Eleventh LACCEI Latin American and Caribbean Conference for Engineering and Technology (LACCEI'2013) "Innovation in Engineering, Technology and Education for Competitiveness and Prosperity" August 14 - 16, 2013 Cancun, Mexico.

PROJECT TINNITUS ECCI-HUS: Design and implementation of an equipment for the objective diagnosis of Tinnitus.

Ramiro Vergara
Hospital universitario de la Samaritana, Bogotá, Cundinamarca, Colombia,
ramiro.m.vergara@gmail.com

Julio Aldonate
Universidad Nacional de Entre Rios, Facultad de Ingenierias, Parana, Entre Rios, Argentina,
jaldonate@bioingenieria.edu.ar

Hermann Davila
Escuela Colombiana de Carreras Industriales, Bogota, Cundinamarca, Colombia,
coordinacion.biomedica@ecci.edu.co

Horderlin Vrangel Robles
Escuela Colombiana de Carreras Industriales, Bogota, Cundinamarca, Colombia,
vroblesv@ecci.edu.co

ABSTRACT

This Document shows the results we get using our own equipment for the study and analysis to guess the tinnitus causes in patiens who have this affection. Fist of all, a conceptual introduction of the disease is done, his physio-pathology, Statistical information around the world and national prevalence, the social and economic impact and life quality. Secondly, a review of frontier technologies for diagnosis of the disease and finally, the database analysis (epicrisis) of some patiens of "La Samaritana" University Hospital which ones had in the past symptomatology associeted with Tinnitus, in order to apply statistical techniques and data mining to be able to classify the most imporntant and her by predict the desease in future patiens.

Keywords: Equipment, Data mining, Tinnitus, Statistical Analysis.

1. INTRODUCTION.

The Tinnitus is defined as the perception of a sound, this could be a buzzing, ringing, whistling, ring, beep, or similar, which does not have an external sound source that generates it close to the ear. Some authors name Tinnitus to a noise in the ear that exceeds 5 Minutes of duration [1-3]. Other authors argue that it is a sound that is generated in the brain (internal noise of the brain) and for the patients who have these symptoms, their tinnitus is called typical [4]. Due to the fact that

each one of the authors defined the Tinnitus according to their research, it emerges the discussion among the objective tinnitus and subjective tinnitus [5]. Subjective Tinnitus is known as the emergence of an internal sound that can only be heard by the patient (in the present it has been developed equipment, in order to hear these sounds). On the other hand, objective Tinnitus is defined as the presence of a sound or humming noise that can be heard by the patient and the physician, in most of the cases, an otolaryngologist (ENT). There are some authors who state that all Tinnitus are subjective; they also ensure that the source of the Tinnitus is neurophysiological or somatic [6]. Somatic Tinnitus is defined as a type of tinnitus of vascular origin, muscular, respiratory or in the temporomandibular union; the presence of these sounds (somatic Tinnitus) guarantee a successful medical evaluation, due to the fact that some of these sounds are the result of vascular lesions problems, intracranial hypertension problems, damages in the middle ear, otosclerosis, and dysfunction in the Eustachian tube. We can ensure that regardless of the source that causes tinnitus, this is processed by the central auditory nervous system and, therefore, is captured and analyzed in the auditive bark.

2. PHYSIOPATHOLOGY OF TINNITUS

2.1. ANATOMY OF TINNITUS.

The physical and mechanical characteristics of the cochlea converted it in a filter which analyzes the frequency spectrum of the sound. According to the research the Objective Tinnitus origins are in the middle ear, it may be because of the movement in the chain of the small bones that constitute it or by vibrations of the oval membrane, generated by the body as an inadvertent and that affect directly the cochlea. The trembling of the chain of bonelets (malleus, incus, and stapes, as shown in Figure 1), produces vibrations of 1 to 3 Hertz approximately and these vibrations cause the inner hair cells of the apex of the escargot, responsible for receiving information of the lowest frequencies, to allow the sounds to be heard by the patient, in most cases young people between 18 and 40 years [9]. The tensioner tympanum or salpinx produces a vibrations or a sensation of click on the ear, which may disappear when the examiner asks the patient to open the mouth. As a result, the diagnosis must be done by the nasal route using optic fiber [10].

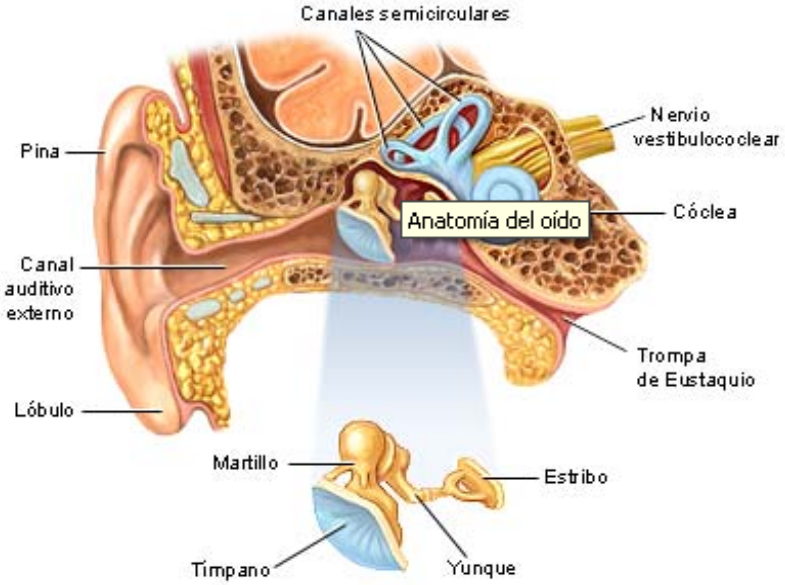

Figure 1. Anatomy of the middle ear

Other type of Objective Tinnitus is the one that presents grave sounds (murmurs), which are related to heart range. The sounds are produced, the majority of the times, in the vascular structures within the head, neck and chest; the causes include: arteriovenous malformations, glomus tumors and aneurysms; at the same time the increase of intracranial pressure and the transmission of the arterial pulsations [11].

2.2. PHYSIOLOGY OF TINNITUS.

Different structures within the auditory system could produce tinnitus. The study of these structures in order to determine the Tinnitus is a problem, because there is no scientifically proven relationship, between the measures of the neuropsychological functions and tinnitus. The study of the physiology of the Tinnitus is vital for the development of the project, taking into account that the definitions about Subjective Tinnitus show that the source is completely pathophysiologic. Many models and theories have been proposed by researchers in recent years, explaining the pathophysiologic grounds of tinnitus [12]. These theories suggest that the capillaries cells, the auditive nerves and the central nervous system are the main cause of the disease [13]. It is clear that there are many other theories but this investigative work does not consider necessary to name them, on the contrary, is trying to find instrument equipment able to diagnose the Objective Tinnitus in patients with that affection.

3. STATISTICAL DATA OF THE TINNITUS.

3.1. WORLD AND NATIONAL PREDOMINANCE.

At the present time, statistically speaking it is said that approximately 10% of the world's population have symptoms of tinnitus, this has been estimated based on the study of databases in different countries [14-16]; for example, in the USA, it has a prevalence of 45 per 1,000 person, which means that about 12 million Americans, a range of 4.5 %, that implies that 12.2 million people in the USA suffer from tinnitus. Table I shows the prevalence of tinnitus in other countries of the world. To extrapolate these data to Colombia, where it is estimated a population of approximately 42 million inhabitants, it has a prevalence of 1 '900,000 inhabitants, suffering from tinnitus. Such data are only estimates, and as it has been said, based on the range of prevalence of the USA; therefore, it can be not relevant for current studies and research work [17].

3.2. IMPACT OF THE TINNITUS.

The disease produces physical consequences (quality of life), also social, economic, etc. As the Tinnitus affects one of the principal senses of the human body, it decreases in a large extent the life level of patients, as well as, its economy and social coexistence. As it increases the levels of stress for people who suffer it, reaching present irritability and bad temper, which prevents a good relationship and understanding with other people in their social circle. Following, we will refer to the impact of the disease on the life quality, on the society and the economy of the people who suffer it.

TABLE I
STATISTICAL DATA OF TINNITUS BY COUBTRY

Country	Inhabitants[1] (Aproximately)	Inhabitants with con Tinnitus (Extrapolate)[2]
Brasil	184'101.109	8'284.549
Venezuela	25'017.387	1'125.782
Perú	27'544.305	1'239.493
México	104'959.594	4'723.181
Alemania	82'424.609	3'709.107
España	40'280.780	1'812.635
Colombia	42'310.775	1'903.984
USA	293'655.405	13'214.493
Japón	127.333.002	5'729.985

[1]Data from wrongdiagnosis.com
[2]Estimated based on EE.UU. data

3.2.1 IMPACT ON THE QUALITY OF LIFE

The first thing to take into account is the severity of the Tinnitus, which in the clinical context refers to the impact in health conditions. The degree of severity is very high due to the increased number of patients with tinnitus than the number of patients who seek treatment [18-19]. The Tinnitus in many patients and people do not represent a disadvantage to continue with their normal life, but for others it may be an uncontrollable hearing problem, which can take you to high level of stress. Currently, it could be said that some indicators or activators may be: emotional and labor stress, physiological factors, exposure to strong noises, unemployment and physical and mental diseases.

3.2.2 IMPACT IN THE SOCIETY.

One of the problems that show up in work places is the excessive noise, which can deteriorate the health of people. These events can take the worker to present loss of the audition that can transform into Tinnitus. These problems are able to deteriorate the daily development of the workers, independently of the activities that they carry out. In spite of this reality, the workers are not able to demonstrate, with some diagnosis team, the presence of Tinnitus on them, losing as a consequence the possible compensations for the damages caused at the work place [20]. For example, in 13 United States, Tinnitus is only reimbursed if, also, the workers shows up auditory deterioration and the demand should be made in a maximum period of 30 to 200 days, according to the limitations of statutes [21]. It can be observed, that the Tinnitus have legal implication levels, because in some cases, the noise is so annoying that it prevented workers to carry out their work correctly although there are now many advances and equipment for the treatment without the diagnosis equipment instrument for the disease.

3.2.3. ECONOMIC IMPACT.

Economic Impact: In many countries the compensation due to Tinnitus makes that governmental entities pay substantial damages claims in health or disabilities caused in the workplace; for example, the war from United States sued the Department of Veterans of the Military Forces,

because according to them the exposure to loud noises during his military service caused the Tinnitus [22]. This led the United States to pay a monthly remuneration around 345 '495,000 million dollars to more than 280,000 veterans of war. Regardless the previous mentioned, there are no estimates of the economic impact of the Tinnitus in global economies, to obtain some estimates requires observing the loss of productivity at work, the medical related to tinnitus, the costs of demands and the payment of wage compensation [23]. In our country there are no reports of the costs associated with tinnitus, since it is not part of the POS (Compulsory Health Plan), as a consequence of the lack of suitable equipment to diagnose the disease and thus be able to rely on a test that certifies the existence of the Tinnitus in people and in other situations, because it is considered as a physiological disease.

4. PROJECT TINNITUS.

Worldwide, many researchers have developed various methods for the diagnosis of this disease, in spite of this, the specialists (ORL) conducted a general review, which compares the noise heard by the patient with sounds of intensity and frequency that you receive through the headphones of the audiometer. This process is called Acufenometria. This procedure is completely subjective, since the specialist does not have any records to verify if what the patient is listening is true or not. Wegel classified the Tinnitus in two groups: the vibratory and not vibratory [24]. The vibrations are those that the examiner can listen easily, or with instruments such as the Laenec stethoscope, (Objective Tinnitus), and the others are those that only the patient hears (subjective Tinnitus). Despite if this and although it has been published a great amount of medical literature about the disease, there is not a hypothesis that postulates that the nature of sound phenomenon for the subjective tinnitus. The students of otorhinolaryngology verified that specialized texts recommend listening with the Laenec stethoscope, ears, periauricular region and the neck, to hear the Objective Tinnitus, but it has been proved to be completely ineffective to detect signal (noise, hum, etc.) in the cases of Subjective Tinnitus.

4.1. STATE OF THE ART.

Although you can find diagnosis equipment for developed in different countries, there is no general consensus. There is not a diagnostic instrument adopted by the ATA (American Association of tinnitus, ATA) used by Otolaryngologists for a review. For example, you can find equipment such as Objective Acufenometro developed by the investigator Ramiro Vergara, Colombian Otolaryngologist specializing in the study of the Tinnitus (tinnitus) [25], designed with the goal of diagnose the vibratory Tinnitus (Objective Tinnitus) in 1995. This instrument of analog technology had a sensor (high sensitivity microphone), which enabled it to grasp the audible signal corresponding to the Tinnitus, display its image on the oscilloscope screen, print it out and then record it on tape. However, its efficiency was only 45 %, that is to say that in 55% of patients they could not have a clear diagnose, and, in addition, the image was mixed with other signals, which prevented display clearly. Neither they were able to filter or magnify the signal. Later, due to the current technological progress, the investigator could improve the design of the Objective Acufenometro to obtain the Analyzer of Tinnitus (Spectral Acufenometro), a computerized electronic instrument. In Germany, specifically inSaarbrücken, the company Mineway, performs diagnostic studies of the Tinnitus using data obtained from a review of Electroencephalography (EEG). There are around 250,000 of new cases of tinnitus per year in Germany and about 1% of the population suffers from chronic tinnitus. For that reason, and taking into account that there is not a tool for the diagnosis, Mineway company, discusses the possible causes within the brain, looking at the data that is generated in the EEG. This analysis shows the comparative values of contrasts found in the brains of patients [26].

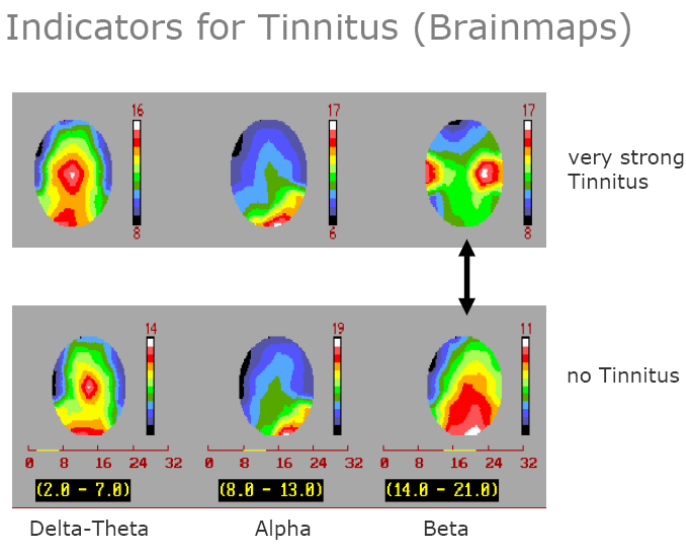

Figure 2. Tinnitus indicator with EEG

The analysis of the information found in the review, is evaluated with methods of mining data. Taking as a reference the affected population, the data delivered by the EEG, the duration of the condition, etc. The data analyzed by the EEG measurements are natural, using the transformed of Fourier in 19 points and 5 basic frequencies: Delta (2 - 4 Hz), Theta (4-7 Hz), Alpha (8 - 13 Hz), Beta (14 - 21 Hz), 1 Hz. They demonstrate the feasibility of mining data for the diagnosis of tinnitus and that with the use of the Wavelet transform in the analysis of the data provided by the EEG it can be improved to obtain more effective diagnosis.

4.2. PHASES OF THE PROJECT.

4.2.1. FIRST PHASE.

Step at which the survey of the equipment required for this purpose was conducted (microphones, amplifiers, etc.). It was made the analysis of medical instrumentation required, purchase and importation of the appropriate materials, phase of possible designs, experimental tests, and selection of optimal experimental design, assembly and final deployment of the same. First it was expected to find a microphone with the adequate sensitivity to perceive any change in the ear canal or in the middle ear within the chain of ossicles; it should be borne in mind that the range of frequencies heard by the human beings is 20 Hz to 20 KHz, although in practice it was noticed that when making an audiometry, in most cases, patients with tinnitus perceived no higher frequencies to 18 KHz. After choosing the most appropriate microphone and import it, the project continued with the selection of the amplifier instrumentation with the adequate gain to amplify these signals, it was observed that they were of very low power, which prevented differentiate the environment noise. Finally, we have implemented the instrument with the proper experimental tests using the laboratory equipment required for the analysis of the signals received.

4.2.2. SECOND PHASE.

After obtaining the instrument equipment for the analysis and processing of specific signals, we analyzed the patients, obtained from the database of the HUS. In order to obtain this database, it was made a filtering of the patients who suffer from the disease (tinnitus), here there was a database

of around 420 people, which presented in its epicrisis the tinnitus. Epicrisis is defined as the summary of the evolution of the patient to a certain disease.
Epicrisis is delivered to discharge patients. After applying the filter, there was evidence that many of the patients did not suffer from tinnitus and, therefore, was a more thorough search in each one of them. 28 Patients were chosen at random (see Table Nº2) as population-based sample for analysis by the instrument. These data were introduced to the Excel and "WEKA" (Waikato Environment for Knowledge Analysis, "WEKA"), respectively, to apply statistical methods consistent with the population-based sample.

TABLE II
DATABASE OF PATIENTS WITH TINNITUS-HUS.

Edad	Genero	Epicrisis	Tinnitus	Embarazo	Hipertensión	Cefalea	Obesidad	Alcohol	Fuma
29	F	49499	SI	SI	NO	SI	NO	NO	NO
77	F	43334	NO	NO	SI	SI	SI	NO	NO
73	F	48849	NO	NO	NO	NO	NO	NO	NO
79	M	50430	SI	NO	NO	SI	NO	NO	SI
20	F	45872	SI	SI	SI	SI	NO	NO	NO
40	M	45627	SI	NO	SI	SI	NO	SI	SI
30	F	44153	NO	SI	SI	NO	NO	NO	NO
75	F	44056	SI	NO	SI	SI	NO	NO	NO
29	F	43507	SI	SI	SI	NO	NO	NO	NO
54	F	47818	SI	NO	NO	SI	NO	NO	NO
18	F	47583	SI	SI	SI	SI	NO	NO	NO
42	F	47528	SI	SI	SI	SI	NO	NO	NO
25	F	46960	NO	SI	NO	NO	NO	NO	NO

5. RESULTS AND SCOPE.

When taking the population sample and enter it in Excel we were able to obtain the following results: 20 of the patients express they suffer from Tinnitus; that is to say, 71.4 %, of this disease is of subjective nature, due to the fact that until that moment the only source was the patient judgment.

From these 20 patients, was found that 60% were pregnant women, of whom 83.3 % suffered from hypertension and 75% had headache. In addition, it was demonstrated that 25% were men who suffered from the disease. Of this figure, two patients were smokers and drinkers of alcohol, the other had Tinnitus for accidents at work; one of them for being close to an explosion of dynamite. This information was also processed in the "WEKA" software, developed in the University of Waikato in New Zealand [27]. As a first step, the data was converted to a file extension of *.arff (Attribute Relation File Format, arff), called tinnitus.arff. The file obtained is shown In Figure 3. It show the nine attributes analyzed: age, sex, tinnitus, pregnancy, hypertension, migraine, obesity, smoking and alcohol.

```
@relation tinitus

@attribute edad numeric
@attribute sexo {femenino, masculino}
@attribute tinitus {TRUE, FALSE}
@attribute embarazo {yes, no}
@attribute hipertension {yes,no}
@attribute cefalea {yes,no}
@attribute obesidad {yes,no}
@attribute Alcohol {yes,no}
@attribute fumar {yes, no}

@data
29,femenino,TRUE,yes,no,yes,no,no,no
77,femenino,FALSE,no,yes,yes,yes,yes,no
73,femenino,FALSE,no,no,no,no,no,no
79,masculino,TRUE,no,no,yes,no,no,yes
20,femenino,TRUE,yes,yes,yes,no,no,no
40,masculino,TRUE,no,yes,yes,no,yes,yes
30,femenino,FALSE,yes,yes,no,no,no,no
75,femenino,TRUE,no,yes,yes,no,no,no
29,femenino,TRUE,yes,yes,no,no,no,no
54,femenino,TRUE,no,no,yes,no,no,no
18,femenino,TRUE,yes,yes,yes,no,no,no
42,femenino,TRUE,yes,yes,yes,no,no,no
25,femenino,FALSE,yes,no,no,no,no,no
28,masculino,TRUE,no,no,yes,no,no,no
29,femenino,TRUE,yes,yes,yes,no,no,no
44,femenino,FALSE,yes,yes,no,no,no,no
31,femenino,TRUE,yes,yes,yes,no,no,no
22,femenino,FALSE,yes,yes,yes,no,no,no
29,femenino,TRUE,yes,yes,yes,no,no,no
24,femenino,TRUE,yes,no,no,no,no,no
21,femenino,TRUE,yes,yes,yes,no,no,no
17,femenino,FALSE,yes,no,yes,no,no,no
35,femenino,TRUE,no,no,no,no,no,no
20,femenino,FALSE,yes,no,no,no,no,no
22,femenino,TRUE,yes,yes,no,no,no,no
21,femenino,TRUE,yes,yes,yes,no,no,no
59,masculino,TRUE,no,no,no,no,no,no
50,masculino,TRUE,no,no,no,no,no,no
```

Figure 3. Tinnitus.arff file.

When entering data in the "WEKA" was observed at the first place that the average age of the patients analyzed is 37.25 years. Then, to the database was applied the classifier OneR, because it is one of the easiest classifiers to use, but at the same time, it simply selects the attribute that best explains the class of the system [28]. The algorithm leads to the conclusion that the best possible prediction with a single attribute is the age, securing 33 years as the threshold for determining the existence of the tinnitus. The hit rate on the dataset itself Training is 89.28 %, as shown in Figure 4.

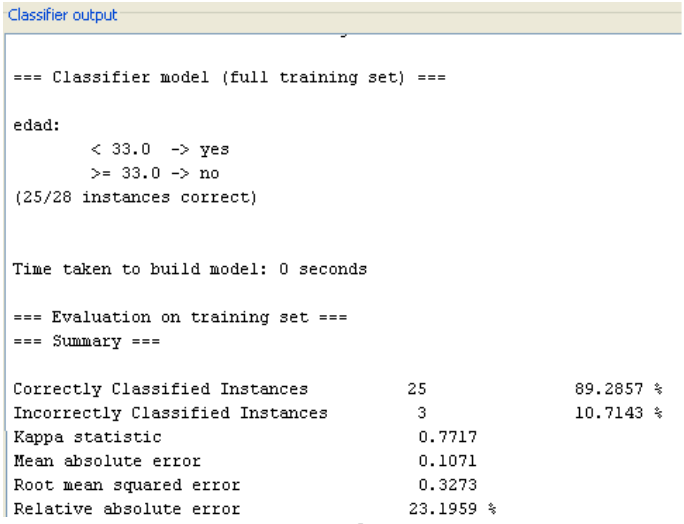

Figure 4. Data analysis in WEKA.

We cannot develop a extend analysis with a small data base. By extrapolating the database of the people who suffer from Tinnitus in the United States, we can say that in Colombia around 1

'900,000 people have tinnitus, as marked in the table I; of this amount was analyzed less than 1 %. But with the people that assured of subjective manner the existence of the Tinnitus, is expected to be carried out the relevant evidence to validate the instrument equipment designed, thereby obtaining a valuation of the same, which will take you to their certification by the scientific community.

6. CONCLUSIONS.

This article provides a global view of the first statistical analysis of the project entitled: "Analysis, Development and implementation of an equipment tool for the diagnosis of tinnitus in patients with this condition in a population-based sample determined". Although Tinnitus can be caused by different pathologies, it is concluded that some Tinnitus are perceived by the equipment designed in the Colombian School of Industrial Careers ECCI, who, during the research developed some clinical criterion to assess the potential patients with Objective Tinnitus. In the meantime, there are many methods for the treatment of tinnitus, although in the majority of the cases is not required to have a surgical intervention, if it is possible to detect the disease effectively, it is much easier for the specialist formulate treatment methods.

Trained professionals to treat the Tinnitus, unknown in many occasions the technological tools that offer the engineers, in particular the electronic and biomedical, for the diagnosis of the disease, and with the help of these conventions are necessary links to the Technological advancement of nations. On the other hand, it was found that 40% of pregnant women presenting with tinnitus, moreover, suffered from high blood pressure and headache, which does not lead to the conclusion that women with preeclampsia have a very high percentage of developing tinnitus.

REFERENCIAS.

[1] Coles, R. Epidemiology of tinnitus: Demographic and clinical features. *Journal of Laryngology and Otology*. (Suppl. 9). 1984, pp. 195 – 202.

[2] Davis, A. C. (1995). Hearing in adults. London: Whurr Publishers.

[3] Hazell, J. W. P. Models of tinnitus: Generation, perception, clinical implications. In J. A. Vernon & A. R. Møller (Eds.), *Mechanisms of tinnitus*, 1995, pp. 57–72 Needham Heights, MA: Allyn & Bacon.

[4] Meikle, M. B., Creedon, T. A., & Griest, S. E. Tinnitus archive 2d ed. Retrieved April 29, 2004, from http://www.tinnitusarchive.org/

[5] Møller, A. R. Pathophysiology of tinnitus. Otolaryngologic Clinics of North America, 36, 2003. pp. 249–266, v–vi.

[6] Hazell, J. Incidence, classification, and models of tinnitus. In H. Ludman & T. Wright (Eds.), *Diseases of the ear*. 1998, pp. 185–195.

[7] Ciocon, J. O., Amede, F., Lechtenberg, C., & Astor, F. Tinnitus: A stepwise workup to quiet the noise within. *Geriatrics*, 50(2), 1995, pp. 18–25.

[8] Perry, B. P., & Gantz, B. J. Medical and surgical evaluation and management of tinnitus. In R. S. Tyler (Ed.), *Tinnitus handbook*. 2000, pp. 221–241.

[9] Bjork H. Objevtive tinnitus due to clonus of the soft palate. *Acta Otolaryngol*. Suppl 1954; vol116: 39-45.

[10] Ward PH, Rabin R, Calcatera TC. Operative treatment of surgical lesions with objective tinnitus. *Ann Otol Rhinol Laryngol.* 1975;84: 473-82.

[11] Sisnamis A. Otologic manifestations of benign intracranial hypertension syndrome: diagnosis and management. *Laryngoscope.*1997; vol 42: 1-17.

[12] Baguley, D. M. Mechanisms of tinnitus. British *Medical Bulletin*, vol 63, 2002, pp. 195–212.

[13] Kaltenbach, J. A. Neurophysiologic mechanisms of tinnitus. *Journal of the American Academy of Audiology*, vol 11, 2000, pp.125–137.
[14] Brown, S. C. *Older Americans and tinnitus: A demographic study and chartbook* (GRI Monograph Series A, No. 2). Washington, DC: Gallaudet Research Institute, Gallaudet University. 1990.
[15] Davis, A. C. Hearing in adults. London: Whurr Publishers. 1995.
[16] Sindhusake, D., Mitchell, P., Newall, P., Golding, M., Rochtchina, E., & Rubin, G. Prevalence and characteristics of tinnitus in older adults: The Blue Mountain Hearing Study. *International Journal of Audiology*, vol. 42, 2003, pp. 289–294.
[17] *Statistics by Country for Tinnitus*, Octubre de 2007. Disponible en http://www.wrongdiagnosis.com**.**
[18] Meikle, M. B. A conceptual framework to aid the diagnosis and treatment of severe tinnitus. *The Australian and New Zealand Journal of Audiology*, vol. 24, 2003, pp. 59–67.
[19] Davis, A., & Refaie, A. E. Epidemiology of tinnitus. In R. Tyler (Ed.), *Tinnitus handbook.* 2000, pp. 1–23. San Diego, CA: Singular.
[20] Tyler, R. S. (2003). Considerations when evaluating a tinnitus patient for compensation. *The Australian and New Zealand Journal of Audiology*, vol. 24, 85–91.
[21] Dobie, R. A. *Medical-legal evaluation of hearing loss, second edition.* San Diego, CA: Singular. 2001.
[22] Henry, J. A., Schechter, M. A., Regelein, R. T., & Dennis, K. C. Veterans and tinnitus. In J. B. Snow, Jr. (Ed.), *Tinnitus: Theory and management*. 2004, pp. 337–355.
[23] Reich, G. E. The costs of tinnitus. *Tinnitus Today*, 2002, vol 27, pp. 18–19.
[24] Wegel, R. L. (1931). A study of tinnitus. *Archives of Otolaryngology*, vol 14,1931, pp. 158–165
[25] Vergara, Ramiro. *Instrumento Electrónico Computarizado Denominado Acufenómetro Espectral (AE),* 28 de diciembre de 2007, disponible en: http://www.wipo.int
[26] Bauer, Mathias. Diagnosis of Tinnitus from EEG Data. *Clinical Data Review & Reporting.* 24 de Marzo de 2006. Disponible en: www.mineway.de.
[27] García, Diego. Manual de WEKA. 28 de diciembre de 2007, disponible en: http://www.cs.waikato.ac.nz/~ml /weka/index.html.
[28] Witten, Ian H. Eibe, Frank. Len, Trigg. Mark, Hall. *Weka: Practical machine learning tools and techniques with java implementations*. Department of Computer Science. University of Waikato. *New Zealand*. 28 de diciembre de 2007, disponible en: http://www.cs.waikato.ac.nz/~ml /weka/index.html.