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Hearing in the Elderly: a Population Study

Audición en la senectud: un estudio poblacional

Abstract

An epidemiological study comparing speech audiometry with self-assessed hearing disability and an analysis of other factors influencing the quality of life was conducted. In the Veneto region (Italy), a representative sample of 2700 independently living individuals of 65 years of age and older was selected for the study. All participants were administered a comprehensive questionnaire and a brief examination at their home, including a general physical examination, speech audiometry, Sanders' Speech Disability test, part I and III, Mini Mental State Examination, CES-D scale for depression, visual acuity, self-reported diseases and physical function. Auditory function was worst in the older individuals: auditory performance was within acceptable limits up to the 75–79 age group, while it rapidly deteriorates in the older groups. This trend is consistent with self-reported auditory disability (Sanders' test). A detailed analysis of the type of errors made in the speech audiometry was conducted for each subject. Speech audiometry is a good indicator of real hearing difficulties faced by the elderly, and it might be preferred to pure-tone audiometry, since hearing deficits with age are not always limited to an increased detection threshold, but include other aspects of hearing such as distortion of sounds, comprehension of speech and noise discrimination.

Sumario

Se realizó un estudio epidemiológico en el que se comparó la logoaudiometría con una autoevaluación de discapacidad y se analizaron otros aspectos que influyen en la calidad de vida. Se seleccionaron 2700 individuos autosuficientes, de 65 años y mayores, habitantes de la región de Veneto (Italia). Todos los participantes resolvieron un cuestionario y se sometieron a un breve examen en sus hogares que incluyó exploración física general, logoaudiometría, la prueba de Sander para discapacidad en el lenguaje, parte I y III, la prueba de estado mental (MMSE), la escala para depresión CES-D, agudeza visual y un auto-reporte de enfermedades y función física. La función auditiva fue peor en los individuos más viejos: el desempeño auditivo estuvo en limites aceptables hasta el grupo de edad de 75-59 y se deterioró rápidamente en los mayores. Este resultado coincide con la prueba de Sander. Se analizó detalladamente el tipo de errores que cada sujeto cometió en la logoaudiometría. Esta prueba vocal es un buen indicador de las dificultades auditivas reales que experimentan los viejos y podría preferirse sobre la audiometría convencional, puesto que los problemas con la edad no siempre se relacionan con un aumento en los umbrales, sino que incluyen aspectos auditivos tales como la distorsión sonora, la comprensión del habla y la discriminación en ruido.

Key Words

Elderly
Hearing impairment
Presbyacusis
Quality of life
Speech audiometry

Introduction

In Italy, as in most developed countries, about 15 per cent of the total population are aged over 65 years.[1] Demographic projections indicate a further increase in the population in this age group, due to longer life-expectancy and a low birth rate.[2] This is leading to an increase in the prevalence of hearing disabilities, with consequences for community rehabilitation services, and is therefore of interest for public health planning. However, there are few epidemiological and population-based studies on hearing disability and handicap, and the methodology varies greatly across studies in terms of number of subjects, age groups and selection criteria. Some studies used questionnaires.[3,4]

Other researchers have performed audiometric studies, mainly using pure-tone audiometry,[5–7] and others have conducted more comprehensive studies, including speech audiometry and otoimmittance testing.[8] Nevertheless, there is complete agreement in the literature that hearing worsens with age and that women perform better than men. It is therefore of great importance to investigate the hearing impairment and its relationship to health and social conditions of the elderly, in order to provide a rational approach for planning social and health services for this group.

To address this problem, hearing impairment and other data relevant to its comprehensive evaluation were analysed in an epidemiological study conducted in the Veneto region (Italy) on a representative sample of

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independently living individuals older than 64 years of age, to provide data on the quality of life of the elderly. All participants were administered a comprehensive questionnaire and received a brief examination in their home by a physician trained to administer interviews and specific performance tests in a standardized manner. The questionnaire collected information on demographic and socio-economic factors such as social and family support, living arrangements, income, self-reported history of medical conditions, and self-reported health status, as well as physical performance, including activities of daily living (ADL)[9] and instrumental activities of daily living (IADL),[10] health behaviours, use of health and social services, mental status and depressive symptoms (CES-D scale).[11] The examination included assessment of general parameters (e.g. weight and height), vision, speech audiometry, and physical performance. The progressive decrease in autonomy in the elderly, including the decreased communicative capabilities and the loss of physical functioning, has important consequences for the quality of life of this group, who tend to become isolated and to avoid most of the situations that require social interaction. This hearing ability was investigated as a major aspect of the quality of life in independently living elderly individuals.

Methods

The details of the methods have been described elsewhere.[12] Briefly, the population of the Veneto Study consisted of a random sample of 2700 individuals aged 65 and older, residing in the community on 1 May 1989 in nine defined geographic areas in the region of Veneto, in northeast Italy. Five of these centres (Conselve, Teolo, Contarina, Chioggia, and Villorba) are rural, and four (Mestre, Verona, Vicenza, and Belluno) are urban. Names and addresses of eligible individuals were obtained from the resident lists maintained by the municipalities. A random sample from each of five age strata (65–69, 70–74, 75–79, 80–84, 85+) was taken, with an over-sampling of those 85 years and older to acquire 20 per cent of the total sample in this age category. Data relative to each sex and age class were adjusted in order to standardize the number of subjects in each class to the demographic data published after the last census (1991).[2] Approximately 8.6 per cent of the total elderly population of Veneto was aged 85 and older in 1989. Eighty-nine per cent of the individuals identified as eligible participated in the study. The 298 non-respondents included individuals who refused to participate or who were not found at home after three visits on different days. Respondents were used when necessary to obtain basic demographic data for non-respondents. After exclusion of four people with missing or incorrect demographic data, the final number available for analysis was 2398.

For the present study, we have analysed the following parts of the questionnaire:

1. Speech recognition was investigated with speech audiometry performed using standard audiometric earphones (TDH 39) and a hi-fi portable tape recorder set at 70 dB SPL pe (peak equivalent) intensity. The protocol for performing speech audiometry at the home of the participants was specifically designed for this study. For each patient, two sets of 10 balanced bisyllabic words were chosen from a previously selected list. Intelligibility (I) was indicated as the percentage of correctly repeated words. Communication difficulties were evaluated using a cut-off of I $\geq$80 per cent to indicate no or mild communication difficulties and a cut-off of I $\leq$50 per cent to indicate severe communication difficulties.

A detailed analysis of the type of phonemic error (relative to the Italian language) made by the subjects during the speech test was performed. The errors were classified as follows: type 1=complete distortion of words, type 2=confusion between phonemes belonging to different phonemic classes, and type 3=confusion between phonemes belonging to the same phonemic class.

2. Parts I and III of the Sanders test[13] translated into the Italian language were administered to each subject, in order to assess self-rated auditory disability both at home and in a social environment.

Each item required two answers. The first related to the level of hearing difficulty in the situation investigated (scaled as in the original Sanders test: "little or no difficulty in understanding =+2; some difficulty =+1; a fair amount of difficulty =−1; great difficulty =−2"). The second related to the frequency with which the difficulty was present (scaled as: "seldom=1; often=2; very often=3). For each one of the 14 items of the Sanders test, the product "level of difficulty" times "frequency" giving rise to negative values indicated the presence of hearing disability (Sanders' impairment). Similarly, negative values of the mean of the scores obtained for all the items of the same subset were considered as indicators of hearing disability in the domestic and social environment. Furthermore, a linear score grading was applied to the same variables for each item in order to grade consistently the increase in level of hearing difficulty (values ranging from 1=little and rare difficulty, to 12=severe and continuous difficulty). The mean score of all the items obtained in this way (Sanders' score) was then compared with the results of speech audiometry.

3. The effect of the general health conditions on the quality of life was investigated with a section of the questionnaire on "subjective opinions on health condition", which included an item of self-evaluation of general health in comparison with peers. The answer to this item was considered as an index of subjective opinion of good general health when the answer was "good" or "excellent",

and as an index of subjective opinion of poor general health when the answer was "poor" or "very poor".

4. The Mini Mental State Examination (MMSE)[14] was used to assess the cognitive status of the subjects. The score was the sum of correct items out of 30 items. Subjects with score 24–30 were considered normal, subjects with score 18–23 were considered affected by mild cognitive impairment, and those with score 0–17 severely impaired.

5. The subjects' history of chronic systemic disease, which could impair the quality of life, was collected through the questionnaire, in order to identify possible correlations with hearing problems. The variables considered were: arthritis; diabetes; hypertension; renal diseases; cerebral infarction or hemorrhage; and Parkinson's disease. The analysis was further extended to examine the relationship between auditory data and various factors relating to the health status. In addition, information on the use of hearing aids was collected. The present paper describes analysis of the relationship between the auditory data and various aspects of health status. A descriptive analysis of the population was conducted using a statistical analysis software package (SPSS-PC).

Results

Table 1 shows the distribution of the subjects by sex and age group corrected by a factor, calculated for each group, in order to standardize the population of the sample to demographic data obtained with the population census of the Veneto region.

Hearing, as shown in this analysis, is worst in the older individuals: speech recognition performance is within acceptable limits up to the 75–79 age group, while it rapidly deteriorates in the older groups. This trend, shown objectively by speech audiometry, is consistent with self-reported auditory disability (Sanders' test). Speech recognition measures (SR) of 2236 subjects (1428 females and 808 males) out of the 2398 tested with speech audiometry were considered valid. From the relative distribution (Figure 1), it can be noted that 74.9 per cent of the population examined had no or little auditory difficulties (SR $\geq$80 per cent) while marked hearing impairment was present in 9.3 per cent of the sample (SR $\leq$50 per cent).

The mean recognition for each age group shows a progressive decrease in the older groups, with a slight increase of slope in those aged 80 years and older (Figure 2), in both men and women. A detailed analysis of the type of errors made on speech audiometry was performed for each subject. The types of error were divided into three categories based on the words non-correctly repeated by the subjects. The first error group included non-repeated or completely distorted words. The other two groups included words in which a phonemic substitution was introduced with a phoneme belonging to the same phonemic category[15] or belonging to a different category, respectively (Table 2).

Figure 3 shows the results of the analysis of the type of errors. It was found that the errors of subjects with lower intelligibility scores were mainly characterized by complete distortion of the word (error type 1), while subjects with better intelligibility scores introduced phonemic errors within the same phonemic category (error type 3).

Of the sampled population, 3 per cent (63 subjects) had a hearing aid. It is interesting to note that only 22.4 per cent of the sampled population with evidence of severe communicative problems on speech audiometry (SR $\leq$50 per cent) had a hearing aid, and only two-thirds of them used the aid.

Tables 3a and 3b show the results of Sanders' questionnaire part I and part III, respectively. The items are listed (column 1) with the percentage of subjects who gave valid answers (column 2). Column 3 shows the percentage of subjects who had greater impairment on the Sanders' test (corresponding to negative scores).

Table 1. Participants in the study standardized to the Veneto population (ISTAT, 1991): distribution by age and sex. Each cell shows the number of subjects (count), the percentage of each age group per sex (row %) and the percentage with respect to the total number of subjects (total %).

Count *Row %* *Total %*	*65–69 years*	*70–74 years*	*75–79 years*	*80–84 years*	*>=85 years*	*Row total*
	363	209	191	111	51	925
M	39.2%	22.6%	20.6%	12.0%	5.5%	38.6%
	15.1%	8.7%	8.0%	4.6%	2.1%	
	472	302	315	228	155	1472
F	32.1%	20.5%	21.4%	15.5%	10.5%	61.4%
	19.7%	12.6%	13.1%	9.5%	6.5%	
Column total	835	511	506	339	206	2398
	34.8%	21.3%	21.1%	14.1%	8.6%	100.0%

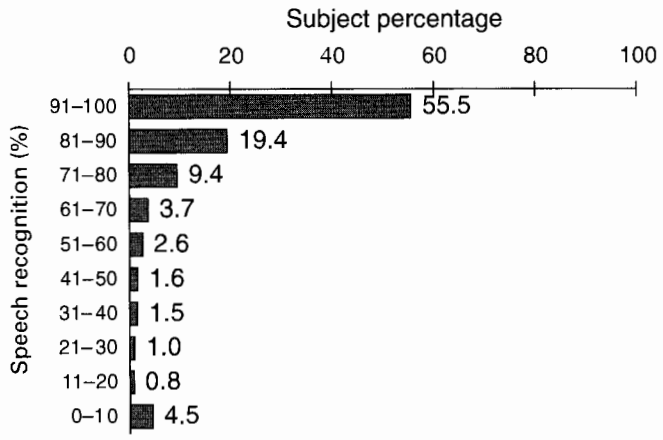

Figure 1. Distribution of speech recognition scores.

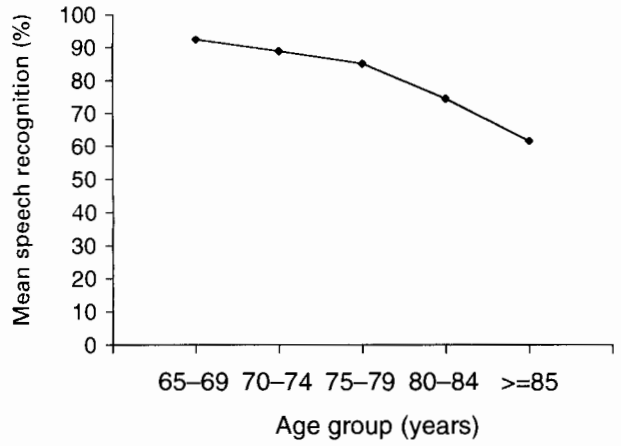

Figure 2. Mean speech recognition by age group.

A few items assess a greater overall hearing difficulty. They comprise situations in background noise (as in items I.2, III.1, III.6 and III.7), or those in which there is an absence of visual cues (items I.3. I.6, and I.7). The same level of hearing difficulty is noted when percentages of hearing disability for each item are plotted as a function of age group (Figures 4 and 5). The number of subjects with hearing impairment is shown to be consistently higher for these items in all age groups. Therefore, the hearing situations represented by these items correspond to situations of greater difficulty for the general population. All items show that the prevalence of hearing disability increases with age, with an increase in the slope for subjects >79 years of age.

The prevalence of hearing disability amounts to 9.7 per cent of the examined population (Figure 6). It is interesting that these results are consistent with those obtained with speech audiometry, where severe communicative difficulties (SR ≤50 per cent) were found in 9.3 per cent of the population. The Sanders score was highly correlated with intelligibility (Pearson correlation=0.64, $P<0.001$) over subjects. This is consistent with the similarity in distribution and age function trend shown in the figures relative to intelligibility and the Sanders score.

Table 2. Distribution of number (N) and percentage (%) of subjects in error categories.

	N	%
Subject tested with speech recognition	2240	100
<100 per cent	1393	62.2
Complete distortion (1)	574	41.2
Phoneme confusion in different category (2)	174	12.5
Phoneme confusion in same category (3)	42	3.0
(1) + (2)	483	34.6
(1) + (3)	48	3.5
(2) + (3)	9	0.6
(1) + (2) + (3)	65	4.6

The distribution by sex shows that 11.4 per cent of male subjects and 8.6 per cent of female subjects, in the examined population, report subjective hearing disability. The prevalence of hearing disability is greater for both sexes in the situation presented in Sanders' part III, being 12.5 per cent versus 10.1 per cent for males, and 9.8 per cent versus 8.1 per cent for females in social environment and home environment, respectively (Figure 6).

The relationship of the Sanders' score relative to the age groups is consistent with hearing disability being higher in the older participants, with an increase in the slope for subjects > 79 years of age (Figure 7).

In the population examined, the index representing self-reported health status was found to be quite constant up to 85 years of age, with a prevalence in subjective opinion of poor general health ranging from 11 to 12.5 per cent in the age classes under 85, increasing to 15 per cent for the subjects 85 years and older. Furthermore, in the age classes under 85, women report poor general health more often than men, while in the class of >85 years, there is no difference between sexes. The self-reported opinion on health condition was influenced by all the chronic systemic diseases investigated; for example, the prevalence of subjective opinion of poor general health is higher in cases with cerebral infarction or haemorrhage (30.8 versus 11.2 per cent) and in those with Parkinson's disease (30.2 versus 11.7 per cent).

In the group with hearing impairment on speech audiometry, 20.8 per cent of the individuals reported poor general health while in the group with no hearing impairment, the prevalence of such subjects was 10.8 per cent (Chi-square $P<0.01$). Similar results were found with Sanders' questionnaire, in which the prevalence of poor general health was 21.6 and 11 per cent in the group with and without Sanders' disability, respectively (Chi-square $P<0.01$).

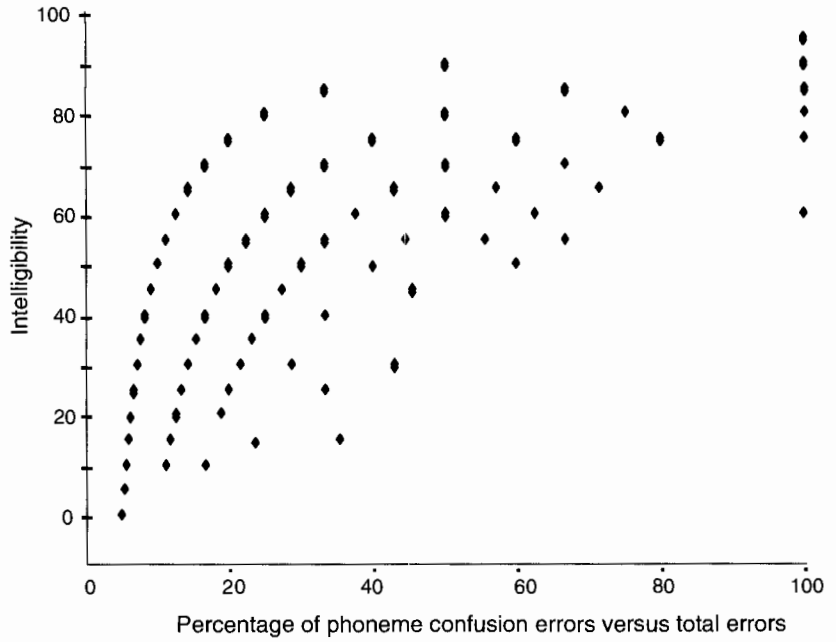

Figure 3. Relative weighting of confusion errors versus intelligibility. Speech recognition is expressed as the percentage of correctly repeated items and is shown on the X-axis. The ratio of type 2 errors (confusion between phonemes belonging to different phonemic classes) and type 3 errors (confusion between phonemes belonging to the same phonemic class) over the total number of errors is shown on the y-axis. It can be seen that the errors of subjects with lower speech recognition scores were mainly characterized by complete distortion of the word (left side of the figure).

Table 3. Subjects were asked to report how much difficulty they had in hearing people talking in the situations described, and how often it happens. (a) Items for subjective assessment of hearing problems in a quiet environment. (b) Items for subjective assessment of hearing problems in a noisy environment. Column 2 shows the percentage of respondents, while column 3 shows the percentage of answers saying the greatest difficulty for the particular item (subjects with responses for level: a lot or very much and frequency of difficulty: seldom, often or very often).

(a)	*Items*	*% respondents (N=2398)*	*% respondents with disability*
I.1	"facing the speaker"	99.7	5.3
I.2	"with radio-TV on"	99.5	13.7
I.3	"quiet + speaker behind you"	99.6	10.1
I.4	"people having a meal"	99.3	7.9
I.5	"people in the living room"	98.9	6.6
I.6	"listening to radio or TV"	99.1	9.6
I.7	"speaking on the phone"	95.1	8.1

(b)	*Items*	*% respondents (N=2398)*	*% respondents with disability*
III.1	"at a party"	80.3	14.3
III.2	"playing cards"	53.3	6.2
III.3	"at the cinema or theatre"	38.3	5.8
III.4	"in church"	83.2	10.4
III.5	"in a restaurant"	69.9	7.8
III.6	"in a car"	86.6	8.4
III.7	"in the street, with traffic"	90.0	13.3

The cognitive function, evaluated with MMSE, was found to decrease progressively with age, in both sexes. Furthermore, subjects with MMSE scores lower than 24 (moderate-to-severe cognitive deterioration) had a greater prevalence of both hearing impairment and disability, with respect to the class of subjects with normal cognitive capability (Figure 8). However, the relative prevalence of impaired speech discrimination is greater than that of disability, especially in the class with impaired cognitive function. The cognitively impaired subjects also reported poorer health status, compared with the group with normal MMSE.

No significant correlation was found between specific chronic diseases and reduced hearing capacity assessed by speech audiometry. However, we found a higher prevalence of Sanders' hearing disability (Chi-square $P<0.05$) in subjects with a history of diabetes or Parkinson's disease (12.6 per cent in diabetics versus 8.5 per cent in non-diabetic subjects; 18.8 per cent in subjects with Parkinson's disease, versus 8.8 per cent in subjects with no Parkinson's disease).

Discussion

The results of the speech audiometry have shown a general worsening of hearing performance in the older age groups, with a critical point between the age bands 75–79 and 80–84, when hearing worsens more signific-

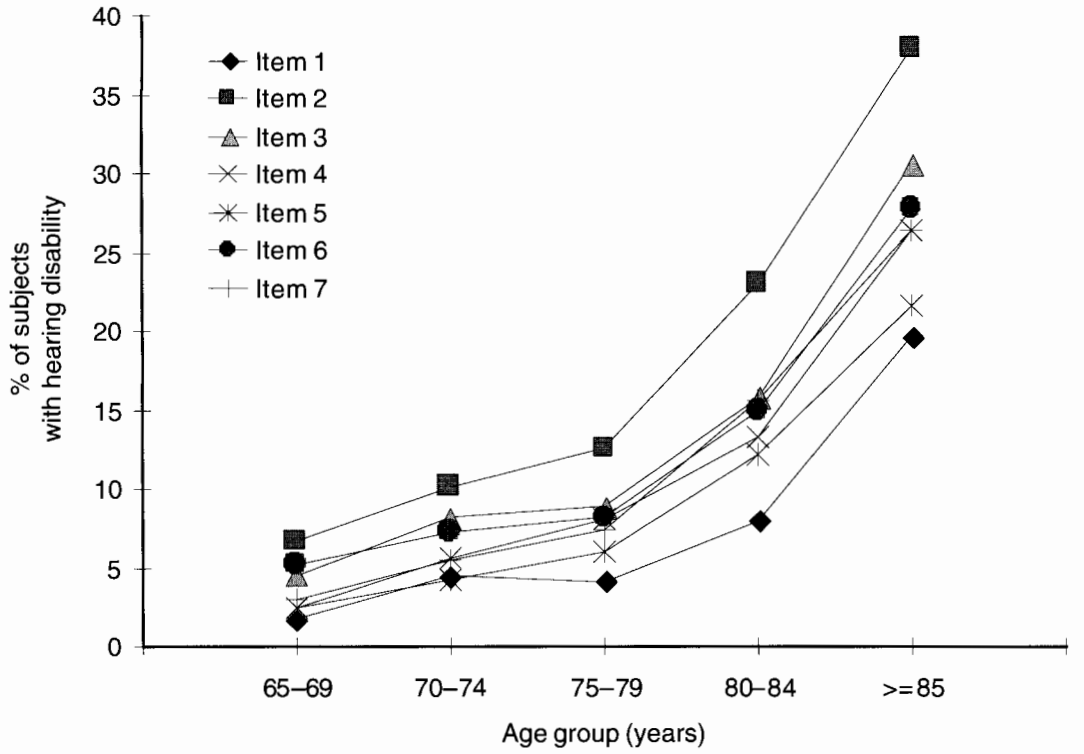

Figure 4. Prevalence of hearing disability by age group: items of Sanders' questionnaire part I.

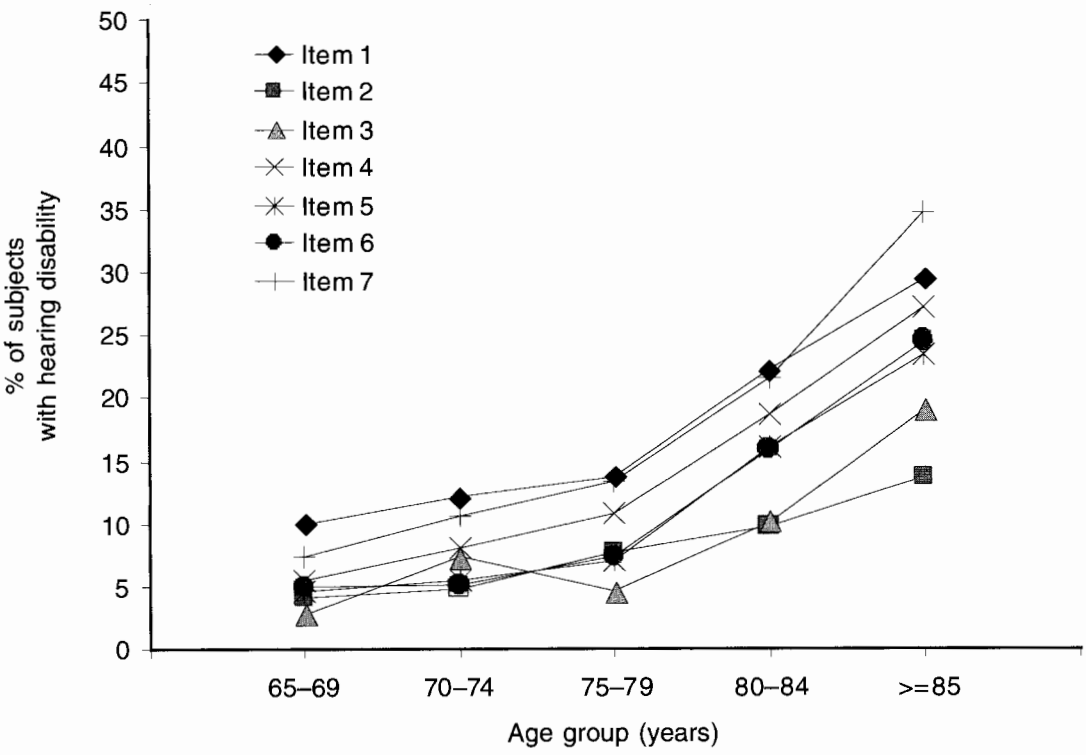

Figure 5. Prevalence of hearing disability by age group: items of Sanders' questionnaire part III.

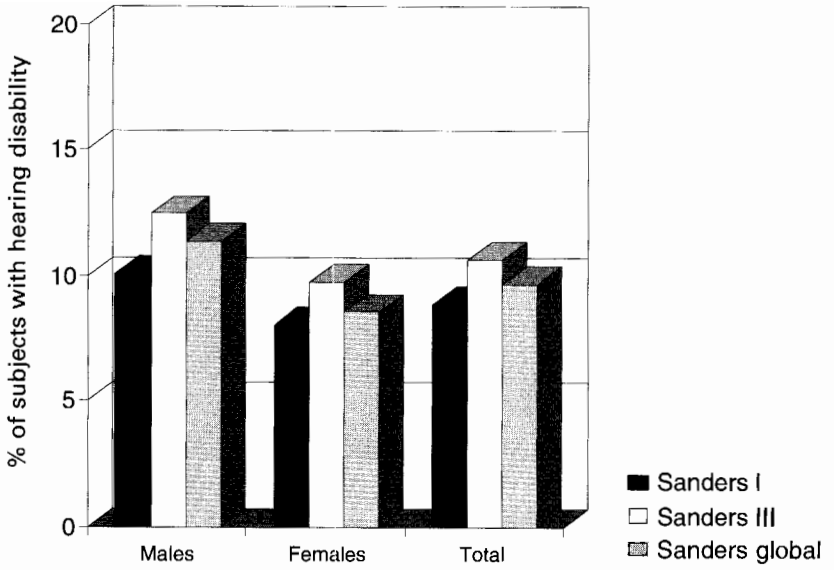

Figure 6. Prevalence of Sanders' hearing disability by sex.

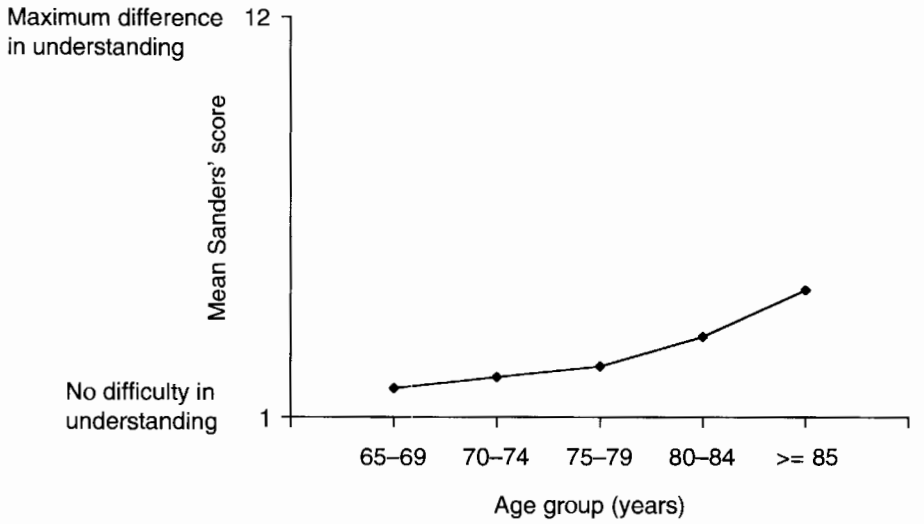

Figure 7. Mean Sanders' score by age group.

antly. Sanders' test provides information about the hearing problems encountered in social and environmental circumstances, where background noise adds difficulties to the hearing tasks,[16–18] as shown by the analysis of individual items. The rationale behind the choice of speech audiometry is that it represents a better indicator than pure-tone audiometry of actual hearing difficulties faced by the elderly, as impairment of hearing function is not always limited to an increased detection threshold, but includes other aspects of hearing, such as distortion of sounds, loudness, spatial localization and comprehension of speech. There is evidence that a large variability of pure-tone average (PTA) configuration and threshold is found in elderly subjects, but that it does not always correlate with the performance on speech audiometry. This seems to indicate that, in some instances, the subject has more hearing impairment than the tonal threshold would predict.[19,20] Furthermore, pure-tone audiometry requires a clinical setup which may represent a drawback in large population-based studies. In fact, several studies on large population samples have been performed using a questionnaire.[3–8]