Noise annoyance and WHO’s new Noise Guidelines from 2018

Danish Sound Day 2019 - Torben Holm Pedersen
Noise Annoyance

An emotional and attitudinal reaction from a person exposed to noise in a given context.

“Noise annoyance is a primary indication that noise is a problem, and by itself noise annoyance means that the quality of life is adversely affected.”
Thinking about the last year or so, when you are here at home, how much does noise from road traffic bother, disturb, or annoy you?

Not at all - Slightly - Moderately - Very - Extremely
Calculation of noise levels - \( L_{\text{den}} \)

- \( L_{\text{den}} \) (yearly average) at the most exposed façade for each respondent

- Nord2000 calculation method taking into account:
  - Ground surface types, including the road surface
  - Traffic intensity, composition and speed
  - Height of receiver (respondents)
  - Wind and weather
  - Screens/buildings
  - Terrain shape
Motorways and urban roads

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Fraction</th>
</tr>
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<tbody>
<tr>
<td>Motorways</td>
<td>3.446</td>
</tr>
<tr>
<td>Urban roads</td>
<td>3.315</td>
</tr>
<tr>
<td>Total</td>
<td>6.761</td>
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</tbody>
</table>

Noise annoyance from urban roads and motorways. Vejdirektoratet report 565, 2016
Highly annoyed: Motorways vs. urban roads

Highly Annoyed (Urban roads) and Highly Annoyed (Motorways) are compared with a graph. The graph shows that for a given sound pressure level ($L_{den}$), the percentage of people who are highly annoyed is higher for urban roads than for motorways. Specifically, the difference is 11 dB, and 2.5 times as many are highly annoyed by urban roads compared to motorways.
Noise annoyance from different sources

The percentage of annoyed is a better descriptor of the problem than noise levels.
Health effects

Number of persons affected

Severity
Health effects

Number of persons affected

Severity

Mortality

Disease (insomnia, cardiovascular)

Risk factors (blood pressure, cholesterol, blood clotting, glucose)

Stress indicators (autonomous response, stress hormones)

Feeling of discomfort (disturbance, annoyance, sleep disturbance)
Cardiovascular diseases

Exposure–response curves of road and aircraft noise and cardiovascular endpoints RTN and hypertension (24 studies, noise indicator LAeq16h); RTN and myocardial infarction (five studies, noise indicator LAeq16h); RTN and stroke (one study, noise indicator LDEN); AN and hypertension (five studies, noise indicator LDN); and AN and MI (one study, noise indicator LDN). RTN=road traffic noise. AN=aircraft noise.

Incident Myocardial Infarction (Blodprop i hjertet)

DK, n = 57,053

Association between exposure to road traffic noise (L_{den}) at the residence at the time of diagnosis and incident MI, adjusted for sex, smoking status, smoking duration, smoking intensity, intake of fruit, vegetables and alcohol, BMI, physical activity, calendar year, education, railway and airport noise, and air pollution. Solid line: incidence rate ratio, dashed lines: 95% confidence interval. The median (56.4 dB) is the reference. The columns at the x-axis show the distribution of exposure to road traffic noise.

Dose–response relation between exposure to road traffic noise (Lden) and incidence rate ratio (IRR) for stroke based on a Cox proportional hazards model with age as the underlying timescale among participants below (A) and above (B) 64.5 years of age. The analyses were stratified by gender and calendar year and adjusted for smoking status and intensity, intake of fruits, intake of vegetables, intake of coffee, body mass index, alcohol intake, physical activity, education, municipality income, exposure to noise from railways and airports, and exposure to air pollution (NOx). The vertical whiskers show the IRRs with 95% confidence.

Diabetes
(Insident diabetes, DK, n = 57.053)

Figure 1. Association between exposure to road traffic noise ($L_{den}$) at the residence at the time of diagnosis and all incident diabetes adjusted for age; sex; BMI; waist circumference; smoking status, duration, and intensity; environmental tobacco smoke; intake of fruits, vegetables, saturated fat, and alcohol; sport; bicycling and walking; school attendance; occupational status; municipality socioeconomic status; railway and airport noise; air pollution; and calendar year. The vertical whiskers show incidence rate ratios (IRR) with 95% CIs at the median of six exposure categories (52–55, 55–58, 58–61, 61–64, 64–67, > 67 dB) when compared with the reference category of ≤ 52 dB.
Breast cancer (Brystkræft)

DK, n= 22,453

Figure 1. Association between residential exposure to road traffic noise ($L_{\text{den}}$ 1-year mean) and (a) estrogen receptor positive breast cancer and (b) estrogen receptor negative breast cancer. Analyses were adjusted for age, parity, age at first birth, hormone replacement therapy status and duration, age at menarche, length of school attendance, BMI, alcohol consumption, alcohol intake, smoking status, intake of vegetables, physical activity (MET score), calendar-year and railway and airport noise. Solid line: incidence rate ratio, dashed lines: 95% confidence interval. The median (57.4 dB) is the reference. The columns at the x-axis show the distribution of exposure to road traffic noise.

Atrial fibrillation

DK, n = 57,053

![Graph showing incidence rate ratio vs. Lden (dB)](image)

**Figure 1** Association between exposure to road traffic noise at the residence 5-years preceding diagnosis and risk for atrial fibrillation in the fully adjusted model. The vertical whiskers show incidence rate ratios with 95% confidence interval at the median of exposure categories (Q2: 52.7-55.9, Q3: 55.9-59.7, Q4: 59.7-64.2 and Q5: ≥ 64.2 dB) compared with the reference category (Q1: < 52.7 dB).
Childrens health and learning
- Traffic noise at school -> poorer reading and memory
- Traffic noise at school and at home -> hyperactivity symptoms

Lymphoma cancer (Non-Hodgkin’s lymphoma)
- Persons exposed to $> 65 \text{L}_{\text{den}}$ has 18 % increased risk

...?
It is a big problem !!!

- In Danmark more than 1.5 mio. persons live above the noise limit ($L_{den} = 58$ dB)
- In 2003 it was estimated that road traffic noise caused 200-500* early deaths per year, (hypertension and heart disease).

10 dB more noise at the residence increase the risk:

- Myokardieinfarkt: 6-8 %
- Hypertension: 6%

- Diabetes: 11 %
- Stroke:11 %
- Artrial fibrillation: 6 %
- Overweight
- Lymphoma cancer (18% $L_{den}>65$ dB) og breast cancer
- Childrens health and learning
- Birthweight?
- …?

* Killed in traffic accidents < 200 pr år
Kilde: Miljøstyrelsens hjemmeside: http://mst.dk/virksomhed-myndighed/stoej/trafikstoej/trafikstoej-og-sundhed/
WHO report 2018 – Main purpose

- to provide recommendations for protecting human health from exposure to environmental noise

- to provide robust public health advice substantiated by evidence, which is essential to drive policy action
Noise sources considered

Road traffic
Aircraft
Railway
Wind turbines
Leisure

*attending nightclubs, pubs, fitness classes, live sporting events, concerts or live music venues and listening to loud music through personal listening devices
Background papers

International Journal of Environmental Research and Public Health, 2017
Special Issue WHO Noise and Health Evidence Reviews*

WHO Environmental Noise Guidelines for the European Region:
A Systematic Review on Environmental Noise and

1. Cardiovascular and Metabolic Effects: A Summary
2. Annoyance
3. Effects on Sleep
4. Cognition
5. Permanent Hearing Loss and Tinnitus
6. Adverse Birth Outcomes
7. Quality of Life, Wellbeing and Mental Health
8. A Systematic Review of Transport Noise Interventions and Their Impacts on Health

* http://www.mdpi.com/journal/ijerph/special_issues/WHO_reviews
WHO: Scatterplot and quadratic regression of the relationship between road traffic noise ($L_{den}$) and annoyance (%HA)
From evidence to recommendations

- **Assessment of the quality of the evidence (The GRADE approach)**
- **Selection of priority health outcomes**
- **Definition of relevant risk increases for guideline levels**
- **Strength of the recommendations**
- **Recommendations for noise:**
  - Road traffic noise
  - Railway noise
  - Aircraft noise
  - Wind turbines
  - Leisure noise
## Relevant risk increase for setting guideline levels

<table>
<thead>
<tr>
<th>Priority health outcomes (DW)</th>
<th>Relevant risk increase for setting guideline level</th>
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</thead>
<tbody>
<tr>
<td>Incidence of IHD (0.405)</td>
<td>5%RR increase</td>
</tr>
<tr>
<td>Incidence of hypertension (0.117)</td>
<td>10% RR increase</td>
</tr>
<tr>
<td>% Highly annoyed (0.02)</td>
<td>10% absolute risk</td>
</tr>
<tr>
<td>% Highly sleep disturbed (0.07)</td>
<td>3% absolute risk</td>
</tr>
<tr>
<td>Permanent hearing impairment (0.0150)</td>
<td>No risk due to environmental noise</td>
</tr>
<tr>
<td>Reading and oral comprehension (0.006)</td>
<td>One month delay in reading age</td>
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</table>

DWs are ratings that vary between 0 and 1, in which 0 indicates no disability and 1 indicates the maximum amount of disability. The rates are derived from large population surveys in which people are asked to rank a specific disease for its impact on several abilities. The DWs have been proven useful in calculating the burden of disease.
Strength of recommendations

- **A strong recommendation**
  - can be adopted as policy in most situations.

- **A conditional recommendation**
  - requires a policy-making process with substantial debate and involvement of various stakeholders.
## WHO: Environmental Noise Guidelines for the European Region

### Road traffic noise

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Strength</th>
</tr>
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<tbody>
<tr>
<td>For average noise exposure, the GDG strongly recommends reducing noise levels produced by road traffic below <strong>53 decibels (dB) ( L_{day} )</strong> as road traffic noise above this level is associated with adverse health effects.</td>
<td>Strong</td>
</tr>
<tr>
<td>For night noise exposure, the GDG strongly recommends reducing noise levels produced by road traffic during night time below <strong>45 dB ( L_{night} )</strong> as night-time road traffic noise above this level is associated with adverse effects on sleep.</td>
<td>Strong</td>
</tr>
<tr>
<td>To reduce health effects, the GDG strongly recommends that policymakers 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.</td>
<td>Strong</td>
</tr>
</tbody>
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**GDG:** Guideline Development Group

### Railway noise

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### WHO guidelines og Danish noise limits

<table>
<thead>
<tr>
<th></th>
<th>Road</th>
<th>Rail</th>
<th>Air</th>
<th>Wind T</th>
<th>Leisure</th>
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<tbody>
<tr>
<td><strong>WHO</strong></td>
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</tr>
<tr>
<td>Recommendation</td>
<td>$L_{den} &lt; 53 \text{ dB}$ $L_{night} &lt; 45 \text{ dB}$</td>
<td>$L_{den} &lt; 54 \text{ dB}$ $L_{night} &lt; 44 \text{ dB}$</td>
<td>$L_{den} &lt; 45 \text{ dB}$ $L_{night} &lt; 40 \text{ dB}$</td>
<td>$L_{den} &lt; 45 \text{ dB}$ ($L_{Aeq} = 40 \text{ dB}^*$)</td>
<td>$L_{Aeq, 24 \text{ timer}} &lt; 70 \text{ dB}$</td>
</tr>
<tr>
<td><strong>Danish noise limits</strong></td>
<td>$L_{den} &lt; 58 \text{ dB}$</td>
<td>$L_{den} &lt; 64 \text{ dB}$</td>
<td>$L_{den} &lt; 55 \text{ dB}$</td>
<td>$6 \text{ og } 8 \text{ m/s: } L_{Aeq} = 42 \text{ og } 44 \text{ dB}$</td>
<td>$37 \text{ og } 39 \text{ dB}$</td>
</tr>
<tr>
<td>Strengthening</td>
<td>$5 \text{ dB}$</td>
<td>$10 \text{ dB}$</td>
<td>$10 \text{ dB}$</td>
<td>$-1 \text{ dB til } 4 \text{ dB}$</td>
<td>$-$</td>
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*For wind turbines: $L_{den} \text{ ca. } = L_{Aeq} 8 \text{ m/s} + 4.7 \text{ dB}*

Conclusion

- **WHO report is an important tool to increase the political focus on the negative effects of noise**
- **The report is made on basis of solid high quality evidence**
- **Since 2015 more studies on the negative effects are published**
- **The recommended dose-response curves are an average of many data – have a critical look in the background articles**
- **Use the socio-acoustic results from The Danish Road Directorate for assessments of the annoyance of road noise in Denmark**
The End

Torben Holm Pedersen – thp@force.dk