Session magistrale

Pollution atmosphérique, exposome et santé

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Après la revolution génomique, La revolution exposomique

Les ingrédients d'une révolution!

- Des questions sociétales et scientifiques majeures

- Une réelle prise de conscience

- Des concepts convergents

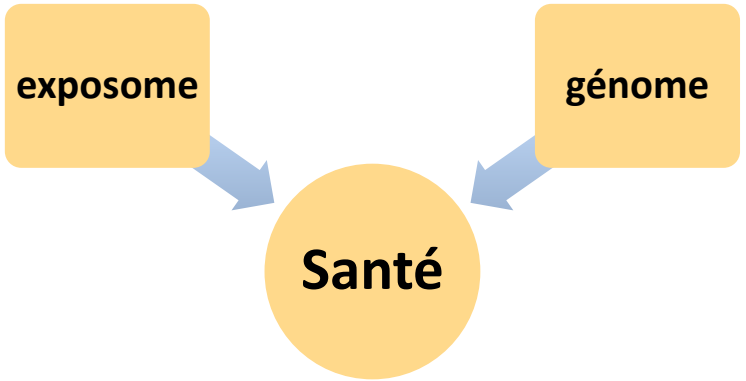
- De grands progrès technologiques

Cancer Epidemiol Biomarkers Prev 2005;14(8). August 2005

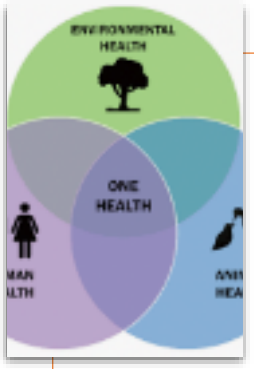
Editorial

Complementing the Genome with an "Exposome": The Outstanding Challenge of Environmental Exposure Measurement in Molecular Epidemiology

Christopher Paul Wild



Les grands concepts

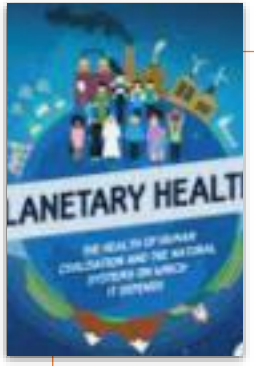


One Health (WHO)

- Ecosystems and human health related
- infections and all stressors

Global Health (UN)

- Worldwide health matters to all countries
- reducing disparities is critical



Planetary Health (Lancet)

- Human health and its dependency on Earth's ecosystems
- Implies planetary boundaries (or earth system boundaries)

Exposome

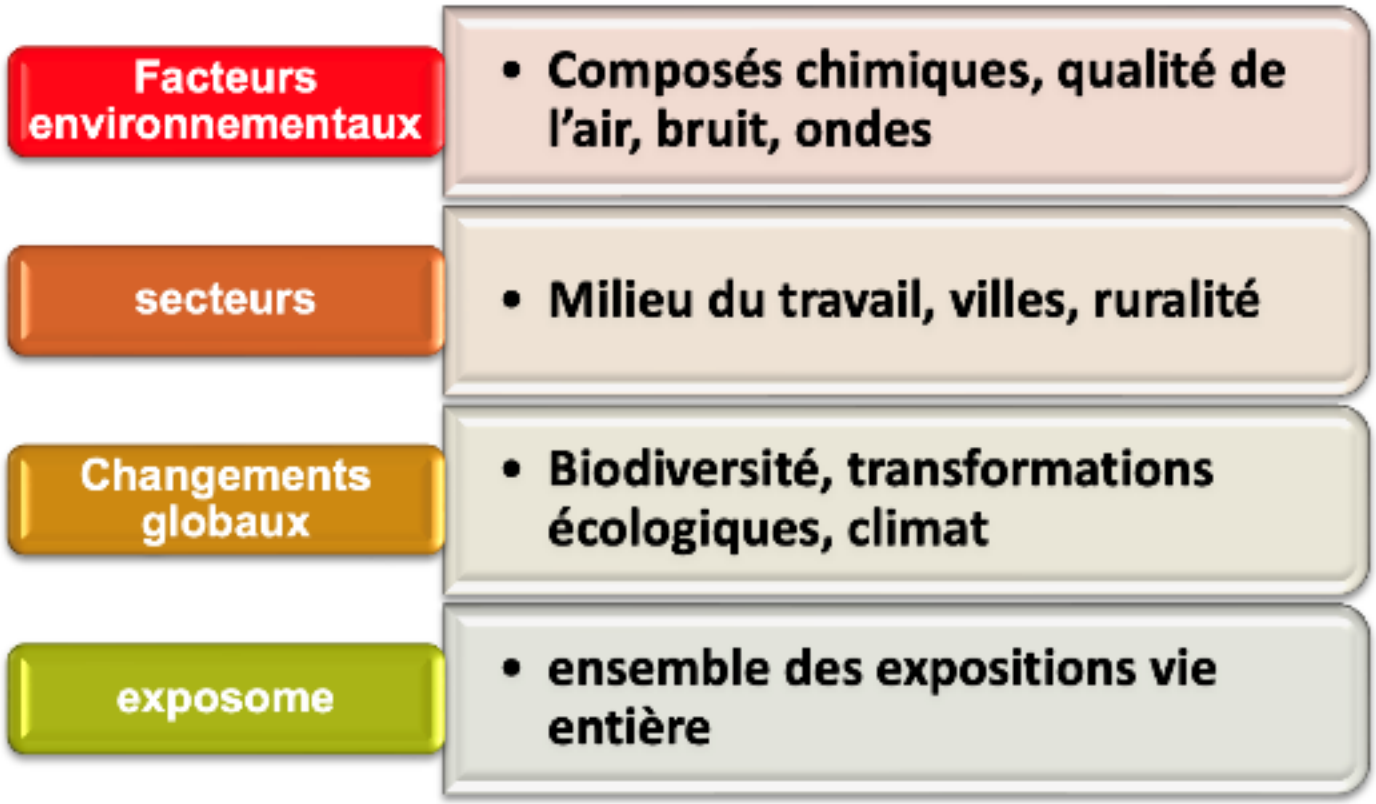
- all environmental stressors all life-long
- complements the genomes

Le champ environnement santé

focal

local

global



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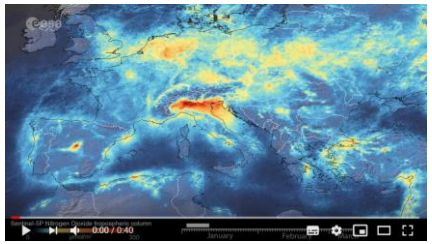
Contributions au Concept d'Exposome

Wild

- **All life-course environmental exposures** from prenatal period onwards; includes internal body processes, external exposures, and lifestyle factors.

Les technologies de l’exposome: détecteurs et satellites

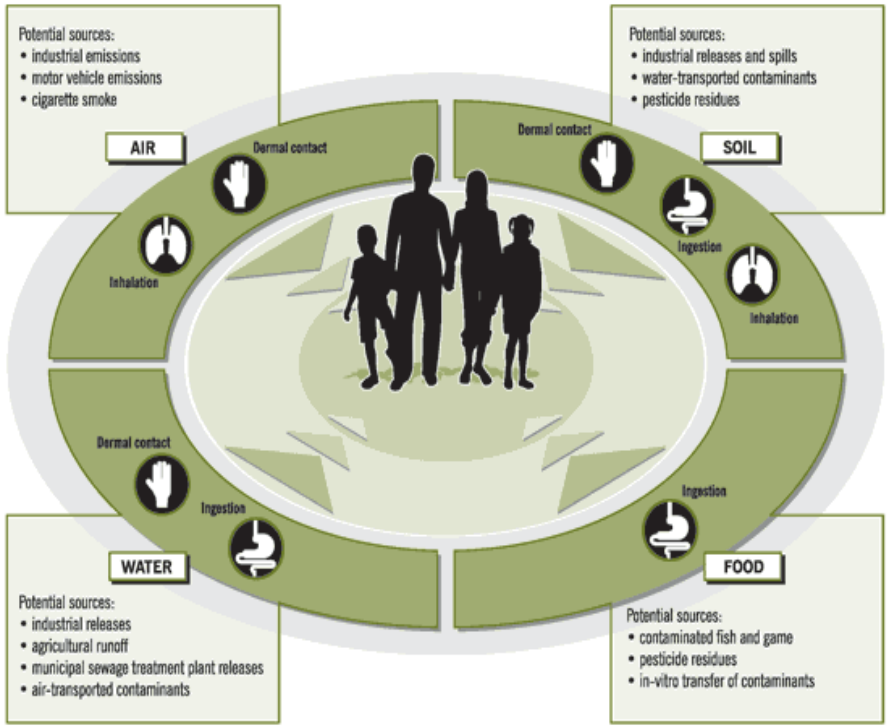
Satellites: pollution de l’air, lumière nocturne



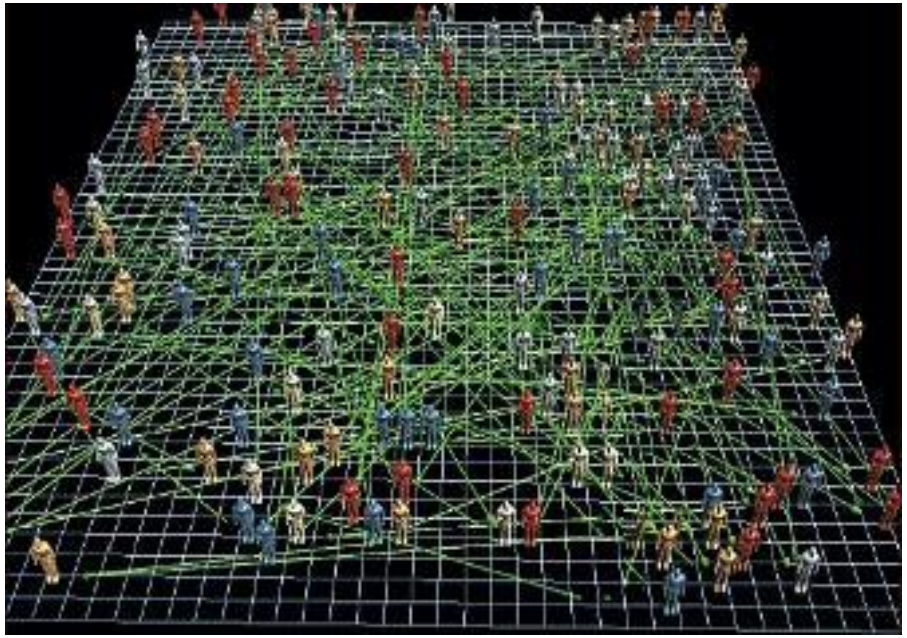
Détecteurs environnementaux: particules, bruit

Capteurs individuels: substances chimiques, poussières, particules, bruit

Les technologies de l'exposome: modélisations



De l'exposition externe à l'exposition interne



Modélisatiion de l'exposition d'un individu

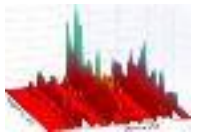
Les technologies de l'exposome: études de populations humaines

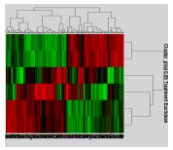
Exposure and Effect biomarkers

Human bio-monitoring

PBTK

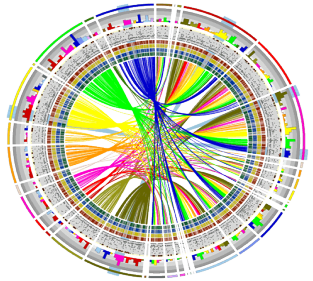
OMICS



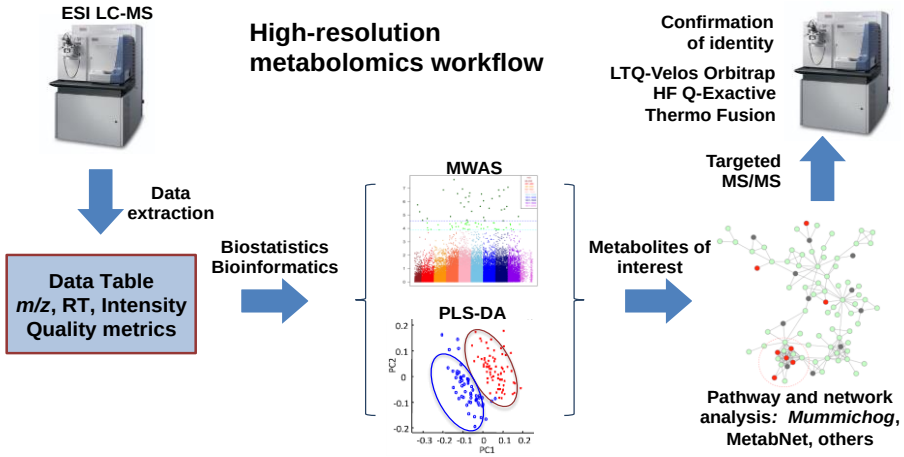


omiques

EWAS: Environment wide association studies
GEWIS: Genome-Environment wide interaction studies



cohortes

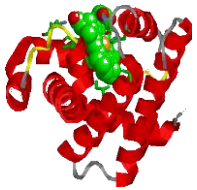


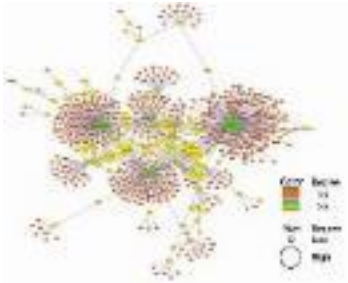
Spectrométrie de masse

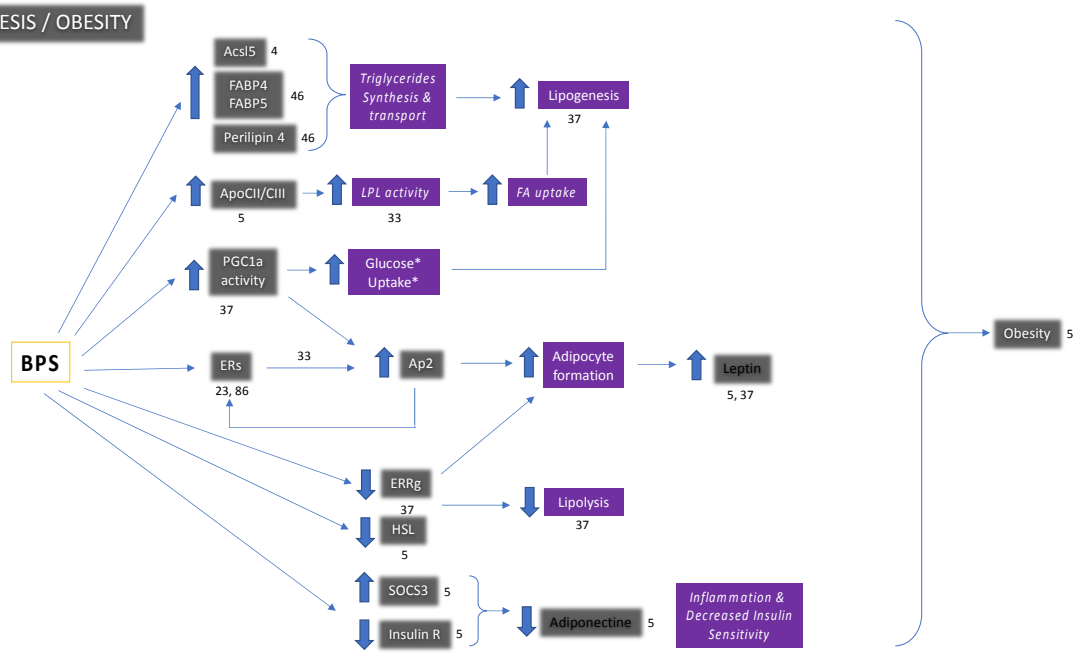
Bioinformatique
Biostatistiques
Science des données

Les technologies de l'exposome: études expérimentale

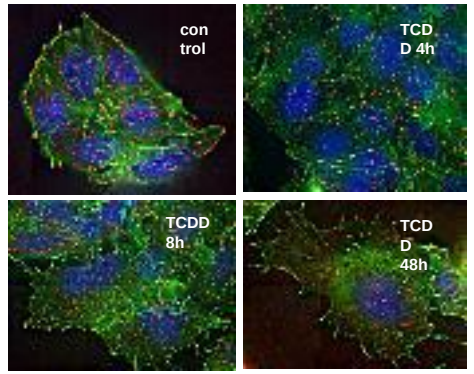
mécanismes







Formalisation des voies biologiques de toxicité



Nouveaux modèles cellulaires

Pollution et Santé

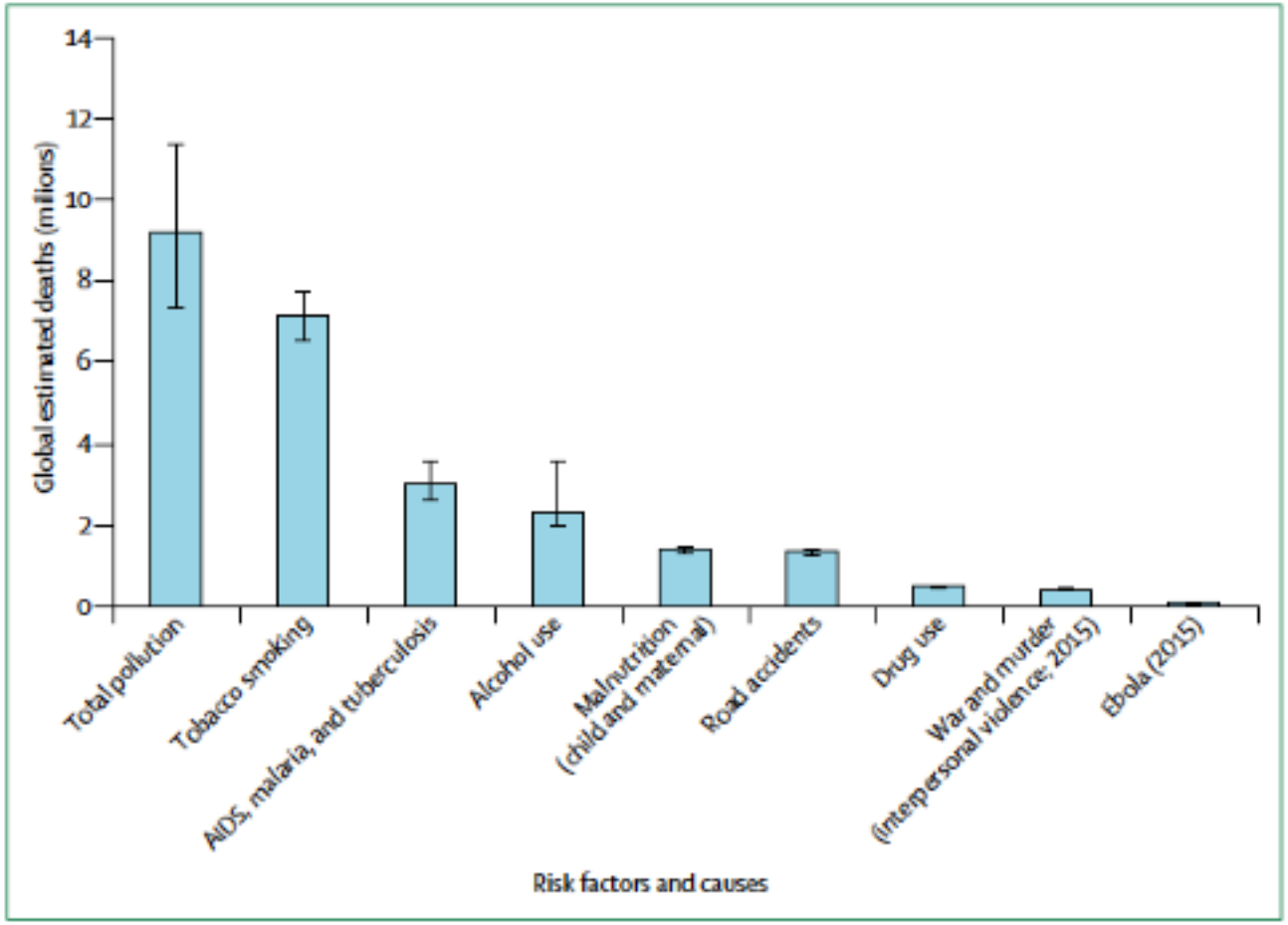


Figure 5: **Global estimated deaths by major risk factor and cause, 2015**
Using data from the GBD Study, 2016.[41]

La pollution de l'air est le plus grand contributeur à la mortalité par pollution

7 million de morts par an

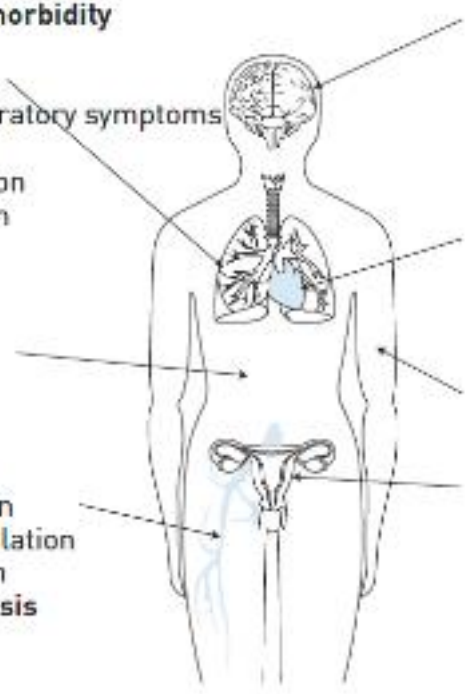
Landrigan et al, Lancet, 2018

Effets de la pollution de l'air sur la santé

Respiratory disease mortality
Respiratory disease morbidity
Lung cancer
Pneumonia
Upper and lower respiratory symptoms
Airway inflammation
Decreased lung function
Decreased lung growth

Insulin resistance
Type 2 diabetes
Type 1 diabetes
Bone metabolism

High blood pressure
Endothelial dysfunction
Increased blood coagulation
Systemic inflammation
Deep venous thrombosis



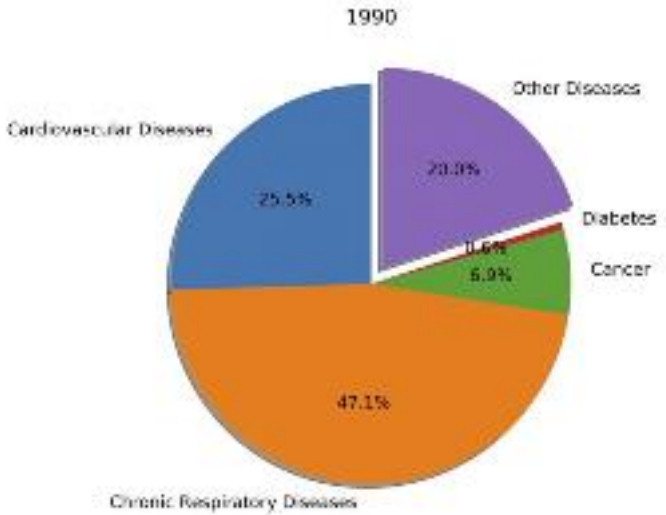
Stroke
Neurological development
Mental health
Neurodegenerative diseases

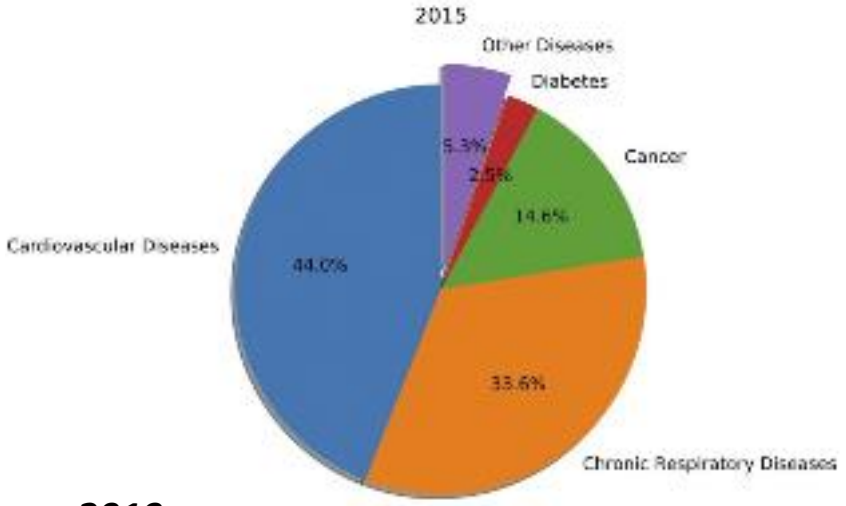
Cardiovascular disease mortality
Cardiovascular disease morbidity
Myocardial infarction
Arrhythmia
Congestive heart failure
Changes in heart rate variability
ST-segment depression

Skin ageing

Premature birth
Decreased birthweight
Decreased fetal growth
Intrauterine growth retardation
Decreased sperm quality
Pre-eclampsia

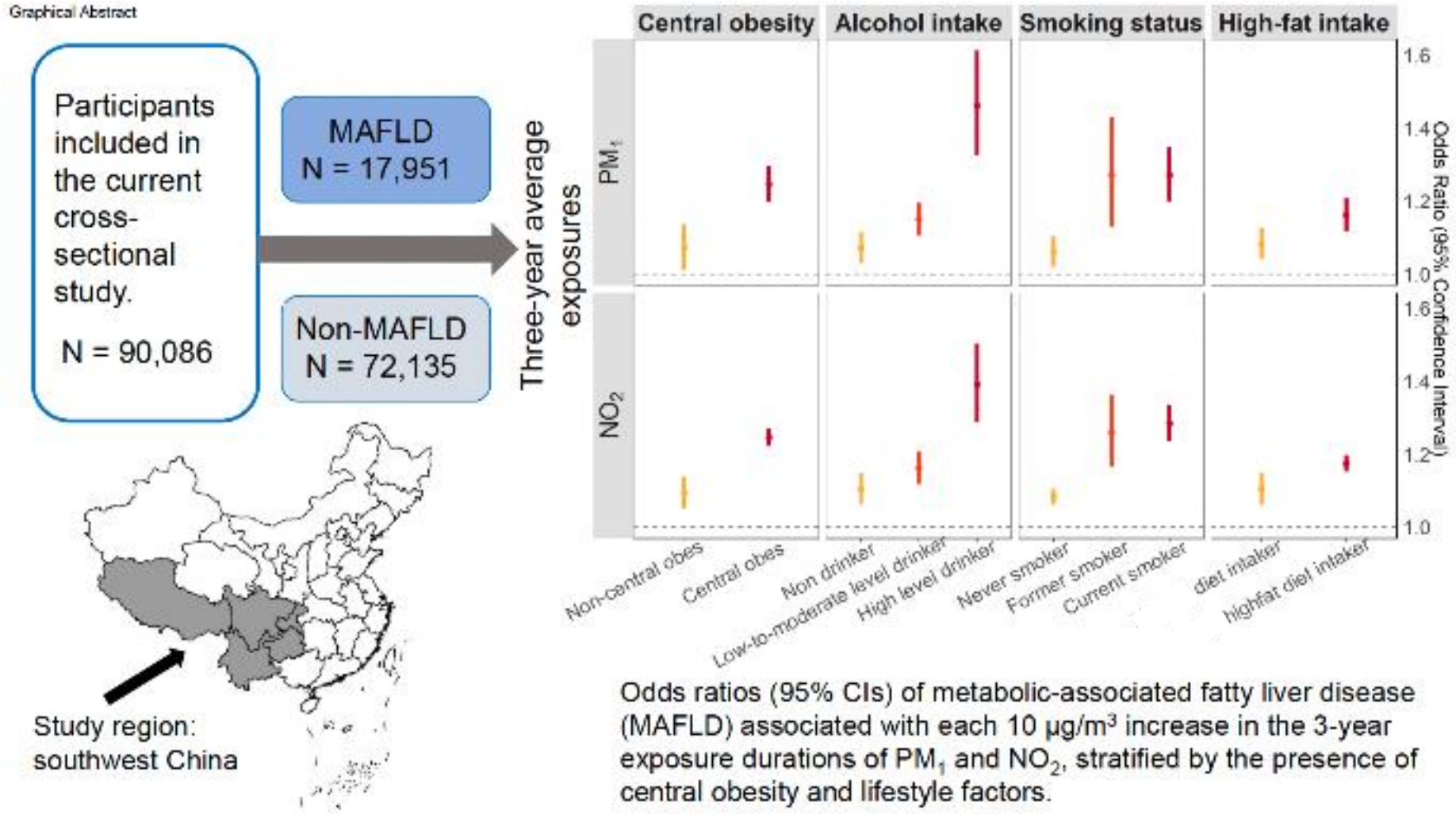
Thurston et al, Eur Resp J, 2017





Chen and Bloom, Plos one, 2019

Pollution de l'air et maladies du foie



Odds ratios (95% CIs) of metabolic-associated fatty liver disease (MAFLD) associated with each 10 μg/m³ increase in the 3-year exposure durations of PM_1 and NO_2, stratified by the presence of central obesity and lifestyle factors.

Pollution de l’air et maladies du foie

Research Article
NAFLD and Alcohol-Related Liver Diseases

JOURNAL OF HEPATOLOGY

Exposure to air pollution is associated with an increased risk of metabolic dysfunction-associated fatty liver disease

Bing Guo[1,#], Yuming Guo[2,#], Qucuo Nima[3], Yuemei Feng[1], Ziyun Wang[5], Rong Lu[6], Baimayangji[7], Yue Ma[1], Junmin Zhou[1], Huan Xu[1], Lin Chen[1], Gongbo Chen[8], Shanshan Li[2], Huan Tong[9,*], Xianbin Ding[10,*], Xing Zhao [1,*] on behalf of the China Multi-Ethnic Cohort (CMEC) collaborative group

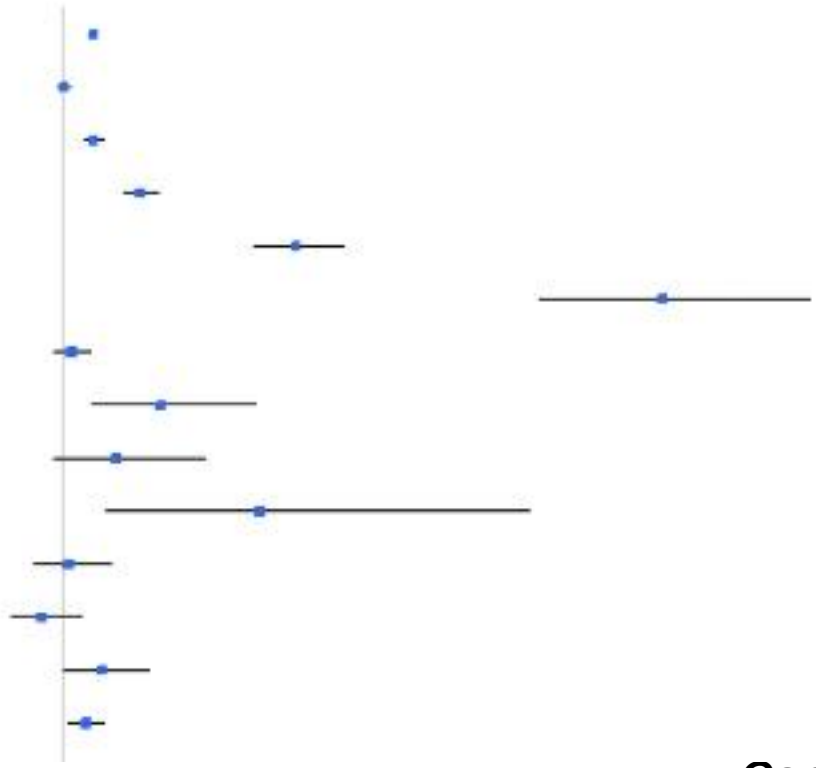
Highlights

- Epidemiologic evidence on the potential role of ambient air pollution in MAFLD is limited.
- This study found significant positive associations between air pollution and the odds of MAFLD.
- Unhealthy lifestyle habits and the presence of central obesity may exacerbate the harmful effects.
- This large-scale human study provides robust results and calls for more prospective studies.

PM2.5 risqué de mortalité par cancer hépatique

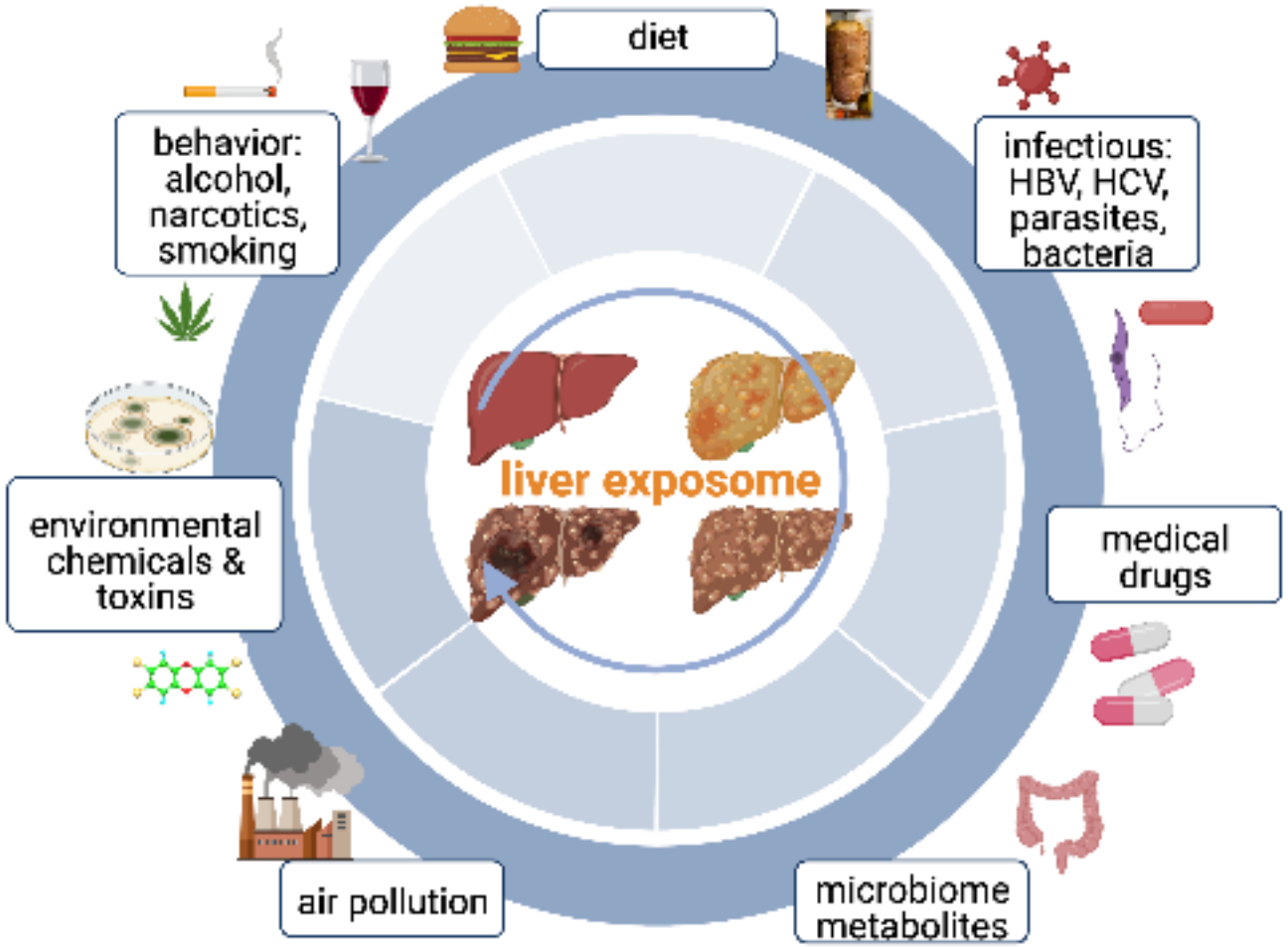
a systematic review showing increased risk of liver cancer mortality but not incidence

Study	Exposure categories	Effect size	Risk estimate (95% CI)
$PM_{2.5}$			
Deng et al., 2017	Per 5 μg/m³	HR	1.18 (1.16, 1.20)
Deng et al., 2017	<10 μg/m³ vs ≥ 10–15 μg/m³	HR	1.00 (0.96, 1.04)
Deng et al., 2017	<10 μg/m³ vs ≥ 15–20 μg/m³	HR	1.18 (1.12, 1.24)
Deng et al., 2017	<10 μg/m³ vs ≥ 20–25 μg/m³	HR	1.46 (1.36, 1.57)
Deng et al., 2017	<10 μg/m³ vs ≥ 25–30 μg/m³	HR	2.40 (2.14, 2.69)
Deng et al., 2017	<10 μg/m³ vs ≥ 30 μg/m³	HR	4.61 (3.87, 5.50)
Turner et al., 2017	Per 4.4 μg/m³	HR	1.05 (0.94, 1.16)
Lee et al., 2019	<36 μg/m³ vs ≥36 μg/m³	OR	1.58 (1.16, 2.16)
Coleman et al., 2020	Per 10 μg/m³	HR	1.32 (0.94, 1.85)
Coleman et al., 2020	Per 10 μg/m³	HR	2.18 (1.25, 3.81)
Guo et al., 2020	<21.63 μg/m³ vs 21.63–23.90 μg/m³	HR	1.03 (0.82, 1.29)
Guo et al., 2020	<21.63 μg/m³ vs 23.90–28.37 μg/m³	HR	0.87 (0.68, 1.11)
Guo et al., 2020	<21.63 μg/m³ vs ≥28.37 μg/m³	HR	1.23 (1.00, 1.51)
Guo et al., 2020	Per 10 μg/m³	HR	1.13 (1.02, 1.24)



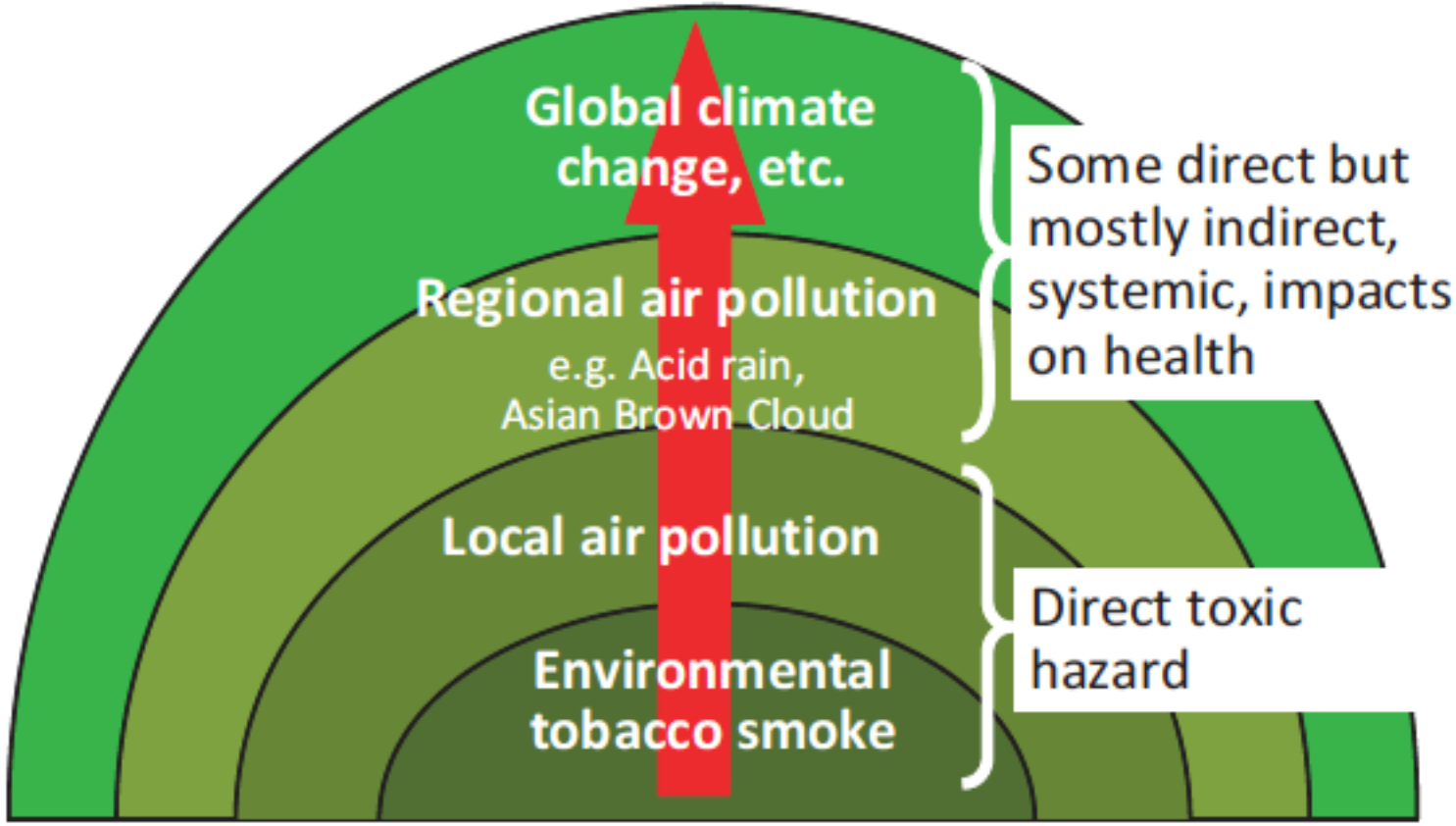
Gan et al, J environ sci. 2023

Exposome et maladies hépatiques



Barouki, 2023

Changement climatique et pollution de l'air à différentes échelles



McMichael et al, 2011

Exposome et changement climatique

Voies d'exposition

Phénomènes extrêmes | **Chaleur** | **Qualité de l'air** | **Qualité quantité de l'eau** | alimentation | Maladies à vecteurs | Facteurs psycho-sociaux

EXAMPLES OF HEALTH OUTCOMES

- Injuries
- Fatalities
- Mental health effects

Heat-related illness and death

- Exacerbations of asthma and other respiratory diseases
- Respiratory allergies
- Cardiovascular disease

- Campylobacter infection
- Cholera
- Cryptosporidiosis
- Harmful algal blooms
- Leptospirosis

- Undernutrition
- Salmonella food poisoning and other foodborne diseases
- Mycotoxin effects

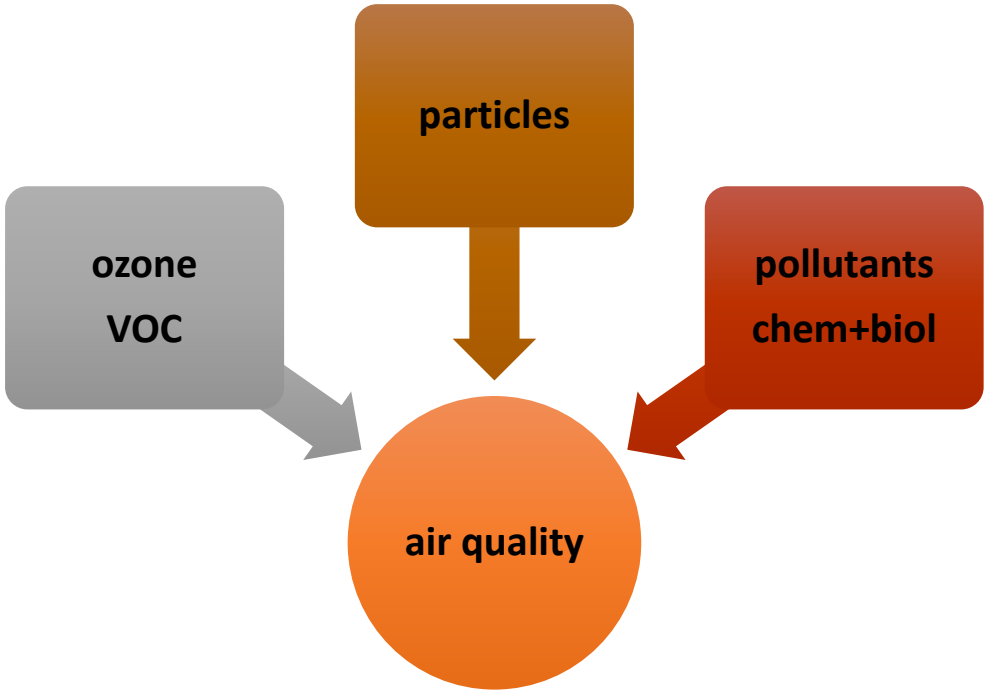
- Chikungunya
- Dengue
- Encephalitis (various forms)
- Hantavirus infection
- Lyme disease
- Malaria
- Rift Valley fever
- West Nile virus infection
- Zika virus infection

Physical and mental health effects of violent conflict and forced migration (complex and context-specific risks)

(Haines&Ebi, 2019)

Polluants de l'air et changement climatique

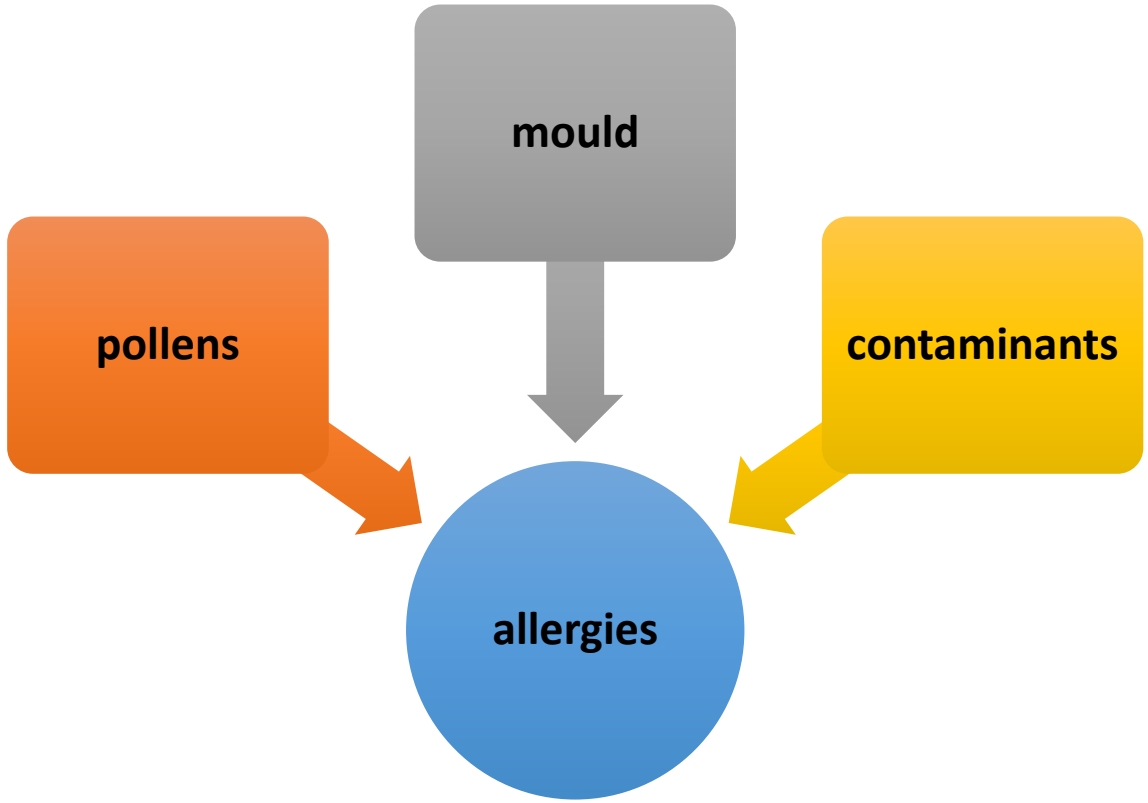
Several environmental stressors contribute to poor air quality: transport, industry, agriculture, urbanisation, CC



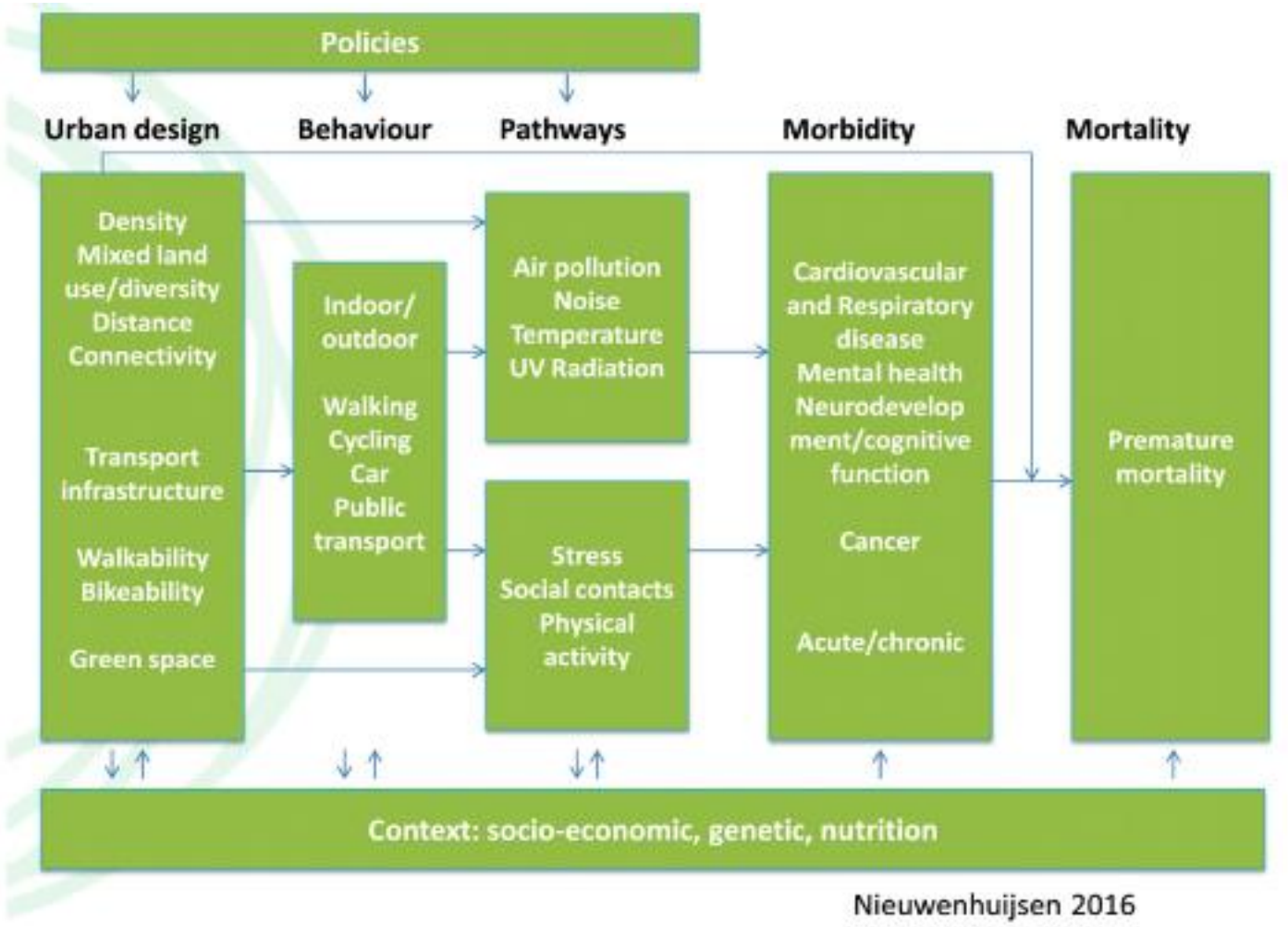
Respiratory, cardiovascular diseases, cancer

Polluants de l'air, changement climatique et allergies

environmental stressors contribute to increased allergies:
pollens, mould, floods, air quality, pollution (immune dysregulation)



L'exposome urbain



- ✓ *Reshaping urban environment using nature-based solutions but also new technologies*
- ✓ *innovative methods and approaches to reduce harmful exposures in urban environments*
- ✓ *Transport, digitalization and healthy living in the urban-suburban-rural continuum*

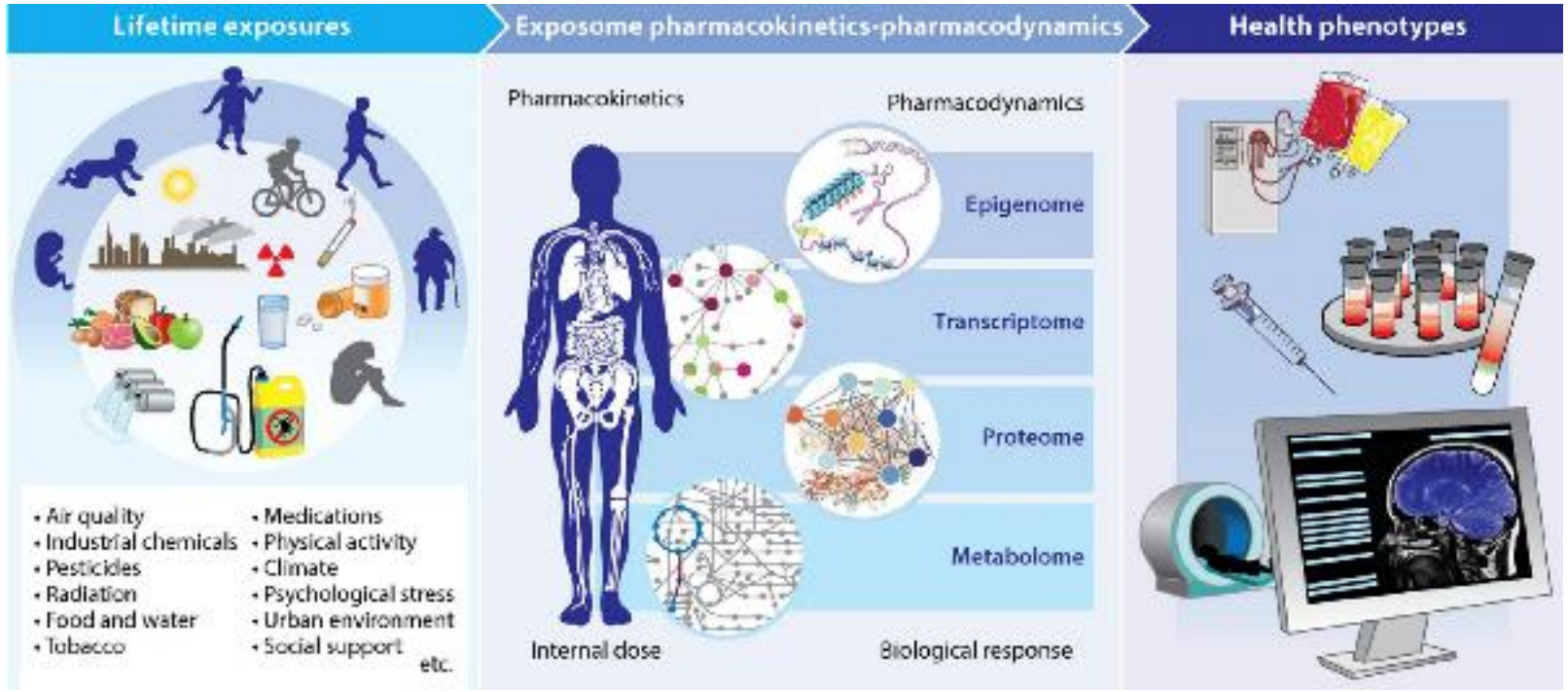
HERA project
heraresearcheu.eu

Exposome et inégalités sociales

Les personnes les plus défavorisées sont plus exposées à la pollution de l'air, au bruit, au déséquilibre nutritionnel. Elles bénéficient de moins d'espaces verts, d'aires de jeux, etc.

A exposition égale il semble que les impacts sanitaires des stress environnementaux soient plus sévères chez les personnes défavorisées

(Deguen et al, M/S 2022)



(Vineis, 2022)

Exposome: implications biomédicales

- ✓ **Innovations conceptuelles et méthodologiques** considérables notamment pour l'évaluation des expositions, de leurs effets et des relations de causalité :
  - Détecteurs/capteurs
  - Surveillance et détection des émergences
  - Modélisation: exposition, environnement et effets
  - Biomarqueurs d'effet
  - Effets des mélanges
  - Médecine systémique: intégration des stresseurs et des effets.
- ✓ Conception **multifactorielle** des pathologies
- ✓ **Education** et formation multidisciplinaires

Exposome: implications pour la prévention

- ✓ Implications en santé publique:
  - règlementation,
  - Développement des CRPPE et des centres anti-poison
  - populations vulnérables (développement, génétique, pathologies associées, alimentation, situation sociale et économique, etc.)
  - messages de santé publique pour la prévention (interaction entre stresseurs: alimentation, chimie, conditions sociales, etc.)

- ✓ Implications au niveau individuel : Prévention de précision (ex: asthme, diabète, personnes âgées, nouveaux nés, etc.)

Définition de la médecine de précision "an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person" (PMI NIH)