Estimation of cumulative exposure to manganese using the exposure database MEGA and occupational histories of male participants of the Heinz Nixdorf Recall Study

Objective

• In 2015, the German Occupational Exposure Limit (OEL) for inhalable manganese (Mn) was reduced to 200 \( \mu \text{g/m}^3 \) due to reports of neurotoxic effects in the low-dose range
• Here we took advantage of a large dataset of personal measurements compiled in the exposure database MEGA and estimated average exposure concentrations for at-risk occupations
• These means were used to calculate cumulative exposure to Mn of men investigated within the framework of the Heinz Nixdorf Recall Study (HNRS)

Methods

I 4,635 personal measurements of inhalable Mn measurements collected between 1989 to 2015 (MEGA)
• Measurements below the limit of quantification (LOQ) were multiply imputed according to their distribution above LOQ (Figure 2)
• Mixed-effects models were applied to the log-transformed Mn concentrations to calculate the annual geometric means (GMs) of shift exposure in at-risk occupations
II Working as welder or in other at-risk occupations (supplemental questionnaire) of 354 male participants of HNRS
III Linking annual GMs with the occupational histories to calculate cumulative exposure to Mn (Figure 1)

\[ \sum GM [\mu \text{g/m}^3] \times \text{Duration [years]} \times \text{Intensity score} \]

Intensity score: working as regular welder (1), frequent welding (0.25), occasional welding (0.1)

Results

• Exposure to Mn was strongly influenced by the major technique and the Mn content of the electrode/processed material (Table 1)
• GMs > 200 \( \mu \text{g/m}^3 \) (OEL) were observed in gas welding and gas metal arc welding with consumable materials of Mn content > 5%
• Median cumulative exposure to Mn: 58 \([\mu \text{g/m}^3 \times \text{years}]\) in all men working in at-risk occupations and 1,121 \([\mu \text{g/m}^3 \times \text{years}]\) in 26 welders

Conclusion

Supplemental questionnaires in addition to the job title are necessary to collect information on major predictors of the exposure level to Mn (e.g. welding technique) in community-based studies like HNRS when estimating neurotoxic effects of occupational exposure to Mn.

Table 1 Model-based estimates of average shift exposure to inhalable Mn for major welding techniques and material predicted for the year 2009 (MEGA database, 1989-2015)

<table>
<thead>
<tr>
<th>Technique</th>
<th>Material</th>
<th>N</th>
<th>GM [\mu \text{g/m}^3]</th>
<th>95% CI [\mu \text{g/m}^3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMAW</td>
<td>Mild steel</td>
<td>1418</td>
<td>95</td>
<td>87 – 105</td>
</tr>
<tr>
<td></td>
<td>Stainless steel</td>
<td>342</td>
<td>54</td>
<td>47 – 62</td>
</tr>
<tr>
<td></td>
<td>Mn content &gt;5%</td>
<td>47</td>
<td>201</td>
<td>138 – 291</td>
</tr>
<tr>
<td>TIG</td>
<td>Mild steel</td>
<td>60</td>
<td>10</td>
<td>8 – 12</td>
</tr>
<tr>
<td></td>
<td>Stainless steel</td>
<td>332</td>
<td>6</td>
<td>5 – 7</td>
</tr>
<tr>
<td></td>
<td>Mn content &gt;5%</td>
<td>10</td>
<td>21</td>
<td>14 – 31</td>
</tr>
<tr>
<td>SMAW</td>
<td>Mild steel</td>
<td>85</td>
<td>40</td>
<td>32 – 51</td>
</tr>
<tr>
<td></td>
<td>Stainless steel</td>
<td>84</td>
<td>23</td>
<td>18 – 29</td>
</tr>
<tr>
<td></td>
<td>Mn content &gt;5%</td>
<td>22</td>
<td>84</td>
<td>56 – 127</td>
</tr>
</tbody>
</table>

GMAW: Gas metal arc welding, TIG: Tungsten inert gas welding, SMAW: Shielded metal arc welding

Figure 1 Quantitative exposure assessment in the HNRS study

Figure 2 Density function of the concentrations of inhalable manganese among welders

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