



Nutritional solutions for a healthy life

Nutritional Solutions to Counteract the Impact of Air Pollution: A BCDEF solution

Daniel Raederstorff, PhD
Manfred Eggersdorfer, PhD

DSM Nutritional Products, Kaiseraugst, Switzerland

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The 2005 WHO Air quality guidelines (AQGs)



Clean air is considered to be a basic requirement of human health and well-being

However, air pollution continues to pose a significant threat to health worldwide

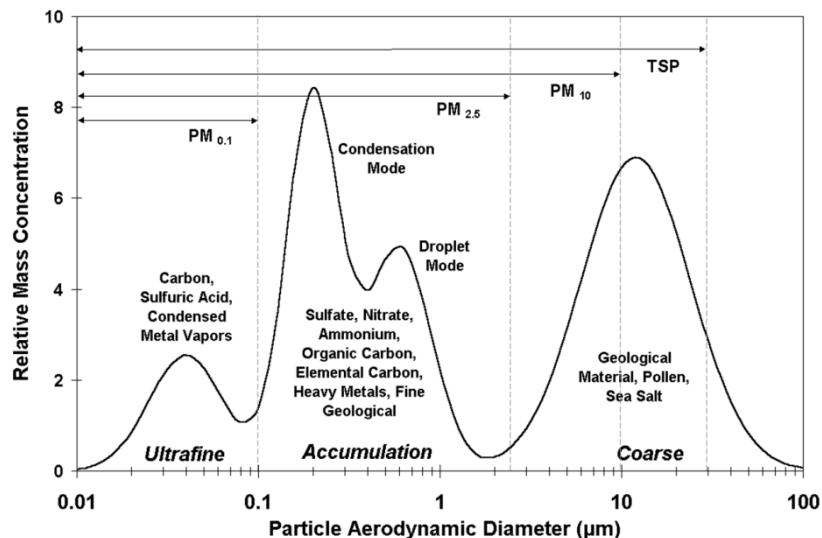
Particulate matter (PM)
Ozone (O₃)
Nitrogen dioxide (NO₂)
Sulfur dioxide (SO₂)

PM_{2.5} Diameter < 2.5 μm

PM₁₀ Diameter ≥ 2.5 μm

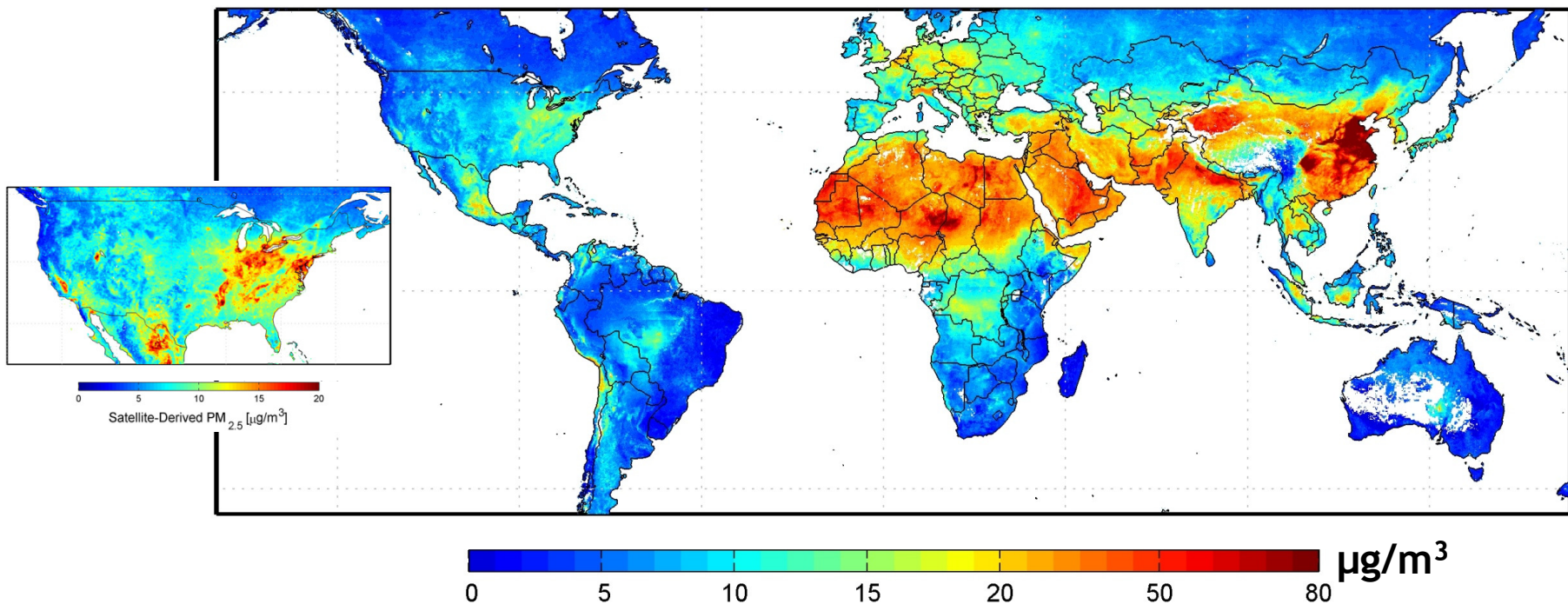
AQGs for PM

PM _{2.5}	10 μg/m ³ annual mean
	25 μg/m ³ 24-hour mean
PM ₁₀	20 μg/m ³ annual mean
	50 μg/m ³ 24-hour mean



Air pollution a global problem

Global satellite -derived PM_{2.5} levels averaged over 2001-06



- An overlap with maps of population density suggest that **more than 80% of the world's population breathe polluted air** that exceeds the WHO recommendation (<10 µg/m³ annual mean).
- White space indicates water or locations containing < 50 measurements.

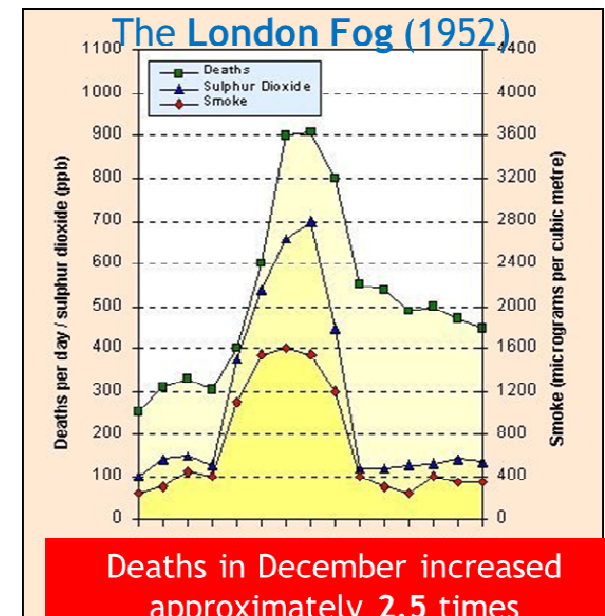
<http://www.nasa.gov/topics/earth/features/health-sapping.html>

Which adverse Health Effects have been linked to PM 2.5?

- Premature death
- Lung cancer
- Exacerbation of COPD
- Development of chronic lung disease
- Decreased lung function
- Heart attacks
- Hospital admissions and ER visits for heart and lung disease
- Pre-term birth, Low birth weight
- Respiratory symptoms and medication use in people with chronic lung disease and asthma
- Increased risk of CVD and diabetes
- Increased risk of cognitive deficits



Air pollution delivers smaller babies
Study of 3 million infants suggests
connection between inhaled particles
and birth weight (Nature, Feb 6, 2013)



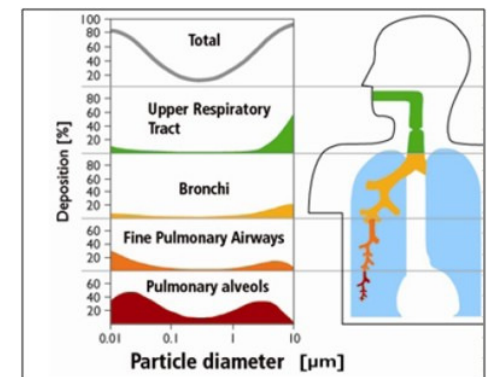
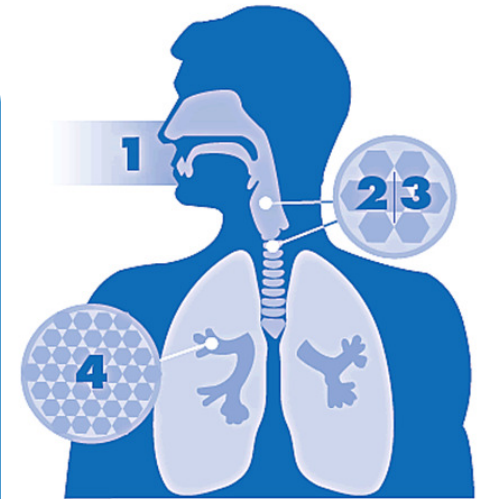
Major responses of the body to air pollution by particulate matter (PM)

- PM enters respiratory system when we inhale
- PM₁₀ is mostly eliminated by cough, sneeze and swallow
- PM_{2.5} travels all the way to alveoli in lung and causes local and systematic harm including:

↑ Oxidative stress

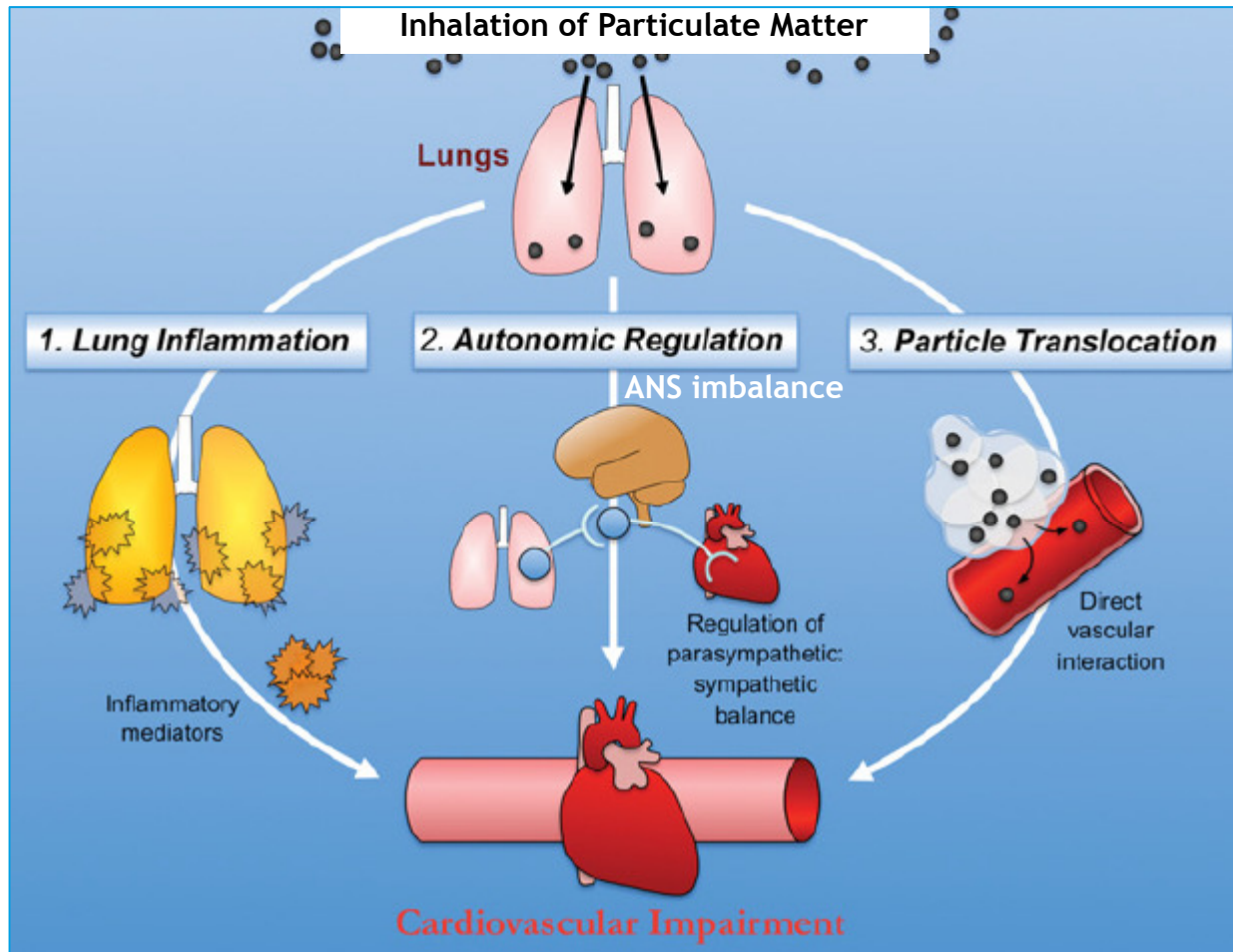
↑ Inflammation insult

Disturb the autonomic nervous system (ANS)



Adapted from www.bcairquality.ca/health/air-quality-and-health.html ;
<http://www.icao.int/environmental-protection/Pages/Contaminants.aspx>

Mechanistic link between PM and CVD

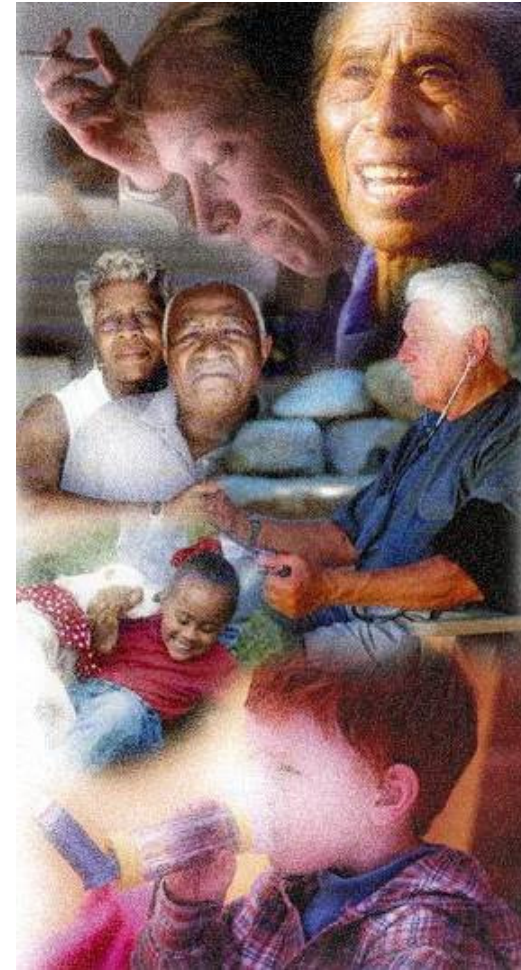


Adapted from Miller M.R. et al., 2014

Short- and long- term exposure to PM air pollution is associated with an increased risk of CV morbidity and mortality

Some population groups are more at risk

- **People with heart / lung disease:**
 - Conditions make them vulnerable
- **Older adults:**
 - Greater prevalence of heart / lung disease
- **Children:**
 - More likely to be active
 - Breathe more air
 - Bodies still developing



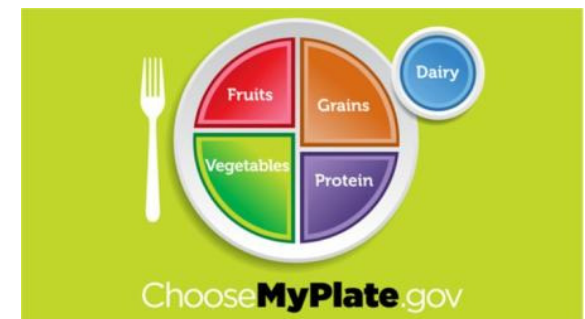
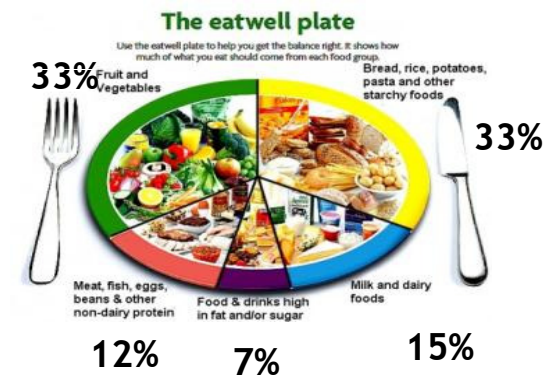
Nutrition & Chronic diseases the link with PM

- Nutrition is a key factor for the prevention of chronic diseases (CVD, diabetes)
- Small dietary changes can lead to a large reduction in the burden of CVD.
 - Eating less fat and fewer calories
 - Decrease sugar, salt and saturated fat intake
 - Increase fiber, fruit and vegetable intake
 - Adequate intake of micronutrients and PUFA

Nutritional epidemiology showed that **specific nutrients play a key role in maintaining a healthy body** and reducing the risk of chronic disease such as CVD.



<http://www.diabeticdietplan.net/diabetic-diet-plan-1/>



Nutrition solution (A BCDEF solution):

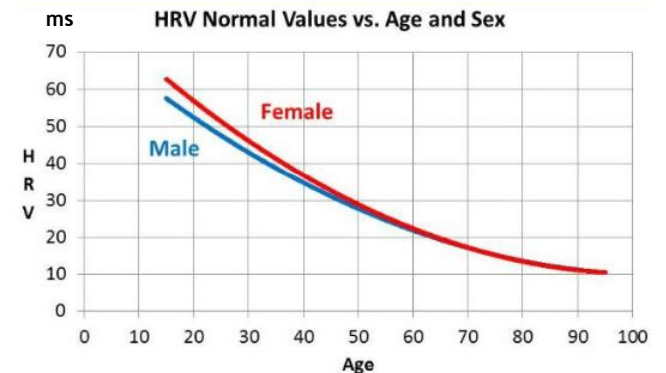
- ❖ B: Vitamin B's
- ❖ C: Vitamin C
- ❖ D: Vitamin D
- ❖ E: Vitamin E
- ❖ F: Fish oil

Heart rate variability (HRV)

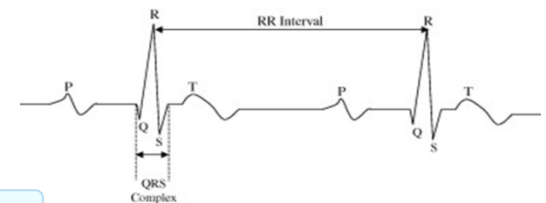
- HRV is regulated by the autonomic nervous system (ANS) and is used to **assess the integrity of the ANS**
- HRV measures the fluctuation between heart beats
 - **Time-domain indices of HRV:**
SDNN is the standard deviation of all normal beat-to-beat interval (RR intervals) over a period of time. In young adults it is about 40-60 ms.
 - **Frequency-domain indices of HRV:** Analysis of the fluctuations in the frequency domains
 - Analysis in the High frequency (HF) range reflect exclusively parasympathetic activity
 - Analysis in the Low frequency (LF) range reflect mainly sympathetic activity
- A reduction in HRV is positively correlated with increased cardiac morbidity and mortality.



HRV declines with age



<http://www.sunscientific.com/What-is-ANS.html>

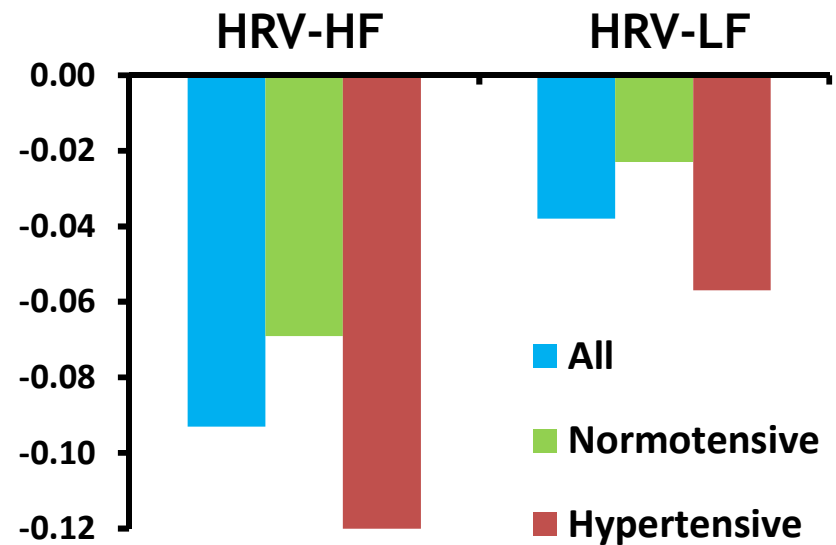


HRV parameters are early indicators of body stress and disease.

Air pollution and HRV among elderly in Mexico city

- In Mexico City, 34 nursing home residents underwent heart rate variability analysis every other day for 3 months.
- 24-hour average levels of PM2.5
 - Indoor PM2.5: 15-67 $\mu\text{g}/\text{m}^3$
 - Outdoor PM2.5: 9-87 $\mu\text{g}/\text{m}^3$
- Daily 1-hour max. ozone levels: 47-228 ppb

Change in HRV for a 10 $\mu\text{g}/\text{m}^3$ increase in PM2.5



- PM2.5 exposure significantly reduced high frequency component of HRV in elderly.
- Hypertensive subjects are more susceptible

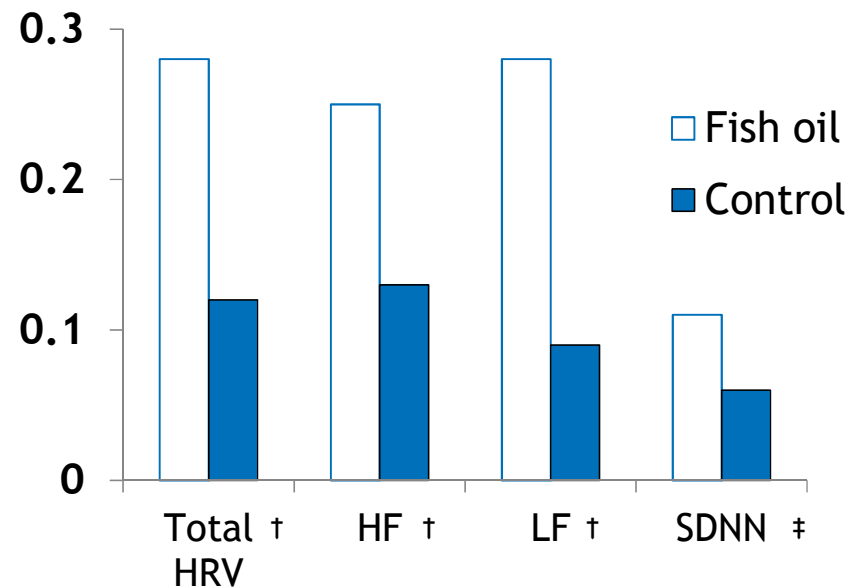
Holguin et al. 2003

Cardiac autonomic changes in elderly supplemented with fish oil

- Elderly subjects (n=58) consumed 2 g/d of either fish oil or soy oil for 4 months after a 2 months pre-supplementation period to establish an HRV baseline for each participant
- Time-domain and frequency-domain analysis of HRV was measured

Fish oil was associated with a significant increase in HRV

Net change from baseline



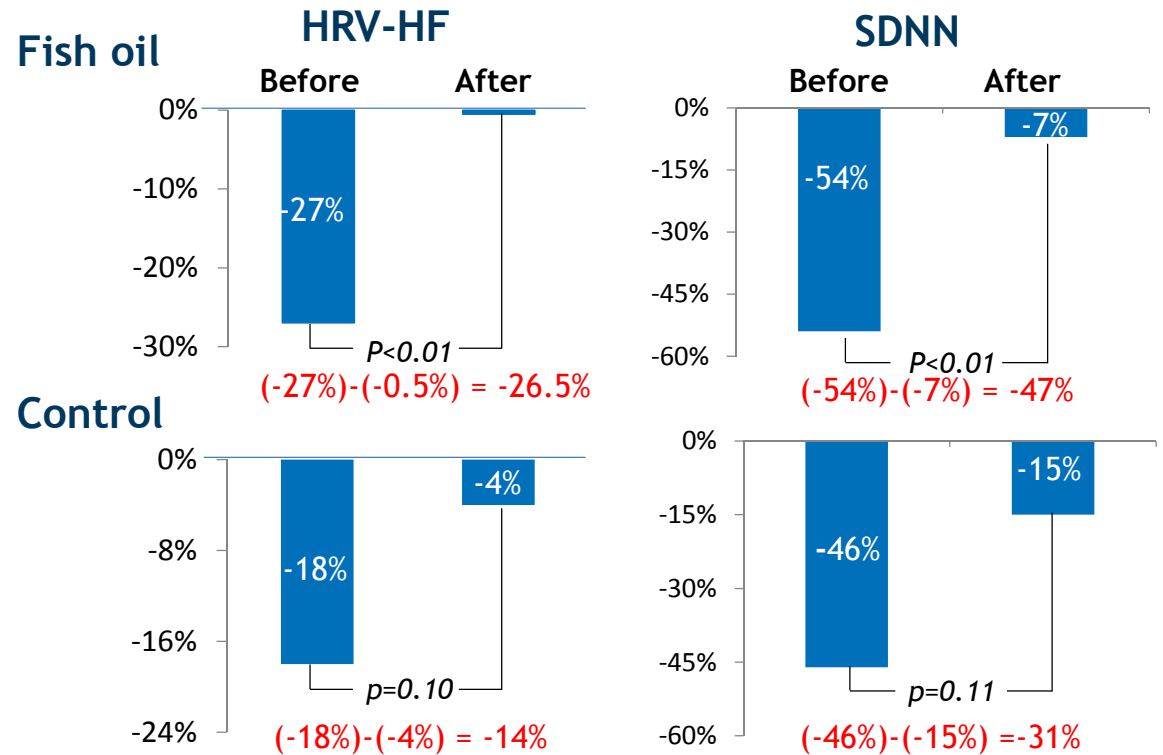
† $\log_{10} (\text{ms}^2)/100,000$
‡ $\log_{10} (\text{ms}^2)$

Holguin et al. 2005

Omega-3 PUFA presented HRV reductions associated with PM2.5

- Elderly from a nursing home (n=50, >60 y) received 2g/d of either fish oil or soy oil for 5 months after a 1 months pre-supplementation.
- Indoor mean PM2.5 levels: 18.6 µg/m³ (8 SD).
- Parameters: Time- and frequency domain analysis of HRV

Change in HRV for an increase in 1 SD (8 µg/m³) of PM2.5



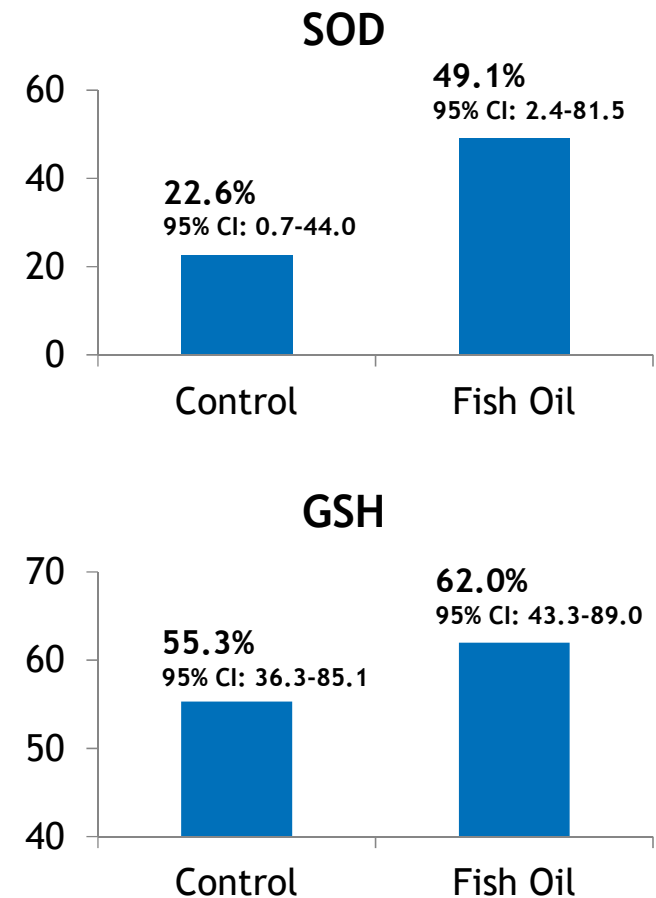
Fish oil significantly decreased the negative impact of PM2.5 on HRV in elderly

Omega-3 PUFA enhanced antioxidant defense in elderly exposed to PM2.5

- Elderly from a nursing home (n=52, >60 y) received 2g/d of either fish oil or soy oil for 4 months after a 3 months pre-supplementation.
- Indoor mean daily levels of PM2.5 38.7 $\mu\text{g}/\text{m}^3$ (14.7 SD).
- Parameters: superoxide dismutase (SOD), glutathione (GSH) and lipoperoxidation (LPO).

- **PM2.5 decreased SOD activity and GSH levels**
- **Fish oil modulated the oxidative stimuli by increasing SOD activity and GSH levels**

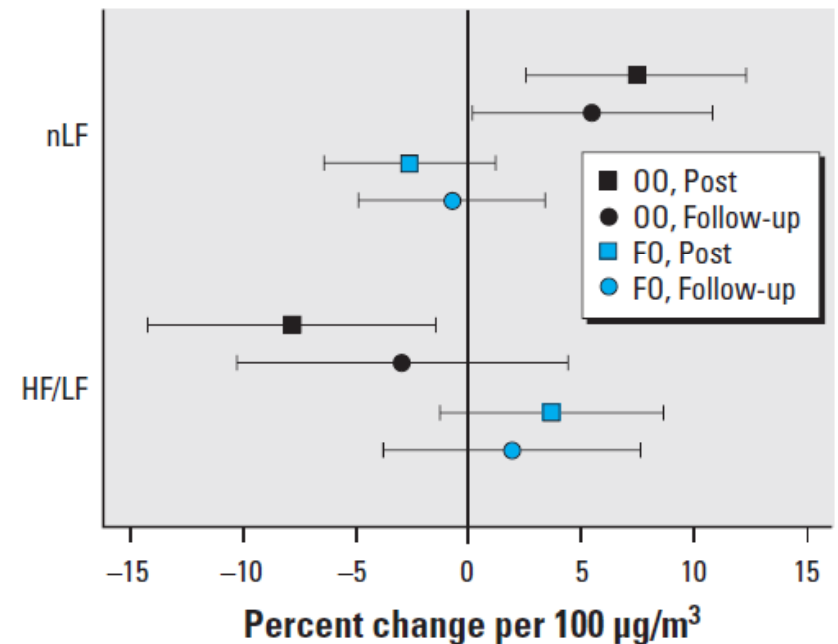
% change from baseline



Omega-3 PUFA attenuate particulate matter induced cardiac effects

- Healthy subjects (n=29, 50-72 y) received 3g/d of either or fish oil or olive oil for 4 weeks before sequential chamber exposure to filtered air or ambient particulate matter (mean mass concentration 278 $\mu\text{g}/\text{m}^3$).
- Parameters: Time and frequency domain changes in HRV and electrocardiographic repolarization changes measured before, immediately after, and 20 h after exposure.

Effect of PM on frequency domain indices of HRV



Omega-3 PUFA protect against the deleterious effects of acute exposure to PM

Tong et al. 2012

Dietary methyl nutrients prevent cardiac autonomic dysfunction induced by PM2.5

Baccarelli et al. 2008

Study design:

- Elderly men (n=549) from the Boston area (Normative Aging Study) had HRV measured in either 1 (n=363) or 2 (n=186) visits.
- The 48-hours moving average of PM2.5 was used as exposure index.
- Genotyping of the C677T MTHFR and C1420 cSHMT were performed.
- Dietary intake of folate, vitamin B6, B12, and methionine were derived from the food-frequency questionnaire.

Results:

- MTHFR 677 CT/TT genotypes had lower HRV than subjects with CC genotypes
- PM2.5 effects on HRV were stronger in subjects with MTHFR 677 CT/TT and cSHMT 1420 CC genotypes
- The reduction in HRV associated with PM2.5 level was abrogated in subjects with higher intakes of B6, B12 and methionine.

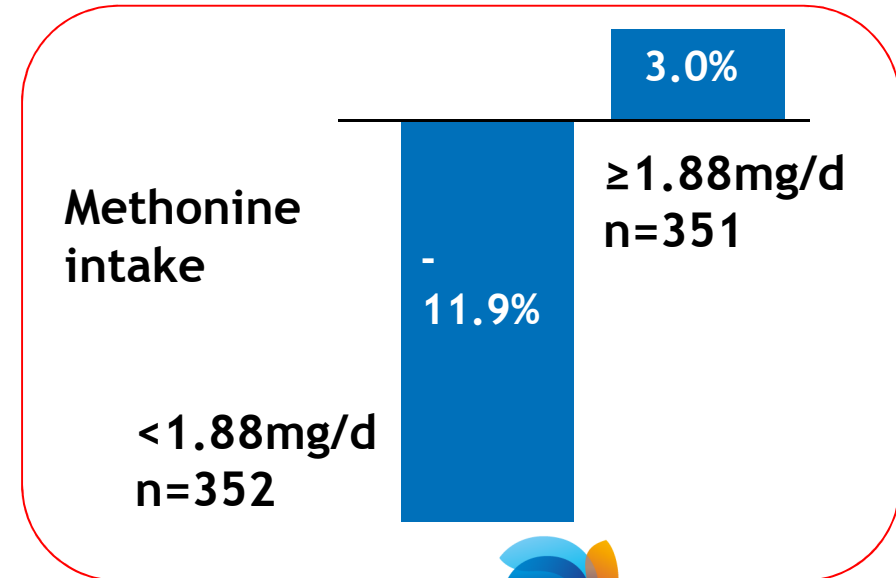
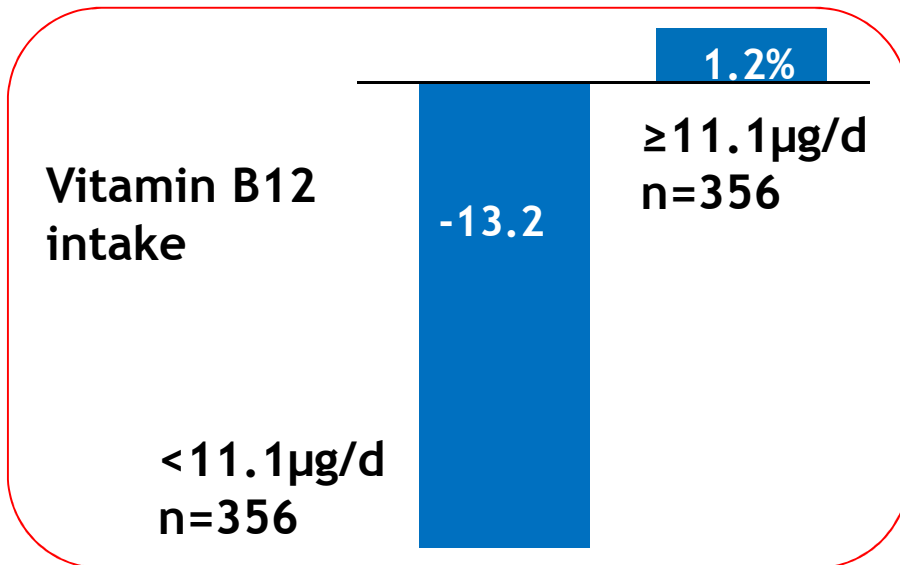
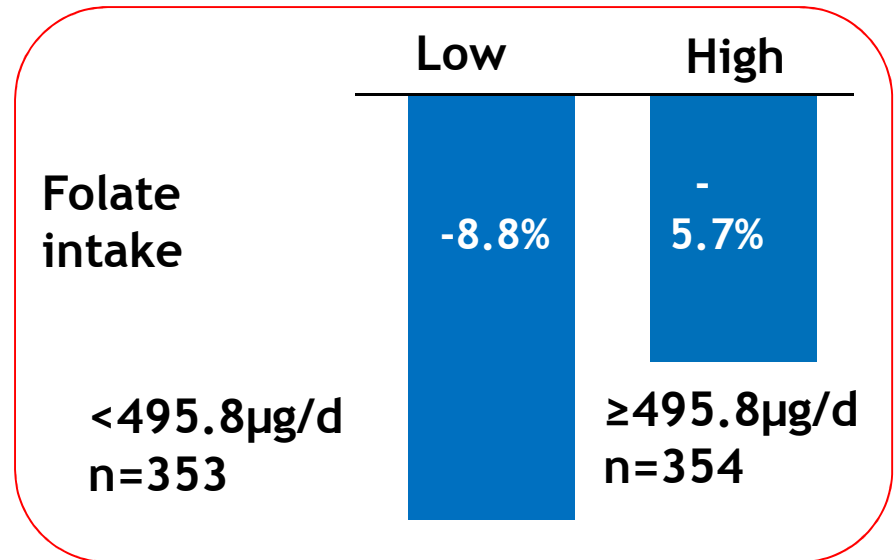
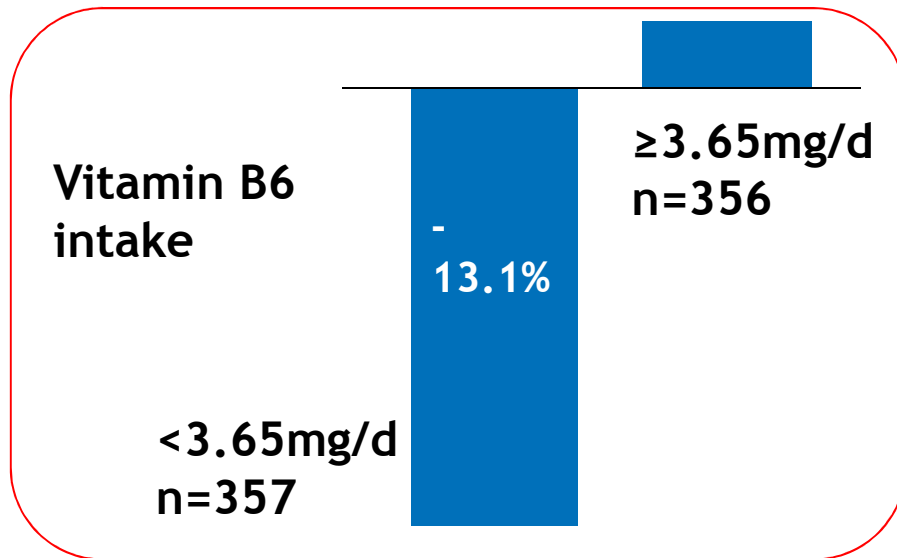
Each 10 $\mu\text{g}/\text{m}^3$
increase
in PM2.5
concentration



7% reduction
in SDNN

SDNN (Time-domain indices of HRV) : standard deviation of normal to normal intervals

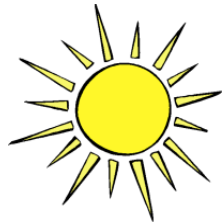
PM 2.5 reduces HRV/SDNN, which is prevented by vitamin B's



Sources of vitamin D

The role of sunshine....

- **Main source:**
Sunlight (UVB 290-315 nm) induces vitamin D production in skin (80 - 90%)



...influenced by various determinants

- Sunshine exposure
- Latitude > 37° / Season
- Ethnicity (skin pigmentation)
- Aging
- **Weather & air pollution**
- Sunlight exposure
- Sunscreen use (>SPF 8)
- Obesity

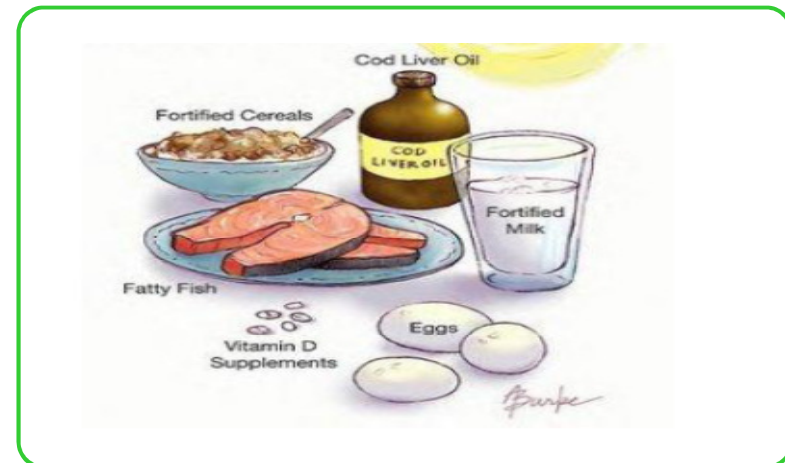
...further factors

- Degree of clothing (veiling)
- Increase in urbanization
- Lifestyle (limited outdoor activity)

- **Minor source:**
Food intake of vitamin D is scarce (10 -20%)
(mainly fatty fish)



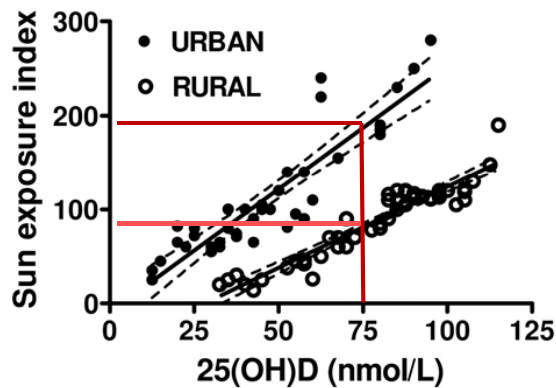
- **Alternative source:**
Fortification and supplements



Air pollution compromise the vitamin D status

- Vitamin D status is usually dependent on skin exposure to sun's UVB radiation
- Air pollution decrease UVB light and thereby reduce skin vitamin D synthesis

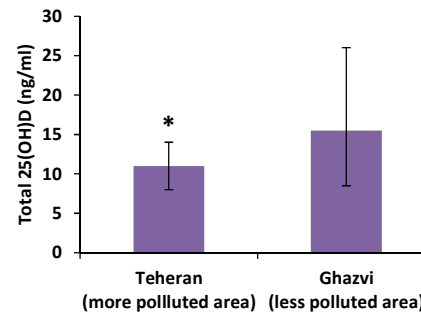
Relationships among vitamin D status and sun exposure index in Belgian urban and rural postmenopausal women



Study conducted in June, July;
age 51 to 81 years

Manicourt et al.
2008

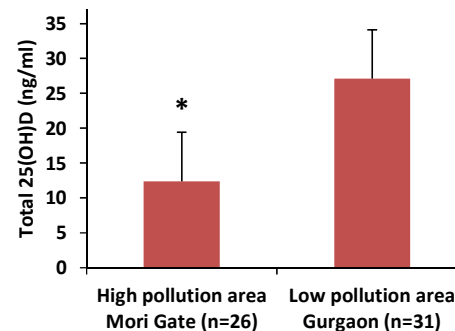
Vitamin D status of healthy women in Iran



Study conducted in
September; age 20 to
55 years ; values are
median (IQ: 25-75)

Hosseiniapanah et al. 2010

Vitamin D status of infants and toddlers in Dehli, India



Study conducted in
March, April; age 9 to 24
months ; values are
mean (1SD)

Agarwal et al. 2002

Air pollution increase the risk of vitamin D deficiency

Antioxidant intervention reduced oxidative stress in subject exposed to PM emissions from coal combustion

Study design: Subject exposed to airborne contamination were supplemented with Vitamins C 500 mg and E 800 mg for 6 months. A panel of biomarkers of oxidative stress was measured before and after supplementation and compared to a control group

Non-enzymatic oxidative stress markers

	Coal em.	AOX suppl.
TBARS	↑	↓
PC: protein carbonyls	↑	↓ Norm
GSH: glutathione	↓	↑ Norm.
PT: protein thiols	↓	↑
α-tocopherol	↓	↑

Enzymatic oxidative stress markers

	Coal em.	AOX suppl.
SOD: superoxide dismutase	↑	↑
CAT: catalase	↑	Norm.
GPx: glutathione peroxidase	↓	Norm.
GR: glutathione reductase	↓	Norm
GST: glutathione S-transferase	↑	Norm.

Antioxidant supplementation improved both enzymatic and non-enzymatic antioxidant defense systems in subjects exposed to PM

Summary

- ❖ **PM2.5 a major component of air pollution is a health threat**

- ❖ **PM 2.5 is a global and long-term problem**

It's solvable, but neither easy nor quick

- ❖ **Nutrition solution:**

 - PM2.5 induced damage are reduced by fish oil and some vitamins**

 - ✓ Omega-3 PUFA improve heart function and attenuated HRV decline induced by PM2.5 exposure.

 - ✓ B vitamins prevented the decline of heart rate variability (HRV) induced by PM2.5 exposure.

 - ✓ vitamin E and C reduce PM2.5 induced oxidative stress

 - ✓ Air pollution has a negative impact on vitamin D status

- ❖ **Various combinations of nutrients may prevent the impact of PM on different aspects of health.**



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Thank you!