Leisure time noise - sources, exposure, and effects on hearing

Jaana Jokitulppo, Akukon Ltd, PhD, Head of the Acoustic Group
Presentation gives answers to following questions:

- Why this subject is important?
- How much noise is too much noise?
- What activities are the most noisy?
- How noise effects on our health?
- How to protect yourself from leisure time noise?
- What should be done to handle this problem?
Sound environments

Work  Hobbies  Traffic  Nature  Home

Public buildings:
Schools  Offices  Shopping Centres  Restaurants  Concert halls  Sport stadiums
We need hearing for..

- Communication
  - Sharing Information, learning
  - Social activity
- At work
  - Sound and noise professionals
    - Musicians, acousticians
  - Communication needed jobs
  - Health professionals (hearing tests)
- Recognising important sounds
  - Safety
- Enjoyment, entertainment
  - Listening and playing music
  - Experiences (films)
- Experience of silence
How sounds effects us?

• **Orientation effect: fight or run away!**
  – Heart beat, blood circulation

• **Effects on sleep**
  – Hearing works while sleeping!

• **Same sound could evoke different kind of emotions**
  – Annoyance, disturbance, scaring, cheering, relaxing, katarsis

  – Music effects us on many ways
Sounds and music are being used

• Part of atmosphere
• Paying attention
• Having special effects
• Influencing of our shopping behaviour
• Many places
  • Concerts, festivals, circus
  • Movies, theatres
  • Shops, Sports games
  • Church

http://www.youtube.com/watch?v=1UrQTI6HTo
Noise increases continuously

• Reasons
  – Traffic growth, industrialisation
  – Technical development

• Contribution of:
  – Economical well being
  – More spare time
  – Variation of activities
  – Modern people eager to have experiences, hedonism
Examples of noise sources

<table>
<thead>
<tr>
<th>Sound Pressure level, dB</th>
<th>Source, example</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>Canon, <em>ear drum damages immediately</em></td>
<td>Hearing damage occurs immediately</td>
</tr>
<tr>
<td>140-160</td>
<td>Shooting guns</td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>Fireworks, jet plane</td>
<td></td>
</tr>
<tr>
<td><strong>120</strong></td>
<td><em>Pain in the ear</em></td>
<td>Upper exposure level</td>
</tr>
<tr>
<td>100</td>
<td>Rock-concert, saw</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>Lawn mover</td>
<td></td>
</tr>
<tr>
<td><strong>85</strong></td>
<td>*Hearing damage occurs, <em>upper exposure level</em></td>
<td></td>
</tr>
<tr>
<td><strong>80</strong></td>
<td><em>Lower exposure level</em></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Traffic</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Normal speech</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Computer</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Whisper</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Hearing level of normal young people</td>
<td></td>
</tr>
</tbody>
</table>

http://www.youtube.com/watch?v=tf_QyFlbA
8w

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# Noise and time 3 dB rule!

<table>
<thead>
<tr>
<th>Sound level</th>
<th>Maximum exposure time</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>8 hrs</td>
</tr>
<tr>
<td>88</td>
<td>4 hrs</td>
</tr>
<tr>
<td>91</td>
<td>2 hrs</td>
</tr>
<tr>
<td>94</td>
<td>1 hrs</td>
</tr>
<tr>
<td>97</td>
<td>30 min</td>
</tr>
<tr>
<td>100</td>
<td>15 min</td>
</tr>
<tr>
<td>103</td>
<td>7 min</td>
</tr>
<tr>
<td>106</td>
<td>4 min</td>
</tr>
<tr>
<td>109</td>
<td>2 min</td>
</tr>
</tbody>
</table>
Scanning electron micrographs of the normal (a) and damaged (b) cochlear sensory epithelium.

**Normal hair cells**

Temporary threshold shift, TTS
Permanent hearing loss, PTS

**Damaged hair cells**

http://www.youtube.com/watch?v=ahCbGjasm_E

http://www.youtube.com/watch?v=Xo9bwQuYrRo
First warnings being exposed too much noise:

- Ears feels blocked
- You hear ears ringing= tinnitus
- You speak louder than normal
- You have to ask you partner to rise his/her voice
Signs of permanent hearing loss

- You have to concentrate carefully that you could hear others
- You can not always hear speech at the first time
- Your friend & Family members says that you talk loud voice
- You listen tv & radio louder than others
- You can not hear doorbell, telephone
- Difficulty to follow what happens
  - E.g at school, cinema/theatre, meetings

http://www.youtube.com/watch?feature=endscreen&v=ar1Dq-M2ok4&NR=1
How fast hearing will be damaged?
Effects of Noise

- Irritation, annoyance, effects on sleep, headache, stress responses
- Increase of heart rate, blood pressure, hormone responses
- Effects on Hearing, TTS, tinnitus, Sound distortion
- Increase of heart rate, blood pressure, hormone responses
- Hyperacusia

- Communication difficulties, social isolation
- Concentration, motivation, learning, language development
- Effects on personality and behavior
- Voice problems

Risk for accidents
Why evaluation of noise exposure is important?

- Development of NIHL is gradual
  - Longitudinal and non-reversible process
  - Harmful effects of noise is often too late noticed
  - Tinnitus effects more and more on quality of life
  - Effects on individuals life, social environment and activities
- Need for communication is important
  - Speaking the most significant way to communicate (fast, effectiveness)
  - Many jobs have changed to communication work
  - Good hearing capacity is needed for the communication and work
- On safety more and more important
Why evalution of leisure time noise exposure is important?

- Noise exposure starts early at childhood
  - Change of society from 60 s (e.g. toys)
  - Hearing protection of children and young people important->future adults!

- Ignorance of effects of noise is general
  - Some sources noise levels are overestimated, some underestimated
What are your main values of life?

<table>
<thead>
<tr>
<th>Good health</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Love</td>
<td>Good relationships</td>
</tr>
<tr>
<td>Interesting work</td>
<td>Nature</td>
</tr>
<tr>
<td>Economical wellbeing</td>
<td>Hobbies</td>
</tr>
</tbody>
</table>
Evaluation of Leisure time noise is important

- Total noise exposure of all the leisure time activities combined less known issue
- Several activities, new comes available continuously
- The difficulty of control the all the activities combined
- NIHL is cumulative process, hearing does not distinct the activities and their noise
Leisure time noise?

- Any high sound level performed during the leisure time activities.

Sources:

- **Music**
  - Discos, pubs, restaurants, concerts, festivals
  - Listening: audio systems (car, home), portable equipment: Mp3, I-pod, mobile phones
  - Playing: practising, performing, band/orchestra
- **Home tools, and equipment indoors and outdoors**
- **Sports**
  - Shooting, hunting
  - Sports games, (often strong music included)
  - Motor sports: driving, games, events
- **Fireworks, toys, games, movies**
Technical development has been fast

So are the dB levels!

<table>
<thead>
<tr>
<th>MP3 Player</th>
<th>LAeq, 1min</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Headphones</td>
<td>Headphone 2</td>
<td>Ear buds</td>
<td>Ear insertec</td>
</tr>
<tr>
<td>Ipod</td>
<td>92</td>
<td>82</td>
<td>94</td>
<td>113</td>
</tr>
<tr>
<td>Nokia N91</td>
<td>98</td>
<td>94</td>
<td>99</td>
<td>123</td>
</tr>
<tr>
<td>Creative</td>
<td>85</td>
<td>75</td>
<td>95</td>
<td>112</td>
</tr>
<tr>
<td>Sony Sappin</td>
<td>80</td>
<td>70</td>
<td>85</td>
<td>107</td>
</tr>
</tbody>
</table>

Source: Institute of Occupational Health 2009
Noise levels of different activities, $L_{Aeq}, \text{dB}$

- Playing in a band/orchestra: 75-135
- Singing: 75-105
- Different musical instruments: 60-120
- Listening to home stereos: 70-100
- Listening via car audio systems: 65-100
- Portable music equipment (MP3): 50-115
- Concerts, festivals, music events: 73-110
- Aerobics: 78-106
- Movies: 70-85
- Discos, music bars: 60-110
- Motor sports: 70-115
- Shooting (hunting): 120-165 $L_{\text{peak}}$
- Fireworks: 120-165 $L_{\text{peak}}$
- Machines and equipment at home: 60-100
- Tools, and machines outdoors: 70-110
- Toys, games: 70-112
- Toy weapons: 120-170 $L_{\text{peak}}$
## Different music instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>LAeq, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band playing</td>
<td>90-135</td>
</tr>
<tr>
<td>Bass</td>
<td>75-83</td>
</tr>
<tr>
<td>Bass guitar</td>
<td>85-100</td>
</tr>
<tr>
<td>Flute</td>
<td>85-111</td>
</tr>
<tr>
<td>Clarinet</td>
<td>92-103</td>
</tr>
<tr>
<td>Cembalo/clavichord</td>
<td>62-65</td>
</tr>
<tr>
<td>Oboe</td>
<td>80-94</td>
</tr>
<tr>
<td>Piano /Grand piano</td>
<td>75-110</td>
</tr>
<tr>
<td>Piccolo</td>
<td>95-112</td>
</tr>
<tr>
<td>Drums (maximum)</td>
<td>86-122</td>
</tr>
<tr>
<td>Saxophone</td>
<td>99</td>
</tr>
<tr>
<td>Cello</td>
<td>80-92</td>
</tr>
<tr>
<td>Trumpet</td>
<td>80-124</td>
</tr>
<tr>
<td>Trombone</td>
<td>85-114</td>
</tr>
<tr>
<td>Organs (church organs)</td>
<td>75-88</td>
</tr>
<tr>
<td>Violin</td>
<td>84-103</td>
</tr>
</tbody>
</table>
**Concerts, LAeq-levels**

<table>
<thead>
<tr>
<th>Artist</th>
<th>Duration</th>
<th>LAeq-Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sting</td>
<td>2h 18min</td>
<td>94</td>
</tr>
<tr>
<td>Deep Purple</td>
<td>1h 47min</td>
<td>110</td>
</tr>
<tr>
<td>Jethro Tull</td>
<td>1h 53 min</td>
<td>100</td>
</tr>
<tr>
<td>Tom Jones</td>
<td>1h 15 min</td>
<td>99</td>
</tr>
<tr>
<td>Bob Dylan</td>
<td>1h 59 min</td>
<td>102</td>
</tr>
<tr>
<td>Bon Jovi</td>
<td>1h 45 min</td>
<td>105</td>
</tr>
<tr>
<td>Tina Turner</td>
<td>1h 52 min-2h 14 min</td>
<td>98-107</td>
</tr>
<tr>
<td>3 Lady´s on stage</td>
<td>2h 22 min</td>
<td>95</td>
</tr>
<tr>
<td>Karita Mattila</td>
<td>1h 16 min-1h 19 min</td>
<td>82</td>
</tr>
<tr>
<td>Kirka</td>
<td>2h 4 min</td>
<td>96</td>
</tr>
<tr>
<td>Smashing Pumpkins</td>
<td>2h 20 min</td>
<td>101</td>
</tr>
<tr>
<td>AC/DC</td>
<td>1h 48min -2h 3 min</td>
<td>108-110</td>
</tr>
<tr>
<td>Savage Garden</td>
<td>1h 21 min</td>
<td>101</td>
</tr>
<tr>
<td>Mötorhead</td>
<td>1h 28 min</td>
<td>107</td>
</tr>
</tbody>
</table>

Year of 2005 in Finland
Famous musicians suffering tinnitus

Neil Young
Pete Townsend (WHO)
Sting
Lars Ulrich & James Hetfield (Metallica)
Eric Clapton
Bono & The Edge (U2)
Anthony Kiedis (Red Hot Chili Peppers)
Phil Collins
John Densmore (Doors)
Steve Lukather (Toto)
Ozzy Osbourne
Huey Lewis
Ville Valo (HIM)

"Tinnitus, man, you can't...You know, there's nothing you can do about it. It doesn't get better. It can only get worse-that's the hell of that thing.

I always have to say "WHAT???," hahaha.
Be careful guys, this could happen to you!

http://www.youtube.com/watch?feature=endscreen&v=QN2yQHJ0uWY&NR=1
## Noise levels of toys

<table>
<thead>
<tr>
<th>Category</th>
<th>Noise Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toy weapons (impulse noise)</td>
<td>132-170</td>
</tr>
<tr>
<td>Toy weapons (continuous noise)</td>
<td>82-99</td>
</tr>
<tr>
<td>Cars, etc. Moving vehicles</td>
<td>80-102</td>
</tr>
<tr>
<td>Tools</td>
<td>94-109</td>
</tr>
<tr>
<td>Simulators</td>
<td>81-100</td>
</tr>
<tr>
<td>Games</td>
<td>81-104</td>
</tr>
<tr>
<td>Soft toys</td>
<td>81-100</td>
</tr>
<tr>
<td>Bicycle horns</td>
<td>92-112</td>
</tr>
<tr>
<td>Key holders</td>
<td>73-80</td>
</tr>
</tbody>
</table>
Sun Volley- Raision Loimu Volley Ball game
7.4.2010 Oulu, $L_{Aeq} = 92$ dB

The graph shows the noise levels over time during a volleyball game. The y-axis represents the noise level in dB, while the x-axis represents time in hours and minutes. Key events such as start, rounds, and break are indicated.

- **Leq**: Long-term equivalent level
- **Max**: Maximum level
- **Peak**: Peak level
Vuvuzela

- According to literature
  - Near horn opening $L_{A_{max}}$ 131 dB
  - 2 m distance $L_{A_{max}}$ 113 dB
  - $L_{A_{eq,2h}}$ during the game 96-107 dB
    - Those who had vuvuzela 100-107 dB
    - $L_{Cpeak}$-levels 133-144 dB

<table>
<thead>
<tr>
<th>*EU 10/2003</th>
<th>In front of horn opening, dB</th>
<th>Next to ear, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Variation</td>
</tr>
<tr>
<td>$L_{A_{max}}$</td>
<td>129</td>
<td>119-133</td>
</tr>
<tr>
<td><strong>Hearing damage limit</strong></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>$L_{A_{eq}}$</td>
<td>121</td>
<td>108-126</td>
</tr>
<tr>
<td><strong>Hearing damage limit</strong>*</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>$L_{Cpeak}$</td>
<td>142</td>
<td>133-144</td>
</tr>
<tr>
<td><strong>Hearing damage limit</strong>*</td>
<td>137</td>
<td></td>
</tr>
</tbody>
</table>

http://www.youtube.com/watch?v=YpXN8BvGp_o
JJokitulppo
Occupational noise exposure

• Continuously occupational problem
  – Occupational NIHL about 1000/year in Finland

• Noisy leisure time may have effect on total noise exposure
  – Appearance of Occupational NIHL faster
  – Hearing loss or tinnitus can interfere the work or even prohibit to do the work (e.g. musicians, acousticians)
  – Also the vocational selection (need for good hearing capacity)
Background of PhD thesis

• Doctoral thesis of Jaana Jokitulppo, University of Kuopio, Department of Environmental Sciences 2009: Non occupational noise - sources, exposure, and effects on hearing
• The Finnish Federation of Hard of Hearing (FFHOH)
  – Teenagers 12-16 years
• National Institute for Health and Welfare (THL) part of the EXPOLIS-study
  – Adults 25-55 years in Helsinki area
• The Finnish Defence Forces (Pori Brigade)
  – Conscripts 19-27 years, arrive and leaving examination
How leisure time noise exposure was calculated and evaluated?

- Occupational noise exposure legislation
  - EU directive 10, 2003 (National legislation VnA 85,2006)
  - Lower and upper action levels 80 dB, 85 dB, (limit value 87 dB)
  - Was calculated with weekly noise exposure according to \( L_{\text{Aeq,40h}} \), ISO 1999
- With Questionnaire
  - Self reported duration of exposure of activity (hours)
  - Subjective estimation of loudness Scale 1-5 (60-100 dB)
  - Hearing Symptoms
  - Audiograms (conscripts)
Results 1

- One of five was exposed over 85 dB leisure time noise at their life time
  - Teenagers and young adults used 40-hrs/week at their noisy leisure time, adults about n. 25-30 hrs/week
  - Weekly noise exposure was gathered many activities, the most significant were:
    - Music bars & discos, concerts, shooting, playing in a band, home tools and motor sports
- Safety level for ears, under 75 dB
  - 20% of teenagers
  - 30% of 19-40 years olds
  - About half of over 40-year olds
Total weekly leisure time noise exposure among all age groups

- weekly noise exposure over 85 dB
- weekly noise exposure over 80 dB
- weekly noise exposure over 75 dB

<table>
<thead>
<tr>
<th>Age Group</th>
<th>% of people exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-16</td>
<td>34</td>
</tr>
<tr>
<td>19-20</td>
<td>27</td>
</tr>
<tr>
<td>25-29</td>
<td>38</td>
</tr>
<tr>
<td>30-39</td>
<td>32</td>
</tr>
<tr>
<td>40-49</td>
<td>18</td>
</tr>
<tr>
<td>50+</td>
<td>20</td>
</tr>
</tbody>
</table>

- 77% for weekly noise exposure over 85 dB
- 69% for weekly noise exposure over 80 dB
- 56% for weekly noise exposure over 75 dB
Results 2

Tinnitus sometimes or often
- Over 70% of teenagers and conscripts
- 25% of adults

• TTS sometimes of often
  - About 50% of teenagers and conscripts
  - Over 10% of adults

• Symptoms were experienced especially those with high personal weekly noise exposure
### Weekly noise exposure and hearing symptoms – Conscripts, LAeq, dB

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Never 0</th>
<th>Sometimes 1</th>
<th>Often 2</th>
<th>Continuously 3</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinnitus related to noise</td>
<td>78</td>
<td>80</td>
<td>86</td>
<td>82</td>
<td>All</td>
</tr>
<tr>
<td>Tinnitus for other reason</td>
<td>79</td>
<td>81</td>
<td>84</td>
<td>87</td>
<td>All</td>
</tr>
<tr>
<td>Pain in ear</td>
<td>79</td>
<td>80</td>
<td>85</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sound unpleasant</td>
<td>79</td>
<td>80</td>
<td>83</td>
<td>92</td>
<td>All</td>
</tr>
<tr>
<td>Sound distortion</td>
<td>79</td>
<td>81</td>
<td>85</td>
<td>93</td>
<td>All</td>
</tr>
<tr>
<td>TTS</td>
<td>78</td>
<td>81</td>
<td>84</td>
<td>95</td>
<td>All</td>
</tr>
</tbody>
</table>
Results 3 - Hearing loss

1/5 conscripts had hearing loss BEFORE the military service

Most of them related to leisure time noise

1/3 had hearing loss at the END OF SERVICE of

The most effect was with less hearing protection usage rate of combat training in field
Hearing of Shooters - conscripts, before military service

Hearing Category
- Shooter
- Non-shooter
Conclusion of Thesis

- Most sound exposure takes 15-20 years
  - At most at the age of 25-30 years, decrease after 40 years
- Risk of hearing loss
  - 1 of 3 of teenagers and young adults (under 40 years)
  - 1 of 5 adults (over 40 years)
- 1 of 5 hearing loss of Conscripts before military service
- 1 of 3 hearing loss of Conscripts after military service
- Shooters having hearing loss already before the military service
- Auditory symptoms general, especially tinnitus & TTS signals with high exposed noise levels
- Hearing protection hardly use
What should be done?

Noise levels must be reduced!!

- Legislation, especially with children hearing protection!
- Noise control (authorities, event arrangers)
  - Measurements, checking
  - Noise reduction
    - Technical opportunities (e.g. limiters)
    - Planning, design (acoustical & audio planning)
- Health examinations
  - Audiograms, hearing symptoms questionnaires
- Education
  - Into schools education systems
  - Key professionals: teachers, trainers, designers etc.
- General education
  - Hearing conservation programs, Campaigns
- Hearing protectors
  - Nice looking, ->To trend. Loosers do not use HPD!!!
How to protect your hearing?

- Avoid noisy environments
- Set the volume level lower if possible
- Decrease the time of the noise exposure
- Allow silence breaks to your ears
- Go further the noise source
- Do not by noisy tools and equipment, remember also toys!
- When buying a tool/machine, by the one with low noise level
- Listening to music:
  - Use high quality headphones and equipment
  - Poor headphones makes you set the volume level higher
  - Take care of others, they may not want hear as loud as you do
  - While moving in traffic, you should hear the sounds of traffic
- Use hearing protectors, and carry always them with you!
- Take care childrens' hearing

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Hearing protectors

- Ear muffs, Headband
  - Electronic
  - Helmet mounted
  - Communication

- Ear plugs
  - Semi-inserted plugs
  - Musicians ear plugs
  - Personal ear plugs

http://www.youtube.com/watch?v=vke_3G-dTT8
How to prevent noise indoors?

• Discussion & communication
  – Speak normal voice, One speaks at the time
  – Never shout to ear, even though it is fun idea!

• Rooms, halls, corridors
  – Do not run, shout, or slam doors

• Pay attention to noise
  – Is the room acoustically appropriate for hearing and speaking?
  – Is the sound insulation adequate?
  – Is there other noise sources, such as air ventilation, data projectors etc. ?

• Less people in the same room
• Tools to register the noise levels
THE MOST IMPORTANT THINGS ARE SAID WITH LOW VOLUME LEVEL!

Thank you!