Aircraft noise and cardiovascular disease

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Key Researchers

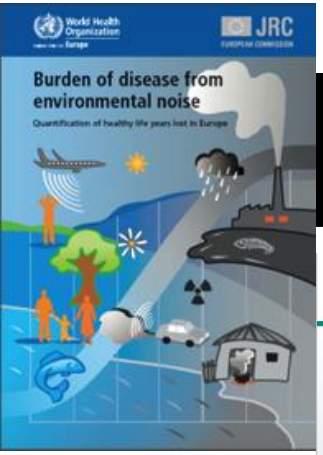
Andreas Daiber

Marin Kuntic

Mette Sørensen, Martin Röösli, Mathias Basner

Global Burden of Disease due to Transportation Noise

World Health Organisation and the European Environment Agency



World Health Organization

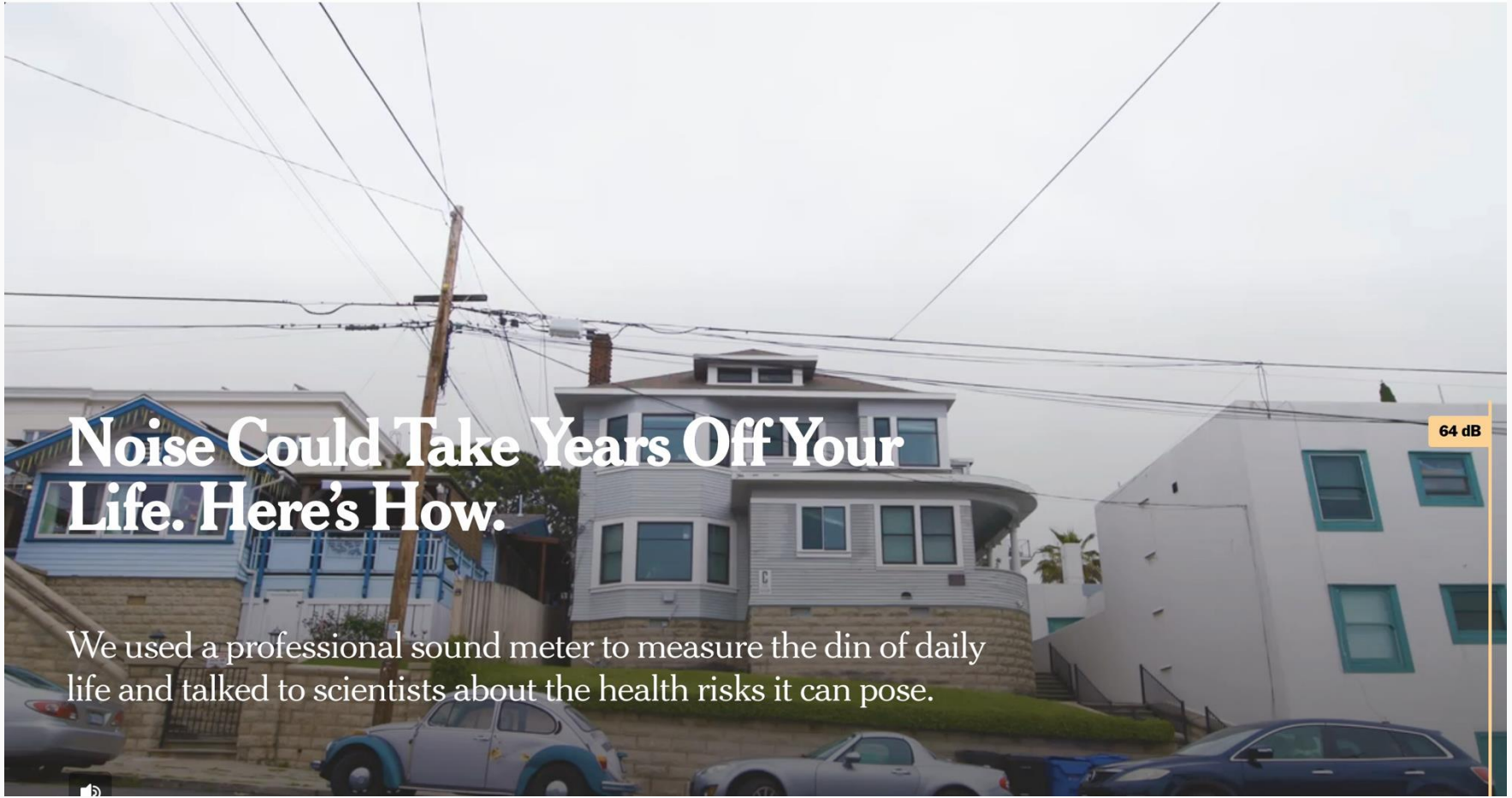
WHO:

The most underrated environmental risk factor
Second most important environmental reason for health problems
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 150 million Europeans in towns and cities are exposed to noise levels more than **55 decibels** from road (120), rail (22) and air traffic (4), where adverse health effects are expected

Keeping noise levels < 55 dB Lden (road noise) will save 110.000 lives per year (Mette Sørensen personal communication)

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

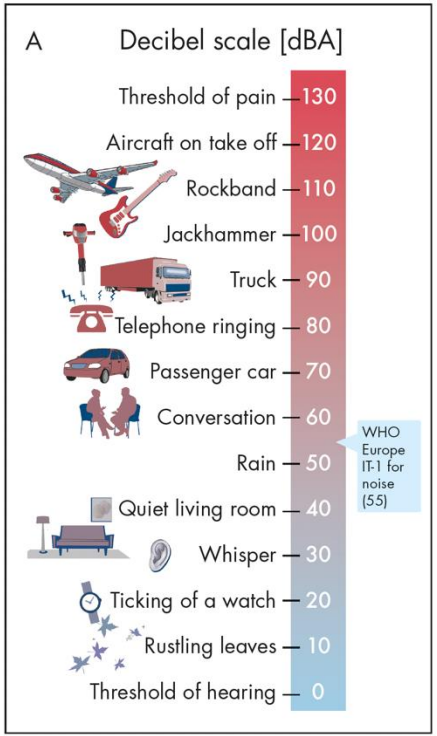


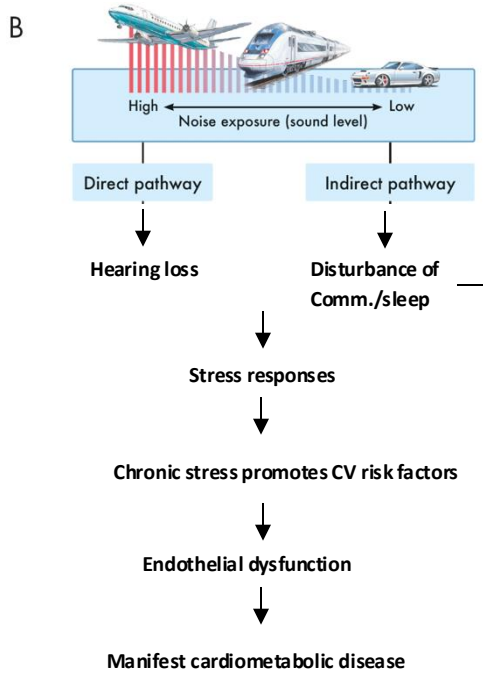
Noise Could Take Years Off Your Life. Here's How.

We used a professional sound meter to measure the din of daily life and talked to scientists about the health risks it can pose.


62 dB

Noise and CVD: Proposed Mechanisms

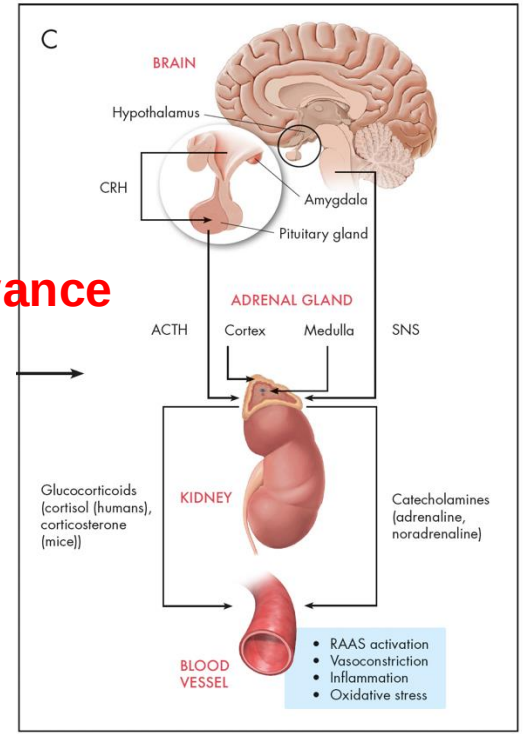




Annoyance

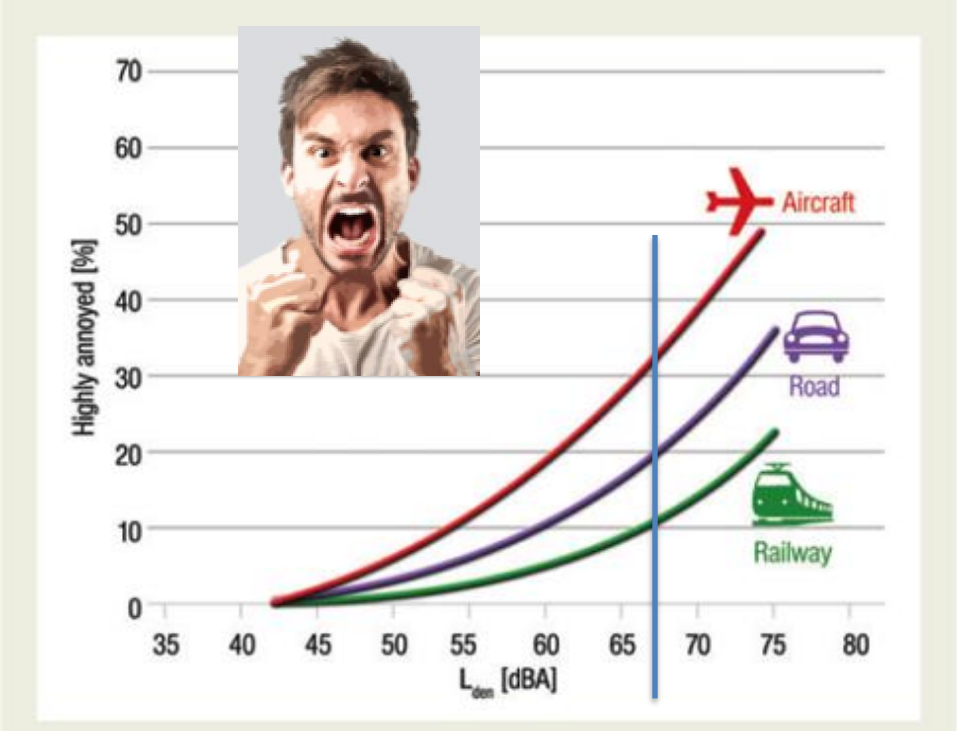
Anger

Noise triggers HPA –Axis
(Hypothalamic-pituitary-adrenal)

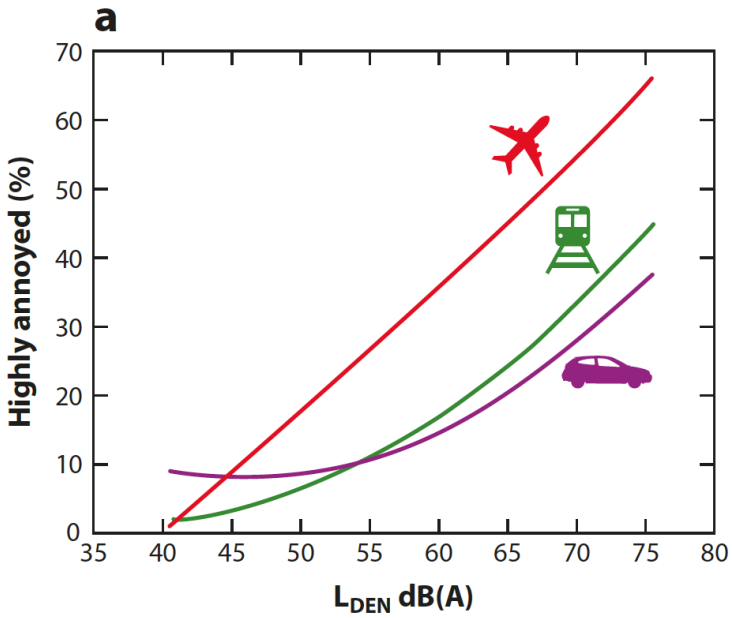


Münzel et al. Circulation Research 2025

Aircraft Noise Most Annoying



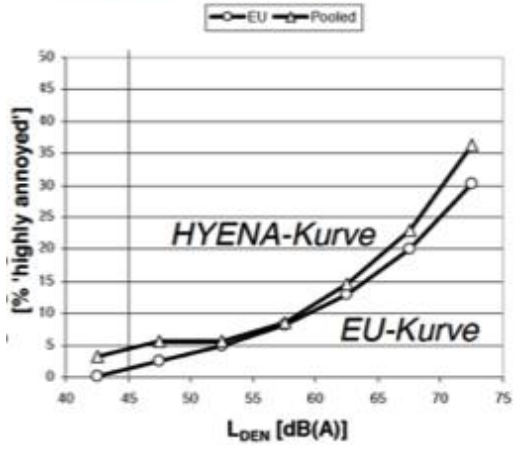
Münzel, Daiber, Basner, Babisch Eur H J 2014



Annu. Rev. Public Health 2020. 41:309–28

Increase in annoyance in response to aircraft noise within the last ten years

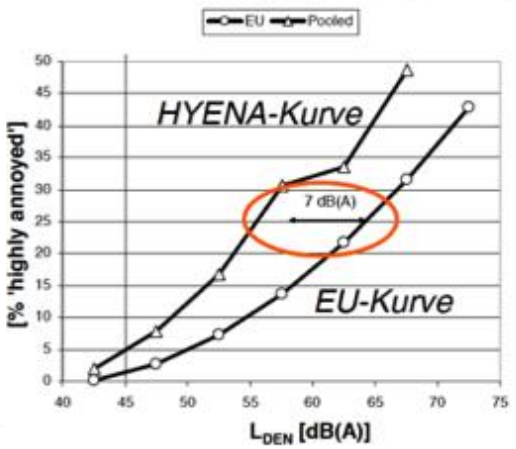
Road Traffic Noise



HYENA Study
6 European Airports

% 'highly annoyed'

Aircraft Noise



Quelle: Babisch, 2009

ESC European Society of Cardiology
European Heart Journal (2019) 0, 1–11
doi:10.1093/eurheartj/ehz820

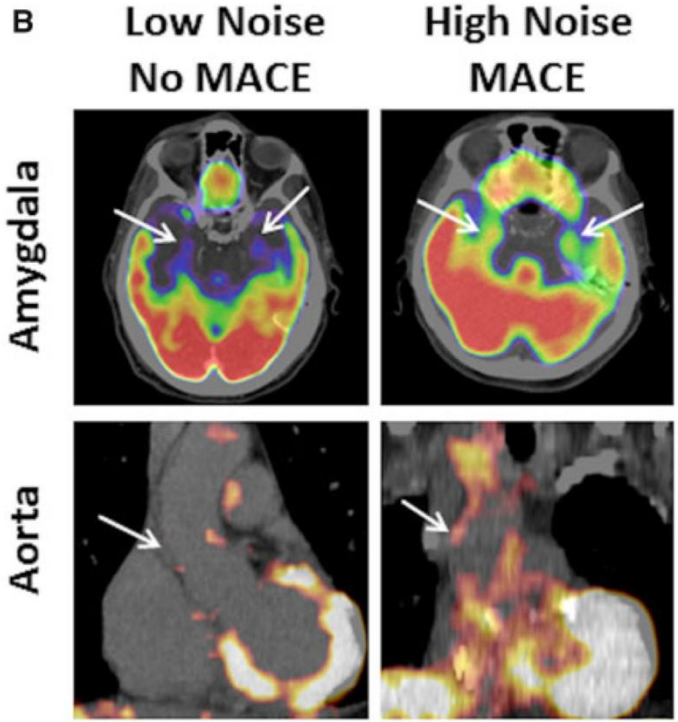
CLINICAL RESEARCH
Imaging

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*]

Amygdala, part of the Limbic System

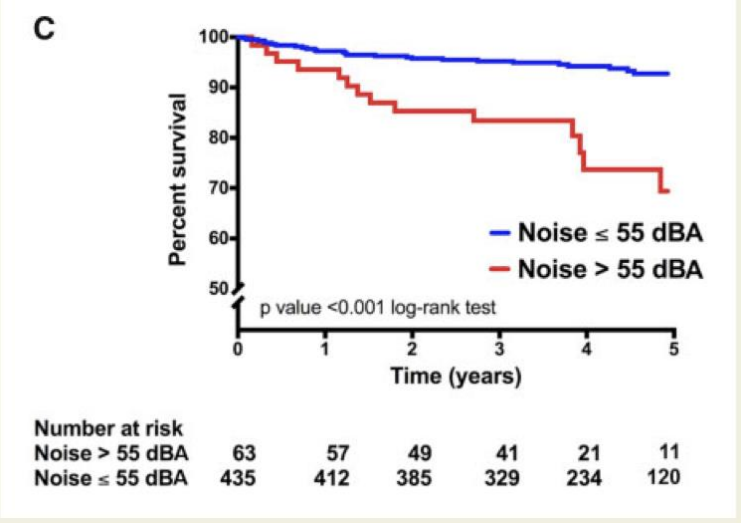
Amygdalar activity correlates with vascular inflammation



- **amygdala modulates the fear, anxiety, anger, annoyance 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 (within 5y)

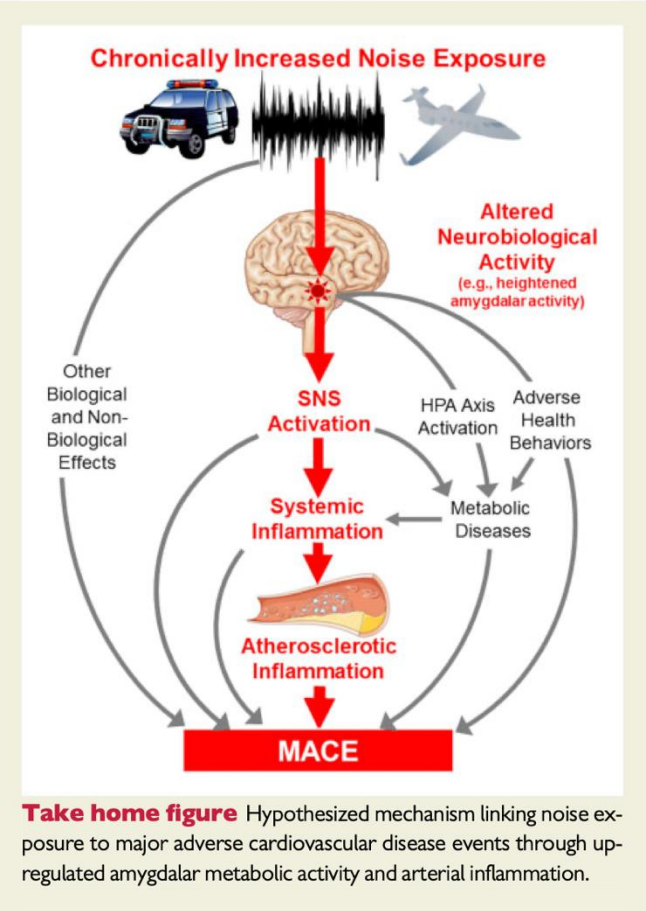
Osborne et al. EHJ 2020

Higher Annoyance, more vascular inflammation



MACE:

CVD Death
Myocardial Infarction
Heart Failure
Coronary and peripheral Revascularization



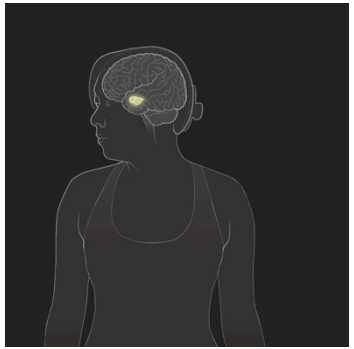
Take home figure Hypothesized mechanism linking noise exposure to major adverse cardiovascular disease events through up-regulated amygdalar metabolic activity and arterial inflammation.

Osborne EHJ 2021

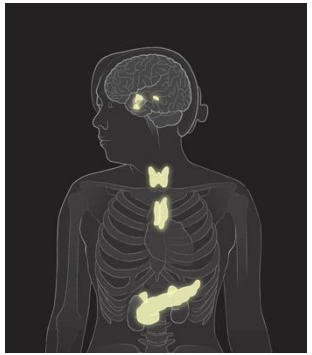
Stresscascade

Noise, unwanted sound

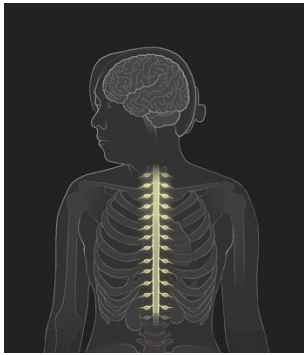
Activation of the Amygdala



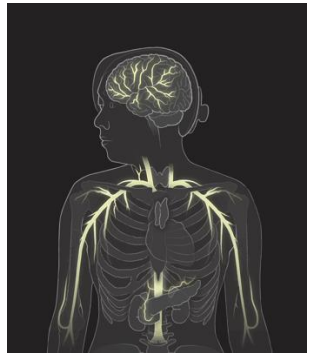
Production of Stress Hormones



Sympathetic nerve activation



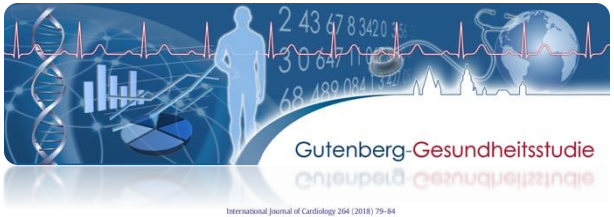
Vessel inflam-mation
Myocardial Infarction
Stroke



NOISE → **Cardiovascular Disease**

New York Times 2023

Annoyance and Arrhythmia and Cerebral Disease



International Journal of Cardiology 264 (2018) 79–84

Contents lists available at ScienceDirect

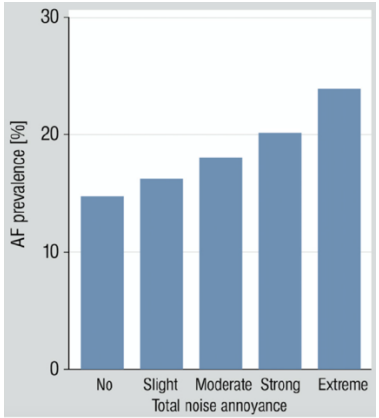
International Journal of Cardiology

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

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 [h], Karl Lackner [f], Mette Sørensen [g], Jürgen H. Prochaska [a], Philipp S. Wild [a], Thomas Münzel [a,*]

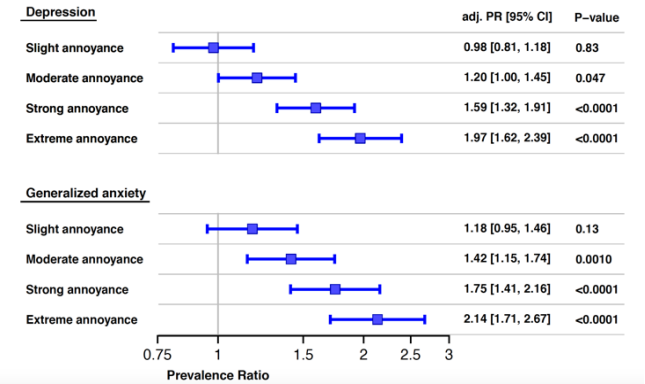
Gutenberg Health Study
Prospective Cohort Trial Mainz
15.000 Participants



RESEARCH ARTICLE

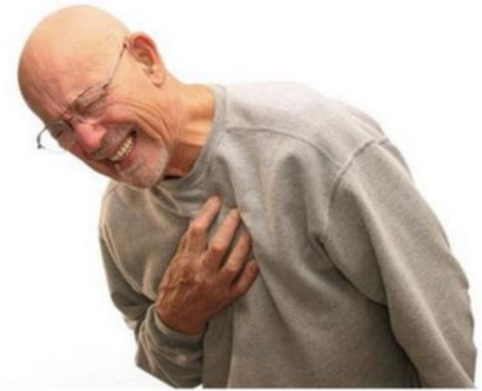
Noise Annoyance Is Associated with Depression and Anxiety in the General Population- The Contribution of Aircraft Noise

Manfred E. Beutel[1]*, Claus Jünger[2], Eva M. Klein[1], Philipp Wild[3,4,5], Karl Lackner[6], Maria Blettner[7], Harald Binder[7], Matthias Michal[1], Jörg Wiltink[1], Elmar Brähler[1], Thomas Münzel[2]



The meaning of annoyance with respect to cardiovascular health has to be strongly upgraded !!

Noise is associated with CVD



For all cardiovascular diagnoses combined, the risk increased by 3.2% per 10 dB(A) higher road traffic noise

ENVIRONMENTAL IMPACTS ON CARDIOVASCULAR HEALTH AND BIOLOGY COMPENDIUM

Transportation Noise Pollution and Cardiovascular Health

Thomas Münzel, Michael Molitor, Marin Kuntic, Omar Hahad, Martin Röösli, Nicole Engelmann, Mathias Basner, Andreas Daiber, Mette Sørensen

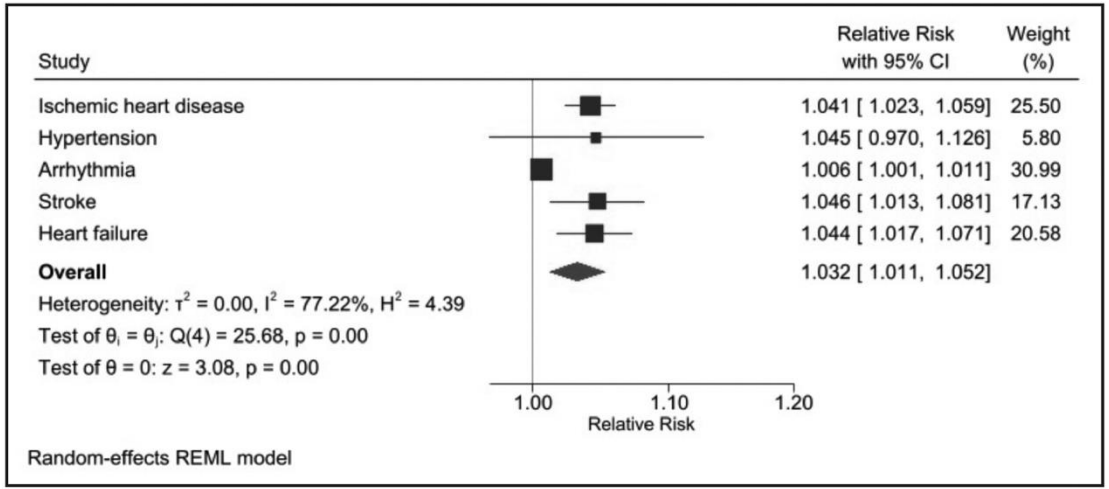


Figure 2. Relative risks obtained in meta-analyses of a Umbrella+ review from 2023 estimating the association between road traffic noise and cardiovascular disease.[19]

Circulation Research 2024

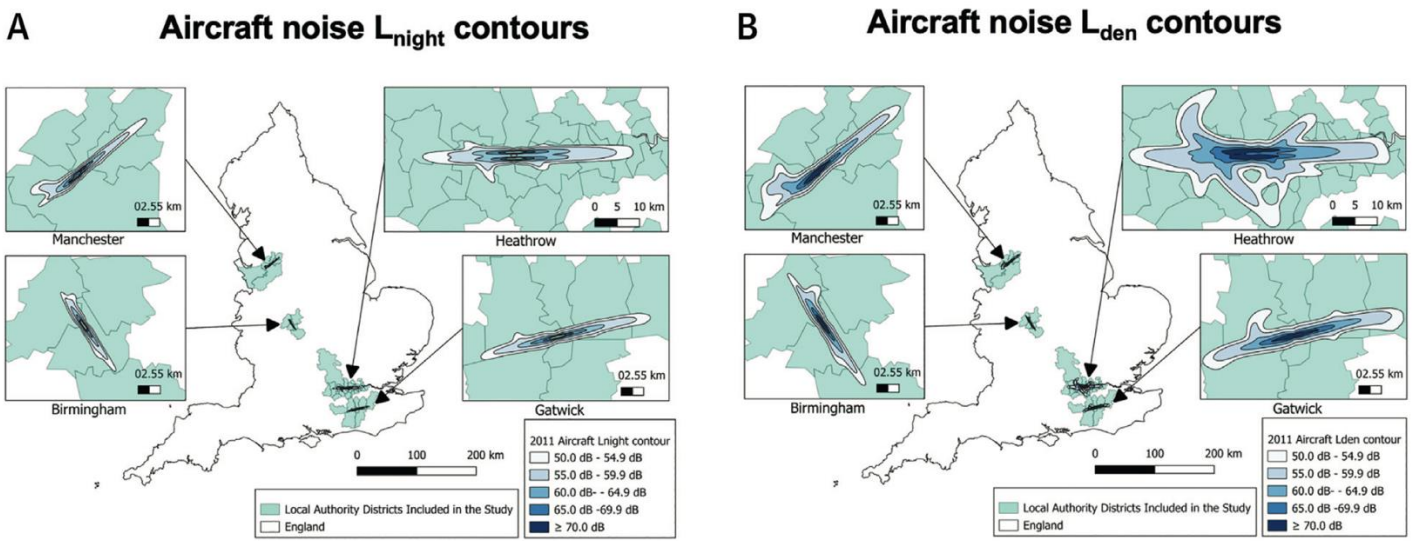
JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY VOL. ■, NO. ■, 2024

Higher Aircraft Noise Exposure Is Linked to Worse Heart Structure and Function by Cardiovascular MRI

Constantin-Cristian Topriceanu, MD,[a,b,c,*] Xiangpu Gong, PhD,[d,e,*] Mit Shah, MBBS, PhD,[f,g] Hunain Shiwani, BMBS,[b,c] Katie Eminson, BSc,[d,h] Glory O. Atilola, PhD,[i] Calvin Jephcote, PhD,[d] Kathryn Adams, BSc,[d] Marta Blangiardo, PhD,[i] James C. Moon, MB BCh, MD,[b,c] Alun D. Hughes, MBBS, PhD,[a,b] John Gulliver, PhD,[j] Alex V. Rowlands, PhD,[h,k] Nishi Chaturvedi, MD,[a,b] Declan P. O'Regan, MBBS, PhD,[f,g] Anna L. Hansell, MB BChir, PhD,[d,e,h,i,†] Gabriella Captur, MD, PhD[a,b,l,†]

Airports

FIGURE 1 **Aircraft Noise Contours Around the 4 UK Major International Airports**



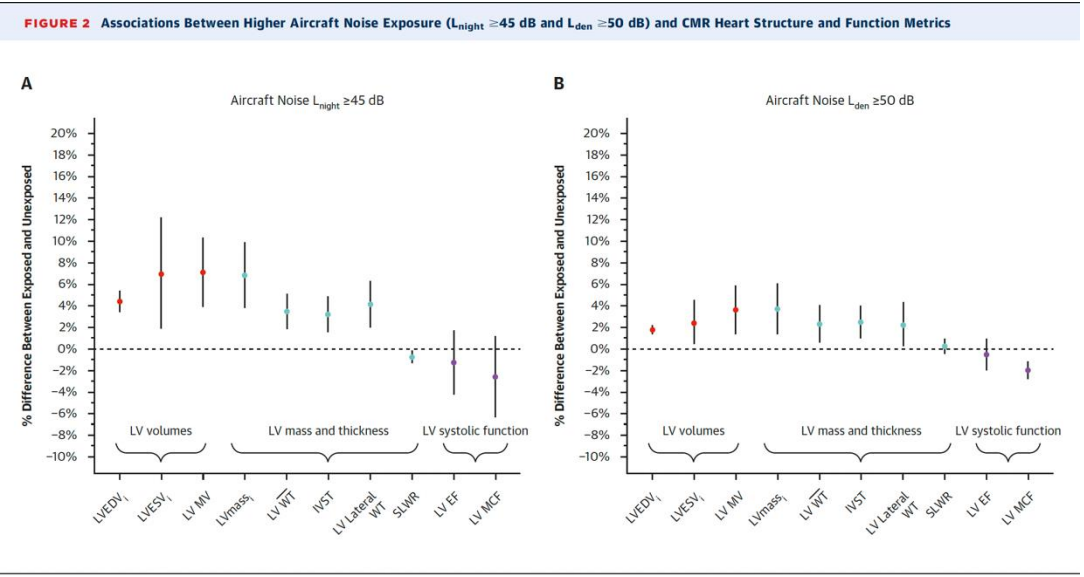
Local authority districts surrounding the 4 UK major airports (London Heathrow, London Gatwick, Manchester, and Birmingham), along with the noise contours provided by the UK Civil Aviation Authority, are presented for (A) nighttime aircraft noise levels (L_{night}) and (B) 24-hour day-evening-night aircraft noise levels (L_{den}) in 2011.

Study design :

- 26.658 study participants had an MRI 2014
- Higher Lnight (>45dB)or higher Lden (>50 dB) were experienced by 2.9% and 8.4% of participants, respectively.
- Out of the 3,635 study participants included, 2,532 (70%) did not move home from recruitment up until 2022
  - NONMOVERS (for 11 years), important for long-term risk calculation
- Noise levels provided from 2011
- 3y noise exposure

Results 1:

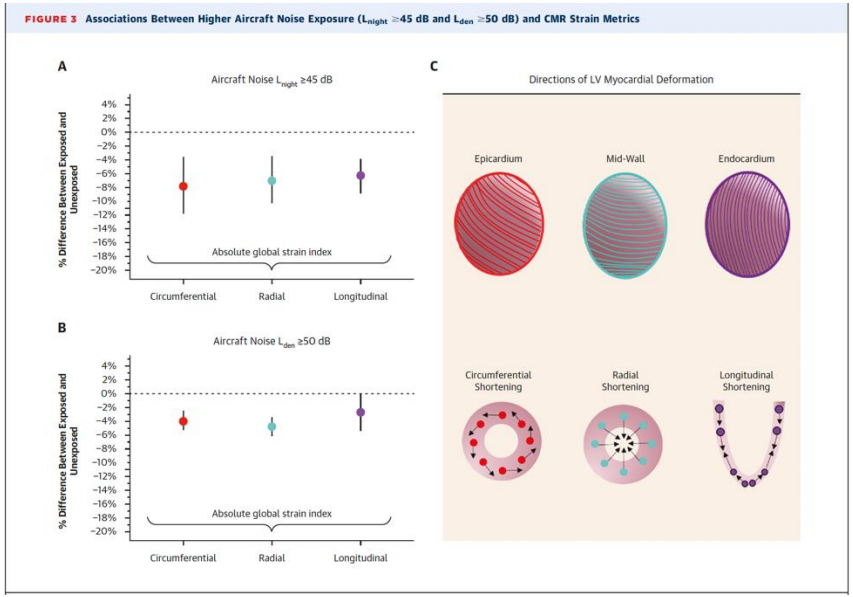
LV mass and Volumes



- > 45dBA Lnight -> 7% greater left ventricular (LV) mass 4% thicker LV walls
- a 7% greater LV mass associates with a 32% greater risk of MACE.

Results 2:

Left ventricular dynamics



Caused by:

- **They also had worse LV myocardial dynamics (eg, an 8% lower global circumferential strain**
- **which associates with a 27% higher risk of MACE).**

- **Mediation analysis:**
- mediated by an increased **body mass index and high blood pressure** — factors that can be **associated with chronic stress and sleep disturbances** caused by noise.

Conclusions:

"This study clearly and unequivocally shows, once again, that aircraft noise is not just a nuisance but a serious health risk."

- In particular, the significantly more pronounced side effects caused by nighttime aircraft noise call for a consistent noise-free night from 10 p.m. to 6 a.m.

EDITORIAL COMMENT

The High Stakes of High Decibels

The Cardiovascular Fallout From Aircraft Noise

Thomas Münzel, MD,[a] Marin Kuntic, PhD,[a] Paul Stamm, MD,[a] Frank Schmidt, MD,[b] Sanjay Rajagopalan, MD,[c] Andreas Daiber, PhD[a]

How does noise damage the vasculature ?

Frank Schmidt

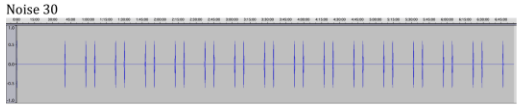
Ascan Warnholtz

Mathias Basner

Methods:

Simulated nighttime aircaft noise

30



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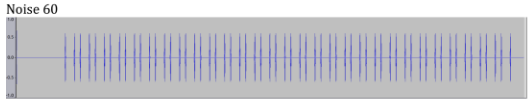
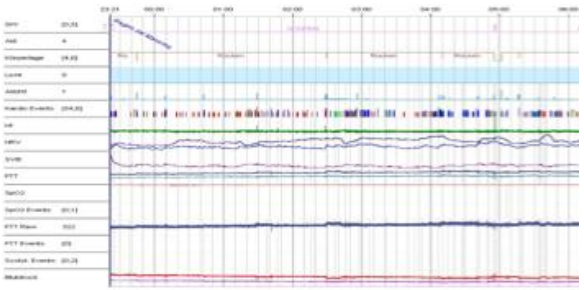


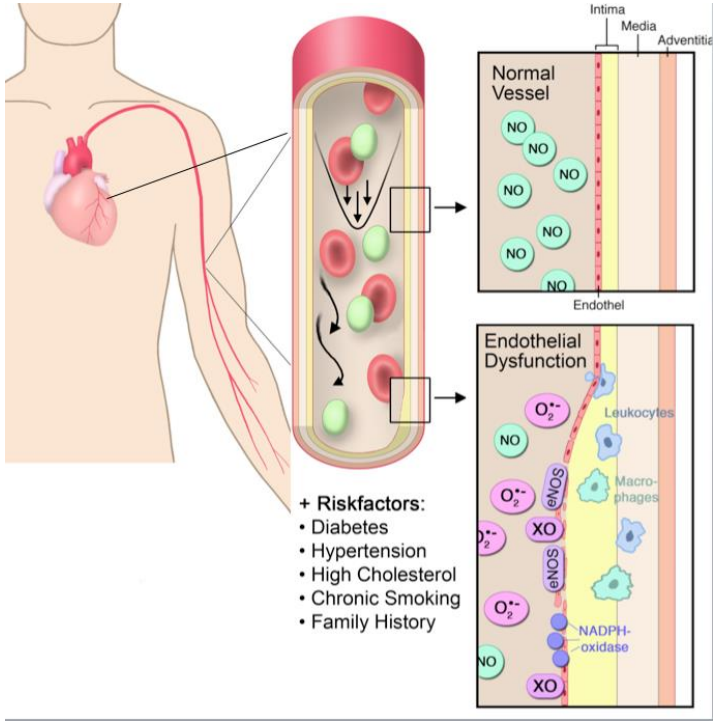
MP3 Player

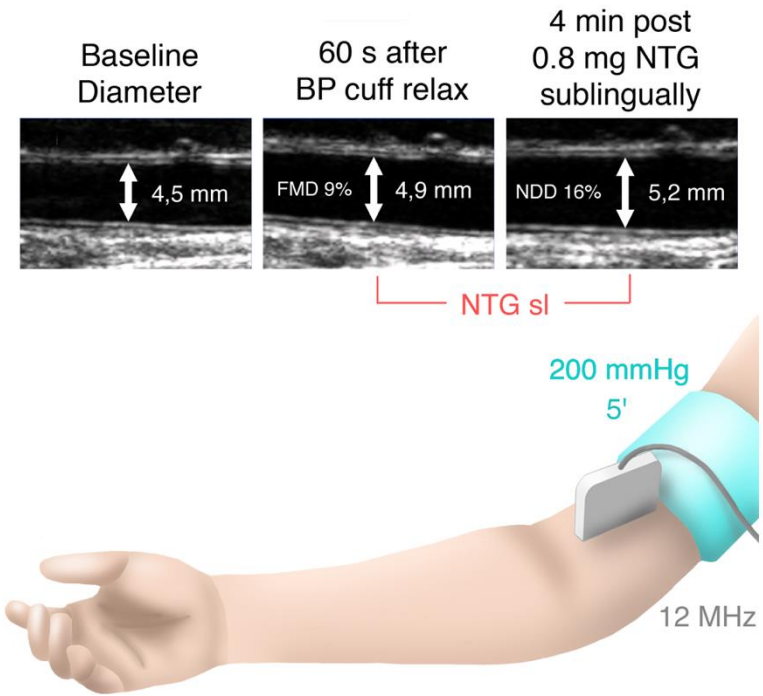
Polygraphic screening devices (SOMNOWATCH PLUS)



- **Field study**
- **30 or 60 Flights per night**
- **Peak sound pressure levels: 60 dBA**
- **Mean sound pressure levels: 43 and 46 dBA**
- **Noise from the Düsseldorf Airport**

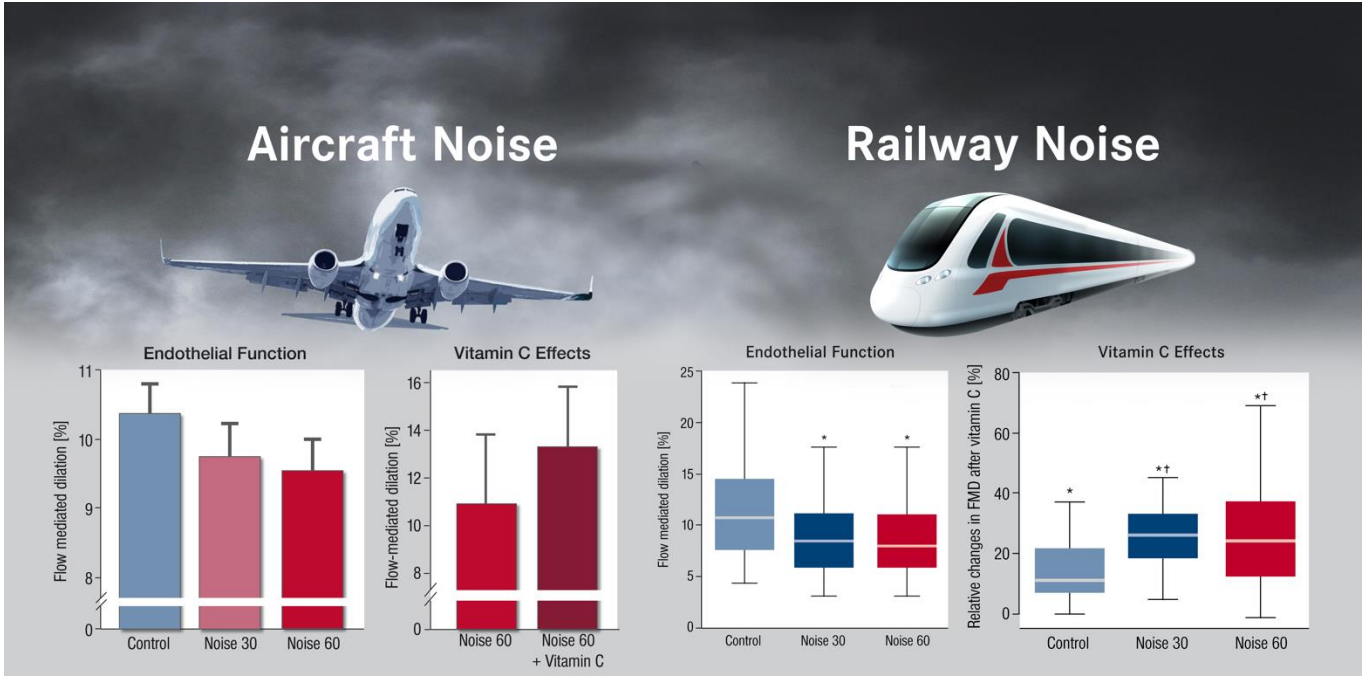
The endothelium regulates vascular tone

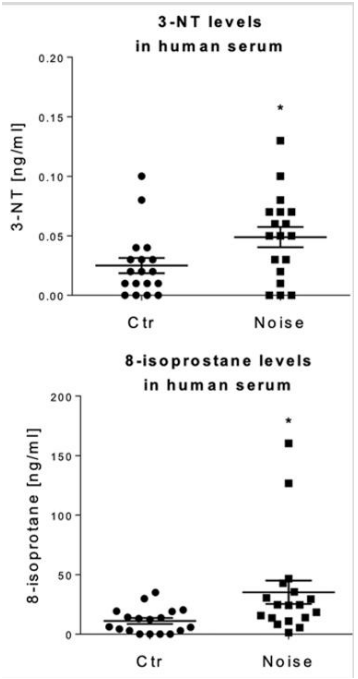




Münzel et al. Annals of Medicine. 2008; 40: 180–196

Nighttime noise causes endothelial dysfunction





Nat.Rev.Cardiol.2021 ; Schmidt et al EHJ 2013, BRC 2015, CJC 2022, Circ Res 2024

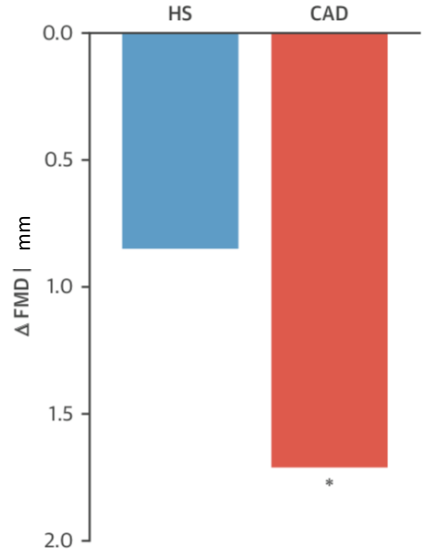
JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY VOL. 71, NO. 6, 2018

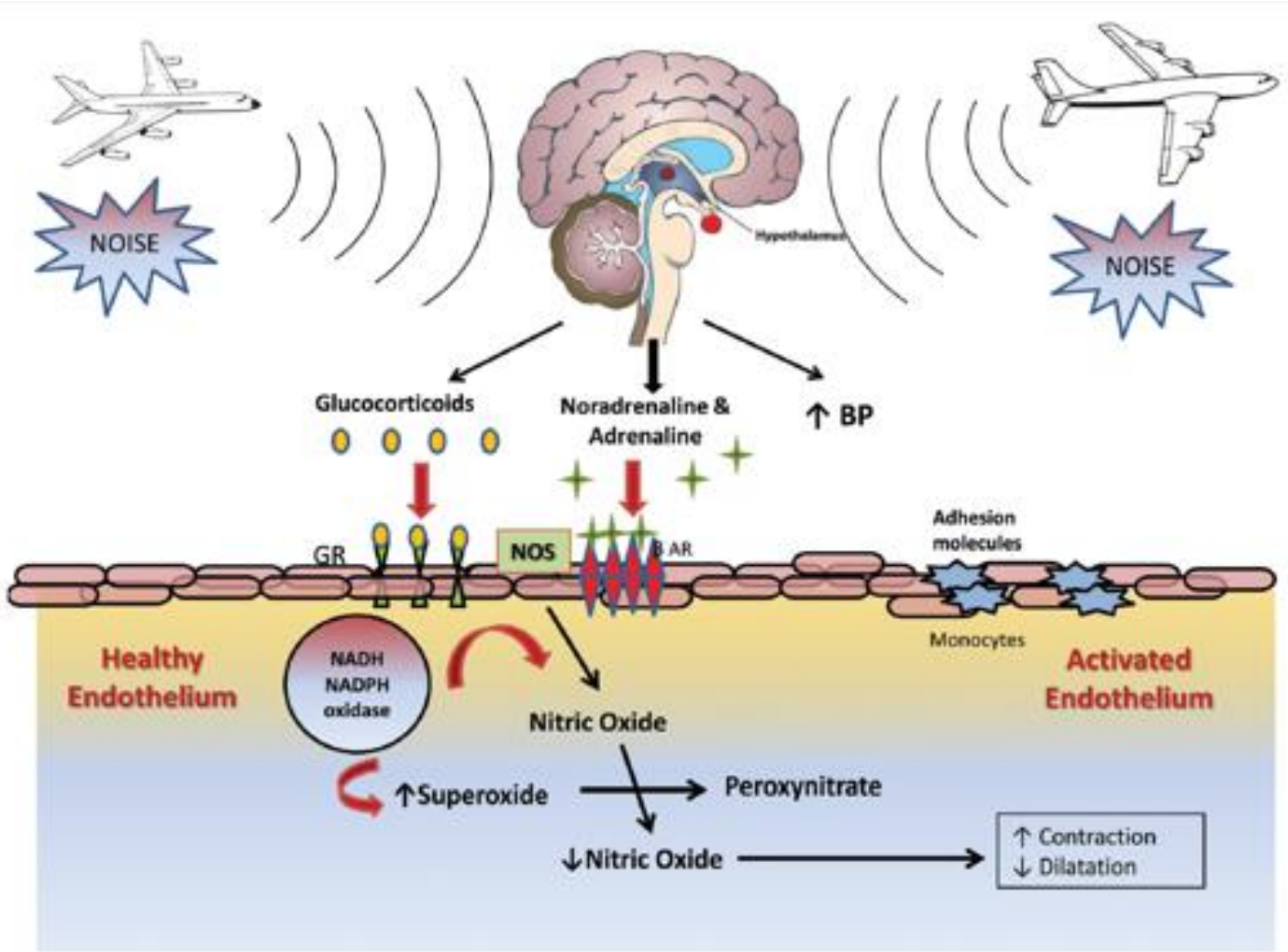
REVIEW TOPIC OF THE WEEK

Environmental Noise and the Cardiovascular System

Thomas Münzel, MD,[a] Frank P. Schmidt, MD,[a] Sebastian Steven, MD,[a] Johannes Herzog, MD,[a] Andreas Daiber, PhD,[a] Mette Sørensen, PhD[b]

FIGURE 1 Impact of Aircraft Noise Exposure on Endothelial Function of Healthy Subjects and Patients With Established Coronary Artery Disease




NOISE
NOISE
Hypothalamus
Glucocorticoids
Noradrenaline &
Adrenaline
↑ BP
GR
NOS
β AR
Adhesion
molecules
Monocytes
Healthy
Endothelium
NADH
NADPH
oxidase
Nitric Oxide
Activated
Endothelium
↑Superoxide
Peroxynitrate
↓Nitric Oxide
↑ Contraction
↓ Dilatation

REVIEWS

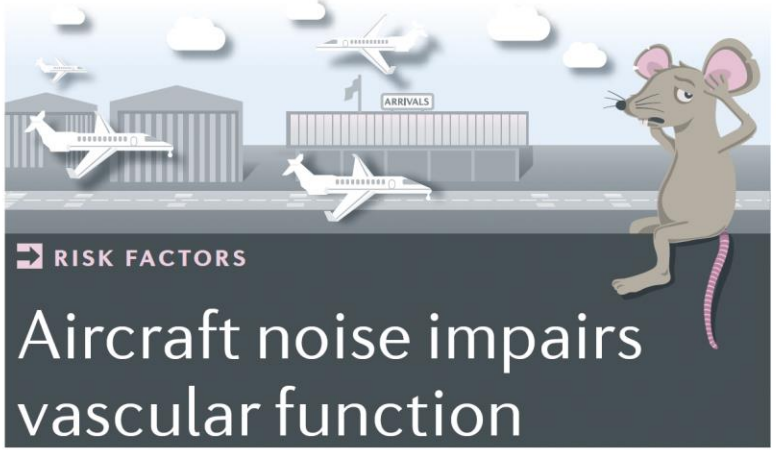
Check for updates

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

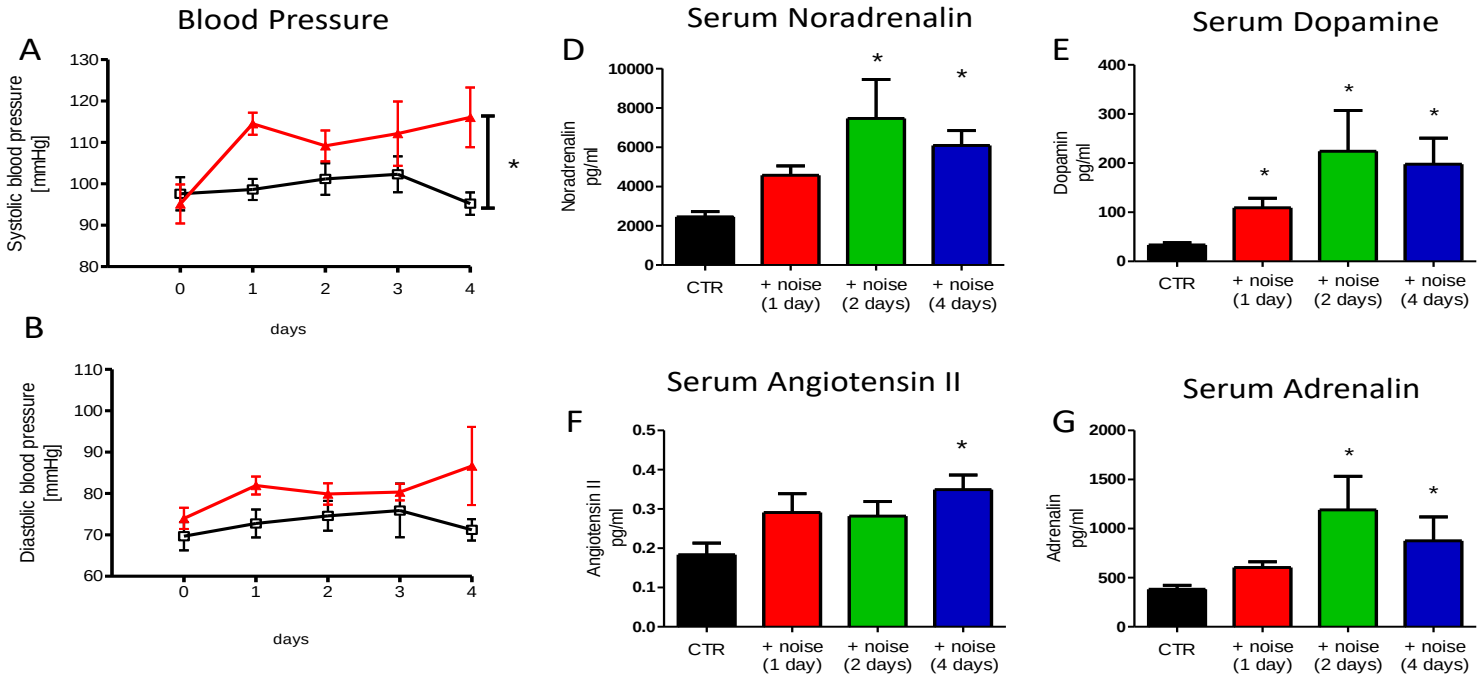
RESEARCH HIGHLIGHTS



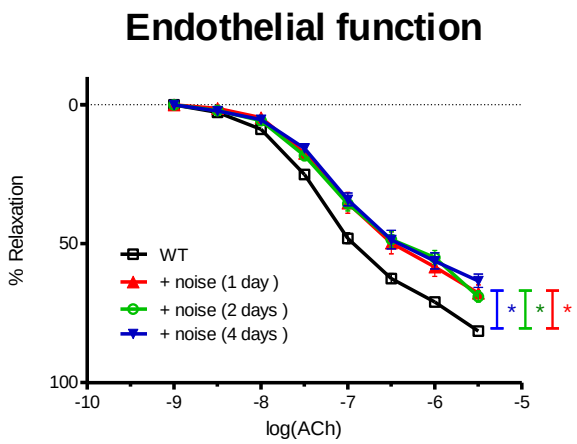
V. Summersby/Macmillan Publishers Limited

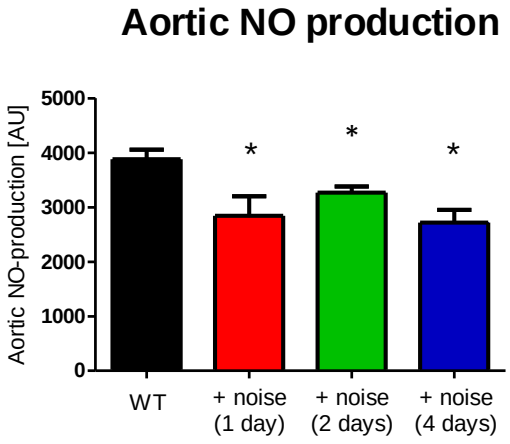
European Heart Journal (2017) **00**, 1–12
doi:10.1093/eurheartj/ehx081

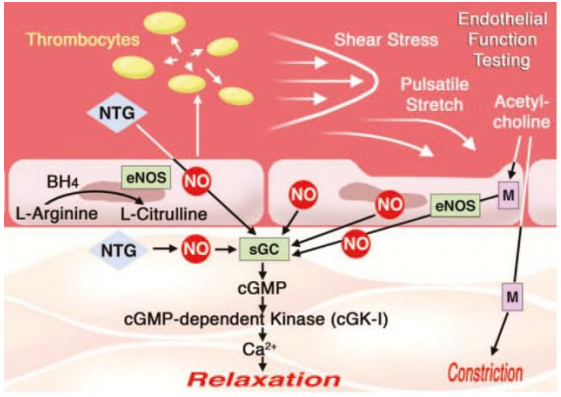
Effects of noise on vascular function, oxidative stress, and inflammation: mechanistic insight from studies in mice



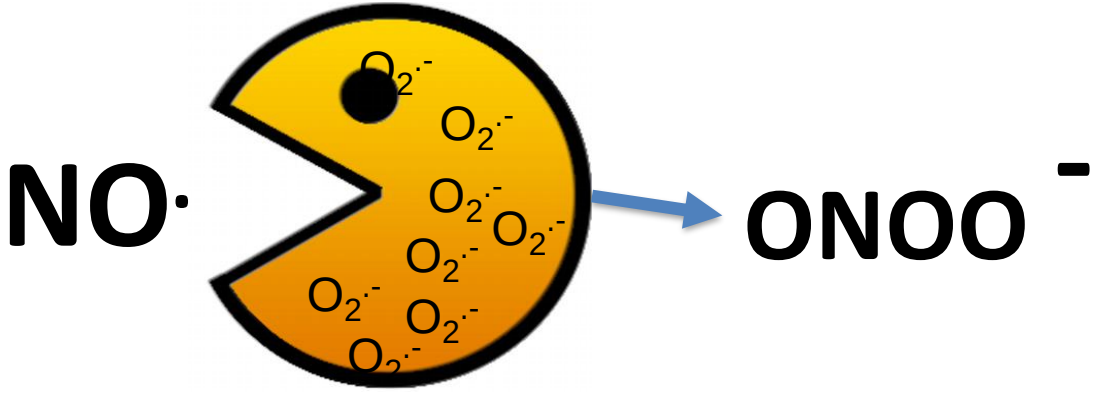
Vascular function, NO production:



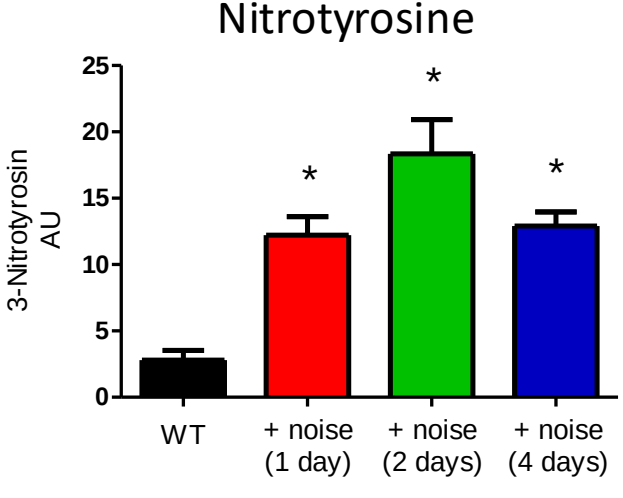


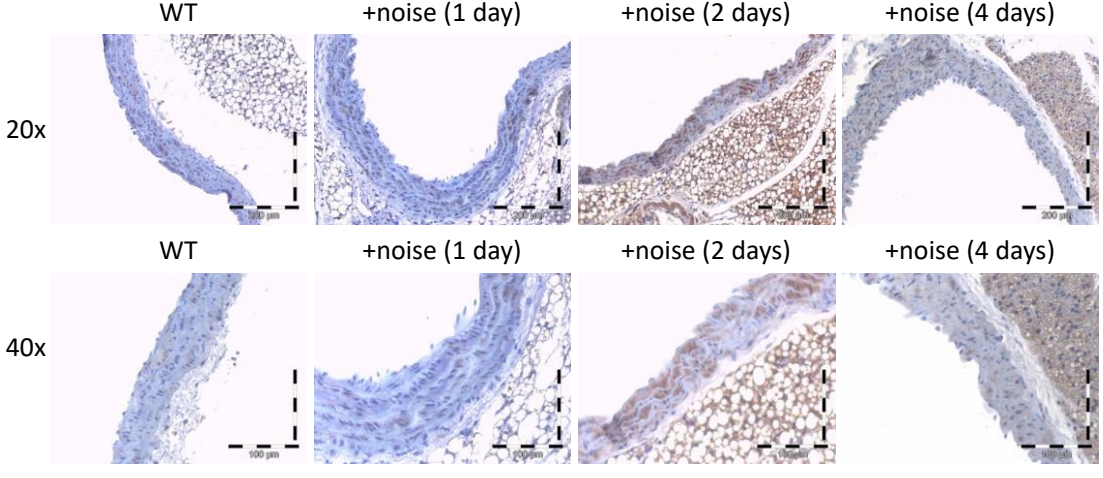


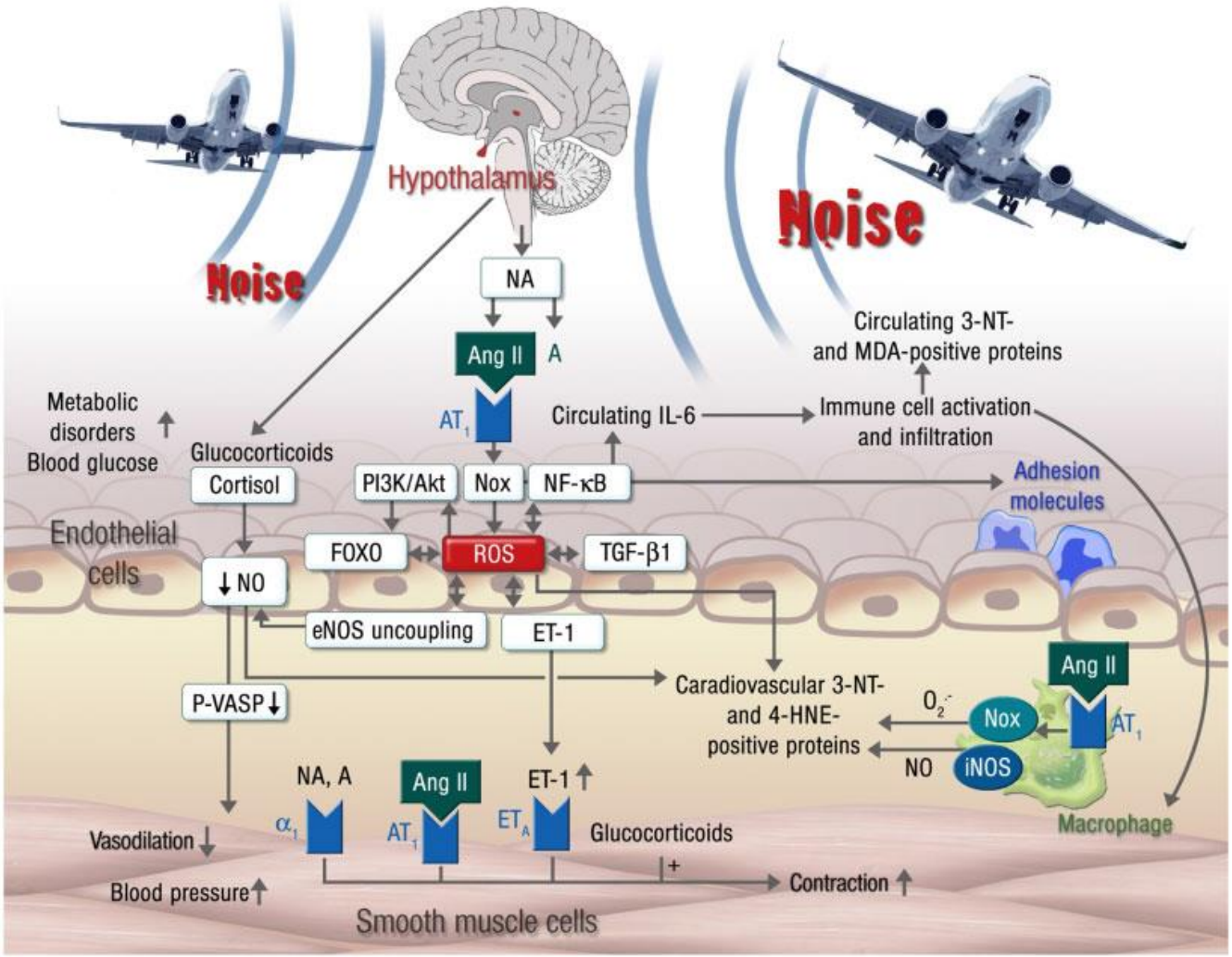
Noise causes oxidative Stress



Diabetes
Hypertension
Smoking
High Cholesterol






Noise
Hypothalamus
Noise
NA
Ang II
A
AT1
Circulating 3-NT- and MDA-positive proteins
Metabolic disorders Blood glucose
Glucocorticoids
Cortisol
Circulating IL-6
Immune cell activation and infiltration
PI3K/Akt
Nox
NF-κB
Adhesion molecules
Endothelial cells
FOXO
ROS
TGF-β1
↓ NO
eNOS uncoupling
ET-1
P-VASP↓
Caradiovascular 3-NT- and 4-HNE- positive proteins
Ang II
O2-
Nox
AT1
NO
iNOS
Macrophage
NA, A
Ang II
ET-1↑
α1
AT1
ETA
Glucocorticoids
Vasodilation↓
Blood pressure↑
+
Contraction↑
Smooth muscle cells


Nighttime Noise in Particular Damaging !

European Heart Journal (2011) **32**, 1484–1492
doi:10.1093/eurheartj/ehr007

CLINICAL RESEARCH
Prevention/epidemiology

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

Francesco P. Cappuccio[1*†], Daniel Cooper[1], Lanfranco D'Elia[2], Pasquale Strazzullo[2], and Michelle A. Miller[1†]

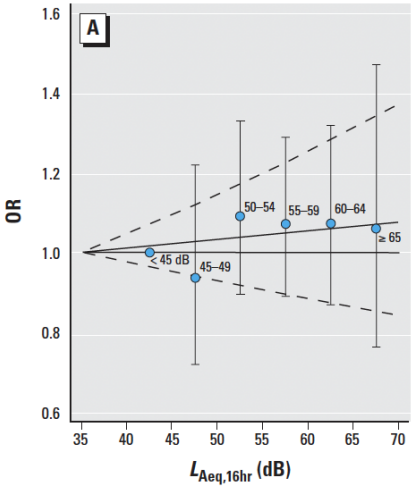
[1]Warwick Medical School, University of Warwick, CSB Building, UHCW Campus, Clifford Bridge Road, Coventry CV2 2DX, UK; and [2]Department of Clinical and Experimental Medicine, Federico II Medical School, University of Naples, Naples, Italy

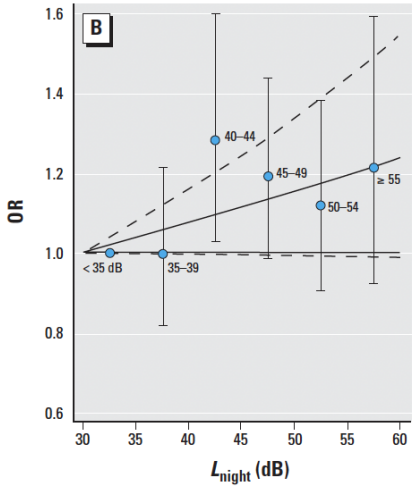
Received 7 August 2010; revised 13 December 2010; accepted 13 January 2011; online publish-ahead-of-print 7 February 2011

Hypertension and Exposure to Noise Near Airports: the HYENA Study

Lars Jarup,[1] Wolfgang Babisch,[2] Danny Houthuijs,[3] Göran Pershagen,[4] Klea Katsouyanni,[5] Ennio Cadum,[6] Marie-Louise Dudley,[1] Pauline Savigny,[1] Ingeburg Seiffert,[2] Wim Swart,[3] Oscar Breugelmans,[3] Gösta Bluhm,[4] Jenny Selander,[4] Alexandros Haralabidis,[5] Konstantina Dimakopoulou,[5] Panayota Sourtzi,[7] Manolis Velonakis,[7] and Federica Vigna-Taglianti,[6] on behalf of the HYENA study team

[1]Department of Epidemiology and Public Health, Imperial College London, St Mary's Campus, Norfolk Place, London, United Kingdom; [2]Department of Environment and Health at the Federal Environmental Agency (UBA), Berlin, Germany; [3]National Institute of Public Health and Environmental Protection (RIVM), Bilthoven, the Netherlands; [4]Institute of Environmental Medicine (IMM), Karolinska Institutet, Stockholm, Sweden; [5]Department of Hygiene and Epidemiology, National and Kapodistrian University of Athens, Athens, Greece; [6]Environmental Epidemiologic Unit, Regional Agency for Environmental Protection (ARPA), Piedmont Region, Grugliasco, Italy; [7]Laboratory of Prevention, Nurses School, National and Kapodistrian University of Athens, Athens, Greece





- **Nighttime noise**: significant increase blood pressure
- **Daytime noise**: no significance
- Per 10 dBA/Odds ratio Night: 1.14 !

Nighttime noise: more risk for hypertension ?

ORIGINAL ARTICLE

Is aircraft noise exposure associated with cardiovascular disease and hypertension? Results from a cohort study in Athens, Greece

Konstantina Dimakopoulou,[1] Konstantinos Koutentakis,[1] Ifigeneia Papageorgiou,[1] Maria-Iosifina Kasdagli,[1] Alexandros S Haralabidis,[1] Panayota Sourtzi,[2] Evangelia Samoli,[1] Danny Houthuijs,[3] Wim Swart,[3] Anna L Hansell,[4,5] Klea Katsouyanni[1,6]

the night. Specifically, the OR for hypertension per 10 dB increase in Lnight aircraft noise exposure was 2.63 (95% CI 1.21 to 5.71). Doctor-diagnosed cardiac arrhythmia was significantly associated with Lnight aircraft noise exposure, when prevalent and incident cases were considered with an OR of 2.09 (95% CI 1.
to 4.08). Stroke risk was also increased with increasing

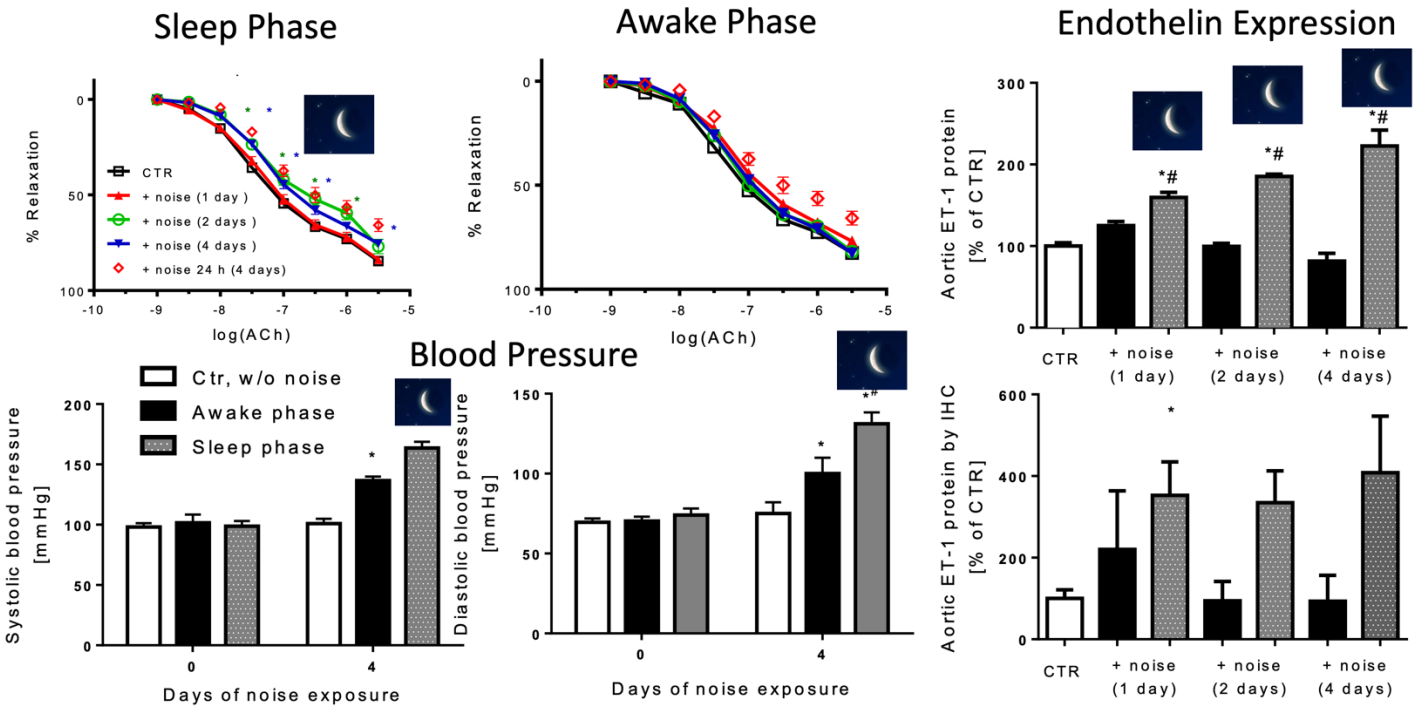
ORIGINAL ARTICLE

Does aircraft noise exposure increase the risk of hypertension in the population living near airports in France?

Anne-Sophie Evrard,[1] Marie Lefèvre,[1] Patricia Champelovier,[2] Jacques Lambert,[2,3] Bernard Laumon[4]

Results After adjustment for the main potential confounders, an exposure–response relationship was evidenced between the risk of hypertension and aircraft noise exposure at night for men only. A 10-dB(A) increase in L_{night} was associated with an OR of 1.34 (95% CI 1.00 to 1.97).

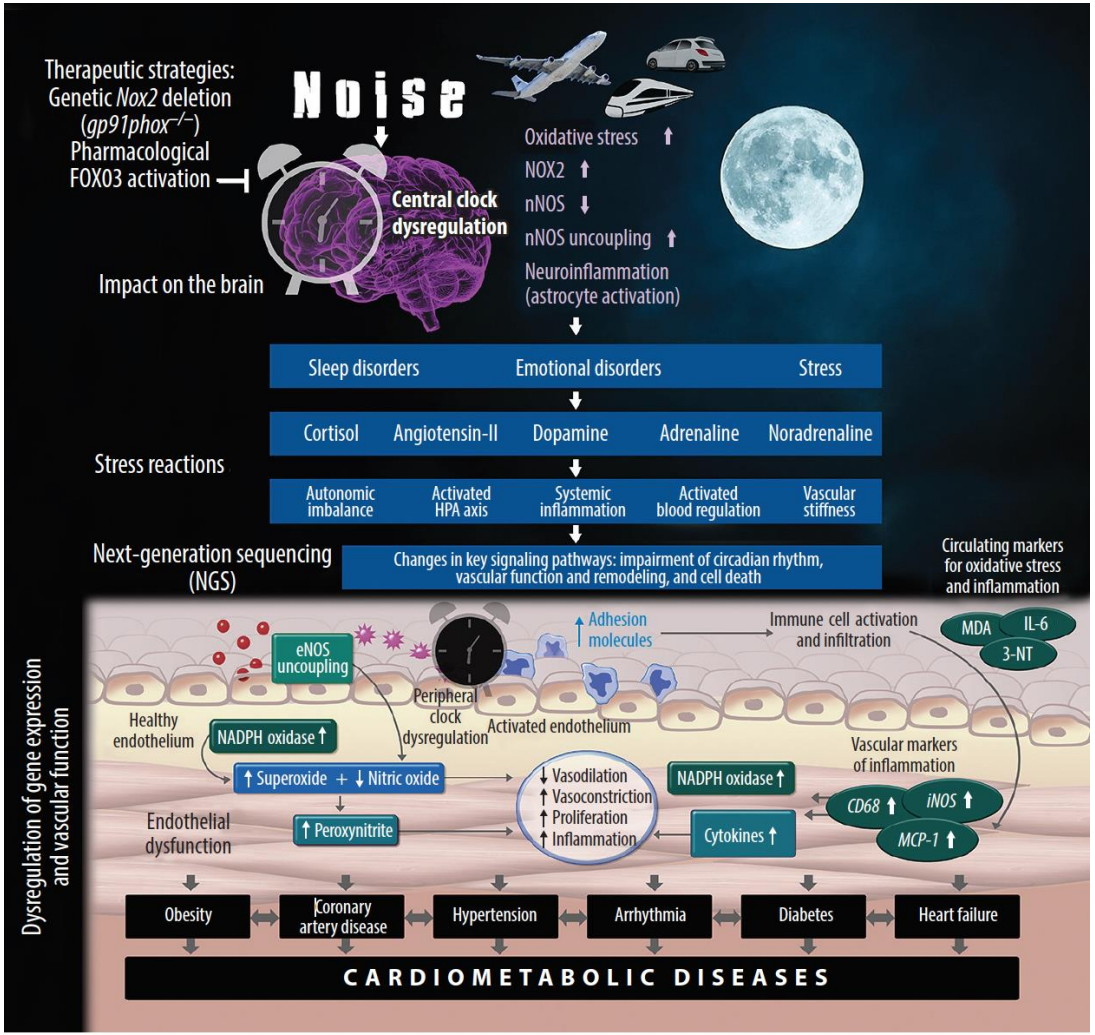
Nighttime noise in particular damaging



Kroeller Schön European Heart Journal 2018

Annual Review of Public Health

Adverse Cardiovascular Effects of Traffic Noise with a Focus on Nighttime Noise and the New WHO Noise Guidelines



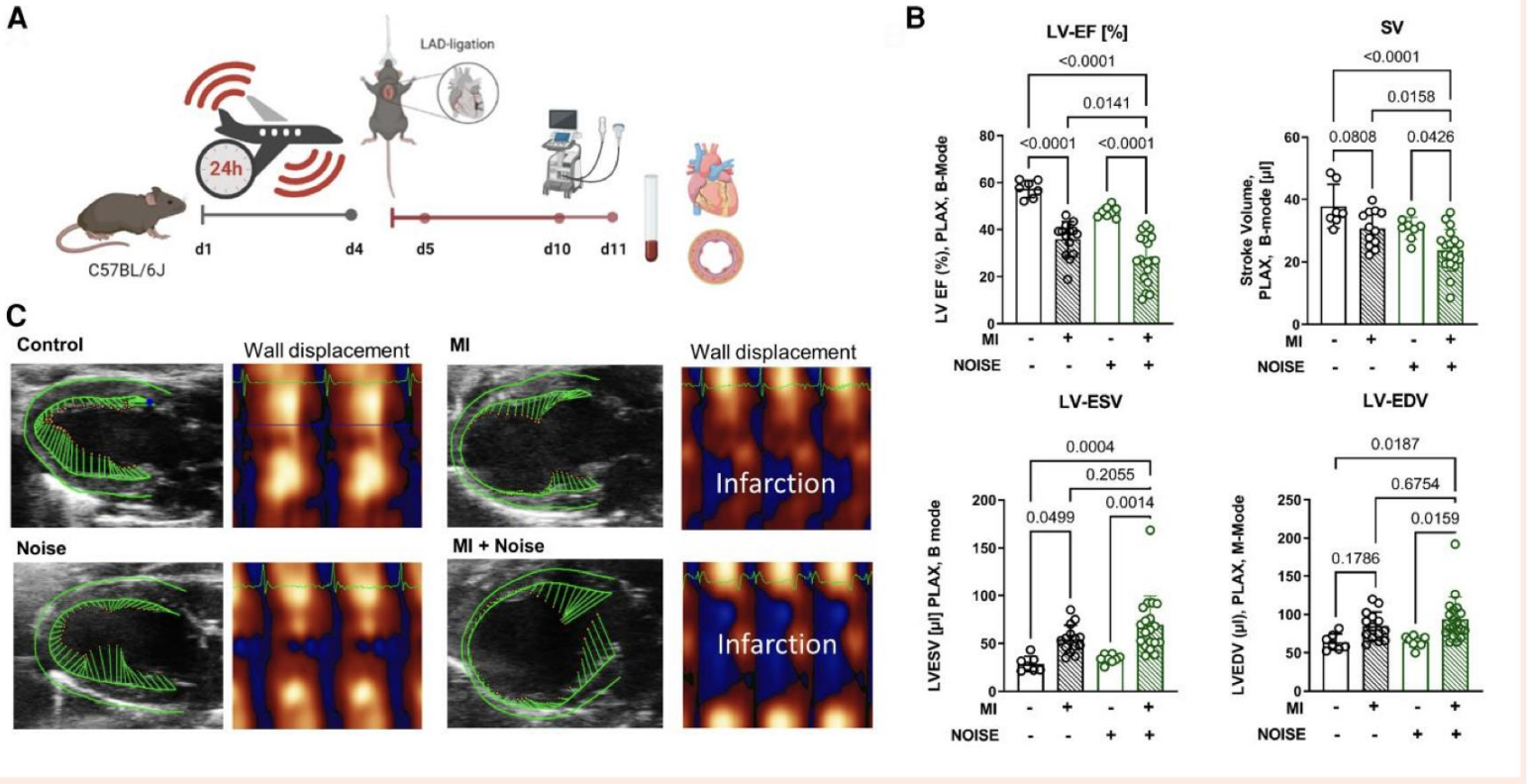
ESC European Society of Cardiology

Cardiovascular Research (2023) **119**, 1416–1426
https://doi.org/10.1093/cvr/cvad021

Aircraft noise exposure induces pro-inflammatory vascular conditioning and amplifies vascular dysfunction and impairment of cardiac function after myocardial infarction

Michael Molitor [1,2,3†], Maria T. Bayo-Jimenez[1†], Omar Hahad[1,3], Claudius Witzler[2], Stefanie Finger[2], Venkata S. Garlapati[1,2,3], Sanela Rajlic[4], Tanja Knopp[2], Tabea K. Bieler[2], Melania Aluia[1,2,3], Johannes Wild[1,2,3], Jeremy Lagrange[2,5], Recha Blessing[1], Steffen Rapp[6], Andreas Schulz[6], Hartmut Kleinert[7], Susanne Karbach[1,2,3], Sebastian Steven[1,2,3], Wolfram Ruf [2,3], Philipp Wild[1,2,3,6], Andreas Daiber[1,2,3†], Thomas Münzel [1,2,3*†], and Philip Wenzel[1,2,3*†]

Larger infarcts, worde left ventricular function



Gutenberg Health Study

Table 2 Echocardiographic and inflammatory parameters of the study population with MI and with or without noise annoyance

Aircraft noise annoyance	*No (n = 46)*	*Yes (n = 54)*	*P-value*
Echocardiography			
LV-EF (%)	65.6 (5.6)	62.5 (5.2)	**0.0053**
E/E′	8.71 (6.92/10.1)	8.21 (6.8/10.42)	0.6
LVMI (g/m^2.7)	38.8 (34.1/47.4)	44.3 (37.8/51.6)	0.088
RWT	0.44 (0.11)	0.43 (0.08)	0.5
Inflammatory parameters			
C-reactive protein	1.5 (1.2/3.3)	3.05 (1.77/5.81)	**0.0094**

Data are described as mean ± standard deviation (or with median Q1, Q3 if they are skew > 3) or percentage.
Significance $p<0.05$ is indicated by bolt values in the last column. LV-EF, left ventricular ejection fraction; LVMI, left ventricular mass index; RW, Relative wall thickness.

Environmental Research 238 (2023) 117108

Contents lists available at ScienceDirect

Environmental Research

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

Aircraft noise exposure and risk for recurrent cardiovascular events after acute coronary syndrome: A prospective patient cohort study

Hans-Georg Olbrich [a,*], Martin Röösli [b,c], Eva Herrmann [d], Christian Maschke [e], Kerstin Schadow [a], Torsten Hähnel [f], Hans-Jürgen Rupprecht [g], Martin Kaltenbach [h]

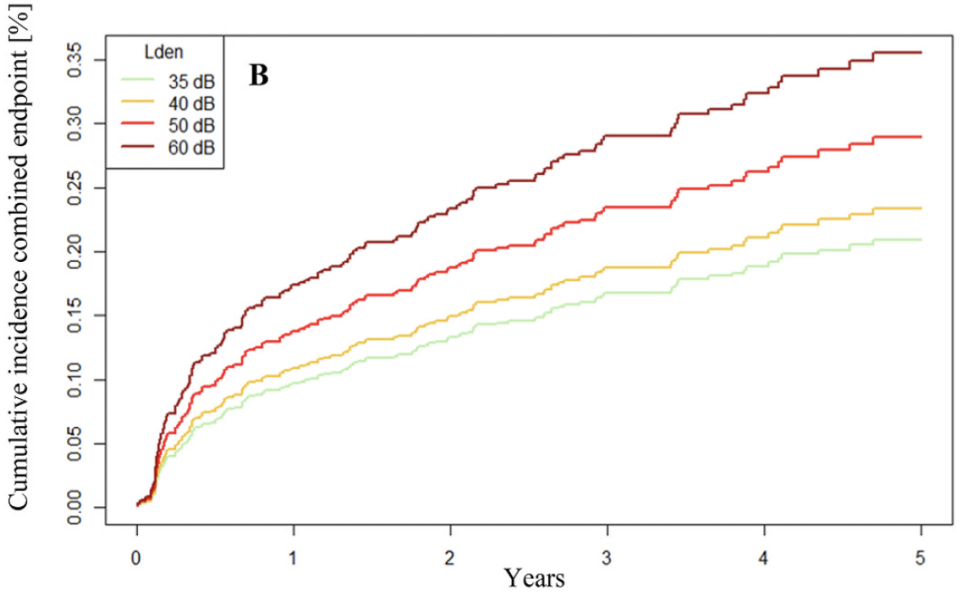


Fig. 3. Cumulative, confounder adjusted, incidence rates over 5 years of observation for the non-fatal (A) and combined (B) endpoints in relation to various levels of L_{den}, adjusted for age, sex, smoking status, body mass index, alcohol consumption, physical activity, and school education.

cardiovascular death, myocardial infarction, stroke, bypass surgery or percutaneous coronary intervention with stent implantation.

Mitigation of Transportation Noise Vascular Side Effects: Experimental Insight

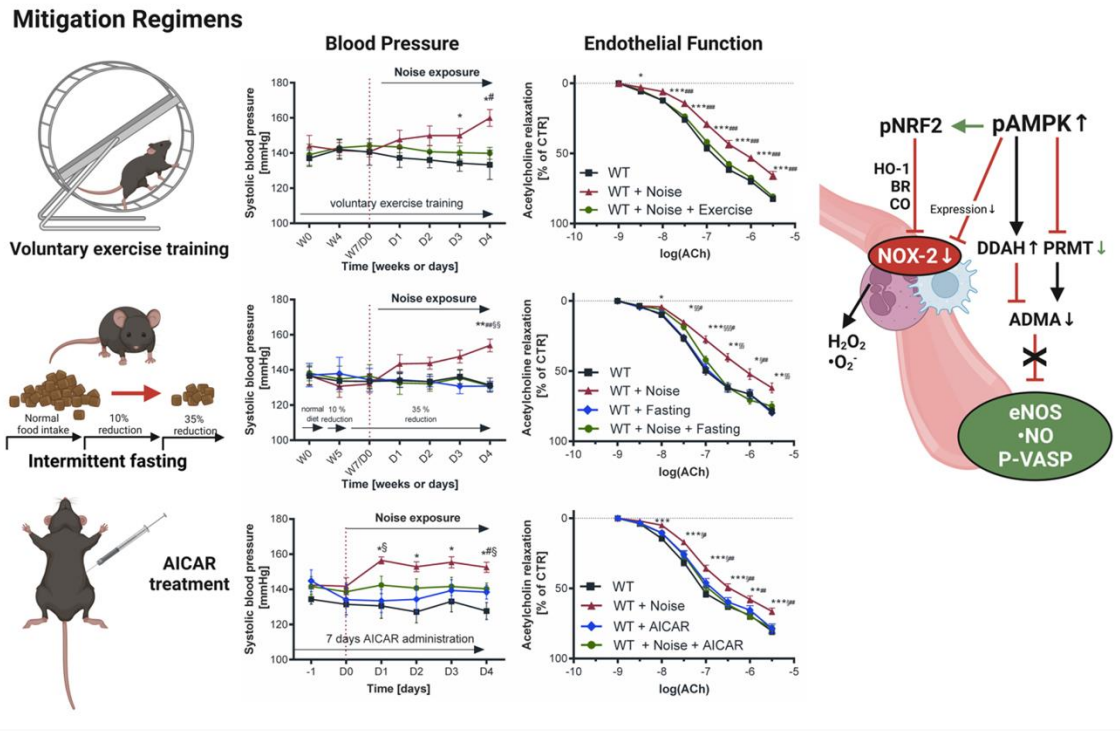
Noise mitigation: experimental studies

Role for endothelial AMP-Kinase

ESC European Society of Cardiology
European Journal of Preventive Cardiology (2023) **30**, 1554–1568
https://doi.org/10.1093/eurjpc/zwad075

FULL RESEARCH PAPER
Air pollution and environmental science

Mitigation of aircraft noise-induced vascular dysfunction and oxidative stress by exercise, fasting, and pharmacological α1AMPK activation: molecular proof of a protective key role of endothelial α1AMPK against environmental noise exposure



Reduction of noise stress with alpha and betareceptor blockade

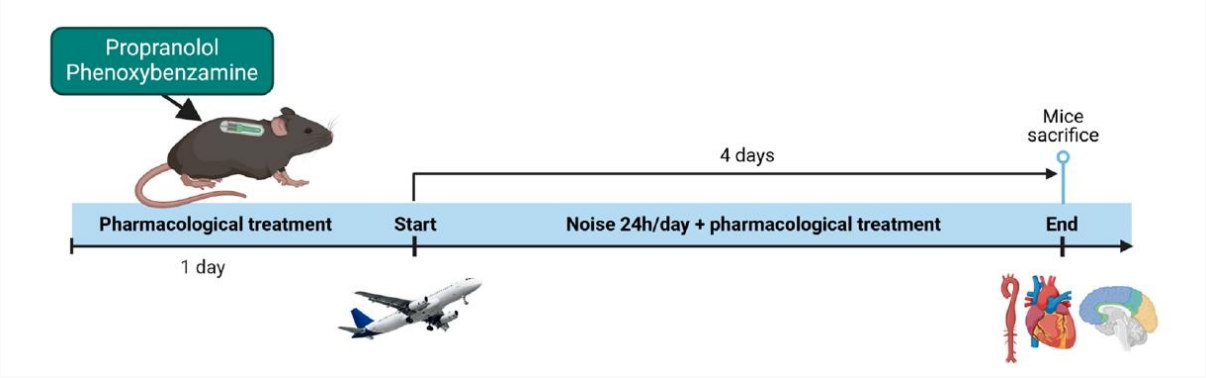
antioxidants

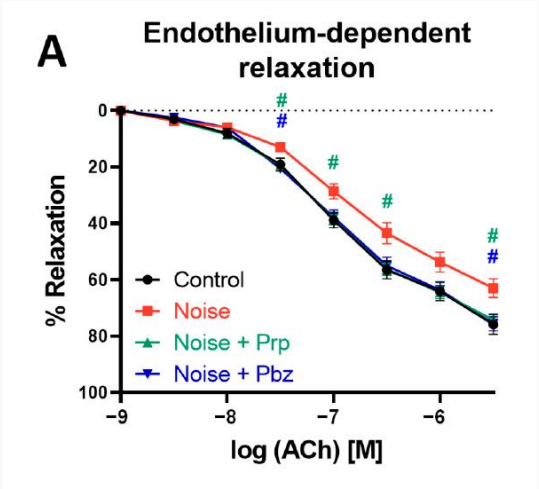
MDPI

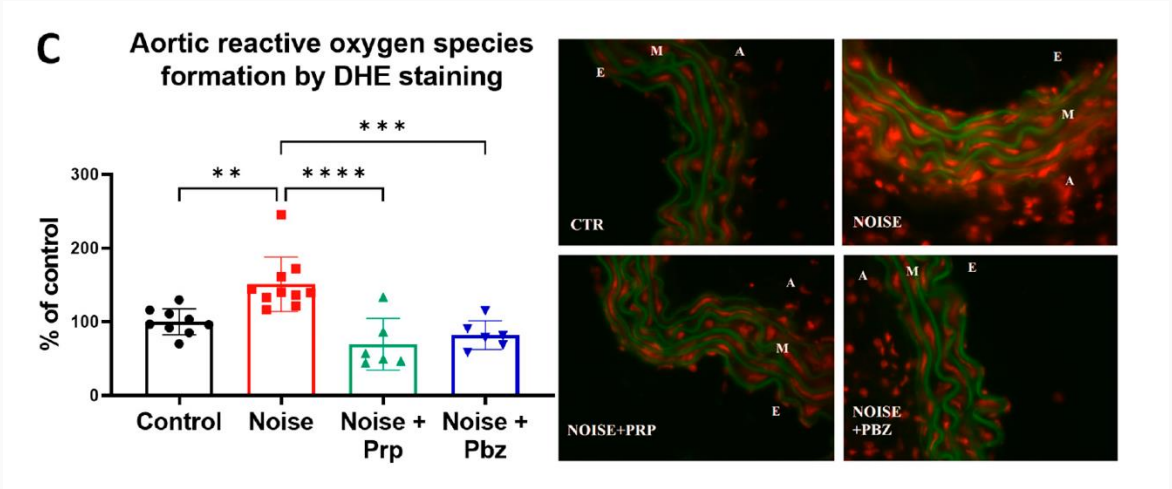
Article

Interventions by Cardiovascular Drugs Against Aircraft Noise-Induced Cardiovascular Oxidative Stress and Damage

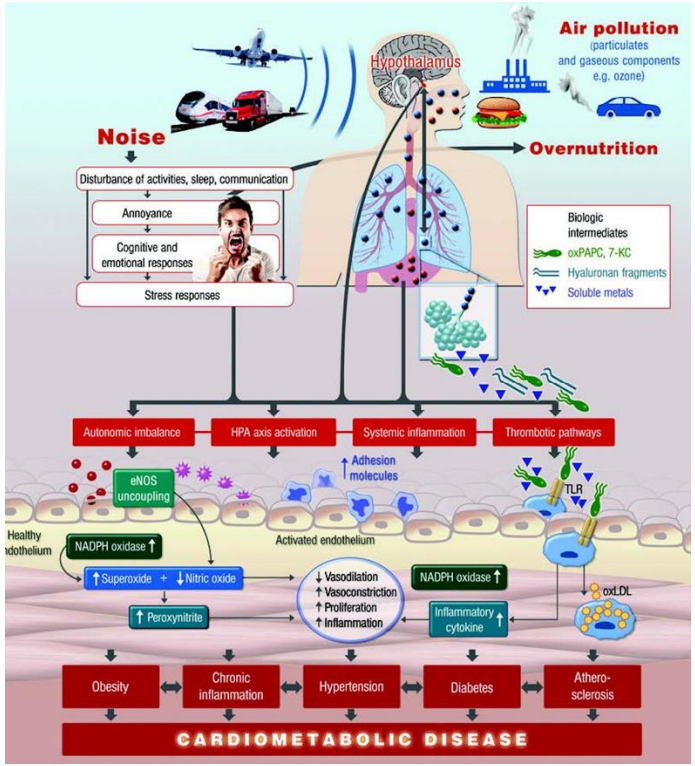
Marin Kuntić [1,2,†], Ivana Kuntić [1,†], Jiayin Zheng [1], Leonardo Nardi [3], Matthias Oelze [1], Arijan Valar [1], Dominika Mihaliková [1], Lea Strohm [1], Henning Ubbens [1], Qi Tang [4], Liyu Zhang [4], Guilherme Horta [3], Paul Stamm [1], Omar Hahad [1,2], Dilja Krueger-Burg [3], Huige Li [2,5], Sebastian Steven [1,2,6], Adrian Gericke [4], Michael J. Schmeisser [3], Thomas Münzel [1,2] and Andreas Daiber [1,2,*]

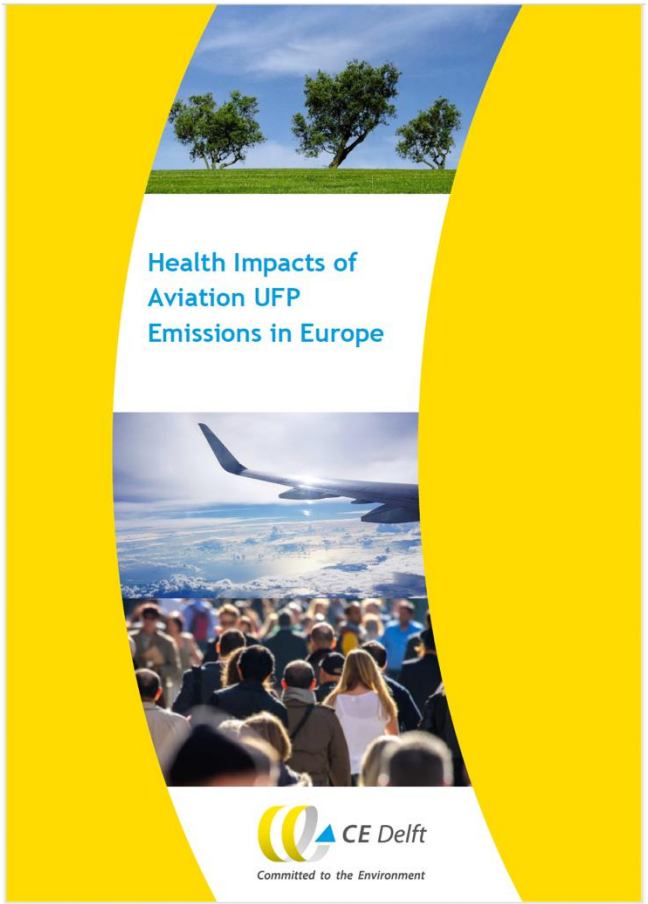

Propranolol
Phenoxybenzamine
Mice
sacrifice
4 days
Pharmacological treatment
Start
Noise 24h/day + pharmacological treatment
End
1 day


A
Endothelium-dependent
relaxation
% Relaxation
log (ACh) [M]
Control
Noise
Noise + Prp
Noise + Pbz


C
Aortic reactive oxygen species
formation by DHE staining
% of control
Control
Noise
Noise +
Prp
Noise +
Pbz
CTR
NOISE
NOISE+PRP
NOISE
+PBZ

Noise and air pollution coexposure





Aviation's health effects on populations near airports

Aviation emissions are a climate concern, and also have a serious impact on air quality. Yet, this issue has not received much attention from regulators or the aviation industry.

When jet fuel is burnt, it releases particulate matter (PM) of different sizes, including ultrafine particles (UFPs), tiny particles below the size of 100 nanometre in diameter - approximately 1000 times smaller than a human hair. Despite growing evidence that **UFP exposure can contribute to respiratory symptoms, heart rate variability, blood pressure problems and have long-term effects on mortality,** this pollutant remains largely under researched and unregulated.

The study **provides a first estimate of the health effects caused by aviation-related UFPs in Europe**, by summarizing the available scientific evidence, and extrapolating data from the Amsterdam Schiphol Airport area to the main European airports. The analysis estimates that **a total of 280,000 cases of high blood pressure, 330,000 cases of diabetes, and 18,000 cases of dementia may be linked to UFP emissions among the 51,5 million people living around the 32 busiest airports in Europe.**

More research required:

- Cardiovas-cular risk factors + noise
- Air Pollution + noise

+ Noise, +Air Pollution (N); both N+N

Redox Biology 59 (2023) 102580

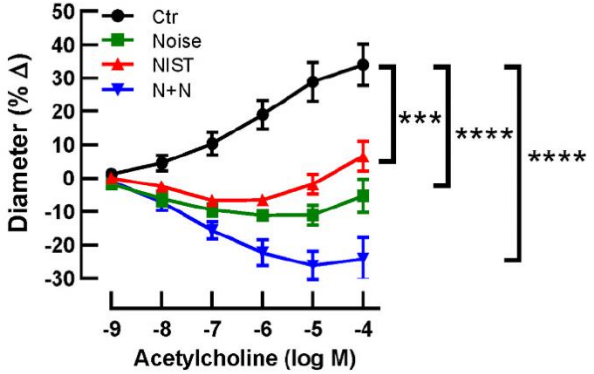
Contents lists available at ScienceDirect

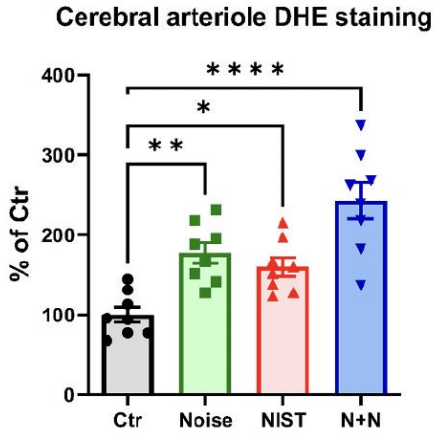
Redox Biology

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

Co-exposure to urban particulate matter and aircraft noise adversely impacts the cerebro-pulmonary-cardiovascular axis in mice

Marin Kuntic [a,1], Ivana Kuntic [a,1], Roopesh Krishnankutty [b,1], Adrian Gericke [c], Matthias Oelze [a], Tristan Junglas [a], Maria Teresa Bayo Jimenez [a], Paul Stamm [a,d], Margaret Nandudu [a], Omar Hahad [a,d], Karin Keppeler [a], Steffen Daub [a], Ksenija Vujacic-Mirski [a], Sanela Rajlic [a,e], Lea Strohm [a], Henning Ubbens [a], Qi Tang [c], Subao Jiang [c], Yue Ruan [c], Kenneth G. Macleod [b], Sebastian Steven [a], Thomas Berkemeier [f], Ulrich Pöschl [f], Jos Lelieveld [g], Hartmut Kleinert [h], Alex von Kriegsheim [b,1], Andreas Daiber [a,d,*,1], Thomas Münzel [a,d,**,1]





Additive negative effects

Europa / Funding & Tenders Portal notification

Dear Madam/Sir,

Congratulations. Your proposal has reached the stage of Grant Agreement preparation.
To view the evaluation results and the instructions on how to provide additional information and data required for the preparation of your Grant Agreement, log on to the Funding & Tenders Portal > My Project(s) (https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/myarea/projects) and click on Action > Manage Project.

Regards,
Grant Management Services

Markopolo:

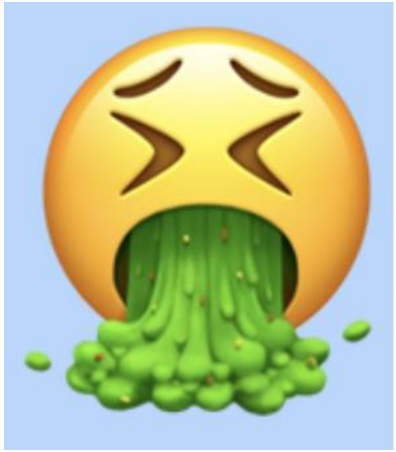
Markers of pollution

MARKOPOLO

9.3 Millionen for 4 years

Prof. Andreas Daiber

The future…….



The future

2050: Total world population: 9.7 Billion People

Total aircraft passenger number in 2050: 10 Billion