International Journal of Audiology 2003; 42:2 S17–2 S20

Stig Arlinger

Department of Audiology,
University Hospital,
Linköping, Sweden

Negative consequences of uncorrected hearing loss—a review

Abstract

Hearing loss gives rise to a number of disabilities. Problems in recognizing speech, especially in difficult environments, give rise to the largest number of complaints. Other kinds of disabilities may concern the reduced ability to detect, identify and localize sounds quickly and reliably. Such sounds may be warning or alarm signals, as well as music and birds singing. The communicative disability affects both hearing-impaired people and other people in their environment—family members, fellow workers, etc. Hearing-impaired people are not always aware of all the consequences of the impairment; they do not always know what they are missing. Several studies have shown that uncorrected hearing loss gives rise to poorer quality of life, related to isolation, reduced social activity, and a feeling of being excluded, leading to an increased prevalence of symptoms of depression. These findings indicate the importance of early identification of hearing loss and offers of rehabilitative support, where the fitting of hearing aids is usually an important component. Several studies also point to a significant correlation between hearing loss and loss of cognitive functions. Most of these studies show such a correlation without being able to show whether the hearing loss caused the reduction in cognitive performance or if both the hearing loss and the cognitive decline are parts of a common, general age-related degeneration. A couple of these studies, however, indicate that the uncorrected hearing loss may be the cause of cognitive decline. Whichever alternative is true, the correlation should be seen as a clear indication for early hearing aid fitting for those needing it. Monaural hearing aid fitting in subjects with bilateral hearing loss may give rise to a reduced ability to recognize speech presented to the unaided ear, the so-called late-onset auditory deprivation effect. This functional decline is reversible in some but not all subjects after fitting of a hearing aid also on the previously unaided ear.

Key Words

Hearing loss
Speech communication
Quality of life
Depression
Cognitive functions
Auditory deprivation

Disability and handicap

Hearing loss is an often underestimated disturbance of a sensory function. It has been shown to negatively affect physical, cognitive, behavioural and social functions, as well as general quality of life, and is clearly related to depression and dementia. It is estimated that approximately 10% of the population in many Western countries suffer from a hearing loss of a such a degree that it affects ordinary daily life. The prevalence of hearing loss is strongly related to age (Davis, 1995; Rosenhall et al, 1999).

A lesion in the auditory sense organ can give rise to various forms of impairment, most commonly hearing loss, tinnitus, or hyperacusis. In this review, the focus is on hearing loss and the possibilities of overcoming at least some of its effects by means of hearing aids.

The kind of lesion that dominates in the developed countries is the sensorineural lesion, primarily involving the cochlea, with loss of hair cell function. This kind of lesion gives rise to both quantitative and qualitative effects, both attenuation and distortion (Plomp, 1978).

A hearing loss gives rise to disabilities of various kinds, e.g. loss of ability to detect sounds, to recognize speech, especially in adverse conditions, and to localize sound sources. In response to questions about problems in understanding speech in background noise or reverberation, young normal-hearing people typically answer 'rarely' (Cox, 1996), while people with slight-to-moderate hearing loss, on average, answer 'often' (Cox & Alexander, 1995). In order for hearing-impaired people to pick up as much as possible of the acoustical world, they have to concentrate much more than normal-hearing people. The fatigue caused by this extra concentration is an additional component among the consequences of uncorrected hearing loss. The reduced ability to detect sounds may affect sounds such as those of doorbells or telephones, traffic sounds that may signal immediate danger, and sounds of importance for quality of life, such as music or bird song.

Disability may in turn give rise to handicap or, in other terminology, affect the hearing-impaired person's participation in interactions with other people. Increasing difficulties in recognizing the spoken messages of others, having to ask for repetition too often, and still not being sure about having understood correctly, often lead to withdrawal from social activities, rejection of invitations to parties, and no more visits to theatres, cinemas, churches, lectures, etc. This, in turn, leads to reduced intellectual and cultural stimulation, and an increasingly passive and isolated social citizen.

In a German study (Kiessling et al, 1996), a group of 99 subjects of various ages with slight-to-moderate hearing loss were asked to fill in a questionnaire, the Gothenburg Profile, which assesses both disability and handicap caused by the

Stig Arlinger
Department of Audiology,
University Hospital,
S-581 85 Linköping, Sweden
E-mail:

hearing loss. To questions regarding the degree of problems in recognizing speech, the average response was 'half the time'. To questions regarding handicap, focusing on how the hearing loss affects social interactions with other people, or behaviour and reactions in various situations, the average answer was 'now and then'.

In the USA, Ventry & Weinstein (1982) administered a 25-item questionnaire to 100 persons above 65 years of age with varying degrees of hearing loss, from none at all to profound. The questions concerned two categories—emotional consequences of hearing impairment, and problems and reactions related to specific situations. On a scale running from 0 to 100, the subjects with hearing thresholds within normal range scored, on average, 9.9, those with mild hearing loss scored 23.7, those with moderate hearing loss scored 42.7, and those with severe-to-profound hearing loss scored 76.0.

A hearing loss affects communication with other people. Thus, the effects concern not only hearing-impaired people, but also, to a high degree, people around them—family, fellow workers, etc. Also, these people have to put more effort into communication with the hearing-impaired person: they need to speak more slowly and with better articulation, turn their face towards the hearing-impaired person to allow lipreading, and move closer rather than talking from a distance or from a neighbouring room. As a consequence of these increased demands, there is a high risk that people will make less contact with the hearing-impaired person, who will become still more isolated.

Often, the hearing-impaired person is not clearly aware of all the consequences of the hearing loss. This may be due to the slow progress of the loss, which is the typical pattern, as well as to the fact that the hearing-impaired person does not think of the existence of all the sounds that have become inaudible. This is clearly illustrated by the finding often reported by people after having been fitted with their first hearing aids of rediscovering sounds the existence of which they had long since forgotten.

Wellbeing and quality of life

As pointed out above, longstanding uncorrected hearing loss in the elderly often results in withdrawal from a variety of social activities, which in turn may affect quality of life as well as mental health and wellbeing. Reduced auditory and intellectual stimulation may give rise to changes in the central nervous system, and may affect the development of dementia.

The National Council on the Aging in the USA (Seniors Research Group, 1999) organized a study in which 2304 elderly hearing-impaired persons, hearing aid users as well as non-users, answered a questionnaire. In addition, 2090 significant others of hearing-impaired people answered another questionnaire. The results showed that hearing-impaired people who did not use hearing aids more often stated that they felt sad or depressed, were worried, showed paranoid tendencies, took part in less social activity, and experienced more emotional turmoil. Both the affected people and their significant others reported benefits from hearing aid use in terms of better relationships at home, more confidence, and better relationships with others. Family members reported such benefits more often than the hearing-impaired people themselves. The most common reasons for not using hearing aids in this group were that they felt that their hearing was not bad enough or that they got along without one.

Scherer & Frisina (1998) at the Veterans Administration in the USA compared two groups, each with 20 subjects in the age range 60–81 years; one group had normal hearing (average hearing threshold levels at 1, 2 and 4 kHz 11 dB, range 5–16 dB), while the other group had slight-to-moderate hearing loss (average 25 dB, range 13–41 dB). Both groups showed normal cognitive functions. Although the groups were small, the results showed that even a slight hearing loss gives rise to increased problems of speech recognition in noise and reduced feeling of wellbeing.

Cognitive functions

A research group in Berlin, Germany, has reported a series of studies concerning the correlation between changes in sensory function with age and intellectual and cognitive functions. Lindenberger & Baltes (1994) reported on a study of 156 persons in the age range 70–103 years (mean age 85 years). In the age range 70–84 years, the mean hearing loss (five-frequency average 0.5–4 kHz) was 50 dB for the men and 44 dB for the women. In the group above 85 years of age, the corresponding values were 59 dB and 58 dB, respectively. Only about 17% of the subjects had access to hearing aids. In addition to hearing thresholds, visual acuity was tested, and cognitive functions were assessed by a series of tests. Taken together, the results from the visual and auditory tests explained close to half of the total variance and 93% of the age-related variance in the cognitive tests. The authors interpret these results as support for a model in which age-related differences in cognitive functions represent an indirect consequence of age-related differences in vision and hearing. Sensory function is seen as a strong predictor in late life of individual differences in intellectual function. The authors admit, however, that the results may be interpreted as visual and auditory acuity being very sensitive to negative age changes in cognitive functions such as attention and discrimination. Unfortunately, the subgroup that had access to hearing aids was not compared with those who did not.

A later report from the same authors (Lindenberger & Baltes, 1997) presented the results from an extended group of 516 persons in the same age range, with 16% of the subjects using hearing aids. The results here essentially confirmed the results from the previous study: sensory function is significantly correlated with cognitive function in elderly persons. The model that they present suggests that the relationship between age, sensory function and cognitive function implies that age-related differences in cognitive functions are so strongly related to sensory–sensorimotor function (vision, hearing, balance) that age in itself has no significant effect on cognitive functions after control for sensory–sensorimotor function.

A third report from the same group (Baltes & Lindenberger, 1997) concerned 687 subjects over the wider age range from 25 to 103 years by complementing the 516 from the previous study with 171 younger subjects in the age range 25–69 years. None of the younger subjects used hearing aids. The results showed that sensory function was a good predictor of age-related differences in cognitive function, and that the relationship between sensory function and cognitive function increased with age. The authors conclude that the mechanisms behind age-related changes in sensory function are also behind age-related changes in cognitive function. However, their results still do not allow an interpre-

tation in terms of cause and effect, i.e. that reduced sensory function gives rise to reduced cognitive function through sensory deprivation.

An Italian study (Appolonio et al, 1996) involved 1192 subjects in the age range 70–75 years in northern Italy. Both cross-sectional and longitudinal data obtained over a 6-year period were presented. The subjects were divided into three groups according to auditory and visual function. Group A (275 subjects) were considered to have normal auditory and visual acuity, while group B (673 subjects) had reduced visual and/or auditory acuity with access to correction by glasses and/or hearing aids. The third group C (244 subjects) had reduced visual and/or auditory acuity without access to any correction. Of these, 20 were affected in both vision and hearing, 106 had hearing loss but normal vision, and 118 had normal hearing but reduced visual acuity. Socio-economic status, quality of life and cognitive functions were assessed by means of questionnaires. Health state was assessed in terms of use of medical care, and mortality was recorded during the 6-year study period. The statistical analysis showed significant differences between the groups. Group C showed significantly poorer outcome than groups A and B in quality of life and cognitive function. When controlling for differences in socio-economic factors, significant differences remained in quality of life between groups B and C and between groups A and B. The analysis of mortality during the 6-year period showed a significantly higher mortality rate among men in group C than among men in group A and group B after correction for differences in socio-economic status and general state of health. No differences were found for women. The conclusion drawn by the authors is that poor health as such cannot alone explain the differences in mortality between the men in the three groups in the study, but that auditory and visual function play an indirect role through their effects on general physical health and on social relations. They consider the results as strongly supporting the need to check visual and auditory functions among the elderly, and to encourage them to use sensory aids when these functions are reduced.

Cacciatore et al (1999) studied 1332 persons older than 65 years (mean age 74 years) in southern Italy. They assessed hearing loss, cognitive function, depression and quality of life by means of questionnaires. Hearing loss was reported by 27% of the subjects. Use of hearing aids was recorded. A strong correlation was found between hearing loss and reduced cognitive function, independent of age and educational level. Also, the correlation between hearing loss and depression was statistically significant. Use of hearing aids reduced the symptoms of depression. Greater hearing loss was associated with reduced quality of life. The conclusion drawn by the authors is that the use of hearing aids may have a protective effect against reduced cognitive function and provide better quality of life for elderly people.

Similarly, a Japanese study has shown a significant correlation between hearing loss, cognitive function and depression, based on 747 subjects in the age range 65–98 years (Naramura et al, 1999). The authors could not draw any conclusions about cause and effect, however, but suggested that regular checks of hearing for early detection of hearing loss may contribute to the preservation of good quality of life among the elderly.

Uhlmann et al (1989), in the USA, investigated a group of 100 elderly (above 65 years) subjects with dementia, and a control group of equal size, matched for age, gender, and educational level. Hearing acuity was measured (0.5–3 kHz), and cognitive function and depression were assessed by means of validated questionnaires. Hearing aids were used by 17 subjects in the dementia group and 13 in the control group. Hearing loss was significantly more common in the test group than in the control group. The probability of dementia was significantly higher in a subgroup where hearing loss exceeded 40 dB. The degree of hearing loss showed a significant correlation with reduced cognitive function in both the test group and the control group. This significant correlation remained after control for differences in age, level of education, gender, medication, and depression. The authors concluded that their results support the hypothesis of hearing loss contributing to reduced cognitive function in the elderly. This, in turn, may increase the symptoms of dementia and result in reduced functionality. Correcting the hearing loss by the use of hearing aids cannot be expected to prevent dementia, but may reduce the consequences of the disease.

A common finding among the reports reviewed above is a significant correlation between hearing loss and reduced cognitive function. This makes a study from The Netherlands interesting (Smits et al, 1999); this showed cognitive function to be significantly correlated with the probability of surviving a 5-year period in a group of 2380 subjects, randomly selected in the age range 55–85 years. Speed of information processing was the specific cognitive function that showed the strongest correlation with mortality. The authors assume a general biological decline to be the most likely hypothesis to explain the predictive ability of the cognitive functions.

Mulrow et al (1990) reported on a study concerning 188 elderly persons with hearing loss, in which half of the subjects were randomly selected for hearing aid fitting, and the other half were placed on a waiting list for hearing aids. The groups were comparable with regard to demographic and clinical variables and degree of hearing loss. Quality of life, depression and cognitive functions were assessed initially, as well as after 6 weeks and 4 months. Changes over the 4-month period differed significantly between the two groups. The hearing aid group reported significant improvements in social, emotional and communicative functions, as well as in cognitive function and depression. Also, assessment by significant others regarding social and communicative function agreed with this.

A later report (Mulrow et al, 1992) concerned 192 elderly (mean age 72 years) hearing-impaired people over a period of 12 months after the fitting of hearing aids. Using standardized questionnaires for quality of life, depression and cognitive function, they found a significantly improved quality of life and reduced degree of depression; this effect was stable over the observation period. Cognitive functions showed only small changes, which returned to baseline after 12 months; however, only two of the subjects showed significantly reduced cognitive function.

Late-onset auditory deprivation

A special aspect of untreated hearing loss concerns the auditory deprivation effect, which may occur in people with bilateral, essentially symmetrical, hearing loss with only monaural hearing aid fitting (Arlinger et al, 1996). The effect appears as a reduced ability to recognize speech presented to the ear that has not been

fitted with a hearing aid and which has therefore been exposed to significantly less auditory input than the aided ear for a long time; both ears show essentially identical unchanged pure-tone hearing thresholds. The first report came from the USA (Silman et al, 1984). The effect typically appears after one or a few years of monaural hearing aid use, and has been shown in both children and adults (Gelfand & Silman, 1993; Hattori, 1993). After changing to binaural hearing aid fitting, the effect may disappear completely or partially, but in some cases the effect may remain despite this. A follow-up study reported on six adult patients showing the effect but with rather different recovery patterns after they started using binaural fittings for at least 8 h/day (Gelfand, 1995). Two of the cases showed complete recovery after 1 year of binaural use. Two other cases showed partial recovery with remaining asymmetry even after 2 and 5 years of binaural use, respectively. The two remaining cases showed no recovery even after 5 or 6 years of reported binaural hearing aid use. No obvious factors could predict the different recovery patterns. None of the studies reported on binaural speech recognition in sound fields, and thus it is not known whether the effect also involves reduced ability to make use of binaural integration.

Conclusions

Uncorrected hearing loss represents an auditory disability involving reduced speech recognition ability, especially in difficult environments, and reduced ability to detect, identify and localize sounds. This affects the lives of both the hearing-impaired person and significant others. The hearing-impaired person is not always aware of all the consequences.

Uncorrected hearing loss gives rise to a poorer quality of life, related to isolation, reduced social activity, a feeling of being excluded, and increased symptoms of depression. There is a significant correlation between uncorrected hearing loss and reduced cognitive functions. There is no clear proof that hearing loss is the cause of the reduced cognitive function, but indirect evidence from some studies supports this hypothesis. If the hearing loss is indeed a cause of cognitive decline, this is a very strong argument for early detection of hearing loss and fitting of hearing aids. However, hearing loss and cognitive decline having a common cause is also a good reason for early detection and fitting of hearing aids: The cognitive decline will exacerbate the consequences of missed information due to the hearing loss. The more auditory information that is available, the easier it will be for the impaired cognitive system to process it successfully.

Monaural hearing aid fitting in subjects with bilateral hearing loss may give rise to a late-onset auditory deprivation effect, appearing as a reduced ability to recognize speech presented to the ear that has been deprived of significant auditory stimulation. The effect may or may not be reversible. This is considered a strong argument for bilateral fitting being the standard procedure in hearing aid dispensing (Arlinger et al, 1996).

References

Appolonio, I., Carabellese, C., Frattola, L. & Trabucchi, M. 1996. Effects of sensory aids on the quality of life and mortality of elderly people: a multivariate analysis. *Age Aging*, 25, 89–96.

Arlinger, S., Gatehouse, S., Bentler, R.A., Byrne, D., Cox, R.M., et al. 1996. Report of the Eriksholm Workshop on auditory deprivation and acclimatization. *Ear Hear*, 17, 87S–98S.

Baltes, P.B. & Lindenberger, U. 1997. Emergence of a powerful connection between sensory and cognitive functions across adult life span: a new window to the study of cognitive aging? *Psychology and Aging* 1997; 12:12–21.

Cacciatore, F., Napoli, C., Abete, P., Marciano, E., Triassi, M., et al. 1999. Quality of life determinants and hearing function in an elderly population: Osservatorio Geriatrico Campano Study Group. *Gerontology*, 45, 323–328.

Cox, R.M. 1996. *The Abbreviated Profile of Hearing Aid Benefit (APHAB)—Administration and Application*. Phonak Focus No. 21. Stäfa: Phonak.

Cox, R.M. & Alexander, G.C. 1995. The Abbreviated Profile of Hearing Aid Benefit. *Ear Hear*, 16, 176–186.

Davis, A. 1995. *Hearing in Adults*. London: Whurr Publishers.

Gelfand, S.A. 1995. Long-term recovery and no recovery from the auditory deprivation effect with binaural amplification: six cases. *J Am Acad Audiol*, 6, 141–149.

Gelfand, S.A. & Silman, S. 1993. Apparent auditory deprivation in children: implications of monaural versus binaural hearing. *J Am Acad Audiol*, 4, 313–318.

Hattori, H. 1993. Ear dominance for nonsense-syllable recognition ability in sensorineural hearing-impaired children: monaural versus binaural amplification. *J Am Acad Audiol*, 4, 319–330.

Kiessling, J., Bachmann, J. & Margolf-Hacki, S. 1996. Computerunterstützte Erfassung der Subjektiv empfundenen Hörstörung und des daraus resultierenden Handicaps mit Hilfe von Frageninventaren. *Audiologische Akustik*, 35, 110–123.

Lindenberger, U. & Baltes, P.B. 1994. Sensory functioning and intelligence in old age: a strong connection. *Psychology Aging*, 9, 339–355.

Lindenberger, U. & Baltes, P.B. 1997. Intellectual functioning in old and very old age: cross-sectional results from the Berlin aging study. *Psychology Aging*, 12, 410–432.

Mulrow, C.D., Aguilar, C., Endicott, J.E., Tuley, M.R., Velez, R., et al. 1990. Quality-of-life changes and hearing impairment. *Ann Intern Med*, 113, 188–194.

Mulrow, C.D., Tuley, M.R. & Aguilar, C. 1992. Sustained benefits of hearing aids. *J Speech Hear Res*, 35, 1402–1405.

Naramura, H., Nakanishi, N., Tatara, K., Ishiyama, M., Shiraishi, H., et al. 1999. Physical and mental correlates of hearing impairment in the elderly in Japan. *Audiology*, 38, 24–29.

Plomp, R. 1978. Auditory handicap of hearing impairment and the limited benefit of hearing aids. *J Acoust Soc Am*, 63, 533–549.

Rosenhall, U., Jönsson, R. & Söderlind, O. 1999. Self-assessed hearing problems in Sweden: a demographic study. *Audiology*, 38, 328–334.

Scherer, M.J. & Frisina, R. 1998. Characteristics associated with marginal hearing loss and subjective well-being among a sample of older adults. *J Rehab Res Dev*, 35, 420–426.

Seniors Research Group. 1999. *The Consequences of Untreated Hearing Loss in Older Persons*. Washington, DC: The National Council on the Aging.

Silman, S., Gelfand, S.A. & Silverman, C.A. 1984. Late-onset auditory deprivation: effects of monaural versus binaural hearing aids. *J Acoust Soc Am*, 76, 1357–1362.

Smits, C.H.M., Deeg, D.J.H., Kriegsman, D.M.W. & Schmand, B. 1999. Cognitive functioning and health as determinants of mortality in an older population. *Am J Epidemiol*, 150, 978–986.

Uhlmann, R.F., Larson, E.B., Rees, T.S., Koepsell, T.D. & Duckert, L.G. 1989. Relationship of hearing impairment to dementia and cognitive dysfunction in older adults. *JAMA*, 261, 1916–1919.

Ventry, I.M. & Weinstein, B.E. 1982. The Hearing Handicap Inventory for the Elderly: a new tool. *Ear Hear*, 3, 128–134.