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Noise

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3pNSc9. Noise in hospitals as a strain for the medical staff
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Noise research in hospitals focuses mainly on the harmful effects on patients. But at least in intensive care units and operation theatres, also the staff is exposed to high levels of noise during considerable portions of working time. Evidence from literature is summarized here. During operation sessions lasting from 30 min. to several hours, reported average Leq values range from 58 to 72 dB(A) with maximum levels above 105 dB(A). Similar noise levels are reported from emergency departments. As concentration, precise communication and fast decisions are necessary in these situations, the acoustical environment has to be considered an enormous strain for the staff and a potential risk with regard to faults at work. But also during normal day and night shifts in intensive care units, noise is mentioned as an important disturbance by the medical staff. Most disturbing are noises from telephones and other communication tools and the signals and sounds from medical devices. Questionnaire surveys result in 80 to 91 % of the staff reporting negative effects of noise in their daily work. A variety of measures for noise reduction and prevention in hospitals is suggested in literature emphasizing that the staff plays a decisive role in such projects.

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Noise exposure in hospitals

“Noise in hospitals” is a theme in specialist literature since decades as can be proved by some examples: even in 1948, an American nurse describes everyday noise problems and suggests some improvements [McBride, 1948]. In 1963, the noise strain of patients in hospitals were discussed in a report to the American Ministry of Health [Goodfriend & Cardinell, 1963]. Also in Germany, the problem was seen quite early: e.g., a methodologically careful study was published in 1993, examining the noise exposure in an operative intensive care station of the university clinics in Duesseldorf [Meyer-Falcke et al., 1993], registering continuously 24-h-sound levels for 4 days. For each hour, the impulse weighted $L_{A,Im}$ was $>60$ dB(A). In the rooms for preparing the anesthesia and for waking-up after operation, the equivalent sound levels $L_{eq}$ varied between 57 and 72 dB(A) and the maximum levels between 73 and 95 dB(A). The maximum levels for electrical devices in these rooms was between $L_{A,max} = 65$ and 80 dB(A), and the sound level of working sounds in these rooms was $L_{A,max} = 69$ to 95 dB(A).

Obviously, the noise load at the working place „operation room“ has not changed so much over the years, and with regard to noise, this is still the area with the highest load in the hospital. Long-term measures in the renowned John Hopkins Hospital (Baltimore, USA) resulted in $L_{eq}$ values between 57 and 70.5 dB(A) per operation with a duration of the operation between 19 and 548 minutes [Kracht et al., 2007]. Regarding the different medical disciplines, table 1 shows detailed informations about the noise exposure during operations. Depending on the kind of operation, there are distinct differences with regard to frequency, bandwidth of the equivalent sound levels measured, and duration of the operation. In the most cases, the equivalent sound pressure levels during operation are clearly above 60 dB(A), and the exposition lasts mostly one hour or longer. Additionally it has to be noted that as a rule maximum levels are $>90$ dB(A) in all disciplines and also $>105$ dB(A) during at least 10 % of the respective duration of the OP. Further, there are systematic differences between the kinds of operation with regard to the frequency spectra and the variance in time of the sound level. Thus, depending on the kind of operation, quite different patterns of acoustical strain might occur.

There are other reports to confirm this conclusion: From orthopedic surgery, maximum sound levels of 108 dB(A) are reported with implementations of artificial knees or hips with short-time peaks of 140 dB(A) [Love, 2003]. On the other hand, a Greek study in 9 hospitals shows only 71.9 dB(A) as the highest equivalent sound pressure level during operation and a maximum level of 84.7 dB(A) [Tsiou, 2008]. Thus, it seems difficult to come to a general judgement on noise strain during operations.
TABLE 1 Average sound level and other data to operations of various clinical disciplines (according to Kracht, 2007).

<table>
<thead>
<tr>
<th>Type of surgery</th>
<th>number of operations</th>
<th>Leq (dB(A))</th>
<th>dB(A)-span across all OPs</th>
<th>period of time (in minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Surgery</td>
<td>3</td>
<td>67,0</td>
<td>59,0–69,0</td>
<td>35–548</td>
</tr>
<tr>
<td>Orthopedics</td>
<td>19</td>
<td>66,5</td>
<td>56,5–70,5</td>
<td>19–37</td>
</tr>
<tr>
<td>Plastic Pediatrics</td>
<td>4</td>
<td>65,0</td>
<td>62,0–68,5</td>
<td>51–117</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>4</td>
<td>65,0</td>
<td>53,0–66,5</td>
<td>36–76</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>8</td>
<td>64,5</td>
<td>60,0–67,5</td>
<td>74–510</td>
</tr>
<tr>
<td>Urology</td>
<td>11</td>
<td>63,5</td>
<td>55,5–67,0</td>
<td>31–157</td>
</tr>
<tr>
<td>Cardiology</td>
<td>10</td>
<td>63,5</td>
<td>57,0–68,0</td>
<td>40–319</td>
</tr>
<tr>
<td>Gastroenterology</td>
<td>9</td>
<td>63,0</td>
<td>55,0–69,0</td>
<td>39–293</td>
</tr>
<tr>
<td>Thoracic Surgery</td>
<td>4</td>
<td>63,0</td>
<td>61,5–63,5</td>
<td>59–240</td>
</tr>
<tr>
<td>Pediatric Orthopaedics</td>
<td>2</td>
<td>58,0</td>
<td>57,0–59,0</td>
<td>66–84</td>
</tr>
</tbody>
</table>

The noise exposure levels reported above from several international studies are not high enough to be considered as a danger for hearing. However, according to the present knowledge of the research on effects of noise, these high average levels and maximum levels – sometimes with a portion of high frequencies – are strong enough to elicit physiological stress responses as well as eliciting disorders regarding communication and performance [Notbohm & Siegmann, 2012(a)(b); Notbohm et al., 2012; Siegmann, 2012; Notbohm, 2012; Notbohm & Siegmann, 2013]. Speech comprehensibility is reduced by maximum levels from 55 dB(A) upwards; with sound level increasing further, concentration is disturbed, background speech becomes very irritating [Schlittmeier & Liebl, 2012; Banbury & Berry, 2005; Sundstrom et al., 1994], and the number of mistakes rises constantly [Ising et al., 2004]. With regard to the highly responsible work in hospitals, lower protective exposure limits for these workplaces should be strived for, e.g., as provided for in the German guideline VDI 2058 with Leq < 55 dB(A) for medical tasks. Still more demanding are the protective goals of the WHO for treatment rooms with Leq day < 30 dB(A) and for patients’ rooms Leq by day < 35 dB(A) and by night < 30 dB(A) with maximum levels up to 40 dB(A). At present, however, these values seem to be far away from reality in our hospitals. Similar results are reported by Notbohm (2012) in a current literature review study 2012 (see also Siegmann & Notbohm 2013).

In the United States, this problem has received attention in the past decade in the ecological context of „green hospitals“ (e.g., [Ulrich et al., 2004]).

Commitment to risk management

The theme of „(clinical) risk management“ attracts more and more importance for modern clinics [Tenckhoff & Siegmann, 2009; Weis, 2009]. Clinical risk management is a method to serve the goal of systematically preventing mistakes or risks with regard to taking care of the patients, thus improving the security of patients resp. reducing the liability risks of the hospital. When being institutionalized as a system of risk management, such a procedure shall help recognizing, evaluating and manage risks in time in order to reduce the risk potential sustainably. Clinical risk management in hospitals includes ( according to Briner et al. [2009] and Middendorf [2005]): „... the structures, processes, instruments, and activities, which support the employees of a hospital in recognizing, reducing, and managing the medical, nursing, and therapeutical risks regarding taking care of the
patients”. The effectiveness of the tool of clinical risk management was proved in several studies [Haynes et al., 2009; Semel et al., 2010].

In this process, a multitude of relevant national and international regulations make great demands on the operating authorities of the clinics concerning the implementation of a risk management in order to maintain the compliance of the clinics and its executives [Wittmann & Siegmann, 2009; Weis, 2009].

Safety of patients is a theme which is increasingly noticed internationally since the American report „To err is human“ was published at the turn of millennium [Kohn, 2000]. The report with scaring figures on avoidable medical injuries and incorrect treatments in the United States was a kind of „big bang“ for a discussion of basics of health policy. The author ascertains in his report for the Institute of Medicine (IOM) that between 2.9 and 3.7 % of all patients admitted to hospitals suffer an „adverse event“, i.e., an injury due to the treatment. The same year, McNeil et al. published a report for the Victorian Government Department of Human Services in Australia, called „Improving patient safety in Victorian hospitals“, according to which about 16.6 % of all stationary admittances to hospitals lead to an “adverse event”. About 50 % of these „adverse events“ were classified as avoidable. Similar results are reported from the British Department of Health in the report „An organization with a memory – Report of an expert group on learning from adverse events in the NHS“ [2000] and also from Vincent & Neale [2001]: according to these references, about 10 % of all stationary admittances in United Kingdom are affected by “adverse events”. With regard to Switzerland, Brühwiler [2010] assumes that probably 1 % of the patients admitted to hospitals sustain serious damages during their stay. In statistical projection, 3000 deaths in health service result for Switzerland, from which 50 % have to be considered avoidable.

In the study „Survey on the introduction of clinical risk management in German hospitals“, Lauterberg [2012] found main emphasis of the study participants on the following risk profiles for general hospitals: clearly leading are problems at organizational cutting points (46,5 %), then drug therapy (34,4%) and hospital infections / hygiene (32,2%). Similar results are reported from Doms 2005 in a legal article.

Unfortunately, the importance of extra-aural effects of noise on performance and error-proneness of the employees is mostly not taken into account, although reduction of concentration and increase of numbers of mistakes is well documented [Ising et al., 2004] (see Table 2). Also background noises, especially speech, is often perceived as disturbing and distracting [Schlittmeier & Liebl, 2012; Banbury & Berry, 2005; Sundstrom et al., 1994]. Other studies demonstrate the effect of the sound level in the station on the sleep quality of the patients with eventual influences on the course of healing [Buxton et al., 2012; Fietze et al., 2008; Golde, 2005; Schrader & Schrader, 2001, Siegmann & Notbohm. 2013].

<table>
<thead>
<tr>
<th>Work</th>
<th>Original level [dB(A)]</th>
<th>Level reduction</th>
<th>Performance enhancement [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dredger work</td>
<td>96</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Clothing factory</td>
<td>82</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Computer work (reduction of the error)</td>
<td>41</td>
<td>6</td>
<td>52</td>
</tr>
</tbody>
</table>

Depending on the amount of noise exposure, an increase of the number of mistakes in the activities of the medical staff can be assumed. If patients suffer damages due to mistakes of the medical staff and the person has acted in a legally culpable manner, the patient is entitled to claims for compensation and damages [Doms, 2005].
Conclusions

The aural and extra-aural effects still have much importance in the working world. The sound levels measured in hospitals are mostly not dangerous for hearing. However, non-aural effects do not receive the necessary attention. Especially the clinical risk management requires an integral perspective. Noise as a stressor does not only put pressure on the employees and results in a higher error rate, but influences also the healing process of patients negatively.

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