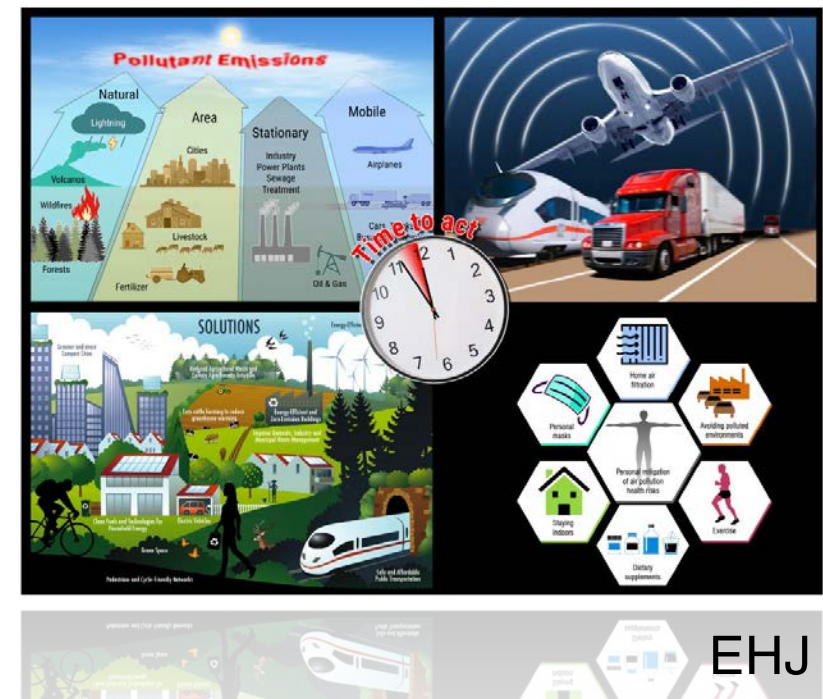
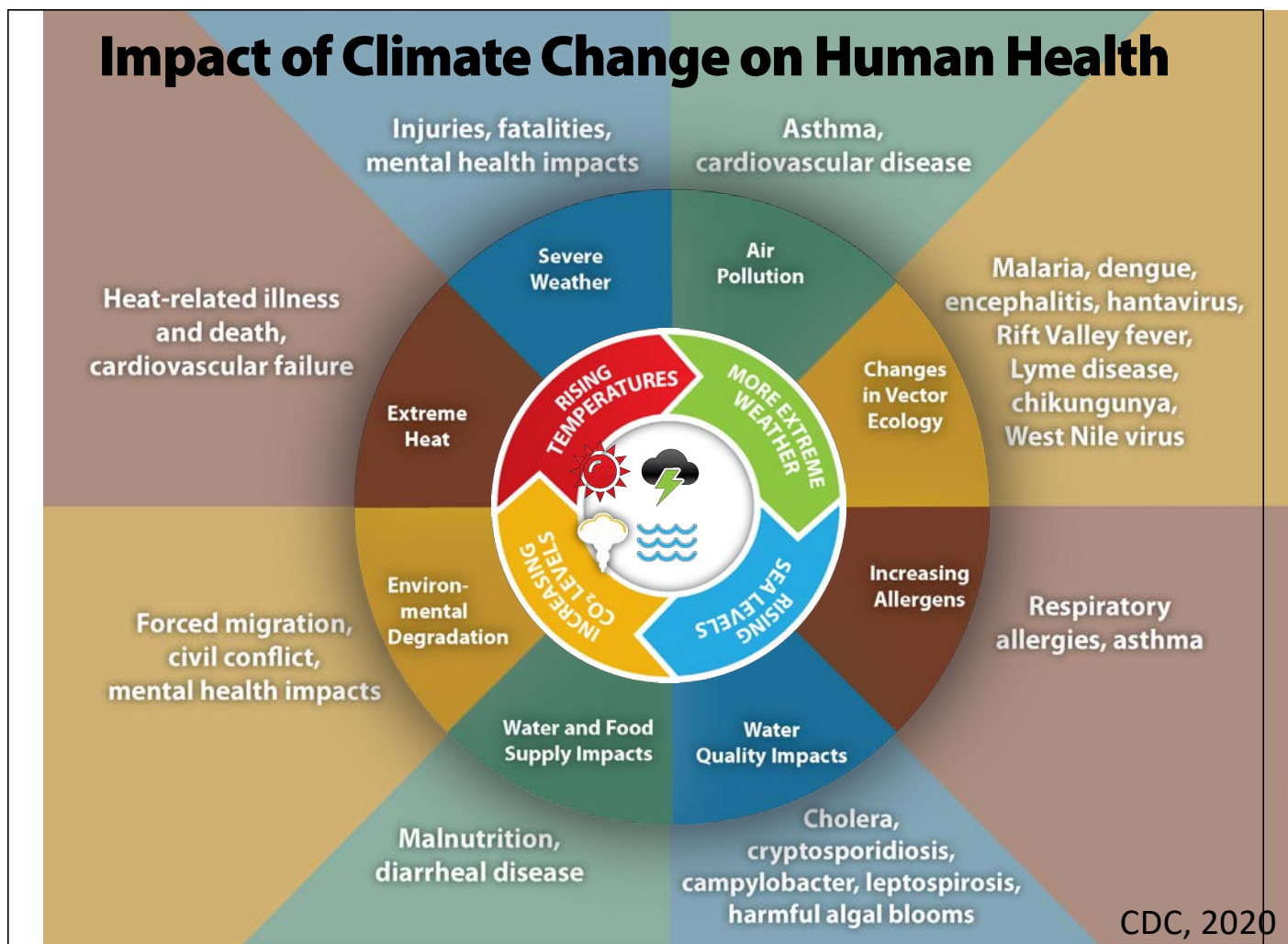


Online zugeschaltet: Lärm - der massiv unterschätzte HerzKreislaufRisikofaktor kommt selten allein

Thomas Münzel, Mainz



Impact of Climate Change on Human Health





**5 Mio
Todesfälle
pro Jahr**

Folgen des Klimawandels

Indien ächzt unter Hitzewelle

Stand: 28.04.2022 15:17 Uhr

Vertrocknete Äcker, Brände und die Stromversorgung kurz vor dem Kollaps: Indien leidet unter einer massiven Hitzewelle - die schlimmste seit dem Jahr 1910. Und die heiße Jahreszeit hat gerade erst begonnen.

En dis

Thoi
Geoi



Air Pollution



Traffic Noise



Light Pollution



Bad Urban City Planning



**Climate Change
High Temperature**

Air and noise pollution have many of the same sources



Science for Environment Policy

IN-DEPTH REPORT 13

Links between noise and air pollution and socioeconomic status

September 2016

- Research suggests that the **social cost of noise and air pollution** in the EU — including death and disease — could be nearly €1 trillion.
- For comparison, the social cost of **alcohol** in the EU has been estimated to be **€50-120** billion and **smoking at €544** billion.

Aircraft



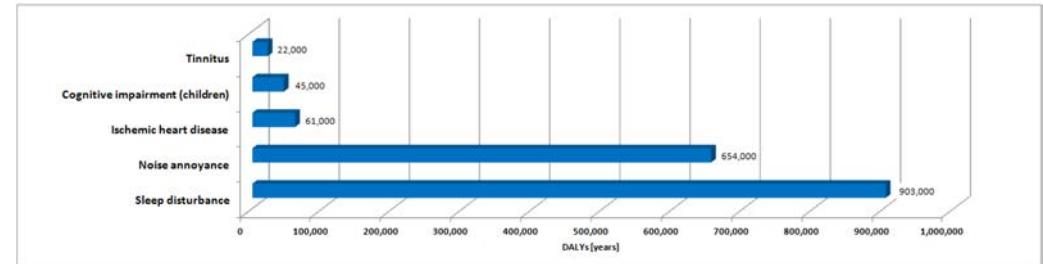
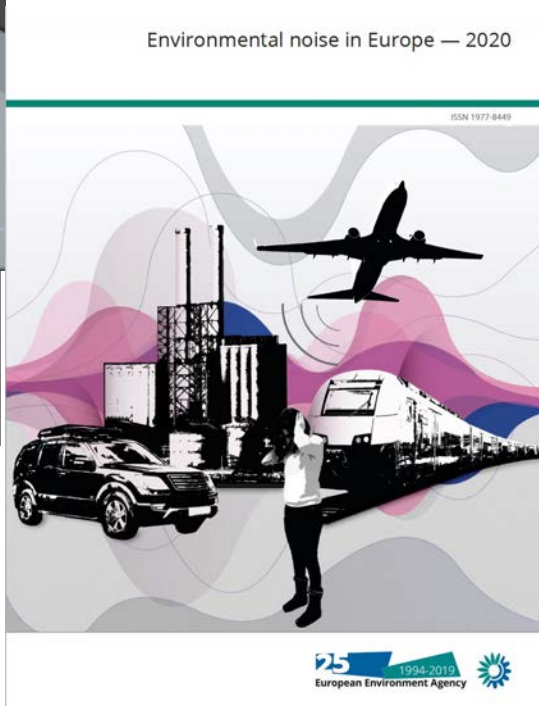
Cars



Railway



WHO/EEA and Noise



- **At least 1.6 Mio healthy life years are lost every year from traffic related noise in the western part of Europe**
- each day nearly **113 million Europeans** in towns and cities **are exposed to noise levels in excess of 55 decibels** just from road traffic.
- **European Environment Agency (EEA):**
- 900,000 cases of hypertension
- 43,000 hospital admissions
- **6.5 Mio people** suffer from **high sleep disturbance**
- **22 Mio people** suffer from **chronic high annoyance**



European Heart Journal
doi:10.1093/eurheartj/

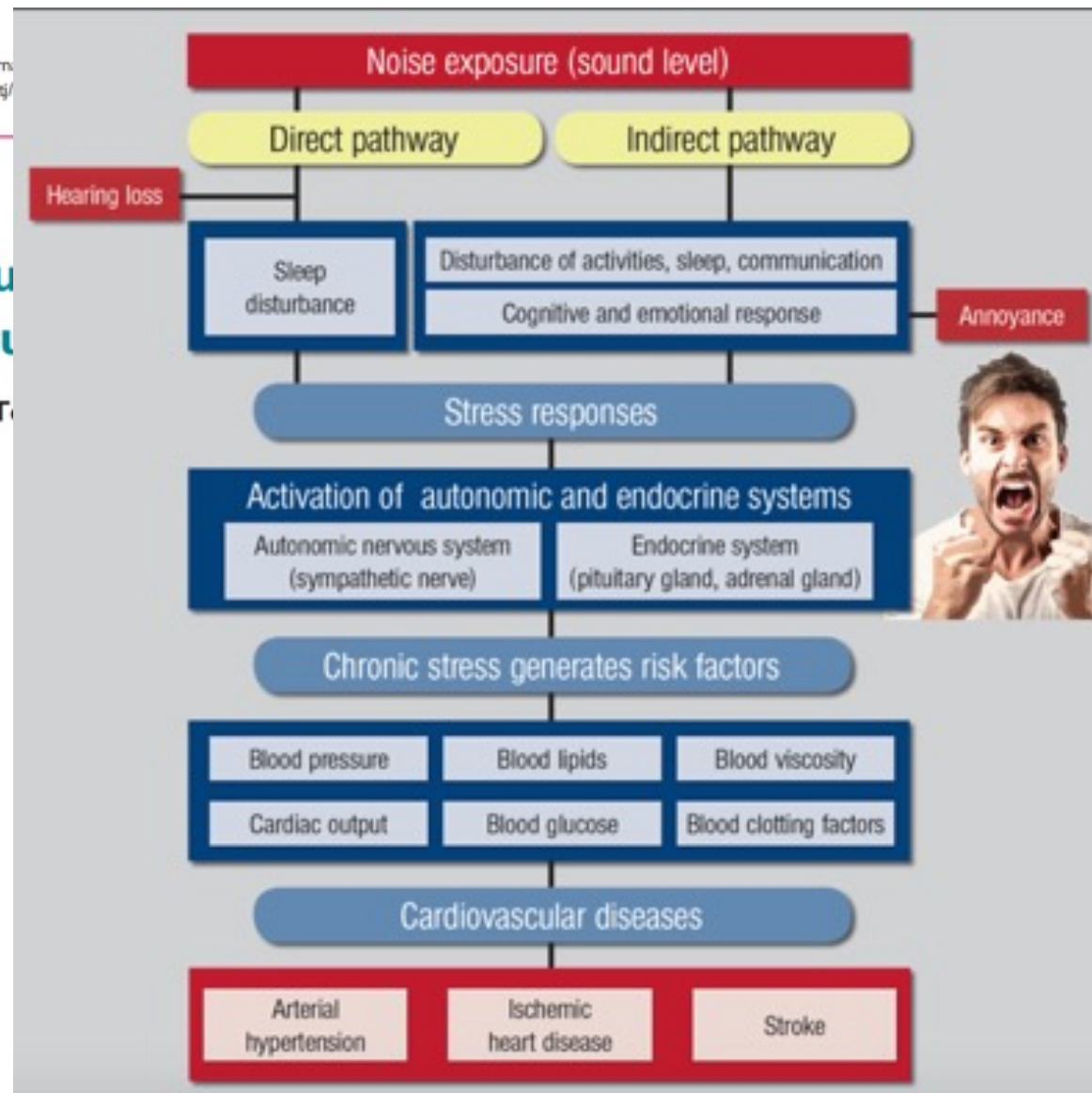
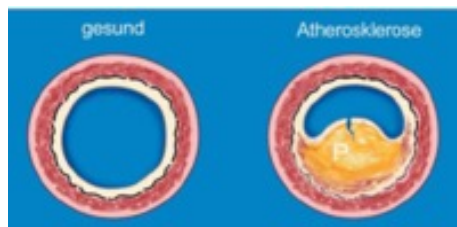
Prevention

Cardiovascular noise exposure

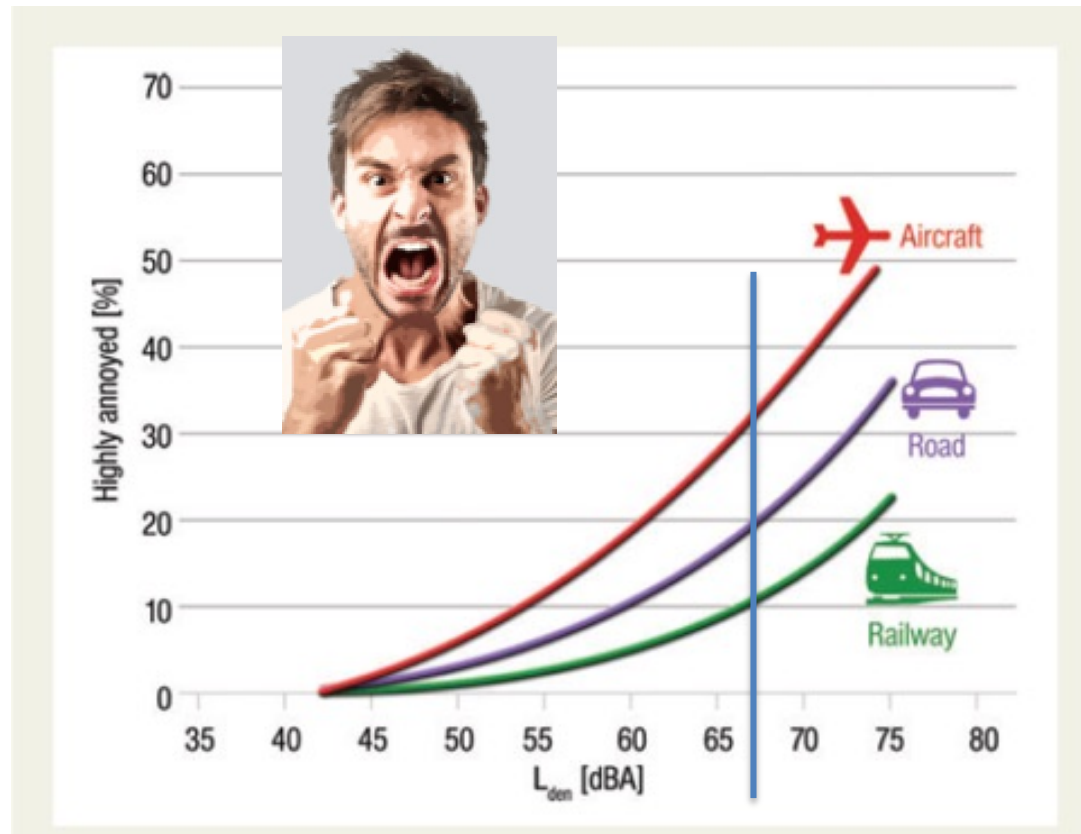
Thomas Münzel^{1*}, T

Noise

?



Aircraft Noise Most Annoying



Münzel, Daiber, Basner, Babisch Eur H J 2014

(Aircraft) Noise and cardiovascular disease

- Hypertension
- Coronary artery disease
- Heart failure
- Stroke



Aircraft Noise and Coronary Artery Disease



European Society
of Cardiology

European Heart Journal (2019) 40, 598–603
doi:10.1093/eurheartj/ehy650

CLINICAL RESEARCH

Prevention and epidemiology

A systematic analysis of mutual effects of transportation noise and air pollution exposure on myocardial infarction mortality: a nationwide cohort study in Switzerland

Harris Héritier^{1,2†}, Danielle Vienneau^{1,2†}, Maria Foraster^{1,2,3}, Ikenna C. Eze^{1,2}, Emmanuel Schaffner^{1,2}, Kees de Hoogh^{1,2}, Laurie Thiesse^{4,5}, Franziska Rudzik^{4,5}, Manuel Habermacher⁶, Micha Köpfli⁶, Reto Pieren⁷, Mark Brink⁸, Christian Cajochen^{4,5}, Jean Marc Wunderli⁷, Nicole Probst-Hensch^{1,2}, and

Conclusion

Our study suggests that transportation noise is associated with MI mortality, independent from air pollution. Air pollution studies not adequately adjusting for transportation noise exposure may overestimate the cardiovascular disease burden of air pollution.

Nighttime noise triggers acute cardiovascular death



European Heart Journal (2020) 00, 1–9
doi:10.1093/eurheartj/ehaa957

CLINICAL RESEARCH
Epidemiology

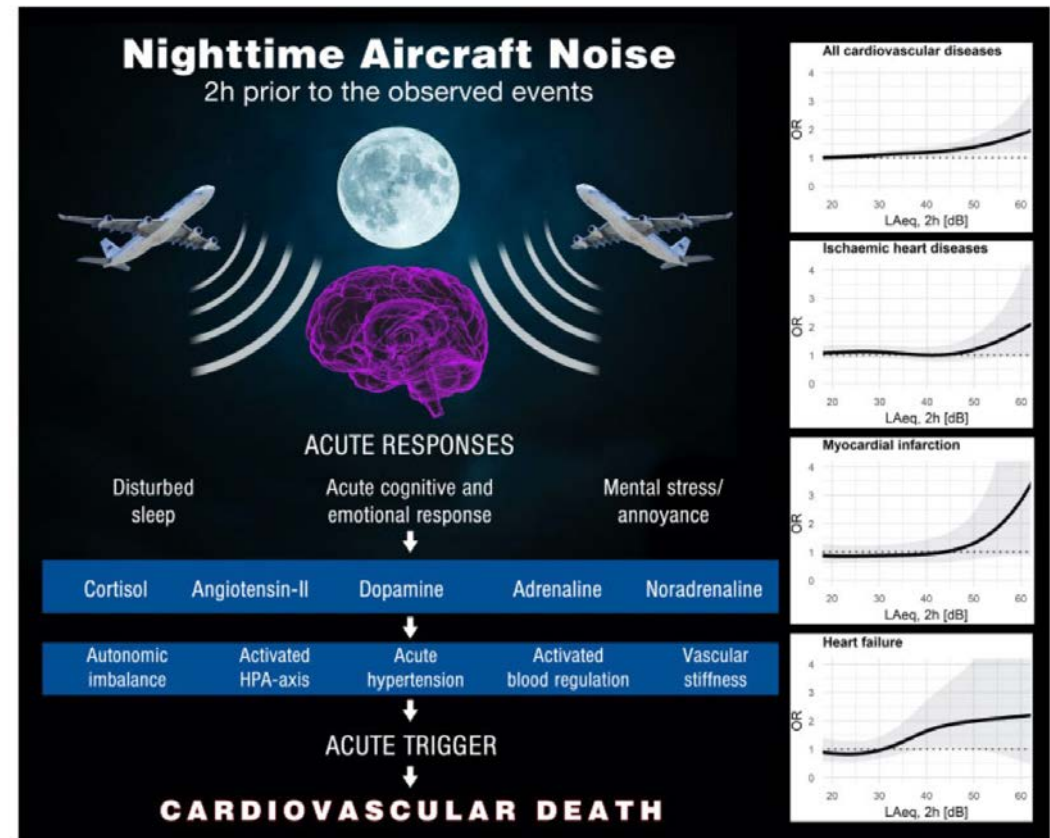
Does night-time aircraft noise trigger mortality? A case-crossover study on 24 886 cardiovascular deaths

Apolline Saucy^{1,2}, Beat Schäffer³, Louise Tangermann^{1,2},
Danielle Vienneau^{1,2}, Jean-Marc Wunderli³, and Martin Röösli^{1,2*}

¹Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Socinstrasse 57, Basel 4002, Switzerland; ²Faculty of Science, University of Basel, Petersplatz 1, Basel 4003, Switzerland; and ³Empa, Swiss Federal Laboratories for Materials Science and Technology, Überlandstrasse 129, Dübendorf 8600, Switzerland

Received 29 July 2020; revised 6 October 2020; editorial decision 4 November 2020; accepted 11 November 2020

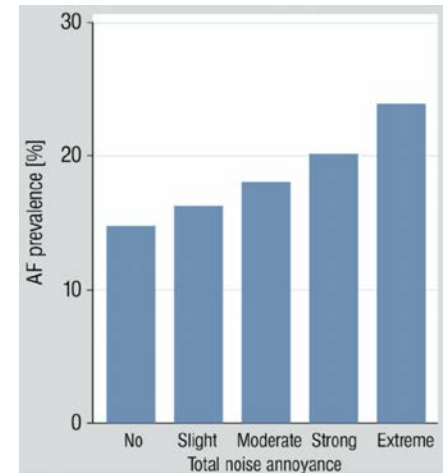
- For night-time deaths, exposure levels 2 h preceding death were significantly associated with mortality for all causes of CVD [OR = 1.44 (1.03–2.04)]
- for the highest exposure group (LAeq > 50 dB vs. <20 dB)]



Annoyance and Arrhythmia and Cerebral Disease



Gutenberg Health Study
Prospective Cohort Trial Mainz
15.000 Participants



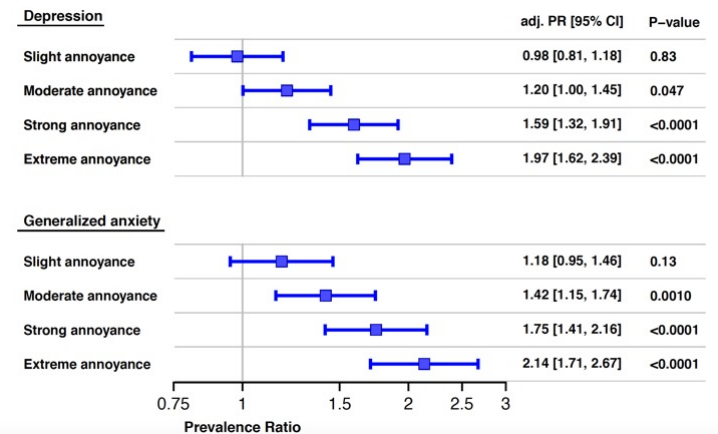
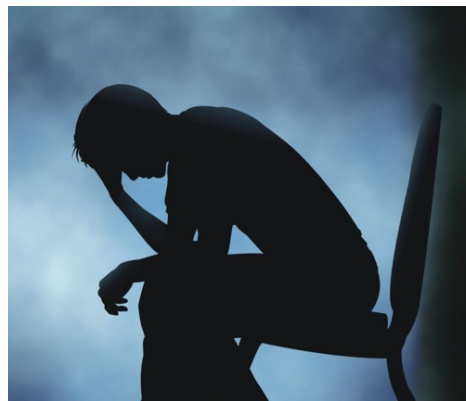
Annoyance to different noise sources is associated with atrial fibrillation in the Gutenberg Health Study

Omar Hahad^a, Manfred Beutel^b, Tommaso Gori^a, Andreas Schulz^c, Maria Blettner^d, Norbert Pfeiffer^e, Thomas Rostock^b, Karl Lackner^f, Mette Sørensen^g, Jürgen H. Prochaska^h, Philipp S. Wild^a, Thomas Münzel^{a,*}

RESEARCH ARTICLE

Noise Annoyance Is Associated with Depression and Anxiety in the General Population- The Contribution of Aircraft Noise

Manfred E. Beutel^{1,*}, Claus Jünger², Eva M. Klein¹, Philipp Wild^{3,4,5}, Karl Lackner⁶, Maria Blettner⁷, Harald Binder⁷, Matthias Michal¹, Jörg Wiltink¹, Elmar Brähler¹, Thomas Münzel²



RESEARCH

 OPEN ACCESS

 Check for updates

Residential exposure to transportation noise in Denmark and incidence of dementia: national cohort study

Manuella Lech Cantuaria,^{1,2} Frans Boch Waldorff,^{3,4} Lene Wermuth,^{5,6} Ellen Raben Pedersen,¹ Aslak Harbo Poulsen,² Jesse Daniel Thacher,² Ole Raaschou-Nielsen,^{2,7} Matthias Ketzel,^{7,8} Jibran Khan,^{7,9} Victor H Valencia,⁷ Jesper Hvass Schmidt,^{10,11,12,13} Mette Sørensen^{2,14}

CONCLUSIONS

This nationwide cohort study found transportation noise to be associated with a higher risk of all cause dementia and dementia subtypes, especially Alzheimer's disease.



European Society
of Cardiology









European Heart Journal (2019) 0, 1–11

doi:10.1093/eurheartj/ehz820

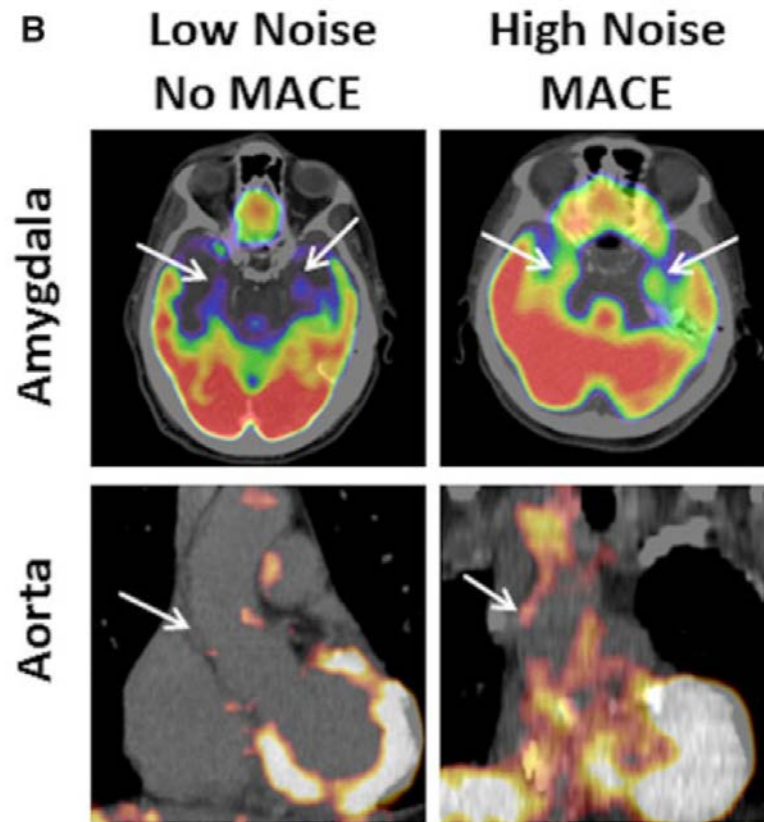
CLINICAL RESEARCH

Imaging

A neurobiological mechanism linking transportation noise to cardiovascular disease in humans

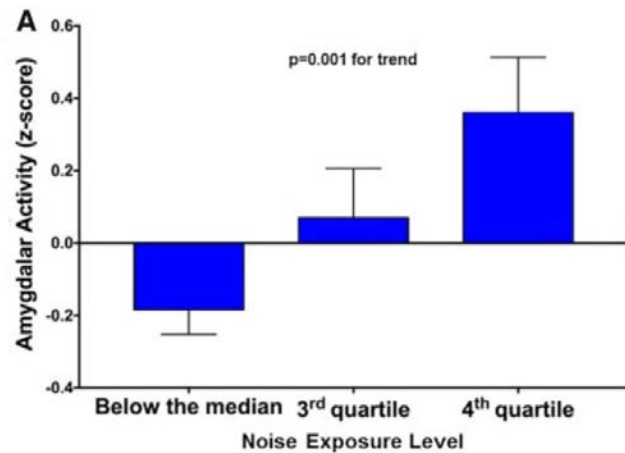
Michael T. Osborne ^{1,2†}, **Azar Radfar** ^{1,2†}, **Malek Z.O. Hassan** ¹,
Shady Abohashem ^{1,2}, **Blake Oberfeld** ¹, **Tomas Patrich** ¹, **Brian Tung**¹,
Ying Wang ^{1,3}, **Amorina Ishai**¹, **James A. Scott** ⁴, **Lisa M. Shin**^{5,6},
Zahi A. Fayad ⁷, **Karestan C. Koenen** ⁸, **Sanjay Rajagopalan** ⁹,
Roger K. Pitman ⁶, and **Ahmed Tawakol**^{1,2*}

Amygdalar activity correlates with noise levels and vascular inflammation

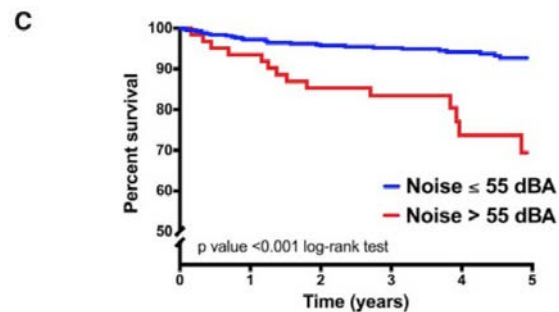


- **amygdala modulates the fear, anxiety response in humans**
- 500 subjects
- No CVD or cancer
- 18 Fluorodeoxyglucose PET/CT
- Increased noise exposure was associated with higher amygdalar activity and, vascular inflammation and MACE

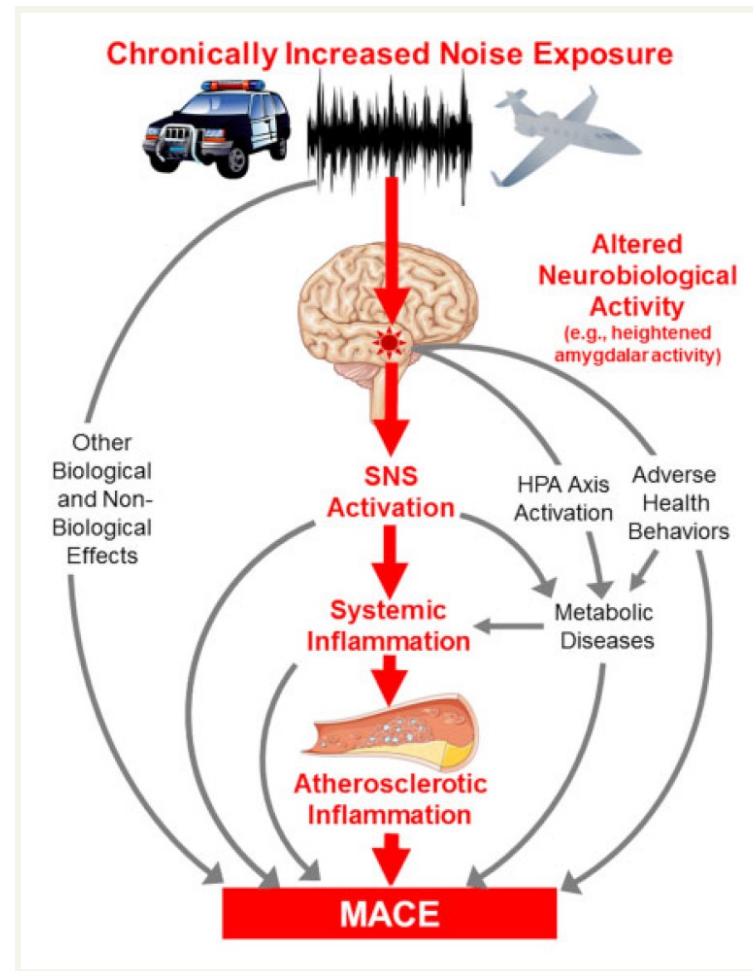
Mechanismen:



CV Tod, Herzinfarkt, Herzinsuffizienz



Number at risk	63	57	49	41	21	11
Noise > 55 dBA	435	412	385	329	234	120
Noise ≤ 55 dBA						



Mechanisms of noise-induced vascular damage?



European Heart Journal (2013) 34, 3508–3514
doi:10.1093/eurheartj/ehz269

CLINICAL RESEARCH

Effect of nighttime aircraft noise exposure on endothelial function and stress hormone release in healthy adults

Frank P. Schmidt¹, Mathias Basner², Gunnar Kröger¹, Stefanie Weck¹, Boris Schnorbus¹, Axel Muttray³, Murat Sariyar⁴, Harald Binder⁴, Tommaso Gori¹, Ascan Warnholtz¹, and Thomas Münzel^{1*}

Clin Res Cardiol
DOI 10.1007/s00392-014-0751-x

ORIGINAL PAPER

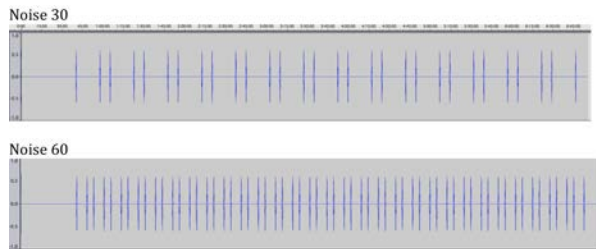
Nighttime aircraft noise impairs endothelial function and increases blood pressure in patients with or at high risk for coronary artery disease

Frank Schmidt · Kristoffer Kolle · Katharina Kreuder ·
Boris Schnorbus · Philip Wild · Marlene Hechtner ·
Harald Binder · Tommaso Gori · Thomas Münzel



Methods:

Simulated nighttime aircraft noise



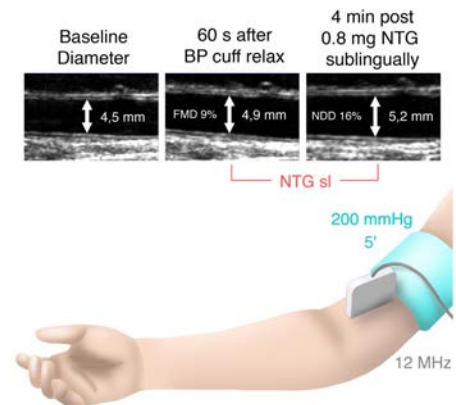
MP3 Player



Polygraphic screening devices (SOMNOWATCH PLUS)



Measurement of endothelial function (flow mediated dilation)



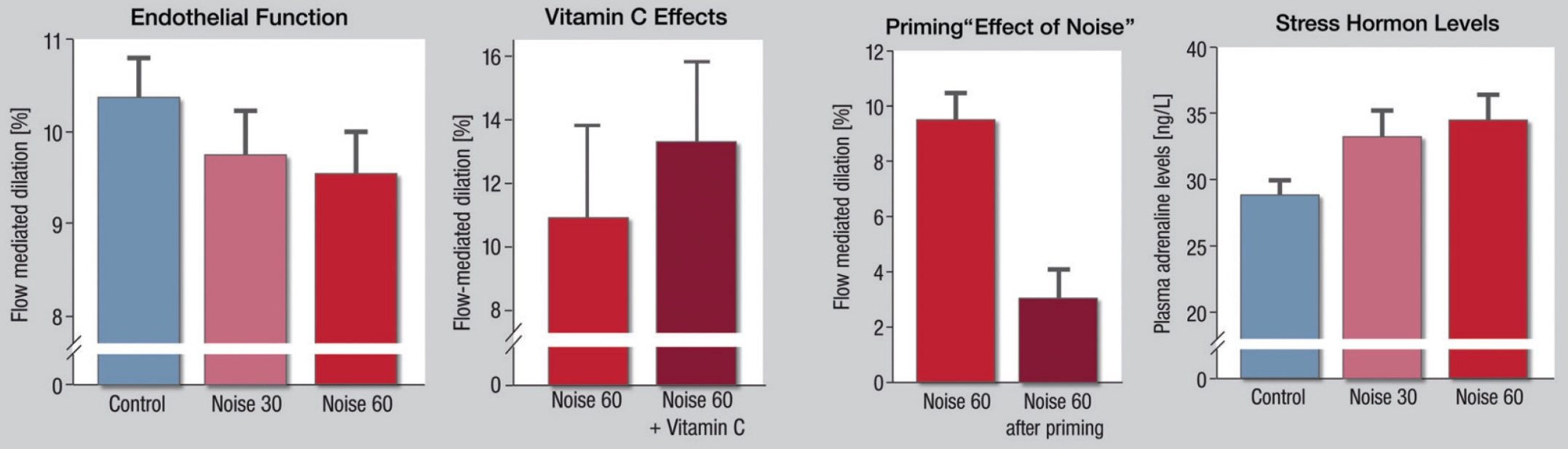
- Field study
- 60 dBA
- 30 or 60 Flights per night
- Mean sound pressure levels: 43 and 46 dBA

Effect of nighttime aircraft noise exposure on endothelial function and stress hormone release in healthy adults

Frank P. Schmidt¹, Mathias Basner², Gunnar Kröger¹, Stefanie Weck¹, Boris Schnorbus¹, Axel Muttray³, Murat Sariyar⁴, Harald Binder⁴, Tommaso Gori¹, Ascan Warnholtz¹, and Thomas Münzel^{1*}

Results:

Healthy subjects



Randomization plan (C-30-60, C-60-30, 30-C-60, 30-60-C, 60-C-30, 60-30-C).

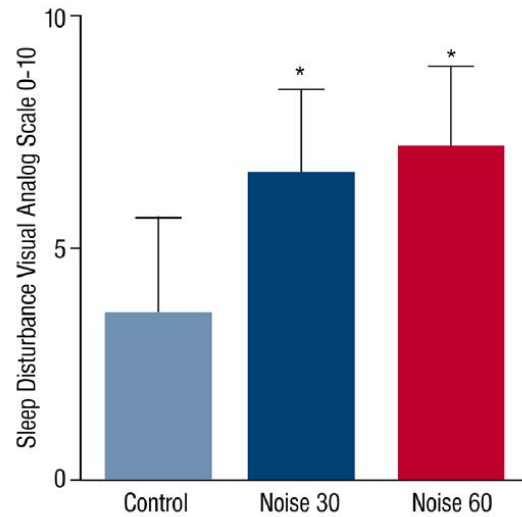


Acute exposure to nocturnal train noise induces endothelial dysfunction and pro-thromboinflammatory changes of the plasma proteome in healthy subjects

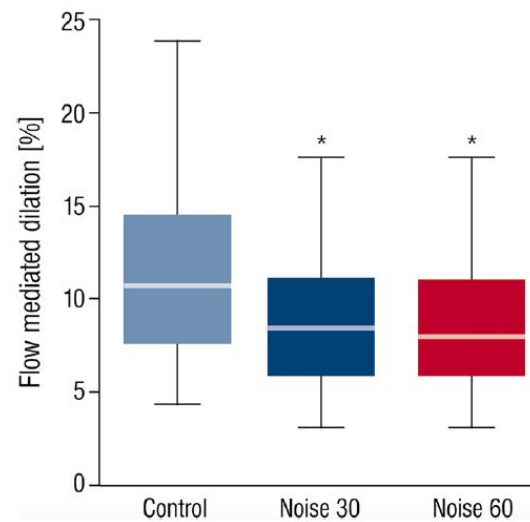
Johannes Herzog¹ · Frank P. Schmidt^{1,8} · Omar Hahad¹ · Seyed Hamidreza Mahmoudpour^{2,3} · Alina K. Mangold¹ · Pascal Garcia Andreo¹ · Jürgen Prochaska^{3,4,5} · Thomas Koeck^{4,5} · Philipp S. Wild^{3,4,5} · Mette Sørensen^{6,7} · Andreas Daiber^{1,5} · Thomas Münzel^{1,3,5}



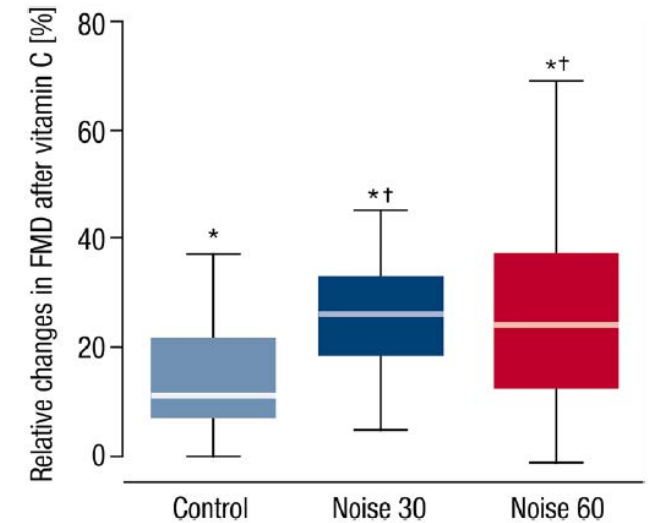
Sleep disturbance

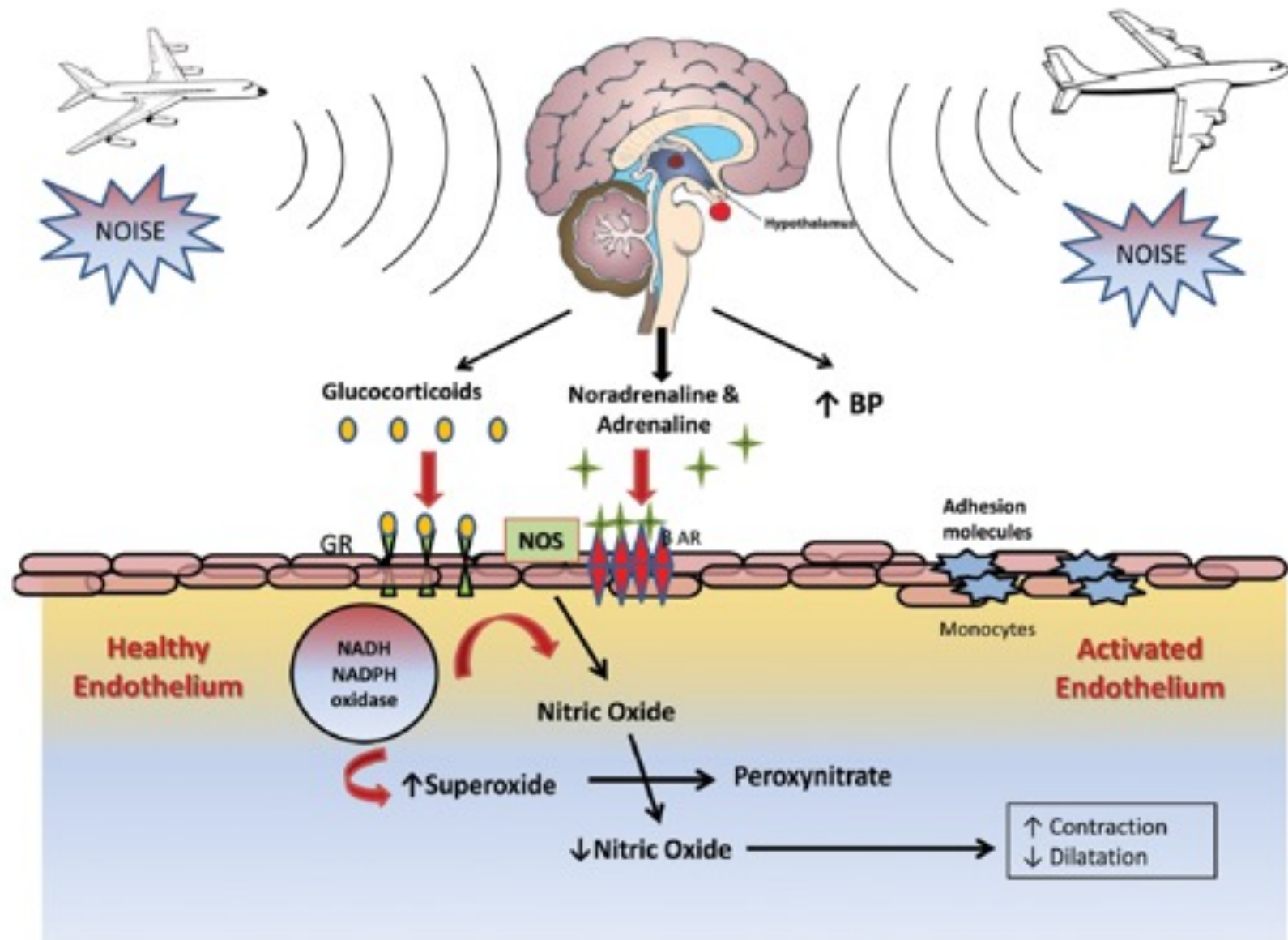


Endothelial Dysfunction



Vitamin C Effects





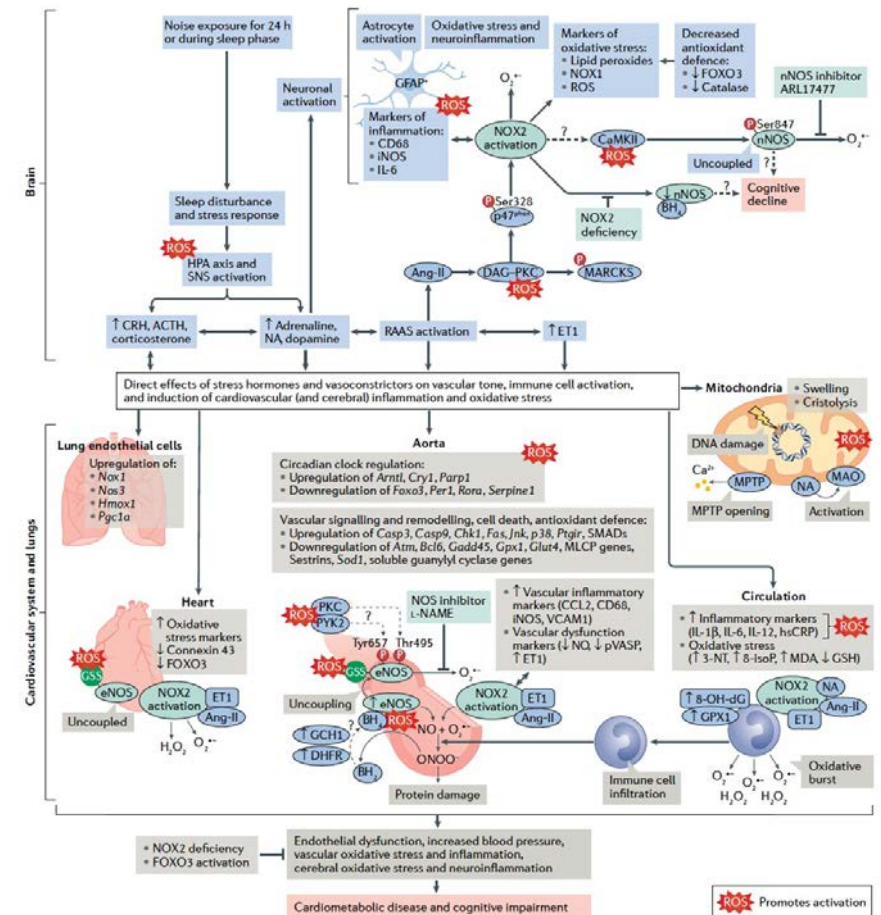
REVIEWS

Check for updates

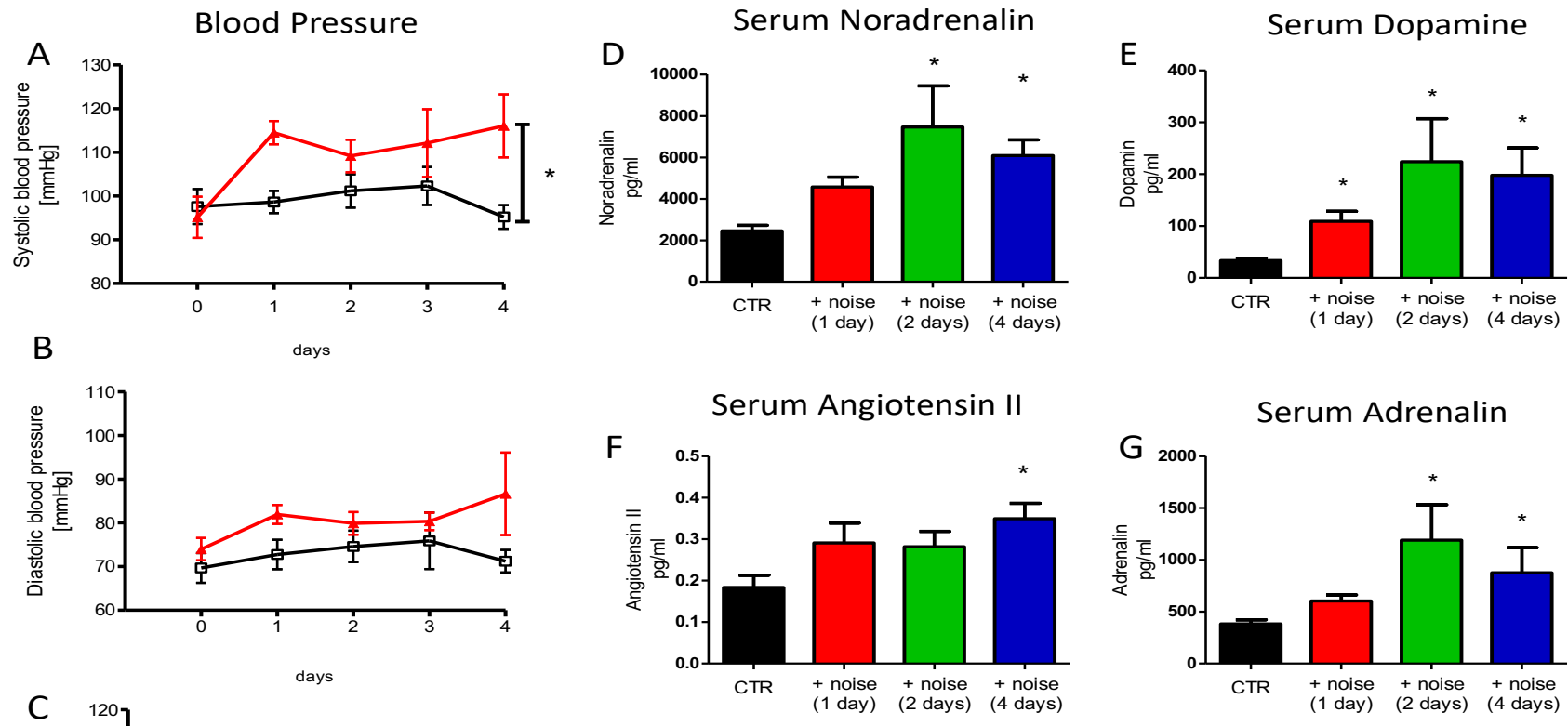
Transportation noise pollution and cardiovascular disease

Thomas Münzel^{1,2}, Mette Sørensen^{3,4} and Andreas Daiber^{1,2}

- Aircraft : Peak Decibel Level, 85 dBA, mean SPL 72dBA
- Noise for 1,2 and 4d
- For comparison: Identical mean sound pressure levels of white noise

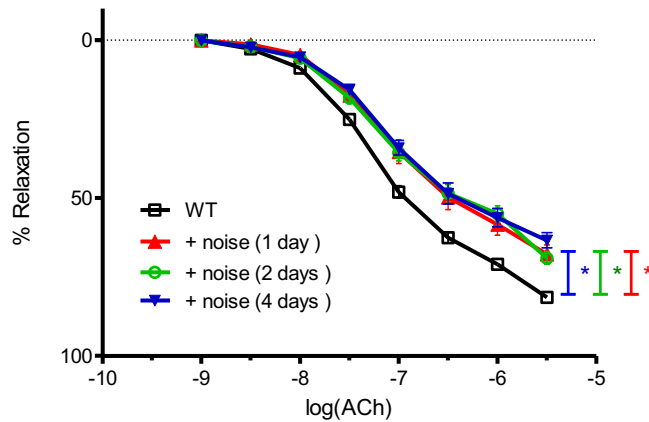


Effects of noise on vascular function, oxidative stress, and inflammation: mechanistic insight from studies in mice

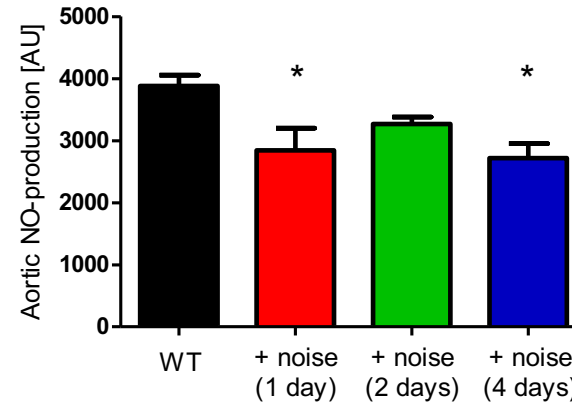


Vascular function, NO production:

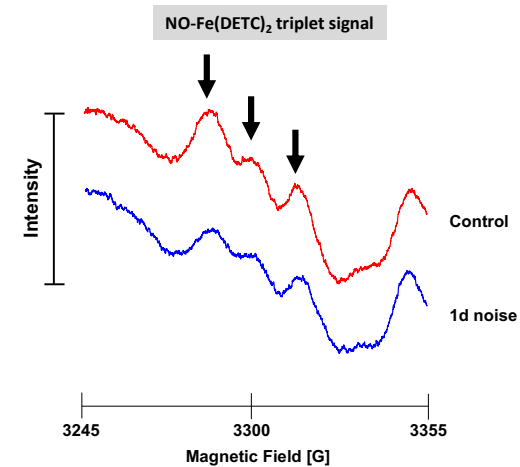
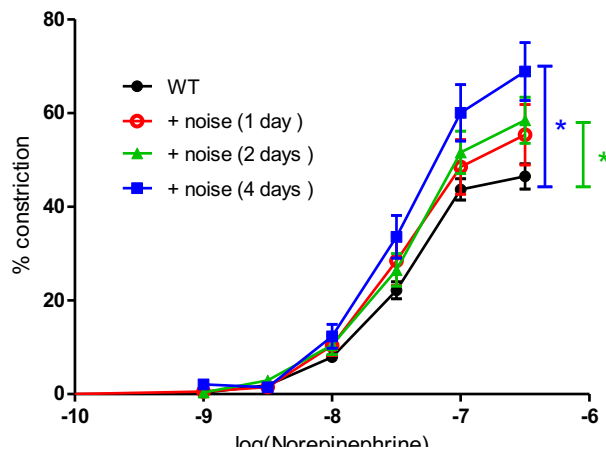
ACh relaxation



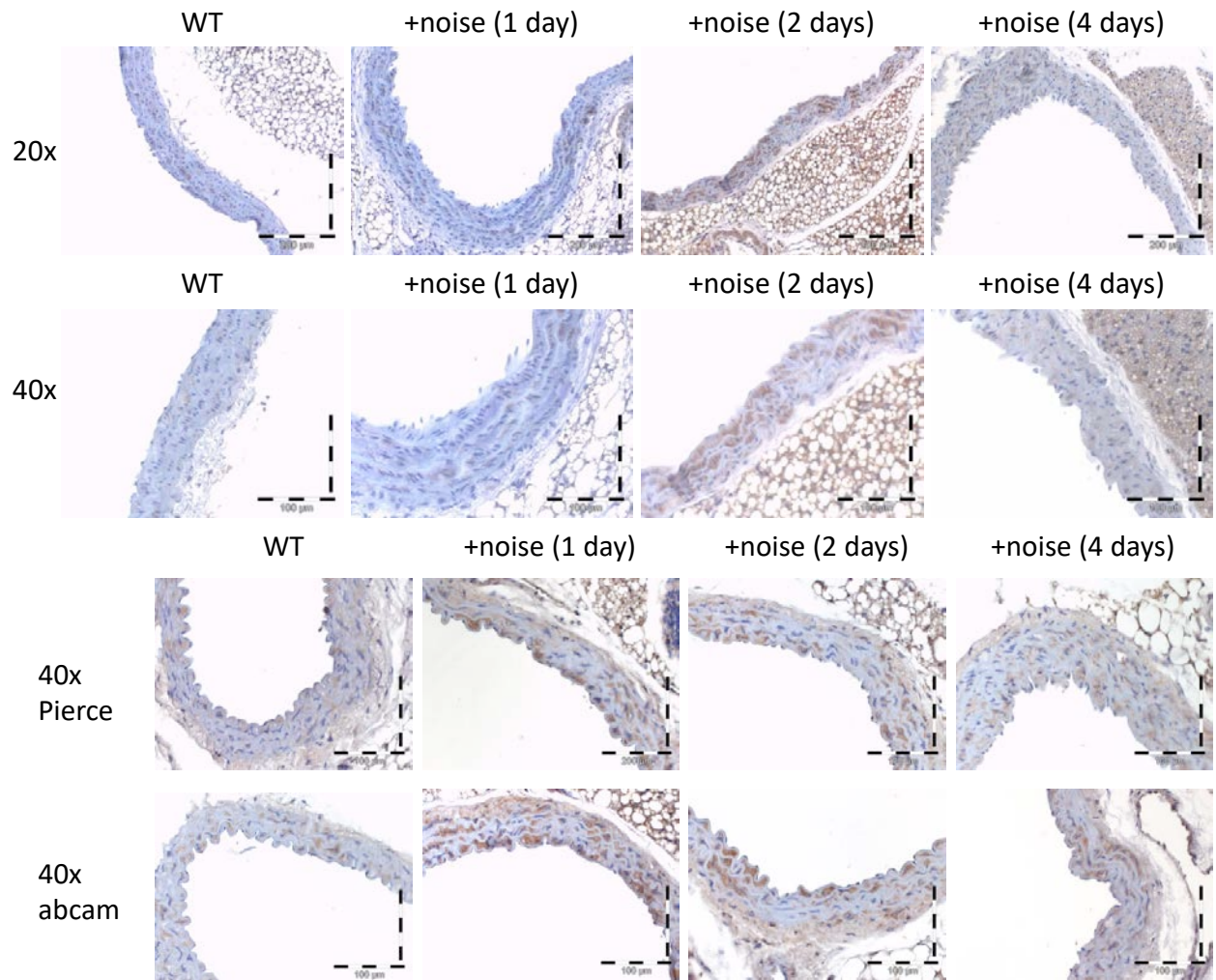
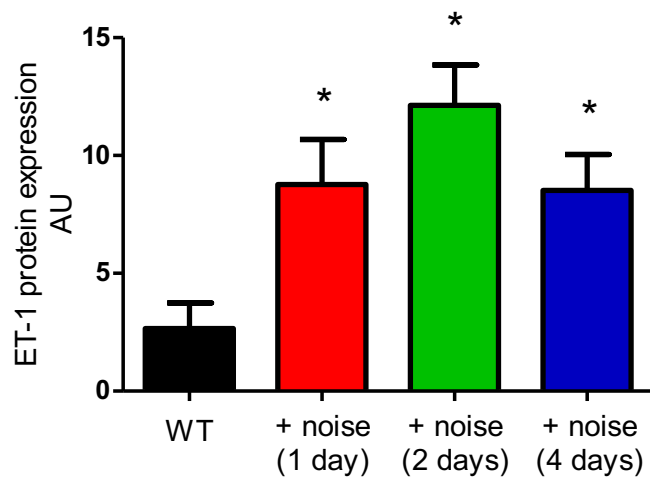
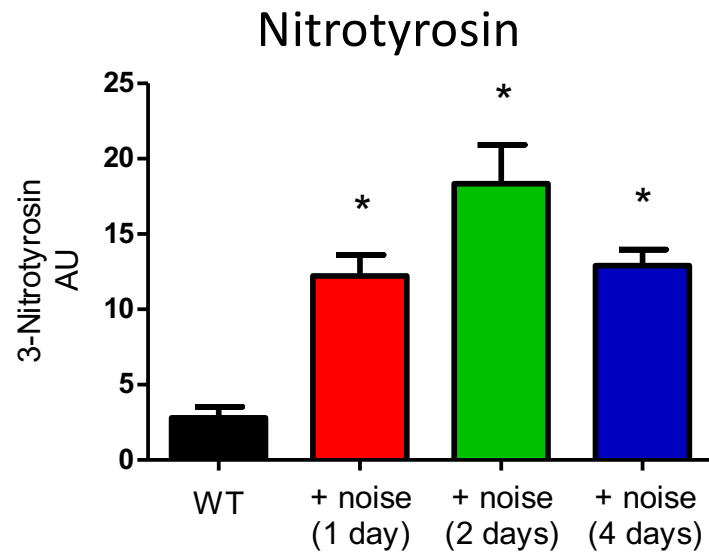
Aortic NO production

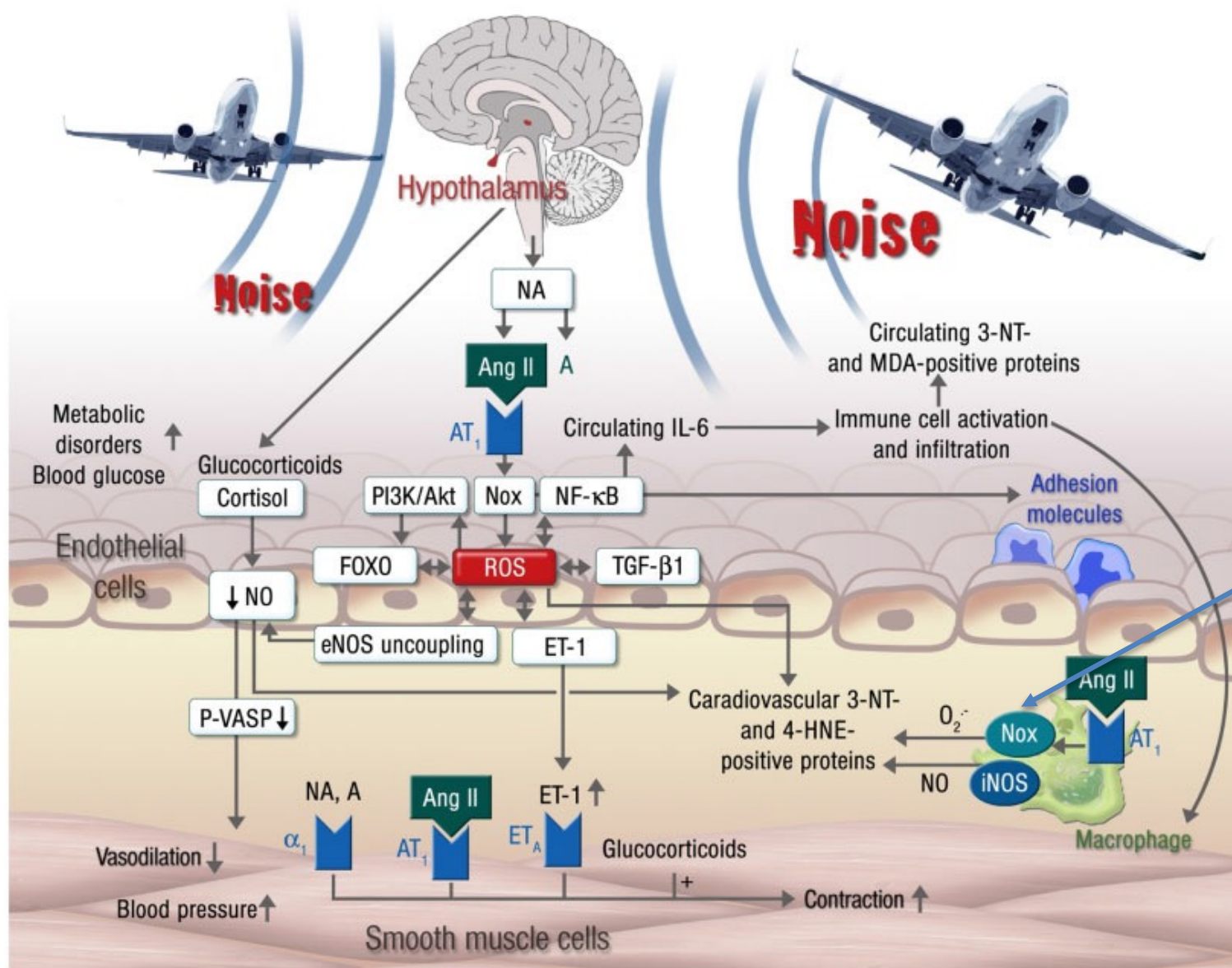


Norepinephrine Constriction



Oxidative Stress ↑ and Endothelin-1 ↑





NOX-2

Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies

**Francesco P. Cappuccio^{1*†}, Daniel Cooper¹, Lanfranco D'Elia², Pasquale Strazzullo²,
and Michelle A. Miller^{1†}**

¹Warwick Medical School, University of Warwick, CSB Building, UHCW Campus, Clifford Bridge Road, Coventry CV2 2DX, UK; and ²Department of Clinical and Experimental Medicine, Federico II Medical School, University of Naples, Naples, Italy

Received 7 August 2010; revised 13 December 2010; accepted 13 January 2011; online publish-ahead-of-print 7 February 2011

Day - versus nighttime noise



European Heart Journal (2018) 00, 1–14
doi:10.1093/eurheartj/ehy333

BASIC SCIENCE

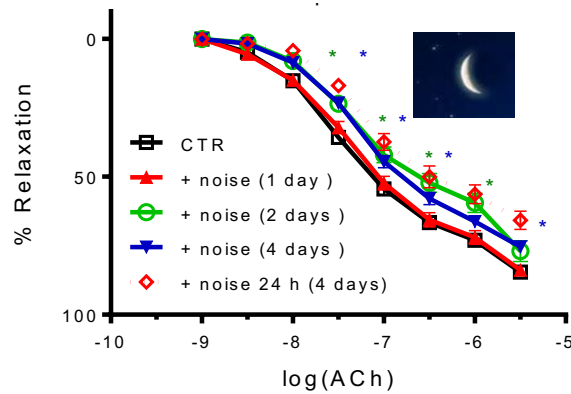
Crucial role for Nox2 and sleep deprivation in aircraft noise-induced vascular and cerebral oxidative stress, inflammation, and gene regulation

Swenja Kröller-Schön^{1†}, Andreas Daiber^{1,2†}, Sebastian Steven¹, Matthias Oelze¹,

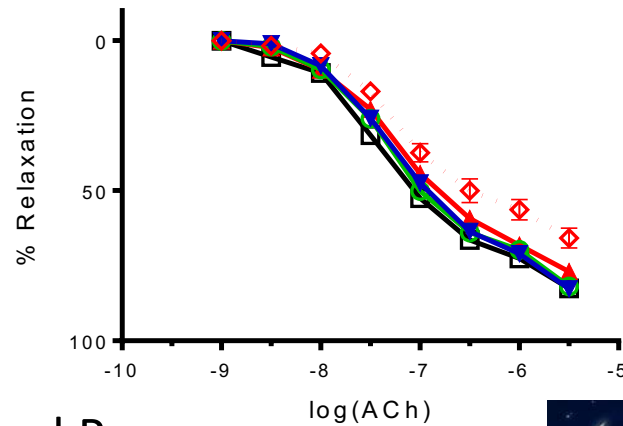
- Nighttime aircraft noise more damaging than daytime noise?
- Adverse cerebral effects?
- NOX2 knockout protective?

Sleep versus Awake Phase Noise

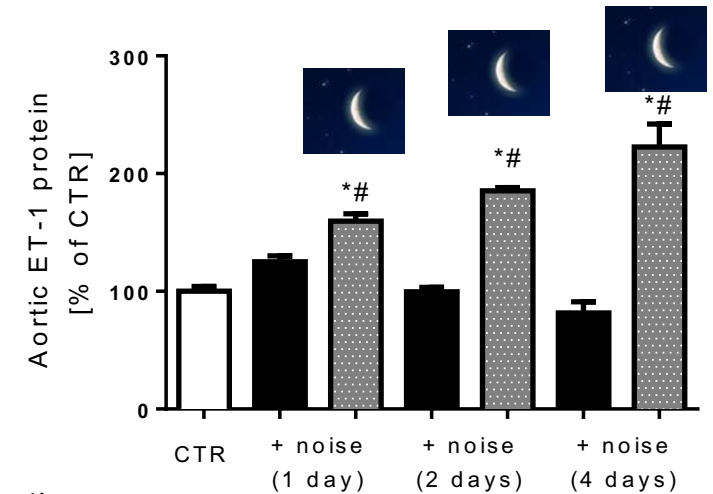
Sleep Phase



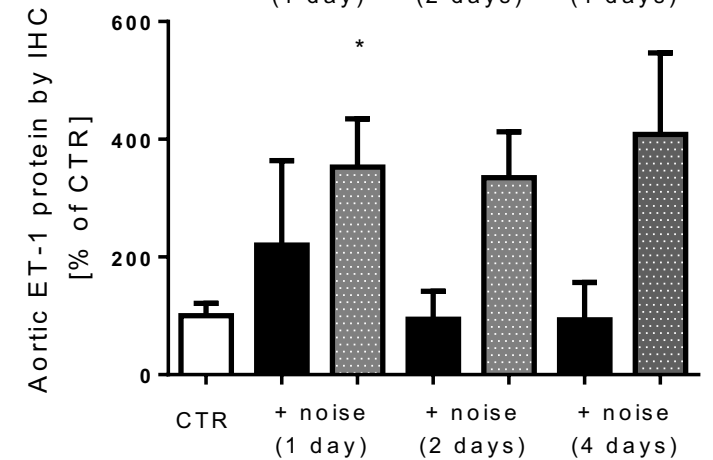
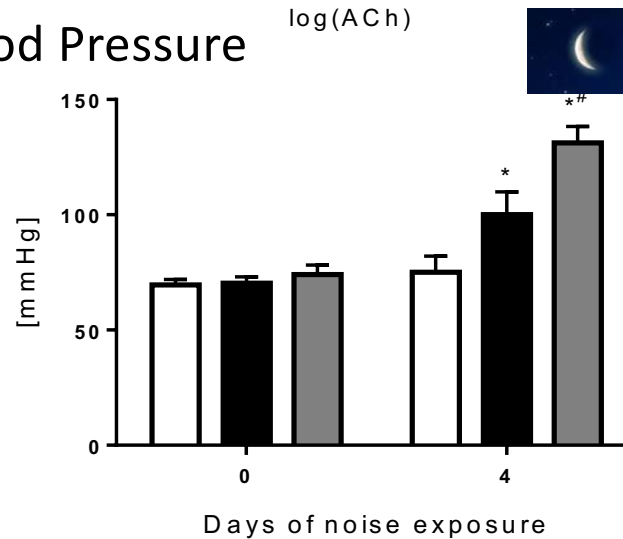
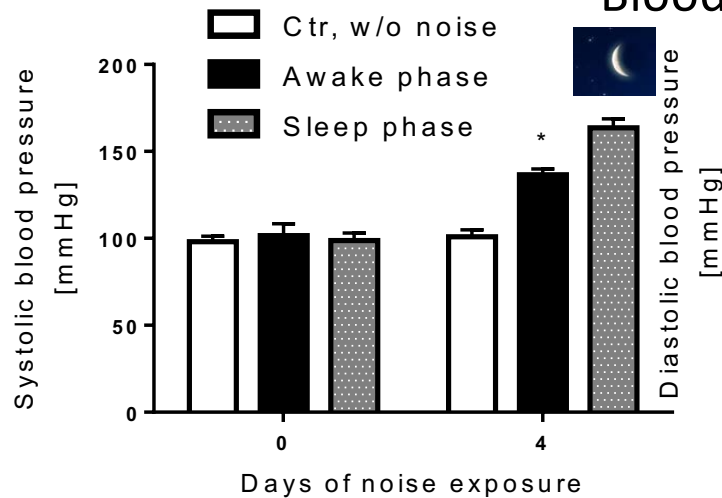
Awake Phase



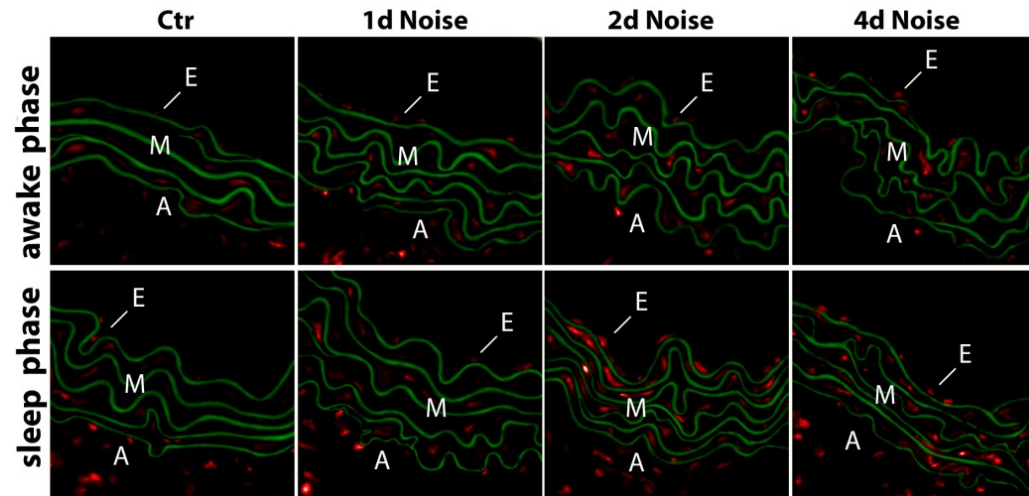
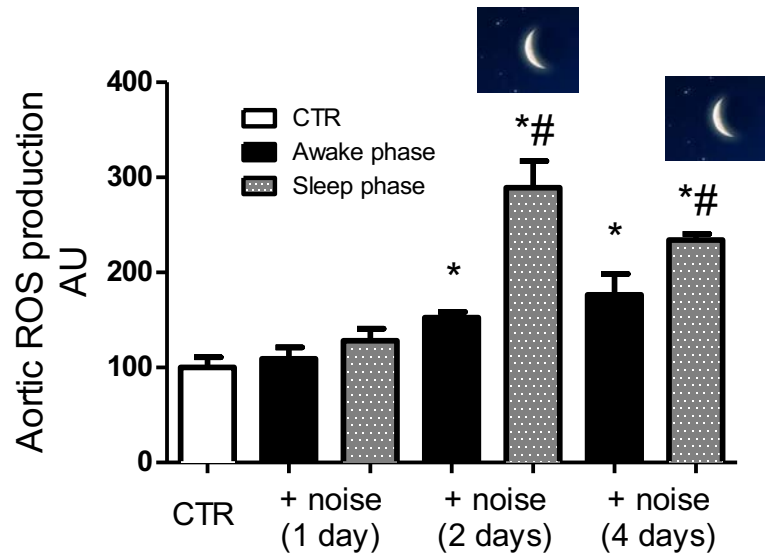
Endothelin Expression



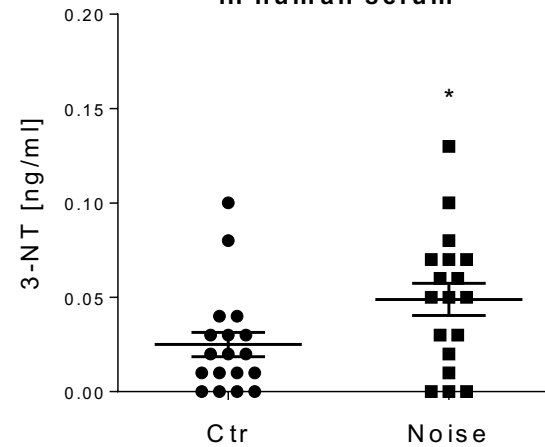
Blood Pressure



Nighttime noise makes oxidative stress in mouse aorta and human plasma

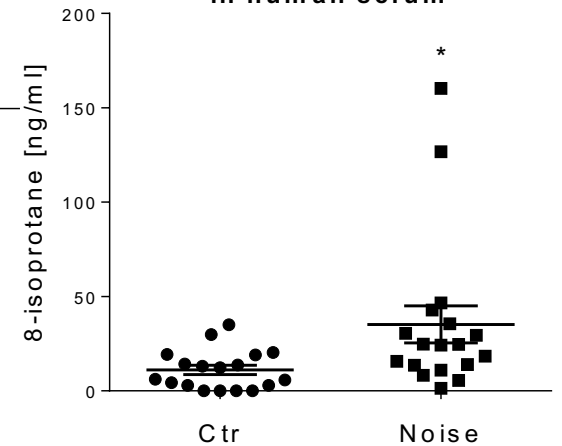


3-NT levels in human serum

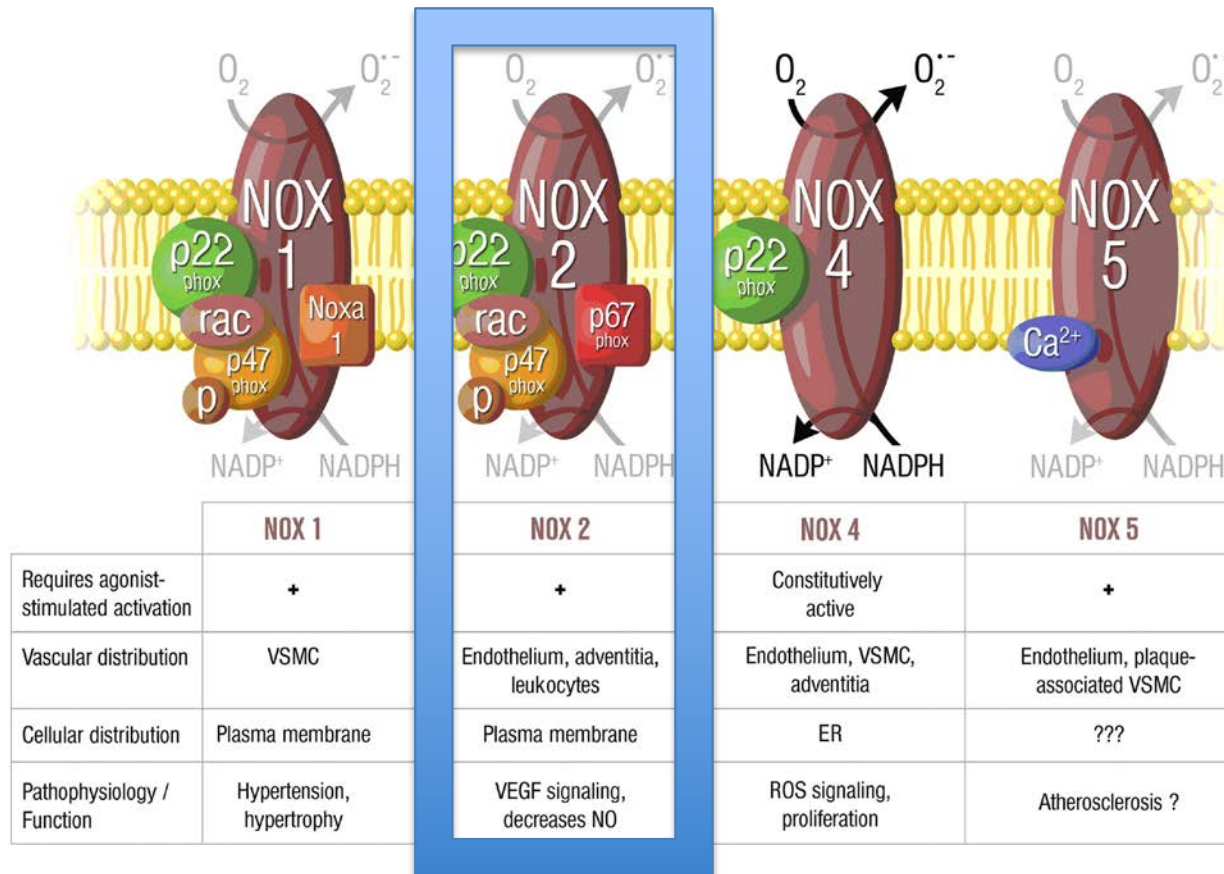


Human Plasma

8-isoprostane levels in human serum



NOX2 knockout protects

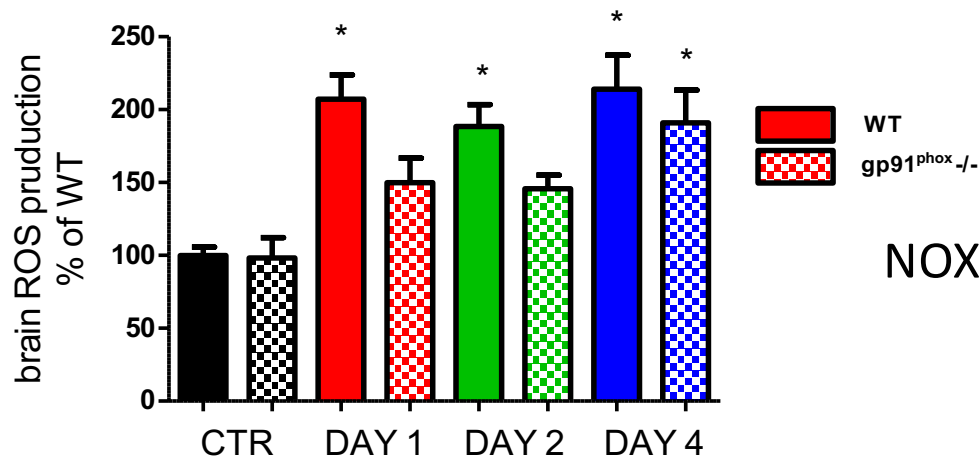


Münzel, Warnholtz JACC 2003

Adverse effects on brain ameliorated by NOX-2 knockout



Aircraft noise increases cerebral oxidative stress



Aircraft Noise downregulates of neuronal Nitric Oxide Synthase

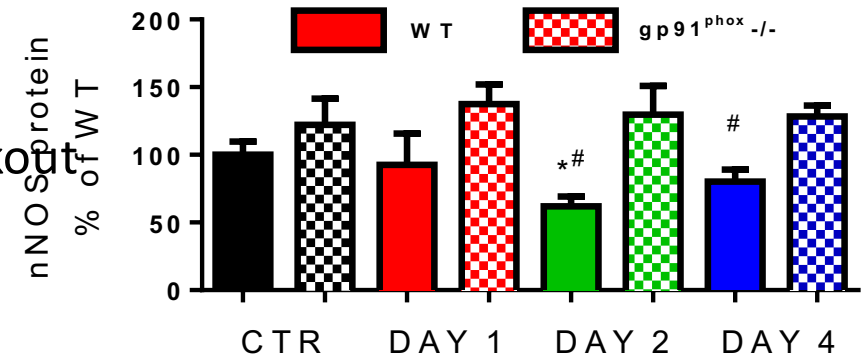
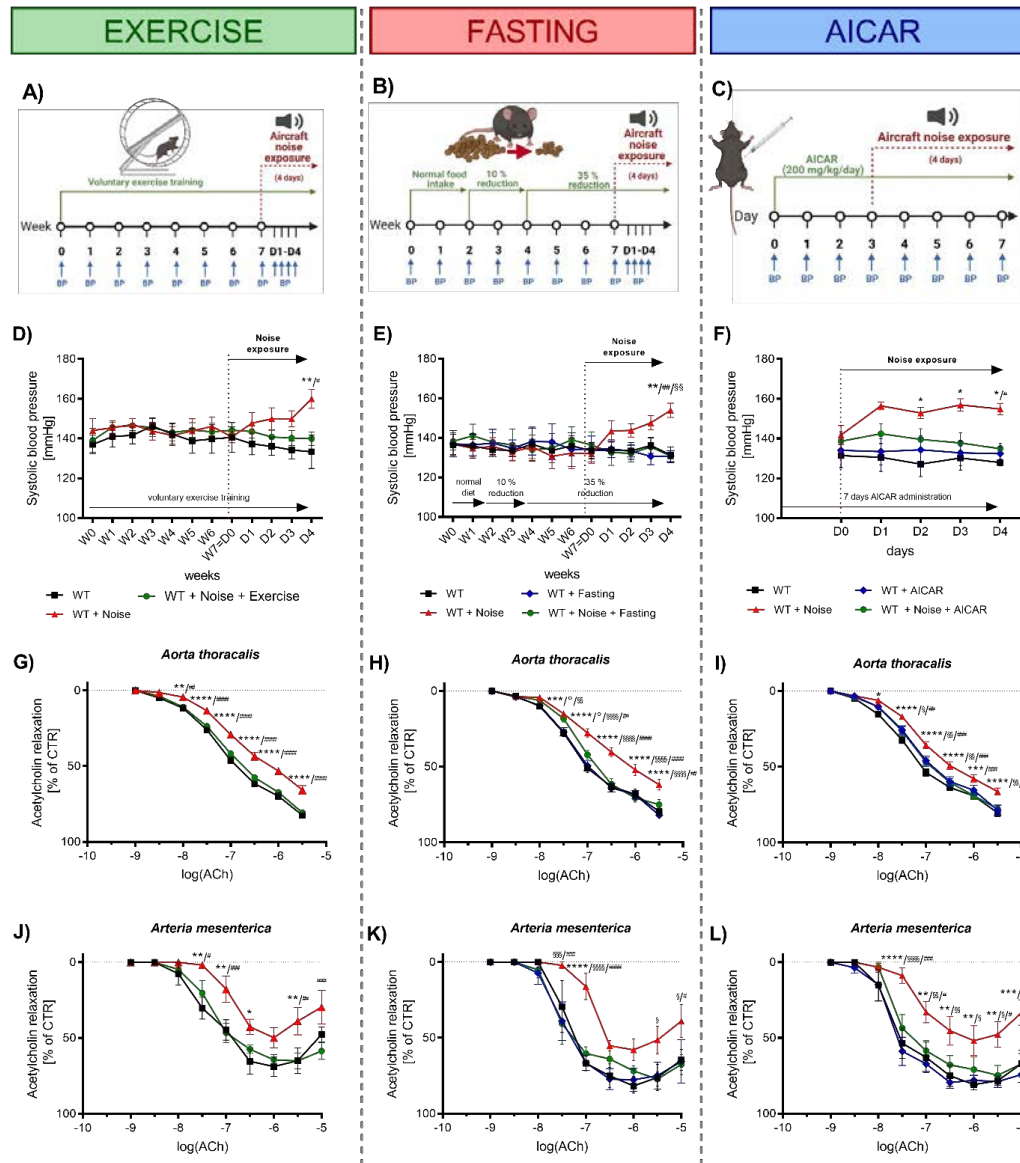


Figure 1



AMP Kinase
Activation reverses
Noise-induced
Endothelial dysfunction

Aircraft and road traffic noise and children's cognition and health: a cross-national study

*S A Stansfeld, B Berglund, C Clark, I Lopez-Barrio, P Fischer, E Öhrström, M M Haines, J Head, S Hygge, I van Kamp, B F Berry, on behalf of the RANCH study team**

Reading Capacity

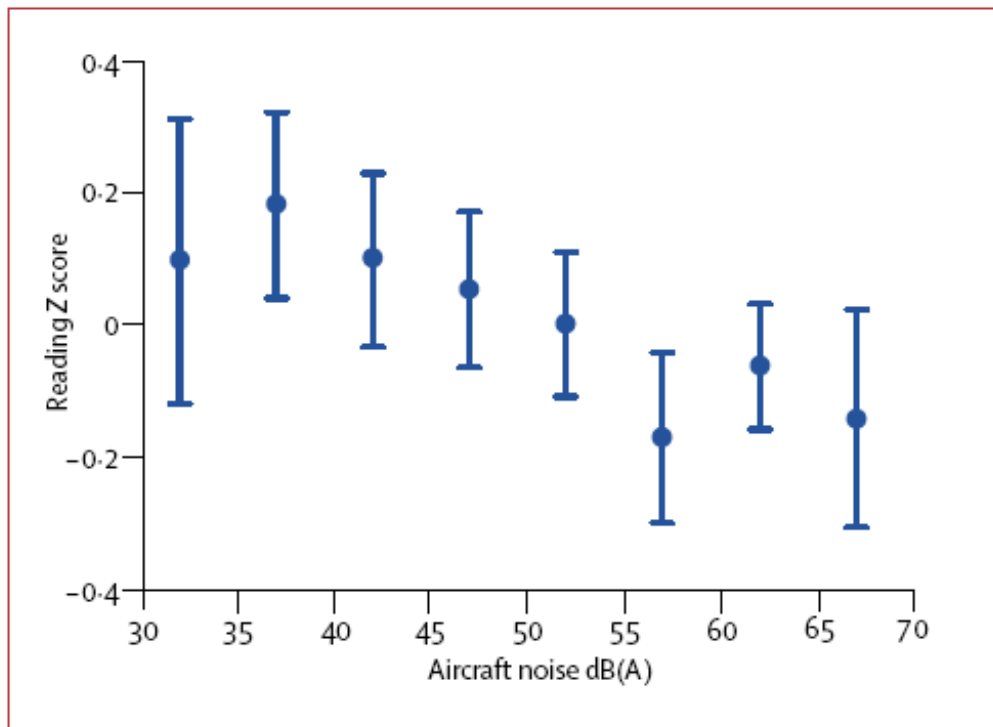
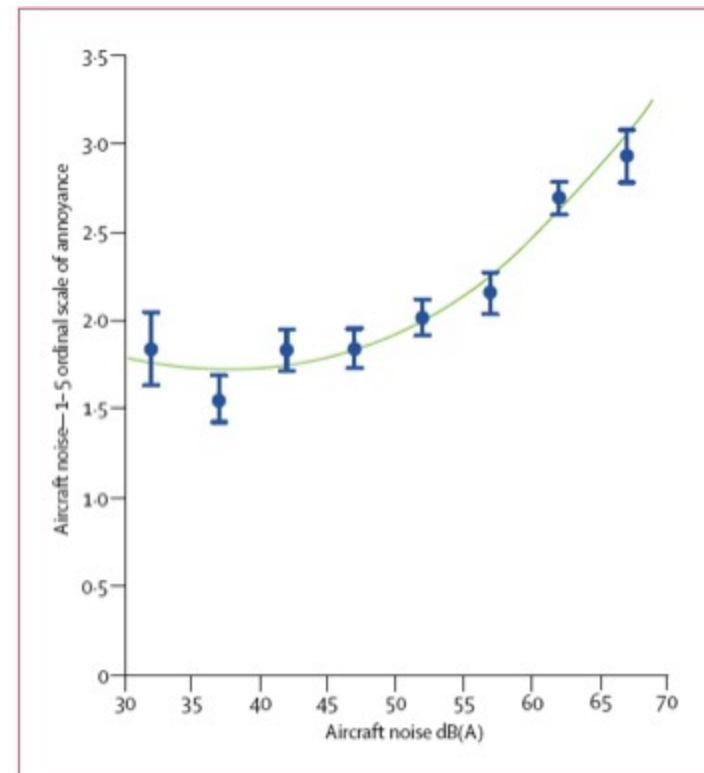


Figure 1: Adjusted mean reading Z score (95% CI) for 5 dB bands of aircraft noise (adjusted for age, sex, and country)

Noise Annoyance



Lancet 2005



Acknowledgement of noise as a
cardiovascular risk factor

Noise mitigation measures and limits

TABLE 1 Noise-Abatement Approaches

Abatement Procedures	Reduction in Noise, dB	Cost-Effectiveness Score (1-5)*
Noise barriers	3-20	2
Brake blocks for trains	8-10	4
Building insulation	5-10	1
Building design	2-15	3
Changing driving styles	5-7	3
Quiet road surfaces	3-7	5
Low-noise tires	3-4	3
Land-use planning and design	Unknown	4
Electric cars	1	1
Traffic management	3	3

*Evaluated by the European Commission in "10 ways to combat noise pollution" (70). Lowest score = 1; highest score = 5.

dB = decibel.

Münzel JACC 2018



Aircraft noise

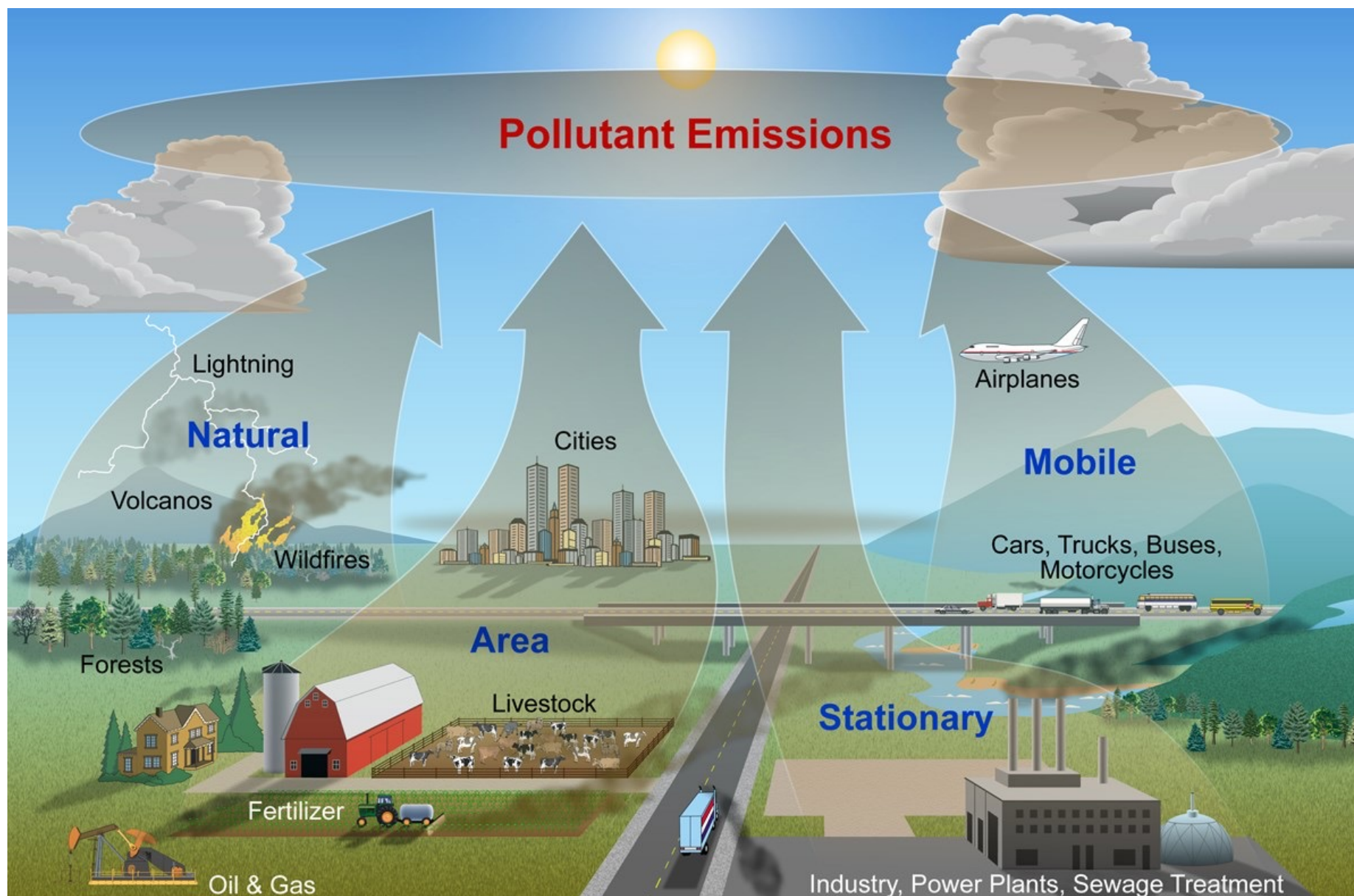
WHO-Noise guidelines

Recommendation	Strength
For average noise exposure, the GDG strongly recommends reducing noise levels produced by aircraft below 45 dB L_{den} , as aircraft noise above this level is associated with adverse health effects.	Strong
For night noise exposure, the GDG strongly recommends reducing noise levels produced by aircraft during night time below 40 dB L_{night} , as night-time aircraft noise above this level is associated with adverse effects on sleep.	Strong
To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from aircraft in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions the GDG recommends implementing suitable changes in infrastructure.	Strong



Road traffic noise

Recommendation	Strength
For average noise exposure, the GDG strongly recommends reducing noise levels produced by road traffic below 53 decibels (dB) L_{den} , as road traffic noise above this level is associated with adverse health effects.	Strong
For night noise exposure, the GDG strongly recommends reducing noise levels produced by road traffic during night time below 45 dB L_{night} , as night-time road traffic noise above this level is associated with adverse effects on sleep.	Strong
To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from road traffic in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions, the GDG recommends reducing noise both at the source and on the route between the source and the affected population by changes in infrastructure.	Strong



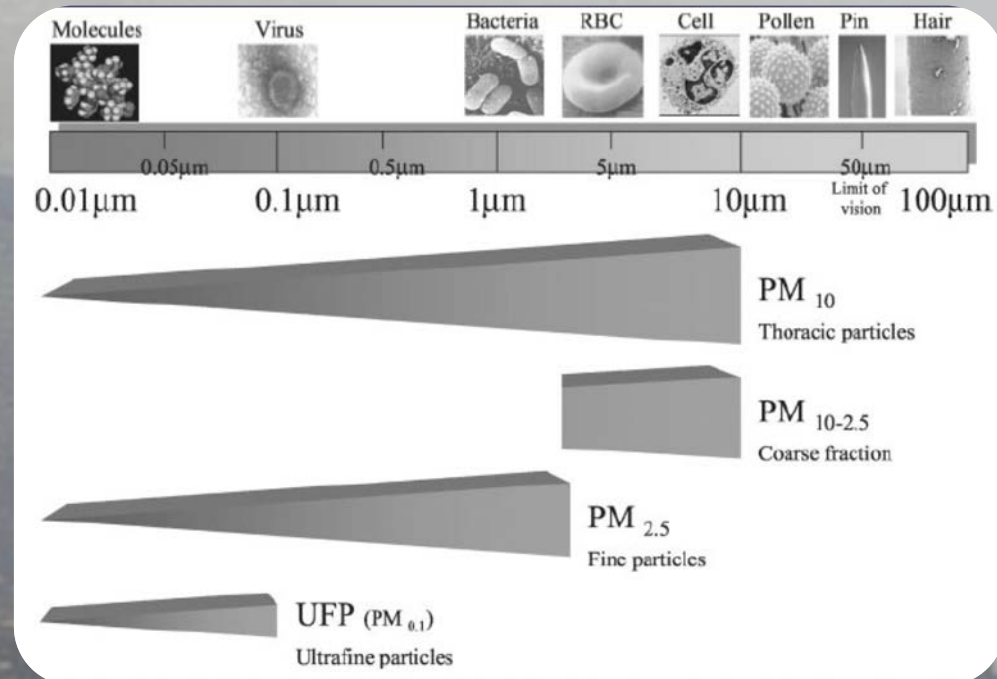
Air pollution

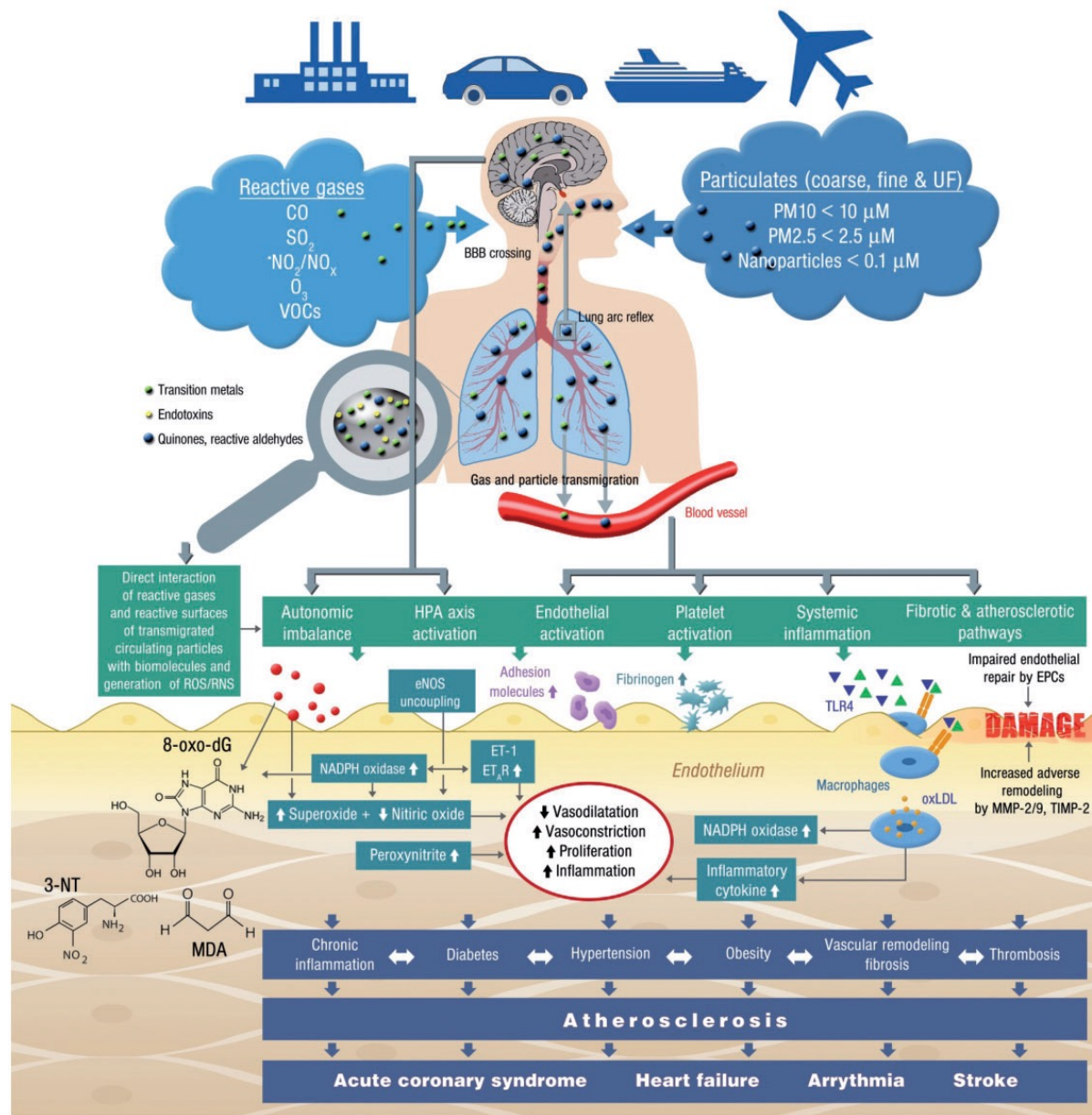
Gases:

- NO_2 : Nitrogen dioxide
- O_3 : Ozone
- CO : Carbon monoxide
- SO_2 : Sulfur dioxide
- CO_2 : Carbon monoxide

Particulate matter

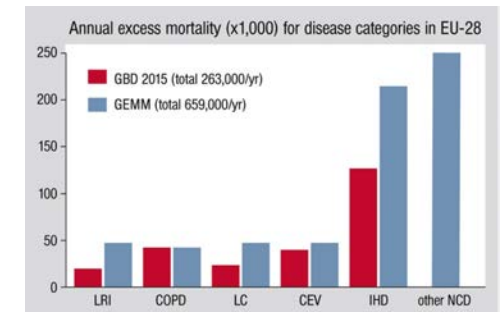
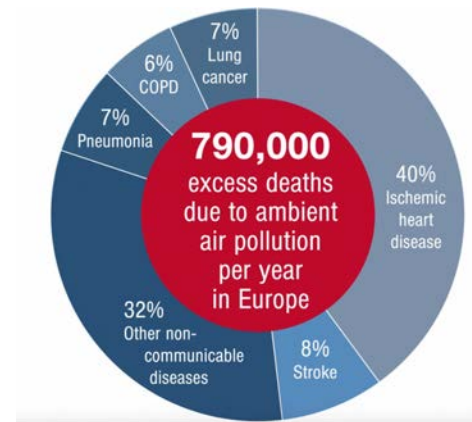
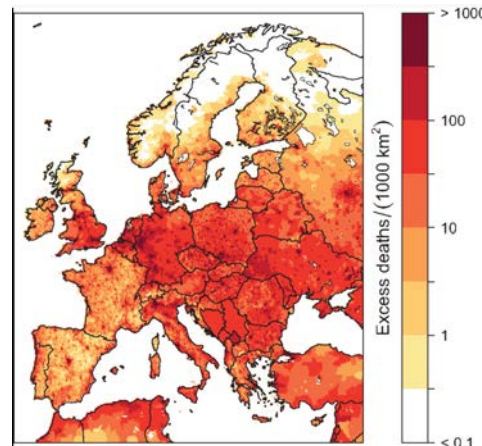
- PM_{10}
- $2.5\mu\text{m}$
- 0.1 ultrafine, size of a virus

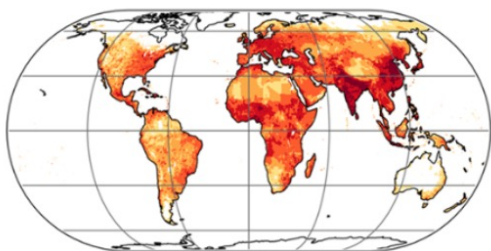




Air pollution and excess mortality

800.000 Europa; almost 9 Mio worldwide





Loss of life expectancy from air pollution compared to other risk factors: a worldwide perspective

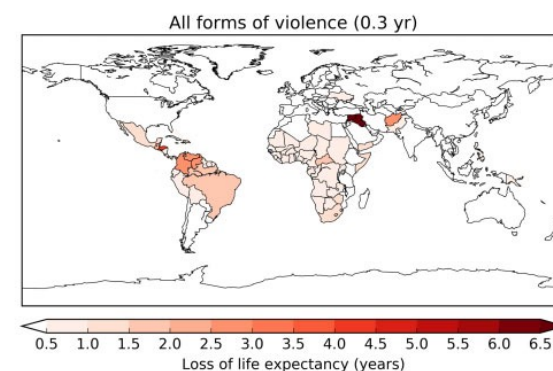
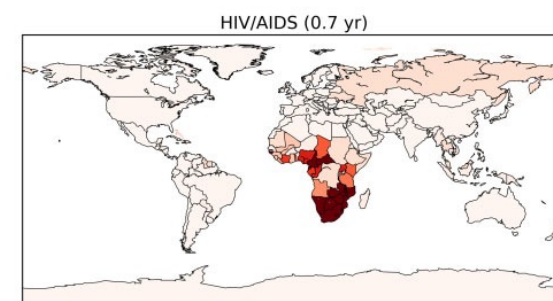
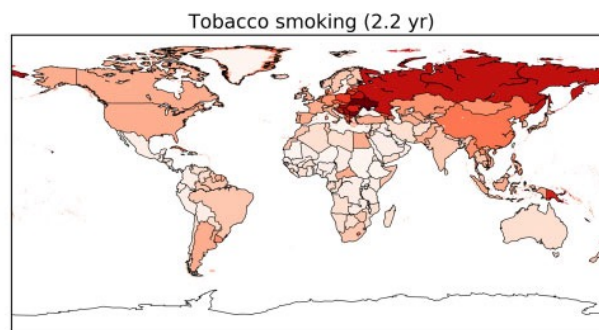
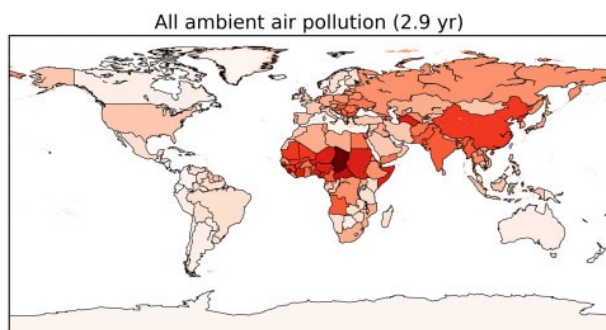
Jos Lelieveld^{1,2*}, Andrea Pozzer¹, Ulrich Pöschl¹, Mohammed Fnais³, Andy Haines⁴ and Thomas Münzel^{5,6*}

Editor's choice: Loss of life expectancy from air pollution compared to other risk factors: a worldwide perspective

8.9 Million die because of PM 2.5

7.2 Million die because of smoking

Loss of life expectancy



Mitigation measures

We need lower limits !



91%

of the world's population lives in places where air quality exceeds WHO guideline limits

> Grenzwert 10 µg/m³

- Europa: 25µg/m³ -> 20/2025
- USA: 12 µg/m³
- Australien: 8 µg/m³ -> 7/2025
- WHO: 10µg/m³ -> **5 µg/m³ 2022**
- Canada: 10µg/m³ -> 8.8/2020

Reduction of fossil fuel and life expectancy

- **Aim: below $5\mu\text{g}/\text{m}^3$**
- A phase out of fossil fuel related emissions (needed to achieve the 2 degree Celsius climate change goal under the Paris agreement) **may save 439.000 lives per year**
- -> increase in life expectancy by 1.2 y
- Mortality reduced by 55%

**Get rid of oil,
gas, coal**



Reduction of personal exposure by filter devices and change of lifestyle



of family history applied and that conventional ASCVD risk factors largely explain the impact of family history.

A family history of premature CVD is simple, inexpensive information that can trigger comprehensive risk assessment in individuals with a family history of premature CVD.¹³⁶

Recommendations for cardiovascular disease risk related to air pollution

Recommendations	Class ^a	Level ^b
Patients at (very) high risk for CVD may be encouraged to try to avoid long-term exposure to regions with high air pollution.	IIb	C
In regions where people have long-term exposure to high levels of air pollution, (opportunistic) CVD risk screening programmes may be considered.	IIb	C

CVD = cardiovascular disease.

^aClass of recommendation.

^bLevel of evidence.



ESC

European Society
of Cardiology

European Heart Journal (2021)
doi:10.1093/eurheartj/ehab48

2021 ESC Guidelines prevention in clinical practice

© ESC 2021

exposure to PM_{2.5}; the long-term effects are associated mainly with PM_{2.5}. The evidence linking exposure to PM and CVD events is based on large-scale epidemiological studies and experimental studies. Associations with ASCVD mortality vary, but the majority of cohort studies link long-term air pollution with an increased risk of fatal or non-fatal CAD, and with subclinical atherosclerosis. Evidence suggests that reduction of PM_{2.5} is associated with improvements in inflammation, thrombosis, and oxidative stress, and a decrease in death from ischaemic heart disease.^{38,160,161} As sufficiently precise individual exposure estimates are hard to obtain, formal risk reclassification is difficult to quantify at present.

Recommendations for cardiovascular disease risk related to air pollution

Recommendations	Class ^a	Level ^b
Patients at (very) high risk for CVD may be encouraged to try to avoid long-term exposure to regions with high air pollution.	IIb	C
In regions where people have long-term exposure to high levels of air pollution, (opportunistic) CVD risk screening programmes may be considered.	IIb	C

CVD = cardiovascular disease.
^aClass of recommendation.
^bLevel of evidence.

3.3.9. Biomarkers in blood or urine

Many biomarkers have been suggested to improve risk stratification. Some may be causal [e.g. lipoprotein(a), reflecting a pathogenic lipid fraction], whereas others may reflect underlying mechanisms (e.g. C-reactive protein reflecting inflammation) or indicate early cardiac damage (e.g. natriuretic peptides or high-sensitivity cardiac troponin).

In the 2016 Guidelines,² we recommended against the routine use of biomarkers because most do not improve risk prediction, and publication bias seriously distorts the evidence.^{106,162} New studies confirm that C-reactive protein has limited additional value.¹⁰³ There is renewed interest in lipoprotein(a), but it too provides limited additional value in terms of reclassification potential.^{163,164} Cardiac biomarkers are promising,^{165,166} but further work is needed.

3.3.10. Body composition

Worldwide, BMI has increased substantially in recent decades, in children, adolescents, and adults.⁴³ In observational studies, all-cause mortality is minimal at a BMI of 20–25 kg/m², with a J- or U-shaped relation in current smokers.^{45,46} Mendelian randomization analyses suggest a linear relation between BMI and mortality in never-smokers and a J-shaped relation in ever-smokers.⁴⁴ A meta-analysis concluded that both BMI and waist circumference are similarly strongly and continuously associated with ASCVD in the elderly and the young and in men and women.⁴⁷

Among those with established ASCVD, the evidence is contradictory. Systematic reviews of patients with ACS or HF have suggested an 'obesity paradox' whereby obesity appears protective.^{167,168,169} However, this evidence should be interpreted with caution as reverse causality and other biases may be operating.⁴⁵

disease (CHD), stroke, and CVD mortality.¹⁵⁷ Ambient PM pollution recently ranked as a leading modifiable mortality risk factor and also responsible for attributable disability adjusted life-years at the global level.¹⁵⁸ A recent model estimated that loss of life expectancy due to ambient air pollution is similar to, if not exceeding, that due to tobacco smoking, and accounts for a global excess mortality estimated at 8.8 million/year.¹⁵⁹

The short-term attributable effects on mortality are linked primarily to exposure to PM, nitrogen dioxide, and ozone, with an average 1.0% increase of all-cause mortality for an increment of 10 µg/m³ in

Future projects:

- Cardiovascular risk factors plus noise
- Air Pollution + noise

