Health, 2020, 12, 353-367
https://www.scirp.org/journal/health
ISSN Online: 1949-5005
ISSN Print: 1949-4998

Technology Usage among Elderly with Self-Reported Hearing Disability: Results from InveCe.Ab

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How to cite this paper: Vaccaro, R., Colombo, M., Abbondanza, S., Rolandi, E., Pettinato, L. and Guaita, A. (2020) Technology Usage among Elderly with Self-Reported Hearing Disability: Results from InveCe.Ab. *Health*, **12**, 353-367.
https://doi.org/10.4236/health.2020.124029

Received: March 21, 2020
Accepted: April 20, 2020
Published: April 23, 2020

Abstract

Background: Awareness of hearing disability in the elderly has adverse cognitive and functional consequences over time, in a longitudinal population-based study. **Aim:** To analyze the hypothesis that over time old people aware of hearing disability make less use of technology and lose more instrumental activities of daily living than peers with other self-reported hearing conditions. **Methods:** We analyzed 1171 healthy participants in the longitudinal population-based InveCe.Ab study. The consistency between self-reported hearing loss with clinician-evaluated hearing status (Whispered Voice Test; WVT), was categorized by consistency as: unaware of hearing loss (UHL), aware of hearing loss (AHL), only subjective hearing loss (OSHL), without hearing loss (noHL). **Results:** At baseline (2010), hearing loss was found in 159 [13.6% (95% CI: 11.7 - 15.7)] of the participants [28 = 17.6% (95% CI: 12.0 - 24.4) AHL; 131 = 82.4% (95% CI: 75.6 - 88) UHL], while 23 [2.3% (95% CI: 1.4 - 3.4)] of the subjects with normal WVT had OSHL. Mobile phone usage was significantly associated with different consistency categories ($p < 0.001$). It was lower in AHL and OSHL than in noHL subjects ($p = 0.004$ and $p = 0.008$) and UHL ($p = 0.007$ and $p = 0.011$). Doing shopping, using transportation, medication management and handling finances varied depending on consistency categories. Logistic regression models showed that, after 4 years (second follow-up: 2014), among AHL subjects, compared to noHL ones, the odds of having less use of mobile phone had increased over threefold, the odds of acquiring dependence in doing shopping had increased over six fold. Cognitive domains performances (*i.e.* executive, memory and visuo-spatial) were independently associated with maintaining mobile phone usage and instrumental activities of daily living. **Conclusion:** Self-reported hearing disability is linked to subsequent loss of mobile phone usage and functional dependency. As cognitive performances independently influence technology usage and functional impairment, targeted preventive interventions should address functional impact of perceived hearing loss, but also encourage social participation and improve mobile phone usage. Trial registration: ClinicalTrials.gov, NCT01345110; registered on April 29, 2011.

Keywords

Technology, Self-Reported Hearing, Instrumental Activities, Population-Based Study, Cognition

1. Introduction

Hearing loss (HL) is a common chronic condition in elderly people, affecting two-thirds of individuals 70 years or older [1]. In a Canadian population representative sample, 93% of those aged 70 to 79 years old had an audiometrically measured hearing loss. Yet only 19% of persons in that age range complained self-reported hearing loss. In that overall sample (wherein age spanned from 40 to 79 years) unperceived hearing loss was more common among adults with mild or unilateral measured loss, independently from previous exposure to environmental risk factors. Unexpectedly, people who rated their health very positively were more likely to have unperceived hearing loss. Further, individuals who had experienced tinnitus were less likely to have unperceived hearing loss [2].

Midlife hearing impairment is a risk factor for temporal lobe volume loss. Poorer midlife hearing, particularly in the right ear, was associated with declines in hippocampus and entorhinal cortex [3]. Beyond delayed biological consequences, diminished hearing implies a lot of bio-social adverse consequences, including depression, cognitive decline and dementia [4] [5]. The association between HL and cognition has been consistently reported in observational studies. The mechanisms underlying such association are manifold and possibly bi-directional [6]. More, longitudinal studies support the notion of hearing impairment as associated with later cognitive decline, whilst the opposite temporal sequence seems disproved. Furthermore, treatment studies suggest significant improvements in cognitive performances with hearing aid use, whereas cognitive performances returned to baseline when the hearing aids stopped being used [7].

The current understanding depicts an association between hearing and cognitive impairment starting at the level of mild hearing loss, with the risk of cognitive decline and dementia increasing in a dose-dependent manner with worsening hearing loss [8]. Yet, surprisingly, a greater association between hearing and cognitive impairment was found in individuals with normal but less performant hearing, compared with those with hearing impairment [9].

Self-reported hearing is used in epidemiological studies with the aim to assess the burden caused by age-related sensory impairment where hearing loss cannot be measured by audiometry [10].

Perceived hearing difficulty provides reasonable estimates of hearing loss. Perceived hearing difficulty may be associated with an increased risk of mortality [11] and with the use of positive strategies to cope with hearing loss in daily life, *i.e.* hearing aids use [12].

We previously investigated the relationship between self-reported hearing disability and clinician-evaluated hearing status, and its longitudinal consequences on cognitive impairment and functional decline. Our results showed that awareness of hearing disability in the elderly has adverse cognitive and functional consequences over time, in a longitudinal population-based study. At baseline, male gender, age, functional and cognitive performance, and depressive symptoms were associated with consistency between self-reported hearing disability and Whispered Voice Test (WVT) hearing status. Longitudinal analysis revealed worsening functional performance and selective attention, global cognitive deterioration, and depressive symptoms in the aware group [13].

Notwithstanding their possible ambivalent attitude towards technology, elderly people may take advantage of technology (e.g. mobile phones) in order to properly fulfill their social and health needs [14]. Yet, to the best of our knowledge, no one has investigated the relationships between technology usage, focusing on mobile phones, and self-perceived hearing conditions, and its intertwinement with cognitive and functional status.

Therefore, we aimed to shed light on this relationship, hypothesizing that over time older people aware of their hearing disability would stop using technology and lose more instrumental activities of daily living than peers with other self-reported hearing conditions.

2. Materials and Methods

2.1. Study Design

This work was conducted within the framework of the InveCe.Ab (Invecchiamento Cerebrale in Abbiategrasso), a single-step multidimensional population-based study, consisting of a cross-sectional and a longitudinal phase (ClinicalTrials.gov, NCT01345110; April 29, 2011).

Following a single age quintile in a longitudinal study format allows us to minimize the confounding effect of age. The study is being conducted in a specific geographic area; hence, the recruited cohort is homogeneous with respect to age and ethnicity. Moreover, the choice to study individuals aged 70 - 74 years is based on the observation that this is considered to be a "transitional age" between late adulthood and old age, especially in terms of cognitive function, and that social and lifestyle factors still influence cognitive aging during this time [15].

The study design is described in details elsewhere [16]. Briefly, in each wave of the study, participants underwent a multidimensional assessment (social, medical and neuropsychological), performed by trained interviewers, geriatricians and neuropsychologists.

The eligible population consisted of all 1644 people born between 1935 and 1939 and residing in Abbiategrasso on the prevalence day (November 1st, 2009). Of these, 1321 agreed to take part in the study, giving a response rate of 80.4% [17]. Enrolled participants underwent two, four and eight-years follow-up evaluations.

For the purposes of the present work subjects participating in baseline (2010) and four-years (second follow-up: 2014) follow up were considered eligible. Subjects affected by dementia, psychiatric or active neurological disorders, those who refused medical or neuropsychological evaluation, and those with an incomplete evaluation were excluded from the analysis. These subjects were not included in order to rule out confounding factors linked to dementia, mental disorders, and incompleteness of information. The cross-sectional analysis was thus performed on 1171 subjects, while the number of participants included in the longitudinal analysis differed from test to test, due to missing values (as detailed in the results section below). The study procedures were in accordance with the Declaration of Helsinki of 1964 and the following amendments. The study protocol was approved by the Ethics Committee of the Department of Internal Medicine and Medical Therapy of the University of Pavia on October 6th, 2009 (Committee report 3/2009). All the participants were informed about the study procedures and signed a written informed consent for the use of their personal data.

2.1.1. Consistency of Self-Reported Hearing Disability with Clinician-Evaluated Hearing Status

The primary endpoint of the study was the relationship of self-reported hearing disability with technology usage and independency in instrumental activities of daily living.

The first step of the study was the variables definition. Self-reported hearing disability was investigated during the social assessment. The interviewers asked the participants whether they experienced hearing problems that reduce their capacity to carry out any everyday activities (yes/no). The participants' hearing status was also evaluated by geriatricians using the WVT and defined as a binary variable: hearing loss and normal hearing. Hearing loss was coded 1 if it was either unilateral or bilateral. The WVT is a simple and reliable screening test for detecting hearing loss [18], and it is also recommended for use in the elderly [19]. Briefly, the examiner stands behind the seated patient and whispers a standardized combination of numbers and letters and then asks the patient to repeat the sequence. Patients who repeat at least three out of a possible six numbers or letters correctly are considered to have passed the screening test (coded 0).

By combining the clinician's evaluation with the subject's self-report of hearing status, we obtained a new variable, named consistency of self-reported hearing disability with WVT hearing status, according to which the participants were categorized as: unaware of hearing loss (subjects with hearing loss but not self-reported hearing disability; UHL), aware of hearing loss (subjects with both hearing loss and self-reported hearing disability; AHL), only subjective hearing disability (subjects with normal hearing but self-reported hearing disability; OSHL), and without hearing loss (subjects with normal hearing and no self-reported hearing disability; noHL).

2.1.2. Technology Usage

The technology usage was evaluated during the social assessment through a brief questionnaire covering the last year use (coded 1) of different type of technologies: car, remote control, debit card, mobile phone, personal computer and internet (**Appendix**).

2.1.3. Instrumental Activities of Daily Living (IADL)

The level of independence in everyday functioning was assessed, during the social assessment, using the Italian version of the IADL scale [20]. This scale is widely used and it has shown a good validity in measuring competence of elderly in carry out complex activities [20], although its psychometric properties, like that of other of commonly used IADL questionnaires, are unavailable or with low quality standard [21]. IADL scale evaluates independence (coded 1) versus dependence (coded 0) in eight different complex activities: using the telephone, shopping, preparing meals, doing housework, doing laundry, using transportation, medication management, and handling finances. In this way, we obtained an IADL score [16] (range 0 - 8) that represents the total number of activities in which complete independence is reported.

2.1.4. Cognitive Domains

Cognitive domains scores were calculated from the neuropsychological test adopted in the InveCe.Ab study: the free-hand Clock Drawing Test, the Rey Auditory-Verbal Learning Test (RAVLT; immediate and delayed recall), the Babcock Story Recall Test, the Attentional Matrices, the Raven Coloured Progressive Matrices test and the Semantic Verbal Fluency Test, the Trail Making Test (TMT; part A and B), the Rey-Osterrieth Complex Figure (copy and recall), as previously described [16]. The cognitive domains were calculated using a simple standardization approach. Briefly, raw test scores were z-standardized using baseline mean and standard deviation (sd) of the sample. TMT z-scores were reversed so that more positive scores represent better performances. Standardized scores were averaged to obtain cognitive domains scores. The number and the composition of the cognitive domains scores was defined using a data-driven approach based on exploratory factor analysis detailed in the Statistical analysis paragraph.

2.1.5. Other Variables

The following sociodemographic variables were considered: gender (female/male), age at baseline, years of education.

2.2. Statistical Analysis

The data collected during the baseline wave of the "InveCe.Ab" study were analyzed cross-sectionally, while those collected at the four-year follow-up of the same study were analyzed longitudinally. Statistical analyses were performed using SPSS Statistics 17.0 (SPSS Inc. Released 2008. SPSS Statistics for Windows, Chicago: SPSS Inc.).

2.2.1. Baseline Analysis

Mean values with standard deviation (sd) were used to summarize the quantitative variables, while percentages (%) were used to describe the categorical variables. To evaluate associations between consistency of self-reported hearing disability with WVT hearing status (UHL, AHL, OSHL, noHL) and categorical variables, the chi-square test (χ^2) or Fisher's exact test was performed. Similarly, to evaluate relationships with quantitative variables, a parametric analysis of variance (ANOVA) was applied. If the associations with consistency categories (UHL, AHL, OSHL, noHL) were significant, then post-hoc group multiple comparisons were performed using the Tukey HSD test.

To determine the latent dimensions of the 11 neuropsychological tests of the battery, exploratory factor analysis (EFA) was performed on baseline raw test scores using the principal component extraction method. An oblique rotation technique (Oblimin) was applied, since different cognitive domains were expected to be partially correlated. The Kaiser criterion (eigenvalues ≥ 1.0) was used to determine the number of components to be extracted. Each variable was assigned to the corresponding factor if: 1) the highest loading was greater than 0.40; 2) no cross-loading was present (*i.e.* loading of 0.40 or higher on two or more factors).

2.2.2. Longitudinal Analysis

Logistic regression models were performed in order to identify factors associated (*i.e.* consistency categories, sociodemographic factors and cognitive performances) with stopping using technology and acquired dependency in instrumental activities of daily living from baseline to 4-years follow up. A p value of less than 0.05 was retained as significant.

3. Results

3.1. Baseline Results

Table 1 summarizes the significant baseline characteristics, technology usage and instrumental activities of daily living among participants defined by consistency of self-reported hearing disability with clinician-evaluated hearing status in the 1171 participants analyzed. The estimated prevalence rate of clinician

Table 1. Baseline statistically significant characteristics of the overall study population and in the participants defined by consistency categories[a].

	Consistency of self-reported hearing disability with WVT hearing status					
	N = 1171	**UHL**	**AHL**	**OSHL**	**noHL**	**p**
Gender, n (%)						0.047*
Female	624 (53.3)	55 (42)	15 (53.6)	14 (60.9)	540 (54.6)	
Male	547 (46.7)	76 (58)	13 (46.4)	9 (39.1)	449 (45.4)	
Age, mean ± sd	72.17 ± 1.29	72.2 ± 1.31	73.11 ± 1.16	72.04 ± 1.29	72.14 ± 1.28	<0.001
Mobile phone, n (%)						<0.001*
No		17 (13)	10 (35,7)	8 (36,4)	138 (14)	
Yes		114 (87)	18 (64,3)	14 (63,6)	851 (86)	
IADL score, mean ± sd	7.85 ± 0.72	7.86 ± 0.65	7.46 ± 1.14	7.36 ± 1.7	7.87 ± .67	<0.001
Doing shopping, n (%)						<0.001**
No		3 (2.3)	6 (21.4)	3 (13)	40 (4.1)	
Yes		127 (97.7)	22 (78,6)	20 (87)	946 (95.9)	
Using transportations, n (%)						0.003**
No		4 (3.1)	2 (7.1)	3 (13)	16 (1.6)	
Yes		127 (96.9)	26 (92.9)	20 (87)	973 (98.4)	
Medication management, n (%)						<0.001**
No		2 (1.5)	3 (11.1)	3 (13)	14 (1.4)	
Yes		128 (98.5)	24 (88.9)	20 (87)	974 (98.6)	
Handling finances, n (%)						0.007**
No		2 (1.6)	2 (7.4)	2 (8.7)	11 (1.1)	
Yes		123 (98.4)	25 (92.6)	21 (91.3)	963 (98.9)	

*chi square; **Fisher's exact test. [a]Subjects were categorized on the basis of the consistency of their self-reported hearing disability with WVT hearing status as follows: UHL = unaware of hearing disability; AHL = aware of hearing disability; OSHL = only subjective hearing disability; noHL = without hearing disability (normal hearing and no subjective hearing disability).

evaluated hearing loss was 13.6% (N = 159/1171; 95% CI: 11.7 –15.7); of these hearing-impaired subjects, 82.4% (N = 131/159; 95% CI: 75.6 – 88) were not actually aware of having hearing loss (UHL), while 17.6% (N = 28/159; 95% CI: 12.0 – 24.4) were aware of their condition (AHL). The subjects with OSHL made up 2.3% of the subjects with normal WVT hearing status (N = 23/1012; 95% CI: 1.4 - 3.4). The presence of unilateral and bilateral hearing problems did not differ between the UHL and the AHL groups ($\chi^2 = 1.393$, $p = 0.294$).

Mean years of education of the overall study population were 7.05 (±3.24). However, schooling was not significantly associated with the different consistency categories ($p = 0.279$). Gender ($p = 0.047$) and age ($p = 0.001$) were significantly associated with the different consistency categories. In particular, the subjects in the UHL group were more likely than those in the NoHL group to be men ($p = 0.007$). The AHL subjects were older than the UHL ($p = 0.004$), OSHL (p = 0.018) and noHL subjects (p = 0.001). Both the AHL and the OSHL subjects had lower IADL scores than the noHL ones (p = 0.025 and p = 0.007, respectively).

Most people were independent in using mobile phones. Older adults AHL and OSHL had lower use of mobile phone (the 35.7% and the 36.4% respectively). Post hoc analysis showed that AHL and OSHL subjects had lower mobile phone usage compared to UHL subjects (p = 0.007 and p = 0.011, respectively) and to NoHL ones (p = 0.004 and p = 0.008, respectively).

Most people were independent in IADL. Post hoc analysis showed that AHL and OSHL subjects were less independent than NoHL subjects (p = 0.025 and p = 0.007).

Doing shopping, using transportations, medication management and handling finances are significantly associated with the different consistency categories. Older adults with AHL and those with OSHL did less shopping (the 21.4% and the 13%, respectively). Post hoc analysis revealed that AHL and OSHL subjects were less independent in doing shopping than those UHL (p < 0.001 and p = 0.044). AHL were also less independent in doing shopping than NoHL subjects (p = 0.001).

Elderly people with OSHL did less use of transportations (the 13%). Post hoc analysis showed that OSHL subjects were less independent in using transportations than NoHL subjects (p = 0.008).

Older adults with AHL and OSHL were less independent in medication management (the 11.1% and the 13%, respectively). Post hoc analysis revealed that AHL and OSHL subjects were less independent in medication management then UHL subjects (p = 0.036 and p = 0.025, respectively). AHL and OSHL subjects were also less independent in medication management compared to NoHL subjects (p = 0.009 and p = 0.006, respectively).

Older adults with AHL and those with OSHL had low handling finances (the 7.4% and the 8.7%). Post hoc analysis showed that AHL and OSHL subjects were less independent in handling finances than NoHL subjects (p = 0.046 and p = 0.034).

3.2. Longitudinal Results

According to the results of the logistic regression analysis (**Table 2**), awareness of hearing loss (AHL) and cognitive domains performances (*i.e.* executive, memory and visuospatial), independently of other factors, were associated with stopping using of mobile phone and acquired dependency in instrumental activities of daily living. Specifically, in AHL group with respect to NoHL group, the odds of stopping the use of mobile phone was increased over threefold, the odds of acquiring dependence in using transportation was increased over six fold.

Subjects with higher executive composite scores showed a 43% decrease in the odds of stopping the use of mobile phone. They showed also a 27% decrease in the odds of an acquired dependence in doing shopping, an almost 50% decrease in the odds of an acquired dependence in using transportations, and a 36%

Table 2. Logistic regression models for identifying factors associated with stopping using technology and acquired dependency in instrumental activities of daily living (reference group: independence) from baseline to 4-years follow up.

	Stopping using mobile phone		Acquired Dependence in doing shopping		Acquired Dependence in using transportations		Acquired Dependence in medication management		Acquired Dependence in handling finances	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
UHL (ref noHL)	1.103	0.612 - 1.989	1.078	0.641 - 1.811	0.585	0.200 - 1.710	0.617	0.234 - 1.631	0.988	0.595 - 1.641
AHL (ref noHL)	3.75***	1.243 - 11.313	2.025	0.652 - 6.291	6.118***	1.701 - 22.006	3.059	0.793 - 11.803	2.235	0.756 - 6.602
OSHL (ref noHL)	1.586	0.550 - 4.572	1.378	0.514 - 3.694	2.219	0.601 - 8.186	2.080	0.570 - 7.592	1.176	0.447 - 3.090
Age at baseline	1.027	0.884 - 1.193	1.071	0.941 - 1.220	1.053	0.842 - 1.318	1.144	0.926 - 1.415	1.039	0.917 - 1.177
Executive composite score	0.570*	0.441 - 0.737	0.736***	0.587 - 0.923	0.505*	0.356 - 0.716	0.643***	0.453 - 0.912	0.505*	0.402 - 0.634
Memory composite score	0.695**	0.545 - 0.886	0.671*	0.542 - 0.829	0.945	0.663 - 1.346	0.565*	0.405 - 0.790	0.828	0.675 - 1.015
Visuospatial composite score	0.765*	0.602 - 0.973	0.846	0.683 - 1.049	0.566*	0.407 - 0.788	0.818	0.588 - 1.139	0.677*	0.550 - 0.834

*p < 0.001; **p < 0.005; ***p < 0.05.

decrease in the odds of an acquired dependence in medication management. Finally, they had an almost 50% decrease in the odds of an acquired dependence in handling finances.

Subjects with higher memory composite scores showed a 31% decrease in the odds of stopping the use of mobile phone, a 44% decrease in the odds of an acquired dependence in medication management, and a 32% decrease in the odds of an acquired dependence in doing shopping.

Finally, subjects with higher visuospatial composite scores had a 24% decrease in the odds of stopping the use of mobile phone, a 44% decrease in the odds of an acquired dependence in using transportations and an over 30% decrease in the odds of an acquired dependence in handling finances.

4. Discussion

As previously reported by the authors [13], the prevalence rate of presbycusis, identified by means of the WVT, was 13.6% in our sample. This estimate is lower than that reported by the World Health Organization on the basis of audiometric evaluation [22], but higher than the 10.7% reported in another study population in which the WVT was administered [23].

Multiple determinants may interact in presbycusis, but little is known on the relationship between self-rated hearing disability and each of the determinants. In our sample the self-reported hearing disability was not associated with schooling, although education is commonly recognized as a factor associated with presbycusis when measured with pure-tone audiometry [24]. In line with recent works, our results indicated that gender and age are associated with self-reported hearing difficulty. In particular, persons with hearing problems, even if they are unaware of them, are more likely to be male with respect to subjects without hearing problems [24]. On the other hand, age increases the ability to self-rate hearing disability [25].

In our sample, mobile phone usage was significantly affected by perceptions of hearing disability independently of the clinician-evaluated hearing loss. As we have not registered the time point of the self-perceived hearing loss neither of the mobile phone usage, we cannot hypothesize a causal relationship between mobile phone usage and perceived hearing loss. However, a previous work showed that mobile phone usage does not affect sudden sensorineural hearing loss [26].

As previously reported by the authors, functional performances are associated with consistency between self-reported hearing and WVT hearing status, *i.e.* among subjects with self-reported hearing disability [13]. In the present work we have showed that the self-reported hearing loss, independently of actual hearing problems, affects baseline instrumental activities of daily living, *i.e.* doing shopping, using transportations, medication management and handling finances. That could probably come from the fact that the awareness of hearing problem leads to avoid certain situations pertaining to the complexity of the task or to the world outside the home.

In the present work we also have demonstrated the four-years association between the awareness of hearing disability and stopping the use of mobile phone. This finding highlights the importance of the perceptions of self in adopting behaviors of avoidance or suppression of communication activities, resulting in loneliness and social isolation. This aspect is worthy of attention when clinicians arrange for targeted interventions because one way to reduce loneliness is to improve connections between older adults and their social network, which can be achieved through an increased sense of confidence and belonging via the use of digital technology (*i.e.* mobile phone) [27].

Our results also showed a longitudinal association between the awareness of hearing disability and using transportation and a trend in the association between the awareness of hearing disability and the acquired dependence in doing shopping. This finding confirm that hearing is crucial in instrumental activities in later life, especially those that implies communication skills [28].

Furthermore, we found that, after four years, cognitive performances, independently of other factors, were associated with stopping the use of mobile phone and dependency in activity of daily living, consistently with our previous work [13]. In particular, higher executive performances exert a protective influence on losing the mobile phone usage and acquiring dependence in doing shopping, using transportations, medication management and handling finances. These findings confirm the role of the multitasking abilities, *i.e.* planning, monitoring and concentrating, in instrumental activities of daily living [29]. Baseline higher memory performances were associated with decreased odds of subsequent loss of mobile phone usage and acquired dependence in medication management. This suggests the protective role of learning and recalling of new information for both activities. Finally, higher visuospatial performances had a protective influence on subsequent loss of mobile phone usage and acquired dependence in using transportations and handling finances. We hypothesize that they share a common processing such as mental rotation, spatial cognition and flexibility in the hierarchical organization of objects and configurations [30].

Our results showed that self-perceived hearing disability reduce mobile phone usage and functional independence over time. This is of some importance because hearing disability could make the difference between independence and the need for formal support services. Based on our results, clinicians should prompt referral of individuals with self-reported hearing loss (AHL, OSHL) not only for audiometric evaluation, but also targeted interventions, in order to prevent functional impact of perceived hearing loss. However, further researches are needed in order to improve the understanding of the independent cognitive factors implicated in the progression of functional disability. Rehabilitation options include the use of hearing aids to improve hearing capacity, and perceptual training to enhance perception of sounds and speech. In addition, educational program and counselling may improve mobile phone usage in order to maintain cognitive functioning, reduce the psychological impact of progressive awareness of hearing loss, reduce social isolation and enhance social connectedness [31] [32] [33] [34].

The strengths of the present study include the fact that hearing difficulties in an elderly Italian population were investigated in the context of a multidimensional assessment. This approach allowed us to confirm the relationship between self-rated hearing loss, independently of actual hearing condition, and mobile phone usage and functional decline. However, we acknowledge that our study has some limitations: i) we did not collect data on the possible causes of hearing loss, e.g. specific noise exposure, and were therefore unable to investigate the relationship between environmental risk factors and subsequent hearing problems; ii) since the participants did not undergo an audiometric evaluation, we could not look for differences between AHL and UHL subjects related to the severity of objective hearing loss; that said, the two groups were homogeneous for the presence of unilateral and bilateral hearing problems; iii) the level of independence in everyday functioning was assessed using the IADL scale, a widespread questionnaire, although more data on its psychometric properties are needed.

5. Conclusion

In this study we found that self-perceived hearing disability reduces mobile phone usage and functional independence over time. On the basis of the results of our longitudinal analysis, we conclude that individuals with self-reported hearing disability, independently of their actual hearing condition, are more likely to stop the mobile phone usage and acquire subsequent functional dependency. Clinicians should prompt referral of individuals with self-reported hearing loss (AHL, OSHL) not only for audiometric evaluation, but also targeted interventions, with the perspective of prevention of functional impact of perceived hearing loss, encouraging social participation and improving mobile phone usage.

Contributors

RV conceived this study, carried out statistical analyses and drafted the manuscript; MC conceived the study design and reviewed the manuscript for important intellectual content; SA conceived and carried out the neuropsychological evaluations; ER and LP carried out the neuropsychological evaluations; AG was responsible for the design of InveCe.Ab study, reviewed and supervised the entire work. All authors read and approved the final manuscript.

Acknowledgements

The authors are grateful to "Federazione Alzheimer Italia", Milan, for supporting the "Golgi Cenci" Foundation's research activities.

Funding

No funding was obtained for this study.

Ethical Approval and Consent to Participate

The study protocol was approved by the Ethics Committee of the Department of Internal Medicine and Medical Therapy of the University of Pavia on October 6th, 2009 (Committee report 3/2009). All the participants were informed about the study procedures and signed a written informed consent for participating in the study. In case of participants with dementia a written consent was obtained from their legal representatives.

Availability of Data and Material

Additional data are available on request from the corresponding authors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

The technology usage questionnaire.

"What kind of technologies did you have used during the last year (more than one answers are accepted)?"

☐ car
☐ remote control
☐ debit card
☐ mobile phone
☐ personal computer
If yes:
☐ internet

Note: if an item is present, code as 1.