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Swiss Tropical and Public Health Institute
Schweizerisches Tropen- und Public Health-Institut
Institut Tropical et de Santé Publique Suisse

Ultrafine Particles and Health: Reviewing the Evidence in the Current Policy Context

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Prepared for

21. ETH Conference on Combustion Generated Nanoparticles

Health Session (6A)

Zürich, June 21th 2017 13:00

Ultrafine particles and health

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KNOWN

- UFP have many toxic features that affect health
- Primary UFP are already subject to ambitious regulations of emissions

BUT:

- What are the long-term health effects under real-life conditions?
- What is the added value of ambient UFP standards?

→ Need assessment of epidemiological evidence and integration into current policy context

Air pollution – a symphonic issue

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- Air pollution is an orchester of complex pollutants caused by many sources and factors
- Health effects are orchestrated by hundreds of pathways
- Host reactions are orchestrated by multiple modifying factors
- Air quality management is an orechestrated set of various strategies and policies

→ Added value of regulating ONE «string?

Content

- Epidemiological evidence for health effects of UFP
- Policy context

Current state of UFP literature reviews

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- HEI Report 2013
- U.S. EPA works on Integrated Science Assessment (ISA) for Particulate Matter (including UFP) → release of draft early 2018
- Will be relevant input for update of WHO Air Quality Guidelines (2016-2019+)
- German Environmental Agency mandated a “lean review” to University of Düsseldorf (Prof. Barbara Hoffmann) with Swiss TPH (LUDOK Team: Ron Kappeler) as supporting partner

More to hear…
See you at the 22nd NPConference 2018 !

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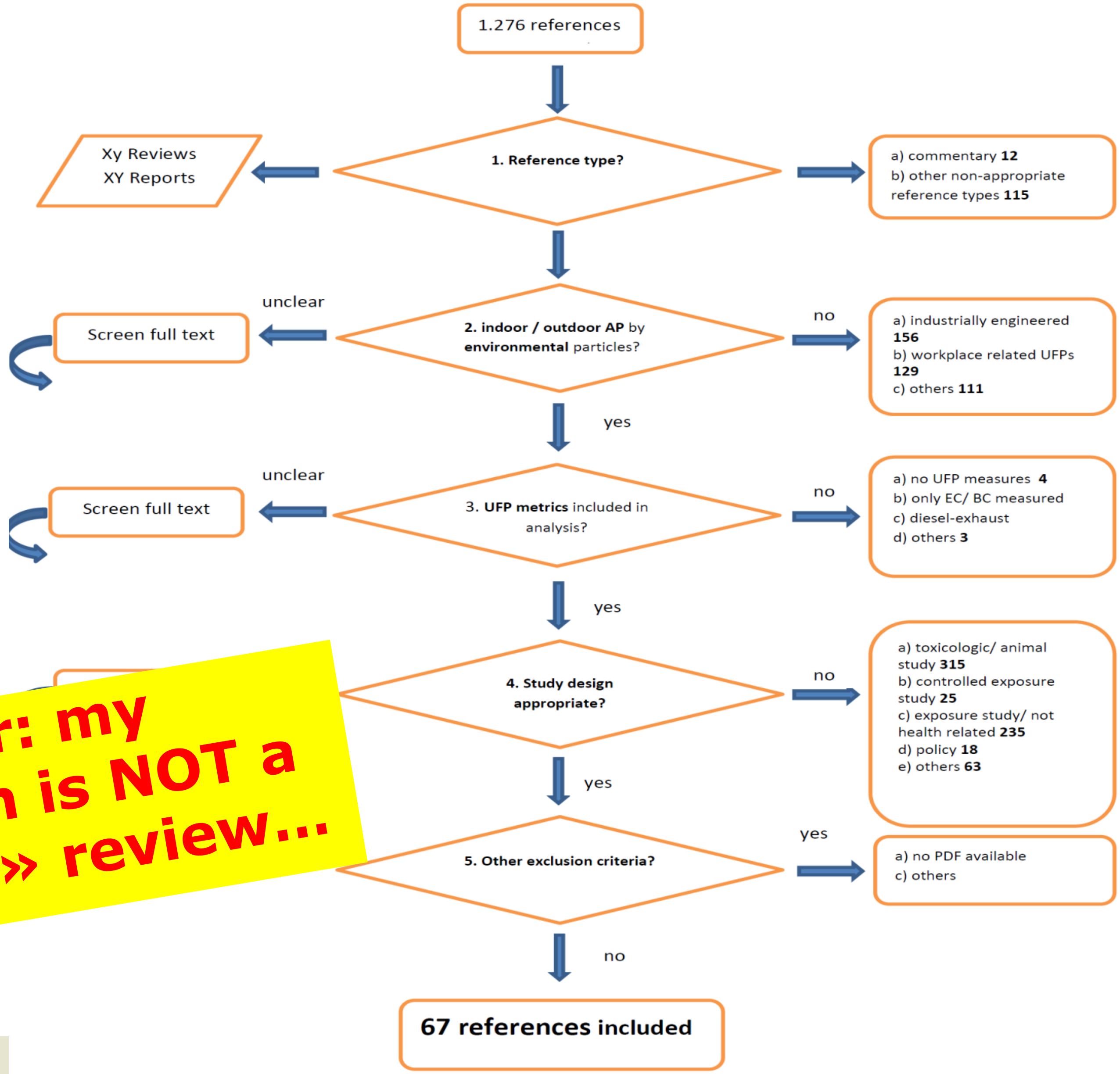
Ron Kappeler
LUDOK Team
Swiss TPH



Disclaimer: my presentation is NOT a «systematic» review…

Examples on

ACUTE EFFECTS

(effect of «yesterdays UFP» on «todays» health)

in populations

UFP = Ultrafine particles

5-day average quasi-Ultrafine particles are associated with systemic inflammation

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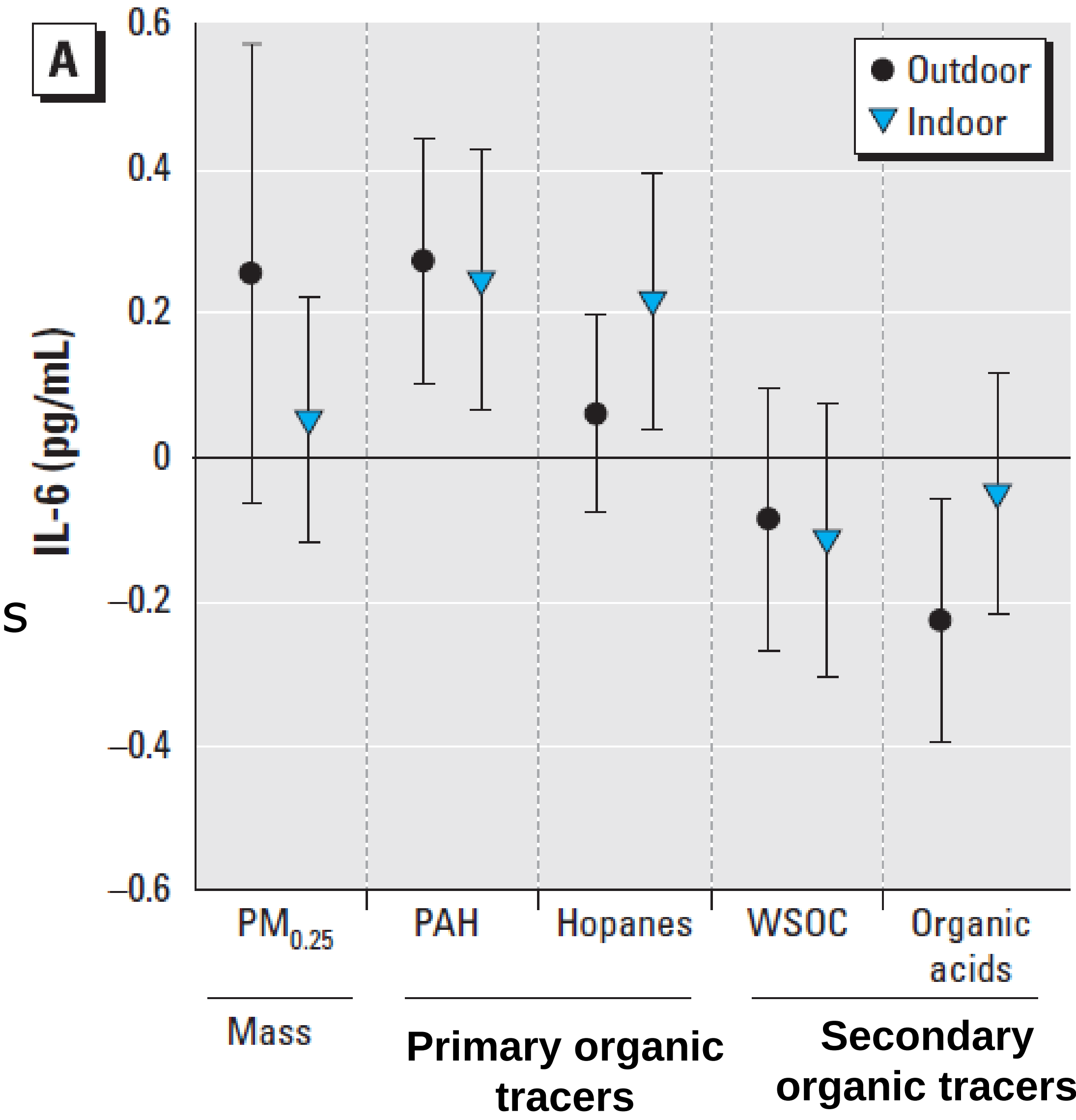
Delfino et al, Env H Perspect 2010) -   60 elderly subjects

Example of IL-6

(very similar findings
for TNF-alpha)

- Associations with Primary Organic Aerosol
- No association with Secondary Organic Aerosols



Complex system – complex results

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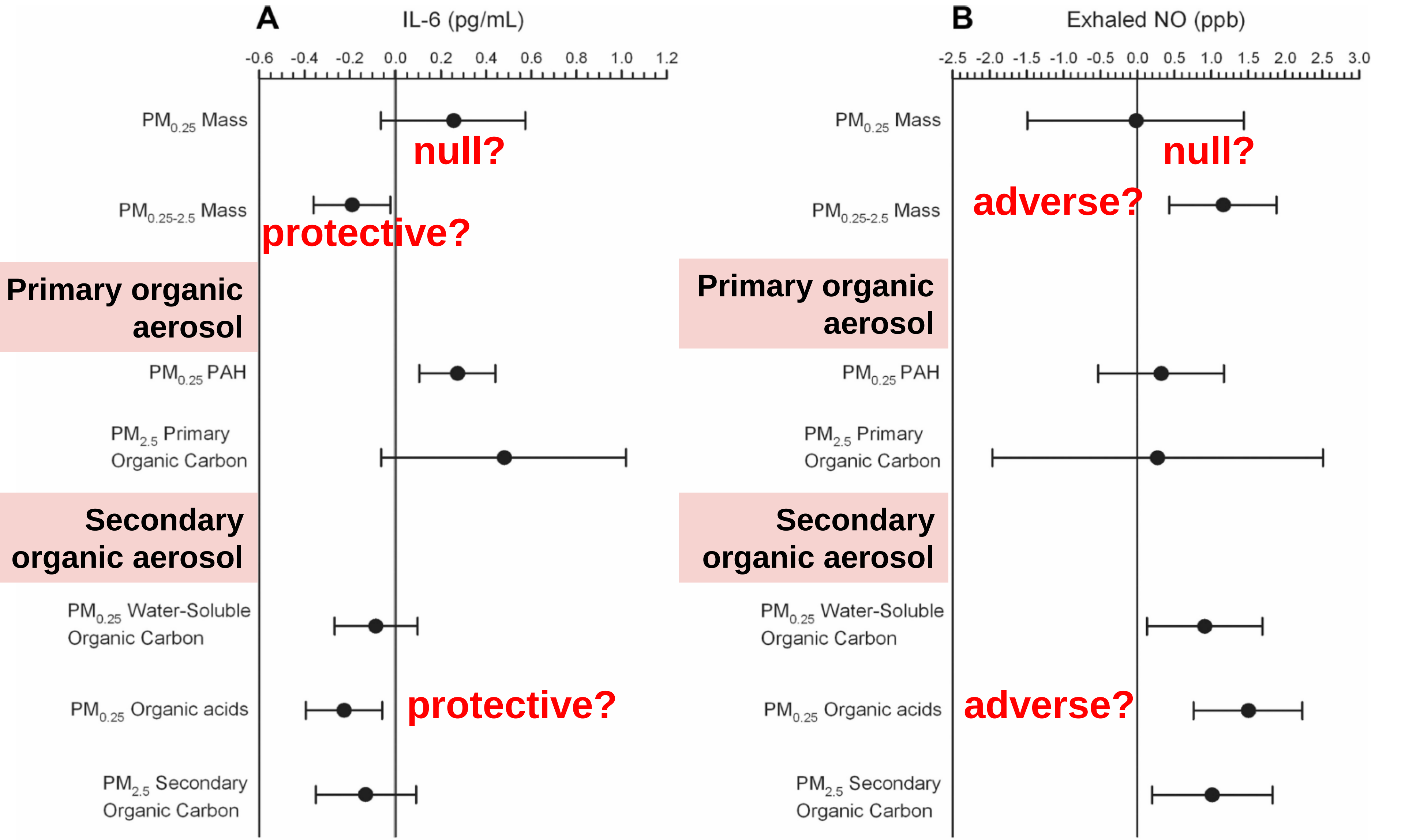
Effects of home-outdoor 5-day mean concentrations in elderly (Delfino et al, Epidemiology 2010)



Inflammatory and Cardiovascular acute effects of source specific fractions of PM

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Wu et al, Env Sci Technol 2014, Panel study in 40 healthy students

	mass	
total $PM_{2.5}$	82.0	
PMF S1: traffic emissions	5.1	**Null findings**
PMF S2: coal combustion	10.7	**TNFα; Bloodpressure**
PMF S3: secondary sulfate/nitrate	34.2	**TNFα; Peak-flow**
PMF S4: metallurgical emission	0.6	**Null findings**
PMF S5: dust/soil	12.4	**Null findings**
PMF S6: industry	4.9	**Bloodpressure, Peakflow**
PMF S7: secondary organic aerosol	7.1	**Null findings**
unknown	7.0	**Null findings**

BUT... **Rich et al, Env Sci Technol 2013; 47:**

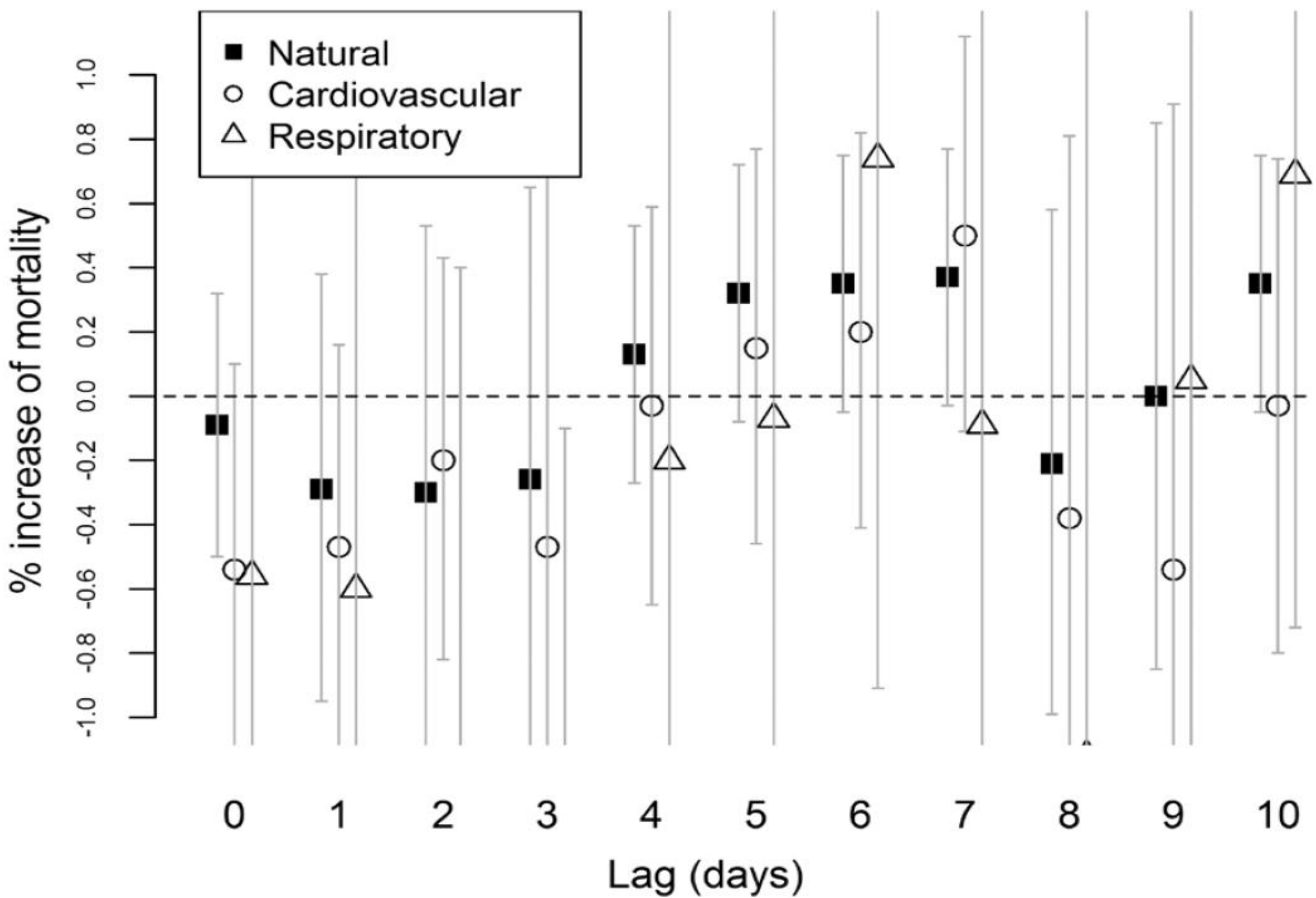
«The triggering of myocardial infarction by fine particles is enhanced when particles are enriched in secondary species»

Association Between Short-term Exposure to Ultrafine Particles and Mortality in Eight European Urban Areas

Massimo Stafoggia,[a,b] *Alexandra Schneider,*[c] *Josef Cyrys,*[c,d] *Evangelia Samoli,*[e] *Zorana Jovanovic Andersen,*[f]

Epidemiology, 2017

- **UFP are not significanlty associated with mortality**
- **UFP estimates were sensitive to adjustment for PM or NO2**

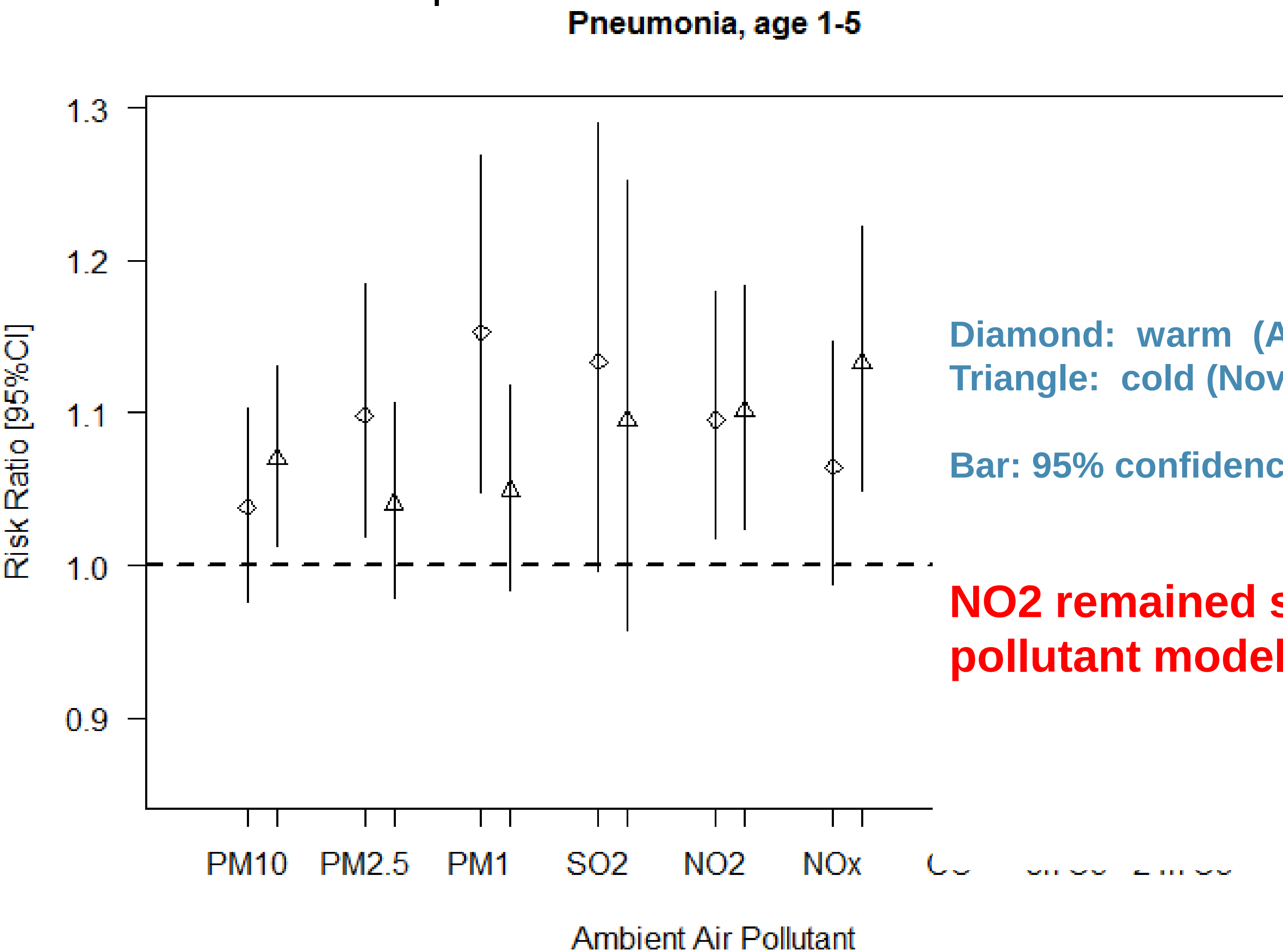


% increase of mortality

per 10’000 particles/cm³

As air pollution increases, hospital admissions of young children increase (Hanoi, Vietnam)

Nhung Nguyen Thi Trang, et al, (submitted 2017) (PhD student @ Swiss TPH) – do not cite nor quote



Diamond: warm (April-October),
Triangle: cold (November – March),

Bar: 95% confidence intervals

NO2 remained stable in all 2-pollutant models !

Examples on
LONG-TERM (chronic) EFFECTS
(effect of «life-time» exposure to UFP on long-term health)

Needs for long-term effect studies

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- Spatial distributions of long-term exposure to UFP
- Spatial distributions of long-term exposure to co-pollutants → spatial correlations between UFP and other markers of pollution

HEI Perspectives 3

January 2013

Insights from HEI's research

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Understanding the Health Effects of Ambient Ultrafine Particles

HEI Review Panel on Ultrafine Particles

Epidemiologic Studies

- **Studies of long-term exposure to ambient UFPs.** The kinds of data that have provided broad support for epidemiologic investigations of the public health implications of long-term exposure to $PM_{2.5}$ and PM_{10} — multiple years of monitoring data, using consistent methods, in major urban areas representing millions of people — have simply not existed for UFPs.

Spatial determinants of UFP
(Land-Use Regressions)

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Amsterdam, NL (Hoek et al, EnvSciTechnol 2010)

Traffic intensity and distance ; household density (300m); port (3000m)

Girona, Spain (Rivera et al, Atmos Env 2012)

High density popluation (1000m); distance to road intersection; household density (100m)

Montreal, Canada (Weichenthal et al, Env Res 2016)

Temp, Wind speed, park space, open space, local roads, lenght of rail, annual NO2, population denisty (LUR)

4 SAPALDIA regions, Switzerland (Eeftens et al, Env Health 2016)

Traffic load (250m); road lenght (100m); major road (100m)

Rome, Italy (Cattani et al, Atmos Env 2017)

Traffic intensity / distance – ratio; population density; green space in 5

Augsburg, Germany (Wolf et al, Atmos Env 2017)

Traffic load (50m); industry (300m); semi-natural area (100m); green space (500m); building density

For Boston: see next talk by D. Brugge

Land Use Regression Models for Ultrafine Particles in Six European Areas

Erik van Nunen,[*,†] Roel Vermeulen,[†] Ming-Yi Tsai,[‡,§,∥] Nicole Probst-Hensch,[‡,§] Alex Ineichen,[‡,§] Mark Davey,[‡,§] Medea Imboden,[‡,§] Regina Ducret-Stich,[‡,§] Alessio Naccarati,[⊥] Daniela Raffaele,[⊥] Andrea Ranzi,[#] Cristiana Ivaldi,[∇] Claudia Galassi,[○] Ma
David Donaire-Gonzalez,[◆,¶,∞] Marta Cirach,[◆,¶,∞] Led
Kees Meliefste,[†] Daan Buijtenhuijs,[†] Bert Brunekreef,[†] I
and Gerard Hoek[†]

Env Sci Tech 2017

More to hear from EXPOSOMICS at NPC 2018!

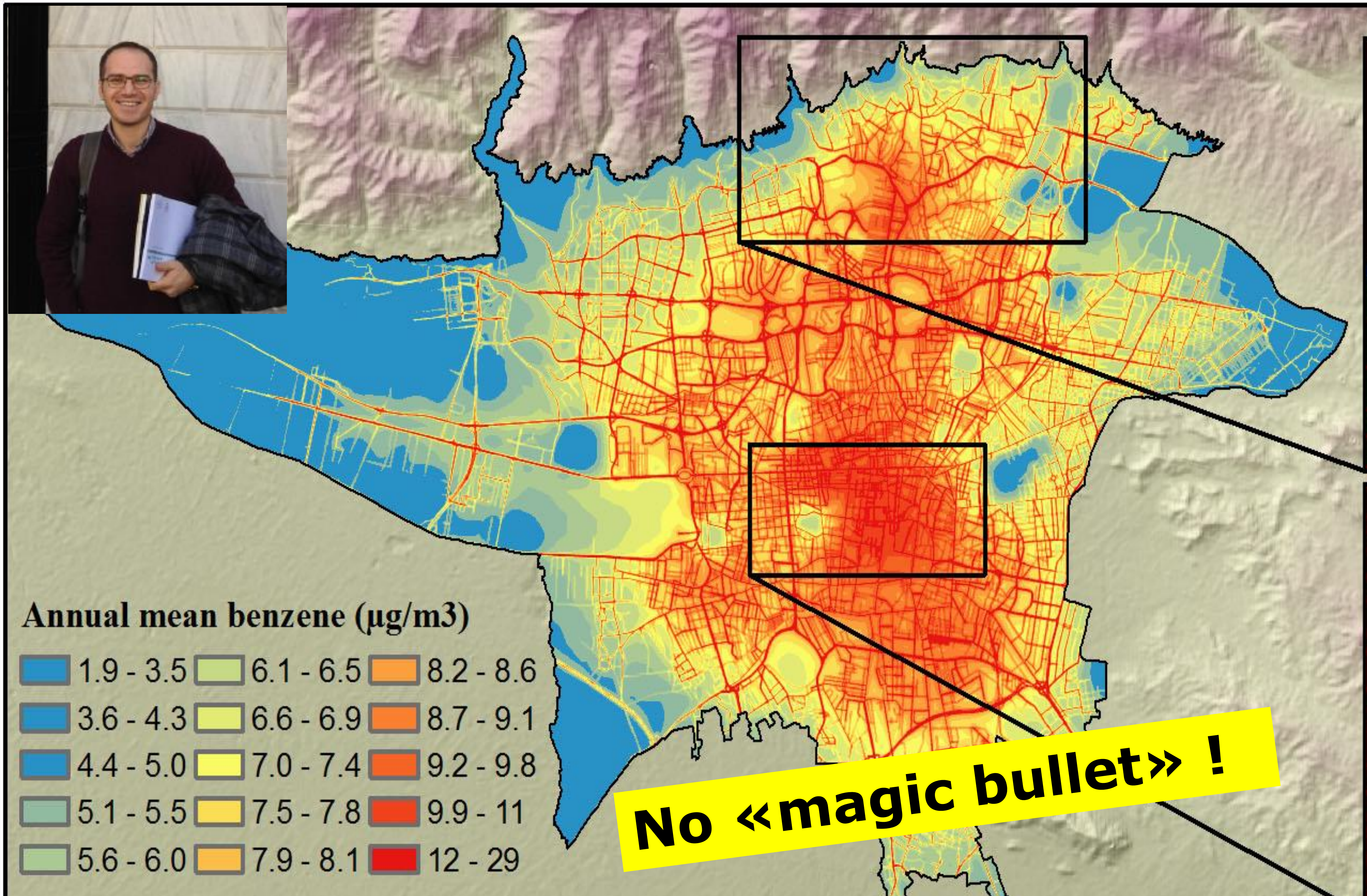
Map of Europe highlighting study areas.

A) Basel

	Intercept
NT	Traffic intensity on nearest road
NT	Road length of all major roads in a buffer of 50m
PP	Sum of low and high density residential land in a buffer of 500m
PP	Sum of low and high density residential land in a buffer of 1000m
RE	Number of restaurants in a buffer of 100m
RE	Number of restaurants in a buffer of 1000m

Spatial land-use regression model for benzen, Tehran (Iran), 2015

PhD Thesis Heresh Amini, Swiss TPH; AQCC Tehran; Sharif University (Vahid Hosseini)

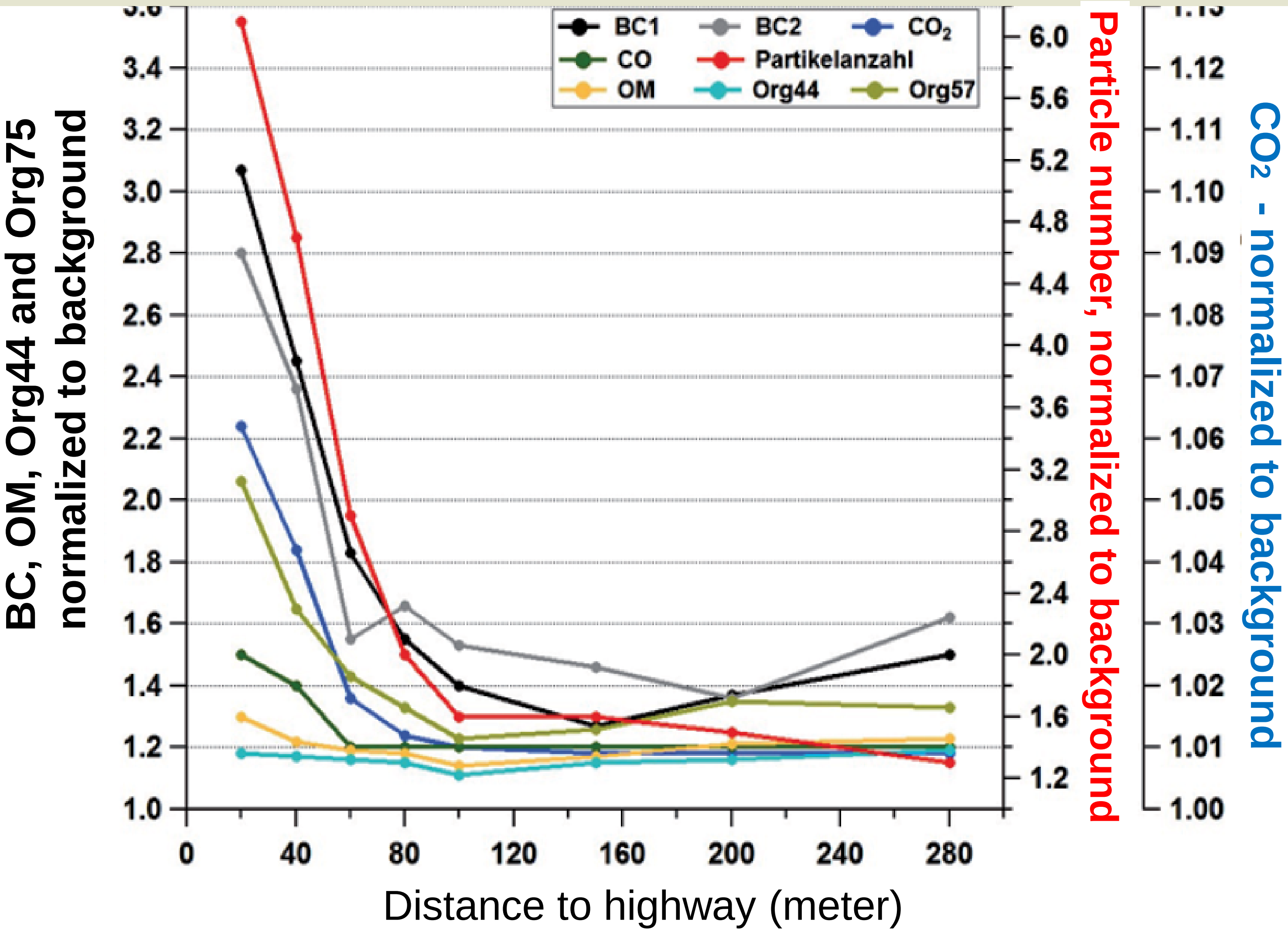


Living along traffic corridors does not only result in very high exposure to UFP…. - a complex mixture of traffic-related pollutants follows the same spatial distribution

(e.g.: BC, organic material, organic aerosol markers, particle number concentration, CO, CO2)

All scales normalized to «background levels»

background = 1



Daten: Paul Scherrer Institut (PSI)

Spatial variance of Particle Number Concentration explained by other markers (R^2)

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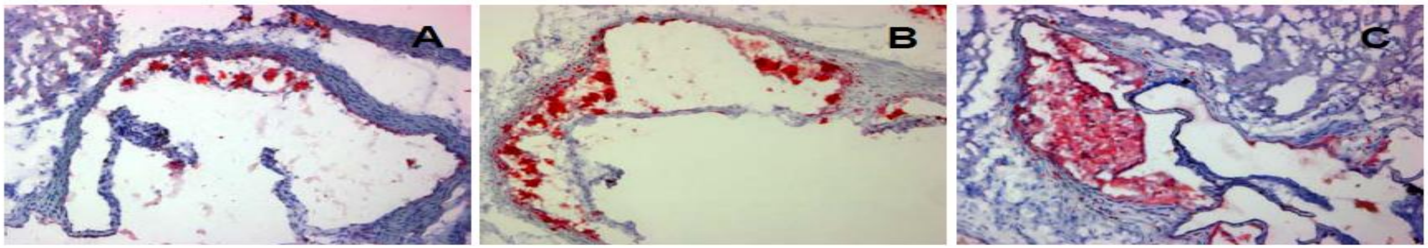
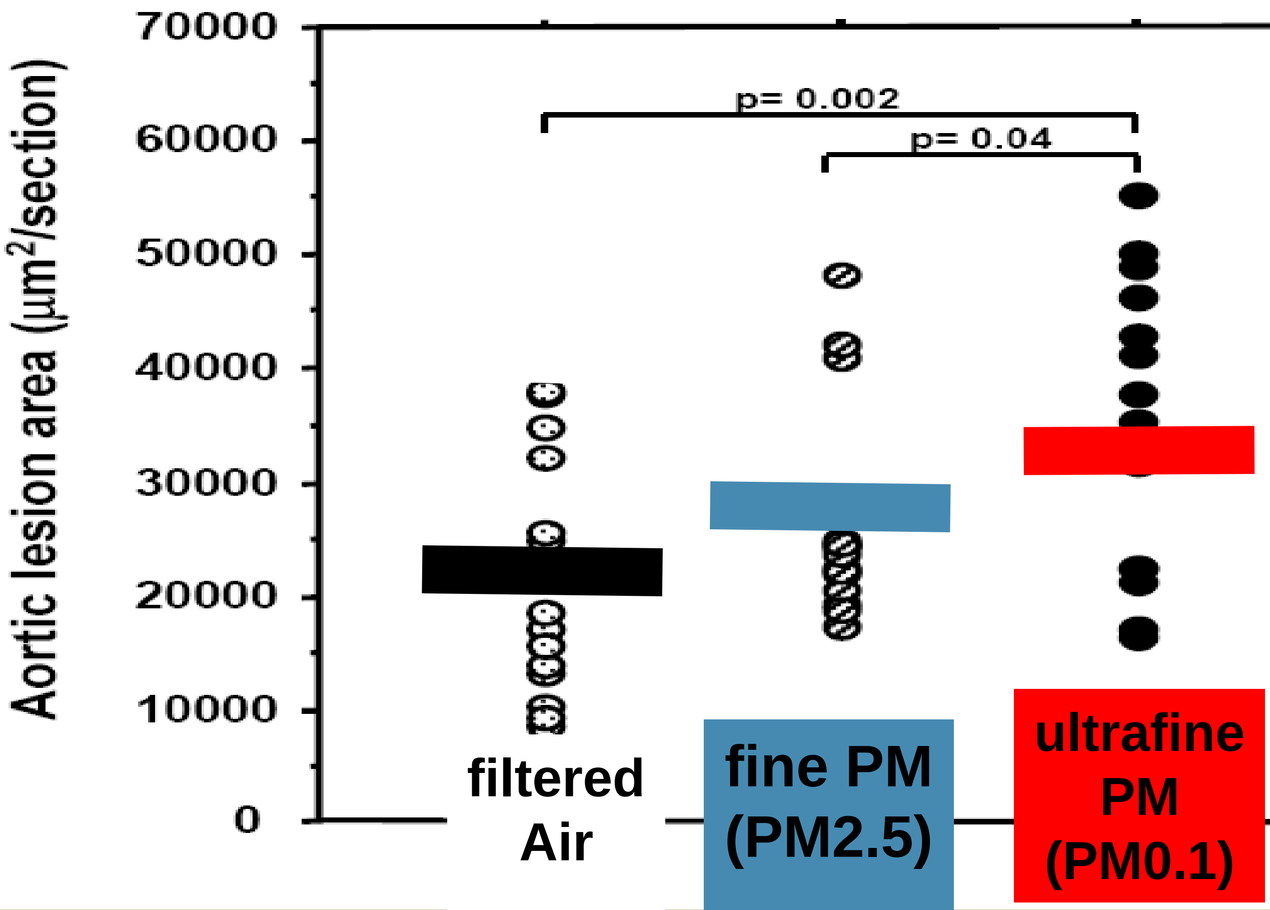
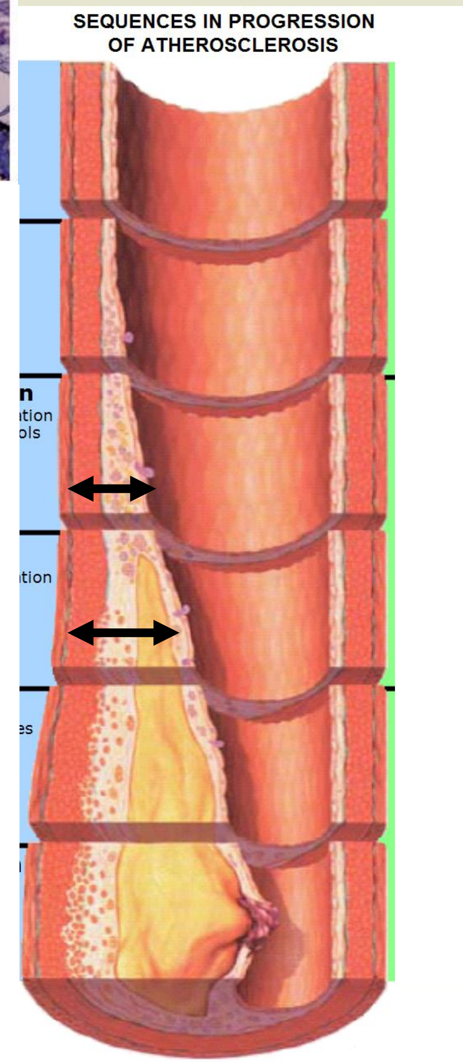
From 4 cities of the Swiss SAPALDIA study; 67 measurement sites) Eeftens et al, 2016		Range of the 4 within-city R^2 between PNC annual mean and…:	Rome (Cattani et al)
NO2	0.81	**0.47-0.82**	**0.38**
PM2.5	0.41	**0.10-0.43**	**0.37**
PM2.5 absorbance	0.74	**0.07-0.86**	**0.44**
PM10	0.62	**0.10-0.72**	**0.34**
PM coarse	0.42	**0.02-0.33**	**0.34**
Lung depos. surface area	0.90	**0.63-0.98**	**--**

Traffic related PM from Highway 405 caused atherosclerosis in mice

Araujo et al, Circul Res 2008







Carotid intima-media thickness (CIMT) is associated with home-outdoor levels of pollutants in the Swiss SAPALDIA study –

(4 sites; 1500 subjects age >50)

Aguilera et al – Env H Perspect 2016

(so far the only CIMT study with UFP)

PM10 (per 10ug/m3)		2.33% (0.28, 4.38)
PM2.5 (per 5.6ug/m3)		2.63% (0.5, 4.77)
Vehicular source PM2.5	(per IQR)	1.67% (-0.13, 3.48)
Particle Number Conc (12k = IQR)		2.06% (0.03, 4.10)

BUT:

PNC, adjusted for PM2.5 0.63% (-3.60, 4.86)

… and Pearson corrleation home outdoor PM vrs PNC very high (~0.9)

Post-menopausal breast cancer was associate with home outdoor NO2 but not with UFP

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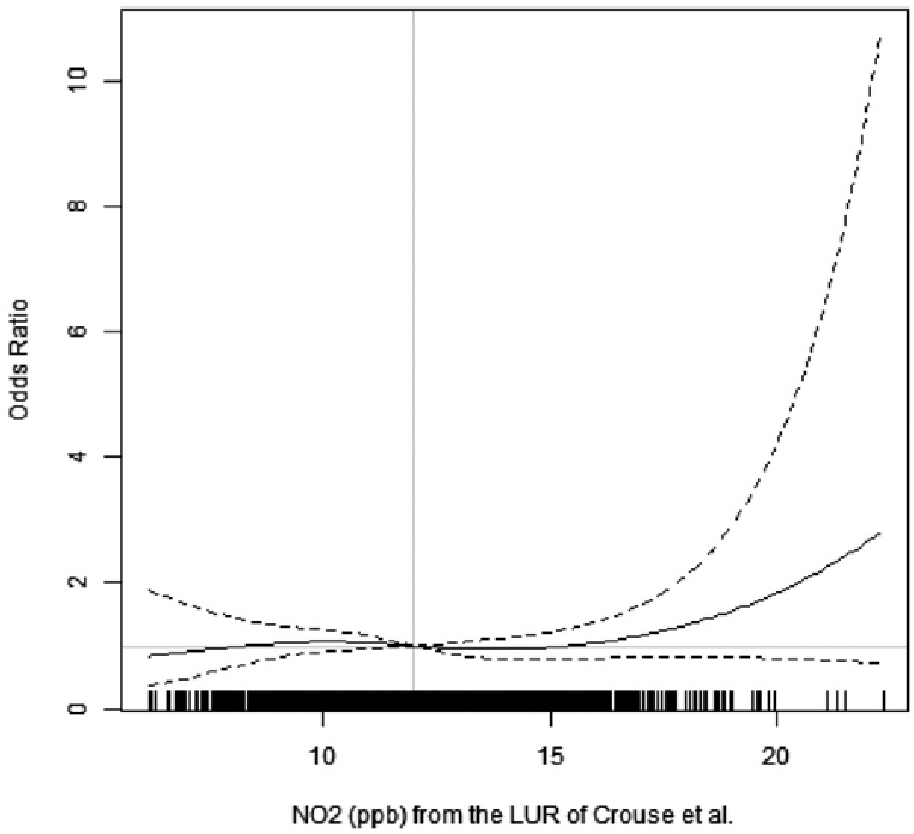
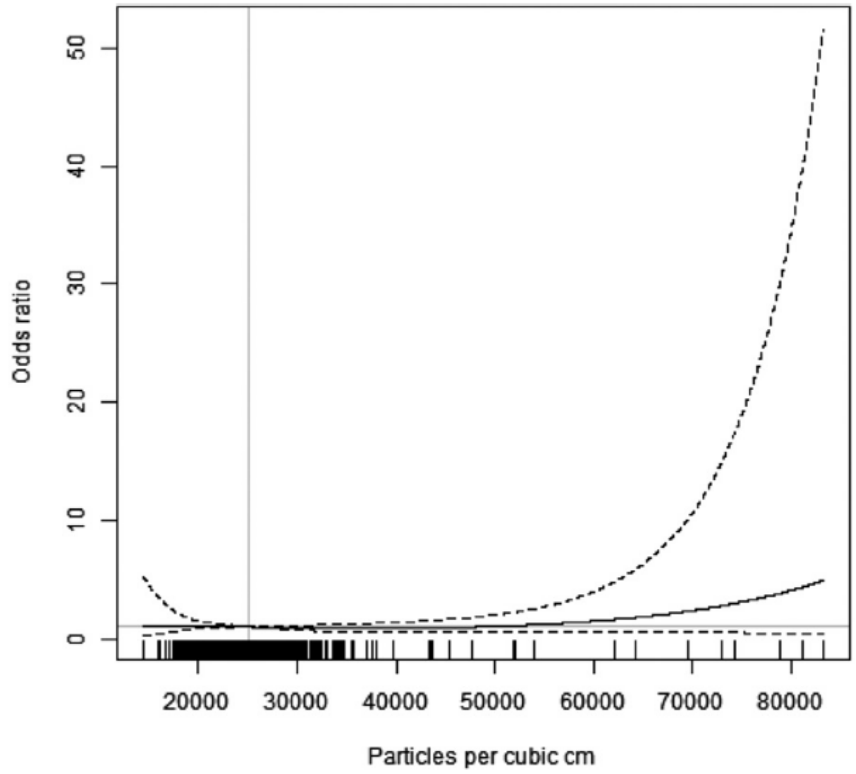
Case-control study, Montreal; Goldberg et al, Env Res 2017

(no two-pollutant models)





Home outdoor ultrafine PM are associated with prostate cancer; case-control study (Montreal)

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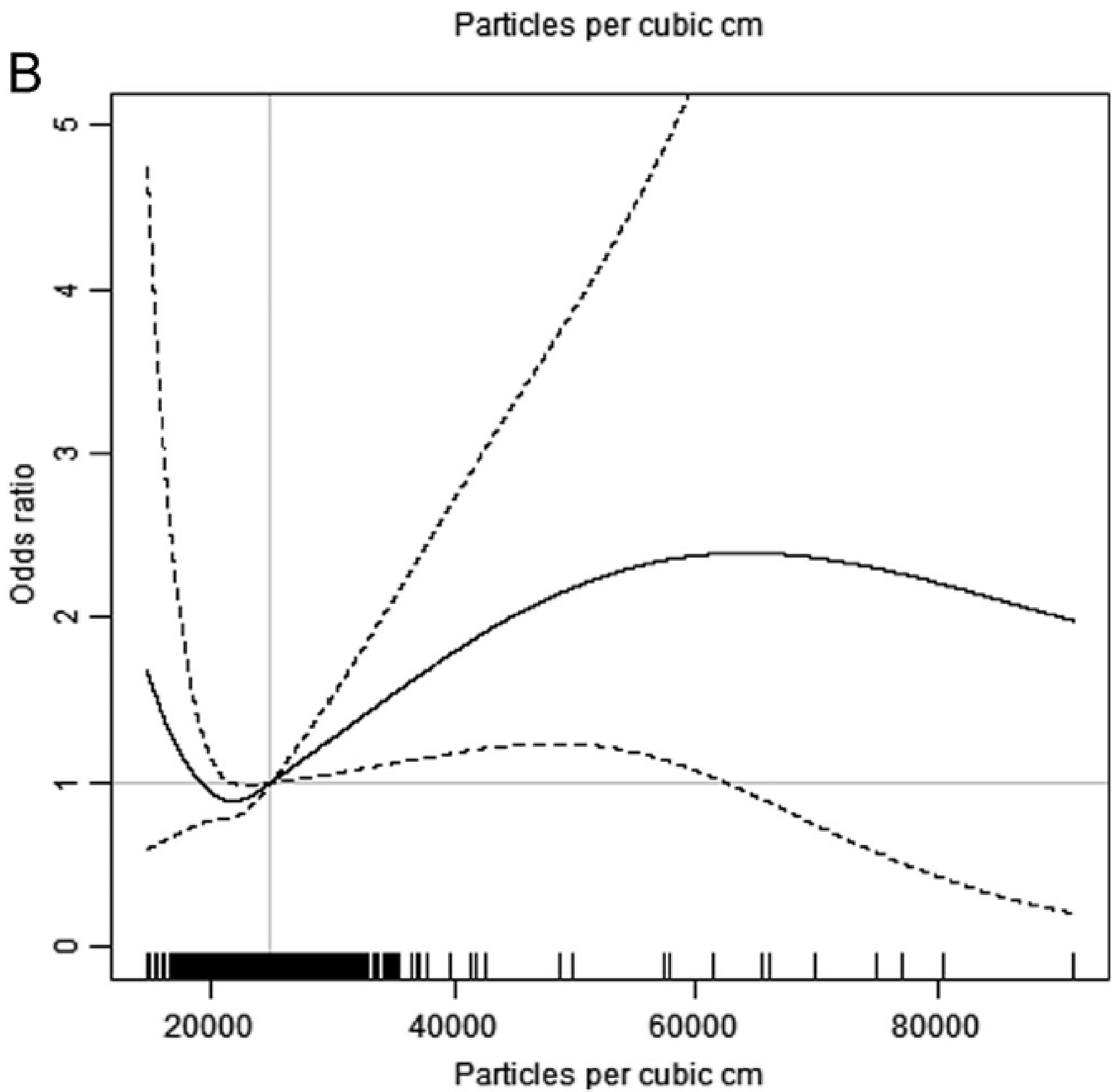
Weichenthal et al, Env Res 2017



Ischemic Heart Disease mortality in the Californian Teacher's Study

Ostro et al ; Env H Perspect 2015

Association (risk ratio), per Inter-Quartile Range of exposure

PM2.5 mass conc.	1.18 (1.08-1.30)
UFP mass conc.	1.10 (1.02-1.18)
Anthropogenic Sec Organic Aerosols (UFP)	1.25 (1.13-1.39)

Two-pollutant model:

UFP mass conc.	1.03 (0.94-1.12)
Anthropogenic Sec Organic Aerosols (UFP)	1.19 (1.08-1.31)

Content

- Epidemiological evidence of health effects of UFP
- Policy context

Policy needs

1. Enforce «highest possible fuel quality»
2. Enforce **existing** EMISSION Standards (Euro VI/6)
3. Set & enforce **existing** science based ambient AIR QUALITY STANDARDS as proposed by WHO
4. Put rigorous measures of control and sanctions in place

→ under above conditions no urgency for new air quality standards for e.g. UFP

Gerrit Kadijk:
"Most effective way: vehicle emissions must be as low as possible"

Trends in ambient concentrations of NO2
Swiss NABEL Network (1986-2015)

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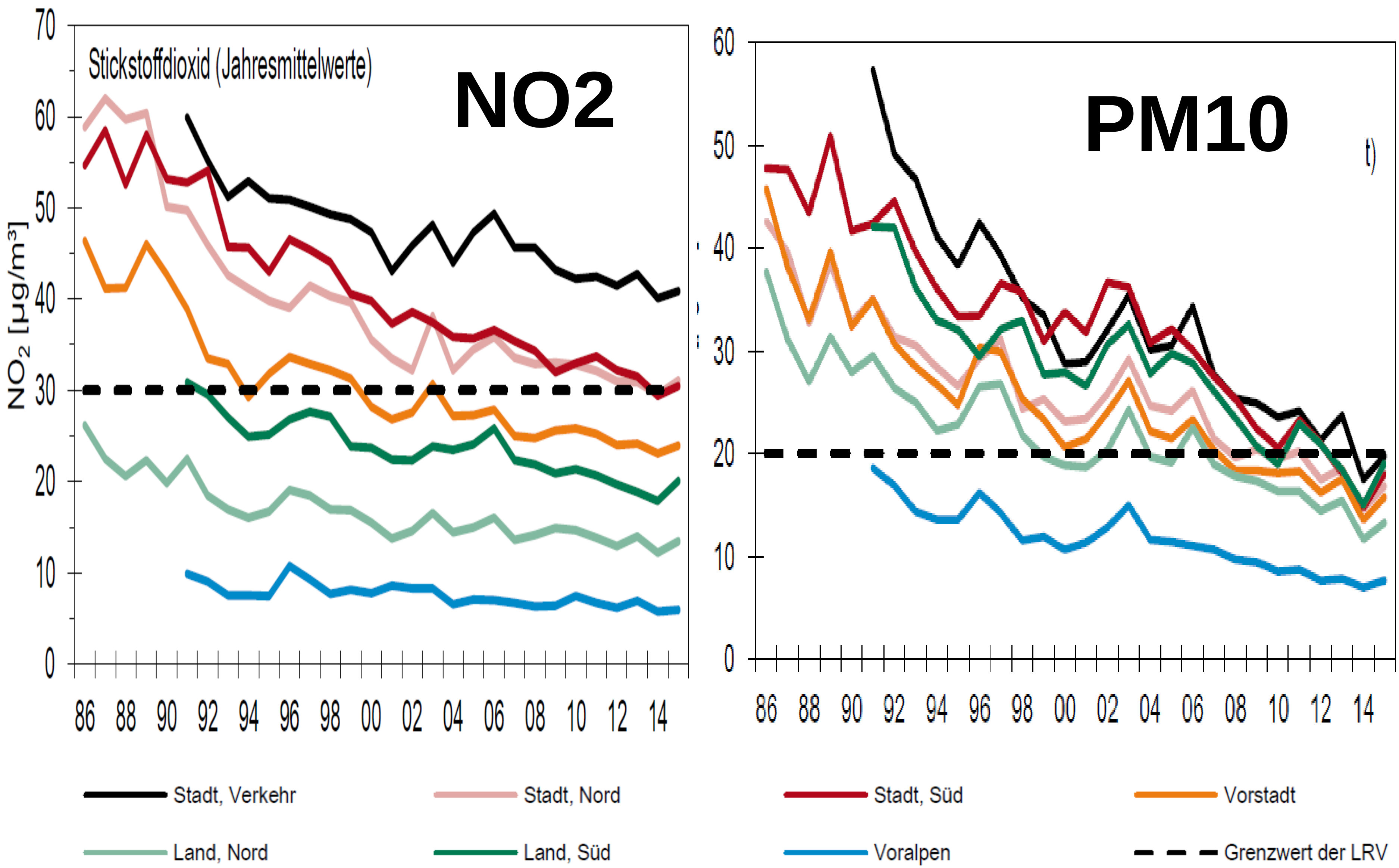
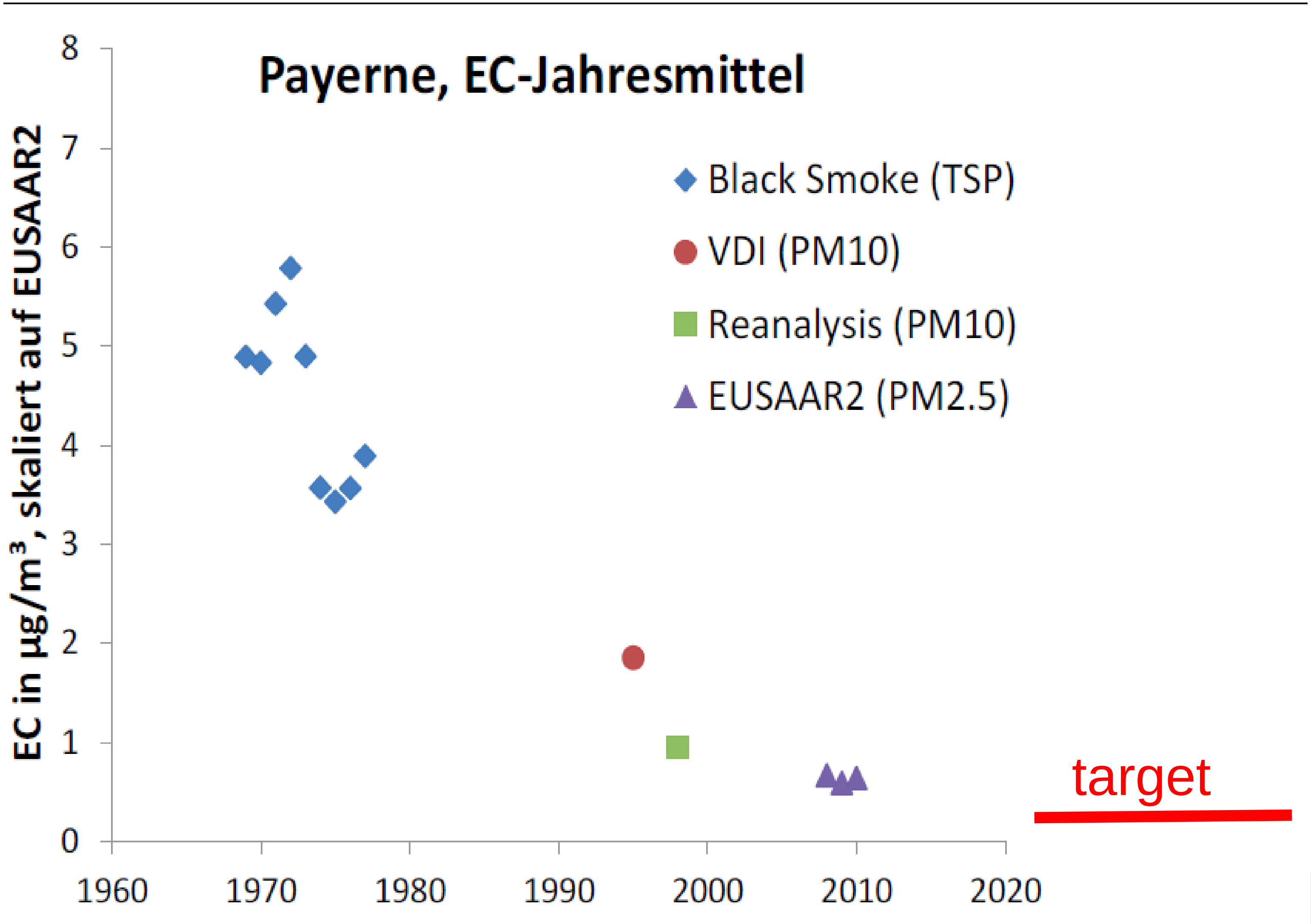


Strong reduction in soot despite not having an ambient air quality standard for soot / EC / BC
(Payern, Switzerland)



We need Globalized air quality standards

Int J Pub Health 2017: Kutlar Joss et al (open access)

Public health oriented air quality standards

«standards» do not protect health !

	WHO Guidelines	Afghanistan, Cameroon, Iceland, Iran, Switzerland (Australia)	State of California	U.S.A. Federal Mexico	Norway	E.U.	India	China and many others
PM_{10} Annual Mean	20 $\mu g/m^3$	20 (AUST: 8 for $PM_{2.5}$!)	20	-- but $PM_{2.5}$ of 12	25	40	60	70

% of countries with standards for ≥ 1 pollutant	
European Region	94%
South-East Asia	64%
Region of Americas	57%
Eastern Mediterranean Region	52%
Western Pacific	44%
African Region	36%
Total	**60%**

Set and enforce science based targets as proposed by WHO to protect health!

EU limits are NOT SCIENCE BASE and do NOT protect people’s health

Pollutant	EU limit	% citizens Exceeding EU limit	Science based Guidelines of WHO	% citizens Exceeding WHO limit
PM10	50 µg/m³ in 24 h	16	20 µg/m³ a year	50
PM2.5	25 µg/m³ a year	8	10 µg/m³ a year	85
BaP	1 µg/m³ a year	20	0.12 ng/m³ a year	88
NO_2	40 µg/m³ a year	8	40 µg/m³ a year	8
SO_2	125 µg/m³ in 24 h	<1	20 µg/m³ in 24 h	38
O_3	120 µg/m³ in 8 h	8	100 µg/m³ in 8 h	96

Stronge governance needed

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Call for globalized standards in

- ❑ **Fuel quality**
- ❑ **Emissions**
- ❑ **Ambient concentrations**

Needed to abate the ever increasing global inequity in air quality and related health burden caused by the poor environmental governance (abused by globalized industries)

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Int J Public Health
DOI 10.1007/s00038-017-0952-y

ORIGINAL ARTICLE

Time to harmonize national ambient air quality standards

Meltem Kutlar Joss[1,2] · Marloes Eeftens[1,2] · Emily Gintowt[1,2] · Ron Kappeler[1,2] · Nino Künzli[1,2]

Western countries outsource pollution to other countries !

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Nature, April 2017

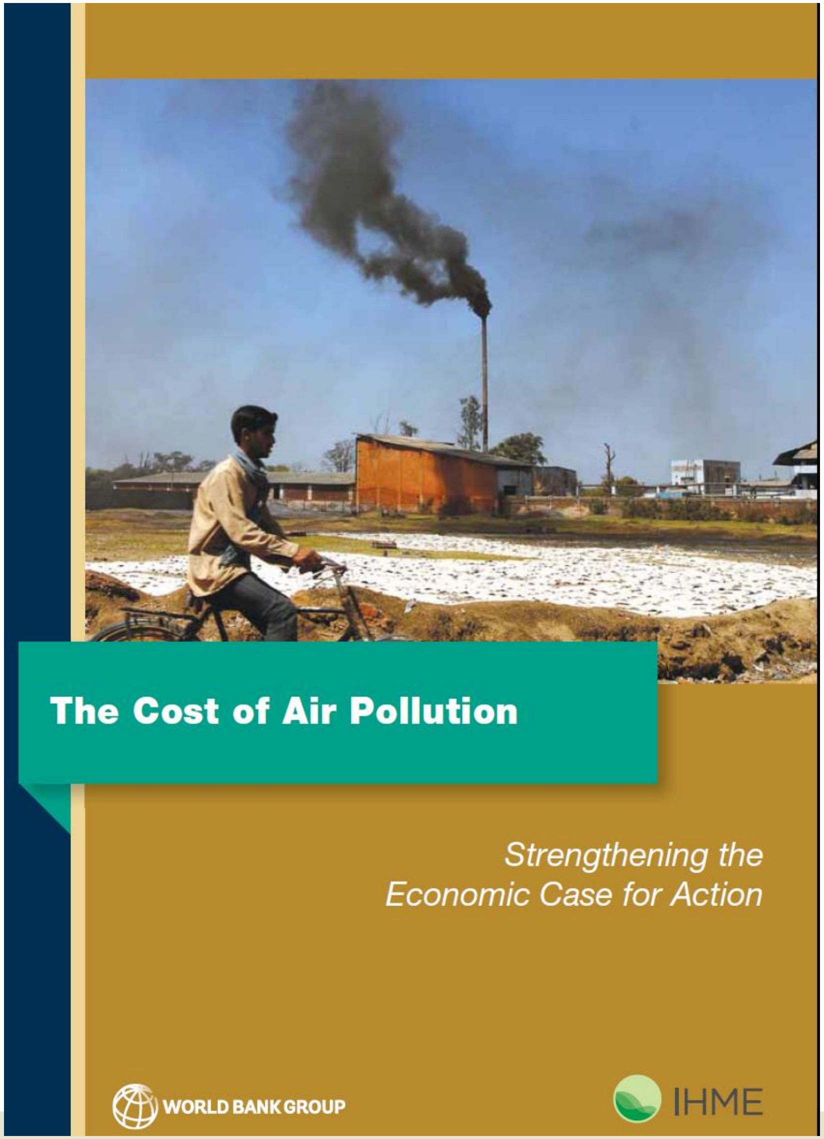
Transboundary health impacts of transported global air pollution and international trade

Qiang Zhang[1]*, Xujia Jiang[1,2]*, Dan Tong[1]*, Steven J. Davis[1,3], Hongyan Zhao[1], Guannan Geng[1], Tong Feng[1], Bo Zheng[2], Zifeng Lu[4], David G. Streets[4], Ruijing Ni[5], Michael Brauer[6], Aaron van Donkelaar[7], Randall V. Martin[7,8], Hong Huo[9], Zhu Liu[10], Da Pan[11], Haidong Kan[12], Yingying Yan[5], Jintai Lin[5], Kebin He[1,2,13] & Dabo Guan[1,14]

- **Western Europe & USA: the only regions causing (substantially) higher air pollution** (= death & diseases) **in OTHER COUNTRIES** (than at home) **to accomodate their own CONSUMPTION**
- **China, India, Asia take the highest share of air pollution** (= death & diseases) **for the production of goods CONSUMED IN OTHER COUNTRIES**

Costs of air pollution related health impacts are very large

See World Bank Report 2016 on costs of air pollution



Rigorous measures of control and sanctions needed

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Nature 2017

Impacts and mitigation of excess diesel-related NO_x emissions in 11 major vehicle markets

Susan C. Anenberg[1]*, Joshua Miller[2]*, Ray Minjares[2], Li Du[2], Daven K. Henze[3], Forrest Lacey[3]†, Chris topher S. Malley[4], Lisa Emberson[4], Vicente Franco[2]†, Zbigniew Klimont[5] & Chris Heyes[5]

Global consequences of VW (et al) Directors' decision to manipulate software:

~38'000 premature death /yr globally caused by the excess NO2 (via the NOx driven formation of PM and O3)

Consequences of unequal standard setting: «African quality» diesel

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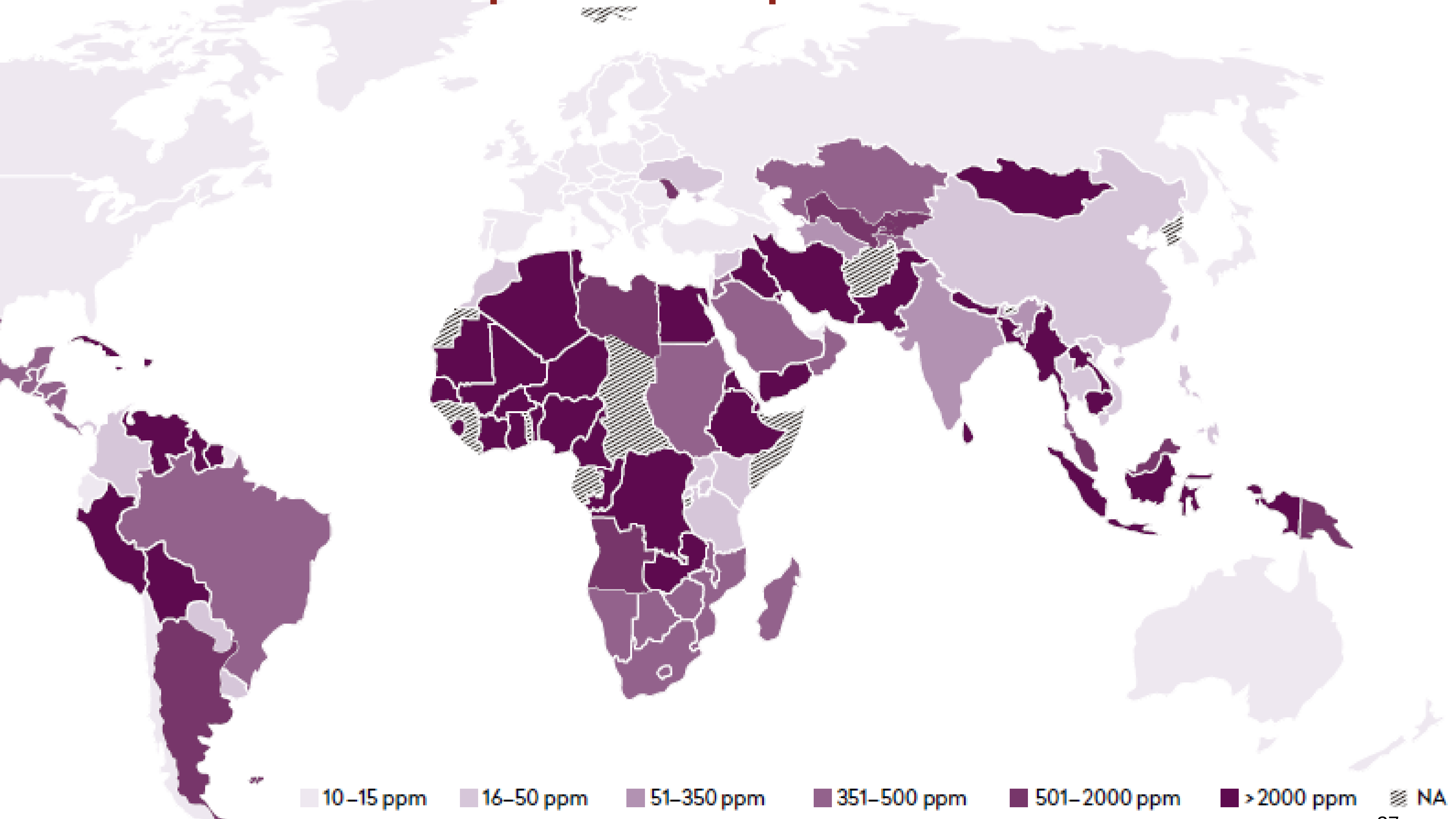
An investigation of PublicEye (Swiss NGO)

National Standards for permitted Sulphur-content of diesel



Sulphur levels as measured in «African Quality» diesel samples (ppm)

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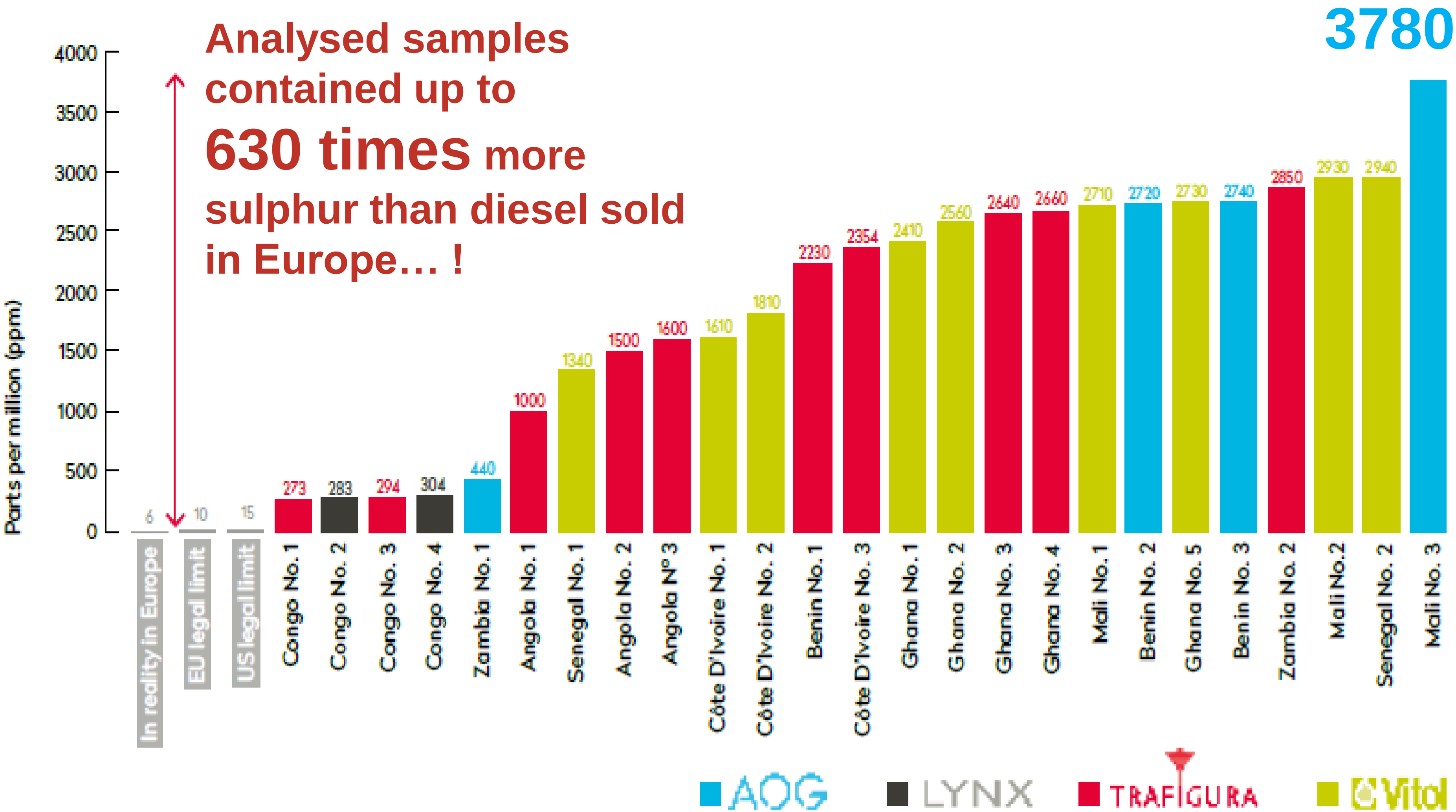
- Swiss traders are responsible for 61% of these sells (…and its consequences on death and diseases)
- Blending objective: sell the «poorest (legally) possible quality»



In sum…

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- UFP are toxic (as are many of the 100’s of pollutants in air pollution)
- Long-term health effects unclear
- Systematic review of health effects of UFP and its independence from other regulated pollutantns needed
- Added value of air quality standards for UFP at this stage not yet clear
- **BUT: available technology and policies could lead to substantial improvements and compliance with WHO Guideline values if governments do their job to regulate…**

Thank you

Nino.Kuenzli@SwissTPH.ch

Welcome on the SwissTPH LUDOK-Data base with the air pollution and health literature

http://ludok.swisstph.ch/fmi/iwp/cgi?-db=ludok_web&-loadframes