Audition and exhibition to toluene - a contribution for the theme

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SUMMARY

Introduction: With the technological advances and the changes in the productive processes, the workers are displayed the different physical and chemical agents in its labor environment. The toluene is solvent an organic gift in glues, inks, oils, amongst others.

Objective: To compare solvent the literary findings that evidence that diligent displayed simultaneously the noise and they have greater probability to develop an auditory loss of peripheral origin.

Method: Revision of literature regarding the occupational auditory loss in displayed workers the noise and toluene.

Results: The isolated exposition to the toluene also can unchain an alteration of the auditory thresholds. These audiometric findings, for ototoxicity the exposition to the toluene, present similar audiograms to the one for exposition to the noise, what it becomes difficult to differentiate a audiometric result of agreed exposition - noise and toluene - and exposition only to the noise.

Conclusion: The majority of the studies was projected to generate hypotheses and would have to be considered as preliminary steps of an additional research. Until today the agents in the environment of work and its effect they have been studied in isolated way and the limits of tolerance of these, do not consider the agreed expositions. Considering that the workers are displayed the multiples agent and that the auditory loss is irreversible, the implemented tests must be more complete and all the workers must be part of the program of auditory prevention exactly displayed the low doses of the recommended limit of exposition.

Keywords: noise, occupational, toluene, hearing loss, noise-induced, workers.

RESUMO

Introdução: Com os avanços tecnológicos e as mudanças nos processos produtivos, os trabalhadores estão expostos a diferentes agentes físicos e químicos em seu ambiente laboral. O tolueno é um solvente orgânico presente em colas, tintas, óleos, dentre outros.

Objetivo: Comparar os achados literários que evidenciam que trabalhadores expostos simultaneamente a ruído e solventes têm maior probabilidade de desenvolverem uma perda auditiva de origem periférica.

Método: Revisão de literatura a respeito da perda auditiva ocupacional em trabalhadores expostos a ruído e tolueno.

Resultados: A exposição isolada ao tolueno também pode desencadear uma alteração dos limiares auditivos. Estes achados audiométricos, por ototoxicidade a exposição ao tolueno, apresentam audiogramas semelhantes ao por exposição ao ruído, o que torna difícil diferenciar um resultado audiométrico de exposição combinada - ruído e tolueno - e exposição apenas ao ruído.

Conclusão: A maioria dos estudos foi projetado para gerar hipóteses e deveria ser considerado como passos preliminares de uma pesquisa adicional. Até hoje os agentes no ambiente de trabalho e seus efeitos têm sido estudados de maneira isolada e os limites de tolerância destes, não consideram as exposições combinadas. Considerando que os trabalhadores estão expostos a múltiplos agentes e que a perda auditiva é irreversível, os testes implementados devem ser mais completos e todos os trabalhadores devem fazer parte do programa de prevenção auditiva, mesmo expostos a baixas doses do limite de exposição recomendado.

Palavras-chave: ruído ocupacional, tolueno, perda auditiva provocada por ruído, trabalhadores.
INTRODUCTION

With the technological advances and the changes in the productive processes, the workers are displayed daily the different physical and chemical agents in its labor environment, which - in one number significant of situations - finishes for being to revert at risk to the health. This picture is presented still more unsafe when the prevalence of these risks turns it agreed exposition of these products to the noise.

In the last few decades, the occupational auditory losses have been argued in scientific publications, constituting a problem of important health in our society. However, studies appear on other agents, beyond the presence of the noise in environments of work of innumerable productive processes, that agreed, represent a potential risk to the hearing (1).

Amongst main ototoxic chemical composites, can be detached metals, suffocating and the solvents, considering this last group, most present in the half industrials. The toluene is solvent an organic present in glues, inks, oils, amongst others, and its evaluation in the labor environment is through its urinary bioindicador (examination of acid hippuric) (2).

In this article, we will present studies of the effect combined between noise and toluene, in intention to extend the knowledge how much to the effect of the concomitant exposition between the solvent and noise.

REVISION OF LITERATURE

The human being exposition to the toluene occurs from the occupational use, in the domestic environment, through the inhalation with abuse ends and of the ambient exposition. The biggest source of ambient exposition to the toluene is the production and use of the gasoline. Great amounts of toluene are introduced in the environment annually through the use of the gasoline and the production and processes of oil refinement. To calculate the levels of exposition human being proceeding from air, the ground and the water can be difficult (3).

In the last few decades, the occupational auditory losses have been argued ostensive in the half academic for the fact, unquestionable, to consist in a problem of important health in our modern society. However, more recent studies disclose that the presence of chemical agents, in association to the noise make to boosting the loss of hearing in the work environment (1).

The adverse effect of organic solvents in the health had been described in many studies (4, 5, 6). The decreases or moderate concentrations in air, organic solvents can cause temporary symptoms as euphoria, migraine, and vertigo (7, 8) whereas, in raised levels more can lead the cardiovascular anesthesia, problems and illnesses of the respiratory ways (6). The exposition of long stated period can still cause damages for the Central Nervous System as Cognitive Deficits and Emotional, what it would harm good a practical of the worker in its occupational environment, exactly that in simple tasks (9).

The toluene is a aromatically hydro-carbon, liquid and colorless, with characteristic odor, derivative of the tar of the mineral coal and the oil, used as solvent for inks, in the production of explosives, dyestuffs, medicines and detergents and as solvent industrial for rubber and oils and still in the production of other chemistries (10). It is widely used in the graphical industry. It is one of the components of the glue of shoemaker and the gasoline. This last one corresponds the main source of atmospheric emission and exposition of the population in general.

The Toluene is a solvent used of ample form in processes of anthropic transformation, particularly as solvent. In this condition, the related aromatically chemical product can, given to the degree of volatileness in conditions standard of temperature and pressure - 25ºC and 1atm - to arrive bigger impacts to the human being, revealed in the form of irritation of the skin and the mucosa. The acute effect of the toluene are similar those derive from the ethanolic poisoning, propitiating a picture of stimulation followed of depression of Central Nervous System (SNC). Already in situation of chronic exposition the risks are of hepato-toxicity, nephrotoxicity and auditory loss (5, 11).

The mechanisms of action of ototoxic substances cause functional damages or cellular damages in the internal ear, mainly in the final structures of the hearing and balance, acting first to the level of the cerebral trunk or in the auditory ways central offices (12).

When is about the auditory loss properly said, the characteristics of the audiometric curve of a attacked patient of exclusive exposition the noise or of another one, with confirmed diagnosis of ototoxicity are sufficiently similar. This because both the pictures are of sensorineural origin, denote cochlear injuries, tend to be irreversible, high frequencies attack initially (acute sounds) and almost always are bilateral (2).

The ototoxic effect of the chemical agents - and amongst these, of solvent the organic ones - has configured in subject of inquiry of great number of researchers.
The NIOSH identified the emergent necessity to establish safe limits for agreed chemical substance exposition and noise (13). European consists of Directive 2003/10/EC that establishes requirements of minimum security in the health of displayed workers the risks, that the employer will have simultaneously to give to particular attention for displayed workers the chemical agents and noise, when leading in account the risk evaluation (14).

The bridge most significant of available literature on the effect of the Toluene in the Auditory System happens essentially of two origins: cases where the patients inhaled the solvent voluntarily (15) and of lead laboratorial experiments with animals. These studies evidence that the exposition to high concentrations of Toluene, for the different ways of administration (verbal, subcutaneous or inhalation) accent the auditory loss. In complementary way to this thesis, in the studies carried through in animals, it was possible to notice great synergism between this solvent and exposition to the noise.

Such conclusion is corroborated by experimental evidences with animals, where the inhalation to high levels of toluene harms the auditory system and causes loss of the audible thresholds.

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**Discussion**

With the growth of the productivity and the advance of the technology, the risks of accidents and illnesses of occupational origin had increased and given origin to some harmful effect to the quality of life, to the individual and collective security of the worker.

In a study with 151 workers of the sector of rotogravure of a graphical industry of São Paulo, displayed simultaneously the noise (85-94dB) and toluene (78-390 ppm), the agreed effect of the simultaneous exposition to both was investigated the agents on the hearing and the balance (16).

In this study, using tests of hearing and balance, the workers had been divided in three groups: displayed the noise and toluene, displayed only the noise and without exposition. In the found results, the percentage of the auditory loss observed in the displayed group the two agents was significantly bigger of what in the others two groups.

Moreover, the measures of the consequence of the acoustic muscle had suggested that the joined auditory losses in this group were significantly different of the ones of the displayed group to the noise, over all with respect to probable localization of the injury. One more time here, the percentage of imperfections in the balance selection was significantly bigger in the group of workers displayed to both the agents.

Still in the same line of research, another study leads an inquiry with organic solvent and noise, observing its occupational effect. The searched individuals were all workers of rotogravure industry, of the masculine sex, with more than one year of company (17).

As mechanism of collection of data the audiometric examination and immittance testing had been used, beyond questionnaire (age, time of work, chemical time of exposition the noise and products, diabetes, hypertension, infection of ear, ototoxic medicine use, activities of leisure with noise, military service).

The workers had been divided in four groups: 50 displayed workers without any type of exposition, 50 workers with exposition alone the noise (88-97dB), 51 workers the noise (88-98 dB) and toluene (100 ppm) and 39 different displayed workers the mixture of solvent (the component greater of these mixtures was the toluene).

The results had shown to prevalence of bigger auditory loss in the group with simultaneous exposition the noise and toluene (53% in the group with exposition the noise and toluene, 8% in the group without exposition, 26% in the group with exposition only noise and 18% in the group with different exposition the mixture of solvent). In the results of the examinations of immittance testing, was met conscription presence, mainly in the groups of displayed workers to the noise and to the noise and toluene.

In the year of 1993, another study investigated workers displayed to an average concentration of 97ppm of solvent, that had presented absolute latencies and greater interpeaks in the waves in intervals I-III-V in the PEATE in relation to not displayed. With these data, one suggested that the alterations caused for the toluene can be situated in the region of the brainstem and auditory ways central offices. All the individuals of this study had normal audiometry and absence of related symptoms the exposition the solvents (18).

In one another study with solvent and noise inside of the demanded limits, in a producing company of packings with approximately 800 employees, the presented results had not shown boosting of effect. Occurrence of auditory losses in displayed workers only the solvents had over all called the young attention and workers e with little time exposition. In this research one used of the audiometry examinations and immittance testing, and the collaborators had been separate and three groups: exposition only to the...
noise, exposition only to solvent and the agreed exposition (19).

In experiments with animals, were used diverse pairs of solvents and the incidence of the interactions of not additive ototoxic. Male rats of the race Long Evans had been used in places where doses of solvent (10% of concentration) were managed per 5 days of 8:30 16:30 hours of Monday a Friday. The effect were compared of 2 the 13 days after the exposition and the auditory function was gotten in the following week of exposition using BERA (reply of potential evoked in the brain). The solvents used had been trichloroethylene (TCE), toluene (TOL), mixing xylene (XYL) and chlorobenzenes (CBZ) and the combination was TOL+TCE, XYL+TCE, XYL+CBZ, CBZ+TOL (20).

For results these authors had gotten evidences of that the combination in way dose-additive of the ototoxic solvents in the effect of the hearing of the rats. In the study with CBZ+TOL the effect had developed throughout the week and not immediately. The threshold of the displayed group was of 10dB bigger of what in the group of control.

According to authors, exactly with the gotten results, cannot conclude that the solvents always will be agreed additively in its effect in the hearing, therefore get synergism when the toxic effect of the agreed expositions is bigger of what the addition of the observed effect.

In a study with rats with long exposition to the toluene for inhalation had presented found suggestive of injuries in the central initial system without evidences of injuries in the peripheral initial function (21).

With the objective to study the effect of the toluene in the structure and function of the Auditory System, it is applied tests of potential evoked (BERA - evaluation of the cochlea) in adult rats of the masculine sex, of changeable average weight between 450-500g, and created in laboratory. The experiment had beginning when the offspring reached the limit of 200 days of life, lasting for understood changeable interval between 3 and 4 months. Completed the sixth month of age the animals had been confined in individual boxes, isolation condition in which had been kept per the 30 days that had preceded the beginning of the experimental process (22).

After to be sedated received electrodes capable to measure their evoked potentials the rats had been submitted the changeable dosages of vapors of toluene with concentrations, respectively of 1000, 1250, 1500, 1750 and 2000 ppm, for a regular period of 6 daily hours, during five days of the week, throughout 4 months.

The gotten results had indicated that only three of the dosages of toluene that the animals had been submitted - of 1500ppm, of 1750ppm and of 2000ppm - had produced confirmed alteration of auditory threshold. The exposition to the toluene resulted in significant auditory deficit in the amplitude of the average frequency (8-24 KHz) of the adult rats. The gotten result showed an alteration to cochlear, for the inhalation of the toluene and the main found was the cochlear trauma located in the way of organ of Corti (16-20 KHz) and half it for the apex (4-5 KHz).

Other authors had searched the effect of the simultaneous exposition of the toluene (2000 ppm) and of the noise (92 dB) in rats. These animals had been displayed to the toluene during 6h/day, 5 days of the week, for the period of one month. The results had shown the harmed induction of auditory, external loss hair cells and damaged stereocilia with bigger predominance in the rats displayed simultaneously to the noise and the toluene. The cochlear damage induced for the toluene or noise was caused by two different mechanisms, poisoning and mechanic (23).

With all the existing information and scientific results until then, new research had shown again to the occupational effect of the exposition of workers to solvent and the noise of an rotogravure industry, adding the calculation of the concentration of these mixtures in air and the examination of hippuric acid. 124 workers had participated of the study with solvent exposition to the mixture of acetate (mainly toluene, ethanol and ethyl) and different levels of noise. A questionnaire with all the workers were made (historical of work, psychosocial aspects, chemical medicines, health in general, exposition the noise and products), audiometry examination and immittance testing. Piss of these employees after hours of working was also harvested, for examination of hippuric acid (24).

The results of the audiometry had pointed 49% of the workers with bilateral auditory loss and the immittance testing results had suggested auditory upheaval central or to retrocochlear in the majority of the workers. The results had also shown alteration of the examination of hippuric acid in 95% of the workers. With this, worsening of the auditory loss was suggested, when the worker also is displayed to the toluene (from the data of acid hippuric) and 4 times more possibilities of auditory loss in workers with exposition the toluene and noise. The concentration of toluene in the air did not present significant relation with the auditory loss of the workers and with the results of hippuric acid.

In the evaluation of 64 rats displayed the toluene and ethanol, was divided the animals in 3 groups with exposition and a group of control. The first group was
displayed toluene vapors (1750 ppm, 6 hours per day, 5 days of the week for 4 months). As the group was displayed to ethanol (4g/kg for 4 months), which was injected way displayed gastric intubation and later in surrounding air for 6 hours; e the third group was displayed simultaneously to the toluene and ethanol (ethanol was injected before the exposition to the toluene). Examination of hippuric acid in the animals displayed to the toluene was realized. Piss was collected in 1º day and later each 4 days. No drunk or food was given to the animals during the exposition (25).

The results had shown that the auditory loss is more frequent in the exposition the toluene and ethanol of what only the toluene. Ethanol pure modifies the metabolism of the toluene. Auditory loss in the isolated exposition to ethanol was not evidenced.

The cochlea of displayed rats was also evaluated to the toluene, from the examination of Electrocochleography. The study was developed using two groups with each one 8 adult rats. The first group was displayed toluene vapors (1750 ppm) during 6h per day, 5 days of the week, for 4 months and second hand it did not have exposition (26).

After this period of exposition, was realized the examination of Electrocochleography and the results had not only shown alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. Thus the lost cells of the Cochlea were concentrated in the region of low medium frequencies and suggested relation of auditory loss with the exposition to the toluene.

In one another study with transitory otoacoustic emissions evoked (EOAET) and the suppression effect, a displayed group was observed the noise and toluene, comparing with a group only displayed with the noise and one another one without exposition. Had been evaluated 140 collaborators with age enter 18-48 years with normal results of audiometric and immittance testing (27).

The prevalence of absence of answers in the EOAET in at least one of the ears was bigger in the displayed group the noise and toluene (64%) and in the displayed group only the noise (62%), that in the group not displayed (27.5%).

The prevalence of absence of the effect of suppression in the displayed group the noise and toluene was bigger (48.9%) in relation to displayed the noise (17.4%) and not displayed (7.5%).

The risk of absence of suppression in the group noise and toluene was significantly bigger when was compared with the other groups. The results suggest the existence of a neurotoxicity action of the toluene on the a hearing affecting particularly the portion to retrocochlear of the auditory way and causing a type of distinct injury of that one provoked by the noise.

In research on the effect of the surveyed noise and mixture of solvent by means of audiometry of high frequencies, was observed worse thresholds in the comparison of the auditory thresholds in the high frequencies of the displayed group the noise simultaneously and mixes of solvent. This difference was significant for the high frequencies, whereas the results of the thresholds tested in conventional audiometry had not shown significant differences (28).

Was also searched the mixture of solvent alterations in the Evaluation of the Central Auditory Processing in a group of displayed workers. 10 displayed workers to the mixture of solvent and 10 works not displayed had participated of the study, with results of audiometry and immittance testing inside of the normality standards (29).

The findings of the central auditory processing had been lower in the displayed group the mixture of solvent, suggesting that, exactly without presenting alteration in the auditory examination, diligent displayed the mixture of solvent they present difficulties with the daily questions, what was proven with the auditory alterations central offices presented in the processing test.

In the evaluation of the risk of auditory loss in workers of a displayed adhesive industry the noise and toluene, divided the workers in 3 groups: in the first group, 58 workers had been displayed the noise (78.6-87.1dB) and toluene (33.0 ppm, 107.6 ppm and 164.6 ppm); in the second group, 58 workers only displayed the noise (67.9 - 72.6dB); e in the third group, 60 workers of the administrative sector, that did not have any type of exposition, serving of group of control (30).

All had answered to a questionnaire with information of health and style of life and had carried through audiometric examination. The tests had been carried through 14 hours after the ending of the day. The percentage of the auditory loss was calculated from the result of the worse ear. The displayed group the noise and toluene was subdivided in other groups, leading in consideration the level of the noise. Approximately 28% of the displayed workers the noise and toluene worked have more and 20 years. The predominance of the noise concentrations had been: sector noise and toluene: 83.9dB; sector noise 85.0 dB and 70.0 in the administrative sector. But 15% of the displayed workers the noise used EPI. The prevalence of the auditory loss was very bigger in the
group of noise and toluene (86.2%) in relation to the group displayed only to noise (44.8%) and 5% in the administrative group.

In research with expositions the inks and noise, studied painting sectors of automobiles of two companies and verified effect aggravation of the exposition the inks on the auditory thresholds of displayed individuals the noise between 81 and 85dB. The auditory losses verified in the displayed group the noise and inks was similar observed in the group only displayed the noise between 92-107dB (31).

In the evaluation of the effect of the solvent exposition the noise and on the peripheral auditory ways and central in workers of a graphical industry of Guarulhos in the period of September/2004 to August/2005, observed solvent association of the exposition of organic (gasoline, 3 n-hexane and thinner) and the alteration in the central auditory way was verified by means of the result of the test of the evoked potential auditory of long P300 latency (PEAL-P300) (32).

The research was realized with 136 workers and the prevalence of auditory losses found in the displayed group the noise and solvents (23.3%) was considerably bigger that in the others 2 groups, not displayed (8%), only displayed the noise (12.5%), only displayed the solvents (20%).

The results of the study suggest that the exposition to the noise had greater repercussion on the auditory threshold and the exposition to the solvents showed strong association with alterations in the results of the PEALL-P300.

Studies as the described before, in its majority carried through with animals created in laboratories, show to the effect of solvent the agreed exposition or not to the noise and (in this in case that, the toluene) and the different methods of evaluation of the auditory system.

All the realized analyses of association had indicated that the expositions, agreed or not, associate cases of auditory losses. The results had suggested that the exposition the high concentrations of mixtures of solvent and to the toluene in a noisy environment, can increase the risk significantly to acquire a occupational auditory loss. The results of the immittance testing had also suggested alteration of the central auditory system.

The tests of audiometry and immittance testing used in the studies are not enough to evaluate the effect of solvent to the hearing. The other used methods of evaluation, in show to the importance of a complete battery of audiological examinations for determination of the place and type to them of injury.

These other tests had shown that the ototoxic solvents damage the hair cells of the cochlea, suggesting that the toluene can damage cellular membranes selectively. The external hair cells, that facilitate the codification of the auditory information for the motor process of the cochlea, had been the targets most frequent of the ototoxic ones.

It cannot be conclude, however, if the solvents always will be agreed additively in its effect in the hearing. The infinity of products and the different concentrations hinder a trustworthy evaluation of its effect. The induced traumas for solvent would not be caused by the contamination of the fluid, but by poisoning of the fabric involving the ridge external, instead of the auditory nerve (20, 33).

The results had also suggested the existence of a neurotoxicity action of the toluene on the hearing affecting particularly the portion to retrocochlear of the auditory way and causing a type of distinct injury of that one provoked by the noise. The register of the EOAET and the analysis of the suppression effect can serve with instrument important in the precocious detention of the auditory alterations of origin to cochlear and to retrocochlear and for the elaboration of preventive actions in audiologic in work environments (27).

In Table 1, it meets description of main described articles above, in summary, on the mixture of solvent and noise.

**Final Comments**

Until today the agents in the environment of work and effect they have been studied in isolated way and the limits of tolerance of these, do not consider the agreed expositions. Considering that the workers are displayed the multiples agent and that the auditory loss is irreversible, the implemented tests must be more complete and all the workers must be part of the program of auditory prevention exactly displayed the low doses of the recommended limit of exposition. Studies on the ototoxic effect of the toluene in the occupational exposition are not conclusive yet.

It is important to remember that, as for the noise, the simple presence of the studied ototoxic agent (in the case the toluene), is not synonymous of exposition. So that some type of effect in the auditory agency occurs, the absorbed dose, that depends, among others, of the levels of concentrations in the environment and of the time of exposition, must be enough to cause the effect.
## Table 1. Solvent article description on mixture of (including the toluene) and noise:

| Year | Article | Authors | Exposition | Objective | Method | Results | Conclusion |
|------|---------|---------|------------|-----------|--------|---------|------------|
| 1990 | An epidemiological study of the effects of exposure to noise and organic solvents on workers' hearing and balance | Morata, TC | Noise and toluene | To investigate the effect of the simultaneous exposition to the noise and toluene in the hearing and balance of workers | Interviews and tests of applied hearing and balance in 3 groups of workers in an industrial plant of Sao Paulo, Brazil. 75 workers. The hearing and the balance of a group of workers exposed to the toluene and noise (TOL+N) and a group of workers exposed to noise only (N) had been simultaneously compared with a group of workers displaying only the noise (TOL). The results were compared with the noise in the group of workers displaying only the noise. | The percentage of the auditory loss observed in the displayed group of the 2 agents were significantly bigger of what in the 2 other groups. Moreover, the measures of the consequence of the auditory loss also had suggested that the period auditory losses in this group had been significantly bigger of what in the group of displayed workers with noise. | The results suggest that the exposition to the high concentrations of toluene in a noisy environment can increase in an important way the risk to acquire one of auditory damage occupational and that the high noise cannot more considered being as only threat to the hearing of the workers. |
| 1993 | Effects of occupational exposure to organic solvents and noise in hearing | Morata, C. et al | Solvent organic and noise | To investigate the occupational effect of the exposition organic and the noise of workers of a manufacturing industry of the machinery and with more than 1 year of company | Auditory examination, i. e. testing and questionnaire (Sign, tone, sound, time of exposition the chemical noise and peak, latency, hyperacusia, reduction of air, otoscopy, audiometry, use, activities of exercise with noise, military service). Workers divided in 4 groups: 50, 100, 150, and 200 workers, with noise exposition (85 dB), 50 displayed workers with exposition, alone the noise (N85), 50 noise, and 50 toluene (100 ppm) and 50 different displayed workers the mixture of solvent (the component greatest of these mixtures was the toluene). | Audiometry. Presence of bigger auditory loss in the group with simultaneous exposition the noise and toluene. Solubility of exposition of the effect of the noise and the auditory function was gotten in the following week of exposition using BERA (reply of potential evoked in the brain). | Existing Synergism between noise and solvent: the auditory test is not only enough for the evaluation of displayed workers the noise and solvent - resulting of the audiological examination the results are not enough for the study of the effect of the solvent to the hearing. It is necessary a complete battery of audiological examinations for determination of the place and type of injury. |
| 1993 | Acoustic exposure caused by occupational solvents and noise in hearing | Morata, C. et al | Solvent organic and noise | To investigate the occupational effect of the exposition organic and the noise of workers of a manufacturing industry of the machinery and with more than 1 year of company | Examination PEATE in displayed the average concentration of 97 ppm of toluene and not displayed workers | Workers displayed to an average concentration of 97 ppm of solvent, had presented bigger absolute losses and interpeak in the waves in interval I-IV. In the PEATE in relation to non displayed, suggesting that the auditory loss caused for the mixture can be evaluated in the region of the localization and auditory central neural. | All the individuals of this study had a normal and absence of related sympotms to the exposition the agents, what indicate the importance of other tests beyond the audiology, in solvent and noise group. |
| 1994 | Auditory effect provoked by the interaction between noise and solvent: A preventive boarding on audiometry directed the health of the worker | Souza, M.T. | Solvents and noises | To evaluate the effect of solvent directly on the auditory system | Group of workers displayed only the noise, only solvent and the noise and solvent (agreed exposition). | Group of workers displayed only the noise; only solvent and the noise and solvent (agreed exposition). | The infinity of products and concentrations hinders a trustworthy evaluation of its harmful effect. |
| 1995 | Combined effects of several pairs of organic solvents and noise on hearing | Robert, C.S. Schwartz, RM, Sauder, C.L, Pryor, C.T, e Fones, MMM | Several pairs of solvents | To determine the incidence of interactions of ototoxic additives between some pairs of solvent | Solvent used: methylene chloride (CC), toluene (TOL), xylene (XYL), and chlorobenzene (CBZ). The combination was TOL + XYL + CBZ = TOL, TOL + XYL + CBZ = XYL, and TOL + XYL + CBZ = CBZ. | The results had shown that the solvent used ototonic had combined in a way additive in the effect of the hearing of the rats. In the study with TOL + XYL the effect had developed immediately throughout the week. | The results had shown that the solvent used toxic decrease additive in the effect of the hearing of the rats. In the study with TOL + XYL the effect had developed immediately throughout the week. | The results had shown that the solvent used toxic had combined in a way additive in the effect of the hearing of the rats. In the study with TOL + XYL the effect had developed immediately throughout the week. |
| 1995 | Function of the auditory system, the visual systems and peripheral nerve after long term combined exposure to toluene and ethanol | Miller, P, Higmen, M, Johnson, AC | Toluene and Ethanol | To evaluate the hearing of displayed rats toluene and ethanol | Study with rats with long exposition to the toluene for inhibition | The results had shown that the solvent used toxic had combined in a way additive in the effect of the hearing of the rats. In the study with TOL + XYL the effect had developed immediately throughout the week. | The results had shown that the solvent used toxic had combined in a way additive in the effect of the hearing of the rats. In the study with TOL + XYL the effect had developed immediately throughout the week. |
| Year       | Title                                                                 | Authors                  | Methods                                                                 | Results                                                                 | Notes                                                                                     |
|------------|-----------------------------------------------------------------------|--------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| 1996       | Toluene-induced Hearing Loss: A Mid Frequency Location of the Cochlear Lesions | Campo, T. et al          | To study the effect of the toluene in the structure and function of the auditory system, from tests of potential evoked (pure tone) hearing in adult rats. | Rats of the masculine sex had been used, raised in a laboratory of France. | pure tone hearing test was performed. The rats showed an alteration in the results of the pure tone auditory test. The data were analyzed with an ANOVA test. |
| 1996       |                                                                                     | Liu, Y. et al            | To demonstrate the effect of the inhalation of the toluene on the auditory system. | Rats of the masculine sex had been used, created in a laboratory of France. Their weight was between 450-500g and the experiment was initiated when they were 7 months old. The rats were exposed to concentrations of 1000, 1250, 1500, 1750, and 2000 ppm, 6h per day, 5 days of the week, for 4 months. | The rats showed a significant difference in the results of the pure tone auditory test. The data were analyzed with an ANOVA test. |
| 1997       | Correspondence between middle frequency auditory loss in vivo and outer hair cell shortening in vitro | Liu, Y., Rao, D. et al.   | To study the effect of the toluene on the middle frequency auditory loss. | The results showed a significant difference in the middle frequency auditory loss. The data were analyzed with an ANOVA test. |
| 1997       | Combined effects as simultaneous exposure to noise and toluene on hearing function. | Lataye, R. & Campo, P.    | To study the combined effects of noise and toluene on hearing function. | The rats showed a significant difference in the results of the pure tone auditory test. The data were analyzed with an ANOVA test. |
| 1997       | Toluene-induced hearing loss among etchware printing workers               | Morata, C. et al.        | To study the occupational effect of the toluene in workers. | The results showed a significant difference in the results of the pure tone auditory test. The data were analyzed with an ANOVA test. |
| 1998       | Combined Effects of a Simultaneous Exposure to Toluene and Ethanol on Auditory Function in Rats | Campo, P. et al          | To study the combined effect of toluene and ethanol on hearing function. | The results showed a significant difference in the results of the pure tone auditory test. The data were analyzed with an ANOVA test. |
| Year | Title                                                                 | Authors                                                                 | Summary                                                                 |
|------|----------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------|
| 1999 | Toluene Ototoxicity in Rats: Assessment of the Frequency of Hearing Deficit by Electrocochleography | Lataye, R., Campo, P., Loquet, G. | The study was developed in a laboratory on France and used 2 groups of 8 adult rats. The first group was displayed toluene vapors and second hand it did not have exposition. The animals approximately had between 90-120 grams and 4 months of age. The animals of the first group had been displayed vapors of toluene of 0.5 ppm, during 9h per day, 5 days of the week, for 4 months. Only after this period of exposition, the examination of Electrocochleography was realized. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. |
| 1999 | Comparison of toluene induced and styrene induced hearing losses      | Lataye, R., Campo, P., Loquet, G. | The study was developed in a Laboratory on France and used 2 groups of 8 adult rats. The first group was displayed toluene vapors and second hand it did not have exposition. The animals approximately had between 90-120 grams and 4 months of age. The animals of the first group had been displayed vapors of toluene of 0.5 ppm, during 9h per day, 5 days of the week, for 4 months. Only after this period of exposition, the examination of Electrocochleography was realized. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. The study was developed in a Laboratory on France and used 2 groups of 8 adult rats. The first group was displayed toluene vapors and second hand it did not have exposition. The animals approximately had between 90-120 grams and 4 months of age. The animals of the first group had been displayed vapors of toluene of 0.5 ppm, during 9h per day, 5 days of the week, for 4 months. Only after this period of exposition, the examination of Electrocochleography was realized. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. |
| 1999 | Toluene and styrene intoxication route in the rat cochlea            | Blachere, V, Campo, P., Loquet, G, e Roure, M. | The study was developed in a Laboratory on France and used 2 groups of 8 adult rats. The first group was displayed toluene vapors and second hand it did not have exposition. The animals approximately had between 90-120 grams and 4 months of age. The animals of the first group had been displayed vapors of toluene of 0.5 ppm, during 9h per day, 5 days of the week, for 4 months. Only after this period of exposition, the examination of Electrocochleography was realized. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. The examination not only showed alteration of located auditory cells in the portion of lower middle frequencies of the cochlea and in medium frequencies. |

**Audition and exhibition to toluene - a contribution for the theme.**

Augusto et al.

Int. Arch. Otorhinolaryngol., São Paulo - Brazil, v.16, n.2, p. 246-258, Apr./May/June - 2012.
| Year | Study Title and Authors | Exposure and solvent | Methodology and Results | Conclusion and Discussion |
|------|-------------------------|----------------------|-------------------------|--------------------------|
| 2010 | Low level toluene disrupts auditory function in guinea pigs | Toluene | Study of the metabolism of the external hair cells of rats after the exposition low the concentration of toluene. Low toluene concentration 250ppm for 8 hours to the day, 5 days of the week for 1 month. | Cytotoxic activity reduced in the region of medium frequencies of the cochlea was found after exposition to low concentrations of toluene. The direction of the metabolism of the external hair cells can take the auditory loss and permanent loss of these cells. |
| 2011 | Displayed workers simultaneously the noise and toluene: study of the otoacoustic emissions evoked and effect of suppression | Noise and toluene | Study of the transitory otoacoustic emissions evoked (OAE) and the effect of suppression in a displayed group the noise and toluene comparing with the group only displayed to the noise and without exposition. 140 individuals with age of 18-48 years with audiometric and immittance normal had been evaluated. | The prevalence of absence of answers in the OAE/T in at least one of the ears was bigger in the displayed group the noise and toluene (64%) and in the displayed group the noise (62%) that in the group not displayed (27.5%). The prevalence of the effect of suppression in the displayed group the noise and toluene was bigger (48.9%) to stimulation to displayed the noise (37.4%) and not displayed (37.5%). The risk of absence of suppression in the group noise and toluene significantly bigger when was compared with the other groups. |
| 2010 | Evaluation of combined effect of organic solvents and noise by the upper limit of hearing | Noise and mixture of solvent | Study of displayed workers the noise and mixture of solvents by means of audiometry of high frequencies. Comparison of the auditory thresholds in high freq. of the displayed group simultaneously the noise and mixture of solvents observed worse results. | With these data, the authors suggest that the exposure to these agents, mostly inside of the work environment, can increase the occurrence of auditory alterations, being warned about the fact of B/S of exposure daily and many times without the adequate protection. |
| 2011 | Environment of work - a risk plaque | Noise and toluene | To study the auditory damage in displayed workers the noise and toluene in a plant of shoes. During the hours of working of 8 daily hours / 5 days of the week, one analyzed the levels of noise and concentrations of toluene which the workers were displayed and effect of the auditory system. The results had shown that, mostly displayed the levels of noise showed by Norma Regulation of the country (85 dBA/8h - NS-15 MT/BR) and lesser concentrations of toluene of what established for the same norm (58 ppm), group displayed to the exposed auditory noise and the solvent was what presented worse. | The results of the assessment of central auditory processing in a group of workers exposed to solvents showed worse thresholds. This difference was statistical significant for the high frequencies, whereas the results of the thresholds tested in conventional audiology had not shown differences. |
| 2012 | Occupational toluene exposure and auditory function: results from a follow-up study | Toluene and noise | Schrap, M., Derrins, P., Mikophiloa, Z., Biskiakovicz, M. Seavers, A. | Evaluating 383 displayed workers the noise and decreases toluene concentrations, the biological pointer (hippuric acid in piss) was not significant. |
| 2012 | Effect of chemical products and noise on the emergence of the auditory loss | Noise and solvents | Andrea Pires de Mello de Azevedo | Literature review. |
| 2012 | Displayed workers - the evaluation of the central auditory processing in a group of workers exposed to solvents | Solvents | Evaluation of the Central Auditory Processing in a group of displayed workers the mixture of solvents. 10 workers not displayed to the solvent mixture and 10 workers displayed to the solvent mixture had participated of the study. The study was carried through in a laboratory in Santiago, Chile. One has been excluded the workers with auditory alterations. To participate of the study, the results of the auditory and immittance testing had to be inside of normality. At the workers presented examination of normal auditory and immittance testing, however the findings of the auditory processing had been lower in the displayed group the mixture of solvent. | Neurotoxicity products can take or so more serious problems q the auditory loss. It has you evidence of that the auditory loss can be a precocious manifestation of poisoning. Another... Neurotoxicity products can take or so... auditory loss and exposition alone to some chemical products exactly develops auditory loss in low concentrations. |
| 2001 | Environment of work: a risk plaque | Noise and solvents | Study of the metabolism of the external hair cells of rats after the exposition low the concentration of toluene. | Analysis of the levels of noise and concentrations of solvent which the workers were displayed and effect on the auditory system. |
| 2000 | Evaluation of combined effect of organic solvents and noise by the upper limit of hearing | Toluene and noise | Schrap, M., Derrins, P., Mikophiloa, Z., Biskiakovicz, M. Seavers, A. | Evaluating 383 displayed workers the noise and decreases toluene concentrations, the biological pointer (hippuric acid in piss) was not significant. |
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| 2012 | Displayed workers - the evaluation of the central auditory processing in a group of workers exposed to solvents | Solvents | Evaluation of the Central Auditory Processing in a group of displayed workers the mixture of solvents. 10 workers not displayed to the solvent mixture and 10 workers displayed to the solvent mixture had participated of the study. The study was carried through in a laboratory in Santiago, Chile. One has been excluded the workers with auditory alterations. To participate of the study, the results of the auditory and immittance testing had to be inside of normality. At the workers presented examination of normal auditory and immittance testing, however the findings of the auditory processing had been lower in the displayed group the mixture of solvent. | Neurotoxicity products can take or so more serious problems q the auditory loss. It has you evidence of that the auditory loss can be a precocious manifestation of poisoning. Another... Neurotoxicity products can take or so... auditory loss and exposition alone to some chemical products exactly develops auditory loss in low concentrations. |
2006 Hearing loss in workers exposed to toluene and noise
Chang, S.J. et al
Noise and Toluene
To evaluate the risk of auditory loss for displayed workers the noise and toluene. The workers of an adhesive industry had been divided in 3 groups: in the first group, 56 displayed workers the noise (78.6-87.1) and toluene (33.0 ppm, 107.6 ppm and 164.6 ppm), in the second group, 56 displayed workers only the noise (67.3 - 72.0), and in the third group, 50 workers of the administrative sector. It had been answered to a questionnaire with information of health and style of life, had had a test of audiometric examination. The tests had been carried out 14 hours after the ending of the day. The percentage of the auditory loss was calculated from the result of the ear worse. The displayed group the noise and toluene was subdivided in 3 other groups, leading in consideration the level of the noise.

2006 Toxic solvents in car paints increase the risk of hearing loss associated with occupational exposure to moderate noise intensity
EL-Shazly, A.
Paints and Noise
It was studied two painting sectors of automobiles of two companies and verified effect aggravation of the exposition to the inks on the auditory thresholds of displayed individuals. The authors did not specify if former expositions had been considered.

2007 Thesis of Doctored USP - solvent Occupational Exposure to noise and peripheral auditory alterations and central offices.
Dra Alice Penna Bernardi Noise and solvents
To evaluate the effect of the solvent exposition the noise and the peripheral auditory ways and central in workers of a graphical industry. Association of the exposition of 3 organic solvents (gasoline, n-hexane and thinner) and alteration in the central auditory way by means of the results of the test of the evoked potential. The research was carried through with 136 workers with maximum age of 50 years for the process of Presbycusis not to intervene with the results. The prevalence of auditory losses found in solvent the displayed group the noise and... showed to fort association with alterations in the results of the PEALL-P300. Equal results to the FUENTE study (2006).

2008 Ototoxicity of Toluene and Styrene: State of Current Knowledge
Hoel, P. and Lison, D.
Noise and Toluene
Revision of literature of the ototoxic effect of the toluene and the styrene in the auditory system. The limitation found in the study epidemiological is the insufficient characterization of the exposition to the styrene and toluene, with also other solvents. The studies made with animals bring the internal exposition. The potential variable of absorption is different. The individual metabolism must be considered.

Considering that the workers are displayed the multiples agents and that the auditory loss is irreversible, the implemented tests must be more complete and all the workers must be part of the program of auditory prevention mostly displayed the low doses.
Being thus, is important that the managers and/or professionals who work with the question of the Health of the Worker, is alerted of the effect combined concerning the exposition the noise and chemical substances, so that it can search tools for quarrels of effective norms and the programs of auditory conservation, contributing for more good a management in the health of the worker. The perspective of study of the combined effect, not only of the toluene, but of the majority of the chemical agents, must deserve greater attention so that if it can plan measured adequate of protection, rethink the existing Programs of Auditory Conservation.

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