POLLUTION DE L'AIR ET MALADIES RESPIRATOIRES: QUELLES NOUVEAUTES?

Prof. Isabella Annesi-Maesano,
DR1 INSERM, Directeur Adjoint
Institut Desbrest d'Epidémiologie et de Santé Publique (IDESP)
INSERM & Université de Montpellier, France

COI

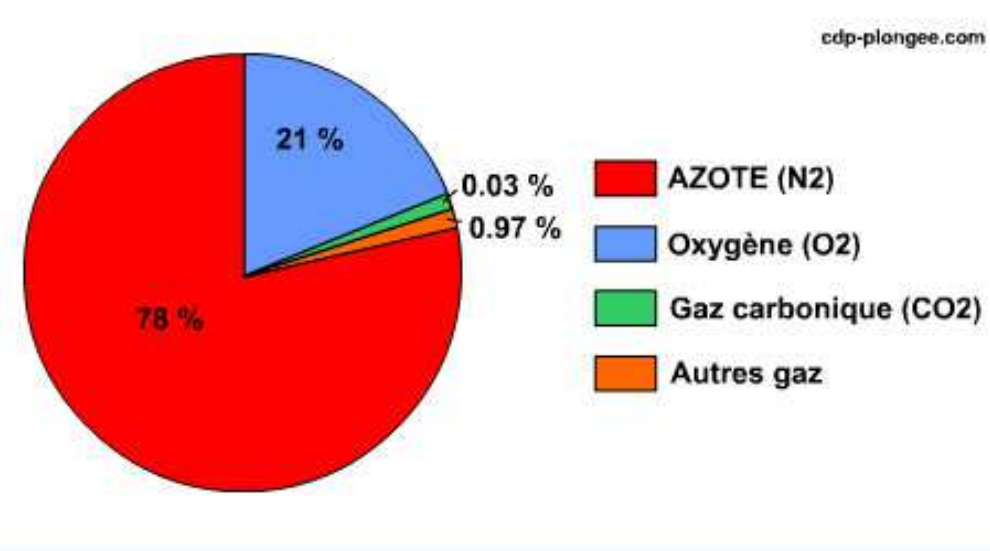
- ERS Ethics and Integrity Committee (Member)
- IRD Ethics Committee (President)
- EAACI ROC
- AAAAI Environmental Exposures and Respiratory Health Committee
- ATS Health Policy Committee
- Société de Pneumologie de Langue Française (GT PAPPEI)
- SFA Scientific Committee (Member)
- CSTB Scientific Committee (Member)
- RNSA Scientific Committee (Member

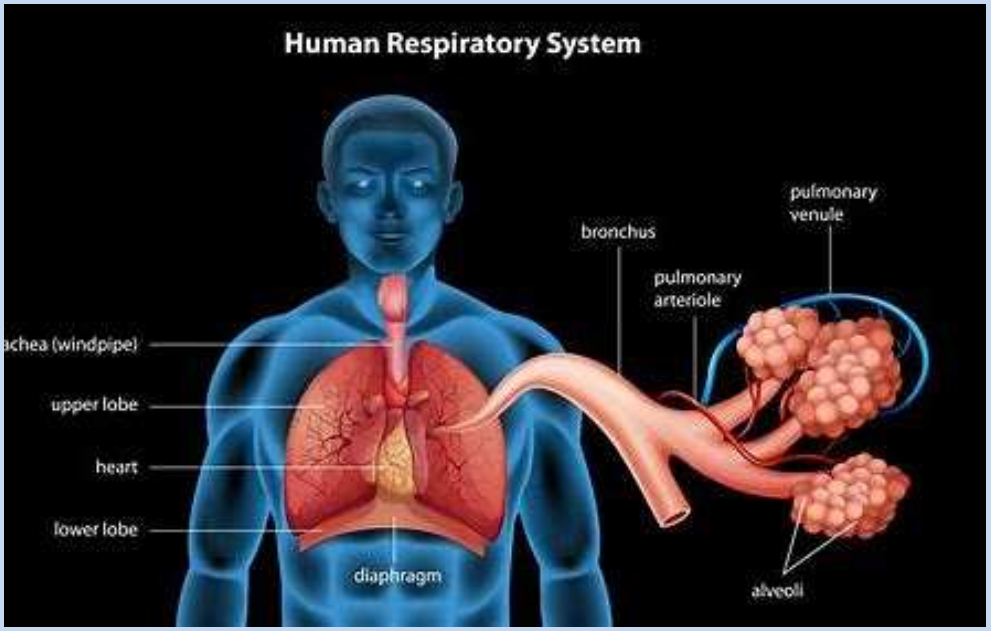
Polluants, sources, exposition: quoi de neuf?

Pollution atmosphérique, pénetration

La pollution de l'air (ou « pollution atmosphérique ») est une altération des niveaux de qualité et de pureté de l'air.

COMPOSITION DE L'AIR





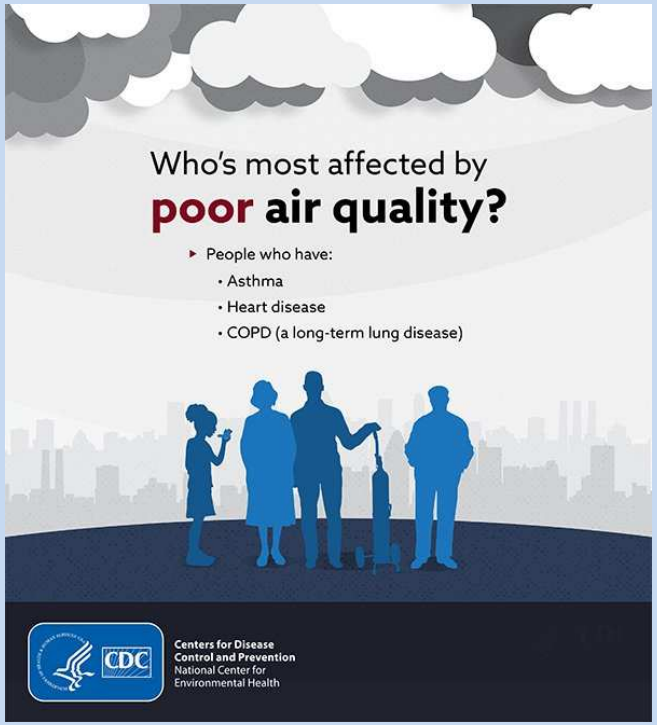
<u>15 000</u> litres d'air par jour (et davantage à l'exercice) dans voies respiratoires et poumons (dans 300 millions d'alvéoles), soit plus de 5,4 millions de litres d'air respirés chaque année ou bien encore 17 cl par seconde.

Surface alvéolaire= 100 m²

Une meilleure prise de conscience de l'exposition

Pollution atmosphérique:

- subit passivement (car il faut respirer)
- présente à l'intérieur (indoors) et à l'extérieur (outdoors) des locaux
  - Maison
  - Bureau
  - Ecole
  - Transports
  - …
- ubiquitaire
- cocktails de polluants
- grande variabilité spatio-temporelle



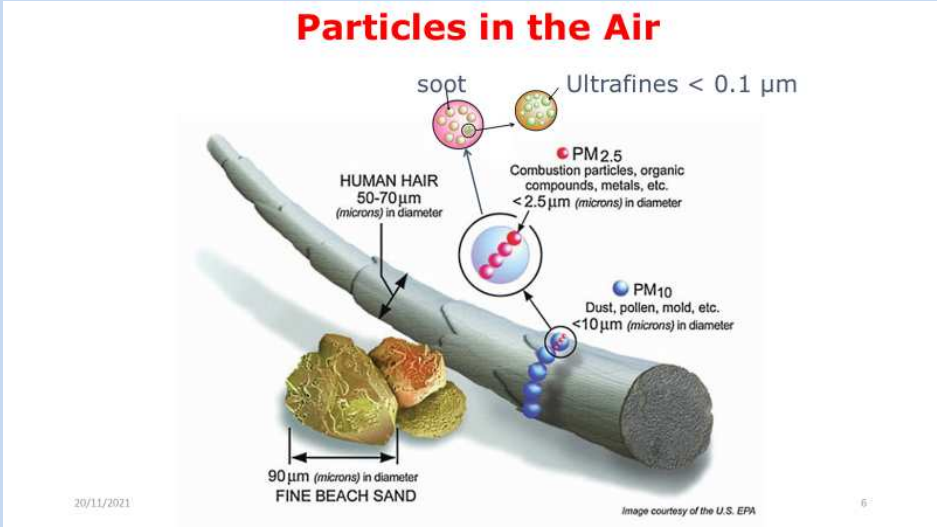
Better knowledge of gases and PM

(Primary and secondary air pollutants)

- Sulphur dioxide (SO_2)
- Nitrogen oxides (Nox, NO2))
- Carbon monoxide (CO)
- Volatile organic compounds (VOC)
- Ozone (O_3)
- …

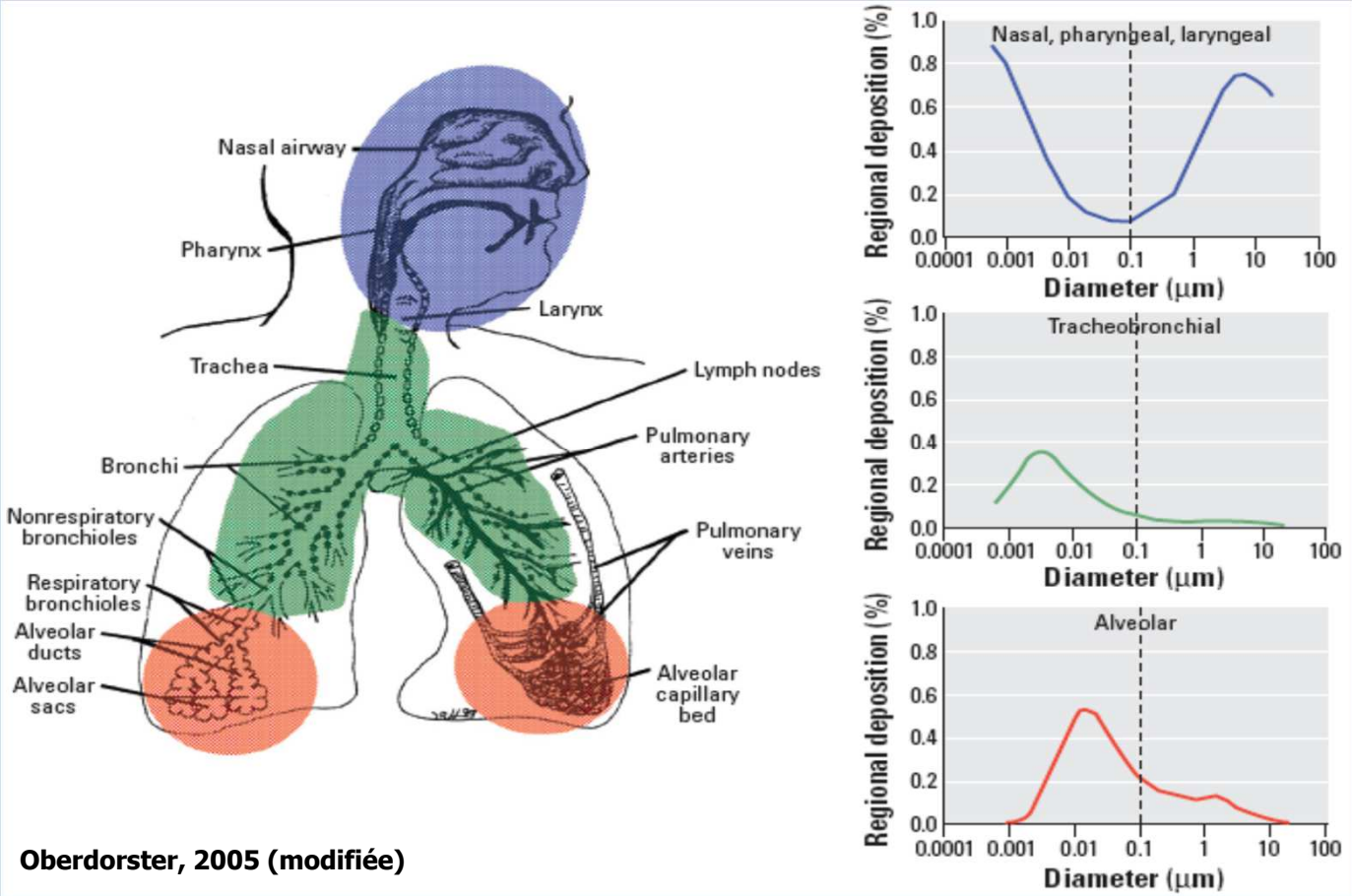
PM=Particulate matter (aerosols) characteristics

- Size



- Composition

Appareil respiratoire : voie de pénétration des PM



Oberdorster, 2005 (modifiée)

ATTENTION AUX UPF!

Old style air pollution

London 1952

New Delhi 2015

Annesi-Maesano, It is not time to lower the guard! ERJ 2015

New Style Air Pollution

Car ban in the French capital

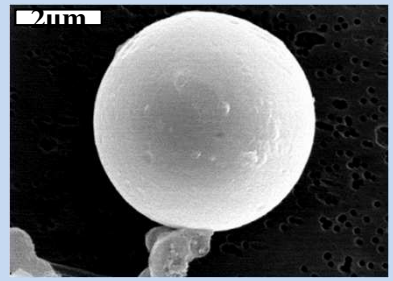
Paris in the smog

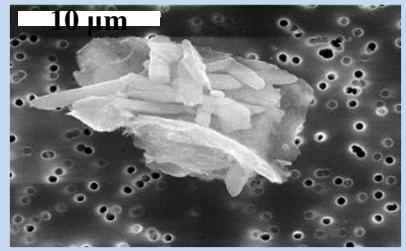
Mar 17th 2014, 12:33 BY S.P. | PARIS

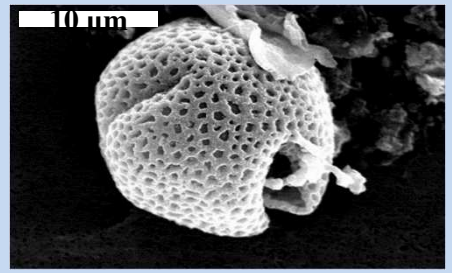
The Economist

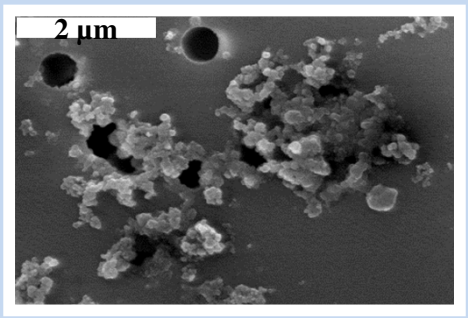
Timekeeper

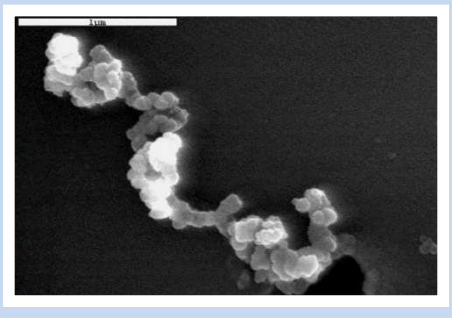
La pollution atmosphérique est visible



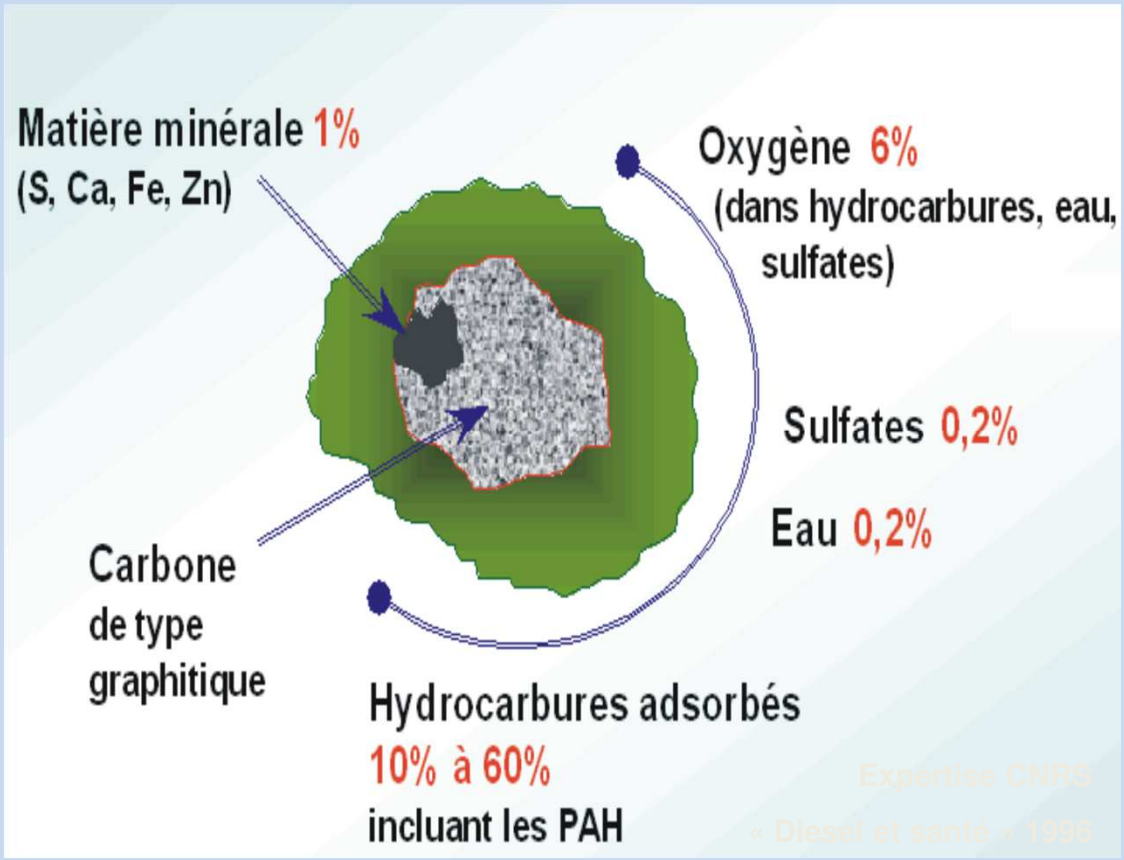








Composition moyenne du DIESEL particules diesel ($PM_{2.5}$)



Source : CNRS

Pollution particulaire agricole

Pesticides, herbicides, fertilisants, PM secondaires

Smog from ‘wildfires’

Moscow, summer 2010

Several indoor air pollutants sources both chemical and biological

Individuals spend up to 90% of their time indoors

- House
- Office/School
- Transports
- HORECA

Where:

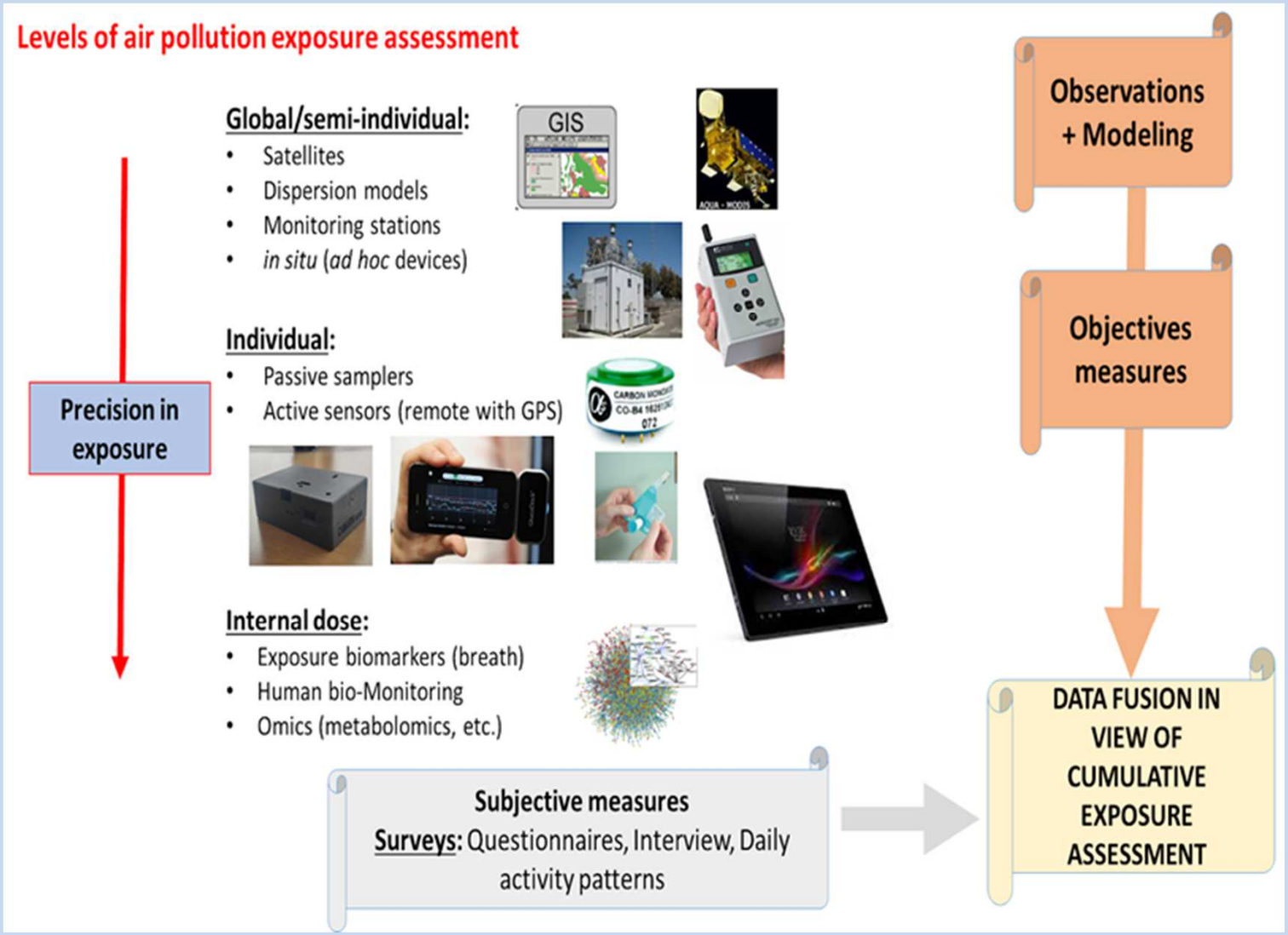
- More pollutants
- Concentrations (higher than outdoors)
- Environment is confined

Biomass / Solid fuel

Emerging indoor air pollution

Phthalates PFAS Plastic

Une meilleure mesure de la pollution atmosphérique



Air quality and health impacts

Nikos Kalivitis[1], Stefania Papatheodorou[2], Cara Nichole Maesano[3], and Isabella Annesi-Maesano[3]

In: Atmospheric Chemistry in the Mediterranean:

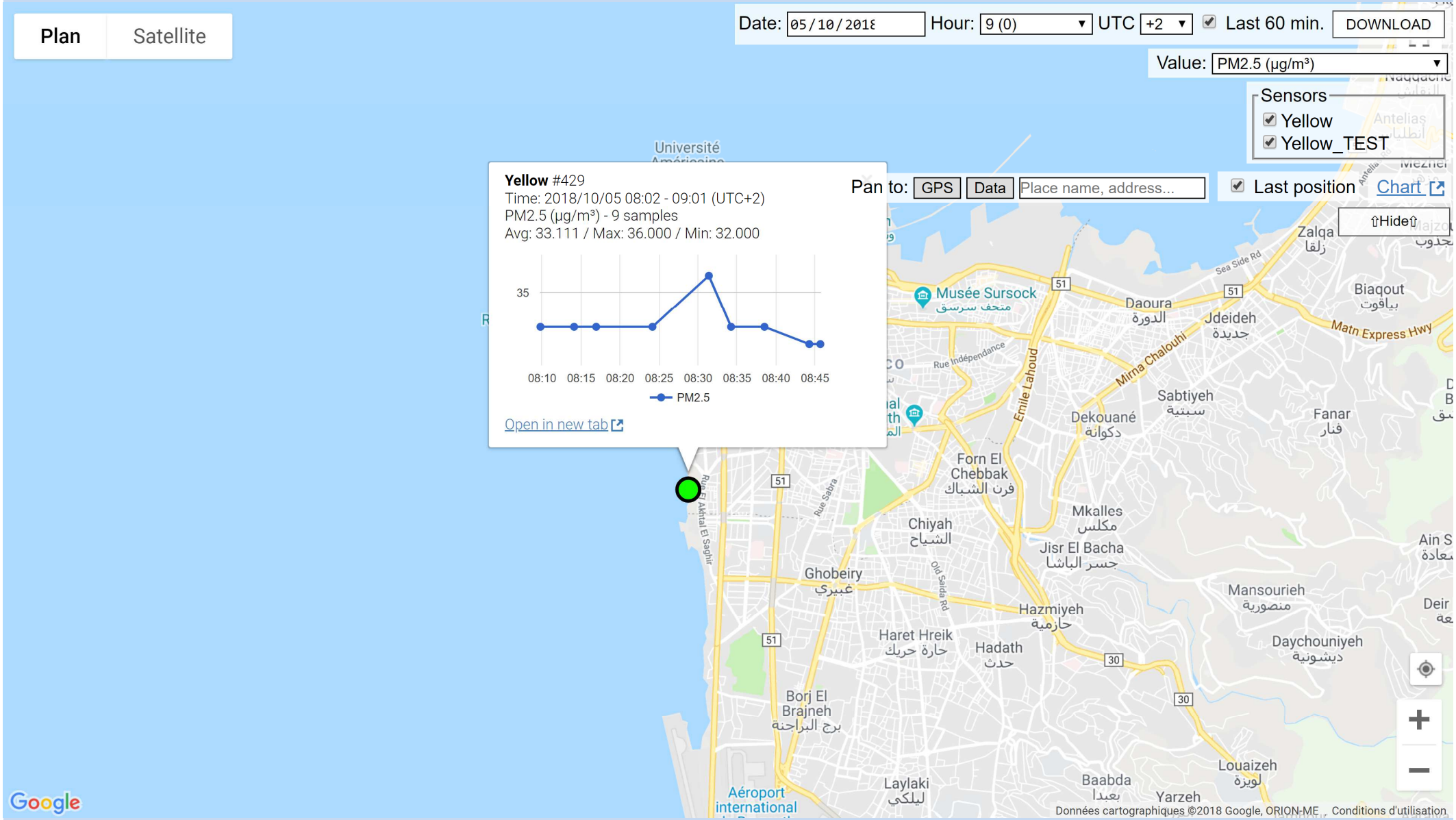
François Dulac, Stéphane Sauvage, and Eric Hamonou Eds.

Canarin

Individual assessments in real-time of:

PM_1, $PM_{2.5}$, PM_{10}
VOCs
T
Hum
Pressure
GPS

G. Pau LIP6 SU
Isabella Annesi-Maesano, EPAR IPLESP, INSERM et SU


Plan
Satellite
Date: 05/10/2018
Hour: 9 (0)
UTC +2
Last 60 min.
DOWNLOAD
Value: PM2.5 (µg/m³)
Sensors
Yellow
Yellow_TEST
Yellow #429
Time: 2018/10/05 08:02 - 09:01 (UTC+2)
PM2.5 (µg/m³) - 9 samples
Avg: 33.111 / Max: 36.000 / Min: 32.000
35
08:10 08:15 08:20 08:25 08:30 08:35 08:40 08:45
PM2.5
Open in new tab
Pan to: GPS Data Place name, address...
Last position
Chart
⇧Hide⇧
Université Américaine
Musée Sursock
متحف سرسق
Zalqa
زلقا
Daoura
الدورة
Jdeideh
جديدة
Biaqout
بياقوت
Matn Express Hwy
Sea Side Rd
Rue Indépendance
Mirna Chalouhi
Emile Lahoud
Sabtiyeh
سبتية
Dekouané
دكوانة
Fanar
فنار
Forn El Chebbak
فرن الشباك
Chiyah
الشياح
Mkalles
مكلس
Jisr El Bacha
جسر الباشا
Ghobeiry
غبيري
Old Saida Rd
Hazmiyeh
حازمية
Mansourieh
منصورية
Haret Hreik
حارة حريك
Hadath
حدث
Daychouniyeh
ديشونية
Borj El Brajneh
برج البراجنة
Laylaki
ليلكي
Baabda
بعبدا
Louaizeh
لويزة
Yarzeh
Aéroport international
Rue Sabra
Rue El Akhtal El Saghir
51
30
Google
Données cartographiques ©2018 Google, ORION-ME
Conditions d'utilisation

Science of the Total Environment xxx (xxxx) xxx

Contents lists available at ScienceDirect

Science of the Total Environment

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

A methodology for the characterization of portable sensors for air quality measure with the goal of deployment in citizen science

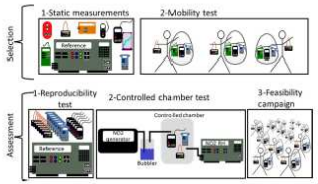
Baptiste Languille [a,*], Valérie Gros [a], Nicolas Bonnaire [a], Clément Pommier [a], Cécile Honoré [b,1], Christophe Debert [b], Laurent Gauvin [b], Salim Srairi [c], Isabella Annesi-Maesano [d], Basile Chaix [e], Karine Zeitouni [f]

[a] Laboratoire des Sciences du Climat et de l'Environnement CNRS-CEA-UVSQ, IPSL, Gif-Sur-Yvette, France
[b] Airparif, Paris, France
[c] CEREMA, Trappes-en-Yvelines, France
[d] EPAR, IPLESP, INSERM et Sorbonne Université, Faculté de Médecine Saint-Antoine, Paris, France
[e] INSERM, Sorbonne Université, Institut Pierre Louis d'Epidémiologie et de Santé Publique IPLESP, Nemesis team, Paris, France
[f] Université de Versailles Saint-Quentin, Versailles, France

HIGHLIGHTS

- Small sensors for personal exposure monitoring are of questionable accuracy.
- A robust methodology was designed and used to select and assess sensors.
- Eight portable sensors were tested, three (AE51, Cairclip, Canarin) were selected.
- The sensors were approved for personal exposure monitoring (BC, NO_2, PM)
- First results from a feasibility campaign involving 15 volunteers are presented.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 8 August 2019
Received in revised form 12 September 2019
Accepted 26 September 2019
Available online xxxx

Editor: Pavlos Kassomenos

Keywords:
Paris region
Black carbon
Nitrogen oxides

ABSTRACT

The field of small air quality sensors is of growing interest within the scientific community, especially because this new technology is liable to improve air pollutant monitoring as well as be used for personal exposure quantification. Amongst the myriad existing devices, the performances are highly variable; this is why the sensors must be rigorously assessed before deployment, according to the intended use. This study is included in the Polluscope project; its purpose is to quantify personal exposure to air pollutants by using portable sensors. This paper designs and applies a methodology for the evaluation of portable air quality sensors to eight devices measuring PM, BC, NO_2 and O_3. The dedicated testing protocol includes static ambient air measurements compared with reference instruments, controlled chamber and mobility tests, as well as reproducibility evaluation. Three sensors (AE51, Cairclip and Canarin) were retained to be used for the field campaigns. The reliability of their performances were robustly quantified by using several metrics. These three devices (for a total of 36 units) were deployed to be worn by volunteers for a week. The results show the ability of sensors to discriminate between different environments (i.e.,

sensors

MDPI

Article

Academically Produced Air Pollution Sensors for Personal Exposure Assessment: The Canarin Project

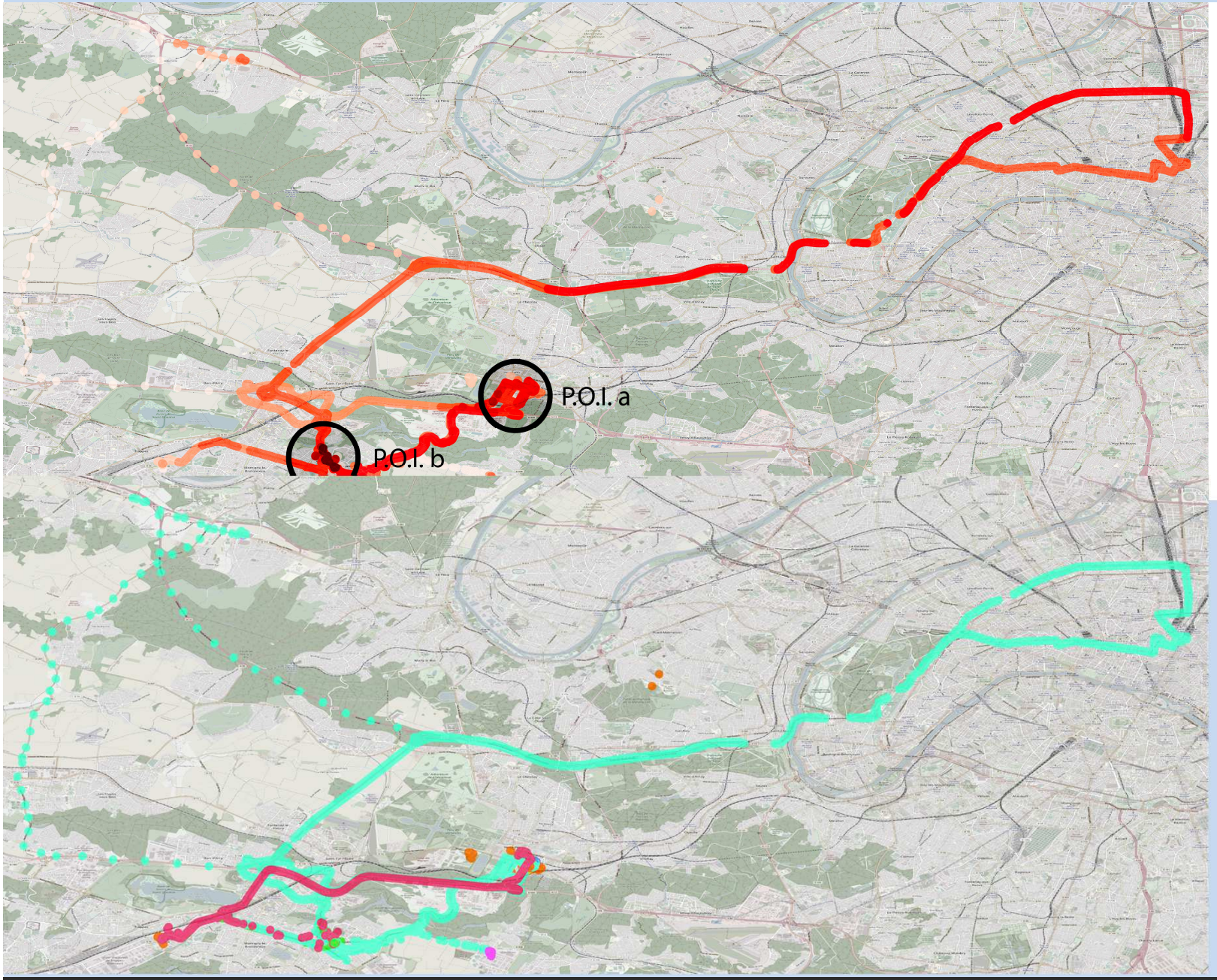
Boris Dessimond [1,2,*], Isabella Annesi-Maesano [2], Jean-Louis Pepin [3], Salim Srairi [4] and Giovanni Pau [1]

[1] Computer Science Laboratory, University of Pierre et Marie Curie, LIP6, NPA Team, 4 Place Jussieu, 75005 Paris, France; giovanni.pau@unibo.it
[2] EPAR Team, Medecine Faculty of Saint-Antoine, IPLESP, INSERM & Sorbonne University, 27 rue Chaligny, 75571 Paris, France; isabella.annesi-maesano@inserm.fr
[3] Laboratoire HP2, Université Grenoble Alpes, Grenoble, INSERM, U1042 and CHU de 24 Grenoble, France; JPepin@chu-grenoble.fr
[4] Centre for Expertise and Engineering on Risks, Urban and Country Planning, Environment and Mobility — Ile de France Territorial Division, Mobility Department, 12, rue Teisserenc de Bort, 78190 Trappes-en-Yvelines, France; salim.srairi@cerema.fr
* Correspondence: boris.dessimond@etu.upmc.fr

Abstract: The World Health Organization has estimated that air pollution is a major threat to health, causing approximately nine million premature deaths every year. Each individual has, over their lifetime, a unique exposure to air pollution through their habits, working and living conditions. Medical research requires dedicated tools to assess and understand individual exposure to air pollution in view of investigating its health effects. This paper presents portable sensors produced by the Canarin Project that provides accessible, real time personal exposure data to particulate matter. Our primary results demonstrate the use of portable sensors for the assessment of personal exposure to the different micro-environments attended by individuals, and for inspecting the short-term effects of air pollution through the example of sleep apnea. These findings underscore the necessity of obtaining contextual data in determining environmental exposure and give perspectives for the future of air pollution sensors dedicated to medical research.

Citation: Dessimond, B.; Annesi-Maesano, I.; Pepin, J.-L.; Srairi, S.; Pau, G. Academically Produced Air Pollution Sensors for Personal

MOBILITE: Contextualisation des données



0–2.5
2.5–5
5–12.5
12.5–25
25–50
50–150
150–500

PM_{10} µg/m³

Bureau
Résidence
Magasin
Parc
Restaurant
Rue
Voiture
Non Assigné

Des valeurs guides d’exposition plus protectives

Valeurs Guides OMS et UE

		Valeurs Guides OMS 2021 recommandées en µg/m³	Valeurs Guides OMS 2005 recommandées en µg/m³	Valeurs limites européennes réglementaires en µg/m³
Particules $PM_{2,5}$	Moyenne annuelle	5	10	25
	24h	15	25	-
Particules PM_{10}	Moyenne annuelle	15	20	40
	24h	45	50	50 à ne pas dépasser + de 35 j/an
Dioxyde d'azote NO_2	Moyenne annuelle	10	40	40
	24h	25	-	200 à ne pas dépasser + de 18 h/an
Ozone O_3	Pic saisonnier	60	-	-
	24h	100	100	-

Air pollution exposure in Europe

EDITORIAL
AIR POLLUTION

The clear and persistent impact of air pollution on chronic respiratory diseases: a call for interventions

Isabella Annesi-Maesano[1], Francesco Forastiere[2], John Balmes[3,4,5], Erika Garcia[6], Jack Harkema[7], Stephen Holgate[8], Frank Kelly[2], Haneen Khreis[9], Barbara Hoffmann[10], Cara Nichole Maesano[1], Rob McConnell[11], David Peden[12], Kent Pinkerton[13], Tamara Schikowski[14], George Thurston[15], Laura S. Van Winkle[16] and Christopher Carlsten[17]

ERJ 2021

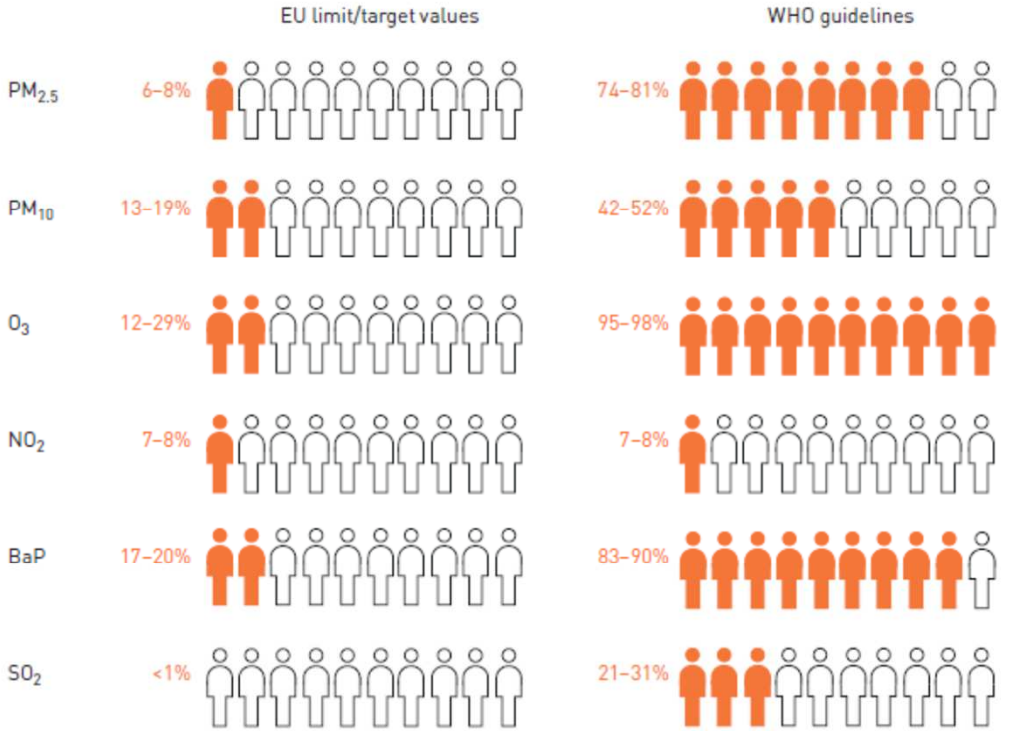
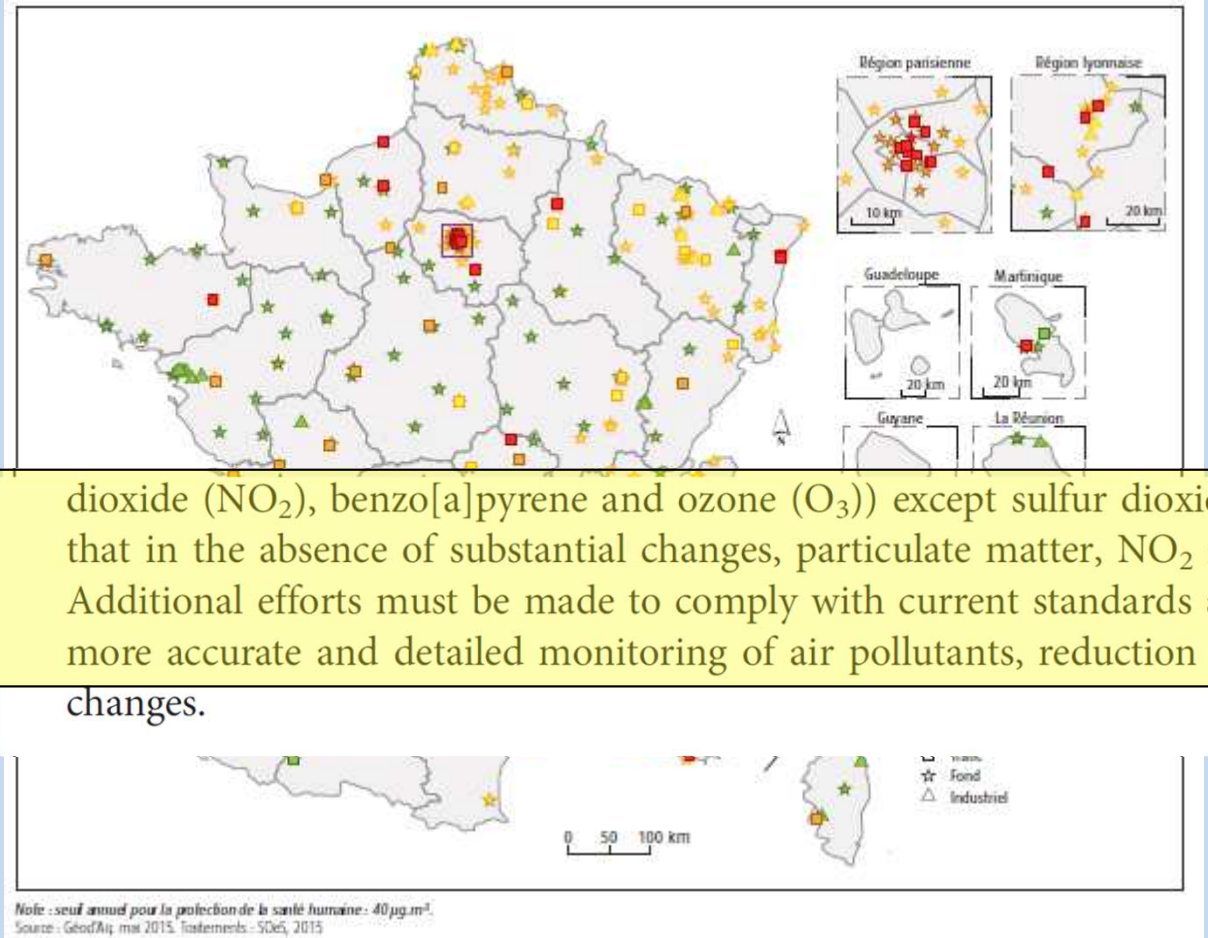


FIGURE 1 Exceedance of air quality standards and guidelines in European urban areas (data from www.eea.europa.eu/themes/air/health-impacts-of-air-pollution). WHO: World Health Organization; $PM_{2.5}$: particulate matter of diameter of 2.5 µm, PM_{10}: particulate matter of diameter of 10 µm; BaP: benzo[a]pyrene. EU reference values (annual value): $PM_{2.5}$: 25 µg·m^{-3}, PM_{10}: 40 µg·m^{-3}, NO_2: 40 µg·m^{-3}, O_3: 120 µg·m^{-3} (8-h mean); SO_2: 125 µg·m^{-3} (24-h mean); BaP: 1 ng·m^{-3}. WHO air quality guidelines: EU reference values (annual value): $PM_{2.5}$: 10 µg·m^{-3}, PM_{10}: 20 µg·m^{-3}, NO_2: 40 µg·m^{-3}, O_3: 100 µg·m^{-3} (8-h mean); SO_2: 20 µg·m^{-3} (24-h mean); BaP: 0.12 ng·m^{-3}.

92-99% of the world population overexposed.

Contentieux européen pour non respect de valeurs limites européennes



Note : seuil annuel pour la protection de la santé humaine : 40 µg.m⁻³.
Source : GéodAir, mai 2015, Traitements : SOeS, 2015

Marseille,
Paris, Clermont-Ferrand, Montpellier, Strasbourg, Lyon, Rouen,

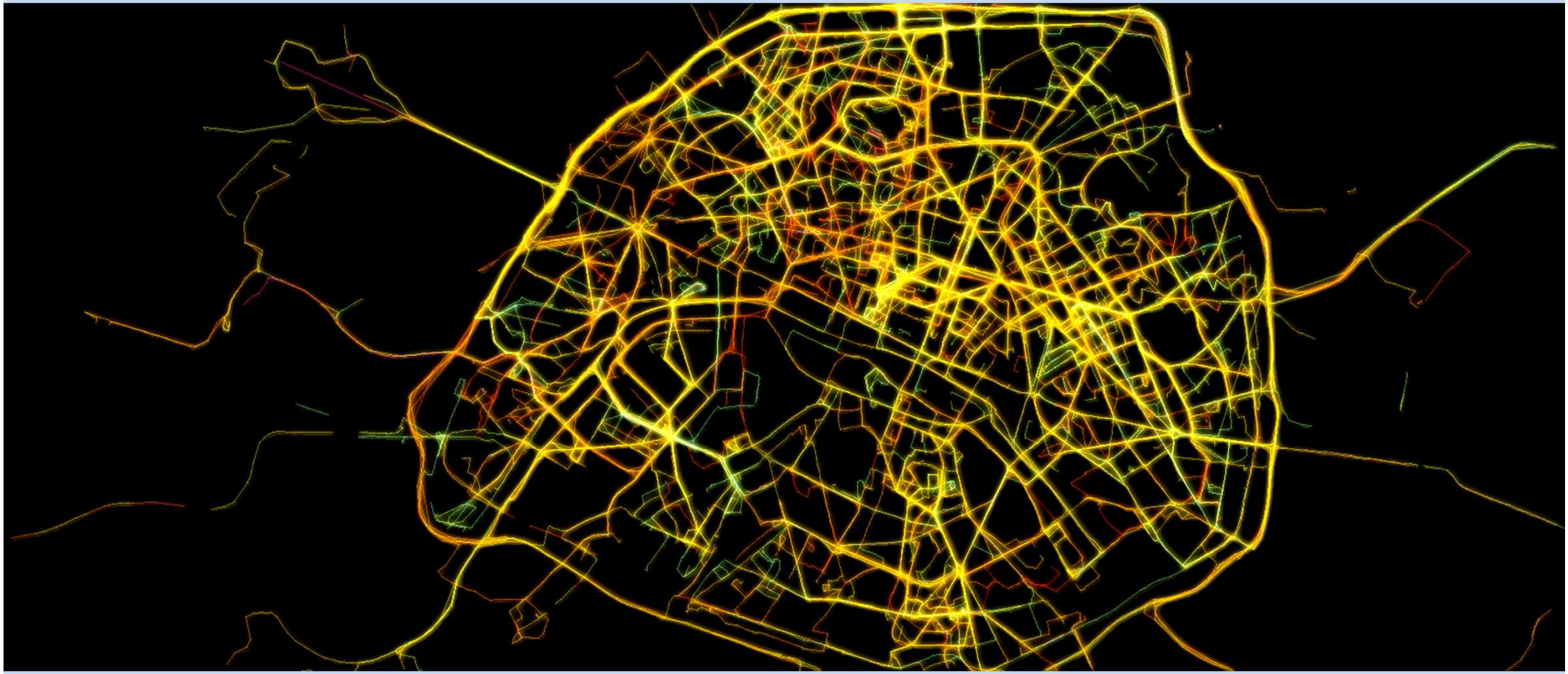
NO_2 Toulon, Toulouse, Reims, Grenoble, Rennes, Nice, Tours, Saint-Etienne, Bordeaux,

la zone urbaine régionale de

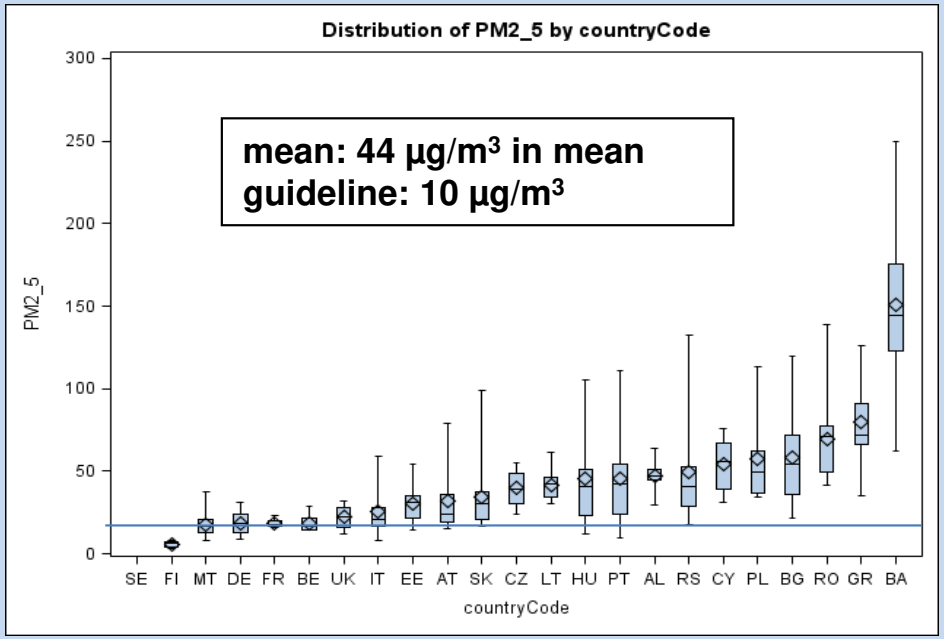
dioxide (NO_2), benzo[a]pyrene and ozone (O_3)) except sulfur dioxide. In addition, current trends indicate that in the absence of substantial changes, particulate matter, NO_2 and O_3 will still exceed limits in 2020. Additional efforts must be made to comply with current standards and guidelines. These should include a more accurate and detailed monitoring of air pollutants, reduction of emissions and individual behaviour changes.

PM10 : 10 zones et agglomérations
Paris, Lyon, Grenoble, Marseille, Martinique-ZUR, Rhône-Alpes-ZUR, PACA-ZUR, Nice, Toulon, et « Douai-Béthune-Valenciennes ».

Pollution in Paris



PM dans les classes de 23 pays Européens



= limit values

Par rapport aux valeurs guide OMS

- $PM_{2.5}$:
  - 13% exposés à > 25 µg/m³ (valeur 24h)
  - 85% exposés à > 10 µg/m³ (valeur annuelle)

Baloch, I. Annesi-Maesano et al Stoten 2020

Effets sanitaires de la pollution atmosphérique

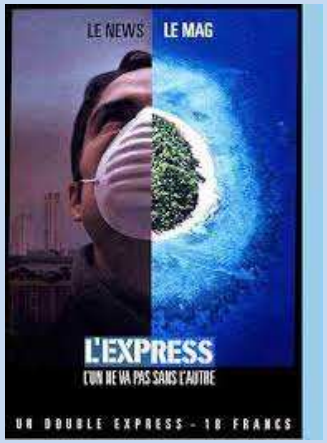
Préoccupation sanitaire majeure

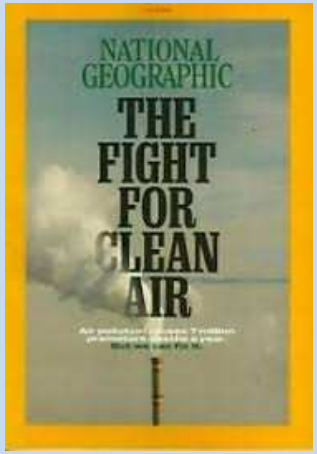

Un grand bol d'air... impur s'il vous plaît !

POLLUTION DE L'AIR

Marseille à bout de souffle

"À Marseille, la pollution de l'air provoque une perte d'espérance de vie de près de 8 mois."

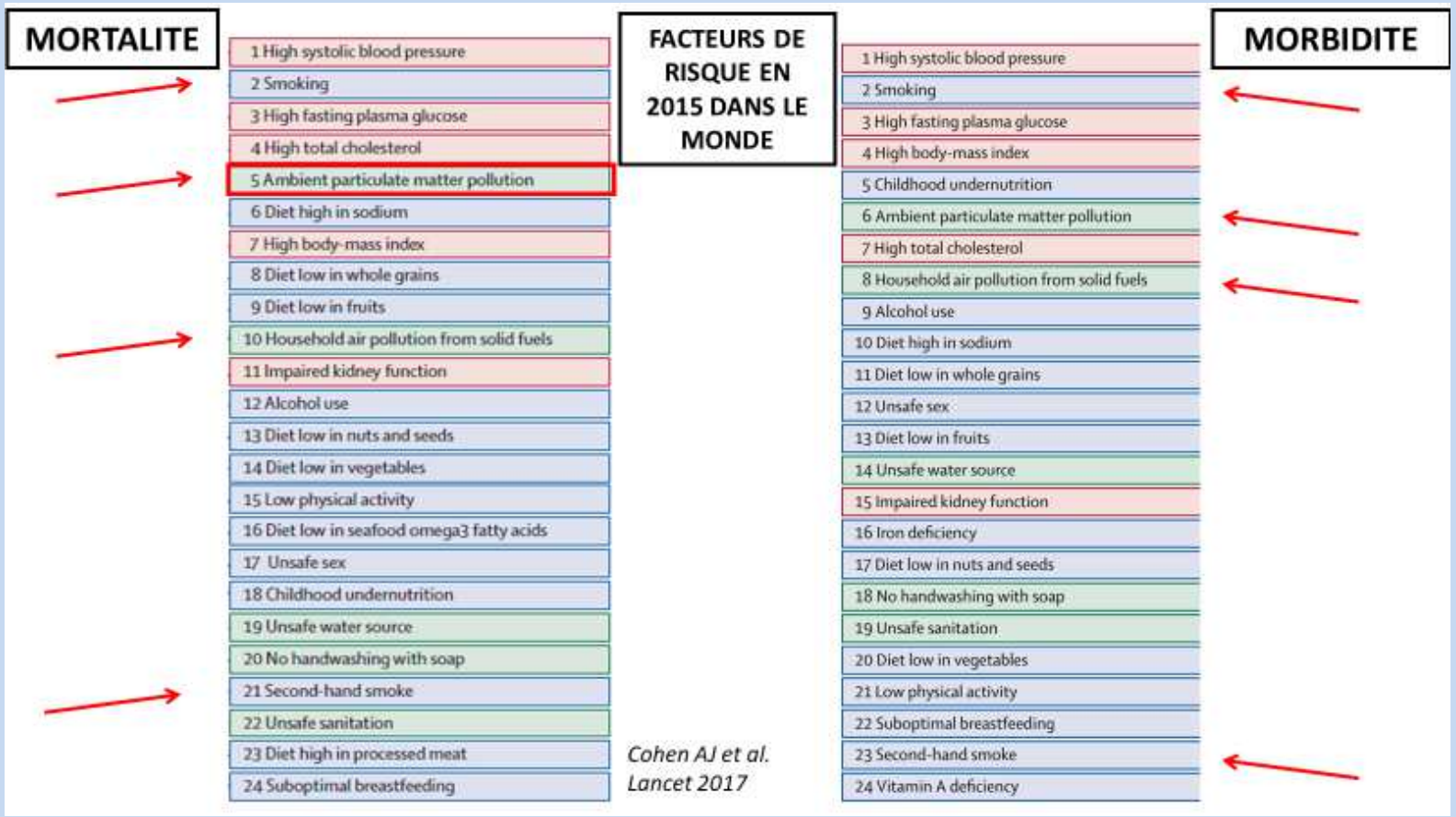




« Air pollution is the new tobacco »

Dr Tedros Adhanom Grebreyesus
WHO Director-General

Global Burden of Disease 2015



DALYs= sum of years lived with disability [YLD] and years of life lost [YLL]

http://www.healthmetricsandevaluation.org/

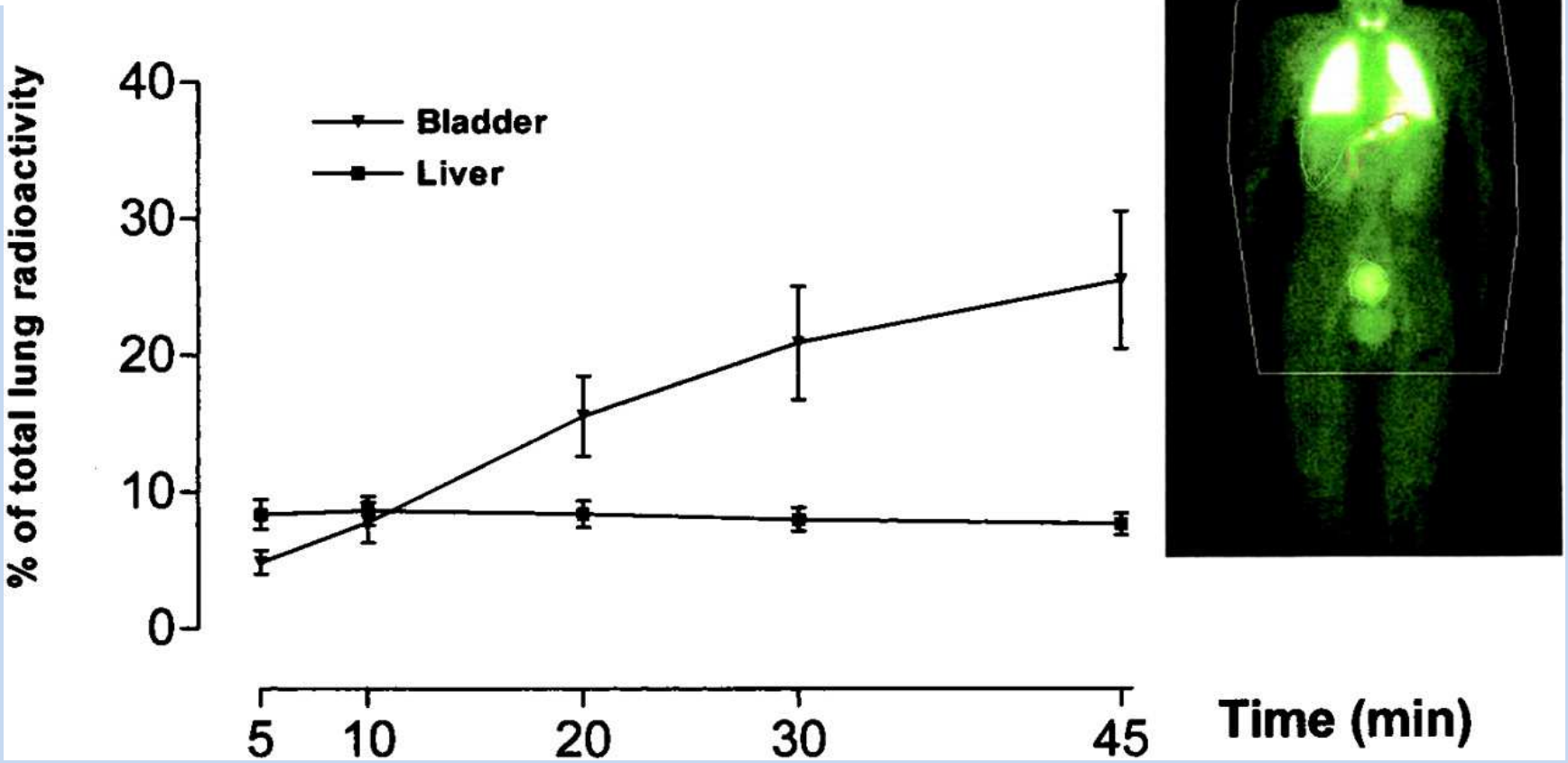
Qu'est-ce que nous avons récemment appris sur les effets sanitaires de la pollution de l'air?

1. La pollution atmosphérique touche plusieurs organes avec des effets à court ou à long terme
2. Il n'y a pas de seuil au dessous duquel les individus sont protégés
   - Effets observés aussi à des concentrations considérées comme protectives (selon les standards de l'OMS ou la CE) lorsqu'il s'agit d'expositions chroniques
   - Effets augmentés chez certains sujets, bien évidemment les sujets malades de maladies chroniques les enfants, les personnes âgées, mais aussi certaines personnes actives très exposées

Tous les organes sont atteints

Passage of Inhaled Particles Into the Blood Circulation in Humans. Nemmar et al. Circulation 2002;105:411.

Ultrafine carbon black particles labeled with Technetium-99 were detected in the blood of human volunteers within 5 – 20 minutes after inhalation



The radioactivity recorded over the liver and bladder expressed as a percentage of the initial lung radioactivity

Several organs and diseases

A joint ERS/ATS policy statement: what constitutes an adverse health effect of air pollution? An analytical framework

George D. Thurston[1], Howard Kipen[2], Isabella Annesi-Maesano[3], John Balmes[4,5], Robert D. Brook[6], Kevin Cromar[7], Sara De Matteis[8], Francesco Forastiere[9], Bertil Forsberg[10], Mark W. Frampton[11], Jonathan Grigg[12], Dick Heederik[13], Frank J. Kelly[14], Nino Kuenzli[15,16], Robert Laumbach[2], Annette Peters[17], Sanjay T. Rajagopalan[18], David Rich[19], Beate Ritz[20], Jonathan M. Samet[21], Thomas Sandstrom[11], Torben Sigsgaard[22], Jordi Sunyer[23] and Bert Brunekreef[13,24]

Eur Respir J 2017; 49: 1600419

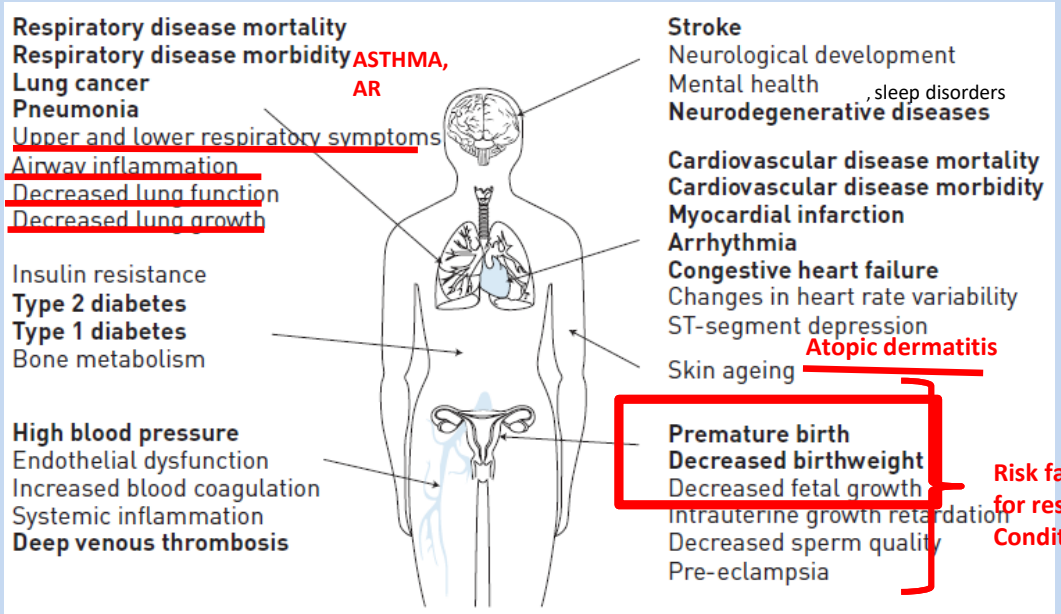


FIGURE 1 Overview of diseases, conditions and biomarkers affected by outdoor air pollution. Updated based on [31]. Bold type indicates conditions currently included in the Global Burden of Disease categories.

4 modes of penetration
1. Inhalation
2. Contact
3. Ingestion
4. Blood-brain barrier (via inhalation)

and actions on the fetus (placental passage)

Effets visibles à faibles doses

Qu’est-ce que nous avons appris sur les effets sanitaires de la pollution atmosphérique?

Des effets observés aussi à des concentrations considérées comme protectives

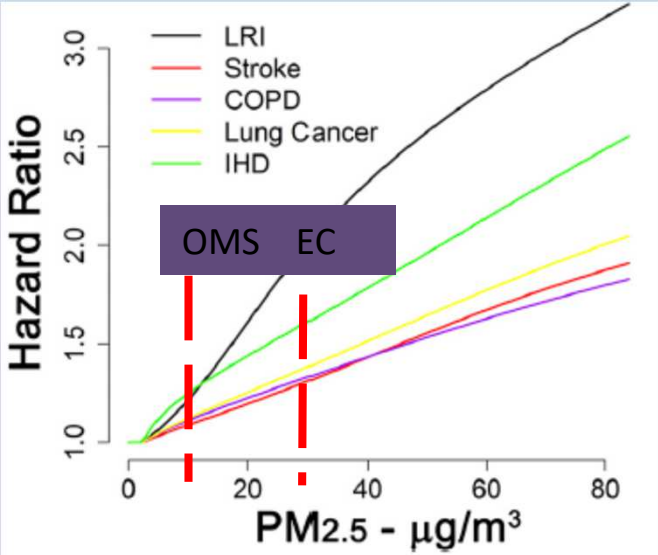
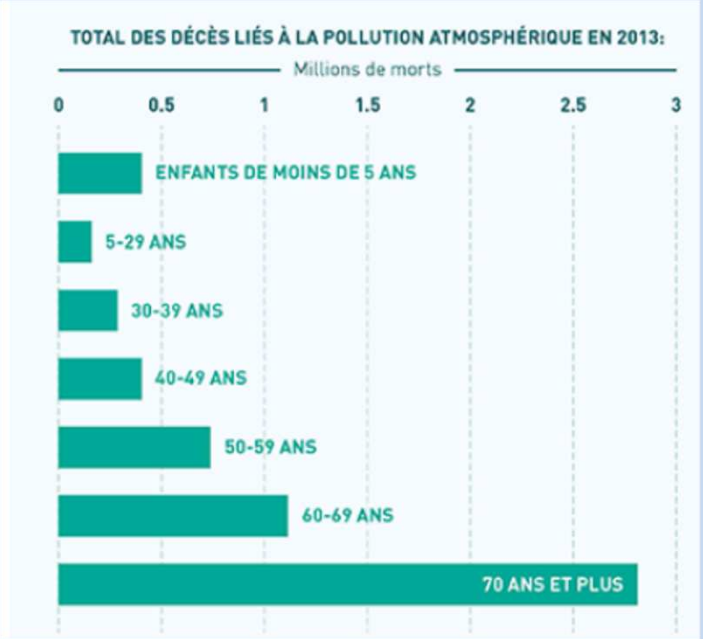


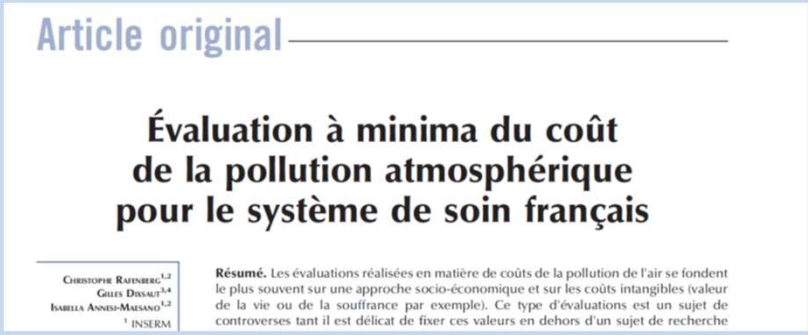
Fig. 1. GEMM hazard ratio predictions over $PM_{2.5}$ exposure range for noncommunicable diseases plus LRIs (NCD+LRI). (*Top*) With 95% confidence interval (gray shaded area). (*Bottom*) GEMM predictions for each of the five causes of death displayed. GEMM NCD+LRI, GEMM IHD, and GEMM stroke were based on the 60- to 64-y-old age group.

Effets augmentés chez certains sujets




UN AIR IRRESPIRABLE
LA POLLUTION ATMOSPHÉRIQUE TUE ET COÛTE DE L'ARGENT
La pollution atmosphérique est le quatrième facteur de risque mortel dans le monde.
UN DES RISQUES ENVIRONNEMENTAUX LES PLUS MORTELS!
Les pertes en vies humaines provoquées par la pollution de l'air sont sources de souffrances et de ralentissement économique.
CHAQUE ANNEE 16% DE TOUS LES DECES ATTRIBUABLES A LA POLLUTION ATMOSPHERIQUE
!

La pollution atmosphérique coûte de l'argent



Article original

Évaluation à minima du coût de la pollution atmosphérique pour le système de soin français

Christophe Rafenberg[1,2]
Gilles Dusault[3,4]
Isabella Annesi-Maesano[1,2]
[1] INSERM

Résumé. Les évaluations réalisées en matière de coûts de la pollution de l'air se fondent le plus souvent sur une approche socio-économique et sur les coûts intangibles (valeur de la vie ou de la souffrance par exemple). Ce type d'évaluations est un sujet de controverses tant il est délicat de fixer ces valeurs en dehors d'un sujet de recherche

Chaque année:

En France (**48 000-100 000 décès** attribuables à la pollution chaque année)

- **2 milliards € de dépenses sanitaires pour maladies cardiopulmonaires** en 2012 (30% du déficit de la SS (Rafenberg & Annesi-Maesano)
- 100 milliards en calculant tous les coûts associés (Sénat)

Dans le monde (**9 000 000 décès** attribuables à la pollution de l'air)

- **225 milliards $ = coût des décès prématurés sur l'économie mondiale, en termes de perte de revenus du travail**

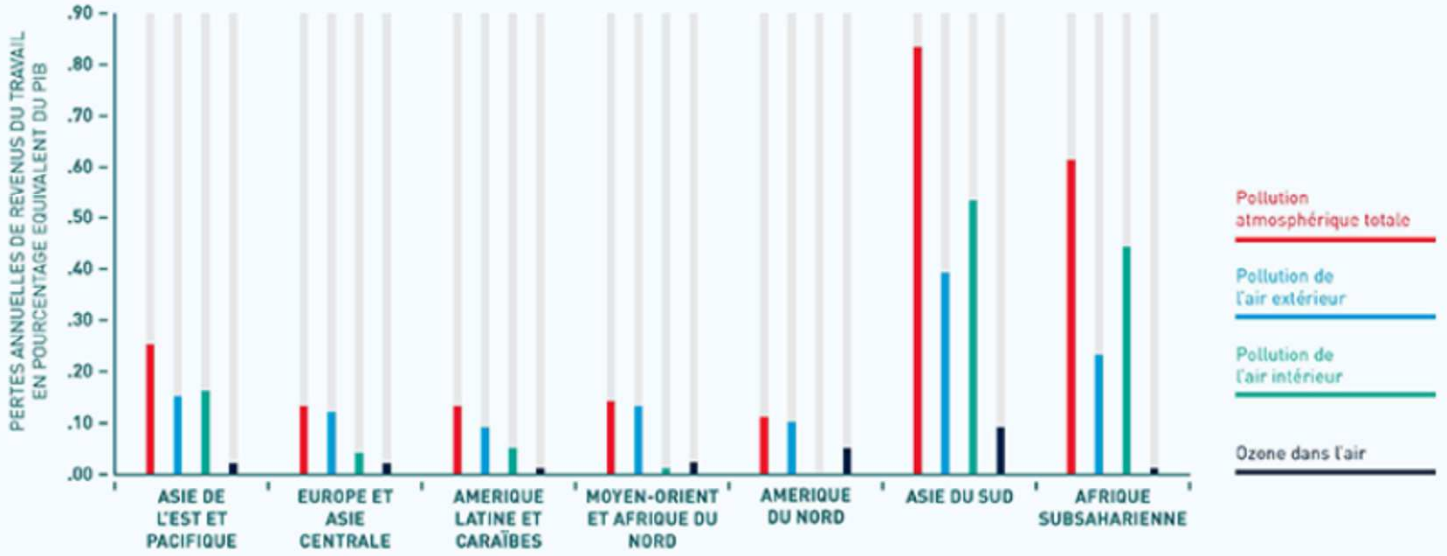
DOMMAGES ÉCONOMIQUES

LES COUTS VARIENT EN FONCTION DU CONTINENT ET DU TYPE DE POLLUTION ATMOSPHERIQUE

La pollution affecte la santé des gens de tout âge. Les décès prématurés des hommes et des femmes d'âge actif entraînent également des pertes de revenus pour l'économie nationale.

LES PERTES DE REVENUS LIÉES À LA POLLUTION DE L'AIR PAR RÉGION, 2013

Les pertes de revenus sont très importantes dans les régions ou la population est jeune. Les pertes de revenus dans les pays d'Asie du Sud ont dépassé 66 milliards de dollars en 2013, l'équivalent de pratiquement 1% du PIB régional.

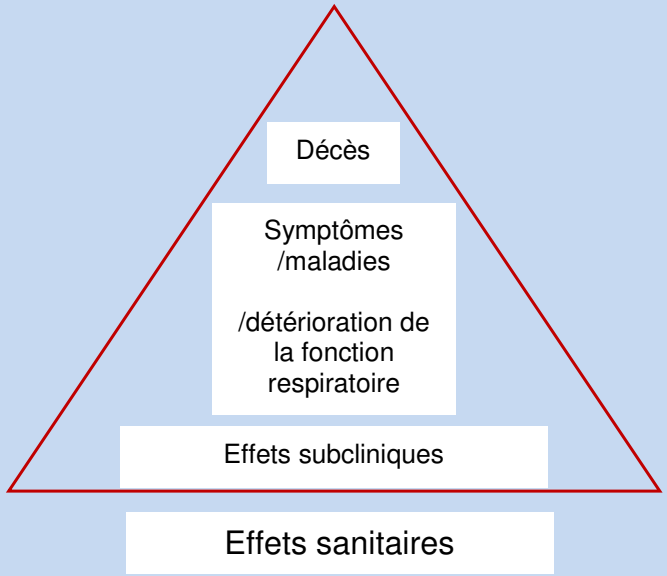


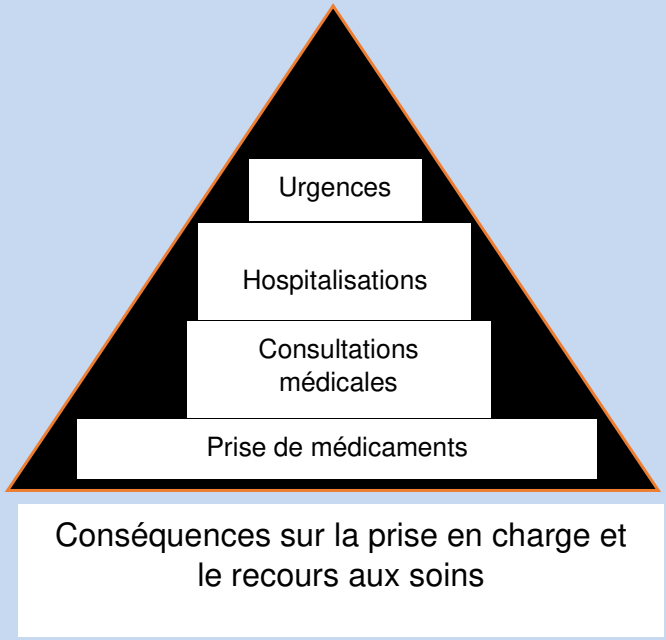
Impact de la réduction des émissions

- En termes de mortalité : entre 110 et 340 décès évitables
- En termes de pathologies chroniques : entre 50 et 170 naissances de faibles poids, entre 40 et 130 cas de cardiopathie ischémique et entre 830 et 2 930 cas d'asthme évitables
- En termes d'exacerbations de symptômes de ces pathologies : entre 140 et 410 hospitalisations pour cardiopathie ischémique et entre 190 et 700 recours aux urgences pour asthme évitables).
- Pour le scénario le plus favorable, les décès évitables représentent une baisse de l'ordre de 5 % des décès évitables pour une baisse des niveux de NO_2 à la valeur recommandée par l'OMS (20 µg/m3)

Impact sur la santé respiratoire

Pyramide des effets et des conséquences sur la prise en charge et le recours aux soins de l'impact de la pollution atmosphérique sur les allergies





2 types d'effets:
- À court terme
- À long terme

Asthme
BPCO
FPI
Cancers du poumon
Infections respiratoires

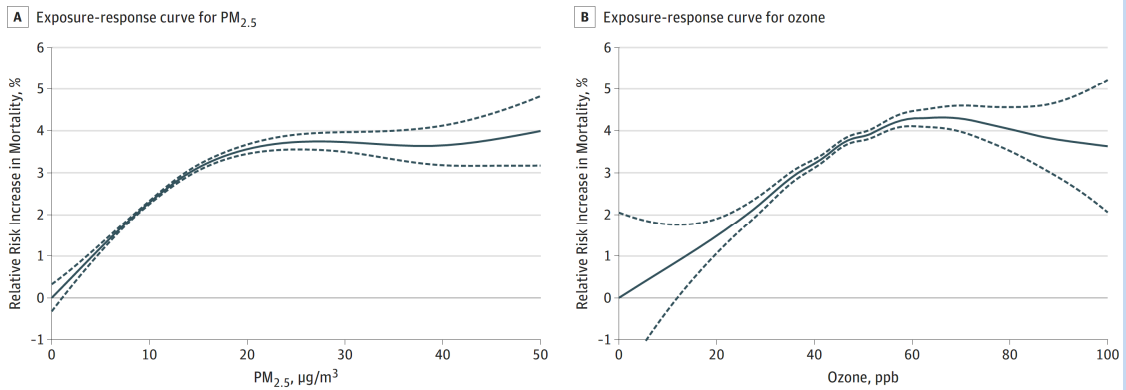
La base de la pyramide indique le pourcentage de la population atteinte

I. Annesi-Maesano, Revue des Maladies Respiratoires 2019

Table 2. Relative Risk Increase and Absolute Risk Difference of Daily Mortality Associated With Each 10-μg/m³ Increase in $PM_{2.5}$ and Each 10-ppb Increase in Ozone

	Relative Risk Increase, % (95% CI)		Absolute Risk Difference in Daily Mortality Rates, No. per 1 Million Persons at Risk per Day (95% CI)[a]	
Air Pollutant Analysis	$PM_{2.5}$	Ozone[b]	$PM_{2.5}$	Ozone[b]
Main analysis[c]	1.05 (0.95-1.15)	0.51 (0.41-0.61)	1.42 (1.29-1.56)	0.66 (0.53-0.78)
Low-exposure analysis[d]	1.61 (1.48-1.74)	0.58 (0.46-0.70)	2.17 (2.00-2.34)	0.74 (0.59-0.90)
Single-pollutant analysis[e]	1.18 (1.09-1.28)	0.55 (0.48-0.62)	1.61 (1.48-1.73)	0.71 (0.62-0.79)
Nearest monitors analysis[f]	0.83 (0.73-0.93)	0.35 (0.28-0.41)	1.13 (0.99-1.26)	0.45 (0.37-0.53)

Figure 5. Estimated Exposure-Response Curves for Short-term Exposures to Fine Particulate Matter ($PM_{2.5}$) and Ozone



A 2-pollutant analysis with separate penalized splines on $PM_{2.5}$ (A) and ozone (B) was conducted to assess the percentage increase in daily mortality at various pollution levels. Dashed lines indicate 95% CIs. The mean of daily exposure on the same day of death and 1 day prior (lag 01-day) was used as metrics of exposure to $PM_{2.5}$ and ozone. Analysis for ozone was restricted to the warm season (April to September). Ppb indicates parts per billion.

2000 – 2012
Toute la population Medicare
39 182 codes postaux

Qian Di, Lingzhen Dai, Yun Wang, Antonella Zanobetti, Christine Choirat, Joel D. Schwartz, et al. Association of Short-term Exposure to Air Pollution With Mortality in Older Adults. JAMA. 2017;318(24):2446-56.

International Journal of Environmental Research and Public Health

MDPI

Article

Long-term effect of outdoor air pollution on mortality and morbidity. A 12-year follow-up study for Metropolitan France

Shreosi Sanyal [1,*], Thierry Rocherau [2], Cara Maesano [1], Laure Com-Ruelle [2], Isabella Annesi-Maesano [1]

Table 1: Long-term risk for mortality in 2012 associated with air pollution* exposure in 1999-2000 at the departmental level in Metropolitan France.

Model I	All-cause	Cardiovascular diseases	Respiratory diseases	Model II	All-cause	Cardiovascular diseases	Respiratory diseases
NO_2	1.003 (1.003-1.004)**	1.000 (0.999-1.000)	0.994 (0.992-0.995)	NO_2	1.002 (1.001-1.002)	1.003 (1.003-1.004)	0.998 (0.997-1.000)
$PM_{2.5}$	1.024 (1.022-1.026)	1.022 (1.015-1.029)	1.037 (1.029-1.044)	PM_{10}	1.029 (1.027-1.031)	1.047 (1.045-1.051	1.056 (1.043-1.069)
O_3	1.002 (1.002-1.003)	0.999 (0.997-1.000)	1.009 (1.008-1.009)	O_3	0.991 (0.990-0.991)	0.993 (0.941-1.049)	1.000 (0.999-1.002)

Note: *According to the CHIMERE dispersion model; **RR for 10 µg/m^3 increase (95% Confidence Interval) of the air pollutant obtained with Poisson regression analysis controlled at municipal level for deprivation index, lung cancer mortality rates as proxy of tobacco smoking and total population.

Une certitude

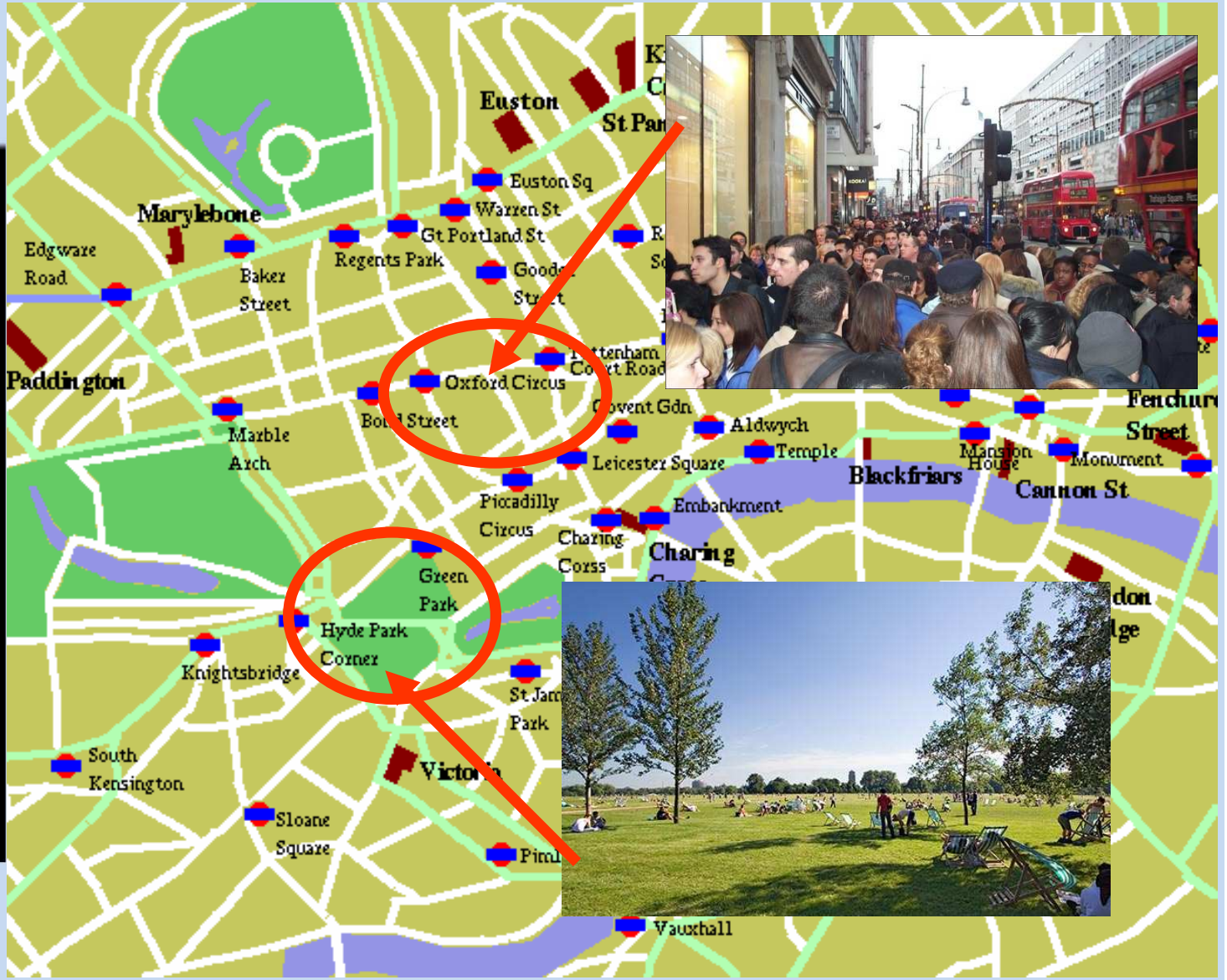
EDITORIAL
AIR POLLUTION

The clear and persistent impact of air pollution on chronic respiratory diseases: a call for interventions

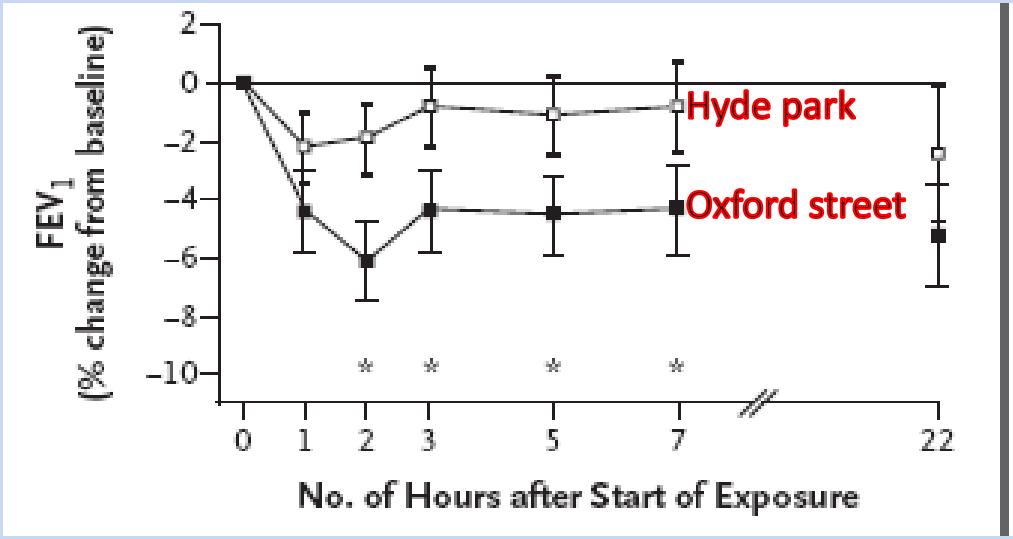
Isabella Annesi-Maesano[1], Francesco Forastiere[2], John Balmes[3,4,5], Erika Garcia[6], Jack Harkema[7], Stephen Holgate[8], Frank Kelly[2], Haneen Khreis[9], Barbara Hoffmann[10], Cara Nichole Maesano[1], Rob McConnell[11], David Peden[12], Kent Pinkerton[13], Tamara Schikowski[14], George Thurston[15], Laura S. Van Winkle[16] and Christopher Carlsten[17]

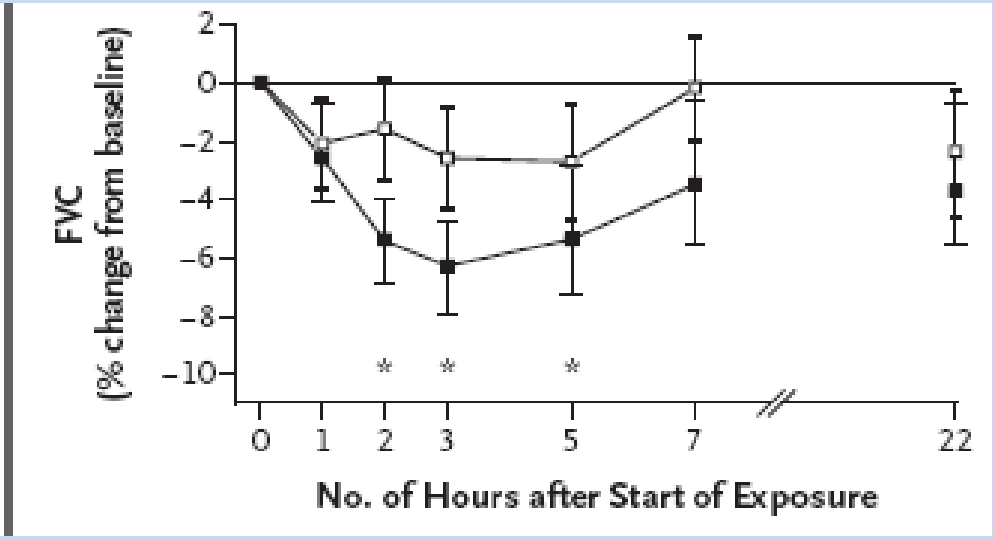
Affiliations: [1]Sorbonne Université and INSERM, Epidemiology of Allergic and Respiratory Diseases Dept, Institut Pierre Louis of Epidemiology and Public Health, Paris, France. [2]Environmental Research Group, King's College, London, UK. [3]University of California Berkeley-University of California San Francisco Joint Medical Program, Berkeley, CA, USA. [4]School of Public Health, University of California, Berkeley, CA, USA. [5]Dept of Medicine, School of Medicine, University of California, San Francisco, CA, USA. [6]Dept of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA. [7]Dept of Pathobiology and Diagnostic Investigation, College of Veterinary Medicine, Michigan State University, East Lansing, MI, USA. [8]Clinical and Experimental Sciences, Faculty of Medicine, University of Southampton, Southampton, UK. [9]Center for Advancing Research in Transportation Emissions, Energy, and Health (CARTEEH), Texas A&M Transportation Institute (TTI), College Station, TX, USA. [10]Institute for Occupational, Social and Environmental Medicine, Center for Health and Society, Heinrich Heine University of Düsseldorf,

Respiratory Effects of Exposure to Diesel Traffic in Person with Asthma



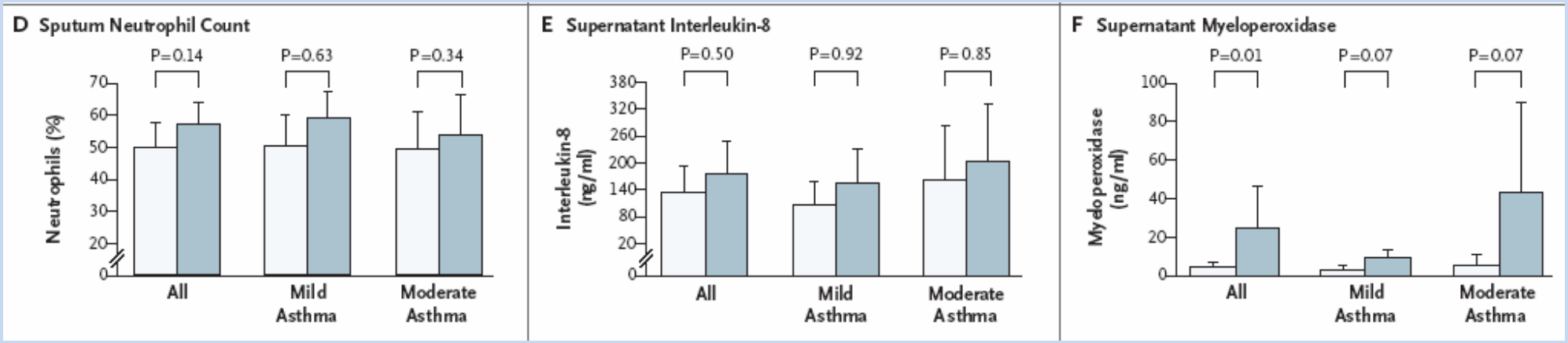
Mc Creanor J,NEJM Dec 2007





Walking for 2 hours on Oxford Street induced asymptomatic but consistent reductions in the forced expiratory volume in 1 second (FEV1) (up to 6.1%) and forced vital capacity (FVC) (up to 5.4%) .

Mc Creanor J,NEJM Dec 2007

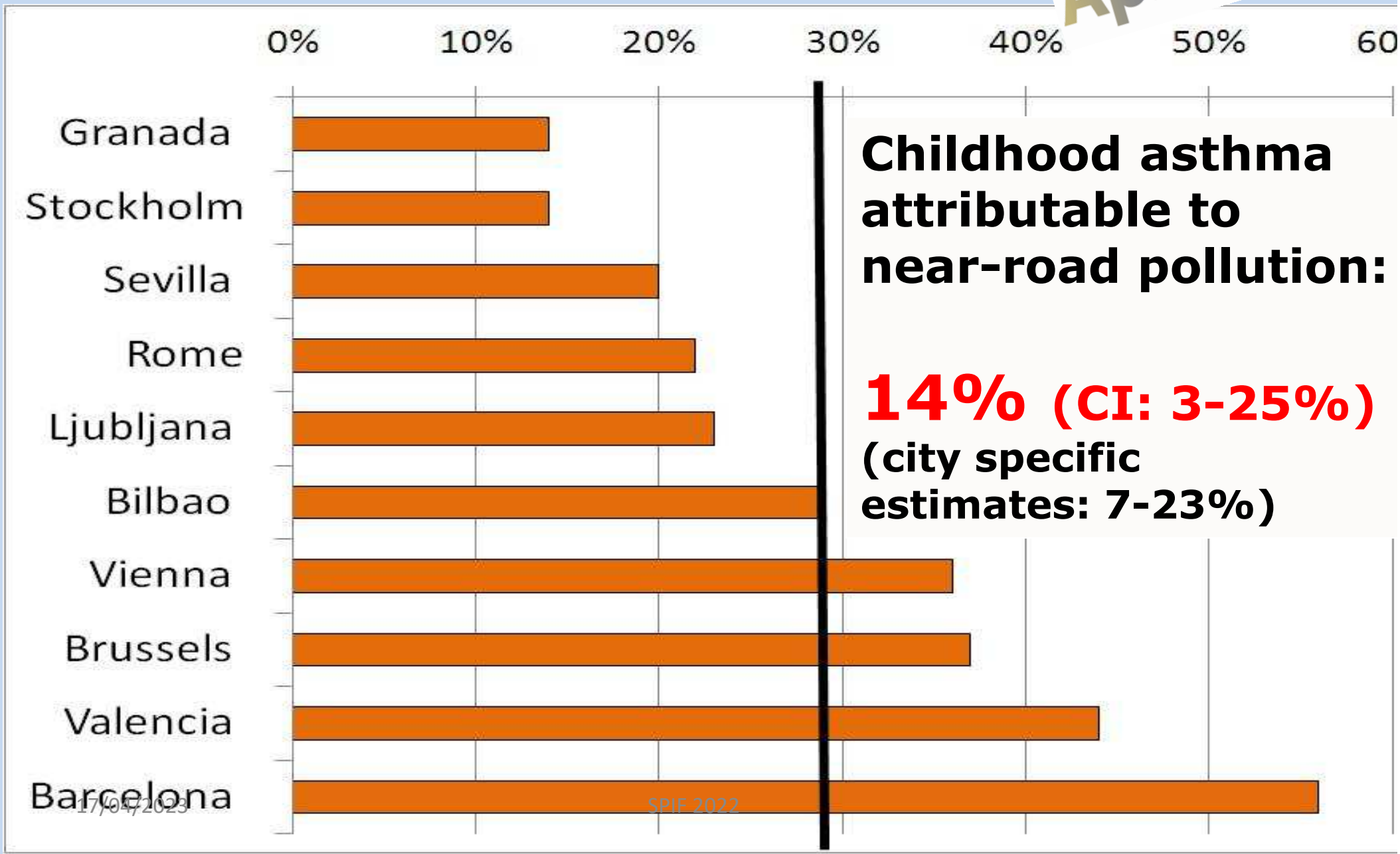


These changes were accompanied by increases in biomarkers of <u>neutrophilic inflammation</u>

Mc Creanor J,NEJM Dec 2007

% of people living within 75 m of roads with >10’000 vehicles per day!

Perez et al, - Eur Respir J –2013



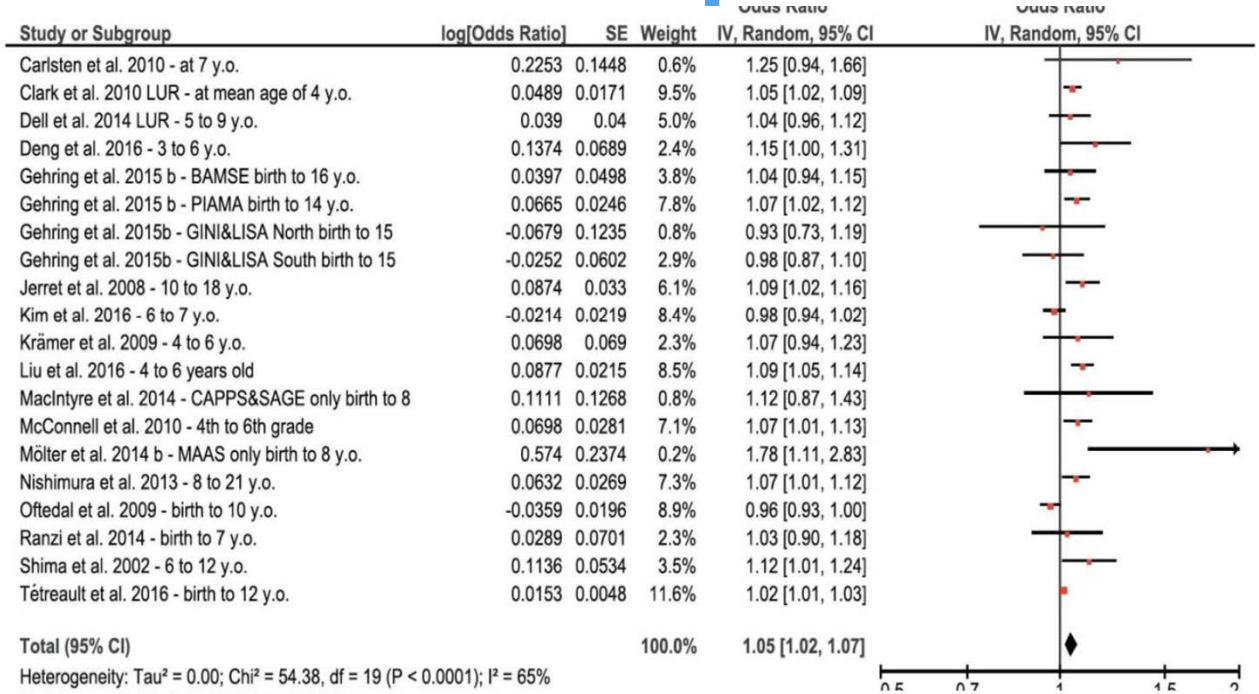
Childhood asthma attributable to near-road pollution:

14% (CI: 3-25%)

(city specific estimates: 7-23%)

Outdoor Air Pollution and New-Onset Airway Disease. An Official American Thoracic Society Workshop Report

George D. Thurston , John R. Balmes , Erika Garcia , Frank D. Gilliland , Mary B. Rice , Tamara Schikowski , Laura S. Van Winkle , Isabella Annesi-Maesano , Esteban G. Burchard , Christopher Carlsten , Jack R. Harkema , Show All...

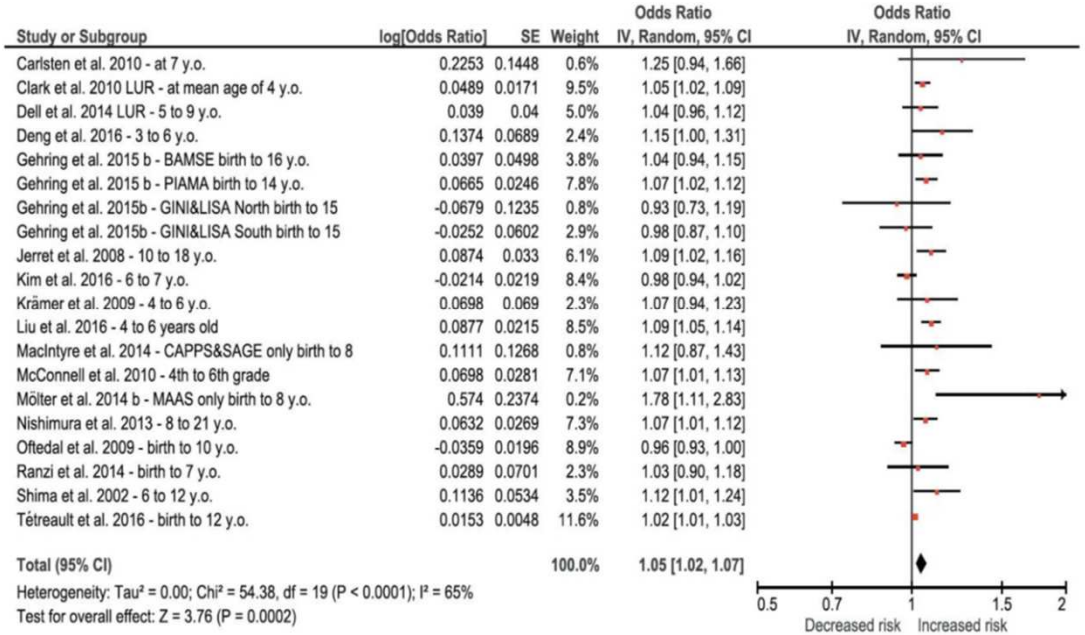


Study or Subgroup	log[Odds Ratio]	SE	Weight	IV, Random, 95% CI
Carlsten et al. 2010 - at 7 y.o.	0.2253	0.1448	0.6%	1.25 [0.94, 1.66]
Clark et al. 2010 LUR - at mean age of 4 y.o.	0.0489	0.0171	9.5%	1.05 [1.02, 1.09]
Dell et al. 2014 LUR - 5 to 9 y.o.	0.039	0.04	5.0%	1.04 [0.96, 1.12]
Deng et al. 2016 - 3 to 6 y.o.	0.1374	0.0689	2.4%	1.15 [1.00, 1.31]
Gehring et al. 2015 b - BAMSE birth to 16 y.o.	0.0397	0.0498	3.8%	1.04 [0.94, 1.15]
Gehring et al. 2015 b - PIAMA birth to 14 y.o.	0.0665	0.0246	7.8%	1.07 [1.02, 1.12]
Gehring et al. 2015b - GINI&LISA North birth to 15	-0.0679	0.1235	0.8%	0.93 [0.73, 1.19]
Gehring et al. 2015b - GINI&LISA South birth to 15	-0.0252	0.0602	2.9%	0.98 [0.87, 1.10]
Jerret et al. 2008 - 10 to 18 y.o.	0.0874	0.033	6.1%	1.09 [1.02, 1.16]
Kim et al. 2016 - 6 to 7 y.o.	-0.0214	0.0219	8.4%	0.98 [0.94, 1.02]
Krämer et al. 2009 - 4 to 6 y.o.	0.0698	0.069	2.3%	1.07 [0.94, 1.23]
Liu et al. 2016 - 4 to 6 years old	0.0877	0.0215	8.5%	1.09 [1.05, 1.14]
MacIntyre et al. 2014 - CAPPS&SAGE only birth to 8	0.1111	0.1268	0.8%	1.12 [0.87, 1.43]
McConnell et al. 2010 - 4th to 6th grade	0.0698	0.0281	7.1%	1.07 [1.01, 1.13]
Mölter et al. 2014 b - MAAS only birth to 8 y.o.	0.574	0.2374	0.2%	1.78 [1.11, 2.83]
Nishimura et al. 2013 - 8 to 21 y.o.	0.0632	0.0269	7.3%	1.07 [1.01, 1.12]
Oftedal et al. 2009 - birth to 10 y.o.	-0.0359	0.0196	8.9%	0.96 [0.93, 1.00]
Ranzi et al. 2014 - birth to 7 y.o.	0.0289	0.0701	2.3%	1.03 [0.90, 1.18]
Shima et al. 2002 - 6 to 12 y.o.	0.1136	0.0534	3.5%	1.12 [1.01, 1.24]
Tétreault et al. 2016 - birth to 12 y.o.	0.0153	0.0048	11.6%	1.02 [1.01, 1.03]
Total (95% CI)			100.0%	1.05 [1.02, 1.07]

Heterogeneity: Tau² = 0.00; Chi² = 54.38, df = 19 (P < 0.0001); I² = 65%
Test for overall effect: Z = 3.76 (P = 0.0002)

NO_2

BC



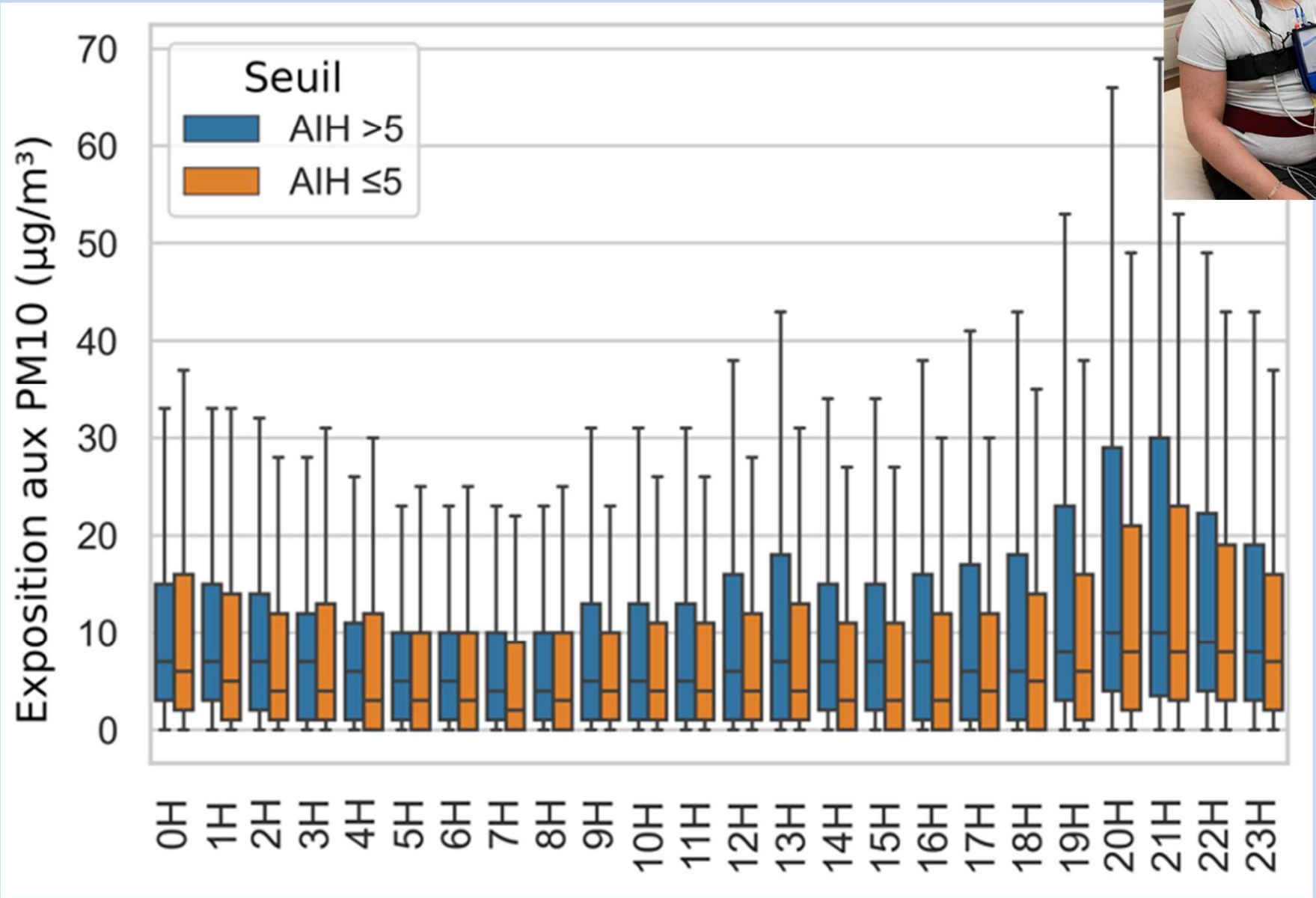
Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlsten et al. 2010 - at 7 y.o.	0.2253	0.1448	0.6%	1.25 [0.94, 1.66]
Clark et al. 2010 LUR - at mean age of 4 y.o.	0.0489	0.0171	9.5%	1.05 [1.02, 1.09]
Dell et al. 2014 LUR - 5 to 9 y.o.	0.039	0.04	5.0%	1.04 [0.96, 1.12]
Deng et al. 2016 - 3 to 6 y.o.	0.1374	0.0689	2.4%	1.15 [1.00, 1.31]
Gehring et al. 2015 b - BAMSE birth to 16 y.o.	0.0397	0.0498	3.8%	1.04 [0.94, 1.15]
Gehring et al. 2015 b - PIAMA birth to 14 y.o.	0.0665	0.0246	7.8%	1.07 [1.02, 1.12]
Gehring et al. 2015b - GINI&LISA North birth to 15	-0.0679	0.1235	0.8%	0.93 [0.73, 1.19]
Gehring et al. 2015b - GINI&LISA South birth to 15	-0.0252	0.0602	2.9%	0.98 [0.87, 1.10]
Jerret et al. 2008 - 10 to 18 y.o.	0.0874	0.033	6.1%	1.09 [1.02, 1.16]
Kim et al. 2016 - 6 to 7 y.o.	-0.0214	0.0219	8.4%	0.98 [0.94, 1.02]
Krämer et al. 2009 - 4 to 6 y.o.	0.0698	0.069	2.3%	1.07 [0.94, 1.23]
Liu et al. 2016 - 4 to 6 years old	0.0877	0.0215	8.5%	1.09 [1.05, 1.14]
MacIntyre et al. 2014 - CAPPS&SAGE only birth to 8	0.1111	0.1268	0.8%	1.12 [0.87, 1.43]
McConnell et al. 2010 - 4th to 6th grade	0.0698	0.0281	7.1%	1.07 [1.01, 1.13]
Mölter et al. 2014 b - MAAS only birth to 8 y.o.	0.574	0.2374	0.2%	1.78 [1.11, 2.83]
Nishimura et al. 2013 - 8 to 21 y.o.	0.0632	0.0269	7.3%	1.07 [1.01, 1.12]
Oftedal et al. 2009 - birth to 10 y.o.	-0.0359	0.0196	8.9%	0.96 [0.93, 1.00]
Ranzi et al. 2014 - birth to 7 y.o.	0.0289	0.0701	2.3%	1.03 [0.90, 1.18]
Shima et al. 2002 - 6 to 12 y.o.	0.1136	0.0534	3.5%	1.12 [1.01, 1.24]
Tétreault et al. 2016 - birth to 12 y.o.	0.0153	0.0048	11.6%	1.02 [1.01, 1.03]
Total (95% CI)			100.0%	1.05 [1.02, 1.07]

Heterogeneity: Tau² = 0.00; Chi² = 54.38, df = 19 (P < 0.0001); I² = 65%
Test for overall effect: Z = 3.76 (P = 0.0002)

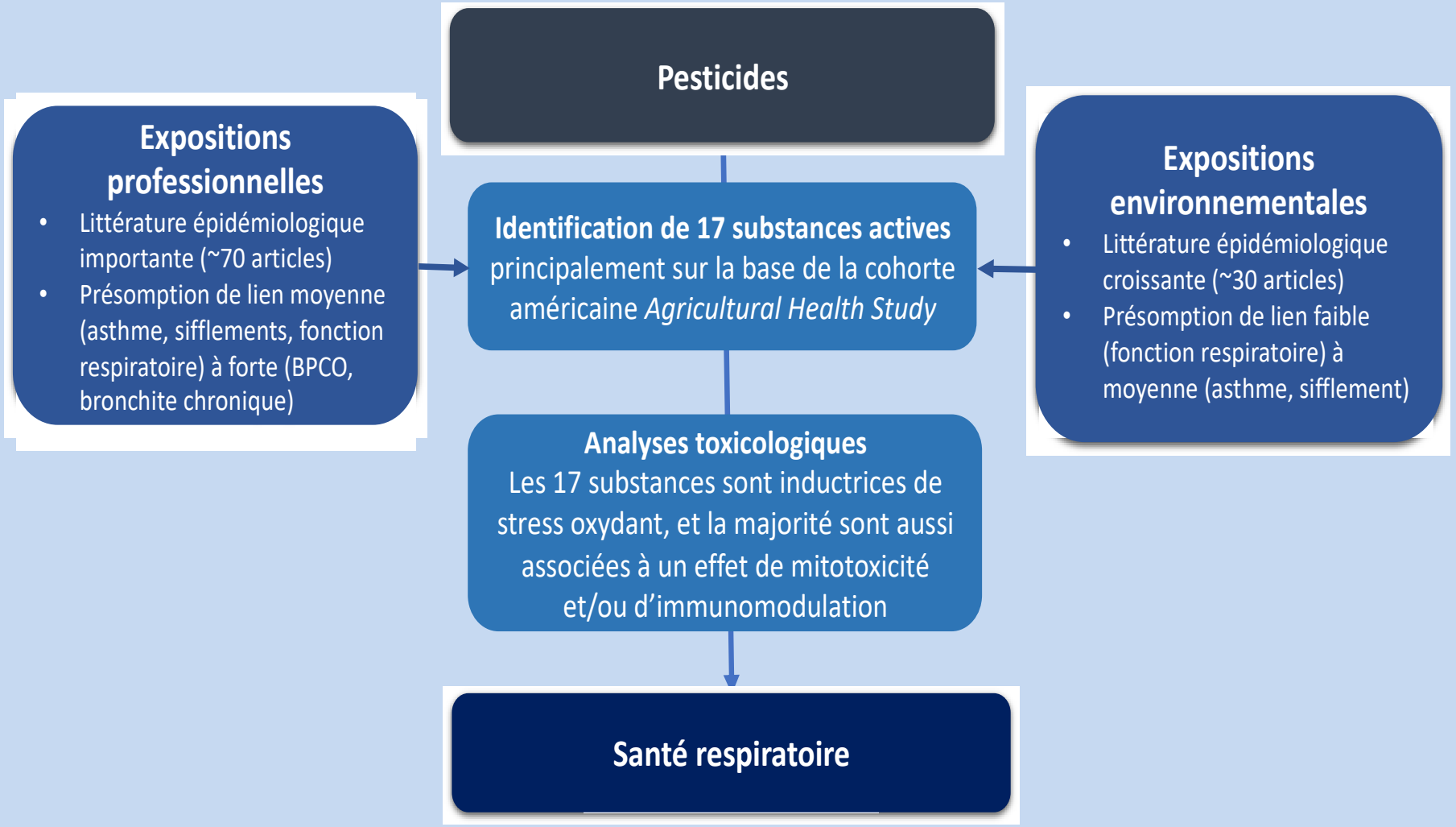
0.5 0.7 1 1.5 2
Decreased risk Increased risk

D’autres données récentes

Pollution particulaire et apnée du sommeil



Pesticides et asthme



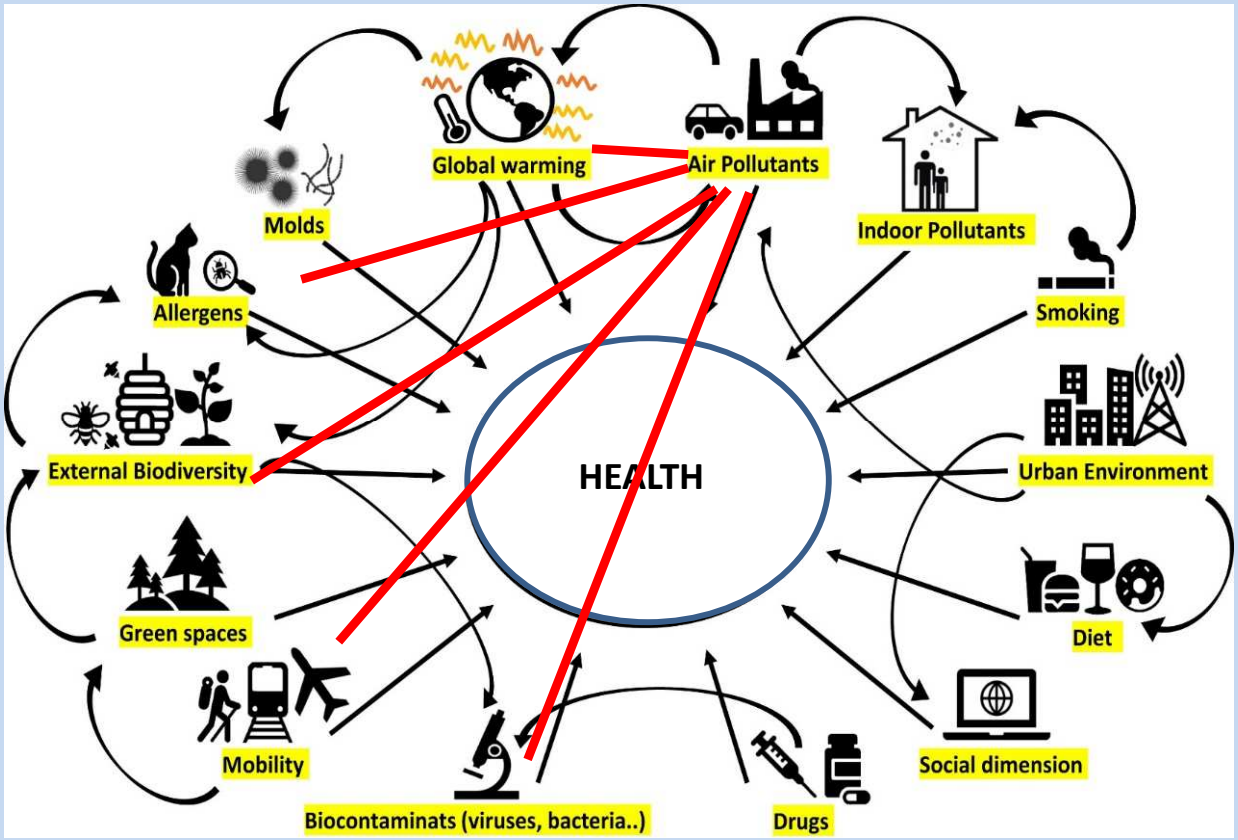
POUR REVENIR AU RATIONALE

- La prévalence des pathologies respiratoires augmente.
- Cela ne peut être expliqué par des transformations génétiques (qui requièrent plusieurs années pour se produire).
- Cela peut être expliqué par des transformations environnementales.
- **Les facteurs environnementaux qui se sont modifiés en parallèle à l'augmentation des allergies doivent être mis en cause**

→ Pollution atmosphérique

Air quality is a part of the exposome and is a major actor of one health approach

Air pollution that may affect animal, human and vegetation health leading is associated with many environmental factors: new infectious agents.



Modifed from: Call to action: Air pollution, asthma, and allergy in the exposome era

Isabella Annesi-Maesano, MD, PhD, DSc, Cara Nichole Maesano, PhD, Benedetta Biagioni, MD, Gennaro D'Amato, MD, Lorenzo Cecchi, MD, PhD

Journal of Allergy and Clinical Immunology 2021 14870-72DOI: (10.1016/j.jaci.2021.05.026)

SPIF 2022

Interaction between pollen, molds and air pollutants

❷ Traffic-related pollutants can trigger the release of allergen-containing granules from grass pollen, and increase the bioavailability of airborne pollen allergens. *(Motta et al 2006)*

❑ Modifications of the pollen morphology following exposure to pollutants

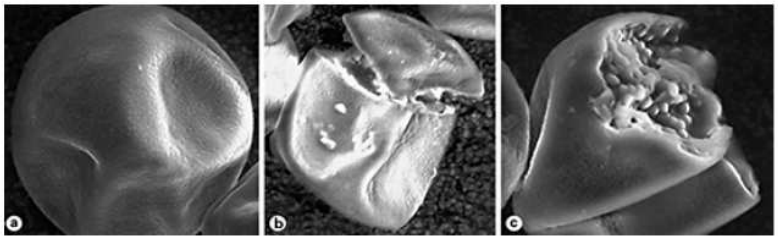


Fig. 1. Examples of damaged pollen grains. Treatment of pollen samples to air or pollutants can induce structural damage of the grains. **a** Intact pollen. ×7,540. **b** Pollen damaged following treatment to 50 ppm NO_2. ×3,000. **c** Pollen damaged following treatment to 0.7 ppm O_3. PCG can be seen inside the broken grain. ×6,000.

❑ Modifications of PCG release following exposure to pollutants

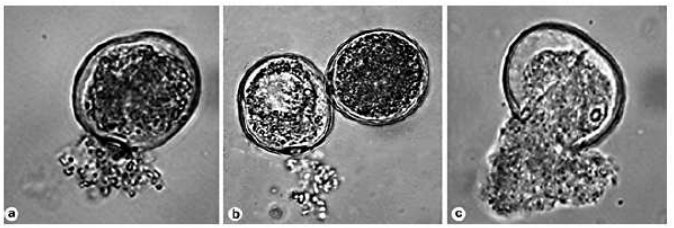


Fig. 2. Release of PCG following contact of pollen grains with water. PCG are expelled from the grain via the pore (**a**, **b**). Only a small proportion of the grains release their cytoplasm, and the remaining grains stay intact (**b**: intact grain on the right). However, in the fragile pollen, PCG release can also occur through breaks of the exine (**c**). ×400.

PCG: Pollen cytoplasmic granules **PCG**

SPIF 2022

IAM Paris 2020

Pollution atmosphérique et COVID-19

REVIEW
INFECTIOUS DISEASE

The impact of outdoor air pollution on COVID-19: a review of evidence from *in vitro*, animal, and human studies

Thomas Bourdrel[1], Isabella Annesi-Maesano[2], Barrak Alahmad[3], Cara N. Maesano[2] and Marie-Abèle Bind[4]

Pros and cons for the role of air pollution on COVID-19 development

Isabella Annesi-Maesano[1], Cara Nichole Maesano[1], Maria D'Amato[2], Gennaro D'Amato[3]

Allergy, 2021

[1]INSERM and Sorbonne University, Epidemiology of Allergic and Respiratory Diseases Department, IPLESP, Paris, France

[2]First Division of Pneumology, High Speciality Hospital V. Monaldi and University Federico II Medical School Naples, Napoli, Italy.

[3]Division of Respiratory and Allergic Diseases, Department of Chest Diseases, High Specialty A. Cardarelli Hospital, Napoli, Italy and Medical School of Specialization in Respiratory Diseases, University on Naples Federico II

Title: COVID-19 Pandemic: A Wake-Up Call for Clean Air

ATS Annals, 2021

Authors: Stephen A. Mein, MD[1], Isabella Annesi-Maesano, MD, PhD, DSc[2], Mary B. Rice, MD, MPH[1]

Multidisciplinary Respiratory Medicine 2021; volume 16:741

SHORT REPORT

OPEN ACCESS

Do gene-environment interactions play a role in COVID-19 distribution? The case of Alpha-antitrypsin, air pollution and COVID-19

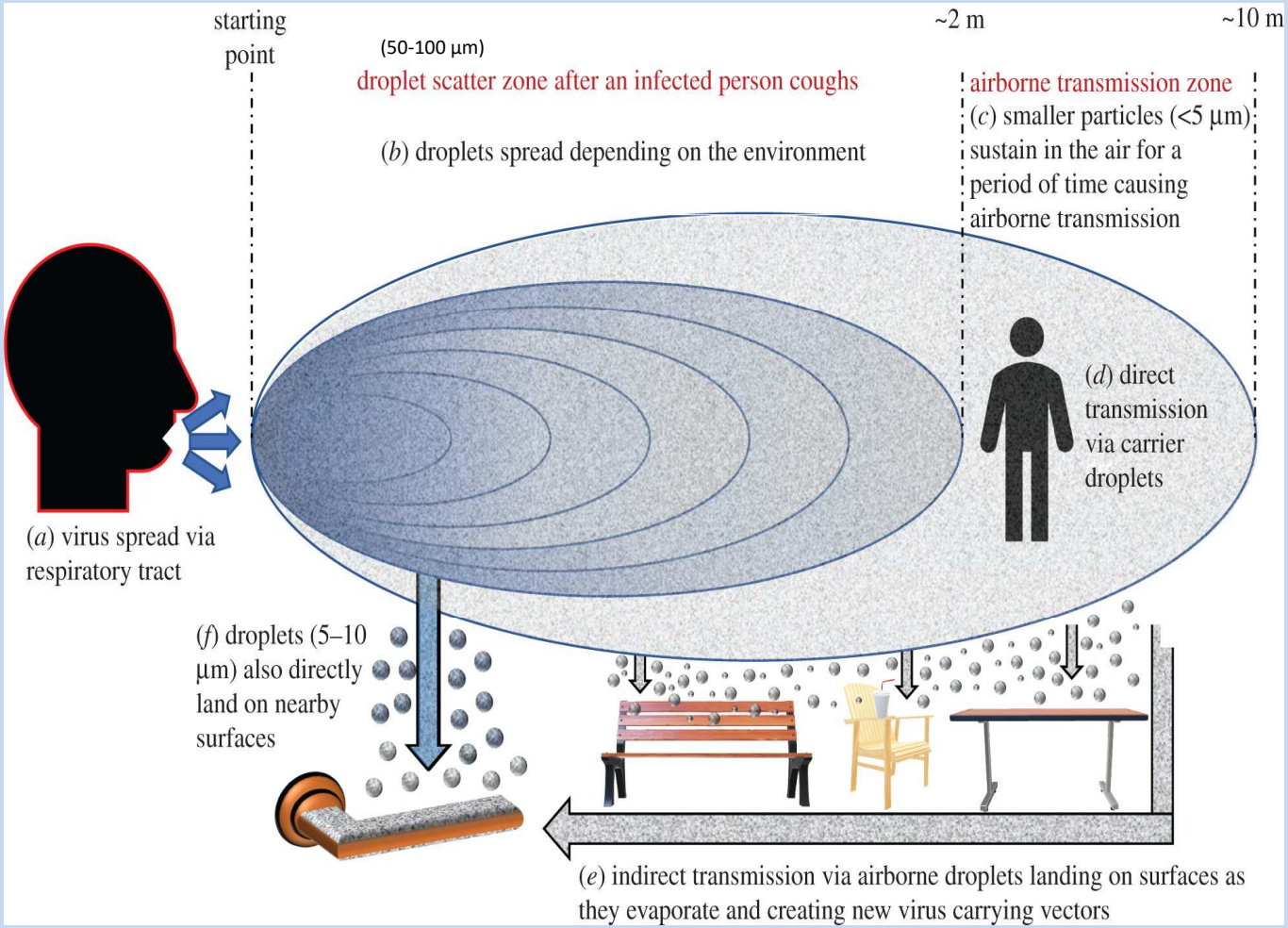
Nicola Murgia,[1] Angelo Guido Corsico,[2] Gennaro D'Amato,[3] Cara Nichole Maesano,[4] Arturo Tozzi,[5] Isabella Annesi-Maesano[4]

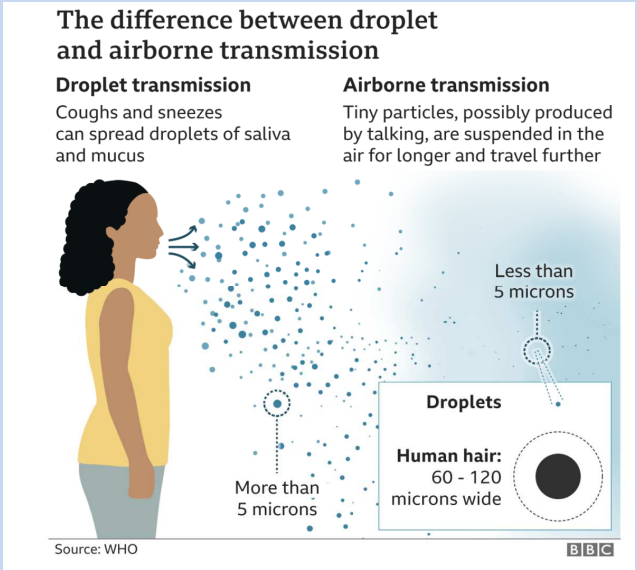
Allergy EUROPEAN JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY EAACI

Has the Spring 2020 lockdown modified the relationship between air pollution and COVID-19 mortality in Europe?

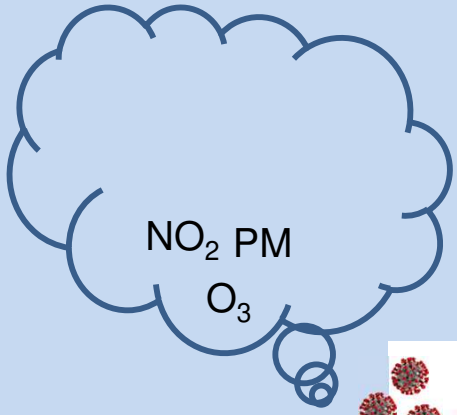
Journal:	*Allergy*
Manuscript ID	ALL-2021-01155.R2
Wiley - Manuscript type:	Letter
Date Submitted by the Author:	19-Jan-2022
Complete List of Authors:	Annesi-Maesano, Isabella; Montpellier Universite d'Excellence Maesano, Cara; Montpellier Universite d'Excellence Dessimond, Boris; Montpellier Universite d'Excellence Prud'homme, Julie; Montpellier Universite d'Excellence Risques Banerjee, Soutrik; Montpellier Universite d'Excellence

SARS CoV-2 transmissions





Effets directs de la pollution atmosphérique rélévants dans le COVID



i)

Altération de la perméabilité des voies respiratoires**

**: ↘ fonctionnement des cellules ciliées des voies respiratoires
↘ phagocytose des macrophages,
↘ défense immunitaire respiratoire

ii)

Effets sanitaires (surtout à long terme) de la pollution

- Maladies cardiovasculaires
- Maladies respiratoires
- Maladies métaboliques (diabète, surpoids…)
- Maladies neurodégénératives
- Maladies du rein
- Cancer
- …

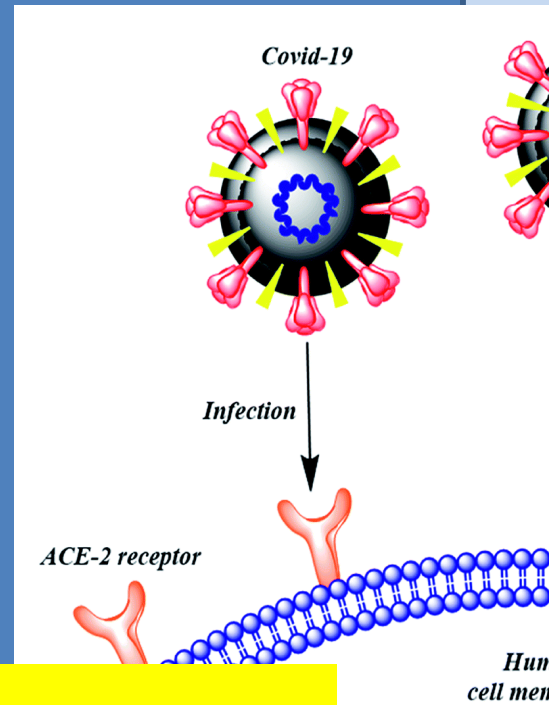
Comorbidités du COVID 19

Risque accru de contagion et de COVID-19

Mécanismes

First author [ref.]	Study location	Period	Air pollutants exposure	COVID-19 outcome	Findings: quantified results	Comments
Long-term exposure						
Fattorini [29]	Italy (regions)	2010–2019	Daily data on distribution of NO_2, O_3, $PM_{2.5}$ and PM_{10} and days exceeding regulatory limits during the last 4 years, and during the last decade (2010–2019) with limits exceeded for at least 35 days according to the national air quality monitoring system	Daily number of confirmed cases	Positive correlations in up to 71 provinces between $PM_{2.5}$, PM_{10}, O_3, and NO_2 and cases ($0.23 \leqslant R^2 \leqslant 0.34$)	No adjustments for meteorological factors and population density
Wu [30]	USA (all inland	Up to 4	County-level	COVID-19 death	A 1 $\mu g.m^{-3}$ increase in	Main analysis adjusted

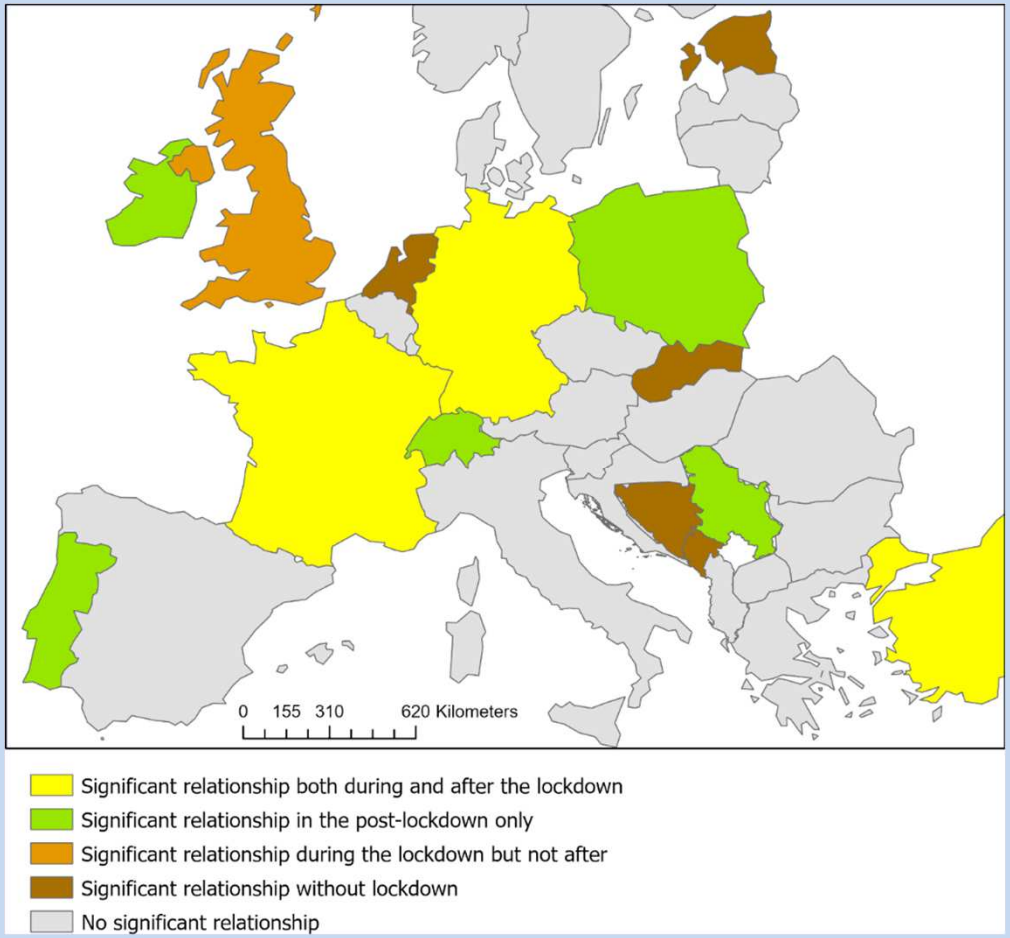
First author [ref.]	Study location	Period	Air pollut exposu
Travaglio [32]	UK Biobank data sources	2018 to 2019	Annual ave daily measureme NO_2, NO a according national air monitoring and hig resolutio pollution es (<2 km awa self-repo addres
Ogen [33]	Europe (66 administrative regions in four countries: Italy, France, Germany, Spain)	Jan to Feb 2020	Troposph concentrat NO_2 (Senti data) takin account ve airflo
Cole [34]	The Netherlands (355 municipalities)	Up to 5 June 2020	Annu concentrat $PM_{2.5}$, NO_2 averaged o



ative risk (or hazard ratio) of excess VID-19 mortality for A and SARS-CoV-1 in hina (assuming that ARS and COVID-19 ortality are similarly fected by long-term exposure to air pollution) from g-term exposure to pollution using the xposure–response nction of the WHO to estimate the ttributable fraction

Hypothèse d'un coup unique

- **L'enzyme de conversion de l'angiotensine-2 (ACE-2) est un récepteur pour les coronavirus, notamment les coronavirus 1 et 2 du syndrome respiratoire aigu sévère (SARSCoV)**
- **L'ACE-2 est surexprimée en cas d'exposition chronique à la pollution atmosphérique telle que à NO_2 and $PM_{2.5}$**
- **L'ACE-2 est augmentée dans le cas de certaines pathologies chroniques**



Allergy EUROPEAN JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY EAACI

Has the Spring 2020 lockdown modified the relationship between air pollution and COVID-19 mortality in Europe?

Journal:	*Allergy*
Manuscript ID	ALL-2021-01155.R2
Wiley - Manuscript type:	Letter
Date Submitted by the Author:	19-Jan-2022
Complete List of Authors:	Annesi-Maesano, Isabella; Montpellier Universite d'Excellence Maesano, Cara; Montpellier Universite d'Excellence Dessimond, Boris; Montpellier Universite d'Excellence Prud'homme, Julie; Montpellier Universite d'Excellence Colette, Augustin; Institut National de l'Environnement Industriel et des Risques Banerjee, Soutrik; Montpellier Universite d'Excellence

Intervention studies

A long terme

Interdiction du diesel à Tokyo en 2003 - maintien à Osaka

Déclin NO2 similaire Tokyo vs Osaka
Mais déclin plus important à Tokyo des PM 2,5

Après ajustement sur les taux de mortalité standardisés pour l'âge à Osaka
Le pourcentage de changement entre les **3 premières années** (Octobre 2000 à Septembre 2003) et les **3 dernières années** (Octobre 2009 à Septembre 2012) :

Toutes causes	- 6%
Causes cardio-vasculaires	-11%
Cardiopathies ischémiques	-10%
Maladies vasculaires cérébrales	- 6%
Maladies pulmonaires	**- 22%**
Cancer du poumon	- 5%

Yorifuji T, Kashima S, Doi H. Fine-particulate Air Pollution from Diesel Emission Control and Mortality Rates in Tokyo: A Quasi-experimental Study. Epidemiology. 2016;27(6):1.

Association of Improved Air Quality with Lung Development in Children

W. James Gauderman, Ph.D., Robert Urman, M.S., Edward Avol, M.S., Kiros Berhane, Ph.D., Rob McConnell, M.D., Edward Rappaport, M.S., Roger Chang, Ph.D., Fred Lurmann, M.S., and Frank Gilliland, M.D., Ph.D.

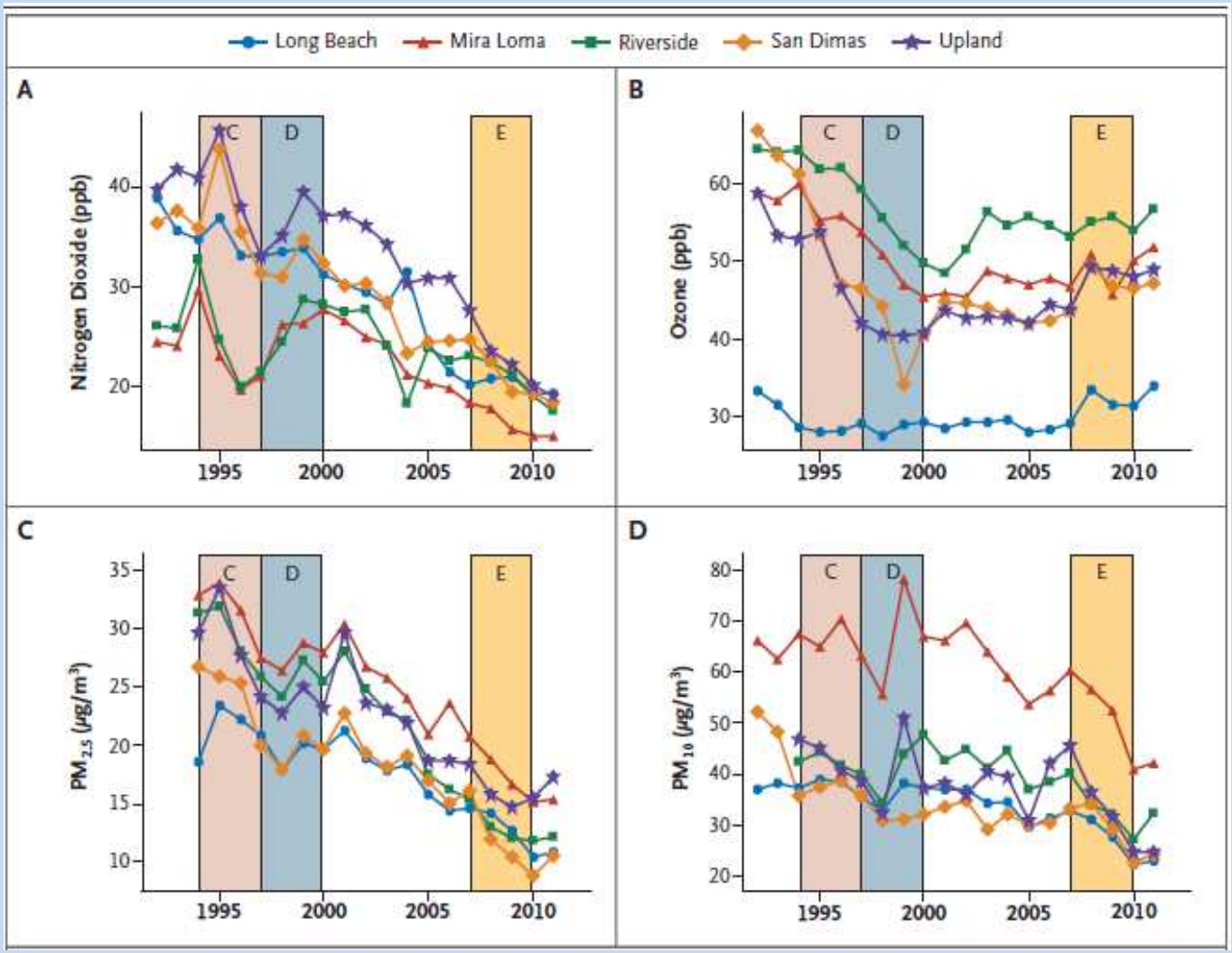
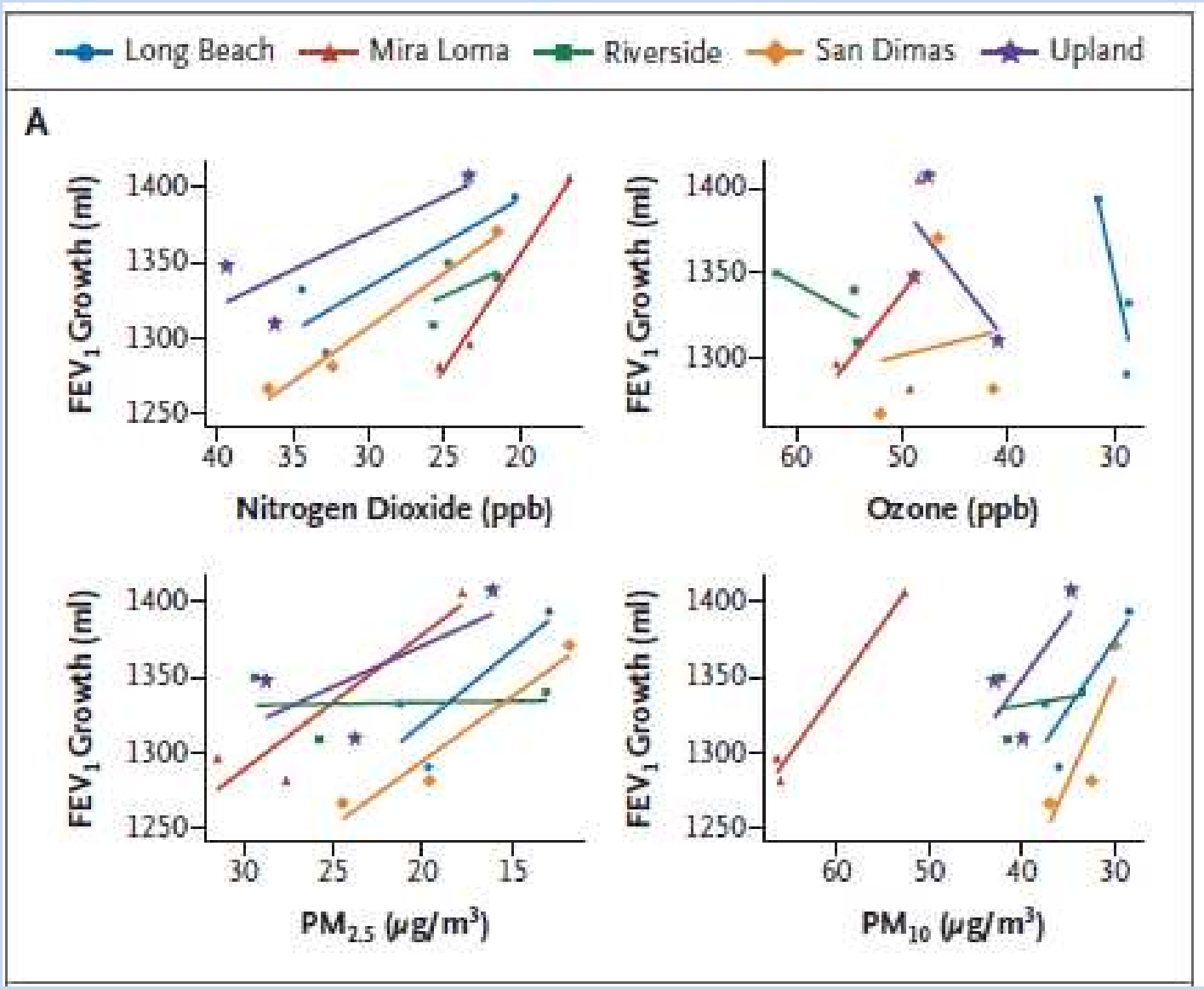


Figure 1. Levels of Four Air Pollutants from 1994 to 2011 in Five Southern California Communities.

Colored bands represent the relevant 4-year averaging period for the analysis of lung-function growth in each of the three cohorts, C, D, and E. $PM_{2.5}$ denotes particulate matter with an aerodynamic diameter of less than 2.5 μm, and PM_{10} particulate matter with an aerodynamic diameter of less than 10 μm.

Figure 2. Mean 4-Year Lung-Function Growth versus the Mean Levels of Four Pollutants.

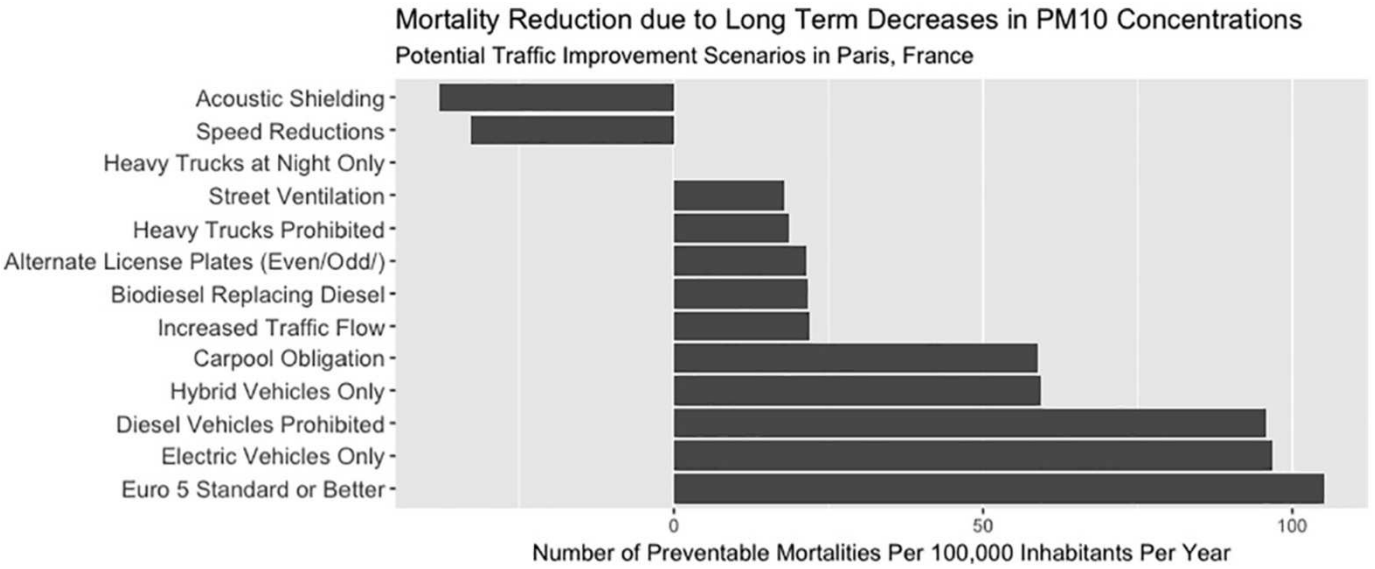


N ENGL J MED 372;10 NEJM.ORG MARCH 5, 2015

HIGHLIGHTS

- Reductions in mortality for 13 hypothetical traffic scenarios in Paris, France.
- Over 100 deaths in 100,000 avoided with stricter emissions standards for vehicles.
- Non-combustion-related traffic emissions are significant and must be addressed.

GRAPHICAL ABSTRACT



Maesano, C., Morel, G., Matynia, A., Ratsombath, P., Bonnety, J., Legros, G., Costa, P., Prud'homme, J., Annesi-Maesano, I. (2019). **Impacts on human mortality due to reductions in PM10 concentrations through different traffic scenarios in Paris, France** Science of The Total Environment https://dx.doi.org/10.1016/j.scitotenv.2019.134257

Questions

1. Quels sont les polluants et leurs sources?
2. Quel est l'état de la pollution atmosphérique? Combien sommes nous exposés?
3. Quel est l'impact de la pollution atmosphérique sur la santé respiratoire (genèse et aggravation)?
4. Sommes-nous tous égaux face à la pollution?
5. Question surprise

What to tell patients?

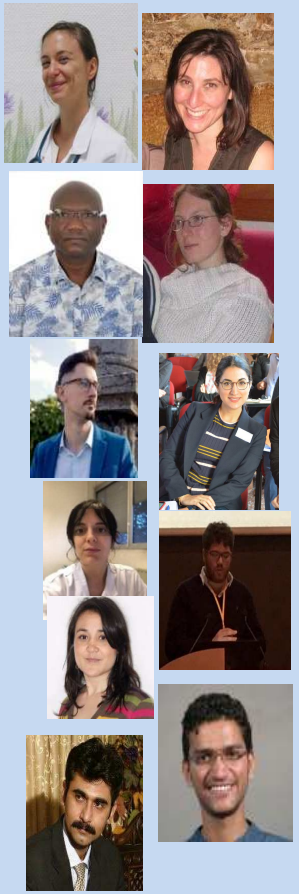
Stop running outdoors?
Ware a mask?
Use air cleaners?
Avoid opening the windows?
Drink more orange juice?
Change your apartment?
Change your genes?

Conclusions

- Individus exposés à une multitudes de polluants atmosphérique à l'intérieur et à l'extérieur des locaux, de façon excessive dans certaines circonstances.
- Rôle établi de la pollution atmosphérique (certains polluants en particulier) dans l'aggravation et le développement de l'asthme et des allergies.
- Coûts socioéconomiques élevés.
- D'autres investigations nécessaires pour cibler d'autres pathologies.

IDESP

https://idesp.umontpellier.fr/



Inserm
Institut national
de la santé et de la recherche médicale

isabella.annesi-maesano@inserm.fr

Promoting clean air

Goal

47. Promoting clean air by reducing outdoor and indoor air pollution will assist in addressing NCDs, including CVD, chronic and acute respiratory disease, and cancers.

Actions

49. Actions in this area that cross-reference with existing action plans, resolutions and conventions, requiring a strong stewardship role of the health sector in working across different sectors and levels of government, include:

- support the regional implementation of World Health Assembly resolution WHA68.8 on health and the environment, addressing the health impact of air pollution;
- continue and enhance efforts to promote the ratification and implementation of the 1979 Geneva Convention on Long-range Transboundary Air Pollution;
- develop appropriate policies that prevent and reduce tobacco consumption, exposure to tobacco smoke and nicotine addiction, with particular attention to young people, non-smokers and vulnerable groups *(14,37)*;
- continue and enhance efforts to decrease and monitor the incidence of acute and chronic respiratory diseases through reduction of exposure to particulate matter and its precursors, especially from industry, transport and domestic combustion, as well as ground-level ozone and other gaseous pollutants, in line with WHO's air quality guidelines *(36)*; and
- develop appropriate cross-sectoral policies and regulations capable of making a strategic difference in order to reduce indoor pollution, and provide incentives and opportunities to ensure that citizens have access to sustainable, clean and healthy energy solutions in homes and public places *(36)*.

Ten principles for clean air

B. Brunekreef, I. Annesi-Maesano, J.G. Ayres, F. Forastiere,
B. Forsberg, N. Kunzli, J. Pekkanen T. Sigsgaard. Eur Respir J 2012; 39:525-528

ERS EUROPEAN RESPIRATORY SOCIETY every breath counts

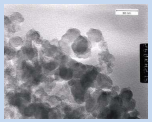
The European Respiratory Society Environment and Health Committee (www.ersnet.org) has developed the following 10 concise principles for clean air, which summarize the scientific state of the art and provide guidance for public health policy.

1) Citizens are entitled to clean air just like clean water and safe food.

2) Outdoor air pollution is one of the biggest environmental health threats in Europe today, leading to significant reductions of life expectancy and productivity.

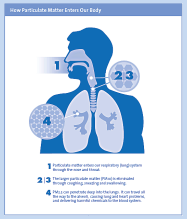
3) Fine particles and ozone are the most serious pollutants. There is an urgent need to reduce their concentrations significantly.

4) Roadside pollution poses serious health threats that cannot be adequately addressed by regulating fine particle mass or ozone. Other metrics such as ultrafine particles and black carbon need to be considered in future research and in further regulation.



5) Non-tail pipe emissions (from brakes, tires and road surface, etc.) pose a health threat for road users and subjects living close to busy roads.

6) Real-world emissions of nitrogen dioxide from modern diesel engines are much higher than anticipated. This may expose many road users and subjects living on stagnating weather that many impact on health, although to what extent requires further research.



7) Global warming will lead to more heat waves, during which air pollution concentrations are also elevated and during which hot temperatures and air pollutants act in synergy to produce more serious health effects than expected from heat or pollution alone.

8) Combustion of biomass fuel produces toxic pollutants. This is true for controlled fires, such as fire places, woodstoves and agricultural burning, as well as for uncontrolled wildfires. There is a need to assess the real health impact of air pollution from these sources in many areas in Europe to inform on the need for better control.

9) Compliance with current limit values for major air pollutants in Europe confers no protection for public health. In fact, very serious health effects occur at concentrations well below current limit values, especially those for fine particles.

10) EU policies to reduce air pollution are needed that ultimately lead to air that is clean and no longer associated with significant adverse effects on the health of European citizens. The benefits of such policies outweigh the costs by a large amount.