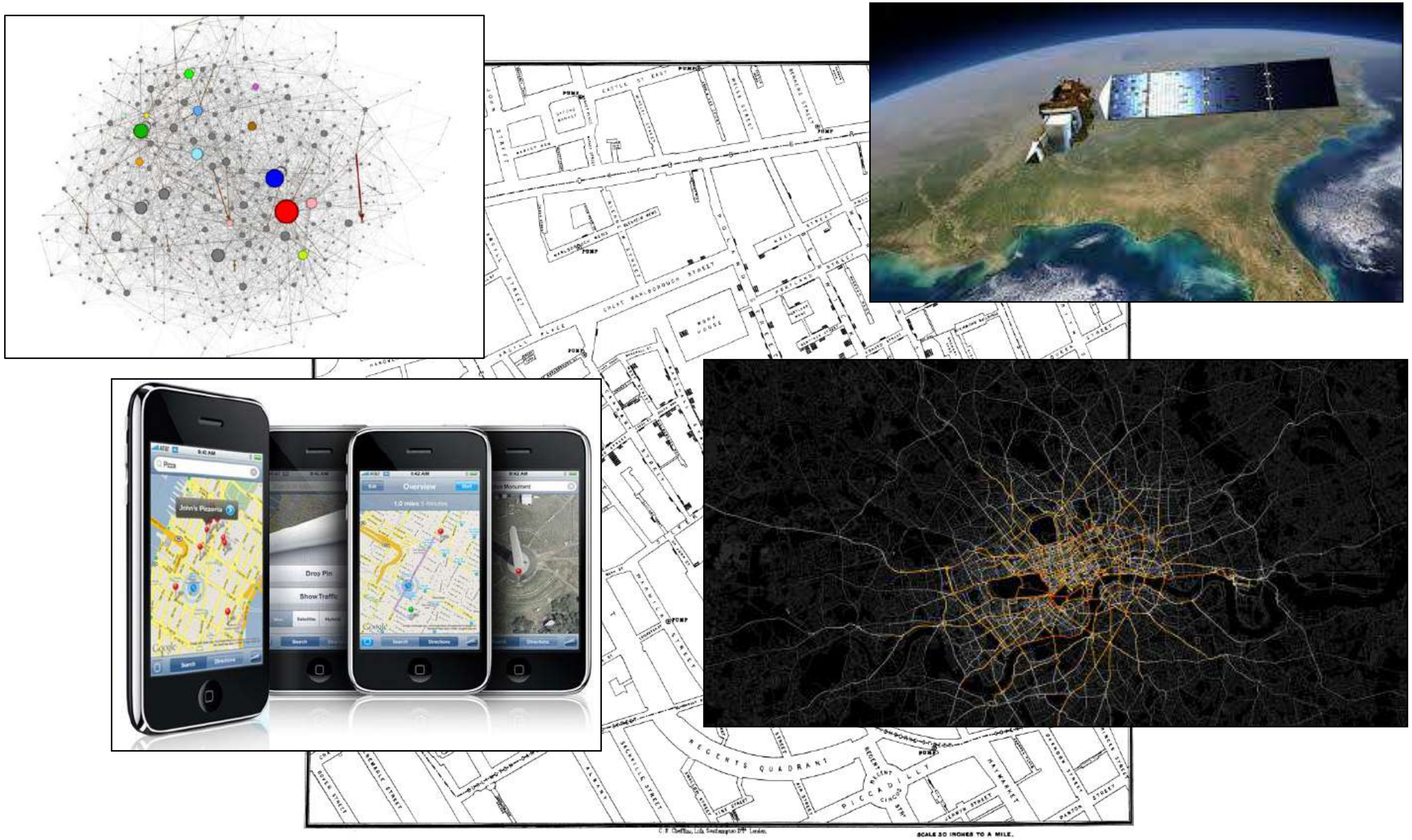
Figure 1 Three different domains of the exposome are presented diagrammatically with non-exhaustive examples for each of these domains



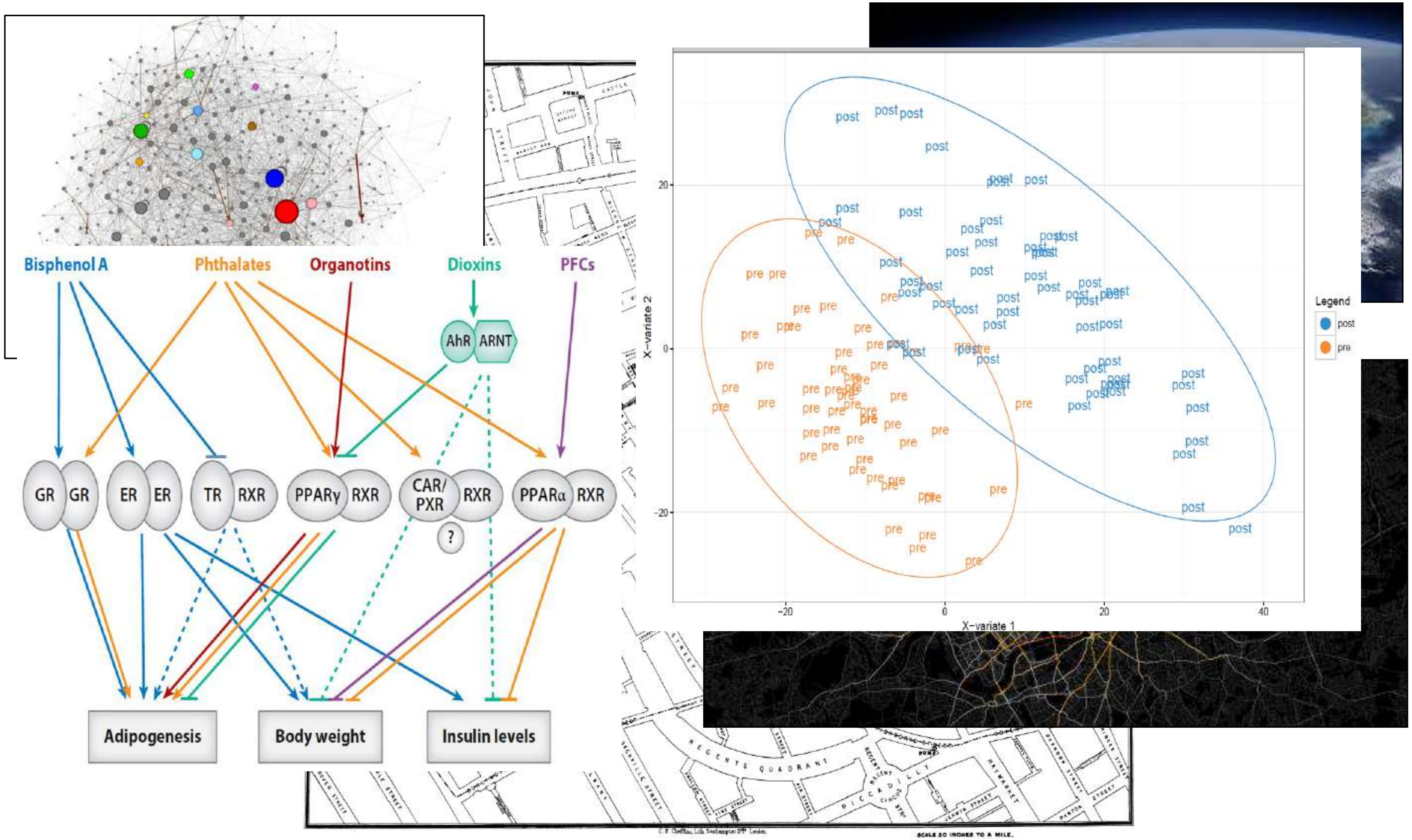


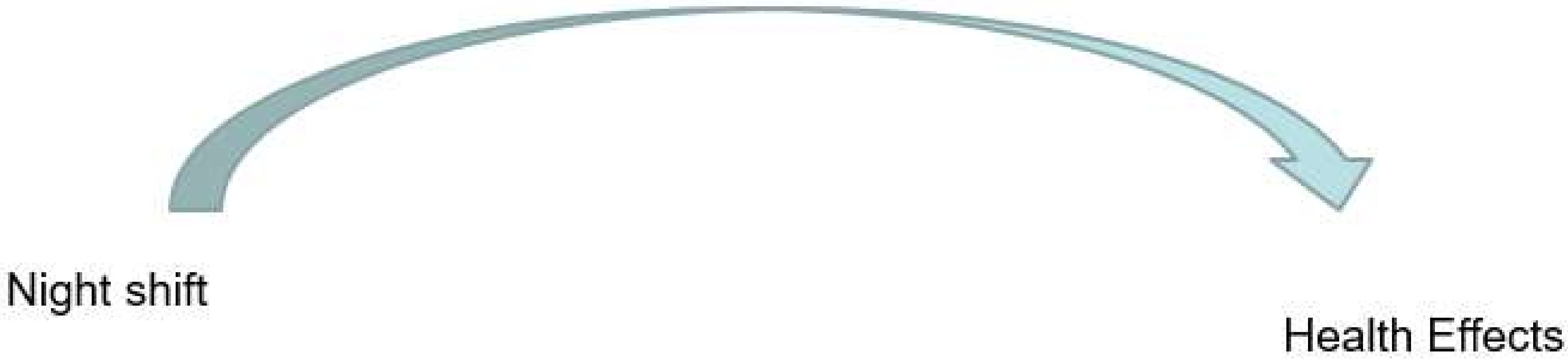
Wild, Int J Epidemiol, 2012

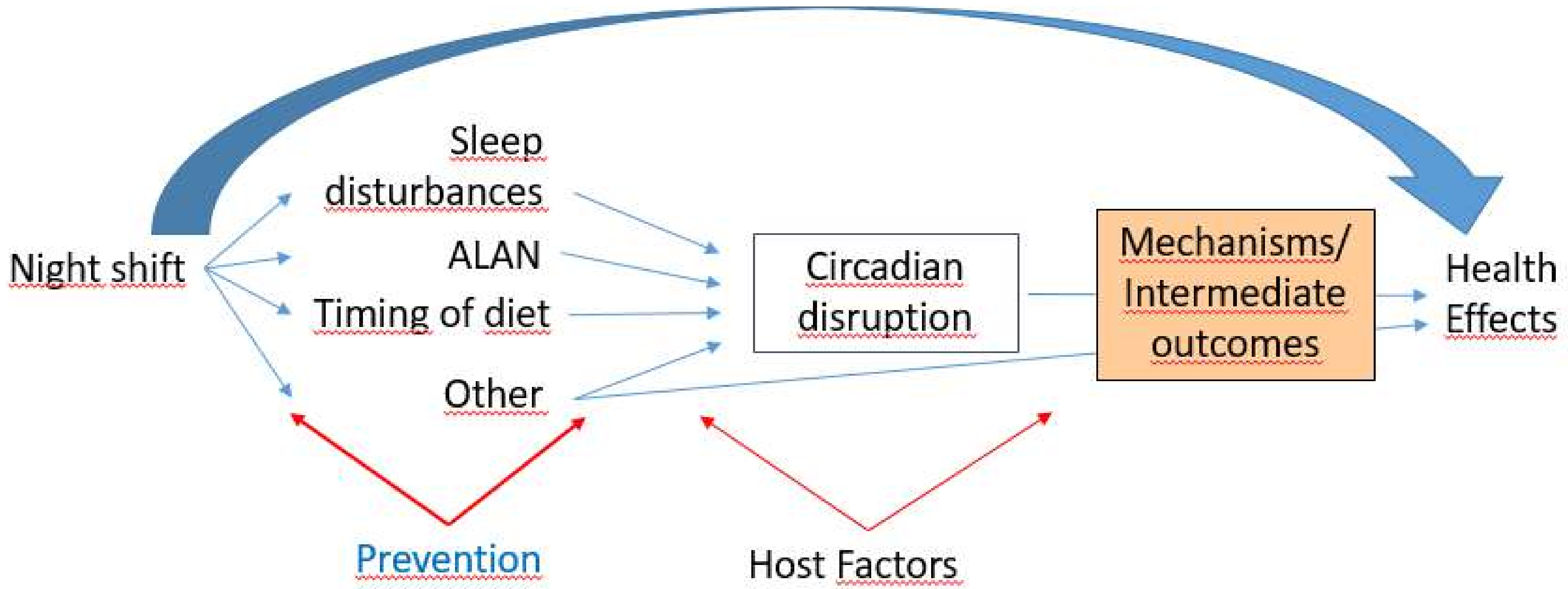
“Modern” Epidemiology



“Modern” Epidemiology




Night shift
Health Effects


Night shift
Sleep disturbances
ALAN
Timing of diet
Other
Circadian disruption
Mechanisms/ Intermediate outcomes
Health Effects
Prevention
Host Factors

Pooling of data

European Journal of Epidemiology (2018) 33:369–379
https://doi.org/10.1007/s10654-018-0368-x

META-ANALYSIS

CrossMark

Night shift work and breast cancer: a pooled analysis of population-based case–control studies with complete work history

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Occupational heat exposure and prostate cancer risk: A pooled analysis of case-control studies

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IEA
International Epidemiological Association

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Original article

Occupational Exposures

Occupational exposures and odds of gastric cancer: a StoP project consortium pooled analysis

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Network on the Coordination and Harmonisation of European Occupational Cohorts (OMEGA-NET)

COST Action: CA16216
Duration: 4 years starting in October 2017

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cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

STAMI NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH

ISGlobal Barcelona Institute for Global Health


6 September 2021

HERA

Health Environment Research Agenda for Europe

EU RESEARCH AGENDA FOR THE ENVIRONMENT, CLIMATE & HEALTH 2021-2030

FINAL DRAFT

HERA CONSORTIUM

HERA project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 825417.

European research agenda on environment, climate and health

Project coordinated by R Barouki, INSERM and M Kogevinas ISGlobal

HERA was a Horizon 2020 coordination and support action project. It developed a European research and innovation agenda on environment, climate and health covering key strategic research and policy aspects. This has been extensively used by the EC.

25 centers and hundreds of researchers and stakeholders contributing

The project has ended but the centers have activated a new coordination action (SPHERA)

https://spheraresearch.org/the-consortium/

Inserm
Institut national de la santé et de la recherche médicale

ISGlobal Barcelona Institute for Global Health

Research Goal 2.4 Changing work and employment conditions

- Climate change, key enabling technologies, the Green Deal and occupational health
- Changing and ageing workforce
- Working time
- Changing employment patterns
- Neglected occupational diseases
- Monitoring, electronic health records, and surveillance in occupational health

HERA
Health Environment Research Agenda

Prevention of Occupational Cancer

	Involuntary	Voluntary
Preventable	Occupation	Tobacco
No Preventable	Genetics	Reproductive factors

Involuntary + Preventable ➔ High priority for public health

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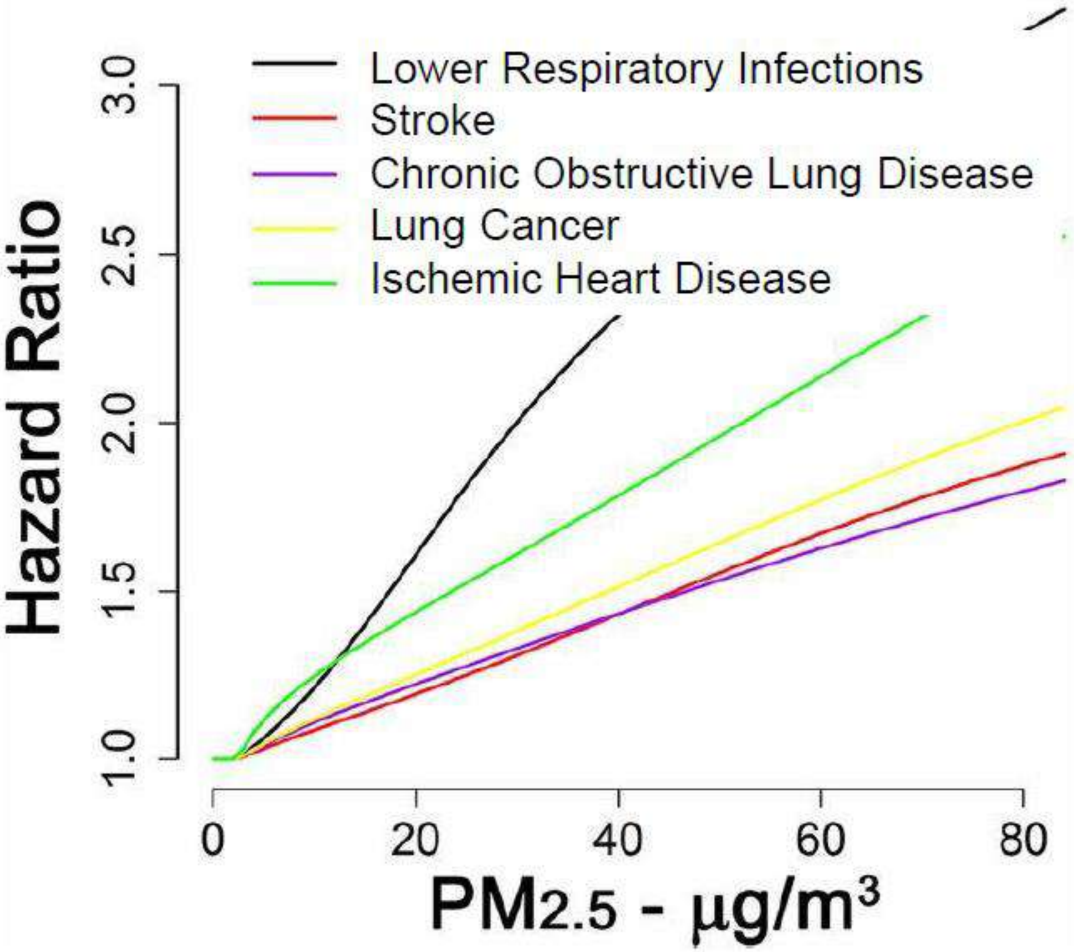
Environment and Cancer

(a very sketchy introduction)

Outdoor air-pollution, Delhi, India

New dose-response curves and stronger evidence on cause specific mortality (Burnett, PNAS 2018)



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Indoor air pollution

The NEW ENGLAND JOURNAL of MEDICINE

SPECIALTIES | TOPICS | MULTIMEDIA | CURRENT ISSUE | LEARNING/CME | AUTHOR CENTER | PUBLICATIONS

ORIGINAL ARTICLE

Effects of Cooking with Liquefied Petroleum Gas or Biomass on Stunting in Infants

Authors: William Checkley, M.D., Ph.D., Lisa M. Thompson, R.N., Ph.D., Sheela S. Sinharoy, Ph.D., Shakir Hossen, M.B., B.S., M.S.P.H., Lawrence H. Moulton, Ph.D., Howard H. Chang, Ph.D., Lance Waller, Ph.D., +29, for the HAPIN Investigators* Author Info & Affiliations

Published January 3, 2024 | N Engl J Med 2024;390:44-54 | DOI: 10.1056/NEJMoa2302687 | VOL. 390 NO. 1

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Water

Arsenic in drinking water

Photo from IARC Monograph 2004

Art exhibition, Dhaka, Bangladesh

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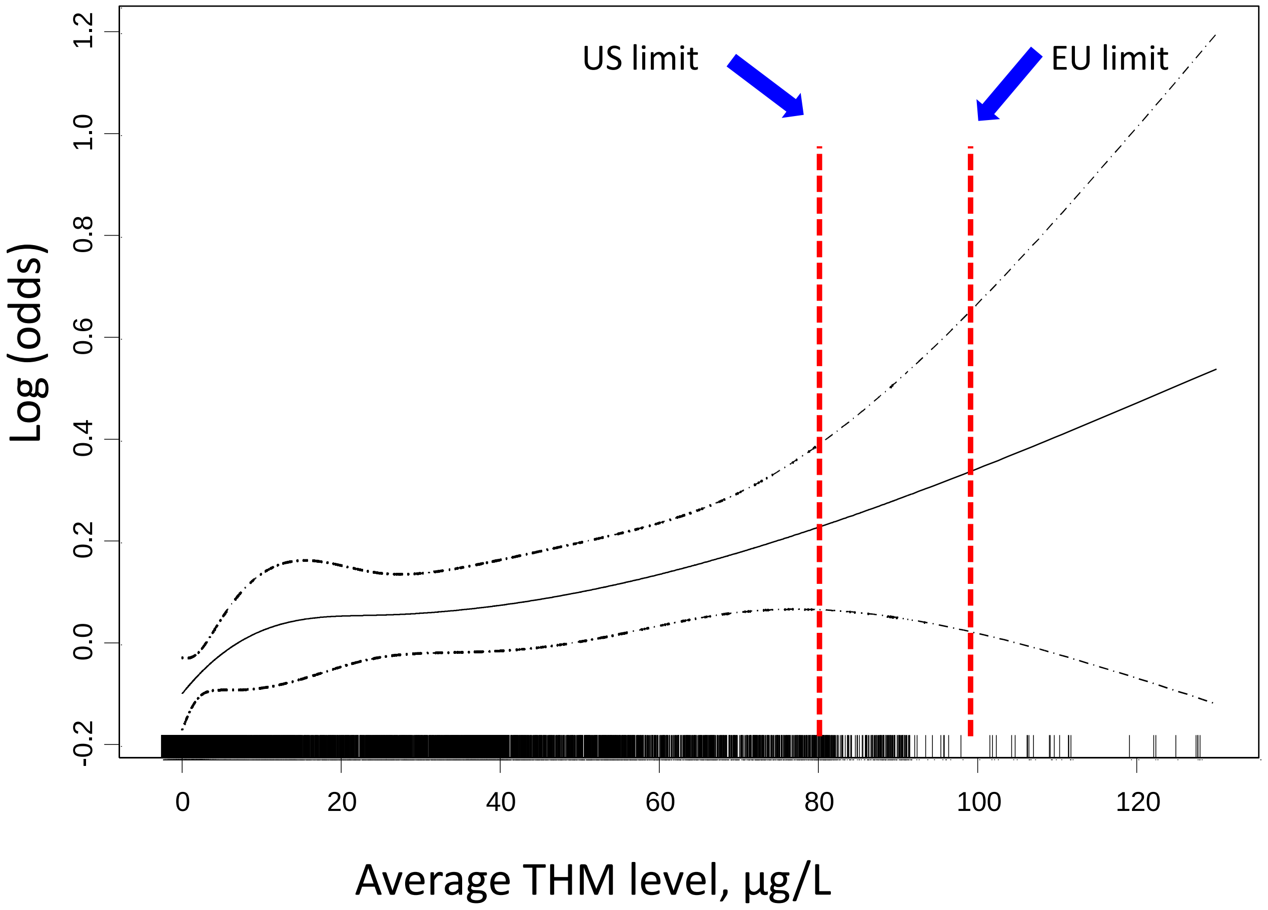
Chemicals in water: Disinfection by-products (DBPs)

Disinfectant (e.g. chlorine) + organic matter → DBPs

- First detected in 1974
- Complex mixture ≈ 700 compounds
- Most common: Trihalomethanes (THM): $CHCl_3$, $CHCl_2Br$, $CHClBr_2$, $CHBr_3$
- Maximum level EU: 100 µg/L; USA 80 µg/L
- Several prevalent DBPs are animal carcinogens (at high doses)
- Several less prevalent are more toxic than THMs

Pooled analysis case-control studies. Bladder cancer risk and average exposure to trihalomethanes (THMs), both sexes



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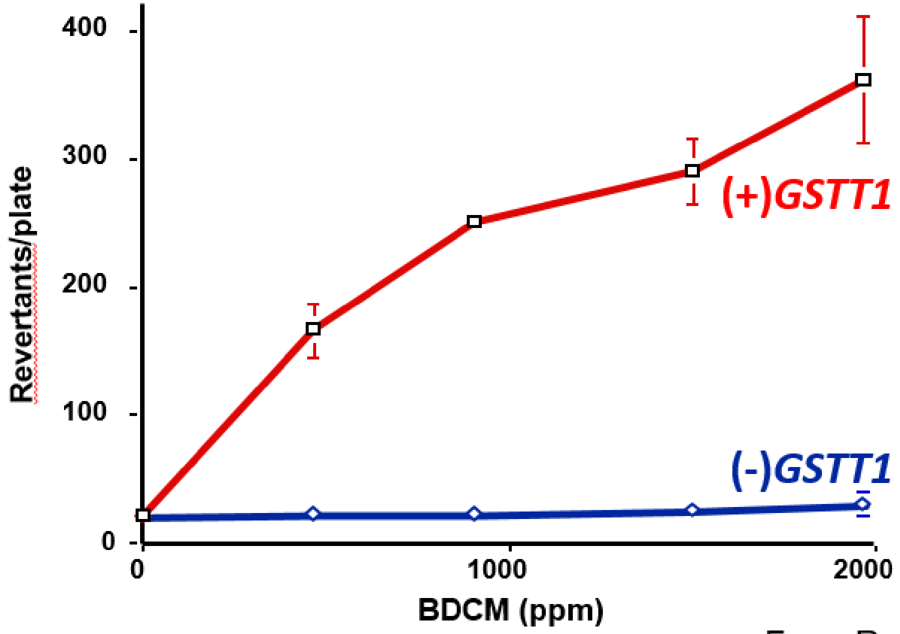
(Villanueva, Epidemiology 2004)

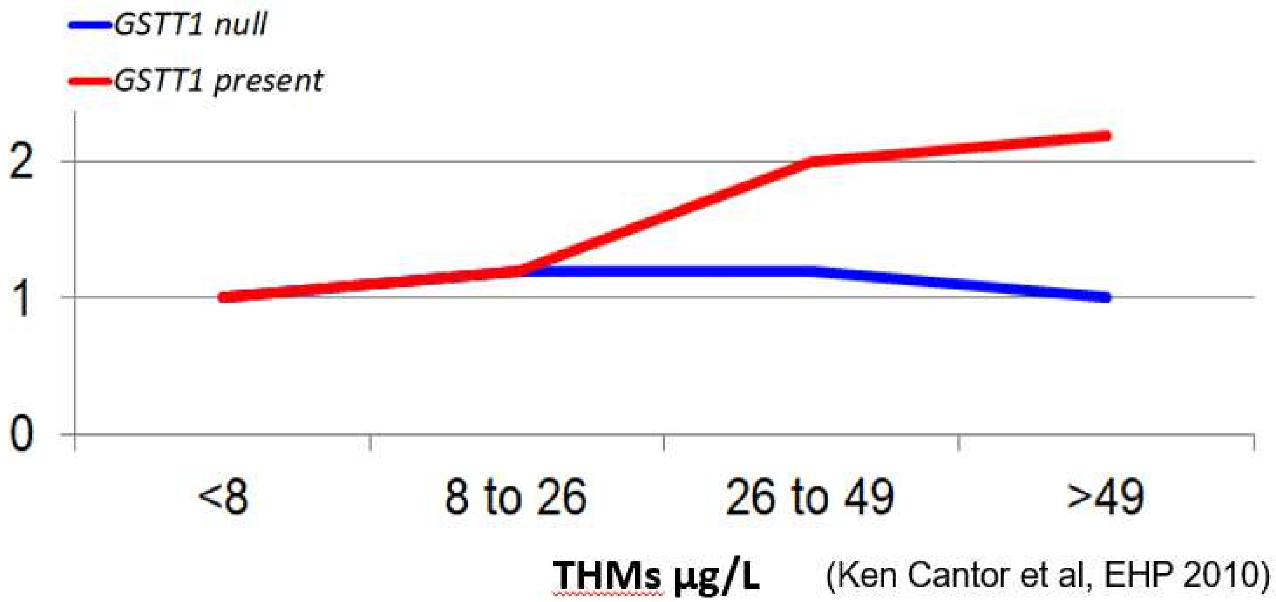
Glutathione S-Transferase Theta (*GSTT1*) metabolizes brominated THMs to mutagenic intermediates

Mutations produced in Salmonella TA1535 (+)GSTT1 and (-)GSTT1 by bromodichloromethane



From Rex Peg

Odds Ratios for the combined effects of polymorphic forms of *GSTT1* and trihalomethane (THM) levels in water on bladder cancer risk, Spain



(Ken Cantor et al, EHP 2010)

Haloalkanes
Chloroform
Bromodichloromethane
Dibromochloromethane
Bromoform
Dibromomethane
Bromotrichloromethane
Dibromodichloromethane
1,1,2-Trichloroethane

Haloacetic acids
Chloroacetic acid
Bromoacetic acid
Dichloroacetic acid
Bromochloroacetic acid
Dibromoacetic acid
Trichloroacetic acid
Bromodichloroacetic acid
Dibromochloroacetic acid
Tribromoacetic acid

Other Haloacids
3-Bromopropenoic acid
2,2-Dichloropropanoic acid
3,3-Dichloropropenoic acid
cis-2,3-Bromochloropropenoic acid
trans-2,3-Bromochloropropenoic acid
2,3-Dibromopropanoic acid
cis-2,3-Dibromopropenoic acid
trans-2,3-Dibromopropenoic acid
3,3-Dibromopropenoic acid
Trichloropropenoic acid
2-Bromo-3,3-dichloropropenoic acid
(E)-3-Bromo-2,3-dichloropropenoic acid
(Z)-3-Bromo-2,3-dichloropropenoic acid
2,2-Dichlorobutanoic acid
cis-Bromobutenoic acid
trans-Bromobutenoic acid
2,2-Dichlorobutenoic acid
2,3-Dibromobutenoic acid
2-Chloro-3-methylbutanoic acid
Chlorophenylacetic acid
3,5-Dibromobenzoic acid
Tribromopropenoic acid

Halo-di-acids
cis-Bromobutenedioic acid
trans-Bromobutenedioic acid
cis-Dichlorobutenedioic acid
trans-Dichlorobutenedioic acid
cis-Bromochlorobutenedioic acid
trans-Bromochlorobutenedioic acid
cis-Dibromobutenedioic acid
(E)-2-Chloro-3-methylbutenedioic acid
(*E*)-2-Bromo-3-methylbutenedioic acid

Haloaldehydes
Dichloroacetaldehyde
Bromochloroacetaldehyde
Dibromoacetaldehyde
Trichloroacetaldehyde (chloral hydrate)
Bromodichloroacetaldehyde
Dibromochloroacetaldehyde
Tribromoacetaldehyde
3-Bromo-4-methoxybenzaldehyde

Haloketones
Bromopropanone
1,1-Dichloropropanone
1-Bromo-1-chloropropanone
1,1-Dibromopropanone
1,3-Dibromopropanone
1,1,1-Trichloropropanone
1,1,3-Trichloropropanone
1-Bromo-1,1-dichloropropanone
1,1,1-Tribromopropanone
1,1,3,3-Tetrachloropropanone
1,1-Dibromo-3,3-dichloropropanone
Pentachloropropanone
Dichlorofurandione
1-Chloro-2-butanone
1-Bromo-2-butanone
Tetrachlorohydroquinone

Halonitromethanes
Dibromonitromethane

Haloamides
Dichloroacetamide
Bromochloroacetamide
Dibromoacetamide
Bromodichloroacetamide
Dibromochloroacetamide
Tribromoacetamide

Haloalcohols
2,2,2-Trichloroethanol
1,1,1-Trichloropropanol

Other halogenated DBPs
3-Chlorobenzeneacetonitrile
2,6-Dichloro-4-methylphenol
2-Bromo-4-chlorophenol
Trichlorophenol
Bromodichlorophenol
Tribromophenol
2-Bromo-4-chloro-6-methylphenol
Dibromomethylphenol
2,4-Dibromo-1-methoxybenzene
2,3,4-Trichlorobenzeneamine
Dibromochloroaniline
2-Bromo-4-chloroanisole
3,4,5-Tribromo-*1H*-pyrazole
2,6-Dibromo-4-nitrophenol
2,6-Dibromo-4-nitrobenzeneamine

Non-halogenated DBPs/contaminants
Propionamide
Benzaldehyde
Benzoic acid methyl ester
Benzeneacetonitrile
Phthalic acid
Diethylphthalate
Benzophenone
Halonitriles
Bromoacetonitrile
Dichloroacetonitrile
Bromochloroacetonitrile
Dibromoacetonitrile
Trichloroacetonitrile

More than 100 DBPs (disinfection by-products) identified in 2 swimming pools in Barcelona

(Richardson et al, EHP 2010)

Haloalkanes
Chloroform
Bromodichloromethane
Dibromochloromethane
Bromoform
Dibromomethane
Bromotrichloromethane
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Dibromomethylphenol
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2,3,4-Trichlorobenzeneamine
Dibromochloroaniline
2-Bromo-4-chloroanisole
3,4,5-Tribromo-*1H*-pyrazole
2,6-Dibromo-4-nitrophenol
2,6-Dibromo-4-nitrobenzeneamine

Non-halogenated DBPs/contaminants
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Benzaldehyde
Benzoic acid methyl ester
Benzeneacetonitrile
Phthalic acid
Diethylphthalate
Benzophenone
Halonitriles
Bromoacetonitrile
Dichloroacetonitrile
Bromochloroacetonitrile
Dibromoacetonitrile
Trichloroacetonitrile

Chloroform
Bromodichloromethane
Chlorodibromomethane
Bromoform

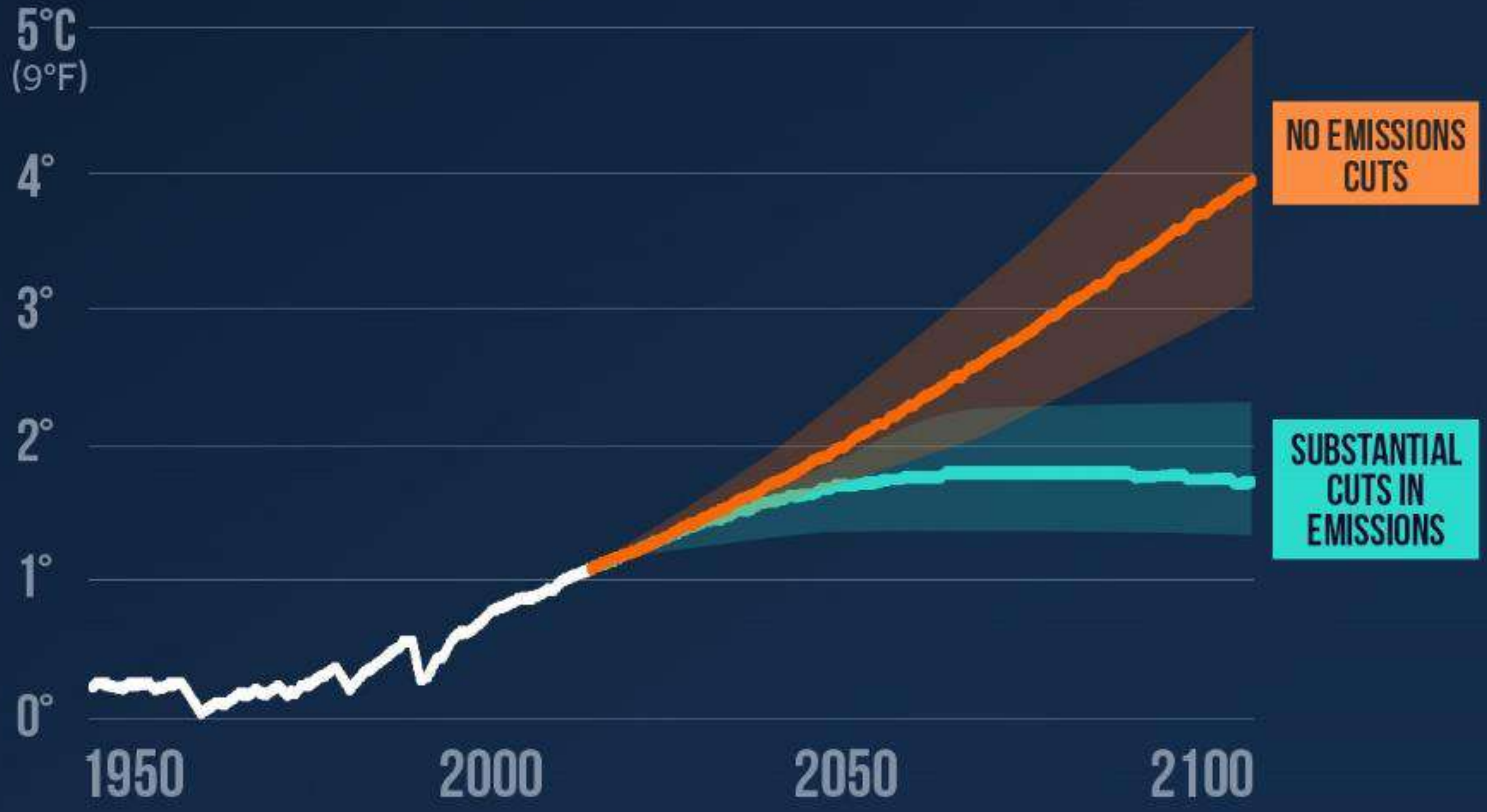
More than 100 DBPs (disinfection by-products) identified in 2 swimming pools in Barcelona

(Richardson et al, EHP 2010)

The evaluation of mixtures is complex and with a difficult solution. Recent advances in the statistical analysis of mixtures

FUTURE TEMPERATURES

WARMING DEPENDS ON CHOICES TODAY



Global surface temperature (°C) anomaly relative to 1850-1900
High warming scenario: SSP3-7, Low warming scenario from SSP1-2.6.
Source: IPCC AR6 WG1

CLIMATE CENTRAL

Infections and Cancer: which could be affected by climate change?

- Some more than others, but we do not have valid predictions and modeling of future changes
- *H. Pylori (stomach cancer)*
- *S Haematobium (Bladder cancer)*
- *Hepatitis viruses, perhaps through indirect mechanisms*
- *EBV, Burkitt's lymphoma in connection with changes in malaria?*
- *Lyme's disease, non-Hodgkin's lymphoma-subtypes??*
- *Zika virus, glioblastomas??*

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We have limited knowledge on potential effects of climate change on cancer

Occupational and Environmental cancer

- About 4% of all cancers are due to work exposures, but varies by country. Estimates for environmental exposures are not well developed
- Exposures to well-identified carcinogens are still here!
- Environmental and particularly workplace exposures decline in high-income countries and increase in middle-income countries
- New risks arise, including climate change
- Historically very productive cancer research (with important findings and some failures); boost from exposome research (environment)
- Valid exposure assessment is a key characteristic of studies on occupational & environmental cancer
- Environmental and Occupational cancer prevention is a global problem!

HTTPS://EPICOH2024.ORG/

THE CONFERENCE WILL HIGHLIGHT RESEARCH FROM EARLY CAREER RESEARCHERS & WILL INCLUDE EXCITING KEYNOTE LECTURES, NETWORKING ACTIVITIES, & MORE!

Barbara Harding

Kurt Straif

Gemma Castaño

Ana Espinosa

Kyriaki Papantoniou

Anna Palomar

Camille Lassale

Marina Ruiz, ISGlobal, ***Jordi Julvez***, Univ RiV, effects on cognition and mental health
Raquel Galan, *ISGlobal*, ***Climent Casals,*** microbiome, Hosp Clinic/ISGlobal
Ana Alfaro, Cristina Marquez, Maria Mata, Lourdes Arjona, field work, ISGlobal
Carlota Dobaño, Ruth Aguilar, Gemma Moncunill, Immunology, ISGlobal
Mariona Bustamante, Genetics, ISGlobal
Antonia Valentin, Marta Cirach, GIS group, ISGlobal
Oscar Pozo, Alex Gomez-Gomez. Hormones, IMIM, Barcelona
Rafa de Cid, **GCAT cohort,** IGTP, Badalona
Silvia Perez, Roderic Guigo, RNA analyses, CRG, Barcelona
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Josep Maria Ramada, Consol Serra, salut laboral, HMAR