Towards the quantification of the burden of disease of environmental noise induced tinnitus - updated

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Acknowledgements

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Plan

- **What** is the Environmental Noise Burden of Disease project
- **Why** use the WHO Burden of Disease (BoD) concept in noise control
- **How** to estimate the Environmental Noise Induced Tinnitus (ENIT) burden of disease
- **Discussion**
- **Conclusion**
Plan

- **What** is the Environmental Noise Burden of Disease project
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What is the Environmental Noise Burden of Disease

- The environmental burden of disease (EBD) is a method to quantify the amount of disease caused by different environmental risks at a populational level.
- Lead, outdoor air pollution.
What is the Environmental Noise Burden of Disease

Quantification of health impacts of noise at a populational level using a comparable framework, definitions and outcome measures

• How much disease burden is currently caused by (attributable to) environmental noise?
Plan

- **What** is the Environmental Noise Burden of Disease project
- **Why** use the WHO Burden of Disease concept in noise control
- **How** to estimate the Environmental Noise Induced Tinnitus burden of disease
- Discussion
- Conclusion
Why Environmental Noise Burden of Disease Project?

- **Quantitative** tool providing rational information
- **Relative** magnitude (quantification) of different diseases, injuries, risk factors
- Makes it possible to compare with other health problems (mental health, cancer) or risks (air pollution, smoking, sedentarity)

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Why is the Environmental Noise Burden of Disease
Summary measure of population health
Why is the Environmental Noise Burden of Disease

Integrates mortality AND morbidity that is adjusted for quality of life in terms of disability (*functional health*), using a single common numerical « health unit » such as DALY (Disability-Adjusted Life Years)
Why is the Environmental Noise Burden of Disease

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Why is the Environmental Noise Burden of Disease

- Integrates mortality AND morbidity that is adjusted for quality of life in terms of disability (*functional health*), using a single common numerical « health unit » such as DALY (*Disability-Adjusted Life Years*)
**Why Environmental Noise Burden of Disease Project?**

- Monitor progress
- Basis for evaluation (potential health gains per environmental risk unit reduction)
- Points to vulnerable population subgroups
- Funds for improving health and health-supporting environments are limited
- Basis for cost-effectiveness of interventions
- Also shows the high preventive potential of environmental health action
Plan

● What is the Environmental Noise Burden of Disease project

● Why use the WHO Burden of Disease concept in noise control

● How to estimate the Environmental Noise Induced Tinnitus burden of disease

● Discussion

● Conclusion
WHO European Centre for Environment and Health


Develop a valid method to quantify the Environmental Noise Burden of Disease
Seven identified health impacts plausibly causally related to environmental noise exposure

- Hearing loss
- Tinnitus
- Cognitive impairments
- Cardiovascular diseases
- Sleep disturbance
- Road traffic injuries
- Annoyance
Seven identified health impacts plausibly causally related to environmental noise exposure

- Hearing loss
- **Tinnitus**
- Cognitive impairments
- Annoyance
- Cardiovascular diseases
- Sleep disturbance
- Road traffic injuries
Although tinnitus often associated with hearing loss, considered *per se* for BoD purposes as natural history, consequences, diagnosis and treatment differ completely from hearing loss.
General concept for DALY

Disability-adjusted life years =
General concept for DALY

Disability-adjusted life years = premature mortality
General concept for DALY

Disability-adjusted life years = premature mortality + years lived with disability caused by specific health problem
Application to environmental noise induced tinnitus

- Global burden for disabling tinnitus
- \( \text{DALY} = \text{YLL} + \text{YLD} \)

where:

- YLL = years of life lost due to premature mortality.
- YLD = years lived with disability.
Application to environmental noise induced tinnitus

No mortality caused by tinnitus: $YLL = 0$
Application to environmental noise induced tinnitus

\[ \text{DALY}_{(\text{tinnitus})} = \text{YLD} \]
Application to environmental noise induced tinnitus

\[ \text{DALY}_{\text{tinnitus}} = YLD = I \times DW \times D \]

where:
- \( I \) = number of incident cases.
- \( DW \) = disability weight.
- \( D \) = average duration of disability (years)
Application to environmental noise induced tinnitus

- Specific burden for ENIT
- \( \text{DALY}_{\text{ENIT}} = \text{DALY}_{\text{tinnitus}} \times \text{PAF} \)

*where:*
\( \text{PAF} = \text{population attributable fraction} \) of global \( \text{DALY}(\text{tinnitus}) \) caused exclusively by environmental noise exposure
Application to environmental noise induced tinnitus

- Specific burden for ENIT

$$\text{DALY}_{\text{ENIT}} = \text{DALY}_{\text{tinnitus}} \times \text{PAF}$$

where:
PAF = population attributable fraction of global DALY(tinnitus) caused exclusively by environmental noise exposure

$$\text{DALY}_{\text{ENIT}} = I \times \text{DW} \times D \times \text{PAF}$$
\[ \text{DALY}_{(\text{ENIT})} = I \times DW \times D \times PAF \]
Tinnitus: definition

Sound perception (for instance roaring, hissing or ringing) that cannot be attributed to an external sound source

«The inability to perceive silence when no external sound stimulus is present»
Tinnitus: definition

- Basically a subjective complaint experienced by the individual with no objective findings or confirmatory exams.
- Will be experienced by almost everyone in their lifetime with virtually no consequences for most (benign tinnitus), but a health problem (symptom/disease) that can cause serious consequences on daily life (disabling tinnitus) for some.
Tinnitus: definition

- Basically a **subjective** complaint experienced by the individual with no objective findings or confirmatory exams.
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Tinnitus: definition

- No unique internationally recognized classification
- Large variation in expression, etiology, effects on a person’s life
Tinnitus: causes

- Tinnitus most often idiopathic, but may be secondary to other pathologies or known risk factors
- One very well known cause is noise exposure
  - Tinnitus caused by acute or chronic environmental noise exposure
  - Leisure noise exposure (high enough levels)
Need to quantify disabling tinnitus caused by environmental noise exposure
Working case definition for BoD purposes
- a case of sound perception (for instance roaring, hissing, ringing, noise in the ears or in the head, or alike) that cannot be attributed to an external sound source, [...]
Working case definition for BoD purposes
- a case of sound perception (for instance roaring, hissing, ringing, noise in the ears or in the head, or alike) that cannot be attributed to an external sound source,
causing disabling consequences in terms of constant disturbance of the emotional, cognitive, psychological or physical state of the patient.
Documented consequences of tinnitus

<table>
<thead>
<tr>
<th>Sleep disturbance (difficulty falling asleep or going back to sleep),</th>
<th>Cognitive effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety</td>
<td>Psychological distress</td>
</tr>
<tr>
<td>Depression (case reports of suicide)</td>
<td>Communication and listening problems (hearing problems),</td>
</tr>
<tr>
<td>Difficulty with concentration</td>
<td>«Frustration»</td>
</tr>
<tr>
<td>Irritability</td>
<td>Tension</td>
</tr>
<tr>
<td>Prevent work</td>
<td>Reduce efficiency</td>
</tr>
<tr>
<td>Restrict participation in social life</td>
<td></td>
</tr>
</tbody>
</table>
$\text{DALY}_{(\text{ENIT})} = I \times DW \times D \times PAF$

Three proposed approaches

1- Global prevalence of chronic disabling tinnitus (survey-based)
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\[ \text{DALY}_{(ENIT)} = I \times DW \times D \times PAF \]

Three proposed approaches

1- Global \textit{prevalence} of chronic disabling tinnitus (survey-based)

2- Exposure-specific approach (relative \textit{risk} per exposure level)
DALY_{(ENIT)} = I \times DW \times D \times PAF

Three proposed approaches

1- Global prevalence of chronic disabling tinnitus (survey-based)
2- Exposure-specific approach (relative risk per exposure level)
3- Percentage of tinnitus derived from the exposure-NIHL risk curve (ISO 1999: 1990)
Tinnitus: epidemiology

- **Ad hoc expert working group** (ENT, clinical, rehabilitation and research audiologists, specialized psychologist, epidemiologists, BoD method experts)

- After comprehensive review available literature + discussion with expert working group, based on
  - Availability of populational studies
  - Good prevalence data from surveys in different countries
  - Prevalence has been used for other BoD calculations

  first approach was chosen, namely

  - **Global prevalence of chronic disabling tinnitus**
    (survey-based approach)
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First approach was chosen, namely

- **Global prevalence of chronic disabling tinnitus**
  * (survey-based approach)
Selection criteria of survey based studies

- Population based sample
- Global quality assessment (10 point scale on internal validity, external validity and data analysis)
- Point prevalence (or one-year prevalence)
- At least one consequence of tinnitus
Selection criteria of survey based studies

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Selection criteria of survey based studies

- Population based sample
- Global quality assessment (10 point scale on internal validity, external validity and data analysis)
- Point prevalence (or one-year prevalence)
- At least one consequence of tinnitus
>400 publications => 99 of interest => 23 epidemiological studies with outcome measures => 8 corresponding to selection criteria*

- No standardized questionnaire for surveys
- No agreed upon case definition in literature

* Deshaies P et al. (2005) Quantification of the burden of disease for tinnitus caused by community noise. Background paper. Unpublished document available from the authors or from WHO Europe office.
Various concepts used by authors

- "moderate to severe annoyance",
- "bothers me moderately or a lot",
- "plagues me all day",
- "moderately serious to unbearable tinnitus",
- "bothers quite a bit",
- "extremely and very annoying tinnitus",
- "at least moderately severe, that caused difficulty falling to sleep, or both",
- "affects quality of life",
- "causes problems affecting ability to lead a normal life"
Many concepts rather non specific and refer to annoying tinnitus which is not necessarily disabling (affecting day-to-day functioning)
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First with sleep disturbance (see paper in06_188.pdf)
- Appealing, but would greatly underestimate, as only one consequence
- No populational data on all consequences
Many concepts rather non specific and refer to annoying tinnitus which is not necessarily disabling (affecting day-to-day functioning)

First with sleep disturbance (see paper in06_188.pdf)
  • Appealing, but would greatly underestimate, as only one consequence
  • No populational data on all consequences

After a recent updating with BoD expert, the one concept that best fits disabling tinnitus for BoD purposes with available data
  • Tinnitus affecting quality of life
  • Tinnitus problems affecting ability to lead a normal life
Two populational studies retained for prevalence calculations

<table>
<thead>
<tr>
<th>Author, year (country)</th>
<th>Sample size (age groups) [sampling]</th>
<th>Disability concept</th>
<th>Severity</th>
<th>Populational prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davis, 1995 (UK)</td>
<td>48 313 Different phases study (&gt;17 years) [random sample] (n=19 023 for retained disability concept)</td>
<td>Tinnitus affecting quality of life</td>
<td>Slight Moderate Severe</td>
<td>3.3 % 1.2 % 0.4 %</td>
</tr>
<tr>
<td>Hannaford, 2005 (Scotland)</td>
<td>15 788 (&gt;13 years) [Nationwide random sample]</td>
<td>Tinnitus problems affected ability to lead a normal life</td>
<td>Slight Moderate Severe</td>
<td>3.6 % 1.2 % 0.4 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Weighted prevalence</strong></td>
<td>Slight Moderate Severe</td>
<td>3.4 % 1.2 % 0.4 %</td>
</tr>
</tbody>
</table>
DALY calculation with prevalence data

\[ P = I \times D \]

where:

- \( P \) = number of prevalent cases.
- \( I \) = number of incident cases.
- \( D \) = average duration of disability (years).
**DALY calculation with prevalence data**

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\[ \text{DALY}_{(\text{ENIT})} = I \times DW \times D \times PAF = P \times DW \times PAF \]

- \( P \) = number of prevalent cases of disabling tinnitus (point prevalence or at most one-year prevalence).
Prevalence data available for 15 years and older only

No sex difference for environmental noise induced tinnitus (literature, experts)
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2001 Population and prevalent cases of disabling tinnitus per severity level for WHO Euro-A epidemiological subregion, 15 years old and more

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Population 2001</th>
<th>Population aged 15 and more</th>
<th>Weighted prevalence per severity level</th>
<th>Prevalent cases of disabling tinnitus per severity level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro-A</td>
<td>413 967 744</td>
<td>344 131 386</td>
<td>Slight: 3.4 %</td>
<td>11 845 523</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate: 1.2 %</td>
<td>4 122 166</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Severe: 0.4 %</td>
<td>1 407 670</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>TOTAL 17 375 359</td>
<td></td>
</tr>
</tbody>
</table>
\( \text{DALY}_{(\text{ENIT})} = P \times DW \times PAF \)

- **DW**
  - A relative severity weight between 0 and 1
    - 0 = Perfect health
    - 1 = Death

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No readily available disability weight for tinnitus from Global Burden of Disease (GBD) project or other sources

Three different approaches proposed
- Comparison with chronic pelvic pain, low back pain, primary insomnia, mild depressive episode
- Canadian CLAMES preference scores
- WHO expert’s opinion, based on tinnitus experts’ description of disabling tinnitus

Slightly disabling tinnitus: 0.01
Moderate-severely disabling tinnitus: 0.11
No readily available disability weight for tinnitus from Global Burden of Disease (GBD) project or other sources

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Moderate-severely disabling tinnitus: 0.11
DALY calculation for disabling tinnitus per severity level for WHO Euro-A epidemiological subregion, 15 years old and more, 2001

<table>
<thead>
<tr>
<th>Severity level</th>
<th>Prevalent cases Euro-A</th>
<th>Disability weight</th>
<th>DALYs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight</td>
<td>11 845 523</td>
<td>0.01</td>
<td>118 455</td>
</tr>
<tr>
<td>Moderate</td>
<td>4 122 166</td>
<td>0.11</td>
<td>453 438</td>
</tr>
<tr>
<td>Severe</td>
<td>1 407 670</td>
<td>0.11</td>
<td>154 844</td>
</tr>
<tr>
<td>TOTAL</td>
<td>17 375 359</td>
<td></td>
<td>726 737</td>
</tr>
</tbody>
</table>

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\[ \text{DALY}_{(\text{ENIT})} = P \times DW \times PAF \]

Population attributable fraction caused exclusively by acute or chronic environmental noise exposure
No populational study on environmental noise induced tinnitus

Three sources

- Perceived cause in 1625 tinnitus patients (Oregon): 23.6% noise alone or combined, BUT occupational + environmental
- Quebec Medical surveillance database > 100 000 blue collar workers: adjusted attributable fraction of 4.6% for tinnitus exclusively caused by environmental noise exposure
- Experts opinion (collaborators and contributors)
  - Individual opinions: proposed 1 to 15%
Consensus on a conservative, but plausible and reasonable PAF: 3%
DALY calculation for environmental noise induced tinnitus per severity level for WHO Euro-A epidemiological subregion, 15 years old and more, 2001

<table>
<thead>
<tr>
<th>Severity of disabling tinnitus</th>
<th>Prevalent cases Euro-A</th>
<th>Disability weight</th>
<th>PAF</th>
<th>DALYs for ENIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight</td>
<td>11 845 523</td>
<td>0.01</td>
<td>0.03</td>
<td>3 554</td>
</tr>
<tr>
<td>Moderate</td>
<td>4 122 166</td>
<td>0.11</td>
<td>0.03</td>
<td>13 603</td>
</tr>
<tr>
<td>Severe</td>
<td>1 407 670</td>
<td>0.11</td>
<td>0.03</td>
<td>4 645</td>
</tr>
<tr>
<td>TOTAL ENIT</td>
<td>17 375 359</td>
<td>_</td>
<td>_</td>
<td>21 802</td>
</tr>
</tbody>
</table>

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Plan

- What is the Environmental Noise Burden of Disease project
- Why use the WHO Burden of Disease concept in noise control
- How to estimate the Environmental Noise Induced Tinnitus burden of disease
- Discussion
- Conclusion
Key elements for DALY calculation

- **Valid** populational prevalence data
- Corresponding to the case definition
- With disability weights matching case definition
- And a conservative, plausible impact fraction
Key elements for DALY calculation

- Valid populational prevalence data
- Corresponding to the case definition
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Comparisons* with some other health problems - Euro-A - 2001

<table>
<thead>
<tr>
<th>Health problem</th>
<th>DALYs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unipolar depressive disorders</td>
<td>4 091 000</td>
</tr>
<tr>
<td>Hearing loss, adult onset</td>
<td>1 857 000</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1 083 000</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>726 000</td>
</tr>
<tr>
<td>Lower respiratory infections</td>
<td>614 000</td>
</tr>
<tr>
<td>Oral diseases</td>
<td>353 000</td>
</tr>
<tr>
<td>Prostate cancer</td>
<td>335 000</td>
</tr>
<tr>
<td>Hypertensive heart disease</td>
<td>317 000</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>208 000</td>
</tr>
<tr>
<td>STDs excluding HIV</td>
<td>79 000</td>
</tr>
</tbody>
</table>

Comparisons with some other health problems - Euro-A - 2001

<table>
<thead>
<tr>
<th>Health problem (from all causes unless mentioned)</th>
<th>DALYs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild mental retardation caused by lead</td>
<td>55000*</td>
</tr>
<tr>
<td>Hepatitis C</td>
<td>30000**</td>
</tr>
<tr>
<td>Upper respiratory infections</td>
<td>26000**</td>
</tr>
<tr>
<td>Tinnitus caused by environmental noise</td>
<td>21000</td>
</tr>
<tr>
<td>Cataracts</td>
<td>19000**</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>18000**</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>16000**</td>
</tr>
<tr>
<td>Periodontal disease</td>
<td>16000**</td>
</tr>
<tr>
<td>Gonorrhoea</td>
<td>15000**</td>
</tr>
</tbody>
</table>

Valid for Euro-A countries

Possibly different in other subregions of the world

- Prevalence of tinnitus?
- Prevalence of disabling tinnitus in different cultures?
Plan

- What is the Environmental Noise Burden of Disease project
- Why use the WHO Burden of Disease concept in noise control
- How to estimate the Environmental Noise Induced Tinnitus burden of disease
- Discussion
- Conclusion
First known estimate of the global burden of disease of disabling tinnitus and environmental noise induced tinnitus
Relative magnitude of disabling tinnitus higher than generally recognized
- Underestimated health problem

Environmental noise induced tinnitus BoD relatively high

ENIT is one of the 7 health impacts of environmental noise exposure
Relative magnitude of disabling tinnitus higher than generally recognized
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Proportional resources for prevention (risk reduction) and control?

BoD can be a strong argument for population, policy makers and politicians
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Mahalo

Thank you for your attention