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Data for health

Biomasse : quels enjeux en terme d'amélioration des connaissances sur les effets sanitaires?

Biomass: what's at stake in terms of improving knowledge on health effects?

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Disclosure

International

- ERS Ethics and Integrity Committee (Member)
- EAACI ROC
- EAACI Environmental Guidelines
- AAAAI Environmental Exposures and Respiratory Health Committee
- ATS Health Policy Committee

National

- IRD Ethics Committee
- Comité prévention et protection (CPP) MEDD
- SFA Scientific Committee (Member)
- CSTB-OQAI Scientific Committee (Member)
- RNSA Scientific Committee (Member)
- Météo France (Commission Santé)
- Société de Pneumologie de Langue Française: GT PAPPEI
- Conseil d'Administration de l'APPA

- **Section Editor for Environmental Health of ERJ (IF: 33) and IJTLD (IF:4)**

Data for health

5 questions

Démarche d'épidémiologie pour la santé publique:

- Définir l'exposition et la mesurer (source au moins)
- Estimer la relation entre exposition et événement de santé
- Calculer le risque au niveau de la population
- Proposer des mesures de prévention

1. What is biomass in
2. How much are individuals exposed to the various forms of biomass at the population-based level?
3. What are the health effects of biomass exposure?
4. What can be done to protect human beings from biomass health effects?
5. Biomass vs. climate change?

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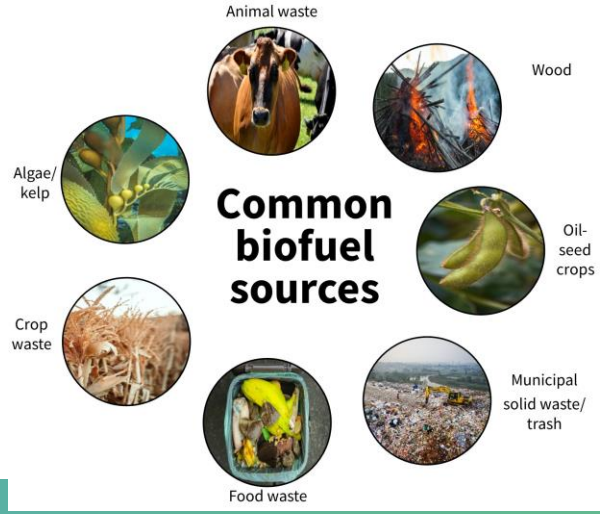
Introducing biomass and its burden

What is biomass?

Biomass is any living or recently living plant or animal-based material that is burned by humans as fuel, for ex. wood, dried animal dung, charcoal, grass and agricultural residue such as straw and sticks, dried leaves and twigs and wild grass.



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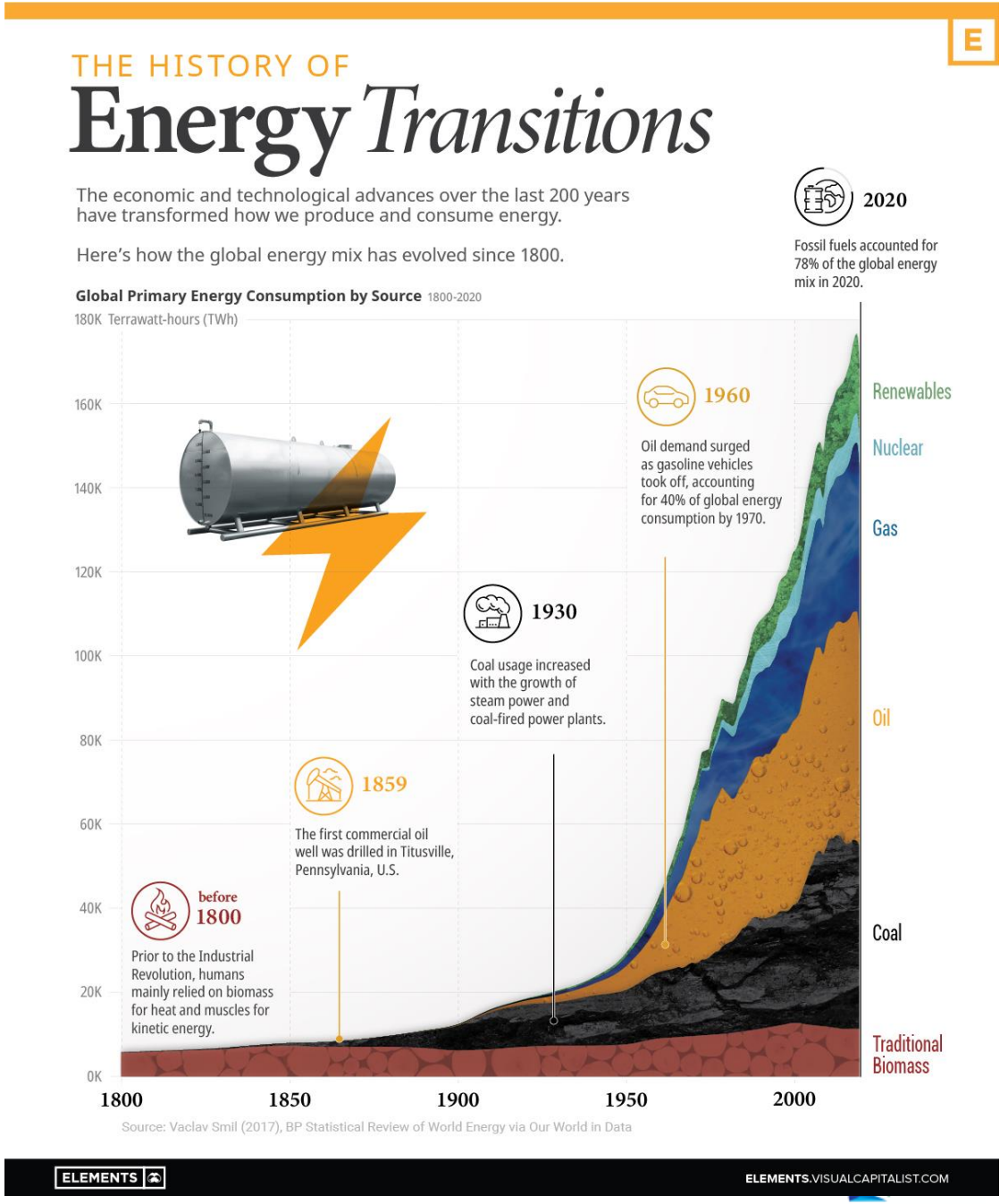
Biomass the oldest kind of energy use

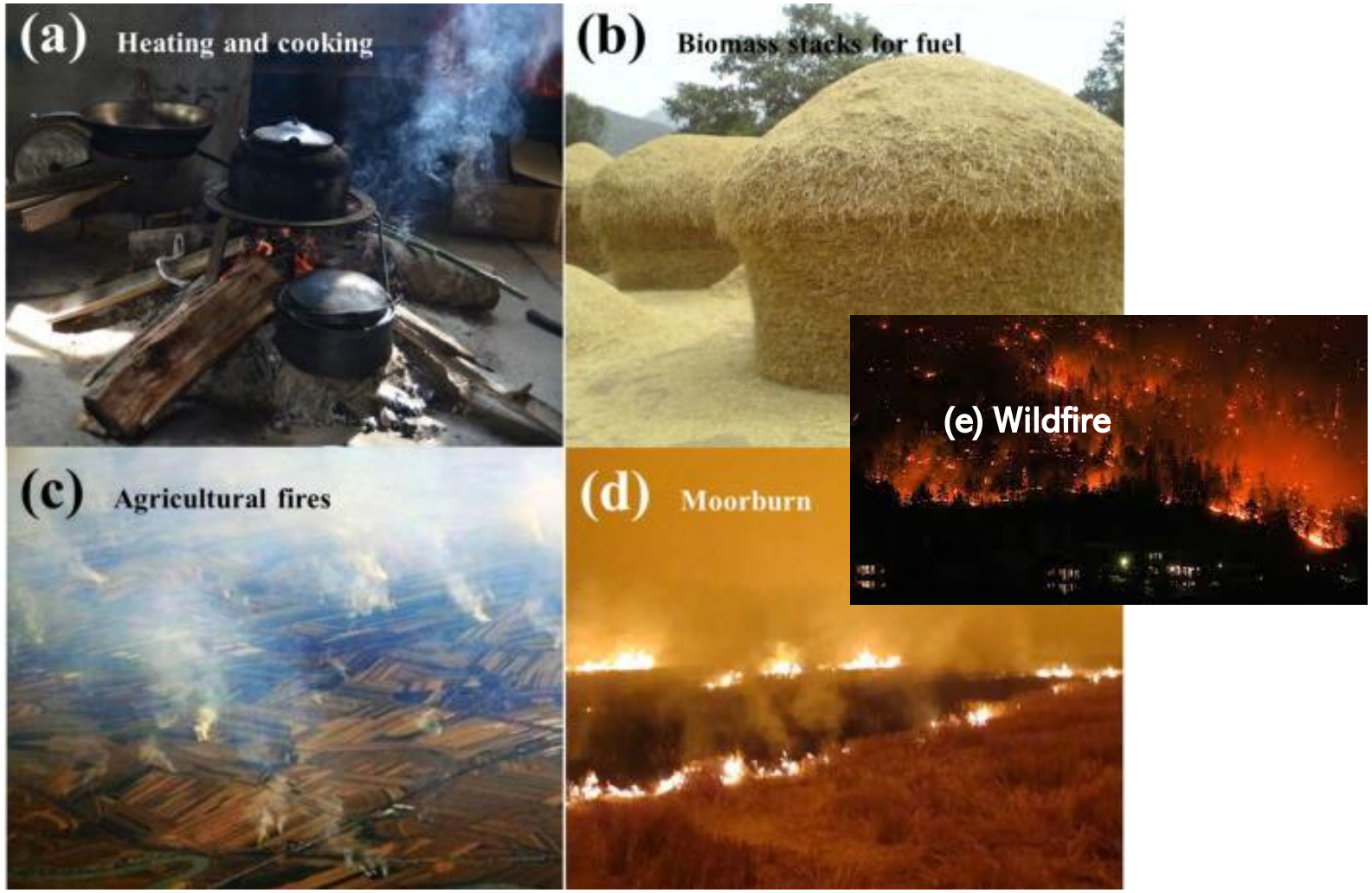
NOT ONLY ENERGY! The drawings in the Chauvet cave were made with pine charcoal.



BIOMASS IN POPULATION BASED STUDIES

Most studies on:

- Biomass used for heating and cooking in developing countries
- Wood burning in industrialized countries
- Wildfire combustion

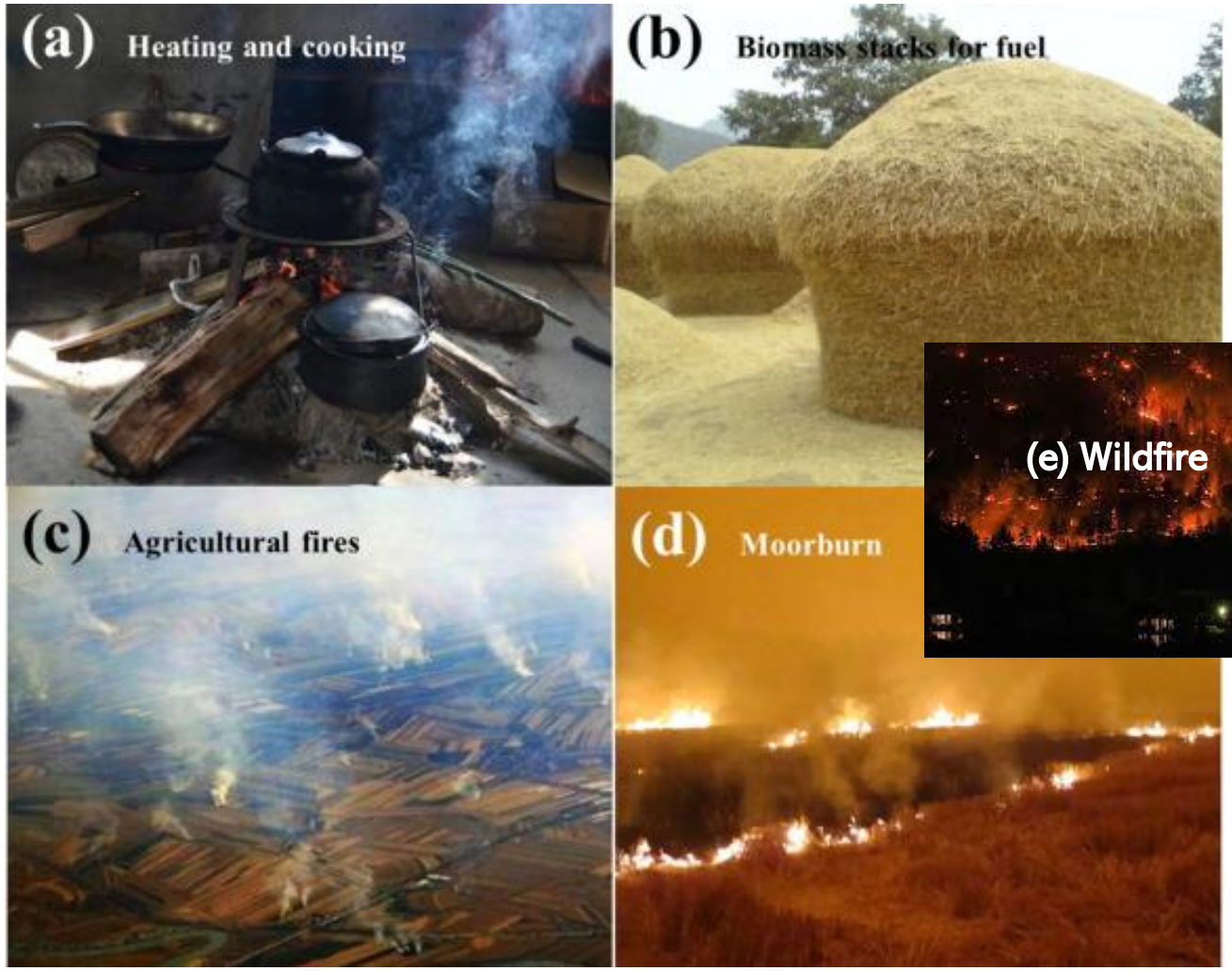


A MULTIPOLLUTON PHENOMENON

Biomass burning composition

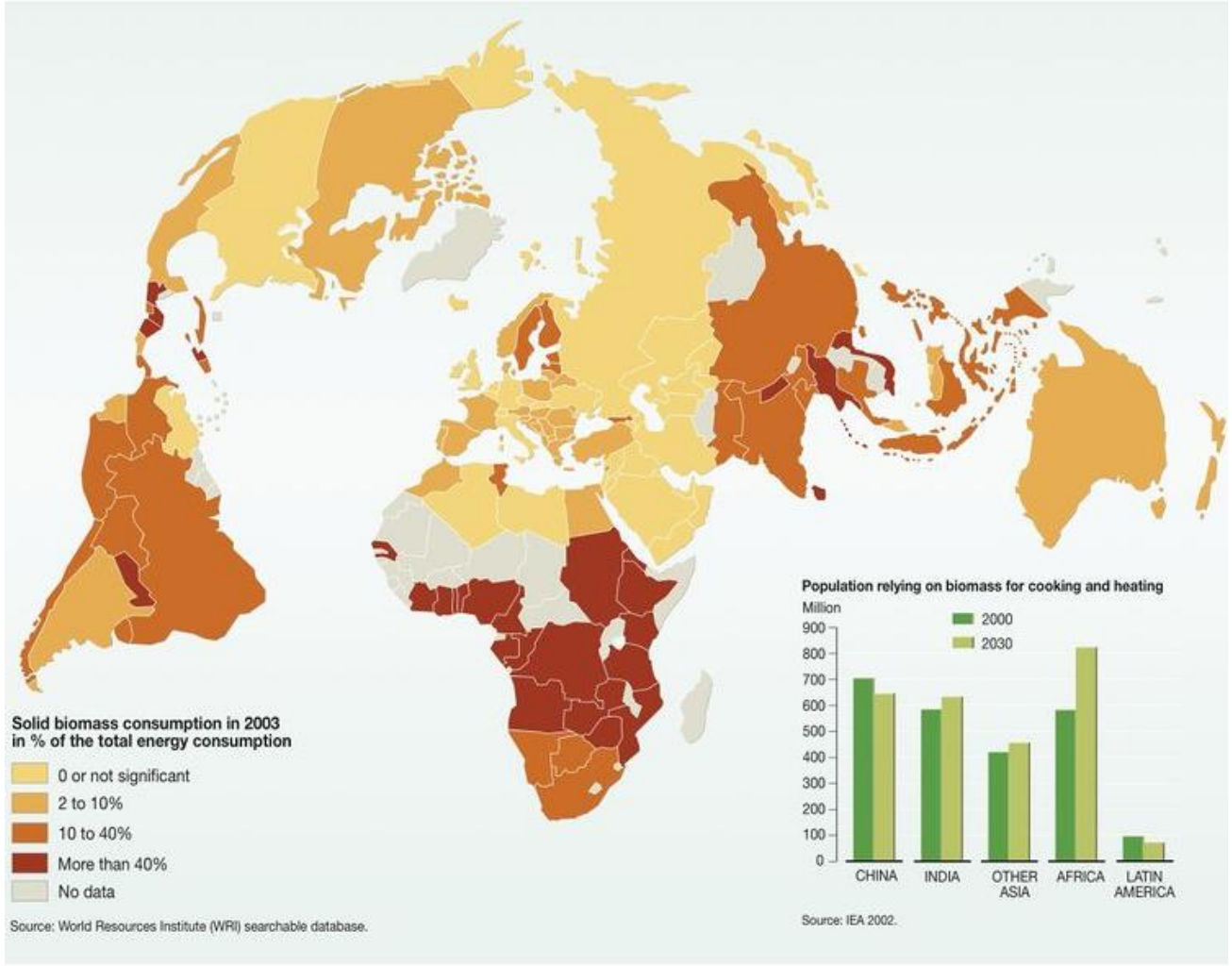
200 compounds

- particulate matter (PM) of various size including UFP (Ultrafine Particles),
- carbon dioxide (CO_2),
- carbon monoxide (CO),
- nitrogen oxides (NOx),
- sulfur dioxide (SO_2),
- volatile organic compounds (VOCs)
- methane,
- non-methane hydrocarbons,
- nitric oxide (NO),
- methyl chloride,
- methyl bromine,
- lead, mercury, etc.
- PAHs (polycyclic aromatic hydrocarbons)



Biomass use/burden?

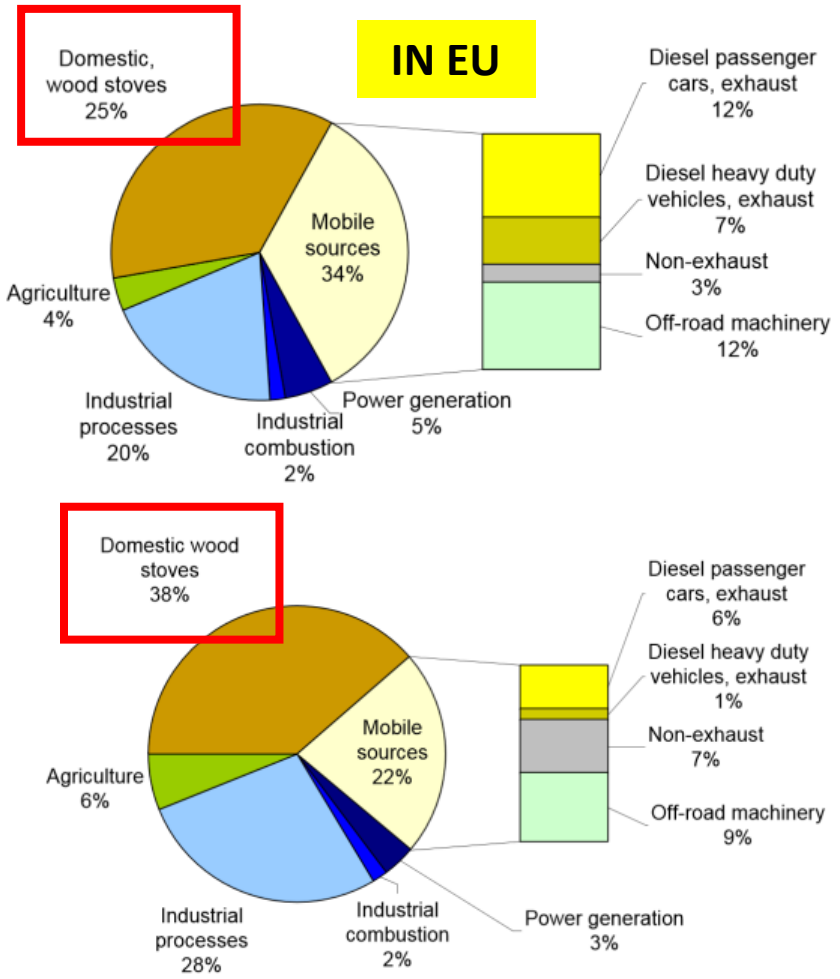
- Worldwide > 3 billion people depend on biomass (derived from many natural sources, plants, and animals), which are intentionally burned for several purposes:
  - developing countries: cooking, lighting, and home heating
  - industrialized countries: heating
- Wildfires and “prescribed” forest and land fires for agricultural purposes
- Occupational exposure (firemen)



Air pollution (IAP) induced by biomass use is very common and increasing

Concentrations

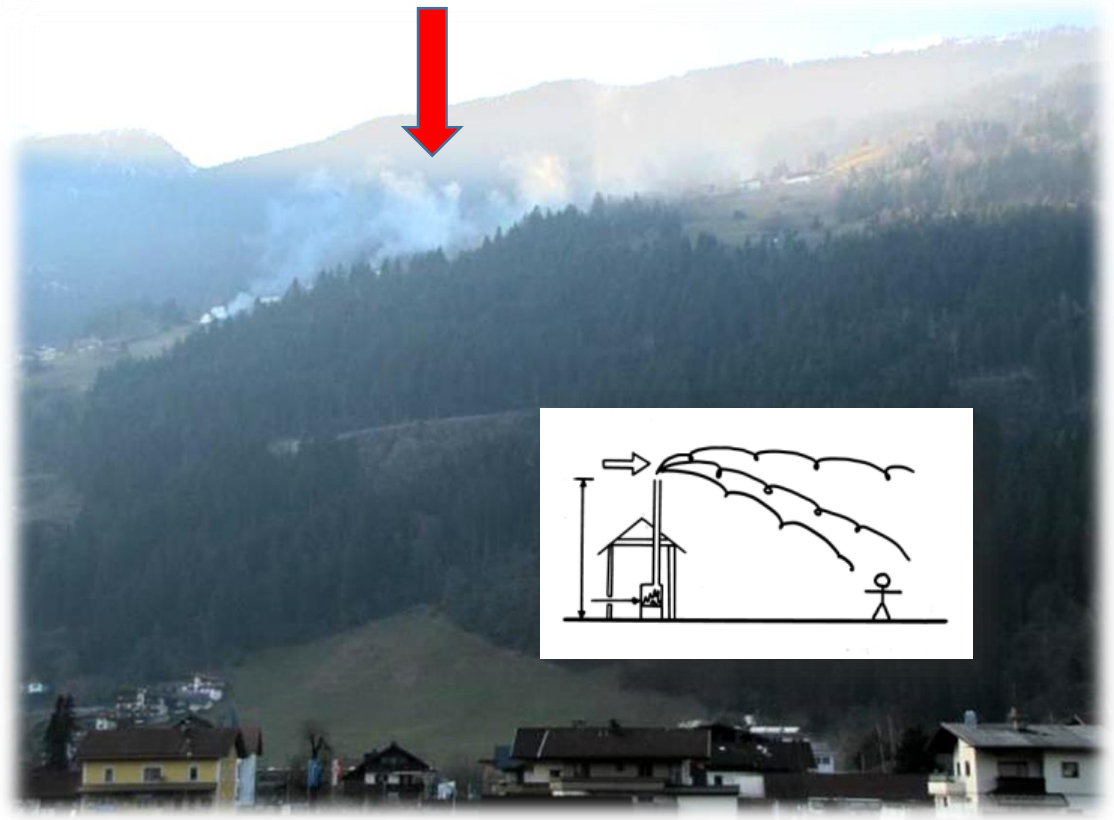
- Homes in developing countries : PM_{10}=300 - 5000 µg/m^3
- Homes in industrialised countries : PM_{10}=100-500 µg/m^3 in case of exclusive wood for heating



WHO Air Quality guidelines: annual 5 µg/m^3; daily 15 µg/m^3

Sigsgaard T, Forsberg B, Annesi-Maesano I. ERJ 2015

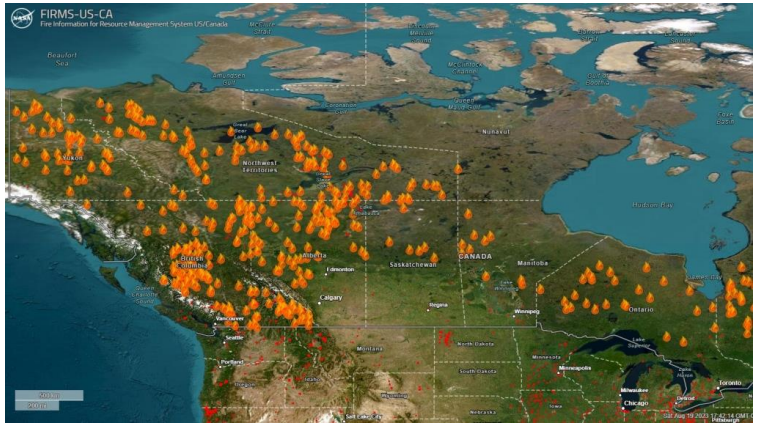
Biomass burning in the industrialized world



Across Europe, a shift towards renewable energy sources increases biomass incineration.

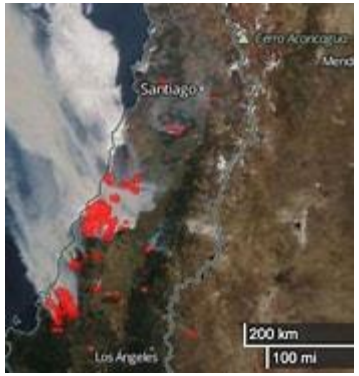
As a response to fuel poverty, biomass burning is seen as a cheap form of fuel & households are now the main source of fine particulate matter emissions in the EU.

Extreme air pollution events related to fires-related biomass (high doses)



Wildfires in Canada 2023 (NASA MAP)

Mega-fires in Canada: 14.2 million ha burned, 87,000 people affected, 1 billion tons of CO_2 released. **France=54,300,000 ha**



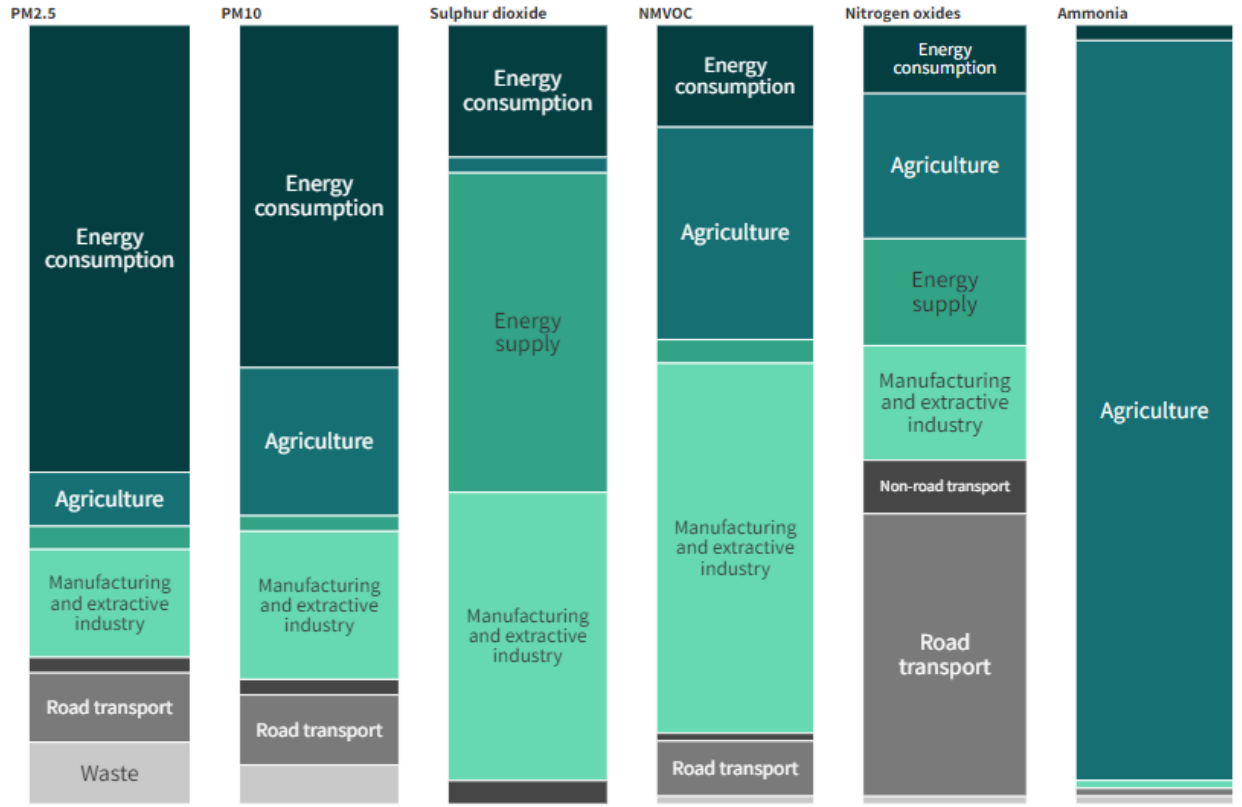
Wildfires in Chili 2024

Burning of rice straws in Thayland 2024

Biomass as an important sources of air pollution

In Europe:

- $PM_{2.5}$: residential, commercial and institutional energy consumption at 58%,
- PM_{10}: residential, commercial and institutional energy consumption at 44%,
- sulphur dioxide: energy supply at 41% and manufacturing and extractive industry at 37%,
- non-methane volatile organic compounds: manufacturing and extractive industry at 47%,
- nitrogen oxides: road transport at 37%,
- ammonia: agriculture at 94%.



Source: European Environment Agency (EEA)
PM2.5 = fine particulate matter; PM10 = particulate matter; Energy consumption = residential, commercial and institutional energy consumption; NMVOC = non-methane volatile organic compounds.

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Article | Published: 18 November 2020

Sources of particulate-matter air pollution and its oxidative potential in Europe

Kaspar R. Daellenbach, Gaëlle Uzu, Jianhui Jiang, Laure-Estelle Cassagnes, Zaira Leni, Athanasia Vlachou,

Abstract

Particulate matter is a component of ambient air pollution that has been linked to millions of annual premature deaths globally[1,2,3]. Assessments of the chronic and acute effects of particulate matter on human health tend to be based on mass concentration, with particle size and composition also thought to play a part[4]. Oxidative potential has been suggested to be one of the many possible drivers of the acute health effects of particulate matter, but the link remains uncertain[5,6,7,8]. Studies investigating the particulate-matter components that manifest an oxidative activity have yielded conflicting results[7]. In consequence, there is still much to be learned about the sources of particulate matter that may control the oxidative potential concentration[7]. Here we use field observations and air-quality modelling to quantify the major primary and secondary sources of particulate matter and of oxidative potential in Europe. We find that secondary inorganic components, crustal material and secondary biogenic organic aerosols control the mass concentration of particulate matter. By contrast, oxidative potential concentration is associated mostly with anthropogenic sources, in particular with fine-mode secondary organic aerosols largely from residential biomass burning and coarse-mode metals from vehicular non-exhaust emissions. Our results suggest that mitigation strategies aimed at reducing the mass concentrations of particulate matter alone may not reduce the oxidative potential concentration. If the oxidative potential can be linked to major health impacts, it may be more effective to control specific sources of particulate matter rather than overall particulate mass.

Aujourd'hui, le bois-énergie en France

En France:

- **3ème source d'énergie la plus utilisée par les Français** derrière l'électricité (55%), le gaz (37%) et devant la pompe à chaleur (13%), le fioul (8%) et le solaire (3%).
- **8% de la consommation finale d'énergie**, contre environ 60% pour les énergies fossiles et environ 25% pour l'électricité.
- **40% des maisons individuelles en France sont équipées d'un chauffage au bois**
- **24% des Français déclarent utiliser le bois** (bûches ou granulés) comme source d'énergie pour se chauffer (dont 12% comme énergie principale et 12% comme complémentaire) (France Bois Forêt (FBF), 2023)

Biomasse source importante de pollution de l'air en France

Le chauffage au bois résidentiel

- représentait en 2022: 45% des émissions totales de particules PM_{10}, 62% des émissions totales de $PM_{2.5}$ et 74% des émissions totales de $PM_{1.0}$ (Source CITEPA)

  - Pour les $PM_{2.5}$, cela représente 8 fois plus que l'ensemble du trafic routier.

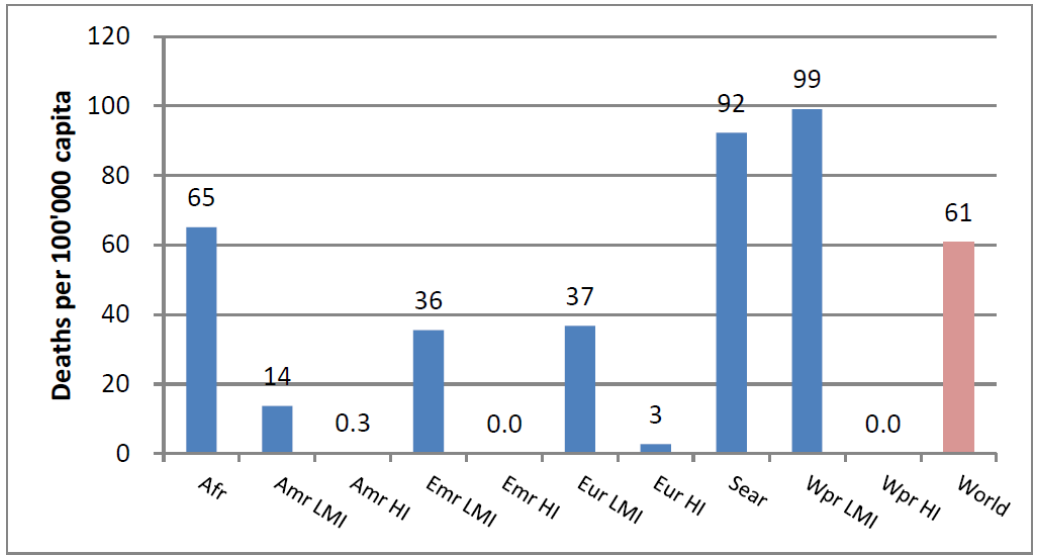
- première source de pollution aux particules fines $PM_{2.5}$ en Ile-de-France (AIRPARIF), en évolution dans les dernières années → 87% des émissions du secteur résidentiel.

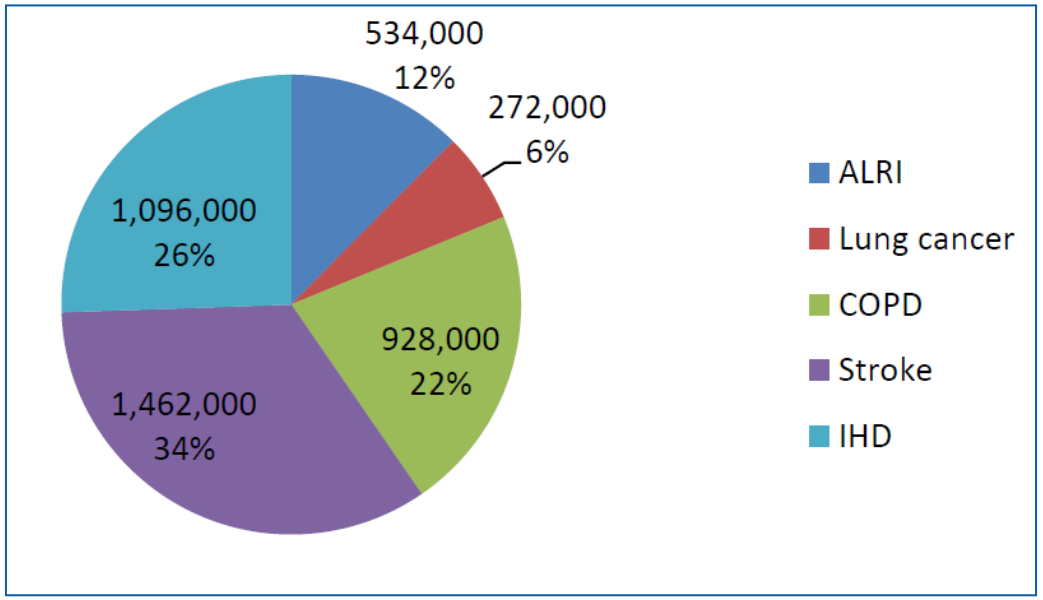
- responsable de près de **67% du carbone-suie (ou « black carbon »), 91%** d'hydrocarbures aromatiques polycycliques **(HAP),** dont le Benzo(a)pyrène, **70% des composés organiques volatils (COV), 63% du monoxyde de carbone, 91% de l'arsenic, 83% du plomb, 80% du chrome** . 91% d'arsenic, 83% de plomb, 80% de chrome

What are the health effects of biomass?

- *Developing countries*
  - Acute respiratory infections in children (ARIs), respiratory symptoms (congestion, cough, phlegm) and diseases (asthma, COPD, TB, lung cancer, etc.), cardiovascular, cerebrovascular and metabolic diseases, reproductive and pregnancy health outcomes, cataracts in adults.
- *Industrialized countries*
  - Low birth weight, respiratory symptoms (congestion, wheeze) and bronchiolitis and asthma in young children, increased medication use, decreases in lung function, asthma and COPD emergency room visits and hospitalizations in adults.

- *Wildfires (excessive exposure)*
  - Respiratory symptoms, asthma medication use, outpatient physician visits, emergency room visits, hospital admissions, and mortality
  - Firemen are highly exposed (but healthy worker effect)





http://www.who.int/indoorair/health_impacts/burden/en/

World Health Organization

Burden of disease from Household Air Pollution for 2012

Air pollution (IAP) induced by biomass use is one of the top 10 risks for the global burden of diseases (WHO

Globally, 4.3 million deaths (mostly in low / middle income countries) are attributable to household pollution (HAP), mainly due to solid (biomass) fuel combustion products.

In EU28: A recent WHO report estimated that ambient PM from residential heating with **wood and coal** is responsible for 61,000 premature deaths per year

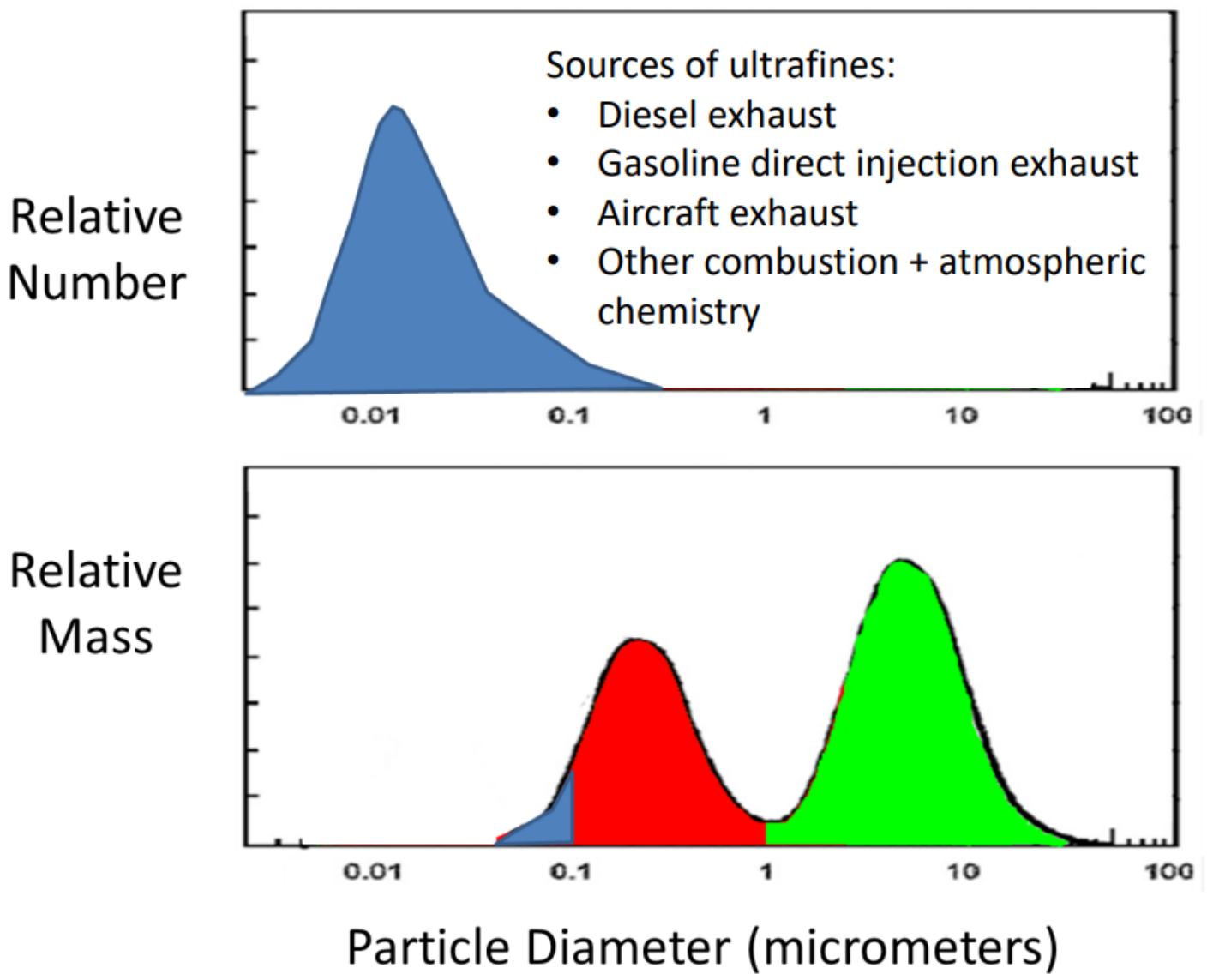
Amr: America, Afr: Africa; Emr: Mediterranean, Sear: South-East Asia, Wpr: Western Pacific; Eur: Europe; LMI: Low- and middle-income; HI: High-income.

ALRI: Acute lower respiratory disease; COPD: Chronic obstructive pulmonary disease; IHD: Ischaemic heart disease.

The culprit?

The various compounds but overall PM (fine and ultrafine)

'Ultrafine' Particles



Adapted from Donaldson K et al. Occup Environ Med 2001;58:211-216

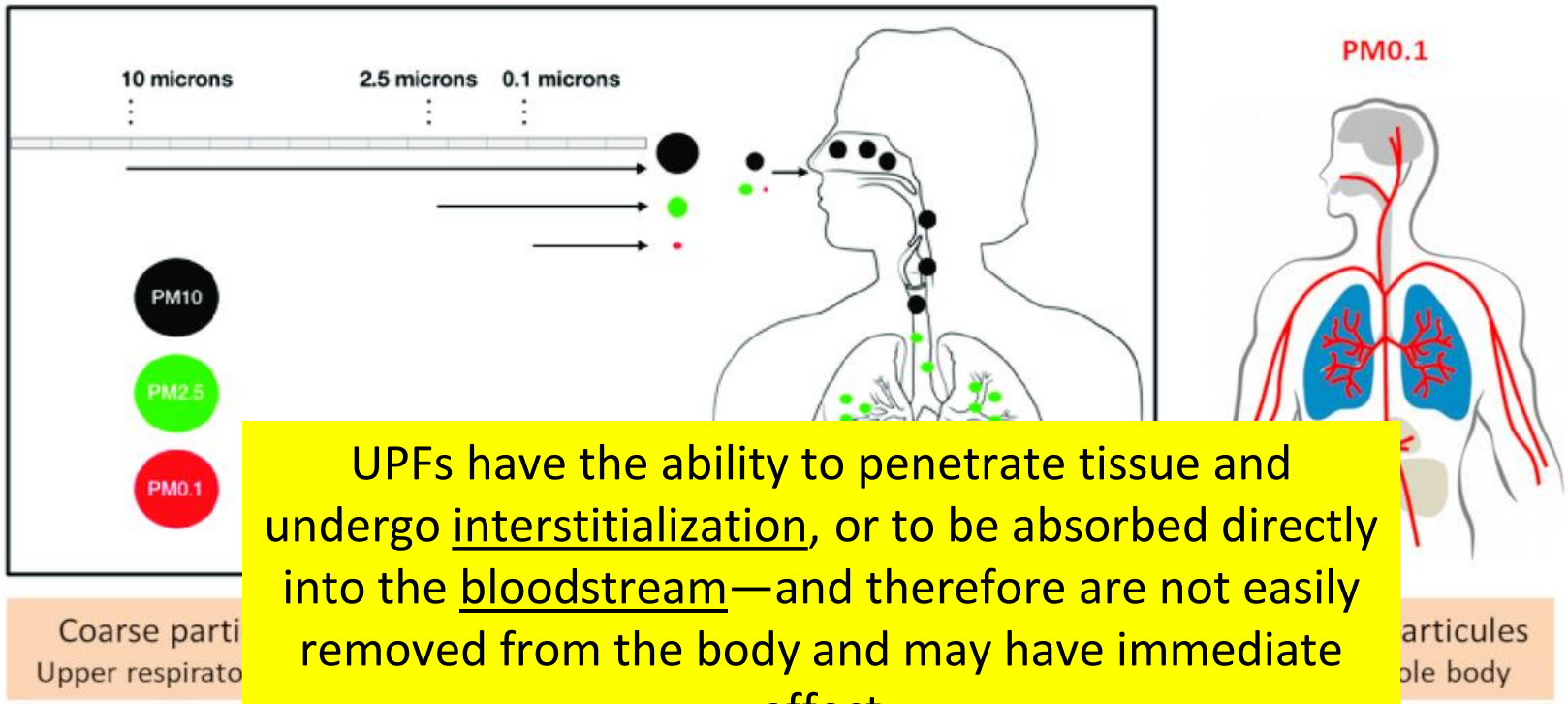
Particles – Does Size Matter? Or Mass? Or Number? Or What?

Mass Area ($\mu g/m^3$)	Diameter (μ)	Number (per ml)	Surface (μ^2/ml)
10	2	1.2	24
10	0.5	153	120
10	0.02	2,400,000	3016

Adapted from Donaldson K et al. Occup Environ Med 2001;58:211-216

Ultrafine Particles penetration

So tiny that it can pass through many of our body's protective armours such as mucous membranes and other barriers, to damage our lungs, heart, brain etc..



UPFs have the ability to penetrate tissue and undergo interstitialization, or to be absorbed directly into the bloodstream—and therefore are not easily removed from the body and may have immediate effect

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Respiratory infections

Household air pollution from biomass fuels accounts for nearly 41% of pneumonia deaths in children under 5 years old, totaling around 600,000 annual fatalities (WHO)

Home › Environmental Science and Pollution Research › Article

Indoor air pollution from solid fuel on children pneumonia in low- and middle-income countries: a systematic review and meta-analysis

Review Article | Published: 23 January 2022

T. Chen et al.

Volume 29, pages 24574–24588, (2022) Cite this article

Environmental Science and Pollution Research

Aims and scope →

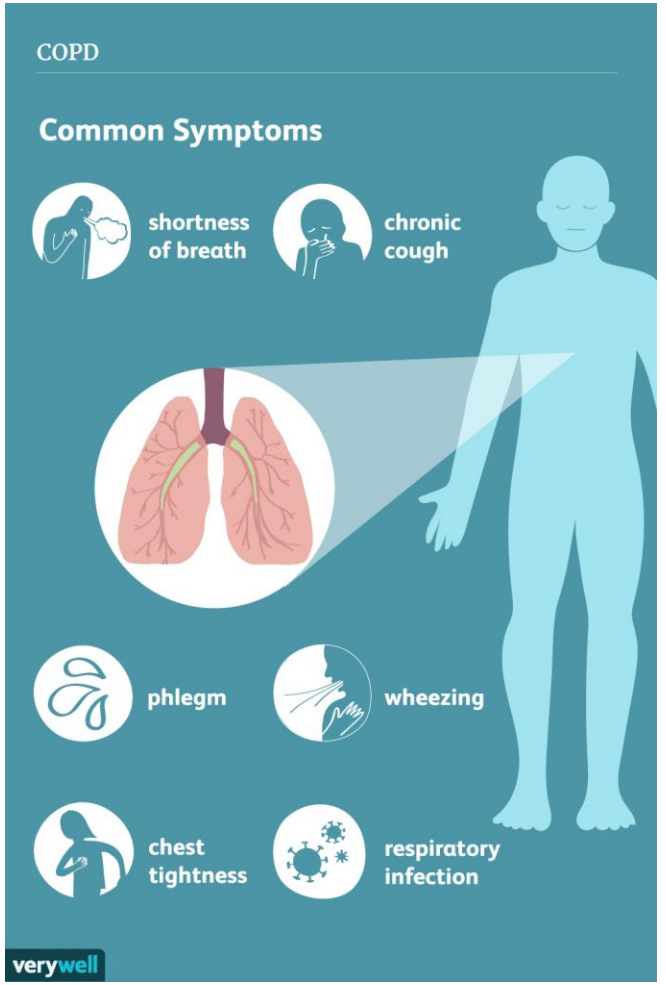
Submit manuscript →

1954 articles → 276 reviewed → 16 used in meta-analysis

Solid (biomass) fuel combustion significantly associated with an increasing risk of childhood pneumonia (OR = 1.66, 95%CI 1.36-2.02).

COPD

- COPD (Chronic Obstructive Pulmonary Disease) is the fourth leading cause of mortality globally, causing more than 3 million death annually and over 80% of these deaths occur in low- and middle-income countries.
- It is also a substantial cause of economic and social burden

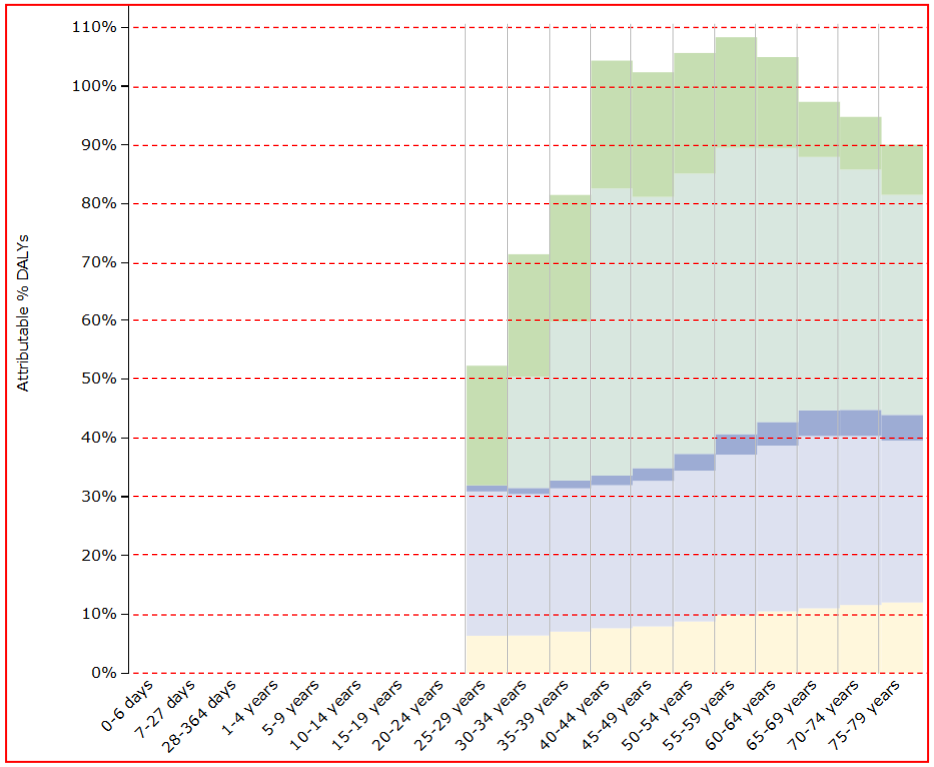


COPD AND BIOMASS

IHME
Institute for Health Metrics and Evaluation

Attributable DALYs for COPD

GBD Cause Patterns



Occupational risk

Smoking

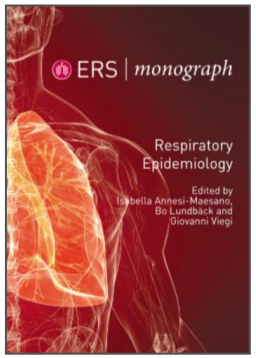
Ozone

Household air pollution

Sanitation

COPD not only due to tobacco smoking!

http://vizhub.healthdata.org/gbd-cause-patterns/



chapter 13

Indoor pollution

Marzia Simoni[1], Isabella Annesi-Maesano[2,3] and Giovanni Viegi[1,4]

2014

Data from meta-analyses on the effects of exposures to the use of solid fuels / biomass.

Outcome	Smoke source	OR (95% CI)	RR (95% CI)
COPD	Solid fuels	2.8 (1.8–4.0)	
	Wood	4.3 (1.3–13.7)	
	Mixed biomass	2.3 (1.5–4.0)	
	Coal	1.8 (1.0–3.3)	
Females	Solid fuels		3.2 (2.3–4.8)
	Biomass fuels	2.4 (1.5–3.9)	
Males	Solid fuels		1.8 (1.0–3.2)
Chronic bronchitis	Solid fuels	2.3 (1.9–2.8)	
	Wood	2.6 (2.1–3.3)	
	Mixed biomass	2.5 (1.9–3.4)	
TB	Biomass fuels	1.5 (1.1–2.2)	
Acute LRTI#	Solid fuels		2.3 (1.9–2.7)
ARI#	Biomass fuels	3.5 (1.9–6.4)	

RR: relative risk; ARI: acute respiratory infection. #: in children.

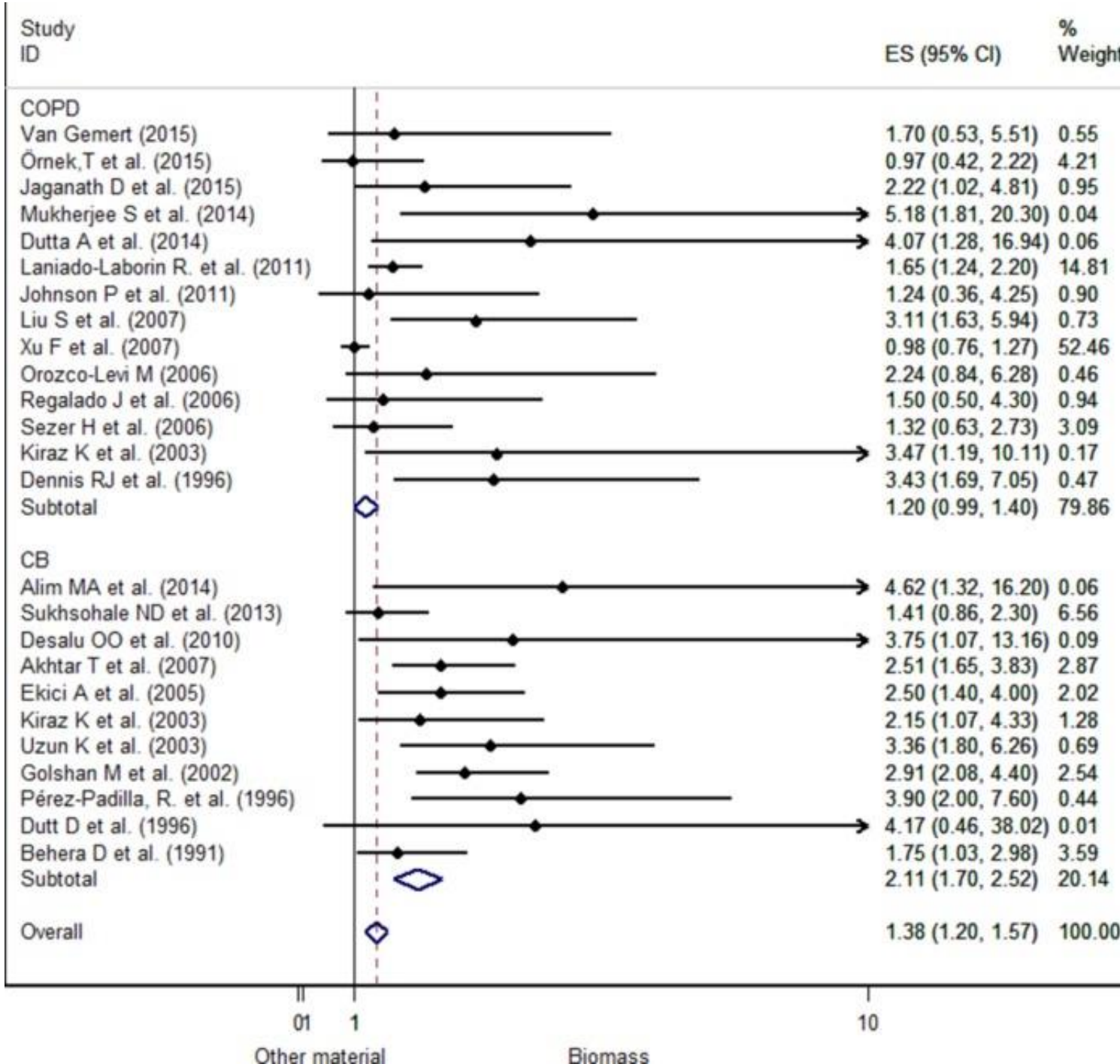
BMJ Open Respiratory Research

Chronic obstructive pulmonary disease associated with biomass fuel use in women: a systematic review and meta-analysis

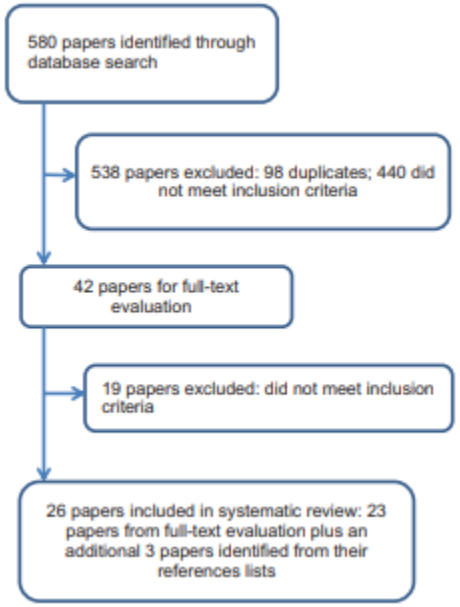
2017

Adama Sana,[1,2,3] Serge M A Somda,[4,5] Nicolas Meda,[1,2] Catherine Bouland[3]

Biomass-exposed women were 1.38 times more likely to be diagnosed with COPD than non-exposed ones (OR 1.38, 95%CI 1.28 to 1.57)



Cardiovascular, cerebrovascular and metabolic diseases



MA of 26 studies, 10 in south Asia, 4 in China, 2 in Turkey, 1 in Iran and 8 in Central and south American:

→ current balance of epidemiological evidence points to an increased risk of cardiovascular disease from HAP as a consequences of using solid and especially biomass for cooking and heating → Relative risks from long term exposure could be 2- to 4- fold

Fatmi, Coggon. BrMedBull 2016

Another study in 77,605 premenopausal women from 10 resource-poor countries → primary use of solid fuel associated with 0.58 mmHg higher systolic BP (95% CI: 0.23, 0.93) as compared to primary use of clean fuel **Arku Env Res 2018**

IDESP

Lung, gastric/esophageal, cervical cancers

- Lung cancer causes more death globally than any other cancer and it is the seventh leading cause of death globally. About 1.5% of lung cancer death are attributed to exposure to carcinogens from biomass fuel smoke annually.
- Biomass emissions are a Group2A carcinogen (CIRC)

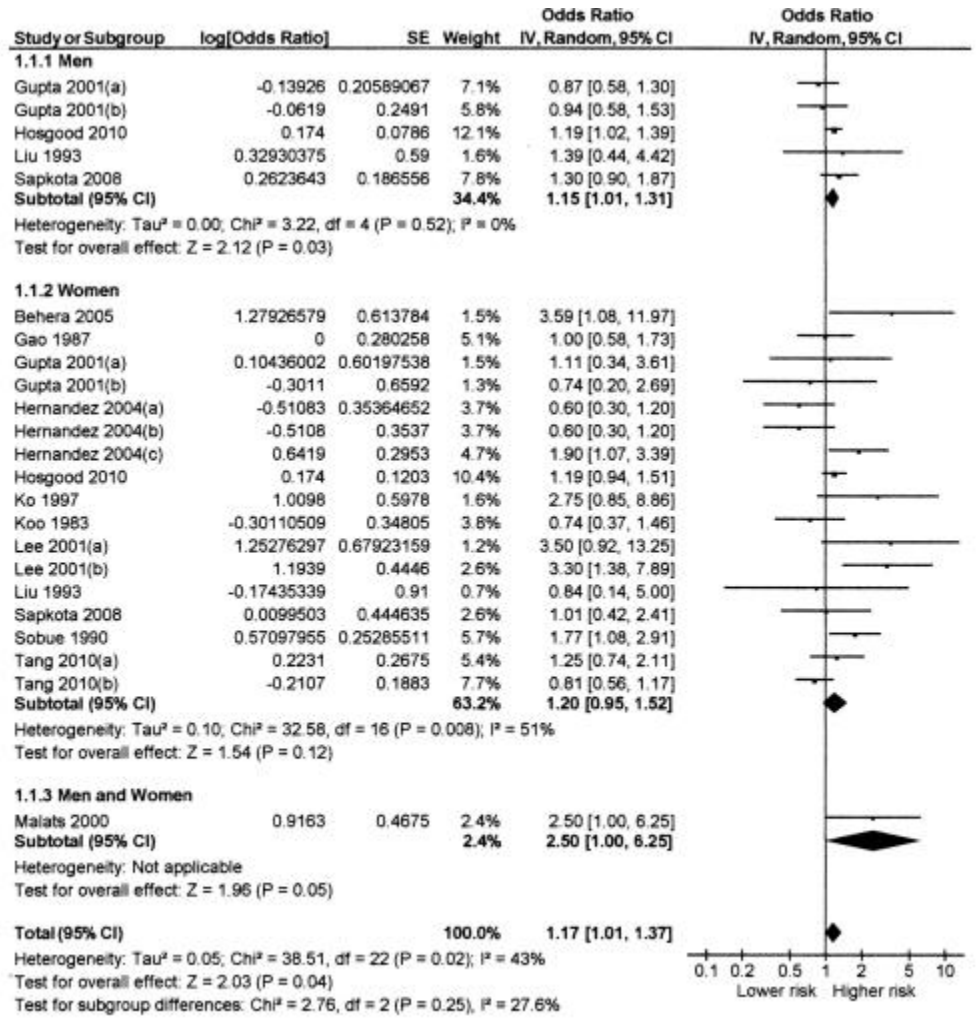


Figure 2 Forest plot of 13 studies (23 estimates) reporting risk of lung cancer with use of biomass fuel in the household, stratified by sex
Notes on studies with more than one estimate (see table 2 for details):

Bruce Thorax 2015

Lung cancer

- First prospective study of wood burning and lung cancer incidence among 50226 U.S. women.
- Higher wood stove/fireplace usage associated with 70 % higher incidence of lung cancer.
- Associations were also elevated when analysis was restricted to never smokers.

Indoor wood burning raises women's lung cancer risk by 43%, says US study

Results from study involving 50,000 women suggest even occasional wood burning can contribute to lung cancer

Gas or propane heating in stoves and fireplaces was also associated with an increased lung cancer risk, but this was far smaller than that from wood burning. Photograph: Iolostock/Alamy

Using an indoor wood stove or fireplace increases women's risk of devel

Mehta Env International 2023

Respiratory health in firemen

Healthy Worker effects

International Journal of *Environmental Research and Public Health*

Open Access Review

The Effect of Fire Smoke Exposure on Firefighters' Lung Function: A Meta-Analysis

by Joana V. Barbosa [1,2], Mariana Farraia [1], Pedro T. B. S. Branco [1,2], Maria Conceição M. Alvim-Ferraz [1,2], Fernando G. Martins [1,2], Isabella Annesi-Maesano [3] and Sofia I. V. Sousa [1,2,*]

Article Menu

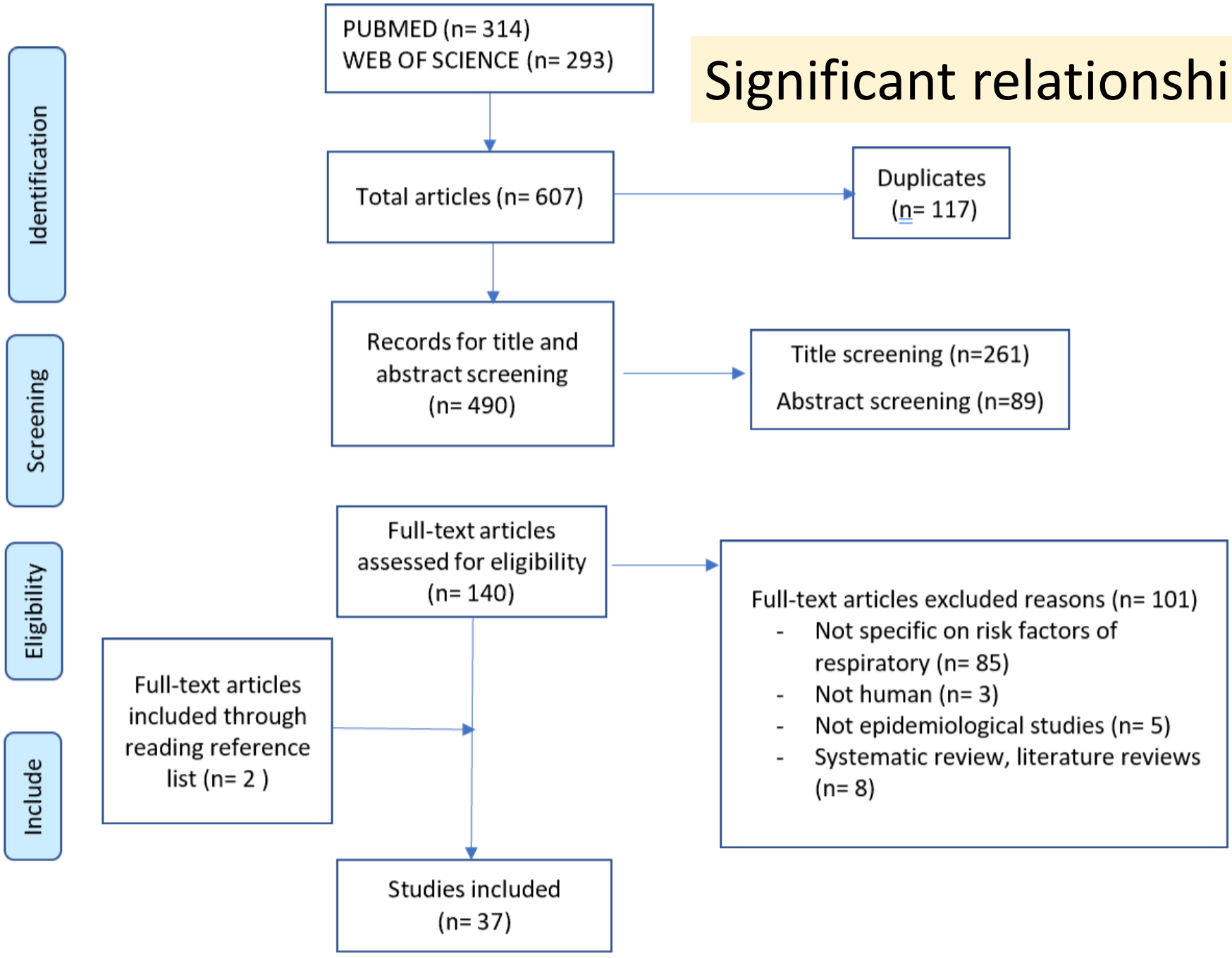
characteristics. A total of 5562 participants from 24 studies were included. No significant difference was found between firefighters' predicted FEV_1 from wildland, 97.64% (95% CI: 91.45–103.82%; I^2 = 99%), and urban fires, 99.71% (95% CI: 96.75–102.67%; I^2 = 98%). Similar results were found for the predicted FVC. Nevertheless, the mean values of firefighters' predicted lung function varied significantly among studies, suggesting many confounders, such as trials' design, statistical methods, methodologies applied, firefighters' daily exposure and career length, hindering an appropriate comparison between the studies.

Last knowledge

BIOMASS	RESPIRATORY EFFECT	Type of articles
Wood burning	Respiratory diseases	Cohort
Wood combustion	Respriratory health	Case-control/Case report
Wood pellet	Respiratory symptoms	ecologic
Wood smoke	Lung function	Cross-over
Wook stove	Lung cancer	Cross-sectional
wildfire	Pulmonary resistence	case-series
	Feno	Randomized, controlled trial
MESH		
("wood burning" OR "wood combustion" OR "wood pellet" OR "wood stove" OR "wood smoke" OR "wildfire") AND ("Respiratory Tract Diseases"[MeSH Terms] OR "respiratory diseases" OR "respiratory health" OR "respiratory function" OR "lung function" OR "lung cancer" OR "pulmonary resistance" OR "feno")		
WEB OF SCIENCE		
("wood burning" OR "wood combustion" OR "wood pellet" OR "wood stove" OR "wildfire") (All Fields) AND ("respiratory diseases" OR "respiratory health" OR "respiratory symptom" OR "lung function" OR "lung cancer" OR "pulmonary resistance" OR "feno") (All Fields)		

Last knowle

Significant relationships

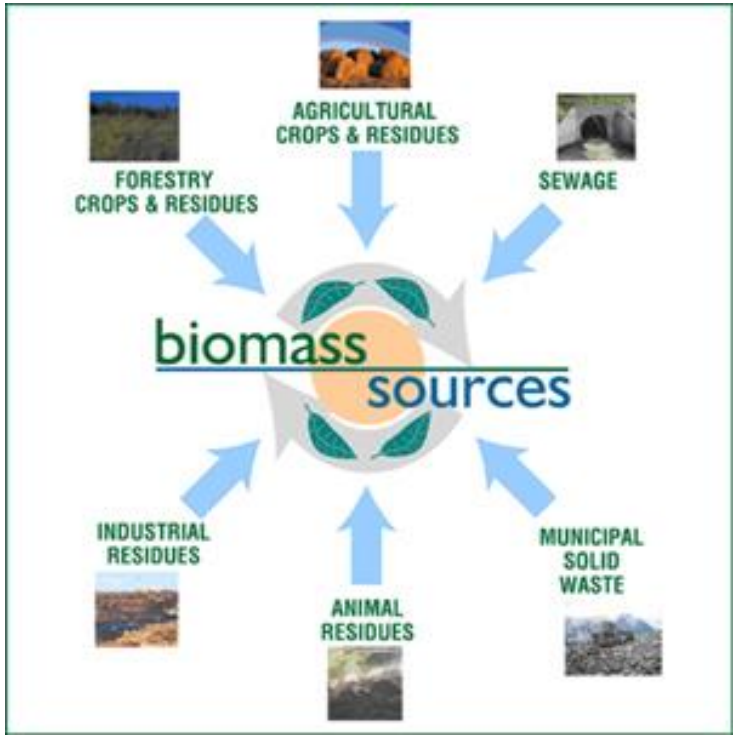


Remediation, mitigation, adaptation?

Improved cook stove, pellets, ventilation etc…

Primary prevention

Primary prevention covers all measures designed to avoid or reduce the risk of health problems (illness, accident, disability). It takes into account not only individual risk behaviors, but also environmental and societal issues.



While cigarette smoking is the leading preventable cause of COPD in the developed world, indoor solid fuel smoke exposure may be the leading preventable cause in lesser developed countries, particularly among women.

Trials of intervention to reduce biomass exposure

- **Childhood ALRIs**

No significant benefit with improved cook stove in MA (**Saleh IJTLD 2020**)

- **COPD**

Significant reduction in COPD: significant reduction in COPD among women with improved cook stove: RR = 0.74 (95% CI 0.61 to 0.90) in MA (**Thakur Thorax 2018**)

- **Asthma** (sparse data):

No improve of childhood asthma quality of life in a randomized control trial of air-filter intervention (**Noonan EHP 2018**)

- **Low birth weight**

An increase of 89 g in the birth weight of children of mothers using the intervention stoves (vs. open fires) (95% CI −27, 204), and reduced odds of a low birth weight child (OR 0.74, 95% CI 0.33–1.66) (**Thompson EHP 2011**)

IDESP

Pellet composition needs to be investigated

Emissions of pelletized biomass fuel: UFP and BC

- In 2018, global wood pellet consumption increased by 130% compared to its 2013 levels, reaching 53 million tons.
  - Half of this consumption took place in Europe (27 million tons; a 60% increase in 5 years), where pellet consumption, for heating purposes only, increased by 220% during the 2013–2018 period, accounting for 15.8 million tons in 2018.-
- In 2019, European pellet consumption increased by 7%, an increase of 1.8 million tons in just one year.

→ The fresh pellet stove PM_1 emissions consisted mainly of Organic Aerosol and black carbon (BC), carbon dioxide and monoxide, nitrogen oxides, and a wide range of volatile organic compounds (VOCs) including PAHs and metals

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Emission factor (EF) of metals from pelletized and uncompressed biomass fuels

Table 1 | EFs (mg/kg, dry basis) of Pb, Cu, Cd, Ni and As for combustion of biomass pellets and raw biomass flues. The results include gaseous phase (G), particle-bound phase (P), and total emission (T). Data are presented as mean ± standard deviation (the sample size is three for each type of fuel)

Biomass		Pb	Cu	Cd	As	Ni
Corn straw	P	0.94 ± 0.28	0.70 ± 0.54	0.09 ± 0.01	8.39 ± 1.57	0.26 ± 0.01
	G	0.05 ± 0.03	0.95 ± 0.50	ND	ND	0.14 ± 0.01
	T	0.99 ± 0.24	1.65 ± 1.04	0.09 ± 0.01	8.39 ± 1.57	0.41 ± 0.003
Corn straw pellet	P	4.07 ± 0.59	2.28 ± 0.55	0.15 ± 0.05	15.81 ± 4.44	0.55 ± 0.21
	G	0.62 ± 0.07	4.11 ± 1.13	ND	ND	0.65 ± 0.14
	T	4.69 ± 0.52	6.39 ± 1.69	0.15 ± 0.05	15.81 ± 4.44	1.20 ± 0.07
Pine wood chip	P	0.85 ± 0.38	2.77 ± 0.90	0.12 ± 0.02	13.11 ± 0.15	0.22 ± 0.05
	G	0.19 ± 0.04	1.41 ± 1.32	ND	ND	0.23 ± 0.19
	T	1.04 ± 0.43	4.18 ± 0.42	0.12 ± 0.02	13.11 ± 0.15	0.45 ± 0.24
Pine wood pellet	P	3.71 ± 1.53	1.96 ± 0.20	0.17 ± 0.09	37.10 ± 2.69	0.70 ± 0.43
	G	0.67 ± 0.14	5.12 ± 0.17	ND	ND	0.25 ± 0.08
	T	4.39 ± 1.68	7.08 ± 0.38	0.17 ± 0.09	37.10 ± 2.69	0.95 ± 0.51

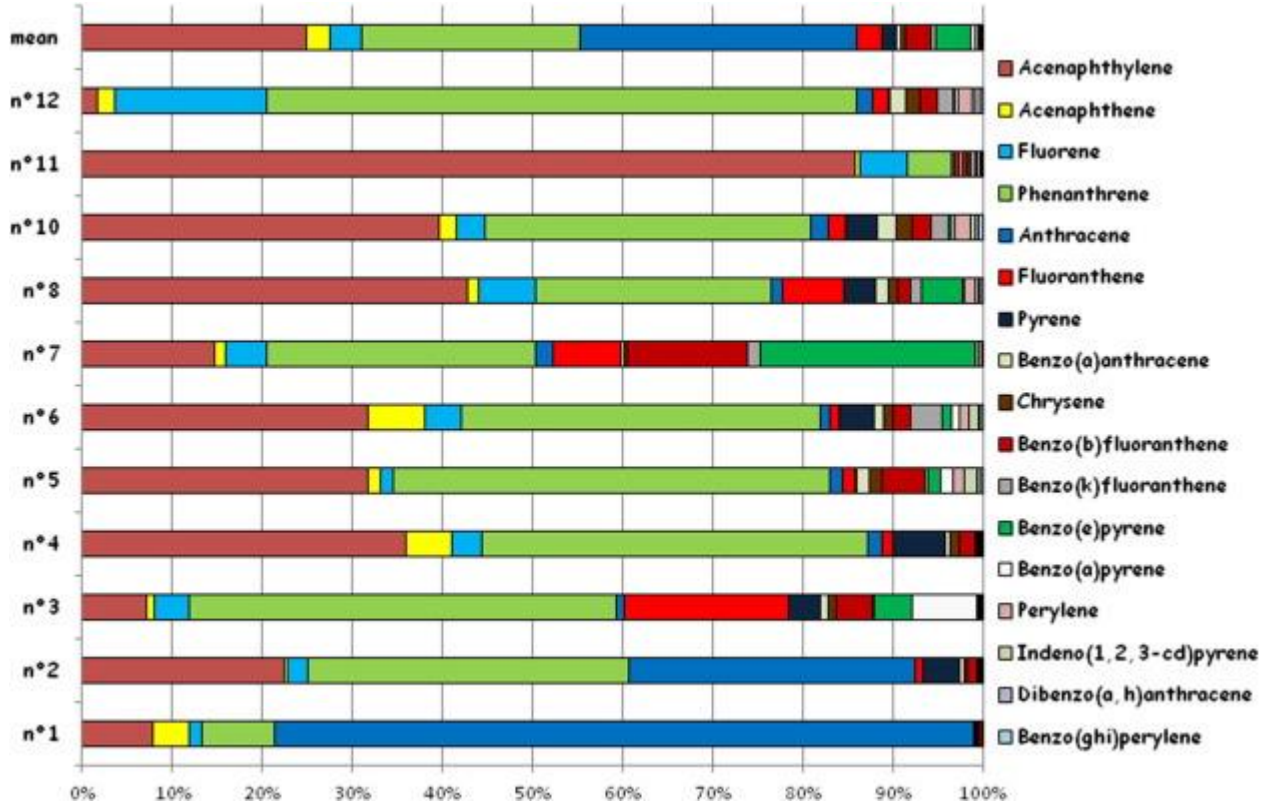
ND: not detected.

Zhang Scientific Reports 2014

Emission factor (EF) of Polyciclic aromatic hydrocarbons (PAHs) from pelletized biomass fuels

Ashes from 11 different pellet types fired in domestic stoves characterized by the presence of 17 PAHs produced by secondary aromatization reactions in the pyrolytic phase of incomplete combustion at temperatures higher than 400 °C.

→ threat to the people and environment due to the presence of carcinogen and mutagen PAHs



Orecchio Licrochemical Journal 2015

The relationship between biomass combustion and climate change is complex and depends on a variety of factors.

Potential (**in theory**) benefits:

- Renewable resource: Biomass, like wood or biofuels, can be a renewable en els, it can be replanted or regrown.
- Carbon neutrality: In theory, burning biomass releases the same amount of growth, creating a closed carbon cycle. This could potentially offset fossil fu els in the atmosphere.

De 10 à,80 ans pour faire pousser un arbre selon l'espèce!!!

Potential drawbacks:

- Incomplete combustion: Burning biomass can release particulate matter, ni bute to air pollution, to climate change and health problems.
- Deforestation: Unsustainable harvesting of wood for biomass can lead to deforestation, which releases large amounts of carbon stored in trees and reduces future sequestration potential.
- Soil degradation: Intensive biofuel crop production can deplete soil nutrients and contribute to soil erosion, negatively impacting land fertility and carbon storage.
- Loss of biodiversity through the ecosystem modification
- Limited carbon neutrality: Achieving true carbon neutrality with biomass is challenging due to factors like transportation, processing emissions, and potential land-use changes.

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Take home messages

- **Biomass use is very common and increasing also in industrialized countries. Biomass burning pollutes both indoors and outdoors**
- **Population studies** have shown that exposure to biomass particles is associated with severe morbidity and mortality (not only respiratory) (but methodological issues)
  - Confirmed by experimental studies (data not shown)
- **Intervention studies** have shown beneficial effects of phasing out biomass for heating (a beneficial effect was also seen after introduction of air filtering devices in the homes of the elderly (data not shown) for COPD and Birthweight)

Other data needed

- Efficient conversion technologies minimizing emissions have not shown their benefits

Other data needed

- **Pellet combustion** may pose threat to the people and environment due to the presence of UFPs, BC, carcinogen and mutagen PAHs
- Careful consideration of the entire lifecycle of biomass – from cultivation and harvesting to conversion and combustion – is crucial to assess the true environmental impact involved in climate change.

Perspectives

- UFPs assessment
- Important regulatory steps would be:
  - the unconditional adoption of the outdoor 2021 PM_{10} and $PM_{2.5}$ WHO Air Quality Guideline values to protect public health.
  - the implementation of UFP WHO Air Quality Guideline values
  - the implementation of indoor Air Quality Guidelines

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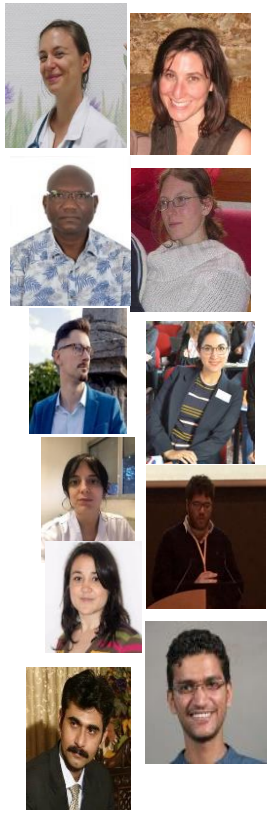

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Biomass use/burde

- Worldwide > 3 bi
  depend on bioma
  many natural sou
  animals), which a
  burned for severa
  - developing cou
    lighting, and h
  - industrialized
    heating
- Wildfires and pla
  land fires for agri
- Occupational exposure

Trends in use:
Biomass combustion mainly in INDOOR household air pollution (HAP), it is also but also important contributor to OUTDOOR air pollution (up to 40% of PM), particularly in developing countries but also and increasing in industrialized countries (domestic heating and wildfires)