Sensory Impairments and Mortality in an Elderly Community Population: A Six-year Follow-up Study

ILDEBRANDO APPOLLONIO, CORRADO CARABELLESE, EUGENIO MAGNI, LODOVICO FRATTOLA, MARCO TRABUCCHI

Summary
Previous studies have shown that sensory impairments adversely affect the quality of life of elderly people, but have failed to demonstrate consistent results on mortality.

We examined the predictive value of hearing and visual impairments on mortality in an urban population of 1140 non-institutionalized elderly subjects, aged 70–75 years. Baseline information was collected in 1986 through a door-to-door interview with a standardized questionnaire and the sensory assessment was performed using bedside tasks: the whispered voice test for hearing and the Snellen chart for vision.

Overall mortality rate at 6 years was 25.5%, with a significant sex difference (males = 37.5%; females = 19.8%) and a significant interaction between sex and sensory impairment.

Bivariate logistic regression showed that hearing deficit was associated with a significant increase in mortality risk only in the men. This increase remained significant even after control for the demographic variables and the global physical health status.

Multivariate logistic regression showed that the effect of hearing deficit on mortality was mediated by psychosocial parameters (mood and social relationships level).

Sensory assessment through simple bedside tests should become part of the routine clinical evaluation of elderly people.

Introduction
During the last decade, various studies carried out both in the community and in nursing homes have identified a number of predictive factors for mortality of elderly people [1–8]. Factors range from fixed variables such as age, sex, educational and financial levels, to potentially more ‘flexible’, variables such as physical or functional health status, degree of social relationships and psychological well-being [9–18]. It is still not clear if the presence and severity of a functionally relevant hearing or visual loss may have a significant effect on mortality rates in the elderly population.

The incidence of sensory impairment among persons over 65 increases exponentially with age; prevalence estimates may range from 10% to 60%, depending on the population studied and the assessment procedures employed [19, 20].

Numerous cross-sectional studies have already suggested a significant impact of sensory impairment on the global health status and the quality of life of elderly people [21–35] and the results from the cross-sectional phase of our study were consistent with this hypothesis [36].

Few studies have analysed longitudinally the effects of sensory impairment on the quality of life of elderly people, and have shown, in general, that subjects with a sensory impairment are more likely to undergo functional decline [37–41]. Even fewer studies have evaluated the relation between sensory deprivation and life expectancy. The results have been inconsistent, some refuting [40] others supporting [42–44] the hypothesis of a significant association. Only one of these studies [40] has considered both vision and hearing functions.

These considerations prompted us to study the predictive value of hearing and visual deficits on mortality in a large elderly population, using a long follow-up and controlling for several functional and demographic parameters.

Subjects and methods
The first phase of the study was carried out between February and June 1986 on a cohort of people aged 70–75 years and living in the community in the centre of Brescia, northern Italy. Data were collected for 91.5% (n = 1192) of all eligible inhabitants (n = 1303), using a door-to-door method, by ten general practitioners who had been specifically trained.
Table 1. Baseline study variables

<table>
<thead>
<tr>
<th>Demographic Variables</th>
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<tbody>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Education: low (&lt; 5 years); high (&gt; 5 years)</td>
<td></td>
</tr>
<tr>
<td>Living situation: alone; with others</td>
<td></td>
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<tr>
<td>Financial status: good; sufficient; insufficient</td>
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<table>
<thead>
<tr>
<th>Quality of Life Variables</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>Affective domain: modified Beck's Depression Inventory (mBDI) [47]</td>
<td></td>
</tr>
<tr>
<td>Cognitive domain: Mental Status Questionnaire (MSQ) [48]</td>
<td></td>
</tr>
<tr>
<td>Functional domain: Instrumental Activity of Daily Living scale (IADL) [49]</td>
<td></td>
</tr>
<tr>
<td>Social domain: Linn's Self Evaluation of Life Function scale (SELF) [50]</td>
<td></td>
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<tr>
<td>Somatic domain: Physical Health Index (PHI) [51]</td>
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</table>

**Sensory Tests**

- **Visual acuity**
  - Test: An E chart positioned at 4 m [53]
  - Criteria for impairment: < 20/50 (i.e. 25% loss, approximately) [54]

- **Auditory acuity**
  - Test: Free-field whispered voice [55]
  - Criteria for impairment: Inability to repeat correctly three numbers or to achieve greater than 50% success over 3 triplets of numbers [56]

- Due to the functional basis of the assessment, performance was tested on both eyes (or ears) simultaneously; in addition, subjects were tested with their sensory aids, if they usually used them.

The mean (LSD) age and length of education of the sampled population were 72.5 ± 1.4 years and 6.5 ± 4.0 years, respectively. Further details about this phase of the study have already been reported [39, 45-46].

The next phase of the study was carried out in June 1992. With the collaboration of the Government Registry Office, we checked the living status (up to May 1992) of the subjects who had been originally interviewed. The status of 52 subjects could not be ascertained but they had not been statistically different from the studied sample in terms of age, sex, functional and mental status. Thus, a total of 371 men and 769 women were entered into the new database and all the subsequent analyses will relate to these 1140 subjects for whom both baseline and follow-up information was available.

**Questionnaire:** A multidimensional questionnaire was used during the first phase seeking demographic information as well as different aspects of quality of life (Table I) [45, 46]. In a parallel study [52] on the same population, affective and cognitive variables were only loosely associated with mortality, but functional and social domains as well as the physical health index were stronger predictors of mortality. The IADL (instrumental activities of daily living) score proved a more useful index than the ADL (activities of daily living) score because the sample comprised subjects living at home with a low prevalence of physical dependence [52]. Thus, the ADL score was not taken into consideration in the present study.

**Sensory assessment:** A functional approach was chosen for the sensory examination in order to reveal only 'ecologically' relevant impairments [35]. Simple 'bedside' procedures were employed: the whispered voice test for hearing and the Snellen chart for vision (see Table I); both are reliable and of adequate sensitivity [19-20; 57-59]. Further details on the methodological aspects of the sensory assessment can be found elsewhere [39].

Based on performances in the sensory tests, the 1140 subjects were classified into four groups: 1. Subjects with adequate vision (VA) and hearing (HA) (n = 913) (VA-HA); 2. Sensory deprived subjects, i.e. those with associated impairments of vision (VI) and hearing (HI) (n = 18) (VI-HI); 3/4. Subjects with a single, uncorrected, sensory impairment, either vision (n = 111) (VI-HA) or hearing (n = 98) (VA-HI).

**Statistical analysis:** The SPSS statistical package was employed [60]. Comparisons among the groups were computed using m x n contingency tables, \( \chi^2 \) and one-way analysis of variance (ANOVA), followed by post-hoc \( t \) test, when appropriate.

Because the follow-up period of 6 years was the same for all study subjects, and the outcome variable was a dichotomous measure, logistic regression analyses could be used to estimate the multivariate odds ratios of death associated with impaired vision or hearing [61].

The mortality effects associated with each sensory variable were initially quantified as non-corrected odds ratios with confidence intervals. The point estimates were further refined using a logistic regression model adjusting for possible confounders. The iterative maximum likelihood method was employed. Baseline variables that were significant predictors of mortality and the sensory variables which survived the logistic regression were finally entered into a multivariate logistic regression. The stepwise method was adopted in order to identify indicators which were independently related to mortality.

**Results**

The six-year mortality for the whole sample was 25.5% (n = 291). Figures 1 and 2 show the distribution of the different variables related to mortality: among the demographic variables, significance was attained only by sex (\( \chi^2 = 41.2 \)), reflecting the higher mortality rate among men than women. More advanced age was only slightly associated with increased mortality rate, probably because of its narrow range in the cohort of subjects aged 70-75 years.

Most of the psycho-social and health status indices were significantly associated with mortality: global physical health status (\( \chi^2 = 35.1 \)), mood level (\( \chi^2 = 13.3 \)), social relationships (\( \chi^2 = 41.7 \)), cognitive functions (\( \chi^2 = 10.5 \)) and self-sufficiency in IADL (\( \chi^2 = 21.7 \)).

Although there was a lower mortality rate among the subjects without sensory problems (24.3%) compared with those with single sensory deprivation (28.8% for those with a vision deficit and 30.6% for those with a hearing deficit) and with those with double impairment (38.9%), this trend did not reach statistical significance (\( \chi^2 = 4.36 \), \( p = 0.22 \)). There was, however, a significant interaction between sensory deprivation and sex [B = -0.14; \( \text{Exp}(B) = 0.86 \); \( p < 0.01 \)] which prompted us to perform separate
analyses for men and women. As Figure 3 shows neither sensory deficit was associated with a significantly increased risk for mortality among women ($\chi^2 = 4.0$). Odds ratios (and 95% CI) were: VI-HA: 1.22 (0.75-2.18); VA-HI: 0.77 (0.36-1.62); VI-HI: 0.98 (0.97-1.02). In contrast there were significant differences in mortality rate between the four subgroups of men ($\chi^2 = 13.9$, p < 0.01). In particular, VA-HI men had a significantly higher mortality rate than VA-HA men ($\chi^2 = 4.27$, p < 0.05). Odds ratios for single impairments were:

**Figure 1.** Distribution of mortality at 6-year follow-up in the whole elderly population, according to the demographic and physical indices (indicated on the left). The bars represent the mortality rate expressed as a percentage, computed for each subgroup (indicated on the right). *p < 0.05 at the corresponding m x n contingency table. PHS = scale for the physical health status.

**Figure 3.** Mortality rate (expressed as a percentage) at 6-year follow-up in male and female elderly subjects, according to the hearing and visual states. *p < 0.05 at the corresponding m x n contingency table.

VI-HA: 1.66 (0.72-3.85); VA-HI: 1.97 (1.02-3.77). In men with double sensory impairments a further significant increase in mortality rate was present: $\chi^2$ (VA-HI vs. VI-HI) = 3.83, p = 0.05; the corresponding odds ratio was 13.67 (1.67-113.6).

Mortality was not the only variable that differed between the sensory-defined subgroups (Table II); hence, the next step was to examine the association of sensory deficits with mortality rate among the men for possible confounders, using logistic regression.

After adjusting for age, years of schooling, economic status and the global physical health index, the mortality rate remained significantly higher both for men with an auditory impairment [B = 0.695; SE = 0.3433; Exp(B) = 2.0036; p = 0.0430] and for those with a double sensory deficit [B = 2.3778; SE = 1.1025; Exp(B) = 9.7550; p = 0.0388] compared with the VA-HA men. Men with a vision deficit only did not experience an increased mortality rate [B = 0.1936; SE = 0.4590; Exp(B) = 1.2136; p = 0.6732].

Sensory impairment was entered into a multiple logistic regression together with the psycho-social and the functional variables (Table III), in a first model restricted to men with a hearing deficit and in a second model to those with double sensory impairment. In the first model, hearing impairment was no longer independently associated with increased mortality; mood level and social relationships emerged as the only two variables independently predictive of mortality. In the second model, double sensory deficit retained an independent relationship with mortality, even though other factors, such as mood level, played a greater role.

**Discussion**

The results of the present study suggest that the strength of the association between sensory impairment and mortality rate in the elderly population is substantial in men with either a hearing deficit or a
### Table II. Comparison of selected characteristics in the male elderly population in the four sensory-defined subgroups

<table>
<thead>
<tr>
<th>Variable</th>
<th>VA-HA (n = 297)</th>
<th>VI-HA (n = 24)</th>
<th>VA-HI (n = 42)</th>
<th>VI-HI (n = 8)</th>
<th>F stat. (df = 3, 1136)</th>
<th>χ² stat. (df = 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years of schooling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>&lt; 5 years</td>
<td>152 (51.2)</td>
<td>15 (62.5)</td>
<td>21 (50.0)</td>
<td>7 (87.5)</td>
<td>5.20</td>
<td></td>
</tr>
<tr>
<td>&gt; 5 years</td>
<td>145 (48.8)</td>
<td>9 (37.5)</td>
<td>21 (50.0)</td>
<td>1 (12.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Living situation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alone</td>
<td>50 (16.8)</td>
<td>3 (12.5)</td>
<td>10 (23.8)</td>
<td>2 (33.3)</td>
<td>1.97</td>
<td></td>
</tr>
<tr>
<td>With others</td>
<td>249 (83.2)</td>
<td>21 (87.5)</td>
<td>32 (76.2)</td>
<td>6 (66.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Financial status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>76 (25.6)</td>
<td>5 (20.8)</td>
<td>9 (21.4)</td>
<td>0 (0.0)</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>Sufficient</td>
<td>125 (42.1)</td>
<td>8 (33.3)</td>
<td>19 (45.2)</td>
<td>5 (62.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient</td>
<td>96 (32.3)</td>
<td>11 (45.8)</td>
<td>14 (33.3)</td>
<td>3 (37.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical health index</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good (0–5)</td>
<td>202 (68.0)</td>
<td>9 (37.5)</td>
<td>25 (59.5)</td>
<td>2 (25.0)</td>
<td>15.7**</td>
<td></td>
</tr>
<tr>
<td>Borderline (6–10)</td>
<td>77 (25.9)</td>
<td>12 (50.0)</td>
<td>15 (37.7)</td>
<td>5 (62.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor (&gt; 10)</td>
<td>18 (6.1)</td>
<td>3 (12.5)</td>
<td>2 (4.8)</td>
<td>1 (12.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SELF Scale</td>
<td>17.3 ± 0.6</td>
<td>13.1 ± 0.9</td>
<td>14.1 ± 0.9</td>
<td>12.0 ± 0.8</td>
<td>3.76***</td>
<td></td>
</tr>
<tr>
<td>MSQ Scale</td>
<td>0.5 ± 0.9</td>
<td>1.0 ± 0.2</td>
<td>0.4 ± 0.5</td>
<td>1.5 ± 0.1</td>
<td>5.28**</td>
<td></td>
</tr>
<tr>
<td>mBDI Scale</td>
<td>12.8 ± 1.12</td>
<td>18.9 ± 12.2</td>
<td>16.8 ± 13.1</td>
<td>26.1 ± 12.9</td>
<td>6.17***</td>
<td></td>
</tr>
<tr>
<td>IADL Scale</td>
<td>0.1 ± 0.2</td>
<td>0.2 ± 0.4</td>
<td>0.3 ± 0.3</td>
<td>0.3 ± 0.4</td>
<td>6.50***</td>
<td></td>
</tr>
</tbody>
</table>

VA = adequate visual function; HA = adequate hearing function; VI = visual impairment; HI = hearing impairment.
SELF = Self Evaluation of Life Function; MSQ = Mental Status Questionnaire; mBDI = modified Beck's Depression Inventory; IADL = Instrumental Activities of Daily Living.
Financial status was self-rated.
n = number of subjects. Numbers in parentheses are percentages for each subgroup.
*p < 0.05; **p < 0.01; ***p < 0.001 at the F or the χ² test.

Double sensory impairment. Such a result stands even after adjustment for possible confounding factors such as demographic variables and global physical health. In contrast, men with a visual dysfunction and sensorily impaired women were not at increased risk.

These conclusions are limited by the characteristics of the sampled population and by the design study. We studied people aged 70–75 years living at home in an urban setting and with 6 years of follow-up. None the less, the data suggest that sensory impairment might be responsible, at least in part, for the excess mortality observed in the elderly men.

The association of sensory impairment with mortality was sex specific in our study: women were not affected. Previous studies in our elderly population had already suggested that the factors which influenced the

### Table III. Multivariate logistic regression in elderly males with either hearing or double sensory deficit, adjusted for functional variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>Exp(B)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing deficit</td>
<td>4032</td>
<td>3595</td>
<td>1.4966</td>
<td>2621</td>
</tr>
<tr>
<td>Cognitive level</td>
<td>0.0525</td>
<td>0.1556</td>
<td>1.0539</td>
<td>0.7357</td>
</tr>
<tr>
<td>Mood level</td>
<td>0.0293</td>
<td>0.0117</td>
<td>1.0297</td>
<td>0.0122</td>
</tr>
<tr>
<td>Social relationships</td>
<td>-0.0306</td>
<td>0.0156</td>
<td>0.9698</td>
<td>0.0498</td>
</tr>
<tr>
<td>Self-sufficiency</td>
<td>1.1340</td>
<td>0.6193</td>
<td>3.1082</td>
<td>0.0671</td>
</tr>
<tr>
<td>Double sensory deficit</td>
<td>2.1383</td>
<td>1.0984</td>
<td>8.4850</td>
<td>0.0496</td>
</tr>
<tr>
<td>Cognitive level</td>
<td>0.0757</td>
<td>0.1557</td>
<td>1.0786</td>
<td>0.6270</td>
</tr>
<tr>
<td>Mood level</td>
<td>0.0260</td>
<td>0.0122</td>
<td>1.0264</td>
<td>0.0335</td>
</tr>
<tr>
<td>Social relationships</td>
<td>-0.0279</td>
<td>0.0163</td>
<td>0.9724</td>
<td>0.0866</td>
</tr>
<tr>
<td>Self-sufficiency</td>
<td>0.7854</td>
<td>0.6947</td>
<td>2.1934</td>
<td>0.2582</td>
</tr>
</tbody>
</table>
quality of life in men and women were partly overlapping and partly different [45, 46]. The long follow-up necessary for an association of sensory impairment with mortality to emerge might indicate that the effect is indirect, and mediated by other factors. The sensory impairment might influence mortality through an effect on quality of life in mood level, functional status and social relationships which had a major and independent role on mortality rates in our population [49], as well as in some others [4, 5, 9–11]. This hypothesis is in line with the data presented by Laforge et al. [40] who followed a population aged over 65 for one year and used self-evaluation for sensory assessment. The use of objective screening tests both for vision and hearing has been recently strongly advocated [62, 63].

An apparently different conclusion was reached by Thompson et al. [42] who carried out a 5-year follow-up of a population sample aged over 75 and found increased mortality associated with visual deficit. This finding was significant only before adjustment for confounding factors. The authors suggested that the association was mainly non-causal and that both visual impairment and mortality reflected global health status. These authors did not examine hearing and therefore their results were not controlled for possible confounding by hearing deficits.

It is possible that a single sensory loss, and in particular a visual loss, may be offset by increased reliance on other sensory systems [64, 65]. Such compensation might be lost in persons with multiple sensory impairments, as suggested by Laforge et al. [40]. Our results are compatible with this model but we must be cautious in view of the small number of subjects who belonged to this group; in our sample only eight men and no women had impairments of both vision and hearing.

With regard to the differential effect of the two sensory deficits, various explanations can be advanced. First, the two sensory deficits might affect psychosocial variables differently both qualitatively and quantitatively. This possibility is supported by our previous study on the same population [36]. Second, there may be a difference in compensation rates between two sensory deficits in relation to both subjective and objective factors. The former can be based either on individual (psychological) or on social (cultural, attitude and tolerance of the environment) grounds; the latter include the different availability and efficacy of corrective interventions (medical, rehabilitative and surgical options).

In conclusion, our data show that a functionally inadequate sensory performance is, at least in specific subgroups of elderly people, related to a higher mortality rate. They strengthen the cogency of the WHO recommendation for screening sensory functions of elderly people [66]. Such an assessment is often overlooked, both by the patient and health care givers [67, 68], leading to a passive acceptance of the resulting disability [69]. Overcoming such a disability has been shown to have substantial benefits for the quality of life of elderly people [70–74]. The association of sensory impairment with mortality and quality of life deserves further specific study to estimate the value of the sensory examination and of the subsequent corrective intervention for the global health of elderly people.

References

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Received in revised form 3 May 1994