

Ototoxicity of industrial chemicals alone or in combination with noise* *

Perchloroethylene

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Introduction

There is increasing epidemiological evidence that exposure to some solvents, metals, asphyxiants and other substances is associated in humans with a risk of hearing loss. On the contrary, the interaction of chemicals and noise has received little attention. This project was undertaken to develop a database of toxicological data from the primary literature, allowing the identification of ototoxic substances and substances that interact with the noise present in the work environment. Critical toxicological data were compiled for chemical substances included in the Quebec regulation (Regulation Respecting Occupational Health and Safety).

Methods

The data were evaluated only for realistic exposure concentrations up to:

- the short-term exposure limit value, or
- the ceiling value, or
- 5 times the 8-h time weighted average exposure limit value (TWAEV) for human data, or
- 100 times the 8-h TWAEV or the ceiling value for animal studies.

We took into consideration the number of studies and for each study the following parameters: studied species, number of subjects or animals, exposure route, characteristics of control groups, exposure levels, audiometric and statistical tests, dose/effect relationship and when available, mechanisms of action.

Using a systematic weight of evidence approach, the information from both human and animal studies was examined. At first, a weight of evidence qualifier was given for both the ototoxicity and the interaction with noise : "strong", "medium", "weak", "absent" or "no study found". Note that weight of evidence qualifier "absent" should not be regarded as evidence that a substance is not ototoxic or that it does not interact with noise.

We built a weight of evidence table (see Table 1) that allowed us to combine the information from both human and animal studies on ototoxicity of chemicals and their interaction with noise. Human data were given more weight in the overall assessment. For example, a "strong" evidence from animal studies combined with an "absence" of evidence from the available human studies yielded a "medium" evidence overall.

Regarding the final conclusion about the ototoxic potential of substances or their interaction with noise, a substance bearing an overall qualifier of "strong evidence" of ototoxicity or interaction with noise was considered as an "ototoxic substance" or as a substance for which there is an "evidence of interaction" with noise. Those with "medium evidence" overall were rated "possibly ototoxic" or "possible interaction". We considered the ototoxic potential of those with only "weak evidence" as "non conclusive". Finally, those for which there was absence of evidence bore the mention "no evidence" of ototoxicity or interaction with noise.

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Table 1

Weight of evidence approach for the assessment of
ototoxicity and interaction with noise
of industrial chemicals

Weight of evidence of studies			Conclusion about ototoxicity	Conclusion about the interaction substance / noise
Human studies	Animal studies	Overall		
S	S	S	O	I
S	M	S	O	I
S	W	S	O	I
S	A	S	O	I
S	X	S	O	I
M	S	S	O	I
M	M	M	PO	PI
M	W	M	PO	PI
M	A	M	PO	PI
M	X	M	PO	PI
W	S	M	PO	PI
W	M	W	NC	NC
W	W	W	NC	NC
W	A	W	NC	NC
W	X	W	NC	NC
A	S	M	PO	PI
A	M	W	NC	NC
A	W	W	NC	NC
A	A	A	NE	NE
A	X	A	NE	NE
X	S	M	PO	PI
X	M	W	NC	NC
X	W	W	NC	NC
X	A	A	NE	NE
X	X	X	X	X

Strength of evidence about ototoxicity or interaction substance / noise

S = Strong, M = Medium, W = Weak, A = Absent, X = No study found

Conclusion about ototoxicity

O=Ototoxic substance, PO=Possibly ototoxic substance, NC=Non conclusive, NE=No evidence, X=No documentation

Conclusion about the interaction substance / noise

I=Evidence of interaction, PI=Possible interaction, NC=Non conclusive, NE=No evidence, X=No documentation

Abbreviations

TWAEV : 8 h time weighed average exposure [limit] value in Quebec

D-TWAEV : Calculated inhaled dose for pulmonary ventilation of 10 m³/d and body weight of 70 kg

Ceiling : Ceiling exposure [limit] value in Quebec

D-Ceiling : Calculated inhaled dose for pulmonary ventilation of 10 m³/d and body weight of 70 kg

STEV : Short term exposure [limit] value in Quebec

C/D reported : Reported concentration or reported dose

CSU/DSU : Reported concentration expressed in standard units of mg/m³ or reported dose expressed in standard units of mg/kg/d

Ratio : For concentrations CSU/TWAEV or CSU/Ceiling and for doses DSU/ D-TWAEV or DSU/D-Ceiling

ASM : Air sampling method

BM : Biological monitoring results

NSM: Noise sampling method

NL: Noise levels

SPL : Sound pressure level

Perchloroethylene

Quebec's Occupational exposure limits: TWAEV: 170 mg/m³ (25 ppm). STEV: 685 mg/m³ (100 ppm)

Conclusion about ototoxicity No evidence	Strength of evidence From human studies: Absent From animal studies: Absent Overall: Absent
Conclusion about interaction with noise No documentation	Strength of evidence From human studies: No study found From animal studies: No study found Overall: No study found

Ototoxicity - Analysis of human studies

Only one study was identified. In volunteers exposed during 4 days up to 50 ppm, no ototoxic effect was observed using auditory brainstem responses test.

Ototoxicity - Analysis of animal studies

Only one study was identified. In rats exposed during 13 weeks up to 800 ppm no ototoxic effect was observed using auditory brainstem responses test.

Interaction with noise - Analysis of human studies

No study was identified.

Interaction with noise - Analysis of animal studies

No study was identified.

Discussion

No ototoxic effect was observed in one short-term study in volunteers and one subchronic study in rats. No human or animal study on ototoxic interaction between perchloroethylene and noise was identified. In summary, there is neither evidence of ototoxicity of perchloroethylene nor of its interaction with noise.

Perchloroethylene

Perchloroethylene

• TWAEV : 25 ppm | 170 mg/m³

D-TWAEV : 24 mg/kg/d

Population

Species : Volunteer

: 10 - 12

Sex : Males

Age : 26.5 years

Exposure

Route : Inhalation

Duration : 4 h/d; 4 d

C/D reported : 10 or 50 ppm

CSU/DSU :

Ratio : 0.4 - 2

ASM :

BM :

NSM :

NL :

Remarks :

Tests

Test type

• Effects reported

Details on test

• Remarks

Auditory brainstem responses

• No effect

Clicks of 70 dB nHL

• Test performed before exposure, during exposure and the day after the end of exposure

Mechanism of action

Authors' conclusion

No ototoxic effect at 50 ppm after a short exposure in humans

Our conclusion

No ototoxic effect at 50 ppm after a short exposure in humans

Perchloroethylene**Perchloroethylene**• TWAEV : 25 ppm | 170 mg/m³

D-TWAEV : 24 mg/kg/d

Population

Species : Rat Fisher 344

: 12

Sex : Males and females

Age : 16 weeks

Exposure

Route : Inhalation

Duration : 16 h/d; 5 d/w; 13 w

C/D reported : 50, 200 and 800 ppm

CSU/DSU :

Ratio : 2 - 32

ASM :

BM :

NSM :

NL :

Remarks :

Tests**Test type**

• Effects reported

Details on test

• Remarks

Auditory brainstem responses

• No effect

Tone pips of 10 and 30 kHz

• Test performed next week after the end of exposure

Mechanism of action**Authors' conclusion**

No ototoxicity after subchronic exposure to 800 ppm in rats

Our conclusion

No ototoxic effect after subchronic exposure to 800 ppm in rats

BIBLIOGRAPHY

- Altmann 1990** Altmann, L., et al. (1990) Neurophysiological and psychophysical measurements reveal effects of acute low-level organic solvent exposure in humans. *Int Arch Occup Environ Health*. 62(7): 493-9.
- Mattsson 1998** Mattsson, J.L., et al. (1998) Neurotoxicologic examination of rats exposed to 1,1,2,2-tetrachloroethylene (perchloroethylene) vapor for 13 weeks. *Neurotoxicol Teratol*. 20(1): 83-98.