

# Workplace Activity in Health Professionals Exposed to Chemotherapy Drugs: An Otoneurological Perspective

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## Abstract

**Introduction** The manipulation of antineoplastic drugs presents high risk for accidents and occupational diseases.

**Objective** To evaluate the auditory and vestibular systems of workers who are exposed to chemotherapeutic treatment in the University Hospital of Universidade Federal de Santa Maria, Brazil, and to identify the use of individual protection equipment, related to the obtained results.

**Methods** This study is a cross-sectional study using a quantitative method. We evaluate 33 male and female workers, ranging from 21–60 years old, of the nursing and pharmacy sectors. The workers underwent conventional Audiologic Assessment; Transient Evoked Otoacoustic Emissions; and Computerized Vectoelectronystagmography.

**Results** The majority of the sample was female (90.9%). Individual protection equipment was used by 90.9% of the workers. Complaints of dizziness were reported by 56.25% of nursing workers and 52.94% of pharmacy workers. Audiological and vestibular assessment results were within normal limits, 96.97% and 74.20%, respectively. However, audiometric configuration of notch type was identified in 75.75% of all workers. Audiometric notches (76%) and altered caloric test (100%) were often associated with decreased use of coal masks.

**Conclusion** Among the workers evaluated, the vestibulocochlear system was within the normal limits. The presence of notch configuration indicates the need to use individual protection equipment.

## Keywords

- ▶ hearing
- ▶ drug therapy
- ▶ occupational health services
- ▶ vestibular function tests
- ▶ dizziness

## Introduction

Cancer is the name given to different diseases which resemble one another by uncontrolled growth of abnormal cells, with invasive potential and originated by multifactorial causes.<sup>1</sup> The disease is considered the second leading cause of death worldwide and is considered a public health problem.<sup>2</sup>

Treatment with chemotherapy, a systemic treatment modality, is considered the major option for cancer control.<sup>3</sup> Chemotherapeutic, antineoplastic, or cytostatic agents are drugs used, in combination or alone, with the aim of eliminating neoplasms. These drugs work on the cell level, interfering in the process of cell growth and division. Most of these drugs are not selective in destroying only tumor cells, and, therefore, also interfere in normal cells.<sup>4</sup>

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As the number of cancer cases increases, so does the demand for professionals involved in the care and treatment of these patients. This, in turn, increases the occupational risks to which these professionals are exposed.

The handling of antineoplastic drugs is considered the major occupational exposure to chemical agents in hospitals, and involves a high risk of accidents and work diseases,<sup>5</sup> affecting mostly pharmacists, nurses, and nurse technicians, who are constantly involved in preparing and administering these drugs. This is because the inhalation of aerosol and percutaneous absorption of residues and particles are the main routes of exposure.<sup>6</sup> Such agents may go unnoticed, leading to an immediate or delayed health-disease process<sup>7</sup> to the worker.

Chemotherapeutic agents have been a constant object of research in the areas of pharmacology and nursing.<sup>5-11</sup> However, organic reactions after exposure to antineoplastic drugs are still unclear. It is believed that these drugs can harm workers' health due to their toxicity, and may cause undesirable and irreversible side effects when exposed and manipulated without safety measures.

According to the literature,<sup>12</sup> gases and vapors present in the hospital environment affect the organism, causing various reactions, such as weakness, fainting, drowsiness, seizure, vomiting, headache, vision disturbances, tremor, cough, conjunctival tearing, and dizziness.

Auditory and vestibular disorders can result from the exposure to ototoxic drugs and noise.<sup>13</sup> The contact with ototoxic drugs, considered cochleo-toxic (affect hearing) and vestibular-toxic (affect balance),<sup>14</sup> can lead to functional changes or cell damage in the inner ear (anterior and posterior labyrinth),<sup>15</sup> acting in the brainstem and/or central nervous system.<sup>15,16</sup>

Hearing is a complex sense that enables us to identify, locate, and process sounds, allowing people to do activities that range from monitoring danger signals and understanding speech to appreciating music. For this system to function properly, all of the path the sound will travel through has to be healthy, from the outer ear to the central auditory pathways.<sup>17</sup> Hearing damage from ototoxicity is characterized by cochlear, bilateral, symmetrical, and irreversible hearing loss. It begins by the high frequencies, and its degree depends on the concentration of the ototoxic element. There may also be tinnitus and dizziness.<sup>18</sup>

In addition to hearing, balance can also be affected by chemotherapy. The vestibular system is responsible for informing about the position and movement of the head, providing us with sense of balance, which assists in the coordination of head and eye movements, as well as in body posture adjustments. When its function is disrupted, unpleasant sensations can occur, such as dizziness, nausea, and a feeling of lack of balance with uncontrollable eye movements.<sup>19</sup>

Brazil's Ministry of Labor's Regulatory Standard number 9 (NR-9) establishes the obligation of the preparation and implementation of Environmental Risk Prevention Programs (ERPP), to preserve the health and integrity of workers. Among the actions of the program are the evaluation and control of risks in the work environment.<sup>20</sup>

To monitor the ototoxicity in hearing as well as in body balance, it is believed that different procedures can be used.

Audiometry is an effective method, because it assesses the auditory pathway quantitatively. Otoacoustic emissions may also contribute, as they directly evaluate the outer hair cells of the cochlea, working as a predictor for hearing loss.<sup>21</sup> On the other hand, the vectoelectronystagmography, crucial in otoneurological evaluation, provides data about the vestibulo-oculomotor function and its correlation with the brainstem, cerebellum and other connections to the central nervous system.<sup>22</sup>

Another important aspect that should be considered in relation to studies involving chemotherapy handling are the ways to reduce occupational exposure to these agents, in particular the adoption of procedures for prevention and the use of Personal Protective Equipment - PPE (goggles, masks, latex gloves, and apron), essential during every stage of drug manipulation.<sup>23</sup>

The focus of studies concerning the effect of chemotherapy is generally patients in oncological treatment, that is, those who receive medication, disregarding the workers who apply it, and are exposed to the drugs on a daily basis.

Thus, the aim of this study was to investigate the health conditions of the auditory and vestibular systems of health care professionals exposed to chemotherapeutic drugs, through conventional hearing evaluation, otoacoustic emissions by transient stimuli, and computerized vectoelectronystagmography; as well as to identify the use of Personal Protective Equipment, connecting it to the results obtained.

## Methods

This was an observational, descriptive, cross-sectional study, which used a quantitative method.

This study was approved by the Research Ethics Committee (CEP) of Universidade Federal de Santa Maria, in section 04.10.2013, under protocol number 306 039, and is part of a project entitled Integrated Otoneurological Evaluation in Individuals Assisted by a University Hospital. The study was conducted at the Ambulatory of Otoneurology - Balance and Audiology sector of a University Hospital.

The sample consisted of 33 health professionals in the Nursing and Pharmacy sectors of a University Hospital, exposed to chemotherapy, with ages ranging from 21 to 60 years old, male and female, after agreeing with participating in the research by reading and signing the Free and Informed Consent.

The investigation adopted the following **inclusion criteria**: being in contact with antineoplastic agents - injectable chemotherapy drugs and/or pills - not necessarily having complaints regarding hearing and/or balance disorders. The **exclusion criteria** involved individuals with neurological, or cognitive impairments, middle ear disorders, and/or significant visual impairments that could prevent vestibular and hearing evaluation.

We tested the health professionals by means of audiological evaluations, composed by anamnesis, to obtain previous and current medical and occupational history of the worker concerning auditory and vestibular complaints, data regarding the history of exposure to chemicals and use of Personal

Protective Equipment (PPE). The patients underwent a visual inspection of the external acoustic meatus using a Heidji otoscope; Pure tone audiometry at frequencies of 250 to 8000 Hz by air conduction (AC), and 500 to 4000 Hz by bone conduction (BC) (in frequencies with auditory thresholds of air conduction above 25dB, in both ears); Logoaudiometry - Speech Recognition Threshold (SRT) and Speech Recognition Percentage Index (SRPI), done in an acoustic booth with a pair of TDH-39P headphones (Vitasons, Porto Alegre, Brazil), using a digital two-channel Otometrics audiometer, model Itera II (Telephonics, Taastrup, Denmark), calibrated according to the ANSI-69 standard; Acoustic Immittance Measures (tympanometry with a 226Hz probe tone, and research of the acoustic reflex of the contralateral stapedius muscle - dBNS with research of the thresholds at 0.5; 1; 2 and 4 kHz, using the Interacoustic middle ear analyzer, model AT235 (Middelfart, Denmark), and Transient evoked otoacoustic emissions (TEOAEs), beginning by the right ear. We used parameters for analysis proposed by the authors,<sup>24</sup> that is, non-linear clicks with regular pulses lasting 80 microseconds ( $\mu$ s), polarity rarefied, in a series of 260 stimuli in eight-clicks blocks each, with repetition frequency of 50 cycles per second. As for the spectrum of emissions, the standard stimulus contains energy distributed in the frequency bands of 0.7; 1.0; 1.4; 2.0; 2.8; and 4 kHz, using the cochlear analyzer Otoread in an acoustic booth.

Then, were evaluated the professionals in terms of vestibular assessment through the computerized Vectoelectronystagmography (VNG), after previous preparation. Initially, their skin was cleaned with alcohol, and then the electrodes were fixed by means of electrolytic paste and adhesive tape (micropore tape) in the periorbital region, disposed as an isosceles triangle: one electrode on each outer eyelid angle of the eye, the other on the front (earth electrode) and the last 2 cm above the glabella (active electrode), enabling the recording of horizontal, vertical, and oblique movements. The individuals were seated in a swivel chair, 1m to the Led's bar. The VNG comprised calibration (horizontal and vertical); research of spontaneous nystagmus with open and closed eyes; research of semispontaneous or directional nystagmus (right, left, top, and bottom); of pendular tracking; of optokinetic nystagmus (clockwise and counterclockwise); of per-rotatory nystagmus or decrescent rotatory pendular test (head 30° forward), and; research of post-caloric nystagmus with stimulus of water at 30° and 44°C, according to the proposed criteria.<sup>22</sup> For the vestibular-oculomotor evaluation, we used the Contronc VNG computerized system, model SCV, version 5.0, and Nistagmus software.

At the end of the collection, the data were tabulated in an online Excel spreadsheet and analyzed statistically. Concerning the statistical method used, we performed a descriptive critical analysis on percentage, mean, standard deviation, and median values, as well as the Fisher's exact test and chi-square statistical analysis.

## Results

The sample consisted of 33 health professionals exposed to chemotherapy agents, of whom 90.9% were female and 9.1%

male, with an average age of 37.18 years ( $\pm$  13.20). The age group from 20 to 35 represented 54.54% of the population, 18.2% between 35 and 45 years, and between 50 and 60 years of age the percentage was 27.3%, as there were no individuals in the age group between 45 and 50 years. 51.52% of these professionals work in the field of pharmacy and 48.48% in nursing.

Considering the professionals exposed to chemotherapy agents working in the areas of nursing and pharmacy, 56.25% and 52.94% reported dizziness, respectively. Upon Chi-square test, there was no statistically significant difference ( $p = 0.84$ ).

Regarding the variable time of service exposed to chemotherapy agents, 51.51% work for less than five years in the field, considering this as the most frequent occurrence; with an average time of 10.66 years ( $\pm$  10.54).

Concerning the presence of dizziness, 54.54% had some type of dizziness, from which 61.12% was non-rotatory and 38.88% rotatory, in addition to 75.75% of neurovegetative symptoms. The main extra-hearing complaints reported in the anamnesis were anxiety (69.7%), stress (56.6%), nervousness (51.5%), headache (45.5%), and depression (30.3%).

In the audiological assessment, 96.97% of the participants had hearing thresholds within the normal range according to the tritone average (0.5, 1 and 2 kHz), and 3.03% had mild sensorineural hearing loss; identifying notch configuration in 75.75% of the individuals; 40% notched at a frequency of 6 kHz (eight RE, two LE), 24% at a frequency of 4 kHz (three RE, three LE), and 36% in both ears at 6 kHz. All evaluated subjects (100%) presented tympanometry curve type A, and the contralateral acoustic reflex was present in 87.87% in the right ear and 93.93% in the left ear. In addition, there were otoacoustic emissions by transient stimuli in 100% of the assessed individuals.

► **Table 1** indicates the distribution of absence and presence of notch in the audiometric configuration of the workers with and without dizziness complaint.

The distribution of presence and absence of notch in the audiometric configuration of Pharmacy and Nursing workers is shown in ► **Table 2**.

The association between the occurrence of normal and abnormal results in research of the post-caloric nystagmus and the presence and absence of notch in the audiometric configuration is identified in ► **Table 3**.

In the vestibular assessment, 31 professionals were submitted to VNG. From the results, 100% of the participants had regular calibration, absence of spontaneous and semi-spontaneous nystagmus with eyes open and closed; 83.87% showed horizontal pendular tracking type I, and 16.13% type II; 70.97% showed vertical pendular tracking type I, 16.13% type II, and 12.90% of the subjects type III; symmetry was present in 90.32% in the optokinetic nystagmus test, and 96.77% in the decrescent rotatory pendular test. In the research of post-caloric nystagmus, we observed the diagnosis of normal reflexes in 74.20% of the participants, hyperreflexia in 12.90%, labyrinth predominance in 9.68%, and 3.22% with hyporreflexia. From the analysis of the results found in vestibular tests, we identified that 74.20% of the

**Table 1** Distribution of absence and presence of notch in the audiometric configuration in workers with and without dizziness

Group	Notch absence N (%)	Notch presence N (%)	Total N (%)	<i>p</i> -value
With dizziness	7 (87.50)	11 (44.00)	18 (54.54)	0.04*
Without dizziness	1 (12.50)	14 (56.00)	15 (45.45)	
Total	8 (100.00)	25 (100.00)	33 (100.00)	

Fisher's exact test \*  $p < 0.05$ .

**Table 2** Association between the occurrence of normal and abnormal results of the post-caloric nystagmus and the presence and absence of notch in the audiometric configuration

Group	Notch		Total N (%)	<i>p</i> -value
	YES N (%)	NO N (%)		
Normal	19 (82.60)	23 (74.19)	23 74,19	0.15
Altered	4 (17.40)	8 (25.81)	8 25,81	
Total	23 (100.00)	31 (100.00)	31 100,00	

Fisher's exact test.

subjects were diagnosed as within the normal range, one (12.90%) subject presented peripheral vestibular deficit dysfunction, and another (12.90%), vestibular dysfunction.

► **Table 4** shows the distribution of occurrence of normal and abnormal results in the research of post-caloric nystagmus in pharmacy and nursing workers.

Considering the health professionals investigated, we observed that 90.9% use some kind of Personal Protective Equipment (PPE): 90.9% wear gloves; 84.84% wear aprons; 69.69% wear common masks; 24.24% wear caps; 21.21% wear activated coal masks, and 9.09% wear goggles.

We present the association between the occurrence of normal and abnormal results in the research of post-caloric nystagmus and whether workers of pharmacy and nursing wear coal masks and gloves or not in ► **Table 5**.

► **Table 6** shows the association between the occurrence of notch in the audiometric configuration and whether workers of pharmacy and nursing wear coal masks and gloves or not.

## Discussion

The population of this study was mostly female. This is similar to the data obtained by other authors,<sup>5-10</sup> who had 63.3%,

70%, and 88% of female subjects, respectively. Health practices are closely related to the act of caring, and this is historically linked to the female gender; therefore, it is natural to find a higher incidence of women in participants of the health sector, especially in nursing.<sup>5</sup>

As regards to age, there was a prevalence of young adults, with 70% of the population aged 20–35 years old.<sup>5</sup> Another author<sup>8</sup> studied a 21–47-year-old age group in this occupation. The study's data are similar to those found in our study.

In the current study, health professionals exposed to chemotherapy agents are categorized in the areas of pharmacy and nursing, corroborating a study<sup>9</sup> that identified such as the areas with higher exposure to such chemical agents in a hospital.

As for the duration of exposure to chemotherapy drugs, we observed in this study that most professionals have been working in the field for less than five years. Such results corroborate other studies found in the literature,<sup>8</sup> in which the time of professional experience of the nursing staff in the chemotherapy sector was higher than two years (76.70%). In contrast, another study<sup>10</sup> found that 67% of the nurses working in the chemotherapy sector had been in the job for more than five years.

**Table 3** Distribution of the presence and absence of notch in the audiometric configuration on workers of Pharmacy and Nursing

Group	Notch		Total N (%)	<i>p</i> -value
	YES N (%)	NO N (%)		
Pharmacy	15 (60.00)	2 (25.00)	17 (51.51)	0.11
Nursing	10 (40.00)	6 (75.00)	16 (48.49)	
Total	25 (100.00)	8 (100.00)	33 (100.00)	

Fisher's exact test.

**Table 4** Distribution of occurrence of normal and abnormal results in the post-caloric nystagmus of workers of Pharmacy and Nursing

Group	Normal N (%)	Altered N (%)	Total N (%)	<i>p</i> -value
Pharmacy	13 (56.52)	2 (25.00)	15 (48.39)	0.21
Nursing	10 (43.48)	6 (75.00)	16 (51.61)	
Total	23 (100.00)	8 (100.00)	31 (100.00)	

Fisher's exact test.

**Table 5** Association between the occurrence of normal and abnormal results in the post-caloric nystagmus and the use or not of coal masks and gloves by workers of Pharmacy and Nursing

PPE	Group	Normal N (%)	Altered N (%)	Total N (%)	<i>p</i> -value
Coal Mask	Yes	7 (30.43)	0 (0.00)	7 (22.58)	0.14
	No	16 (69.57)	8 (100.00)	24 (77.42)	
Total		23 (100.00)	8 (100.00)	31 (100.00)	
Glove	Yes	22 (96.65)	6 (75.00)	28 (90.32)	0.15
	No	1 (4.35)	2 (25.00)	3 (9.68)	
Total		23 (100.00)	8 (100.00)	31 (100.00)	

Fisher's exact test.

Abbreviations: PPE, personal protective equipment.

**Table 6** Association between the occurrence of notch in the audiometric configuration and the use or not of coal masks and gloves by workers of Pharmacy and Nursing

PPE	Group	Notch/yes N (%)	Notch/no N (%)	Total N (%)	<i>p</i> -value
Coal Mask	Yes	6 (24.00)	1 (12.50)	7 (21.22)	0.65
	No	19 (76.00)	7 (87.50)	26 (78.78)	
Total		25 (100.00)	8 (100.00)	33 (100.00)	
Glove	Yes	25 (100.00)	5 (62.50)	28 (84.84)	0.01*
	No	0 (0.00)	3 (37.50)	3 (15.16)	
Total		25 (100.00)	8 (100.00)	33 (100.00)	

Fisher's exact test; \*  $p < 0.05$ .

Abbreviations: PPE, personal protective equipment.

There is a scarcity of epidemiological studies addressing the time of occupational exposure to chemotherapy agents that can cause hearing loss or balance disorders; however, research<sup>25</sup> indicates that individuals in contact with ototoxic chemical products may begin to show hearing loss as early as two or three years of exposure to these substances, while noise exposure would take four to five years. According to that, the population of this study is already within the risk range, considering that hearing loss can be triggered by the ototoxic chemical process.

The current study also highlighted the prevalence of non-rotating dizziness associated with neurovegetative symptoms. In a study<sup>26</sup> conducted with nurses who had direct contact with medications, solutions, antiseptics, chemother-

apy agents, etc., dizziness complaints were reported, but not specified, and persisted even with the use of PPE. Regarding the neurovegetative symptoms, a study<sup>8</sup> identified that 10% of the nurses evaluated showed symptoms such as nausea and heat in the face when in contact with the chemotherapy drug.

In the current study, there were extra-auditory complaints, shown in decreasing order herein: anxiety, stress, nervousness, headache, and depression. This corroborates research<sup>27</sup> conducted with workers of a hospital, which found that headache was the fourth symptom related to work, pointing out the relationship between hospital work and extra-auditory complaints. Such symptoms can be observed either in the preparation or in the administration of antineoplastic drugs without the use of collective or personal



protective equipment, which implies a significant and inappropriate absorption of such substances.<sup>28</sup>

In the same study,<sup>28</sup> risks caused by handling antineoplastic drugs result from the inherent toxicity of the drug and the time of exposure to them. Moreover, the authors report that the extra-auditory complaints can be compared with those presented by patients being treated with these substances.

In the present study, we observed that most professionals in nursing and pharmacy had complaints of dizziness. Despite the lack of studies showing the percentage of occurrence of dizziness in these occupations, it is important to highlight that occupational exposure to antineoplastic drugs can cause immediate (headache, vertigo, dizziness, and vomiting), or late effects (carcinogenesis, mutagenic, and teratogenic).<sup>29</sup>

Among the main drugs used by the population evaluated are carboplatin, cyclophosphamide, cisplatin, doxorubicin, gentamicin, vinblastine, fluorouracil, vincristine, among others. These drugs are causers of reactions that are toxic to the inner ear structures, and could harm the auditory and/or vestibular system, either centrally and/or peripherally.<sup>15-30</sup>

The exposure to these drugs can cause various effects, including vertigo, which was observed in professionals responsible for the preparation or administration of antineoplastics without the use of protective equipment.<sup>9</sup> The same author points out that the effects caused by the contact with these substances can be compared with those presented by patients undergoing antineoplastic treatment.

According to the literature,<sup>31</sup> the use of aminoglycosides and platinum derivatives such as cisplatin have been pointed as the most common cause of permanent hearing loss by ototoxic drugs. The incidence of hearing loss induced by cisplatin ranges from three to 100% in the literature. This data does not differ from those of a study<sup>32</sup> that evaluated children undergoing cisplatin treatment, and identified that ototoxic effects initially affect high frequencies, with subsequent impairment of medium and, subsequently, of low frequencies, according to the cumulative dose of the drug, characterizing the cisplatin-induced hearing loss as sensorineural, bilateral, symmetrical, and irreversible.

In the audiological evaluation of the current study, most workers presented hearing thresholds within the normal limits according to the tone average (0.5, 1, and 2 kHz) and notch configuration in high frequencies.

When evaluating the hearing of patients undergoing treatment with cisplatin, authors<sup>33</sup> state that hearing loss induced by the use of this drug can occur even after the interruption of the treatment, showing the prolonged and cumulative effect of chemotherapy in the human organism. This study also establishes the importance of the audiological routine test battery in patients undergoing chemotherapy. Due to the intense exposure, it is understood that this monitoring should be expanded to professionals who come into contact with these substances.

In the present study, even though lowered tone thresholds were not found, the presence of notch could be identified as an indicator for taking control and prevention measures in relation to the damage caused by ototoxicity. For this reason,

the auditory and vestibular monitoring is believed to be of great importance for early detection of the effects of ototoxicity on workers.

During the audiological assessment, we found a tympanometric curve of type A and contralateral acoustic reflex. Studies<sup>34,35</sup> have shown that the majority of workers exposed to chemical agents have tympanometry curve of type A in both ears; in 75% of subjects in the right ear, and 100% in the left ear, respectively; however, there was a prevalence of bilaterally absent contralateral acoustic reflexes.

Regarding transient otoacoustic emissions, we identified in this study that otoacoustic emissions by transient stimuli were present in the whole population studied, indicating normal cochlear function of outer hair cells. Similar results were found in 100% of the patients treated with cisplatin.<sup>31,32</sup> Otoacoustic emissions (OAEs) are used to monitor hearing in individuals exposed to ototoxic drugs,<sup>36</sup> since they could be a predictor for hearing loss in occupational cases.<sup>21</sup>

Concerning the distribution of presence or absence of a notch in the audiometric configuration of the workers with and without dizziness complaint, in addition to observing statistically significant differences, a positive association was found, since most individuals with dizziness complaints had notch configuration, indicating that there is an association of the facts in this population.

Regarding other associations focusing on clinical exams, no significant differences were found. However, the presence of notch in the hearing configuration could be observed regardless of occupation, as well as a higher percentage of normal results, while in the group of nursing workers there was a higher percentage of abnormal results, respectively; even though we observed no statistically significant difference. In both occupations, there was a higher percentage of normal results (► **Table 2**); and a higher percentage of workers with notch configuration and normal results in post-caloric nystagmus (► **Table 3**). According to authors,<sup>37</sup> most drugs are damaging to the cochlea and, to a lesser extent, the vestibule.

In the literature studied, we did not identify research that made similar associations to those described in the previous paragraph, nor studies using VNG as an evaluation method in the population studied. Therefore, we decided to compare the results obtained in this study with those found through other evaluation methods, as well as those of studies with workers exposed to other chemicals considered potentially damaging to the vestibular system.

Authors<sup>38</sup> evaluating the vestibular system through cephalic auto-rotation in the horizontal plane of patients before and after cisplatin use, concluded that the reduction in the performance of the vestibulo-ocular reflex observed in these patients could be due to chemotherapy, confirming that this instrument is effective for monitoring vestibulotoxicity.

By evaluating workers exposed to organophosphorus compounds, researchers<sup>39</sup> identified 88% of alterations of irritative peripheral vestibular syndrome in VNG, nine by changes in caloric tests, with hyperreflexia in absolute values.

Regarding the use of PPE, gloves were the most common equipment, followed by the apron and common mask. Activated carbon masks and goggles, essential equipment for

handling chemotherapy drugs as they reduce the penetration of aerosols by the worker,<sup>23–40</sup> are used by a smaller share of the population, and the difficulty of access is the justification reported by the workers in this study. In line with a study<sup>41</sup> that asked workers about the availability of PPE, we found that 41.80% of the professionals considered access to these devices as insufficient. These data were also similar to those found in another study,<sup>8</sup> in which 23.3% of the nurses surveyed did not use goggles, coal mask, or disposable apron; another study<sup>5</sup> also identified that 35% of the subjects did not use goggles.

The use of PPE in the professional practice should be investigated and demanded by supervisors and also by employees. The national literature<sup>42</sup> points out that the greater vulnerability of the nursing staff in relation to accidents at work, when compared with staffs of other fields, may be linked to the organizational process and the unavailability of personal protective equipment. While identifying the hazards of exposure to chemotherapy drugs by nurses, a study<sup>8</sup> observed a higher risk among workers who do not use PPE, or do not use it properly. According to authors,<sup>11</sup> there is still a low usage of PPE among healthcare professionals, which constitutes a barrier to the adoption of preventive measures.

We found that there is no association between normal and abnormal results in post-caloric nystagmus and use or not of coal mask in the healthcare professions evaluated. The same was true for the occurrence of notch configuration on audiometry and use of PPE (gloves and coal mask).

Although there is no association, one should take into consideration that the professionals who wear gloves achieved a higher incidence of normal results in post-caloric nystagmus, corroborating a study<sup>39</sup> that linked the possible difference in the outcomes of VNG and non-use of PPE, once 77.8% of the research subjects who do not use PPE showed changes in vectoelectronystagmography.

In addition, there is a higher incidence of notch in the professionals who did not use coal mask. Researchers<sup>9</sup> pointed out that exposure to these substances without precautions can cause risk of contact and/or absorption to workers, be it in the activities which involve handling the substance for preparation, in the administration of the drug, or during the contact with excretions of the patient. Authors<sup>43</sup> detected the presence of antineoplastic drugs in the urine of health professionals who manipulated these drugs without the use of PPE, suggesting that the use of the equipment could prevent such contamination.

It is important to emphasize that the lack of use of PPE may cause the alterations to become even more severe. Due to this, particular attention is needed to the providing of PPE by employers, and its effective usage by workers exposed to chemotherapy drugs when handling, administrating, or applying them, so that possible injuries to the vestibular and hearing health are prevented.

It was possible to notice that the majority of the population studied showed a higher occurrence of normal results on hearing and vestibular evaluation of workers exposed to chemotherapy drugs, but we cannot ignore this small percentage of abnormal findings, since they can provide clinically significant data, especially when used with other procedures.

Furthermore, we believe in the importance of continuing research so as to obtain more information on this topic, once there is a scarcity of studies that discuss it, and the diseases caused by exposure can lead to irreversible consequences for hearing and vestibular health as well as for health conditions in general.

## Conclusion

The pharmacists and nurses exposed to chemotherapy drugs evaluated in this study are mostly young adult women, who have been exposed to the chemical agent at work for less than five years, and who make greater use of gloves, aprons, and common masks as PPE. They have non-rotatory dizziness and neurovegetative symptoms, and anxiety and stress are their most frequent extra-hearing complaints.

Health conditions of the auditory and vestibular systems were within the normal range in most of the evaluated professionals, but with the presence of notch thresholds in pure tone audiometry, commonly identified in workers who reported not having dizziness and had normal caloric test. The association of notch configuration, abnormal caloric test results, and not using coal mask was frequent when compared with the use of gloves; emphasizing the importance of using PPE to maintain the health conditions of these professionals.

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