Burden of disease due to transportation noise in the Nordic countries

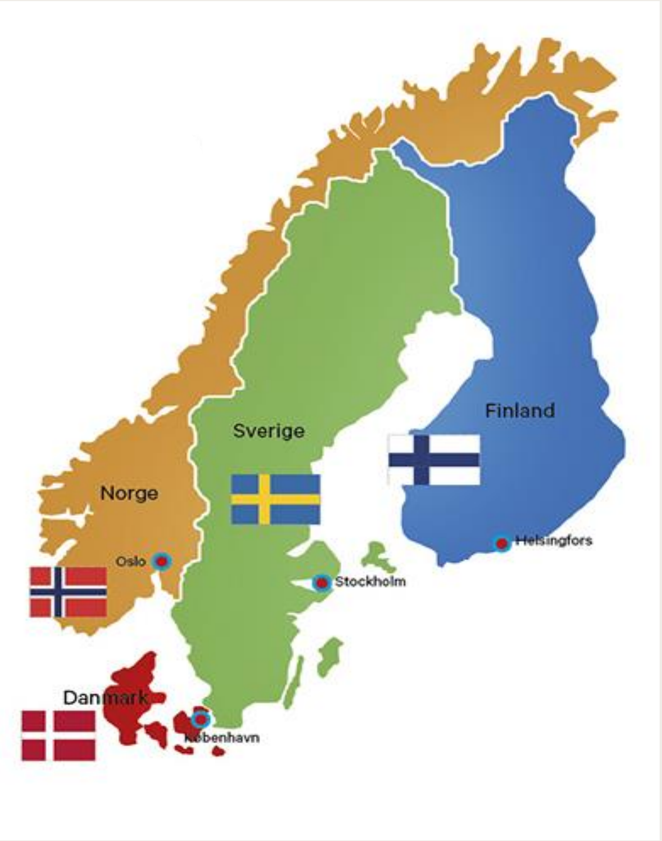
- *experiences with the use of data from strategic noise mapping*

Burden-EU webinar – The relevance of noise for population health: novel insights into estimating the disease burden of environmental noise, 26th January, 2024

Gunn Marit Aasvang
Norwegian Institute of Public Health
Department of Air Quality and Noise

Aims

- Estimate the burden of disease (BoD) due to road traffic and railway noise in the Nordic countries and capital cities
- Establish a common framework for assessment of BoD due to noise in the Nordic countries



- Part of the Nordic collaboration project **NordSOUND**
  - *Funded by NordForsk*

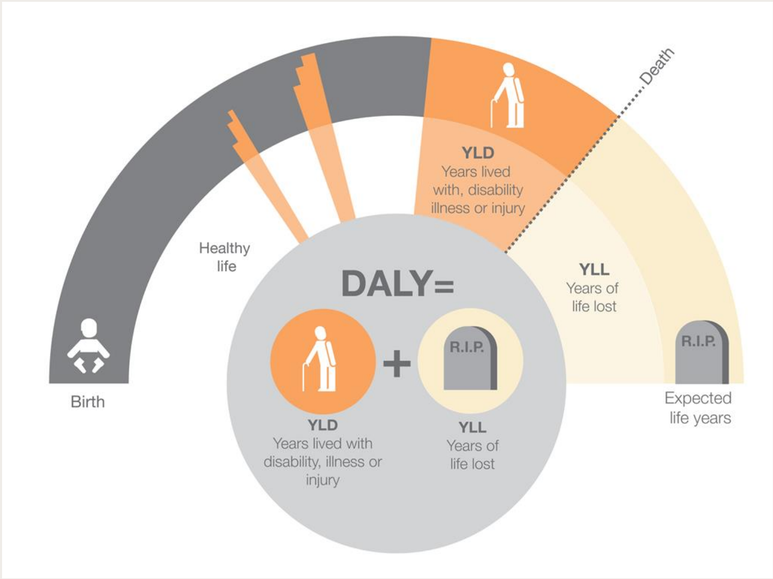
NordSOUND

Methods

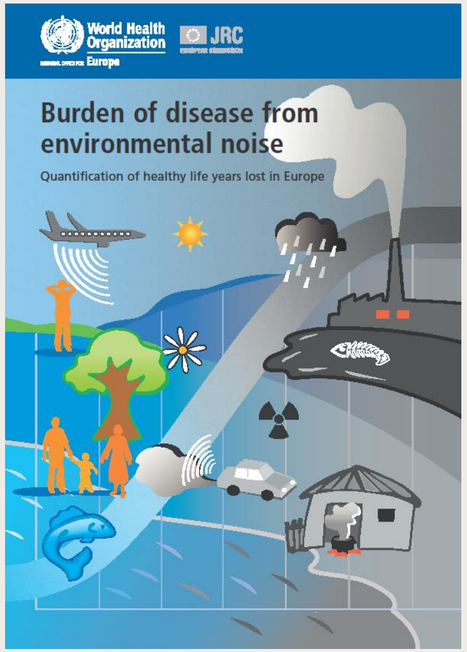
Outline

Burden of disease (BoD) assessment

- BoD was estimated as *Disability-Adjusted Life Years* (DALYs)



- Exposure-based method
  - Noise exposure (L_{den}, L_{night}) distributions (road traffic and railway noise)
  - Exposure-response functions (ERFs)
  - Disability weights (DW) for non-fatal outcomes
  - Background health data (morbidity, mortality)



Method

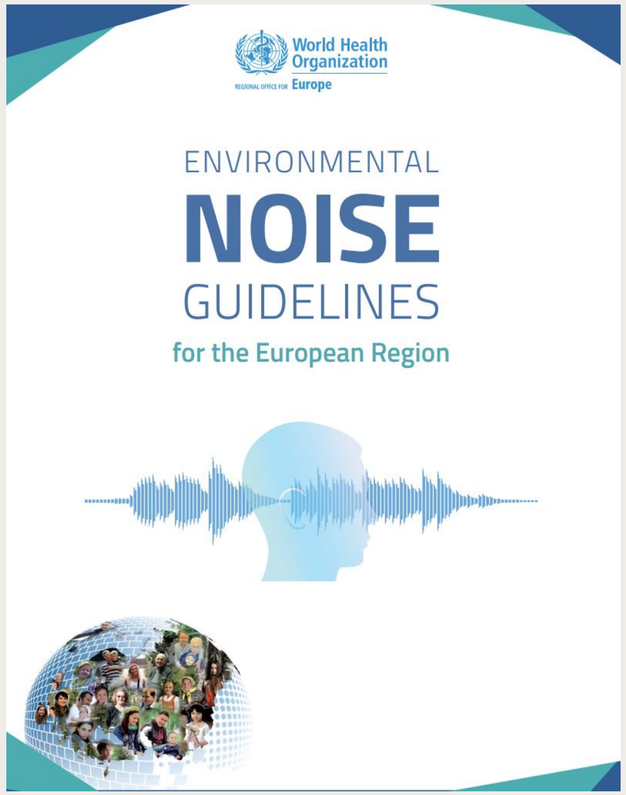
Noise exposure – road traffic and railway

- Noise mappings according to Environmental Noise Directive, END 2002/49/EC
  - Agglomerations with more than 100 000 inhabitants
  - Outside urban areas, along major roads (> 3 mill vehicles a year) and rails (> 30 000 trains a year)
  - $L_{den} \geq 55$ dB and $L_{night} \geq 50$ dB
  - Accessible from The European Environmental Agency (EEA) https://www.eea.europa.eu/themes/human/noise/noise-fact-sheets
  - Available for all Nordic countries
  - Data from the 2016 mapping was used
- Nationwide noise mappings
  - Available for Denmark and Norway
  - Covers all residential buildings in the country

Methods

Health outcomes, ERFs and backround disease rates

- Main health outcomes
  - Annoyance (%HA), Risk function from WHO review, DW = 0.02,
  - Sleep disturbance (%HSD), Risk function from WHO review, DW = 0.07
  - Ischaemic heart disease, IHD (WHO review: RR = 1.08 (1.01-1.15) per 10 dB increase)
- Additional health outcomes
  - Stroke, RR= 1.06 (1.03-1.08) (Roswall et al., EHP 2021)
  - Diabetes, RR= 1.11 (1.04-1.18) (New meta-analysis based on Vienneau et al., 2019)
- Background health data
  - YLD/YLL rates for IHD, stroke and diabetes from the Global Burden of Disease (GBD) study



Method

Estimation of DALYs due to noise

- High annoyance (HA) and high sleep disturbance (HSD)
  - Direct assessment based on noise exposure distribution and ERFs

    Example for HA due to road traffic noise:

    $YLD_{HA} = N_{HA} \times DW$

- IHD, stroke and diabetes
  - Based on RRs and assessment of Population Attributable Fraction (PAF) for each health outcome

    $PAF = ((\Sigma (Pi \cdot RRi) - 1) / \Sigma (Pi \cdot RRi)$ (P*i:* % of population in exposure category *i)*

    Example for IHD due to road traffic noise:

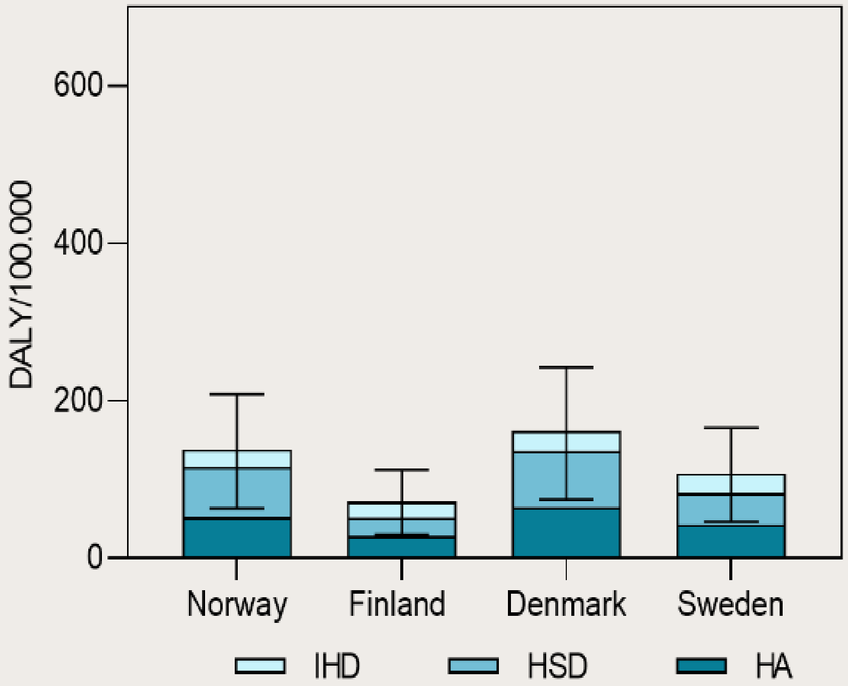
    $YLD_{IHD, RTN} = PAF \times YLD_{IHD, GBD}$

    $YLL_{IHD, RTN} = PAF \times YLL_{IHD, GBD}$

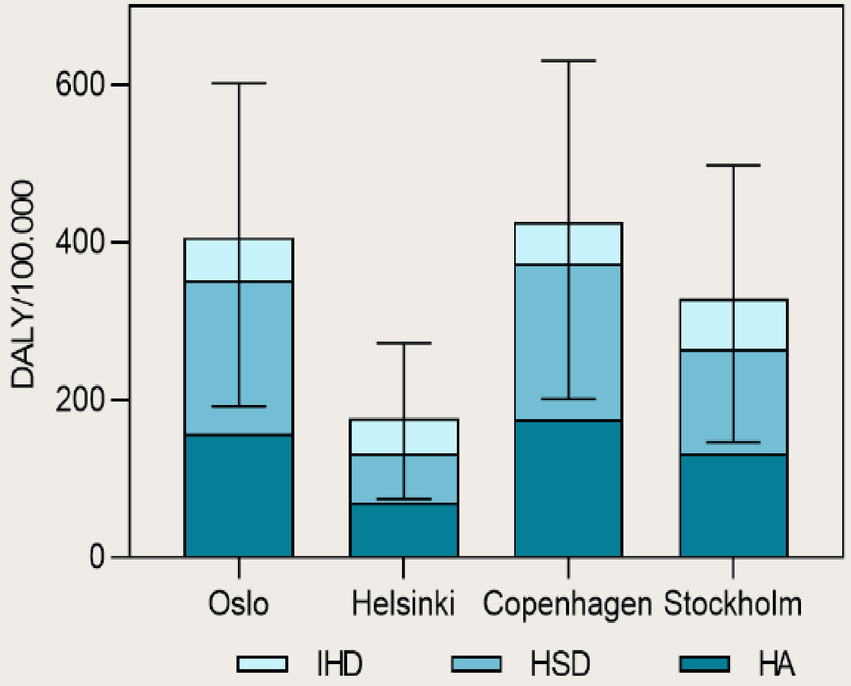
Results

Estimated DALYs due to road traffic noise in the Nordic countries and capital cities

Based on noise exposure data according to END reported to EC for 2016



HA = High annoyance
HSD = High sleep disturbance
IHD = Ischaemic heart disease



Oslo = Oslo and adjacent agglomerations
Copenhagen = Copenhagen and adjacent agglomerations

Results

Estimated DALYs due to road traffic noise in the Nordic countries and capital cities

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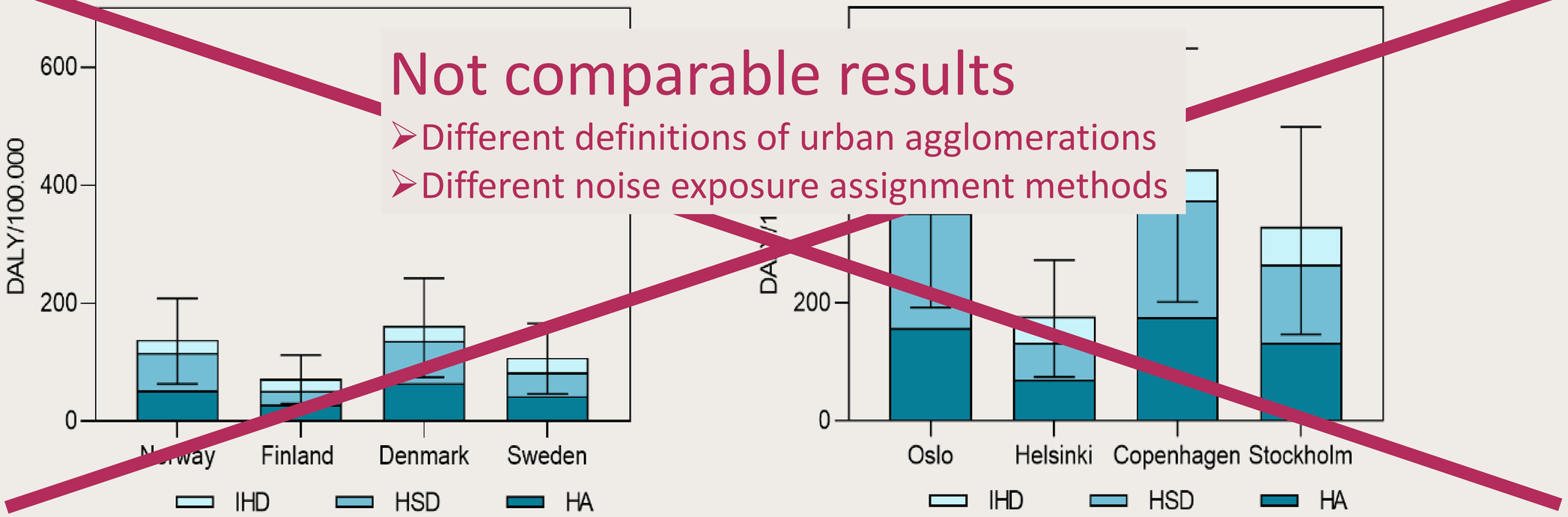


Not comparable results

- Different definitions of urban agglomerations
- Different noise exposure assignment methods

HA = High annoyance
HSD = High sleep disturbance
IHD = Ischaemic heart disease

Oslo = Oslo and adjacent agglomerations
Copenhagen = Copenhagen and adjacent agglomerations

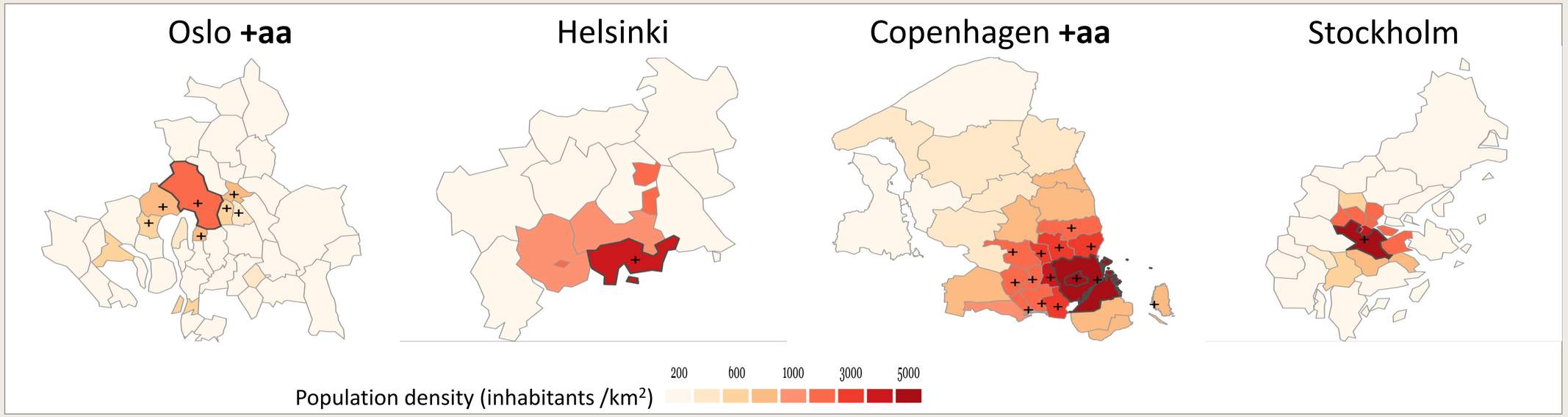
Differences between the Nordic countries

END data reported to the EC (2017)

Geographical areas – Nordic capital cities

With or without adjacent municipalities (< 100.000 inhabitants)

- The criteria used to define geographical areas of agglomerations
  - Sweden appeared to strictly include municipalities with more than 100,000 inhabitants (END criteria)
  - Finland included municipalities with more than 100,000 inhabitants, except Kaunianen with 8,500 inhabitants
  - Norway and Denmark used more flexible definitions and included adjacent agglomerations (+aa), when these aggregated to a continuous urban agglomeration, e.g. Oslo and adjacent agglomeration.

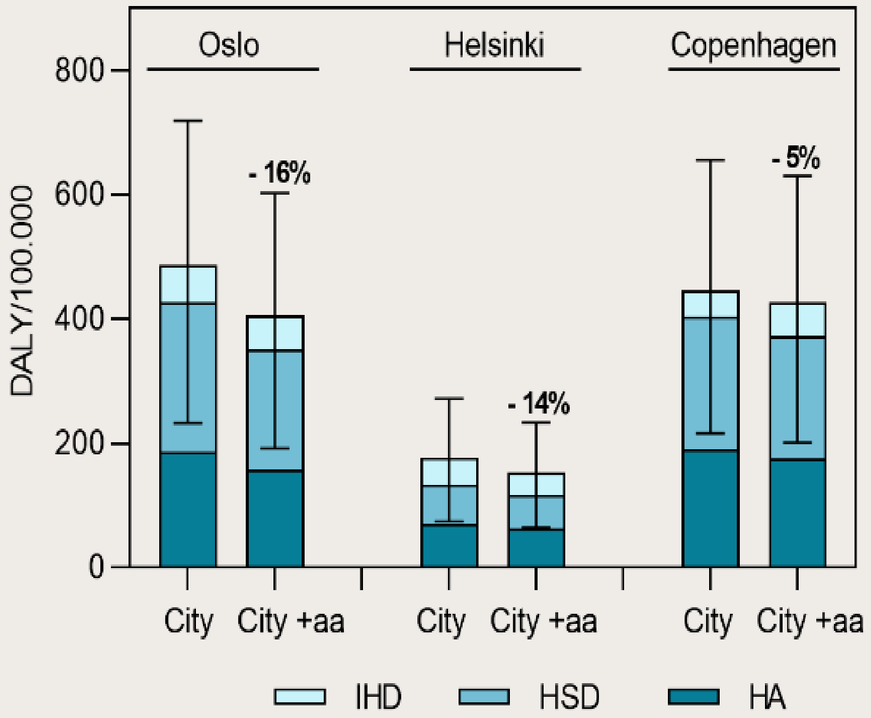


Results

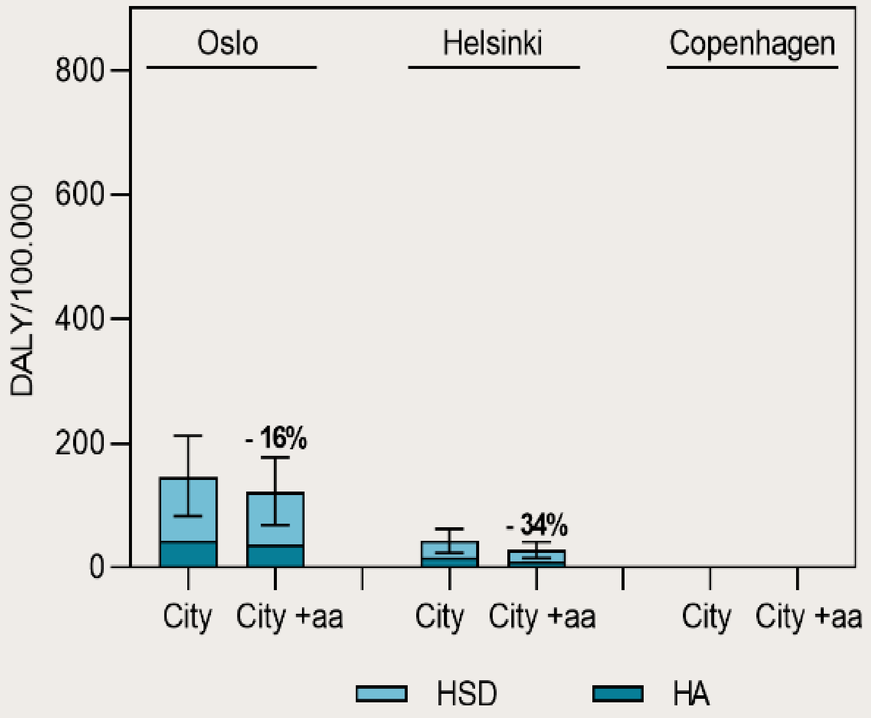
Estimated DALYs due to transportation noise in the Nordic capital cities

Impact of different definitions of agglomeration (Capital city only versus Capital city and adjacent agglomerations (+aa))

Road traffic noise



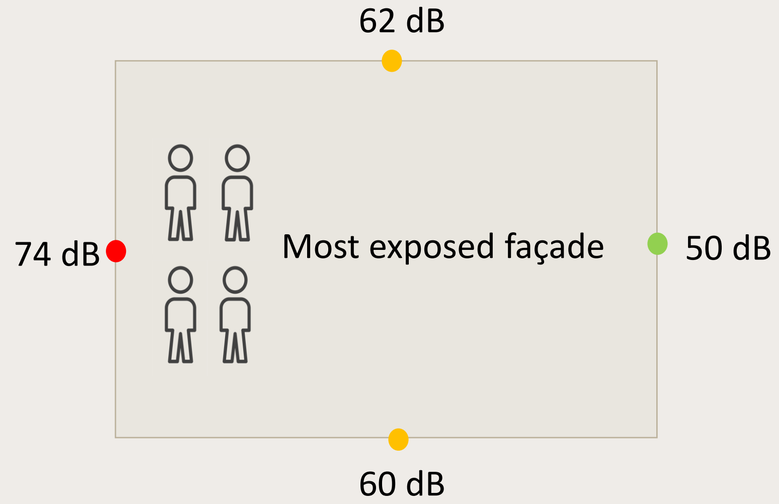
Railway noise



Differences between the Nordic countries

END data reported to the EC

- Noise assignment method
  - Norway, Sweden and Denmark used the Nordic noise models and assigned all inhabitants in a building to the highest noise level calculated for **“most exposed façade”.**
  - Finland employed the **“equal distribution principle”** according to Cnossos-EU



- Impact of noise assignment method on BoD could be assessed for Helsinki as both methods was used
  - For road traffic noise: “Equal distribution” resulted in **56% lower BoD** compared to “Most exposed façade” assignment.
  - For railway noise: “Equal distribution” resulted in **64 % lower BoD** compared to “Most exposed façade” assignment.

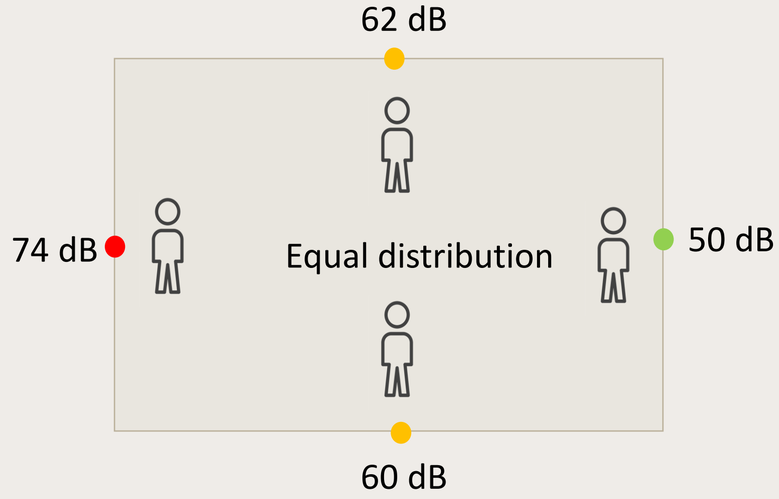
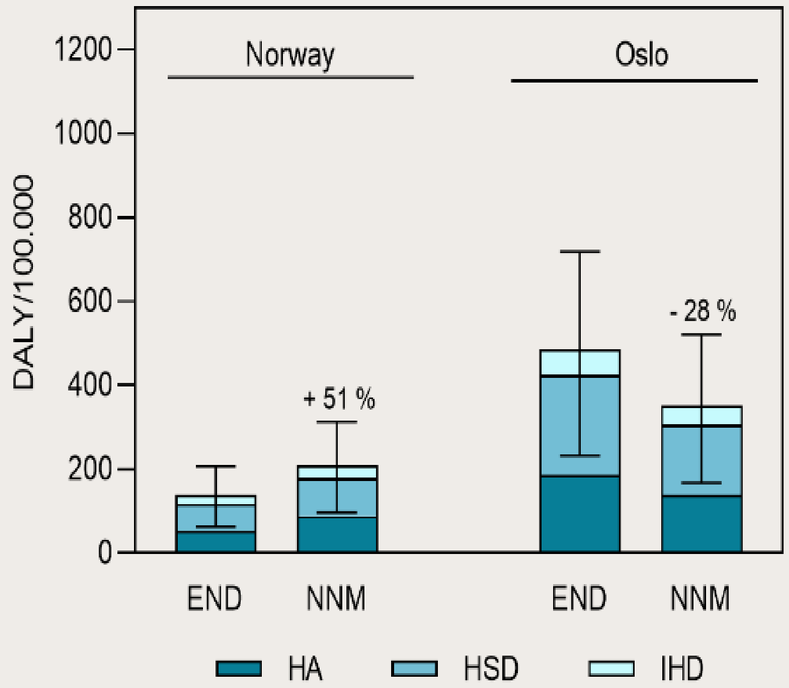


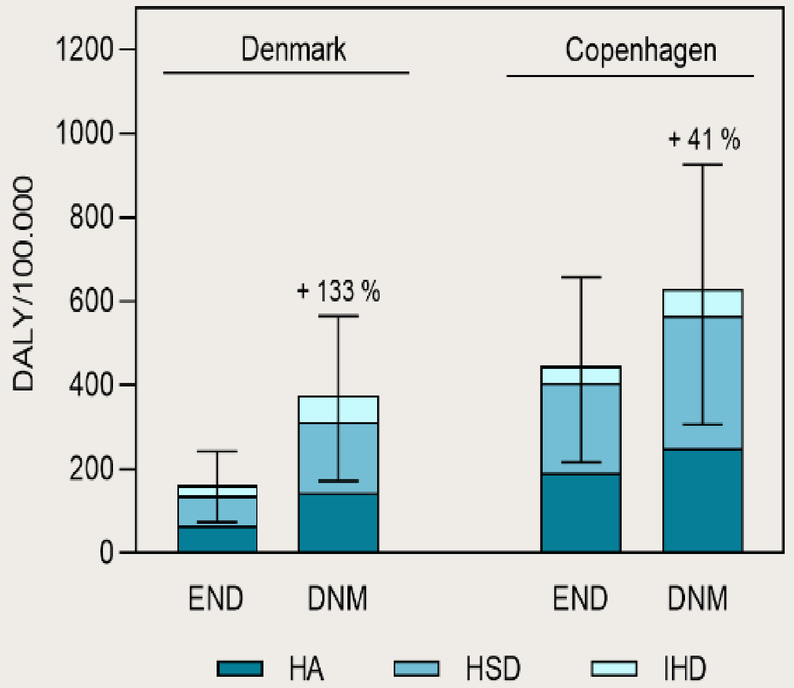
Illustration from colourbox.com

Results

Estimated DALYs due to road traffic noise in Norway and Denmark

Noise exposure based on END versus nationwide noise models





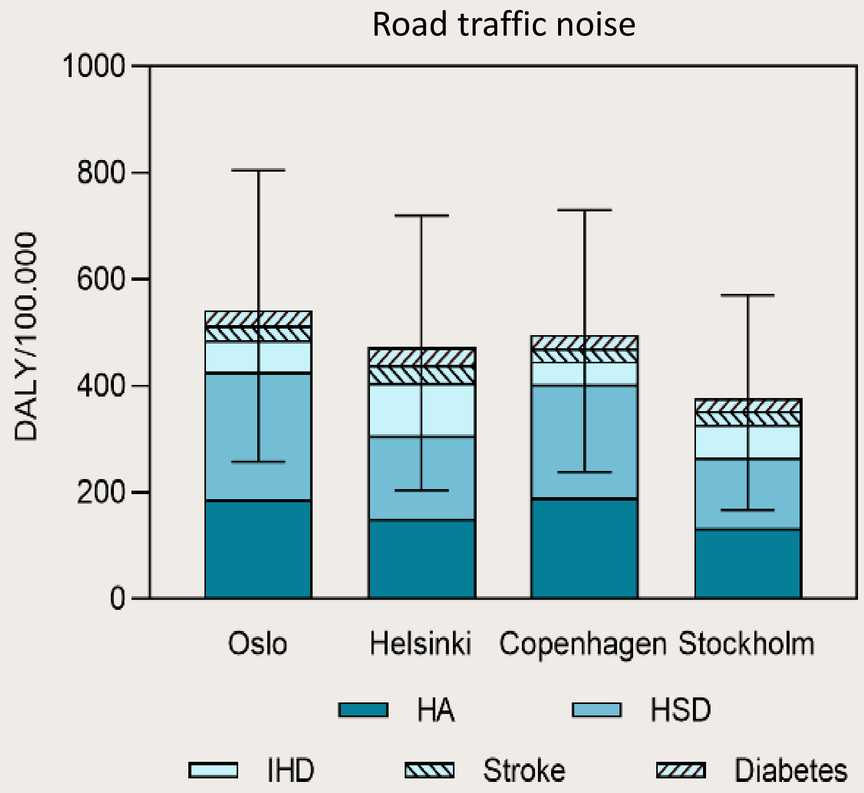
NNM = Norwegian nationwide model
DNM = Danish nationwide model

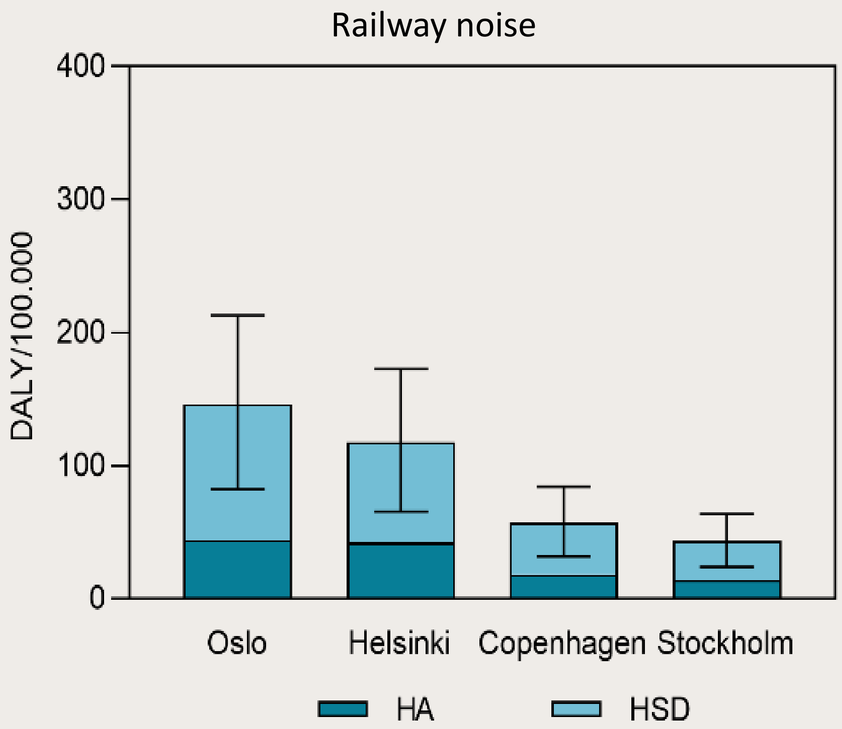
HA = High annoyance
HSD = High sleep disturbance
IHD = Ischaemic heart disease

Results

Estimated DALYs due to transportation noise in the Nordic capital cities

Based on the most comparable input data: capital (municipality only), most exposed facade assignment





Summary and concluding remarks

Burden of disease due to transportation noise in the Nordic countries

- Estimated DALYs based on END data reported to EC (2017) are not comparable, due to:
  - Differences in the definitions of geographical areas, i.e. areas included in the “urban agglomerations”
  - Differences in the noise exposure assignment methods
- No comparable DALYs due to noise could be obtained for the Nordic countries, only for the capital cities
- Based on identified comparable noise exposure data we estimated:
  - 300 – 500 DALYs/100 000 for road traffic noise (Stockholm lowest, Oslo highest)
  - 40 – 140 DALYs/100 000 for railway noise (Stockholm lowest, Oslo highest)
- BoD assessment based on END underestimates the national burden due to noise
- Further harmonization of noise exposure modelling is important to assure comparable BoD estimates across countries and cities

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Gunn Marit Aasvang [a,b,*], Leo Stockfelt [c,d], Mette Sørensen [e,f], Anu W. Turunen [g], Nina Roswall [e], Tarja Yli-Tuomi [g], Mikael Ögren [c,d], Timo Lanki [g,h,i], Jenny Selander [j], Natalia Vincens [c], Andrei Pyko [j,k], Göran Pershagen [j,k], Gerhard Sulo [l], Anette Kocbach Bølling [a,b]

[a] Department of Air Quality and Noise, Norwegian Institute of Public Health Oslo, Norway
[b] Centre for Disease Burden, Norwegian Institute of Public Health, Bergen, Norway
[c] Department of Occupational and Environmental Medicine, Sahlgrenska University Hospital, Gothenburg, Sweden
[d] Occupational and Environmental Medicine, School of Public Health and Community Medicine, Institute of Medicine, University of Gothenburg, Gothenburg, Sweden
[e] Danish Cancer Society Research Centre, Copenhagen, Denmark
[f] Department of Natural Science and Environment, Roskilde University, Denmark
[g] Department of Health Security, Finnish Institute for Health and Welfare, Kuopio, Finland
[h] School of Medicine, University of Eastern Finland, Kuopio, Finland
[i] Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio, Finland
[j] Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden
[k] Center for Occupational and Environmental Medicine, Region Stockholm, Stockholm, Sweden
[l] Department of Global Public Health and Primary Care, University of Bergen, Norway

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ABSTRACT

Background: Environmental noise is of increasing concern for public health. Quantification of associated health impacts is important for regulation and preventive strategies.
Aim: To estimate the burden of disease (BoD) due to road traffic and railway noise in four Nordic countries and their capitals, in terms of DALYs (Disability-Adjusted Life Years), using comparable input data across countries.
Method: Road traffic and railway noise exposure was obtained from the noise mapping conducted according to the Environmental Noise Directive (END) as well as nationwide noise exposure assessments for Denmark and Norway. Noise annoyance, sleep disturbance and ischaemic heart disease were included as the main health outcomes, using exposure-response functions from the WHO, 2018 systematic reviews. Additional analyses included stroke and type 2 diabetes. Country-specific DALY rates from the Global Burden of Disease (GBD) study were used as health input data.
Results: Comparable exposure data were not available on a national level for the Nordic countries, only for capital cities. The DALY rates for the capitals ranged from 329 to 485 DALYs/100,000 for road traffic noise and 44 to 146 DALY/100,000 for railway noise. Moreover, the DALY estimates for road traffic noise increased with up to 17% upon inclusion of stroke and diabetes. DALY estimates based on nationwide noise data were 51 and 133% higher than the END-based estimates, for Norway and Denmark, respectively.
Conclusion: Further harmonization of noise exposure data is required for between-country comparisons. Moreover, nationwide noise models indicate that DALY estimates based on END considerably underestimate national BoD due to transportation noise. The health-related burden of traffic noise was comparable to that of air pollution, an established risk factor for disease in the GBD framework. Inclusion of environmental noise as a risk factor in the GBD is strongly encouraged.

1. Introduction

Noise is an environmental stressor that disturbs communication, concentration, rest and sleep and leads to emotional responses, often measured as noise annoyance (Guski et al., 2017). Noise impacts sleep, both in terms of acute effects on physiological sleep processes as well on subjectively experienced sleep quality (Basner and McGuire, 2018). In the last decade, there has been a continued scientific effort to study the

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