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PAPER ON FRAGILITY AND PRESBYCUSIS

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INTRODUCTION

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AGING AND THE NEEDS OF OLDER PEOPLE: HEALTH STRATEGIES FOR HEALTHY AGING

Over the last few decades, longevity has increased in most countries around the world[1]. This new scenario goes beyond the usual concepts around older age and creates new challenges for healthcare and society. The process of aging is as diverse as the physical and mental condition of elderly people. There are many people who enjoy their faculties and mobility, social interactions, intellectual performance, leisure and sports fully at a very old age. They have become a model, guiding the new healthcare approach to manage aging. In 2002, the World Health Organization (WHO) presented a healthcare policy framework to promote active aging, defined as "*the process of optimizing opportunities for health, participation, and security in order to enhance quality of life as people age*", allowing individuals to "*realize their potential for physical, social, and mental well-being throughout the life course*"[2]. The definition of "older person" over age 60 assumed the threshold set by the United Nations, while acknowledging that chronological age is not an accurate marker of the changes experienced over age, particularly when this threshold might seem young in developed countries as well as in developing countries where significant progress in life expectancy has been accomplished. The WHO advised to adapt this standard to the circumstances, in order to avoid chronological threshold-based discrimination, which would prove counterproductive to the well-being of older people. The very concept of older age or when a person becomes 'elderly' is constantly reviewed in the literature[3].

The goal of the WHO, for older people to remain active and independent, was considered as purely instrumental and insufficient vis-à-vis the real goal: to obtain genuine health results. Therefore, it published its "World Report on Aging and Health" [4] in 2015, advancing a comprehensive public health approach to aging that would truly transform healthcare systems, as they no longer respond to the features of the populations cared for and must engage in the care for the physical and mental abilities, as well as people’s interactions with their environments over their lifetime. The list of factors that contribute to healthy aging is long and diverse, and there are increasingly more references to such prevailing factors as hearing loss, balance disorders and how preventing and treating deafness and/or balance disorders may unleash positive effects on several health-related aspects (cognition, independence, mental health), as they improve overall health and quality of life, thereby reducing the economic impact all these morbidities have on the families and society in general.

The **WHO report** acknowledges that **"*untreated hearing loss affects communications, and can lead to social isolation and loss of autonomy, together with anxiety, depression and cognitive impairment*"**[5]. *Normal-hearing people are usually unaware of the tremendous impact that hearing* *loss may have on the life of a person, and they equate the difficulty to understand the spoken word with intellectual impairment, which often prompts an older person to retreat inwards, as a way to avoid the 'slow' or 'mentally impaired' tag.*"[6] Indeed, in an effort to match healthcare benefits with the needs of older people, the WHO's strategy includes offering suitable hearing solutions to restore communication as a result of a hearing loss[7]. The WHO recommends healthcare systems to render their necessary transformation and encourage change among healthcare professionals, particularly in primary healthcare. This would enable a proactive response to one of the most significant needs of older people: finding a solution to their hearing loss.

Life expectancy at birth in Spain is 83.4 years (80.9 in men and 86.2 in women). Spain ranks third in the world, following Japan and Switzerland, in life expectancy at birth[8]. The fatality rate of the COVID-19 pandemic is 2.74% for the general population, but it spikes to 11.2% among those over age 80[9]. The COVID-19 pandemic is expected to reverse the trend of growing life expectancy in regions with relatively high life expectancy. Eventually, if the prevalence of the pandemic reaches 10%, life expectancy will decrease by a little more than a year. With prevalence at 50%, it will decrease by 5 years[10]. In any case, life expectancy at birth will decrease less than it did following the 1918 influenza, when it dropped by 11.8 years in the United States[11]. Nevertheless, the OECD countries' population structure will maintain its forecast: individuals above 65 years of age will account for more than 30% of the population in many countries, such as Spain, by 2050. As a matter of fact, 15% of the population will be over age 80 in Spain (Figure 1). Beyond the population and the breakdown into age groups, healthcare organizations urge to measure healthy life expectancy for individuals over age 65 (Figure 2). In Spain, 47% of women over age 65 will have worse health for their remaining 23.4 years of life, driven mainly by limitations to their activity. The health of 36% of Spanish men will be impaired. Activity limitation is a determining factor in the need for care of older people. However, the needs of the population with dementia in the short to medium term are more resource-intense. This population will increase from 20.5 in 2019 to 41.8 individuals per 1,000 inhabitants in 2050 (Figure 3).

PRESBYCUSIS, A PUBLIC HEALTH ISSUE: FRAILTY IN OLDER PEOPLE AND AUDITORY AND NON-AUDITORY EFFECTS

Age-related hearing loss, also known as presbycusis, is a decrease in hearing ability that happens with age to most people. Hearing loss is the third most prevalent condition among individuals over age 65, following arthritis and high blood pressure. Some 30% of men and 20% of women in Europe suffer a hearing loss of 30 dB or greater by age 70, and 55% of men and 45% of women at age 80, according to Roth et al[12]. Approximately a third of the people affected by this in Europe suffer a disabling hearing loss. It is estimated that the hearing loss of some 900,000[13] individuals is severe enough to opt to a cochlear implant (CI).

Presbycusis is a significant communication disorder, involving not just a peripheral component (cochlea), but also a core component. This means that patients have difficulty understanding spoken language. Even though their audibility or hearing perception is sufficient, they cannot understand acoustic stimuli with complex patterns (language, music), particularly in noisy environments. The speed of processing within the central nervous system and the timing of the integration of afferent information are altered. Additionally, loss of inhibitory control and spatial memory have been observed, as a result of the loss of sensory nerve cells (hair cells) and the progressive sensory deprivation[14]. Some epidemiological studies show the risk of developing central presbycusis increases by 4-9% with every year of age (starting at around age 55). The prevalence among men is greater[15]. Central presbycusis must be seen as an underrated factor responsible for disrupting the inter-human communications of older people, which gives way to isolation, anxiety and depression. The lack of auditory input is linked to cognitive impairment as well, and in some extreme cases, to age-related dementia[16]. It has tremendous impact on the quality of life of older people[17].

Some recent research suggests that, over time, people with hearing loss are more susceptible to Alzheimer's disease or any other form of dementia[18], and that the age-related hearing impairment is a potentially revertible risk factor that can reduce the severity of the dementia and the Alzheimer's disease[19]. Interestingly, hearing loss has the highest Population Attributable Fraction (PAF) for the onset of dementia, with a relative risk (RR) of 1.9 in populations monitored for 9 to 17 years[20]. Removing the hearing loss factor alone can reduce the cases of dementia by 8%[21.22], more than the other risk factors that are known to contribute to dementia (poor educational level, high blood pressure, obesity, hearing loss, depression, diabetes, physical inactivity, use of tobacco, isolation from social relations, alcohol, pollution, cranial injury), and it is the most easily modifiable.

Frailty is a clinical state where an individual's vulnerability increases. As a result of various diseases and medical conditions, they may become dependent and/or their mortality increases. Their progression towards disability can be delayed and even avoided when identified and managed early[23]. Several prevailing pathologies in older people condition their frailty and have impact on the hearing loss. At the same time, hearing loss itself is a factor contributing to frailty[24]. Detecting aging-related risks early (hearing loss being one example) and acting early can reduce their negative impact on older people[25]. Table 1 shows the size of the population over age 60, comparing the rates between the more and less populated regions of Spain. Table 2 shows an estimate of the cases of dementia that could be avoided by applying hearing solutions, assuming a prevalence of presbycusis in that age group[12] and the feasible reduction of 8% of dementias among those with hearing loss[21].

This document aims to educate on: 1) the type of hearing loss and balance disorder among people over age 55 and the epidemiological and etiopathogenic traits that may be linked to such disorders; 2) the impact produced by the hearing loss and the balance disorders on healthy aging aspects, such as: communication, isolation, dependency, cognition, falls, depression and in short, analyze the quality of life of older people; and 3) the positive impact of treating hearing loss and balance disorders early in older people, in order to improve their communication and cognitive ability, their mental state, autonomy and in short, their quality of life and the benefits this brings to society and the economy.

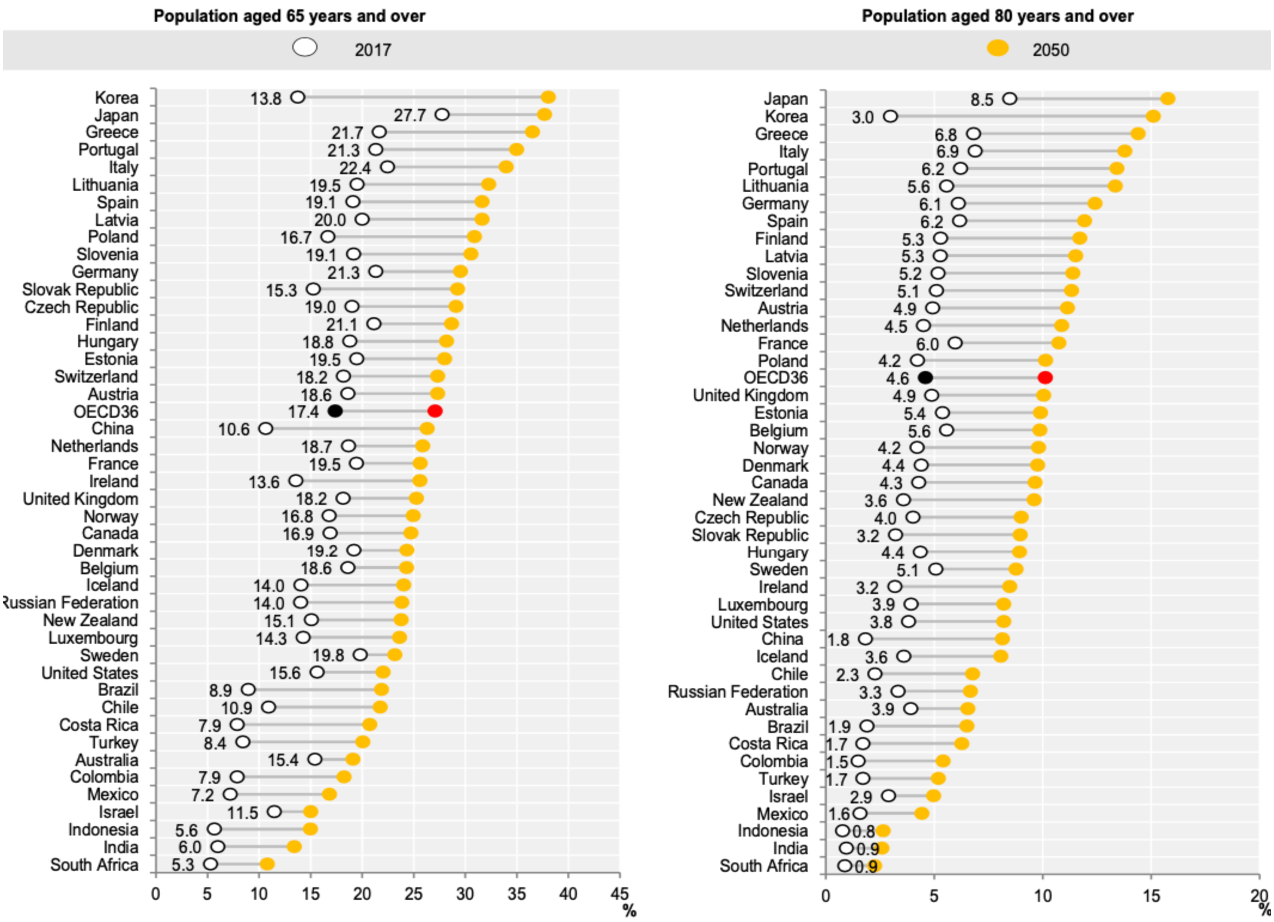

Figure 1. Percentage of older people in OECD countries in 2017 and forecast for 2050. Taken from 'OECD, Health at a Glance 2019: OECD Indicators'[8].

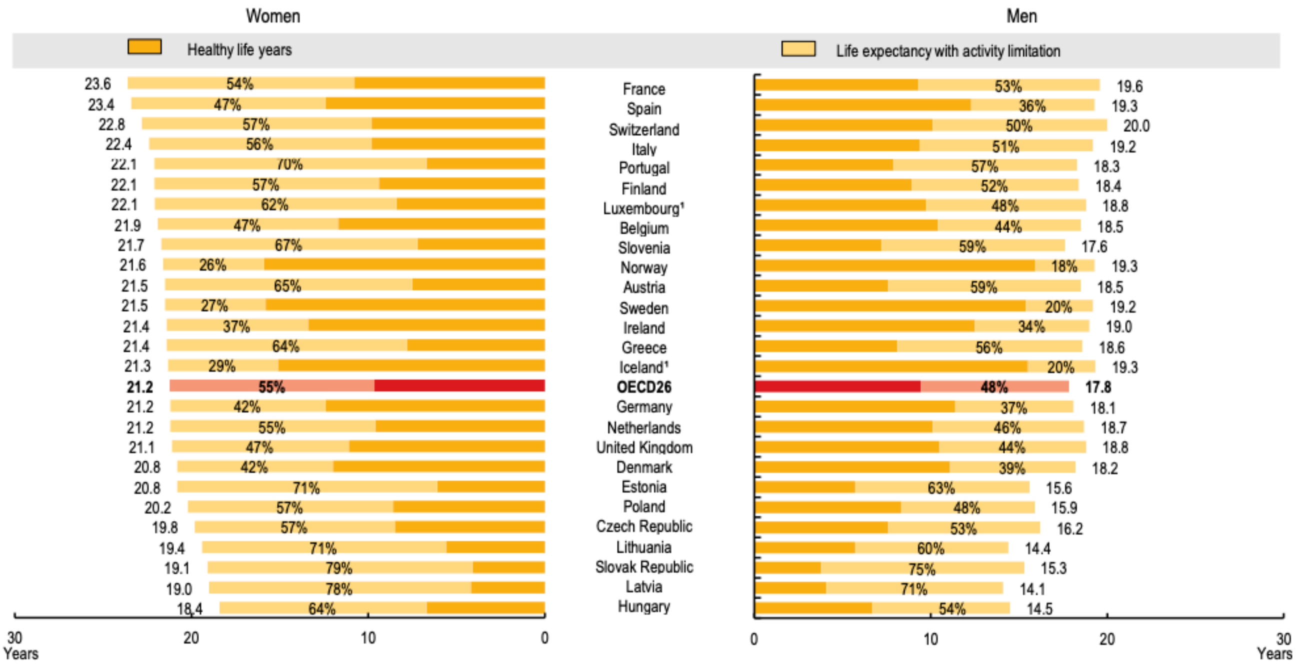

Figure 2. Life expectancy and healthy life expectancy at age 65, by gender. 2017. Taken from 'OECD, Health at a Glance 2019: OECD Indicators'[8].

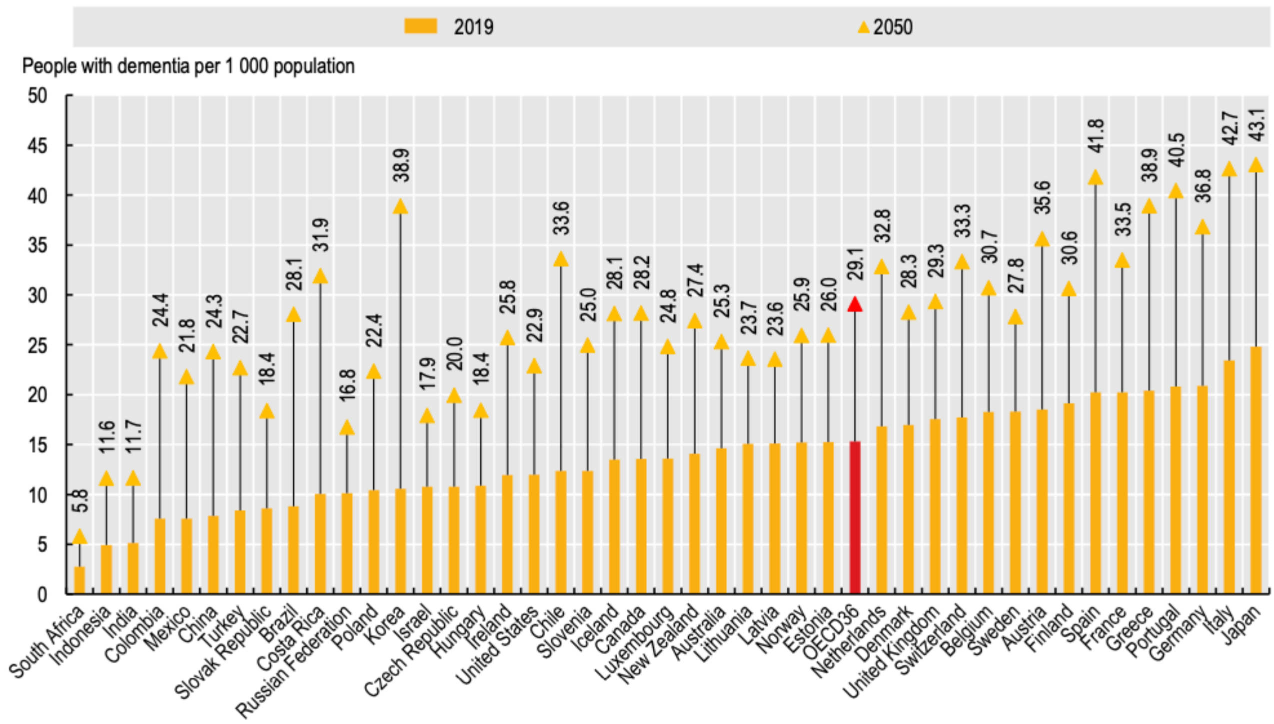

Figure 3. Estimated incidence of dementia in OECD countries, 2019 & 2050. Taken from 'OECD, Health at a Glance 2019: OECD Indicators'[8].

Table 1. Proportion of the older population by age group in the 5 most densely populated provinces of Spain and in the 5 least densely populated. 2019. Source: National Statistics Institute[26].

	Total populatior	61-80 years		81-99 years		≥ 100 years	
		n	%	n	%	n	%
Madrid	6,747,425	1,176,760	17.44	336,900	4.99	1,939	0.03
Barcelona	5,635,043	1,037,296	18.41	307,572	5.46	1,367	0.02
Valencia	2,568,536	486,545	18.94	132,346	5.15	590	0.02
Sevilla	1,957,197	335,695	17.15	78,456	4.01	344	0.02
Alicante	1,885,214	381,185	20.22	92,854	4.93	358	0.02
Palencia	159,846	37,921	23.72	13,340	8.35	74	0.05
Ávila	158,930	35,207	22.15	14,542	9.15	77	0.05
Segovia	154,228	30,524	19.79	12,434	8.06	81	0.05
Teruel	133,291	27,241	20.44	12,059	9.05	95	0.07
Soria	89,912	18,838	20.95	8,701	9.68	78	0.09

Table 2. Avoidable cases of dementia among Spaniards over age 60 by applying hearing solutions to hearing loss in mid-life, taking into account the prevalence of presbycusis by gender[12]. (Our own data based on data from the National Statistics Institute)[26].

	Men	Women	Total
Population > 61 years old	2,867,300	3,969,415	6,836,715
People > 61 years old with presbycusis	1,204,266	1,488,531	2,692,797
Avoidable dementias	96,341	119,082	215,424

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SUMMARY

Age-related hearing thresholds (presbycusis) have been studied and yet, there is not sufficient information and awareness in our social and healthcare systems about the impact of hearing loss on the quality of life of an older person. Additionally, our healthcare system ignores the relation between presbycusis, balance disorders and other associated comorbidities. And yet, this insight has great value to provide early, comprehensive care to older people with hearing loss associated, or not, to balance disorders. It would contribute to fine tune means of prevention and current treatments, while reducing the impact that hearing loss and/or balance disorders may have beyond the sensorial aspects: on the cognition, autonomy and sociability of the patients. Moreover, all these insights must be extremely interesting to public authorities and to the general population, as they support the societal economic impact analysis of older people's hearing loss and balance disorders. We advance the concept of "active aging" or "healthy aging", defined by the WHO as "*the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age".*

This document aims to educate on: 1) the type of hearing loss and balance disorders among people over age 55 and the epidemiological and etiopathogenic traits that may be linked to such disorders; 2) the impact of hearing loss and balance disorders on healthy aging aspects, such as: communication, isolation, dependency, cognition, falls, depression… in sum, analyze the quality of life of older people; and 3) the positive impact of early intervention in hearing loss and balance disorders for older people, to improve their communication and cognitive ability, their mental state, autonomy and in short, their quality of life and the benefits this brings to society and the economy.

INTRODUCTION

Manuel Manrique

The World Health Organization (WHO) defines active aging as "*the process of optimizing opportunities for health, participation, and security in order to enhance quality of life as people age*", allowing individuals to "*realize their potential for physical, social, and mental well-being throughout the life course*". The list of factors that contribute to healthy aging is long and diverse, and there are increasingly more references to such prevailing factors as hearing loss, balance disorders and how preventing and treating deafness and/or balance disorders may unleash positive effects on several health-related aspects (cognition, independence, mental health), as they improve overall health and quality of life, thereby reducing the economic impact all these morbidities have on the families and society in general

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AGE-RELATED HEARING LOSS: PRESBYCUSIS

Manuel Manrique

Age-related hearing loss, also known as presbycusis, is a decrease in hearing ability that happens with age to most people. It is one of the most common conditions suffered by older people. Some 30% of men and 20% of women in Europe suffer a hearing loss of 30 dB or greater by age 70, and 55% of men and 45% of women at age 80, according to Roth et al[1]. Approximately a third of the people affected by this in Europe suffer a disabling hearing loss. It is estimated that the hearing loss of some 900,000[2] individuals is severe enough to opt to a cochlear implant (CI).

Presbycusis is a significant communication disorder, involving not just a peripheral component (cochlea), but also a core component. This means that patients have difficulty understanding spoken language. Even though their audibility or hearing perception is sufficient, they cannot understand acoustic stimuli with complex patterns (language, music), particularly in noisy environments. The speed of processing within the central nervous system and the timing of the integration of afferent information are altered. Additionally, loss of inhibitory control and spatial memory have been observed, as a result of the loss of sensory nerve cells (hair cells) and the progressive sensory deprivation[3]. Central presbycusis must be seen as an underrated factor responsible for disrupting the inter-human communications of older people, which often gives way to social isolation and subdepression. The lack of auditory input is linked to cognitive impairment as well, and in some extreme cases, to age-related dementia[4]. Some epidemiological studies show that the risk of developing central presbycusis increases by 4-9% with every year of age (starting at around age 55). The prevalence among men is greater[5]. Because of all this, hearing loss has broad impact on the quality of life of older adults[6]. Some recent research suggests that, over time[7], people with hearing loss are more susceptible to Alzheimer's disease or any other form of dementia, and that the age-related hearing impairment is a potentially revertible risk factor that can reduce the severity of the dementia and the Alzheimer's disease[8].

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VERTIGO IN OLDER PEOPLE AND AGE-RELATED BALANCE DISORDERS

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The annual prevalence of balance disorders in people over age 65 is 8.3%, even higher among women. The incidence in this segment of the population is 47.1 thousand people per year (1).

The most correct term to refer to physiological changes to the vestibule caused by age is presby-vestibulopathy (PVP). The diagnosis is based on the clinical record and the clinical and otoneurologic examination. This diagnosis pertains to a chronic vestibular disorder, present for more than 3 months in a patient over age 60 who has mild bilateral hypofunction of the vestibulo-ocular reflex. It can be diagnosed with vHIT, the rotary chair or caloric tests (2).

In clinical practice, one must consider this diagnosis for a patient in that age range who mentions at least two of the following issues: 1) systematic, chronic dizziness while standing, walking and with head movements, 2) more than one fall in the previous year, 3) postural instability under dynamic and static conditions, 4) gait disorder: slow, unsteady, unstable.

PVP tends to occur alongside other age-related physiological changes, including visual, proprioceptive, and central alterations (changes to the cortical, extrapyramidal, or cerebellar functions). There are visual alterations (macular degeneration, cataracts), proprioceptive alterations that will produce postural instability under dynamic and static conditions, and vestibular alterations (the vestibular ganglion reduced cell count and the smaller capacity to offset that centrally) (3). A suitable level of vestibular compensation is hard to reach with vestibular deficit. Moreover, the compensation may be incorrect and inappropriate for each of those sensory elements in an older person. The sum of these impairments will give way to greater disability than usual. These impairments must all be treated together in rehabilitation, as leaving one untreated may very well yield therapeutic results below the expectations.

The diagnosis requires at least one fall in the previous year. Falls due to lack of balance are a significant source of morbidity and mortality among older people. Hip fractures and other injuries related to the fall may require hospitalization, a home for the elderly, and translate into high medical care costs. In general, one may say that 3 out of 10 people have fallen at least once, and 2 out of 10 people have fallen more than once in a year. The risk of falls increases by 74% in older adults under psychotropic medication. Benzodiazepines in particular increase the risk of hip fracture by 50%. Anticholinergic drugs are the second pharmacological group most frequently associated with this adverse effect.

The onset of symptoms may very well be at age 60, but balance disorders may not become significant until age 70 (4) or 80 (5).

The parameter of vestibular deficit can be measured in many ways, as already mentioned. The natural aging process has impact on each of them. Being cognizant of this process supports the correct interpretation of what is normal and what is pathological.

Measuring dynamic visual acuity is not a requirement for the diagnosis of PVP. The outcome of this test blends in the action of each of the various systems involved in visual stability during active movements (vestibular, cervical proprioceptive and visuo-oculomotor). A significant reduction (>0.2logMAR) is seen in subjects over age 60, regardless of the head movement plane (6).

Presbycusis and vestibular hypofunction caused by presby-vestibulopathy happen simultaneously to the same patient. This fact is ascribed to the common embryonic origin of the cochlea and the saccule. This parallelism has been determined in patients over age 65 with hearing loss, whose myogenic vestibular potentials are less wide and show greater latency, compared with normal-hearing individuals over age 65 (7). The morphology underpins the cochlear-vestibular functional alteration: the study of temporal bones with and without hearing loss has yielded a negative correlation between the vestibular ganglion cell count and age and the liminar tone audiometry thresholds (8).

Because of all the above, it is recommended to undertake a vestibular study in older patients with hearing loss, in order to diagnose subclinical vestibular issues that could account for the falls (9).

There are multiple studies on the genetics of presbycusis to-date, but less on the genetics of presby-vestibulopathy.

Within the group of vestibular pathologies, genetic alterations have only been found in familial ataxia, bilateral vestibulopathy (6q) and familial Meniere’s disease. In other words, more genetic studies about the cochleo-vestibular function are needed (10).

VESTIBULAR	INDIRECTLY VESTIBULAR	OTHERS
BPPV	Peripheral neurophaty	Polypharmacy (more than 4 drugs)
Meniere disease	Diabetes	Orthostatic hipotension
Recurrent vertigo	Incapacity to stand up without assistance	Tachycardia
Bilateral vestibulophaty	Loss of movement and/or sensation in the feet	Macular degeneration
Chronic BD	Brain stroke*	Clogs in the environment
	Difficulty perciving depth setting	Shuffling walk
		Brain stroke*
		Memory problems
		Osteoporosis
		Parkinson disease
		Depression
		Age
		Glaucoma
		Alcoholism

Table 1. The most common causes of balance disorder in older people.

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ASSOCIATION BETWEEN AGE-RELATED HEARING LOSS AND BALANCE DISORDER

Justo Ramón Gómez and Manuel Manrique

Age-related hearing loss tends to take place in the context of degenerative processes affecting the inner ear. These processes may cause changes to the labyrinth, which would give way to a permanent, symptomatic sensorineural hearing loss and/or vestibular disorders, which lead to balance impairment in clinic.

Older people tend to have hearing and balance issues, and they tend to fall[1]. Identifying modifiable risk factors linked to falls in older people is extremely important for public health. Although hearing has not been usually considered a risk factor for falls in this population, recent reports have proven a strong connection between hearing loss and the incidence of falls[2,3]. Lin[4] points out that hearing loss is distinctly associated with the probability of falls. For every 10 dB increase to the hearing loss, the probability of an individual reporting a fall in the last 12 months increases by 1.4 (95% CI, 1,3-1,5). Other authors have made mention of this probability as well, with remarkably similar ratios[6,7]. In a systematic review and meta-analysis of the literature, Jiam[8] observed that the risk of falling for people with hearing loss is multiplied by 1.69. This association between hearing loss and falls may be accounted for by several mechanisms, such as a concomitant dysfunction of both cochlear and vestibular sensory organs, given their shared location within the labyrinth in the inner ear. Lesser hearing sensitivity could limit space perception directly as well[9]. Finally, paying attention to posture control takes cognitive resources. Less cognitive resources and attention due to hearing loss may impair the postural balance in real life situations and increase the risk of falling. These two factors suggest a cause-effect connection between the hearing loss and the fall. This raises the question of taking action, as hearing loss is very prevalent, but still largely untreated among older people[10,11].

Hearing is important to keep your balance. Traditionally, maintaining postural balance has been described as a process based on the correct interaction of somatosensory, vestibular, and visual systems. The likelihood of impaired balance increases the greater the number of underlying systems affected. The impairment of one of these subsystems tends to be offset by information from the others, hearing included—at least to some extent. Acting on the balance impairment can diminish the risk of falls significantly. Acting on the hearing loss must be a priority to prevent falls and promote the health and wellbeing of older people.

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PREDISPOSING FACTORS LINKED TO PRESBYCUSIS AND BALANCE DISORDERS

GENETIC ASPECTS: TELOMERES AND AGING

Ángel Batuecas

Introduction

Telomeres are special DNA sequences located at the ends of each chromosome. Metaphorically speaking, they are the adhesive at the tip of your shoelace that stops it from fraying. That is the main function of telomeres: stopping the DNA from breaking or damaging during mitosis over its lifetime.

Telomeres are exclusive to eukaryotic cells, and object of constant research about cell division, the lifespan of cells and cancer. Both their discovery in the 1930s and their molecular description in 2009 have been awarded the Nobel prize.

In humans, the sequence 5´TTAGGG 3´ is repeated up to 2,000 times at the end of the chromosome and marks its end (1).

As telomeres mark the end of the chromosome, they prevent the chromosome tips from mixing up and help homologous chromosomes pair during meiosis. The telomeres divide and shorten by some 30 to 200 base pairs with each mitosis, until they have shortened to an extent that prevents the cell from dividing again, as DNA integrity cannot be guaranteed (2). It is a biological clock of sorts. The size of the telomeres indicates cell age.

Indeed, telomeres are valuable and transcendent in cancer research: they do not shorten in tumor cells despite repeated mitosis.

Link between the Size of Telomeres and the Risk of Age-Related Hearing Loss.

In 2002, Seidman (3) established that changes to telomeres can predispose towards age-related hearing loss. There is a direct relation between oxidative stress and the size of telomeres and an inverse relation between the size of telomeres and age (4).

The first research associating age-related sensorineural hearing loss with oxygen-reactive species (free radicals than can produce oxidative damage) was conducted on animals (5).

This research laid the foundation to show that oxidative stress is the link between age-related hearing loss and the shortened telomeres (6).

Shortened telomeres in hearing-loss patients has been proven by analyzing age-related hearing loss in patients over age 70 and controls over age 70 without hearing loss. Shortened telomeres are observed for different types of hearing loss, both pantonal hearing loss and those starting at 2000 Khz, or mild hearing loss. It is not the case of patients with hearing loss in the 8000Hz range only (7).

The link between hearing loss and shortened telomeres has only been established for age-related hearing loss. It has not been proven in young, adolescent, and middle-age patients with hearing loss. In fact, there have been no differences in telomere length found between hearing impaired parents and their children (8).

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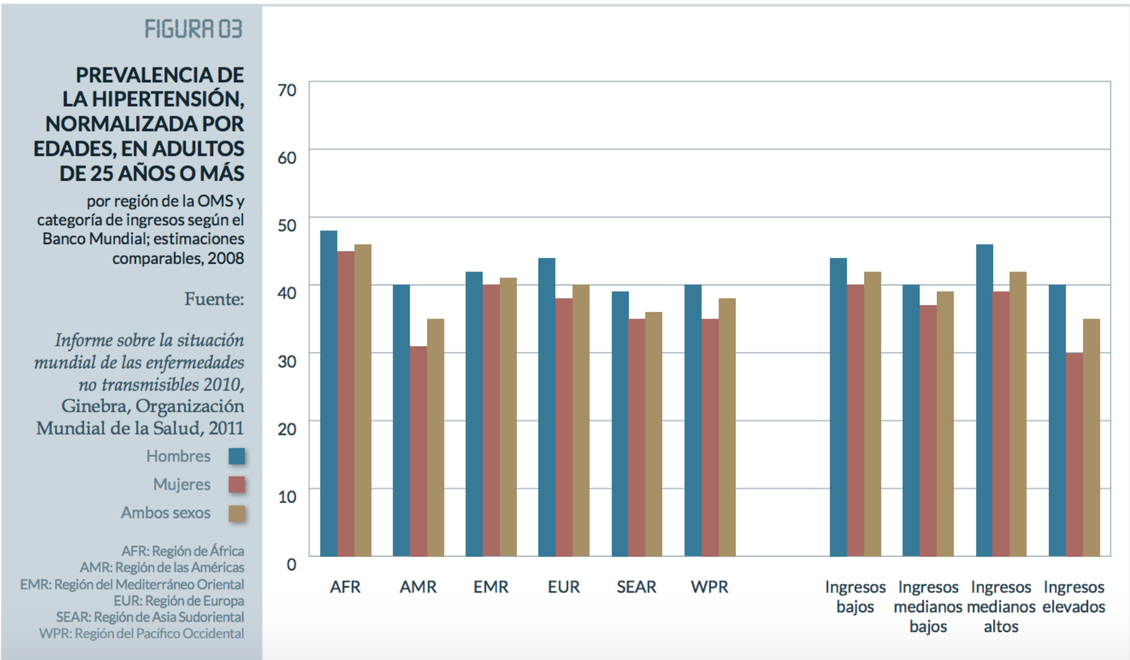
METABOLIC RISK FACTORS: HIGH BLOOD PRESSURE, DIABETES AND HYPERLIPIDEMIA.

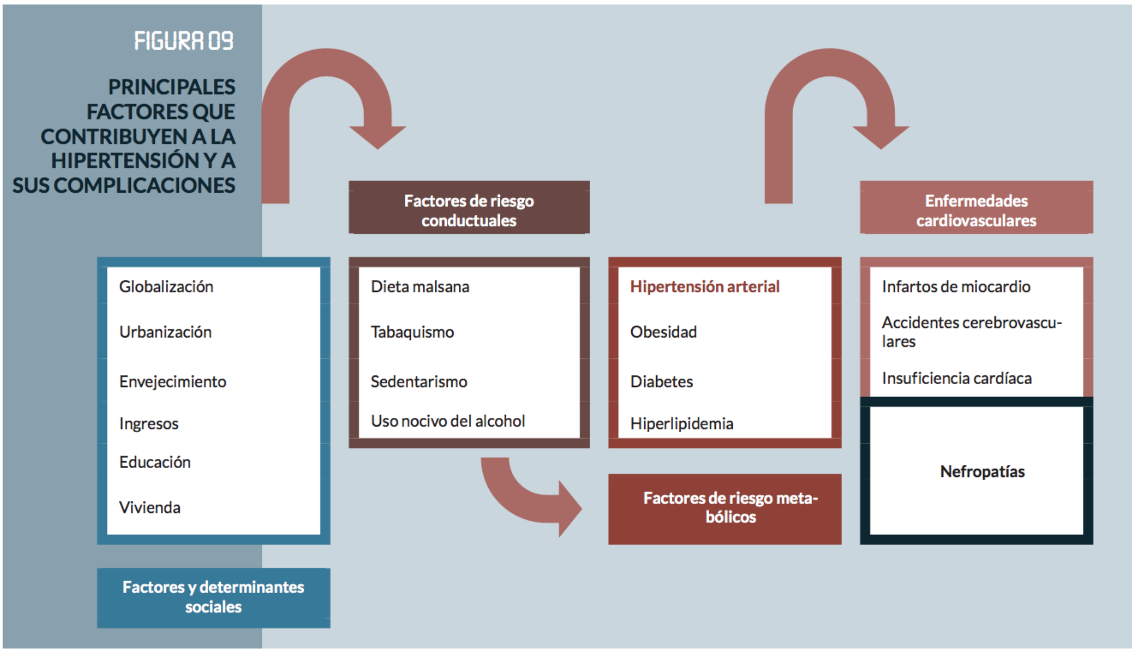
High Blood Pressure

Ana Isabel Lorenzo, Sol Ferrán, Manuel Manrique

High blood pressure is the most frequent chronic disease in adults. The global prevalence of hypertension, or high blood pressure (defined as systolic and/or diastolic blood pressure equal or greater than 140/90 mm Hg) in adults over age 18 was 22% in 2014, according to the latest WHO report[1]. Hypertension is most prevalent in Africa, where 46% of adults over age 25 suffer it. The lowest prevalence is in the American Hemisphere, at 35%[1]. Hypertension tends to be less prevalent in high-income countries (35%), compared with 40% in lower income countries[1]. There are 11 million people (36.7% according to the WHO) who suffer this disease in our country.



According to the WHO, over 5% of the world's population, that is 466 million people, suffer from a disabling hearing loss (432 million adults and 34 million children). It is estimated that more than 900 million people, or one in ten people, will suffer a disabling hearing loss by 2050. A disabling hearing loss is defined as a hearing loss of more than 40 decibels (dB) in the better-hearing ear in adults and a hearing loss of more than 30 dB in the better-hearing ear in children. Most people with a disabling hearing loss live in mid and low-income countries. Approximately a third of the people over age 65 are hearing impaired. Prevalence in this age group is higher in Southern Asia, Asia Pacific, and Sub-Saharan Africa. Deafness affects more than a million people in Spain (out of which 72% are above 65 years of age) and between one and five newborn children per thousand are born with some degree of hearing loss.



Rosen and Olin (1964) found in a study that people between ages 40-59 with a heart disease had poorer hearing sensitivity than people within that age group and no heart disease[5,35]

The hypothesis of the harmful effect of high blood pressure on the cochlea and the vestibular system was developed in 1968 in a study conducted by Hansen et al[2]. Multiple studies have been conducted since, with disparate outcomes[3,35].

Experimental studies with animals have concluded that maintaining the proper cochlear blood flow is critical for the cochlear function and any reduction to the blood supply would limit cochlear function and could result in irreversible damage to all the cochlea[5].

Tan et al[6] set forth in their study about hearing loss and hypertensive retinopathy that patients with hypertensive retinopathy had poorer hearing thresholds in high frequencies. They concluded that vascular compromise is observed in patients with poorly controlled hypertension and associated with hearing loss in the high frequencies. The authors suggest that the hypertensive microangiopathy of the cochlea and retina produce hearing loss and loss of visual acuity, respectively.

Nazar et al,[7] undertook a study where they controlled and treated 217 patients with hypertension and no diabetes mellitus, and no previous exposure to noise or ototoxic drugs for 3 years. They were compared with a healthy control group. The comparative analysis of the results of both groups did not yield significant differences. One may say that the population with well controlled chronic hypertension and the general population have similar audiometric profiles.

On a different note, Marchiori et al [9] studied the association between high blood pressure and hearing loss. They concluded there is a significant association between high blood pressure and hearing loss. They suggest hypertension is a factor that accelerates the deterioration of the hearing system with age[9,10,11]. They also described that hypertension, older age, male gender, and exposure to noise are independent risk factors for hearing loss[6,34]. Chen et al[4] studied the relation between high blood pressure and auditory conditions in older people. They state that hypertension associated with high levels of triglycerides and cholesterol worsen the hearing of older people. Auditory conditions in older people may be the result of long-term hypertension and its complications.

Borg et al[8] conducted an experimental study in which two groups of rats (normotensive and hypertensive, respectively) were exposed to noisy environments and concluded that the group of normotensive rats barely lost any hair cells, compared with the hypertensive rats, which lost more hair cells. Tachibana et al [12] published another study involving rats that revealed the primary site of cochlear impairment: the stria vascularis, followed by the organ of Corti.

Makishima et al[13] studied the histopathology of 80 temporal bones from 40 patients over age 50, paying particular attention to angiosclerotic changes. The histopathological findings correlated with the audiometric and manometric records obtained when the patients were alive. They proved there is a remarkable correlation between the narrowing of the internal auditory artery, the spiral ganglion atrophy and hearing loss.

Then, Esparza et al.[14] in their study on inner ear dysfunction and blood pressure suggested that hypertensive patients may suffer from a cochlear dysfunction associated with the vascular disease resulting from their high blood pressure. High blood pressure may be silent and reveal no clear evidence of vestibular dysfunction.

Several studies show how hearing loss occurs with age and is associated with inappropriate microcirculation due to vascular occlusion, embolus, hemorrhage or vasospasms[15]. Other authors ascribe the hearing loss to the hyperviscosity or microangiopathy associated with DM, hypertension, and the association of several pathologies. [11,15,32]

There are multiple factors to the physiopathology of hearing loss associated with high blood pressure. Damage to a highly vascularized stria vascularis has been proposed as an indirect hearing loss mechanism. The normal function of the stria vascularis is needed to maintain homeostasis in the inner ear. The loss of stria tissue stops the production and retake of potassium, which translate in impaired signal transduction and probably increases the production of free radicals in the inner ear[17,18]. All this produces oxidative stress and hypoxia, and the subsequent capillary damage.

Additionally, the stria vascularis corresponding to high cochlear frequencies is particularly vulnerable to capillary deterioration and thinning of the basal membrane, due to alterations to the cochlear blood flow. This set of homeostatic changes resulting from high blood pressure may amplify the negative effect of extrinsic factors, such as excessive exposure to noise, and lead to an accelerated hearing loss in high frequencies in an area of the cochlea that is tonotopically organized and is also subject to age-related hearing loss[17].

Reed et al[17] observed a strong association between high blood pressure in middle-age patients and high-frequency hearing loss. Using histochemical methods, Carrasco et al[15] proved the existence of adrenergic nervous terminations in the terminal arterioles and radials which branches feed the stria vascularis of mice's cochleae. This study proved the presence and distribution of adrenergic receptors in cochlear microcirculation and observed arteriolar vasoconstriction following the intravascular administration of alpha-adrenergic agonists as well.

A study by Duck et al [16] supports the hypothesis that cochlear damage is more intense with concomitant hypertension[32]. Similarly, this hypothesis was verified in an animal study, given the significant rise in the average loss of hair cells in a group of hypertensive rats with insulin-dependent DM, compared with normotensive rats with insulin-dependent DM. In the same way, there were statistically significant differences in the hearing loss of patients with insulin-dependent DM and hypertension, and normotensive patients with insulin-dependent DM.

Based on these results, it might seem reasonable to support the hypothesis that hypertension is a risk factor for high-frequency hearing loss. Besser et al[37] studied the relationship with cardiovascular diseases and found that the odds of hypertensive individuals were 1.5 greater than those of healthy individuals. They even mention a lineal

relation between blood pressure and hearing loss, where hearing loss increases by 0.03 dB for every 1mmHg.
In the same way, there are several studies covering the association between exposure to noise and developing hypertension and hearing loss[32]. In 1990, Talbott et al,[19] described the existing relation between exposure to occupational noise, noise-induced hearing loss and hypertension.

In 2011, Chan et at[20] undertook a cross-sectional study. They set forth that there is a link between a prolonged exposure to occupational noise and a higher incidence of hypertension. Chan explains that noise is a psychological stress factor. As such, it activates the hypothalamus-hypophysis-adrenal axis and the sympathetic nervous system. This rises the levels of adrenalin, noradrenalin, and cortisol, the three hormones that influence the regulation of blood pressure.[24,25,26]
Many studies have suggested that exposure to occupational noise is linked to consistently high blood pressure or significantly greater risk of hypertension[11,21-23,28-30,32,34]. Others, however, do not find this relation to be statistically significant[19,27]. This difference may be due to the degree of hearing protection of workers: noise levels outdoors are not the actual intensity of noise exposure for the inner ear.[20]
Tarter et al[31] found that exposure to noise levels ≥ 85 dB for more than 5 years is linked to a 28.3 dB HL at 4 kHz among workers in a car assembly.
In the same way, Chan describes in his study that the prevalence of hypertension is greater among groups with hearing loss in mid to high frequencies. There is higher prevalence of hypertension in populations over age 40. He concludes that a noise-induced hearing loss is significantly linked to hypertension after controlling for potential concomitant risks. Hearing loss in high frequencies is a good biomarker of occupational noise exposure. Hearing thresholds above 15dB in 4kHz or 6kHz over more than 5 years are linked to increased risk of hypertension, but this risk disappears when the ears are protected (plugs).
Because of all this, it is concluded that 1. Hypertension is an important risk factor for sensorineural hearing loss in high frequencies. 2. Presbycusis is associated with inappropriate microcirculation. Hypertension causes a microangiopathy that compromises cochlear blood flow and intensifies damage to the cochlea by boosting age-related hearing loss. 3. Consistent exposure to occupational noise is linked to consistently high blood pressure or greater risk of hypertension. This risk lowers with hearing protection. 4. The general population and well-controlled chronic hypertensive individuals have similar audiometric profiles. 5. Hypertension associated with other

comorbidities, such as dyslipidemia or diabetes mellitus impairs the hearing of older people even more.

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Diabetes

Ángel Ramos

Current evidence supports a powerful association between mild-subclinical hearing loss and diabetes mellitus (DM), both type I and type II. Besides, it seems glycemic control, its course and the existence of comorbidities or complications may be factors that predict developing a hearing loss. Nevertheless, it is noteworthy that the strongest statistical correlation between diabetes and hearing loss is found in young patients. This has been particularly studied in type I diabetes, to prevent confounding with age-related hearing loss. Besides, there seems to be a significant association between diabetes mellitus and increased risk of developing sudden hearing loss, particularly in patients with poor glycemic control.

Most of the papers reviewed evidence the implication of DM in hearing loss. Oh et al. [1] found that age and DM were correlated with the prevalence of hearing loss. They showed that DM was a significant predictor of hearing loss (OR 1.398). This study proved that age-related hearing loss (presbycusis) starts in the high frequencies and gradually moves towards mid-range frequencies, and then the low frequencies.

In their study, Rolim et al.[2] tried to prove whether patients with DM and hypertension suffered accelerated hearing loss, compared with individuals without these conditions. They performed two audiometric studies at 3–4-year intervals. They found statistically significant differences for the hypertensive group starting at 4kHz, and for the DM and hypertension group in the 500, 2kHz, 3kHz and 8kHz frequencies.

Besser et al.[3] looked at studies that reveal higher prevalence of hearing loss in the high frequencies and in the mid-low frequencies in patients with altered basal glucose, compared with individuals with normal glucose levels, and individuals with high glycated hemoglobin.

The causal relation has not been proven yet. However, it has been suggested that the responsible physiopathology is mediated by cochlear damage, by circulatory disorders in the inner ear; a change to the endocochlear potential; retrocochlear hearing loss caused by auditory nerve neuritis, onset of diabetic neuropathy; and mitochondrial DNA mutations, alterations to the ATPase pump in the stria vascularis due to blood flow changes, which leads to an increased concentration of sodium in the endolymph.

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Hyperlipidemia

Ana Isabel Lorenzo

The effects of hyperlipidemia on hearing have been researched since 1964, when the first report observed a relation between hyperlipidemia, hearing loss and cardiovascular risk factors[5]. There have been many attempts to describe hearing loss associated with hyperlipidemia. It is induced by a pathological condition (hypertension, hyperlipidemia, or noise). It has been described as a variant of presbycusis[3,4], sensorineural hearing loss in high frequencies[3,5-7].

Some authors found no significant relation between hearing and the level of fasting triglycerides or cholesterol. They found that hearing loss was not greater in a population where fasting blood lipids were higher than in the control population[7,8].

However, most authors have shown a relation between hyperlipidemia and blood flow. The spiral lamina and the stria vascularis are the better vascularized portions of the inner ear, while using the same amount of oxygen the retina does[9]. The sensorineural hearing loss following hyperlipidemia can be associated with atherosclerosis, microvascular embolism, hereditary factors, hypertension and aging[7]. The cochlear vascular walls regulate the cochlear blood flow and produce nitric oxide, a vasodilator[10]. LDL cholesterol can stop cochlear blood flow by blocking the production of nitric oxide in the vascular wall and reducing the motility of outer hair cells[1,3,11,21-24]. It has been proposed that hypertriglyceridemia, hypercholesterolemia, and hyperfibrinogenemia can lead to decreased cochlear blood flow because of hyperviscosity and vascular defects due to atherosclerosis[3,21].

Experimental studies with lipid-rich diets revealed pathological changes to the stria vascularis and the outer hair cells, with additive effects when associated with hypertension and high cholesterol[1]. Satar et al [2] conducted an experimental study in pigs to compare a control group fed with the regular diet, and a cholesterol group, which was fed 1 gr. of cholesterol per day for 4 months. The control group presented normal cochlear structures with regular hearing thresholds, whereas the cholesterol group had profound edema in the marginal layer of the stria, and mild edema in the outer hair cells, in line with the data from the brainstem auditory response, which revealed changes to hearing sensitivity.

Gatehouse et al.[12] researched the connection between hyperviscosity and its effects on the auditory function. In light of that study, it was proven that hyperviscosity can lead to sensorineural hearing loss in higher frequencies, such as 2-4 KHz. It concluded that hearing dysfunction due to hyperlipidemia may be attributed to hyperviscosity, vascular occlusion and greater sensitivity to noise.

Sikora et al. [32] argued that a diet high in cholesterol could increase the sensitivity to noise and provoke hearing loss in rodents. Axelsson and Lindgren[14] observed that people who worked in noisy environments and had elevated serum cholesterol had slightly higher risk of developing sensorineural hearing loss in high frequencies. Erdem et al [3] described that the width of OAE shrank to 4 KHz in patients with hypertriglyceridemia, which is compatible with the pattern of hearing loss seen in hyperviscosity and greater sensitivity to noise in patients with hyperlipidemia.

Suzuki et al.[15] observed that patients with elevated high-density lipoprotein (HDL) cholesterol had better hearing levels in 2 and 4 KHz.

In January 2020, Wang et al[16] concluded that elevated non-HDL cholesterol levels in blood are associated with higher risk of sudden sensorineural hearing loss, and that non-HDL cholesterol levels can be a biomarker that predicts the risk of sudden hearing loss. In the same way, Ballesteros[17] and Aimoni[18] propose that hypercholesterolemia and BMI[19] are associated with sudden sensorineural hearing loss.

In 2009, Cai et al [20] conducted an experimental study in mice and verified that the drugs used to prevent and treat atherosclerosis, such as simvastatin, are otoprotective in mice. In the same way, based on the outcome of an experimental study with 34 mice, Syka and col. [25,22] suggested that atorvastatin could moderate the course of age-related hearing loss in mice.

Several studies have evaluated the effect of statins on hearing, based on the argument that statins are competitive inhibitors of 3-hydroxy-3-methylglutaryl coenzyme A reductase (HMG-CoA), associated with lower plasmatic viscosity and epithelium-derived nitric oxide-mediated vasodilation[22-24]. Leaving aside the reducing effect of cholesterol, statins affect the vascular endothelium and increase the NO synthesis, decrease blood viscosity, and regulate cochlear microcirculation[24,22]. These observations suggest that statins can reduce the microvascular effects of hyperlipidemia[19,22]. Yucel et al[22] published a study about the effect of statins on hearing, and the subjective sensation of tinnitus. They observed that the groups of statins improved in the 6000Hz frequency, but there were no statistically significant differences among them in the audiometry. However, a 2 dB improvement, statistically significant, was found in hearing thresholds after using statins at 6000 Hz. It is too small a difference to be clinically significant. Besides, this outcome could be attributed to the audiometric technician or the patient.

In contrast with these statements, some reports describe that statins may harm hearing. Chung SD et al. [27] examined the association between sudden sensorineural hearing loss (SSNH) and the use of statins in a study. They detected a statistically significant relation between SSNH and the prior use of statins, irrespective of the regular use or not of statins. Olzowy and col. [26] conducted a double blind, clinical trial in which they studied the effect of atorvastatin on hearing loss and tinnitus in older patients. They did not find statistically significant differences in hearing thresholds. However, they found that they could diminish the subjective sensation of tinnitus.

On a different note, metabolic syndrome (MS) is associated with an increase in hearing loss[28-30]. MS is defined as the existence of 3 or more of the following components: 1. Waist circumference ≥ 102 cm in men, and ≥ 88 cm in women, 2. Hypertriglyceridemia ≥ 150mg/dl, 3. Low levels of HDL < 40mg/dl in men and < 50mg/dl in women, 4. High blood pressure: systolic pressure ≥ 130 mmHg or diastolic pressure ≥ 85 mmHg, 5. Elevated glycemia ≥ 20mg/dl[28].

In 2015, Sun et al[28] found that the presence of the metabolic syndrome was significantly associated with hearing loss, both in high and low frequencies. They also observed a positive relation between hearing loss and a greater number of MS components, particularly low HDL level, and high triglyceride level, which revealed a strong association with the increase in hearing loss. In much the same way, Shin et al [29] concluded that the greater the number of MS components, the greater the risk of hearing loss. In 2019, Zhang et al [31] argued that MS has negative impact on the recovery from sudden sensorineural hearing loss, and that the prognosis of these patients worsens the more MS components they have.

Because of all this, it is concluded that: 1. There is a direct relation between dyslipidemia and sensorineural hearing loss in high frequencies. 2. Dyslipidemia increases hyperviscosity, diminishes vasodilation as nitric oxide decreases, and diminishes cochlear blood flow. 3. Dyslipidemia increases the risk of sensorineural hearing loss for individuals exposed to noise. 4. Elevated HDL seems to protect from hearing loss. 5. Statins are protective and can minimize the microvascular effects of dyslipidemia.

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Metabolic Risk Factors: Conclusions

In conclusion, cardiovascular factors related to hearing loss, particularly age-related hearing loss, have been studied in depth. Many significant associations have been found, particularly with diabetes mellitus and high blood pressure. However, we also find studies that do not support this association, and in some cases, they are not clinically relevant, despite being statistically significant.

NON-HEARING CONSEQUENCES ASSOCIATED WITH PRESBYCUSIS AND BALANCE DISORDERS

SOCIAL ISOLATION

Rubén Polo, Manuel Manrique

Multiple studies have proven that social isolation predicts mortality, psychiatric disorders, cognitive and physical impairment among older people. Hearing loss produces a functional deficit where understandability and speech discrimination decline, particularly in noisy environments. This sensory deficit gives way as well to a loss of self-esteem and cognitive and emotional alterations, including shame, pity, or anger, and behavioral, such as social distancing and confinement. All this leads to withdrawing from social gatherings and isolating[1,2]. According to Bowl et al, social isolation can predict mortality due to any reason, as it associates cognitive impairment and depression in older people. They indicate that strategies must be developed to prevent presbycusis-related isolation, which will in turn preclude morbidity associated with social and emotional isolation[3].

Pronk et al.[4] made a prospective analysis of the impact of the auditory status on loneliness and depression on a population of 3107 elderly people. The objective deficit is measured with audiometric studies in noise (*Speech in noise test, SNT).* The subjective hearing deficit is measured with the OECD (long-term disability indicator), which consists of three questions: 1) Can you hold a three-person conversation without your hearing aid? 2) Can you hold a two-person conversation without your hearing aid? 3) Can you use a telephone normally? The degree of isolation is measured in the De Jong Gierveld scale, which evaluates the social component (not having frequent contacts or recurrent groups of people) and the emotional component (lack of a confident relationship (partner, best friend)). The following conclusions are drawn:

1. Men with presbycusis feel significantly more isolated than women with presbycusis. One theory proposed is that men depend more on oral communication than women, and men tend to deny their disease. This leads to greater isolation, as they need to communicate more to feel they belong while they do not ask for help.
2. In couples where one partner has presbycusis, the relationship suffers more, emotionally, than in terms of closeness. There are significant differences versus couples of two normal-hearing individuals.
3. People with presbycusis who live with a normal-hearing person feel significantly more isolated than those who do not. This is driven by the constant comparison of one and another's hearing ability, regardless of the degree of hearing loss suffered.
4. People with presbycusis and a high educational level feel more isolated than people with presbycusis and a low educational level. This is driven by the first being exposed to more demanding auditory situations (conferences, talks, social gatherings). Therefore, even though the objective deficit may not be too large, they are frustrated by not being able to understand conversation well.
5. People with presbycusis who do not use hearing support are significantly more isolated than those who do.
6. The study concludes that hearing aids prevent social isolation for people with presbycusis.

Mick and col.[5] evaluated cross-sectionally the relation between hearing loss and social isolation in older people. They used the Social Isolation Score (SIS) to measure social isolation, and the tone audiometry with the average threshold in conversational frequencies to measure hearing impairment. A population of 1453 is subdivided in two age groups: 60-69 years old and 70-84 years old. In the first group, ages 60-69, 20.6% had hearing loss and 11.9% did not. The isolation index was significantly greater (p=0.003) in those who had hearing loss. In the second group, ages 70-84, 19.8% had hearing loss and 15.6% did not. There were no significant differences in the level of isolation. This is attributed to the size of the sample and the greater social and work-related demands in the younger group. However, it was observed that people in the older group who had hearing loss and felt isolated died sooner than those who felt isolated but maintained auditory levels within the range of normalcy.

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DEPRESSION

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Ageing may also be associated with higher risk of depression (Freeman et al., 2016), including sadness, low self-esteem, guilt, lack of interest in the day to day, disrupted sleep, or appetite, which have impact on the ability to focus (World Health Organization, 2018).

Approximately 15% of older adults have mild symptoms of depression and between 1% to 5% have severe depression disorders (Fiske, Wetherell and Gatz, 2009). In fact, scientific research has proven that hearing loss and depression among older adults (Keidser and Seeto 2017, Rosso et al. 2013) are associated with changes to the psychosocial experience and the impairment of cortical activity, which is a plausible explanation of these concomitant disorders. The association between hearing loss and depression in older adults has been studied and justified widely in the context of the potential influence of psychosocial changes suffered with age. Kiely, Anstey and Luszcz (2013) initially found that the severity of the depressive symptoms was associated with hearing loss in older adults, but it became negligible (that is, it was justified) when difficulty in daily functioning and the degree of daily social interaction were built into the model. Then, evidence shows a sharper decline in hearing when older adults are more socially and emotionally isolated (Pronk et al. 2014). If left untreated, hearing loss may cause chronic stress, eventually leading to depression as an additional stress factor (West, 2017). Therefore, hearing loss may worsen already existing difficulties around psychosocial and functional abilities in older people, thereby increasing the likelihood of depression. At the same time, the most recent evidence shows that psychosocial factors (i.e.: decreased engagement in social activities or access to a social network) do not have any influence whatsoever on the association between hearing loss and depression in older adults (Cosh et al., 2018). The authors suggested that older adults may be accepting hearing loss as part of the regular experience of growing old, and therefore, adapt to auditory changes by modifying/improving their communication skills or using hearing aids to mitigate hearing loss, which in turn mitigates the potential negative impact of hearing loss on psychosocial experiences potentially preceding depression. (Cosh et al., 2018).

Therefore, it is unclear if a psychosocial mechanism in older age explains the association between hearing loss and depression in older adults. Blake J. Lawrence et al. (2019), have undertaken a meta-analysis and systematic literature review to clarify this point. They seek to reveal the association between comorbidity and the potential influence of psychosocial or health aspects that may account for this link in older age.

The most recent evidence suggests that the deterioration of neuropathological mechanisms associated with auditory perception and the regulation of the emotional state may be the reason accounting for the association between hearing loss and depression in older adults. Rutherford, Brewster, Golub, Kim and Roose (2018) have thoroughly reviewed neuroimaging studies showing similar patterns and reduced activity of the limbic system (responsible for emotions and behavior), the frontal cortex (the regulator of emotions, reasoning, and planning), and the auditory cortex in older people with hearing loss or depression. These initial findings suggest a common, neuronal degeneration associated with hearing loss and depression in older adults. However, more evidence is needed to better understand the physiopathology underlying hearing loss and depression in older adults.

To this date, epidemiological studies have frequently reported on the association between hearing loss and depression. Some cross-sectional studies report on the association between hearing loss and depression in older age (Behera et al., 2016; Keidser and Seeto, 2017; Lee and Hong, 2016), while others report on the inexistence of such association (Bergdahl et al., 2005; Chou and Chi, 2005). Similar evidence can be found in cohort studies, in which initial outcomes show that hearing loss is associated with a higher probability of depression among older adults (Forsell, 2000); but later studies have rejected these findings. Contradictory findings in the literature may be due to methodological differences between studies, and the limitations of epidemiological research. Epidemiology is a research method that enables the study of certain health aspects in broad population samples, when a controlled clinical trial is not feasible (i.e.: examine dietary patterns across different countries) or ethical (i.e.: examine the effect of tobacco use on health). However, epidemiological studies are often influenced by biases that undermine the reliability of the outcome. Most statistically significant epidemiological findings are usually not replicated in controlled, randomized trials (which are scientifically more robust) later, as reported by Ioannidis (2016). In fact, large epidemiological longitudinal studies examining changes to health aspects (i.e.: the US national epidemiological survey on health and nutrition) often find statistically significant correlations among all variables of interest (Patel, Ioannidis, Cullen and Rehkopf, 2015). However, considering these limitations, a meta-analysis, and a systematic review of epidemiological studies (cross-sectional and cohort) may shed some light on the association between health aspects (hearing loss and depression) while highlighting the strengths and weaknesses of the existing evidence and offering recommendations for clinical practice going forward.

Prior studies on the association between hearing loss and depression have objectively measured hearing loss with a PTA audiometry (Hidalgo et al., 2009; Kiely et al., 2013). However, some studies report on subjective hearing loss only, measured with results reported by patients themselves (Boorsma et al., 2012; Saito et al., 2010).

Some studies included a percentage of participants with cognitive decline (Perlmutter, Bhorade, Gordon, Hollingsworth and Baum, 2010). Cognitive decline has been described as an abnormal deficit of cognitive function, given the age and educational level. In older adults it may range from mild cognitive impairment to dementia (Albert et al., 2011). There is increasingly more evidence emphasizing the association between hearing loss and cognitive decline in older individuals (Loughrey, Kelly, Kelley, Brennan and Lawlor, 2017). Besides, a decline in cognitive function has been associated with depression (Wang and Blazer, 2015). Therefore, one might expect a stronger association between hearing loss and depression in older adults, which would prove the existence of the cognitive decline as well (Rutherford et al., 2018).

The experience of participants with hearing aids varies across studies (Chou, 2008; Pronk et al., 2011; Rosso et al., 2013). Hearing aids may mitigate the symptoms of depression associated with hearing loss in older adults (Choi et al., 2016; Manrique-Huarte, Calavia, Irujo, Girón and Manrique-Rodríguez, 2016), which could impact the association between hearing loss and depression in observational research.

Besides, a substantial percentage of research does not include results adjusted to the extrinsic influence of covariates (i.e.: health/psychosocial aspects), which undermines the validity of the findings (Al Sabahi, Al Sinawi, Al Hinai, and Youssef, 2014; Chou and Chi, 2005; Hidalgo et al., 2009).

It is also broadly accepted that one cannot infer causality with cross-sectional studies. Therefore, the time-related association between hearing loss and depression cannot be established by this method. Meta-analytical evidence with a reduced number of studies initially showed an association between hearing loss and depression in older adults

(Huang, Dong, Lu, Yue, and Liu, 2010). However, more studies have been published since and the inconsistent findings call for a systematic review and a meta-analysis of the evidence.

Based on all this, Blake J. Lawrence et al. (2019) undertook a systematic review and meta-analysis primarily intended to summarize the available evidence and offer a summarized estimation of the effect an association between hearing loss and depression has on older adults. Secondarily, they sought to examine whether the characteristics of the study (the design, outcome metrics) or the participants (demographics, health) could have impact on the association between hearing loss and depression. A systematic, thorough review of the literature was undertaken by this author, and all available evidence was included in the study to offer a rigorous estimation of the association between hearing loss and depression in older people.

The findings of this systematic review and meta-analysis (Blake J. Lawrence et al., 2019) indicate **that hearing loss entails a probability of depression 1.47 times greater in older people.**

It is ***more likely for older adults with hearing loss to feel emotionally and socially lonely*** (Contrera, Sung, Betz, Li and Lin, 2017; Pronk et al., 2014), ***have poor cognitive function*** (Jayakody, Friedland, Eikelboom, Martins and Sohrabi, 2018; Loughrey et al., 2017) ***and experience difficulty in daily functioning*** (Gopinath et al., 2012), ***which are in turn independently associated with more depression symptoms*** in older age (Hörnsten, Lövheim, Nordström and Gustafson, 2016; Luanaigh and Lawlor, 2008; Wang and Blazer, 2015). As a result, hearing loss may worsen the already existing difficulties associated with the psychosocial and functional abilities in older age, thereby increasing the likelihood of depression.

As part of the stress paradigm, (Pearlin, Menaghan, Lieberman and Mullan, 1981), the extent of social support could explain the association between hearing loss and depression in older adults (West, 2017). In a broad longitudinal study (N > 6000) with American adults (age ≥50), West (2017) observed that ***hearing loss appears as a factor of chronic stress in older adults without sufficient social support***, which leads to the spread of depression as an additional stress factor. Kiely and col. had reported in a previous study (2013) about the association between hearing loss and depression as something that totally justified the social interaction and engagement in mind-stimulating activities. Few studies in this meta-analysis have measured or controlled for social support. Therefore, it has not been possible to investigate this association in the current review. However, the findings of the meta-analysis indicate that older adults with hearing loss have a greater probability of depression. The latest studies suggest that appropriate social support could mitigate the severity of depressive symptoms.

It has been suggested that ***neuropathological changes in an aged brain*** are mechanisms potentially associated with hearing loss and depression in older adults as well (Rutherford et al., 2018). The limbic system and the auditory cortex activity are impaired in people with hearing loss, in response to emotionally positive and negative auditory stimuli (Husain, Carpenter-Thompson and Schmidt 2014; Rutherford et al., 2018). Neuroimaging evidence shows the reduced activation of the frontal cortex as well in older adults with hearing loss (Boyen, Langers, de Kleine and van Dijk, 2013; Husain et al., 2011) and depression (Murrough et al., 2016). These preliminary studies suggest homogeneous neuropathological mechanisms that could favor hearing loss and depression in older people, even though much remains unknown about the cortical pathways associated with hearing loss and depression in older age. Nevertheless, higher quality research combining imaging, audiology and neuropsychology is needed to understand better these associations and establish the time-related association between these two comorbidities.

The general association between hearing loss and depression was significantly, broadly heterogeneous. However, the differences in the study and the characteristics of participants do not justify the variance of this effect. When sufficient co-variates are measured and controlled, cohort studies (as opposed to cross-sectional studies) reveal more significant evidence, because time-related comorbidities of other health disorders can be inferred from them. Cross-sectional studies are subject to methodological limitations as well, including the respondent's biased response and convenience sampling (Sedgwick, 2013), which could artificially boost the link between results when measured at a specific point in time. Therefore, the cross-sectional association between hearing loss and depression could diminish when measured constantly over a period. In any case, assuming both the effects of cross-sectionalism and the cohort, this meta-analysis showed a significant association between hearing loss and depression. The findings of this review suggest that older people tend to suffer from hearing loss-related depression more likely, and that this association may be constant over time.

Measuring the outcome subjectively could provoke a biased response, and the subsequent over- or under-rating of the severity of the health disorder (Daltroy, Larson, Eaton, Phillips and Liang, 1999; Dowling, Bolt, Deng and Li, 2016). Previous studies have suggested that using hearing aids could improve the symptoms of depression associated with hearing loss (Manrique-Huarte et al., 2016). However, this review did not uncover any differences whatsoever in the association between hearing loss and depression irrespective of the objective or subjective measures of hearing loss, or the prior use of hearing aids by a portion of the participants. In a wide community study (N>100,000), Keidser, Seeto, Rudner, Hygge and Rönnberg (2015) found that regardless of the measure used to assess hearing loss or the use of hearing aids by participants, the severity of the hearing loss was associated with more symptoms of depression. As described by Ioannidis (2016), not even the most rigorously and thoroughly executed cohort studies can always establish the time-related association between the variables of interest. Given the current observational findings, one can hardly establish whether an individual's hearing loss precedes the onset of depression or health ailments increase the feeling of depression and have negative impact on the perception of their hearing. It is also important to observe that most research included in this review did not report on the exact proportion of the sample who used hearing aids. Besides, there is a discrepancy between owners and users of hearing aids, since up to 24% of hearing aid owners reported they had never used their hearing aids (Hartley, Rochtchina, Newall, Golding and Mitchell, 2010). Therefore, owners and users of hearing aids are probably represented incorrectly in this meta-analysis. This may have contributed to the null findings. Taking these caveats into account, the outcome of the author's preliminary analysis suggests that hearing loss reported by patients themselves may be a sufficient measure of hearing loss and its association with depression in older age, and that hearing aids may not mitigate the symptoms of depression associated with hearing loss.

Hearing loss is associated with a decline in the cognitive function of older adults (Jayakody et al., Loughrey et al., 2017), and cognitive impairment has been associated with greater levels of depression in older age (Wang and Blazer, 2015). Therefore, we expected a greater probability of depression among the studies including participants with hearing loss and cognitive impairment and those who reported their results unadjusted to the covariates. On one side, the current findings suggest that older people with hearing loss and cognitive impairment are not necessarily facing greater odds of depression, compared with individuals with hearing loss but without cognitive impairment. The association between hearing loss and depression may not be influenced by differences in demographics or health at an individual or group level. However, in line with the null effect of hearing aids, few studies reported on the percentage of their sample and the severity of the cognitive impairment or deficit, examined through the lenses of their connection to hearing loss and depression. Therefore, it remains unclear what percentage of the participants in this meta-analysis had cognitive impairment, which must be considered when interpreting the results.

The ***sensitivity analysis*** did not account for the heterogeneous joint effect of hearing loss and depression either. Some studies were removed from the joint effect as they had reported beta coefficients that should have been converted into OR for this meta-analysis, because their large sample (N>20,000) and their high weight could bias the relation, and because they examined hearing loss and depression in older individuals who lived institutionalized (i.e.: home for the elderly, hospitals) where they are more likely to suffer from severe hearing loss and depression (Boorsma et al., 2012; Cosh et al., 2018; Keidser and Seeto, 2017; Kiely et al., 2013; Krsteska, 2012; Pronk et al., 2011; Rosso et al., 2013; Yasuda et al., 2007). However, the association between hearing loss and depression remained relevant, with heterogeneity varying between mild and broad after each sensitivity analysis. These findings suggest that the relation between hearing loss and depression had not been artificially boosted by the statistical methods used to convert the size of the study effect for the meta-analysis (particularly with large sample studies) or influenced by a potentially clearer association between hearing loss and depression, which is often found in older adults living in an institution. The association between hearing loss and depression was ratified by scant evidence (Schünemann et al., 2013). In fact, the evidence was reduced, considering the limitations resulting from including only observational studies, which lack the methodological rigor of a more robust design (such as clinical trials). Among the GRADE criteria, (Schünemann et al., 2013), only the risk of bias was brought down a notch upon realization that more than half of the studies included did not report on the results adjusted for the covariates. That said, the author's analysis in this study and meta-analysis did not show any difference whatsoever between studies with adjusted results or otherwise. It is important to highlight that the lack of consistency in the evidence did not diminish despite high heterogeneity (I2 = 83.26%) within the joint effect. The heterogeneity of the meta-analysis must be considered within each corpus of evidence (Schünemann et al., 2013), and most studies (>70%) in this meta-analysis reported on minor and medium effects with overlapped standard deviations. We therefore conclude that the differences when estimating the study effect were relatively consistent across studies, which validated the statistically significant, constant association found between hearing loss and depression and reported in this meta-analysis.

There are limitations to this review. Many different results and cut-off points have been used to measure depression and hearing loss. There are studies that have not offered sufficient detail to establish the specific method used. There is only one study (Saito et al., 2010) that reported on the subjective link between hearing loss and depression with a validated, standardized questionnaire (i.e.: The Hearing Handicap Inventory in the Elderly). The remainder of the studies used a range of questions and criteria answered by the patient themselves. The variability of methodologies used to report on the studies has led to a basic classification of variables by the author, which may very well account for the author's null findings, in part, and which has limited our capacity to investigate if the severity of the hearing loss or the depression caused the variance within the total effect. The beta coefficient conversion by Kiely and collaborators (2013) to an OR for this meta-analysis artificially boosted a non-significant finding, to such an extent that it became a considerable, significant association between hearing loss and depression. Eliminating Kiely and collaborators (2013) had no impact on the global effect. Still, the statistical difference across effects should be considered. In fact, current findings are limited to older adults (age≥60) while the evidence suggests that younger adults may have more severe depression symptoms in connection to their hearing loss (Keidser and Seeto, 2017). In order to better understand these concomitant health disorders over a lifetime, the researchers would like to systematically review and meta-analyze the association between hearing loss and depression in populations of younger adults and adolescents. Furthermore, we urge to interpret the findings of the analysis conducted by the authors with caution and to follow the design of randomized, controlled trials in studies going forward. This will yield more consistent evidence about whether hearing aids improve the symptoms of depression in older adults with hearing loss and whether cognitive decline is associated or not with the relation between hearing loss and depression. We also recommend epidemiological studies to adopt more rigorous designs going forward, and to measure, report and control consistently for the influence of using and owning a hearing aid, the course and degree of cognitive decline, the severity of the depression and the hearing loss, and more broadly, the overall health and demographic characteristics (age, years with hearing loss), which may very likely have impact on the association between hearing loss and depression in older age. The findings of this review indicate that ***aural rehabilitation with hearing aids*** may not alleviate the symptoms of depression associated with the hearing loss. Some recent evidence suggests that social support could moderate the association between hearing loss and depression in older age (West, 2017). Therefore, one could think that older people would benefit from educational training (Preminger and Meeks, 2010) and psychosocial therapy (Lindsey, 2016) to equip themselves with the resources needed to deal with changes to their health and quality of life. Adults with severe and profound hearing loss reported not having received psychosocial therapy as part of their aural rehabilitation, despite wanting the referral (Hallam, Ashton, Sherbourne and Gailey, 2006). However, it is important to point out the stigma of depression and health disorders among many elderly people (Conner et al., 2010). It often inhibits them from seeking help, and it makes it harder for audiologists and geriatricians to identify when they might need and benefit from an intervention. The Royal College of Psychiatrists in the UK, for one, reported that close to half of all older adults hospitalized with depression did not have that diagnosis included in their medical history at the moment of hospitalization, and it had not been included in their discharge papers for their General Practitioner (Hood, Plummer and Quirk, 2018). Audiologists would benefit from training to understand better the psychosocial difficulties experienced by older individuals with hearing loss (Ekberg, Grenness and Hickson, 2014) and identify and discuss mental health more confidently with their older patients. The widespread use of depression screening tools (i.e.: The Geriatric Depression Scale, GDS) among healthcare professionals working with older individuals would raise awareness about depression in this population, and more people would benefit from psychologists and psychiatrists specialized in depression (Smarr and Keefer, 2011).

Finally, it is important to note the ***size of the effect found in this meta-analysis***. Hearing loss is associated with a probability of depression 1.47 times greater. Based on the recommended conventions, (Chen et al., 2010), the effect is minimal. When the probability of depression increases however slightly, a small percentage of older people may have depressive symptoms associated with their hearing loss, but not the majority of them; even when the association is statistically significant. In the population at large, we tend to link depression to negative vital events (such as the loss of a loved one, loss of earnings), extended periods of stress, personality disorders, drug abuse, and poor diet (Beck and Alford, 2009). These factors may be worse for older people who see their overall health decline or have a negative perception of aging (Freeman et al., 2016). Healthcare professionals (audiologists in particular) working with older people with hearing loss must be aware of the heterogeneous etiology of depression, and understand that some, but not all older patients will show symptoms of depression associated with their hearing loss.

In conclusion, a systematic, broad review and meta-analysis (Blake J. Lawrence et al., 2019) have identified 35 studies about hearing loss and depression in older people. This review includes two main findings. First, hearing loss is associated with a probability of depression 1.47 times greater in older adults, despite the minimal association. Second, the association between hearing loss and depression may not be influenced by how hearing loss is measured, the use of hearing aids or demographic and/or health aspects. These findings are reinforced by the evidence of a large sample (N>145,000) of older adults, globally representative. A percentage of older adults can develop depressive symptoms associated with hearing loss. We urge healthcare professionals and general practitioners working with them to be cognizant and better informed of the depression suffered with aging.

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Cognitive Impairment

Jaime Marco, Antonio Morant

Hearing loss or hearing impairment is a prevalent condition. It affects 360 million people around the world. It determines various levels of disability, ranging from the physical aspect to social and psychological aspects. The incidence and prevalence of hearing loss is expected to increase considerably over the next few years, due to the demographic transition experienced around the world. (1).

A hearing loss greater than 40 dB in the better hearing ear in adults, and greater than 30 dB in the better hearing ear in children is considered a disabling hearing loss. At present, 80% of the population with impaired hearing live in developing countries, low- and medium-income countries. Hearing loss is a true public health challenge, undoubtedly. It is the most frequent sensory deficit among humans (1).

Approximately a third of people over age 65 have a disabling hearing loss (2).

Three different theories accounting for the association between hearing loss and aging have been put forward in the scientific community:

The first theory, developed through neurophysiological studies and supported by neuroimaging, uses the cognitive overload concept in reference to the brain activity needed to understand and recognize a voice, even though neural plasticity can offset any decline in working memory, hearing and neuronal organization, even in adults.

The second theory is that social isolation and depression provoked by the hearing impairment create a negative perception of one's own health and a reduction in daily activities.

The third theory is that the role of an aged central and peripheral nervous system can alter the synapsis and the anatomy of the central nervous system.

These three theories are not exclusive, but rather they overlap and have influence on the overall clinical status of an individual. All of this results in irreversible neural disorganization, which then triggers an impairment in one's ability to understand the spoken language. Other issues, such as cardiovascular diseases, Alzheimer's disease and other comorbidities and lengthy hospital stays can precipitate this trend (Figure 1).

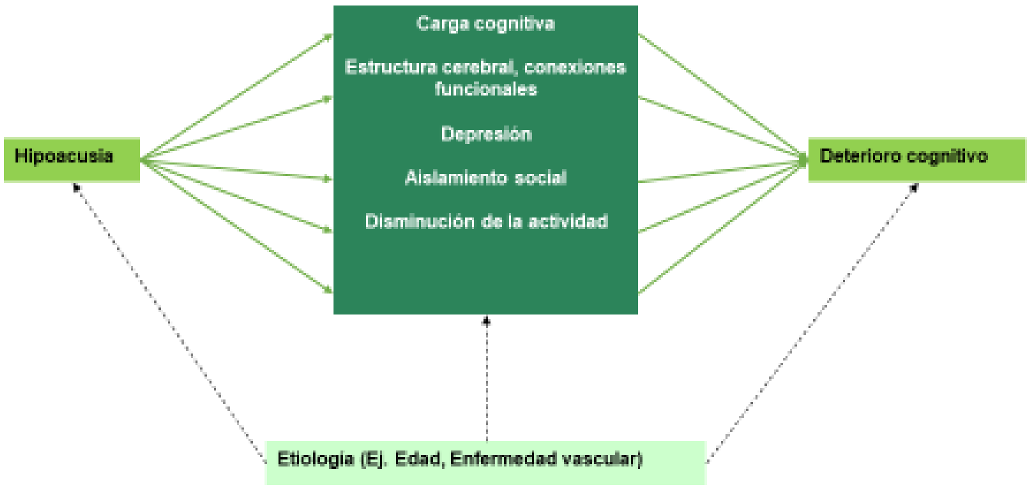

Figure 1. The effect of sensory impairment on the central nervous system and the diseases that affect it.

On average, individuals with hearing loss need 7.7 years to develop a cognitive impairment score of 5 in the 3MS test (a test well-established as indicator of the level of cognitive impairment), compared with the 10.9 years a normal-hearing person would take to score that (3, 4).

Lin's results (4-5) are consistent with previous publications that show the association between a more severe hearing loss and a poorer cognitive function in verbal and non-verbal cognitive tests (6).

In theory, there are several mechanisms involved in the association between hearing loss and cognition. Poor verbal communication associated with hearing loss can lead to errors in cognitive tests. Besides, hearing loss may be overestimated in individuals with subclinical cognitive impairment. Communication difficulties rarely occur as a result of hearing loss (unless it is severe). They are an unlikely hindrance of face-to-face communications in quiet environments (that is to say, when cognitive tests are taken), particularly when experienced staff is doing the testing (7). Lin considers their results to be consistent both in verbal tests (3MS) and non-verbal tests (DSS).

Pioneering studies by Lin (4, 8) and Amieva (9) suggest that the population of older adults with poorly treated hearing loss are more susceptible to different types of cognitive impairment. People with mild, moderate and severe hearing loss are respectively 2, 3 and 5 times more susceptible to dementia than a normal-hearing person. If so, memory loss and cognitive impairment could increase, as the brain must make an additional effort to interpret the sounds it has trouble to receive. Some proposals consider this association can vary when a hearing-impaired person is timely diagnosed and receives a suitable hearing aid (9). However, Wong et al (10) state that the use of hearing aids alone is not enough to curb cognitive decline in hearing impaired individuals.

People with hearing loss see their cognitive skills diminish 40% faster than normal-hearing people. Studies associate this reduced brain function with the hearing level directly (Figure 2).

Figure 2. The effect of hearing loss on speech perception, mental effort and cognitive impairment.

Several studies (4, 9,11,12) declare that hearing loss is associated with poor cognitive execution, and therefore it contributes to the overall cognitive decline. The emotional state is limited due to social isolation and depression. One theory proposes that "if the brain allocates additional resources to try and listen to what is happening, it is probably taking those resources away from elsewhere in the brain, such as thinking and memory". Another effect is that Brodmann areas 41 and 42, in charge of hearing, receive less auditory information. Some proposals consider this association can vary when a hearing-impaired person is timely diagnosed and receives a suitable hearing aid (9, 13).

Addressing hearing loss with hearing aids can alleviate or improve cognitive function in these patients and favor their social engagement. However, they state that the use of hearing aids alone is not enough to curb cognitive decline in people with some sort of hearing loss (10). Since close to 10% of people over age 60 have hearing loss, and 7 years go by from the moment a patient starts having hearing problems to when they decide to use a hearing aid (based on some studies); the population of older people with cognitive impairment is going to be quite large, unless their hearing loss is addressed on time.

The research (9) undertaken by the University of Bordeaux with more than 3,700 people indicated that people who address their hearing deficit with these devices rate better in psychological tests that assess their mood and cognitive skills. The results of the research indicated that individuals with more severe hearing impairments showed less cognitive skills and more symptoms of depression. Conversely, individuals who used their hearing aids had similar cognitive skills to those of normal-hearing individuals.

In short, we currently have sufficient information to confirm that any type of hearing loss—although sensorineural hearing loss is the most researched—is one of many factors having impact on the acceleration of cognitive impairment. We also know that hearing loss is the third most frequent disease in older age. The effect of palliative treatments, such as hearing aids, cochlear implants and mere sound amplifiers can reduce, slow and even stop cognitive impairment.

Let us not forget the economic impact of social aid and direct and indirect costs of treatment for people with cognitive impairment.

A study carried out in Australia totaled the cost for the total population at AUS$ 302,307,969 per year (14)

All these bibliographical references must encourage us to carry out this type of study with Spanish speakers in Spain and Latin America.

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THE POSITIVE IMPACT FOR THE ELDERLY OF EARLY INTERVENTION IN HEARING LOSS AND BALANCE DISORDERS. CLINICAL AND SOCIO-ECONOMIC ASPECTS.

Manuel Manrique

Hearing Loss Is Often a Silent Problem

In most cases, family and friends are more aware of the problem than the patient. It would seem cautious for healthcare professionals to screen for one of the most prevalent chronic diseases affecting older people, but unfortunately, this is not done. It is most unfortunate that the penetration rate of hearing aids and cochlear implants is between 10%-15% among users since they have proven to be effective means to treat hearing loss. These numbers show that we need to take on a holistic approach to this problem, raising awareness among healthcare professionals and society as a whole, and implementing early detection, diagnosis and intervention programs, with optimal monitoring, to ensure that the desired benefits are achieved.

The causes for this low penetration rate may be:

- The person affected denies the problem.
- The hearing aid fitting/cochlear implant programming is delayed, the hearing system is not stimulated for an excessive period of time.
- Mismatch of expectations and results obtained.
- Social stigma linked to age-related hearing loss. The patient opposes wearing a hearing aid visibly.
- Partial approach to the issue, exclusively focused on treating the hearing loss, leaving aside the fact that this impairment is associated with multiple conditions that must be considered.
- Improper control of the hearing aid used.

The Consequences of Presbycusis and Balance Disorders. Their Economic Impact

The impact of presbycusis and balance disorders on an aging population, as in Europe, is high. If hearing loss and balance disorders are not accurately diagnosed and treated, the population of Europe and the world have a smaller chance of active and healthy aging. As mentioned in this document, presbycusis and balance disorders will bring about several effects that undermine the quality of life of the elderly:

- ***Functional Impact***. Hearing loss and decreased autonomy reduce the quality of life in several ways: communication difficulties, increased social isolation, reduced capacity to participate in all areas of social life and contribution to other health issues.

- ***Social/Emotional Impact and Health***. Hearing loss can increase the risk of mental health issues: anxiety, paranoia and depression are some risks one must consider. People with hearing loss are over-represented in the sample of patients with late-life paranoid psychosis. Older individuals with hearing loss are more likely to develop depression compared to normal-hearing individuals.

- ***Cognitive Impact***. A considerable number of publications[1,2] show that hearing loss among the elderly is associated with dementia independently. This sheds light on the factors that contribute to reducing cognitive function in the elderly.

- ***Economic Impact***. Hearing loss leads to the loss of income and employment (Kochkin 2015) (unemployment rates are higher), more sick leaves, less opportunities to advance their professional career, and difficulties to recover a job. The cost of untreated hearing loss in Europe is estimated at €213 billion for 2050. Besides, it is estimated that some 900 million people around the world—out of which 90 million are in Europe—suffer from hearing loss[3,4]. The annual indirect and direct costs of untreated hearing loss in various European countries range from €32,000 in Germany, €23,400 in France, €22,000 in the United Kingdom, €21,300 in Italy, to €16,300 in Spain or €14,000 in Poland[5].

"The Real Cost of Hearing Loss", a report by The Ear Foundation (2014)[6] shows the actual cost of hearing loss for adults, and how to reduce its impact with the latest technology available to treat hearing loss and balance disorders. O'Neil[7] has proven that the economic cost of NOT offering technological solutions to treat hearing loss is greater than the cost of providing these technologies. European healthcare systems need to calculate the actual cost of hearing loss. There is considerable risk in not providing hearing aids, bone-conduction implants, cochlear implants and other hearing solutions. Today, this opens the door to costly demands on healthcare systems and it will generate significant costs in social care going forward. Giving aid to treat hearing loss today changes that individual's life—and saves society some money. A US study[8] compared hearing aid users with non-users. People with severe hearing loss who did not use hearing aids were subject to unemployment rates (15.6%) double those observed among individuals who used their hearing aids (8.3%). The result obtained with cochlear implants can create opportunities in the job market as well. Monteiro[9] described that patients with cochlear implants saw their income increase significantly versus what they earned before the implant. In a study, Clinkard[10] found that 60% of patients were unemployed before getting their cochlear implant. Their unemployment rate was cut down to 49% after the implantation. In a study using a questionnaire to assess the job

satisfaction of patients treated with a cochlear implant, Huarte[11] found that 93.05% of the group felt more motivated to go to work, 79.31% saw themselves as more competent and 67.23% improved their interpersonal relations at work a year after activating their cochlear implant. The study concludes that the cochlear implant has positive impact at work and on social skills, as it benefits the communication skills of implanted patients.

Falls are the most frequent cause of fatal and non-fatal traumatism. Their economic cost is estimated at $67.7 billion in the USA. Among the modifiable risk factors described, drugs, visual impairment, weak lower limbs and vitamin D deficiency have been mentioned. Surprisingly, hearing loss is not mentioned as a predisposing factor, despite the scientific evidence that shows a relation between falls and hearing loss, as pointed out in this document.

Cognitive impairment is a consequence of hearing loss among the elderly, as described in this document as well. In 2010, the prevalence of dementia above 70 years of age in the USA was estimated at 14.7%[12]. There are 6 to 9 million people with dementia in Europe annually. The annual economic cost per person attributable to dementia in the USA was USD$56,290 in 2013[12]. The direct and indirect cost of all brain diseases exceeds €790 billion in Europe, compared with €200 billions of cardiovascular diseases and €150 billions of cancer[13]. The cost of dementia in people above 60 years of age amounted to 0.79% and 0.77% of the gross domestic product of France and Italy respectively in 2009[14]. Managing hearing loss improperly can increase the cost. According to some estimations, Social Services in the United Kingdom could save £28 million if the hearing loss of patients with severe dementia were properly treated, as this would have delayed the need for institutionalized care, and the corresponding economic cost[15].

The Positive Impact of Treating Presbycusis and Balance Disorders

There has been a revolution in the efficacy and power of communication technologies over the last few decades, including hearing aids, bone-conduction implants, cochlear implants and other aids. Healthcare systems are in a better position to face the health disorders and social consequences stemming from hearing loss and balance disorders.

Hearing Aids

Hearing aids are an effective, well-accepted solution to treat hearing loss. According to several studies, their utilization reaches 80-90%. Some systematic reviews have reported that hearing aids are a cost-effective intervention[16,17,18]. The employment rate of hearing aid users is almost double that of non-users[8].

The “American Association of Audiology Task Force” carried out a systematic review of the medical literature and concluded that hearing aids improve the quality of life of its users and reduce the negative effects of hearing loss on psychological, social and emotional aspects[19]. More recent studies about quality of life have revealed the beneficial effect of hearing aids [20,21,22]. Hearing aid users have reported positive results compared with non-users, and described improved socialization, mental and physical health[23]. The use of hearing aids mitigates the risk of social dependence and premature death[24,25], and they have a positive effect on depression[26].

There are increasingly more studies proving that cognitive impairment can be reduced by using hearing aids. An extensive French randomized study with a cohort of 3,670 patients over age 65, proves that stimulating the auditory pathway with hearing aids is beneficial. This study started in 1989-1990, and the participants have been regularly evaluated for 25 years. The study concludes that hearing loss is associated with faster cognitive impairment in older adults, and that older adults who use hearing aids go through a significantly milder process[27].

Cochlear Implants

In general, people with severe to profound hearing loss use cochlear implants. Ever since cochlear implants made their appearance in the 1980s, many studies have evidenced that patients with severe to profound hearing loss, regardless of the age at implantation, can access the spoken language enabled by their implants[28].

Cochlear implants restore auditory perception. In doing so, they reduce the prevalence of tinnitus, improve the quality of life, reduce the symptoms of depression and improve overall cognitive skills[29,30,31].

The cost-benefit advantages of cochlear implantation have been well established in a series of systematic reviews and research[32]. A review in 2011 concluded that unilateral implantation yields a positive cost-benefit balance, including older adults in this assumption[33]. Using bilateral cochlear implants (simultaneous and sequential) has become a staple of clinical practice in the last few years[34,35]. Bilateral cochlear implants offer a superior ability to locate sound and discriminate speech in noisy environments, compared with unilateral implantation in adults[36,37]. A recent economic evaluation in adults with sequential, bilateral cochlear implants in Canada proved a positive cost-benefit ratio[38]. Another multi-center randomized study in Europe compared the use of unilateral vs. bilateral cochlear implants in a post-lingual adult population. It concluded a positive cost-benefit balance for patients with life expectancies equal or greater than 5-10 years[39].

Hearing is important to maintain balance. Postural balance is a process in which the correct functioning of the muscular-skeletal system depended on the correct interaction between the vestibular, visual and somatic sensory subsystems. If one of these subsystems fails, it has impact on keeping balance. This failure may be offset by another subsystem, such as hearing. As correctly mentioned and pointed out by Lin[40], people with hearing loss are twice and three times more likely to suffer falls than a normal-hearing person. Adopting therapeutic measures to repair or rehabilitate injuries affecting balance are key to reduce the risk of falls and can also help treat the hearing problem. One may reasonably argue that treating hearing loss must be a priority when preventing falls and promoting quality of life among older adults.

Finally, early detection and a comprehensive management of presbycusis and/or balance disorders and their etiopathogenic factors are key. This will enable prevention by early intervention, allowing the elderly to maintain their communication, cognitive, mental skills and autonomy. In sum the quality of life of the elderly will improve and the negative impact their dependance has on caregivers and the economic sustainability of healthcare systems will be mitigated as well.

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