

# 4 The epidemiology of hearing and balance disorders

Adrian Davis, Padma Moorjani

## Scope

Epidemiology is defined as ‘the study of how often diseases occur in different groups of people and why’. The epidemiology of hearing and balance disorders is important for at least three reasons: (1) it shows the scale of need in terms of the prevalence of hearing impairment, disability and handicap; (2) it shows those factors that are responsible for the deterioration of hearing and balance; and (3) it shows how effective hearing services (health and other public services) are at meeting the need. In the current healthcare system, both purchasers and providers need to use epidemiological studies in order to provide optimal services to the current client groups, and to forecast the trends in distribution in order to plan future provision.

The major aim of this chapter is to show that hearing disorders constitute a major disability and handicap, and have been under-reported, underestimated in terms of their burden on society, and traditionally under-supplied with appropriate health services to ameliorate that burden through improving quality of life. This will be discussed first for the adult population and then for children.

## Introduction

Deafness is the most frequent sensory impairment in humans, with significant social and psychological implications. It is estimated that approximately 20% of those over 18 suffer from some form of hearing impairment,<sup>1</sup> and about 840 children per year are born in the UK with a significant permanent hearing impairment likely to affect their own and their family’s quality of life. There are three major disorders that arise from auditory- or labyrinthine-based pathology: hearing impairment, tinnitus, and, to a lesser extent, vestibular dysfunction. While the first of these has been documented by some systematic

population studies<sup>1-4</sup> and also by investigation of the elderly in nursing-home or residential settings,<sup>5-8</sup> tinnitus has been relatively under-documented,<sup>9</sup> and vestibular dysfunction rarely documented.<sup>10</sup> The consequence of our lack of knowledge concerning the extent of those who could benefit from rehabilitation for their disorder is a lack of prioritization of services for these people at a primary and secondary level of healthcare. Hearing impairment and tinnitus are not visible to society, and their effects are therefore under-recognized. However, the effects are there and suffered by those relatives and carers who try to communicate with the hearing-impaired or tinnitus sufferer on a regular basis. In addition to this chronic breakdown in communication facility, when there is an exacerbation of the disorders by an accompanied vestibular dysfunction or lack of orientation, the effects may indirectly manifest in a greater number of accidents requiring emergency treatment or surgery and hospitalization.<sup>11</sup> The impact of hearing impairment in children and their families is also considerable and wide-ranging, and changes over time through its impact on the child’s development. The greatest impact of hearing impairment on the child is on the acquisition of language and development of communication, which in turn can lead to poor literacy skills.<sup>12</sup>

The data that are presented are taken from studies that the MRC Institute of Hearing Research has undertaken.<sup>1,2,13-16</sup> The studies that are reported here have been informed by investigations done at other centres and these will be referred to.

## Terminology, definitions and methodology

The terminology and definitions used here are taken from the Audiological, Epidemiological and Genetic Definitions agreed

## 34 Basic science

by the European Union study group on the genetics of hearing impairment.<sup>17</sup> There is a major conceptual distinction between the prevalence of hearing disorders and the incidence of hearing disorders. This requires emphasis. The prevalence of hearing impairment is the total number of instances of a specified degree and type of hearing impairment, e.g. an average air conduction hearing threshold in the better ear (over the frequencies 0.5, 1, 2 and 4 kHz) that is equal to or greater than 25 dBHL, in a given population at a specific time. Prevalence is often used to denote prevalence rate, i.e. the percentage (or proportion) of the given population who have the defined characteristic. On the other hand, the incidence of the defined degree of hearing impairment is the number of new cases of the defined condition occurring in the given population (it is not the number of new cases consulting), per unit time period, e.g. a year. Too often, the term incidence is used when prevalence is meant!

A second emphasis here is the need for population studies of hearing disorders. A population study is the study of a whole collection of units from which a sample may be drawn. Usually, the population is a collection of individual people, but it could also be households, hearing aid clinics or hospitals. For instance, if we study a random sample of 1000 adults taken from the populations of adults aged 70–80 years, and we determine that 603 of this sample reach our criterion for hearing impairment (e.g. as stated above), then the prevalence (or prevalence rate) would be 60.3%. We would try to quantify the accuracy of that prevalence rate by calculating the confidence interval<sup>18</sup> for the given sample. For the sample used in Davis,<sup>1</sup> the 95% confidence interval for the estimated prevalence rate of 60.3% was 52.9–67.3%, using a stratified random sample of 272 people aged 71–80. This means that in 100 replications of the work conducted on this population, with the same sample size and sampling method, we would expect 95 of the replications to have a prevalence estimate falling in the range 52.9–67.3%.

It is useful to distinguish between the concepts of pathology, impairment, disability and handicap.<sup>19–21</sup> Pathology should be considered to be an abnormality of structure, e.g. the middle ear, the cochlea, or the stria vascularis. An impairment is a defect or abnormality of function of the auditory system which is normally measured by psychoacoustical or physiological function, e.g. pure tone hearing threshold, otoacoustical emission, or brainstem response threshold to clicks. Disability is often a consequence of impairment and is the problem(s) that a person experiences and/or reports in basic tasks, e.g. difficulty communicating in a noisy environment, or knowing who is speaking in a group conversation. Handicap arises from the disadvantage resulting from an impairment or disability that limits or even prevents a person from fulfilling a 'normal' role for that person, e.g. social isolation, or extra effort in communicating. An indicator of handicap may be obtained by using a questionnaire to measure an individual's quality of life.

In talking and writing about hearing disorders it is often useful to distinguish between two types of hearing impairment,

sensorineural and conductive. The majority of permanent impairments are sensorineural, i.e. they are related to disease/deformity of the cochlea or cochlear nerve. In these individuals, there is no 'air–bone gap' (over the average thresholds for the frequencies 0.5, 1 and 2 kHz). It is suggested that if the difference between the air conduction and the bone conduction average thresholds is less than 15 dB, and the average hearing impairment on the ear is 25 dBHL or greater (over the frequencies 0.5, 1, 2 and 4 kHz), then an individual can be presumed to have a sensorineural pathology, whereas if the air–bone gap is 15 dB or greater, the individual has a significant conductive pathology contributing to the impairment. This is a working definition rather than a prescriptive one, because the extent to which the middle ear might be involved in any impairment depends on a number of factors, of which the air–bone gap is only one. Of course, the pathology is important, because conductive impairments may be more amenable to surgical intervention to ameliorate the pathology and reduce the impairment. On the other hand, sensorineural impairments of a mild-to-severe type are not amenable to surgical intervention, and the intervention of choice is rehabilitation centred around the use of a personal hearing aid, which aims to reduce the disability (and hopefully handicap) and increase the quality of life. Profound or total hearing impairment may be amenable to intervention using cochlear implants.<sup>22</sup>

In considering healthcare provision (e.g. interventions through which patients or their families benefit) as well as the concepts given above, there is a need to distinguish three further concepts, those of need, demand for services and supply of services. Furthermore, we should not accept that everyone who demands a service actually needs it, or that all services that are provided actually benefit those in need!<sup>10</sup> A pragmatic definition of need<sup>23</sup> used here is the ability of groups in the population to benefit from intervention (usually health, social or educational). Thus those with a substantial conductive impairment may have a need for surgery to improve the middle ear's conduction of sound, those with annoying tinnitus may have a need for tinnitus counselling, those with a sensorineural hearing impairment may have a need for rehabilitative training using a personal hearing aid, and the whole population may have a need to be screened around birth for sensorineural hearing impairment; the list could be extended very easily. Providers of healthcare have to enter into dialogue with society (usually through those who purchase health care) to decide the priority given to the hearing health care needs of the population. The major input into these priority decisions should be the epidemiology (i.e. distribution and determinants) of hearing disorders, which will be modified by the national and local realities, such as the configuration of present services and the cost-effectiveness of the different services provided. The rest of this chapter concentrates on the general epidemiological data.<sup>1,16</sup>

## Prevalence of hearing disorders in adults

Figure 4.1 shows the broad extent of hearing impairment and reported hearing disability in the adult population (aged 18 and over) in the UK. From this, we see that almost one in three of UK adults has at least a mild hearing impairment in one ear, with one in five showing a bilateral hearing impairment. One in four people report that they have great difficulty hearing what is said in a background of noise, with 1 in 10 reporting that they have prolonged spontaneous tinnitus.<sup>24</sup> At a moderate degree of hearing impairment, in the better ear, about 7% of the adult population are impaired.<sup>1</sup> This represents a substantial number of people in the UK who may have a need for some associated services, i.e. who may benefit from the provision of hearing services. Supplying those services is a substantial public health problem, serious enough to warrant considerable debate. This is discussed by several authors,<sup>25–27</sup> and revolves around the criteria for whether the population could benefit from intervention and the criteria by which any benefit is cost-effective. Obviously, hearing disability and handicap are the major targets of rehabilitation, both present and future. However, the extent of hearing impairment is the best predictor of need that can be assessed quantitatively. Both aspects will be presented in this chapter. Some authors<sup>26,27</sup> think that the low threshold for provision of a hearing aid should be set at about 25 dB HL, in the better ear, measured as an average over the frequencies 0.5, 1, 2 and 4 kHz. Other authors<sup>25</sup> consider more complex schemes, and higher thresholds, but the differences are actually quite small operationally and relate mainly to the degree of impairment in the better ear.

Using the lower threshold definition, the prevalence in the adult population (age 18 and over) of a hearing impairment in

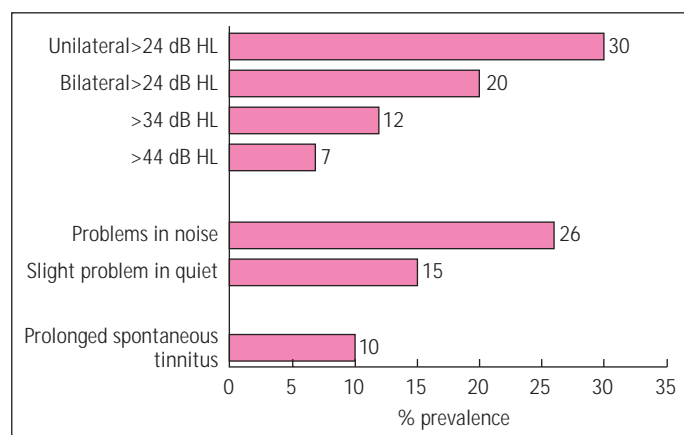


Figure 4.1 The prevalence of hearing impairment at different degrees of severity of hearing disability as shown by finding it 'very difficult' to hear what someone says if there is a background of noise and also by having at least a slight difficulty hearing in quiet. The prevalence of tinnitus that is not only after loud sounds and which lasts for 5 min or more (PST, prolonged spontaneous tinnitus) is also shown.

the better ear of 25 dB HL or greater is 20%. Taking more severe criteria, 12% and 7% are the prevalences for impairments of 35 dB HL or greater and 45 dB HL or greater. The pattern of hearing impairment does change with age,<sup>10</sup> with the higher frequencies being more susceptible to ageing (and noise).

Figure 4.2 shows the prevalence of hearing impairment as a function of age group (see Davis<sup>1</sup> for the confidence intervals and a more detailed description). The data are derived from the National Study of Hearing in the 18–80 age group and from a number of studies for the over 80s.<sup>26,28,29</sup> These do not disagree too much with the estimates made by Soucek and Michaels<sup>30</sup> and by Tolson et al.<sup>8</sup> The estimates up to the 71–80 age group are reasonably accurate in terms of their relatively bias-free derivation. Those for the over-80s have been derived from 862 people using a variety of testing procedures, and are thus more open to criticism. Gatehouse and Davis<sup>31</sup> suggest that at least some of the prevalence in the elderly may be due to central response-based processes rather than peripheral perceptual processing (i.e. it takes a stronger signal for an elderly person to give a response). For public health purposes, this makes very little difference until differential rehabilitation is considered. In any case, it is unlikely that a response bias would make over 10 dB of difference to the hearing thresholds in the over-80s.

The major effects on the prevalence of hearing impairment are shown in Davis.<sup>2</sup> By far the most important was age group, with occupational group and occupational noise exposure having major effects throughout the severity range. In terms of gender, at mild–moderate impairments, men have a higher prevalence at 25 dB HL (odds ratio 1.4:1). The effect of age group, as seen in Figure 4.2, is very large and dominates any other factor. Thus, almost one in five people aged 51–60 have a hearing impairment in the better ear, and one in five of the over-80s has a severe hearing impairment which will render speech almost inaudible without amplification. At least 80% of the over-80s would benefit from a hearing aid, if they could use one, and 40% of the population aged 71–80 would benefit likewise. The problem of hearing impairment in the elderly is thus

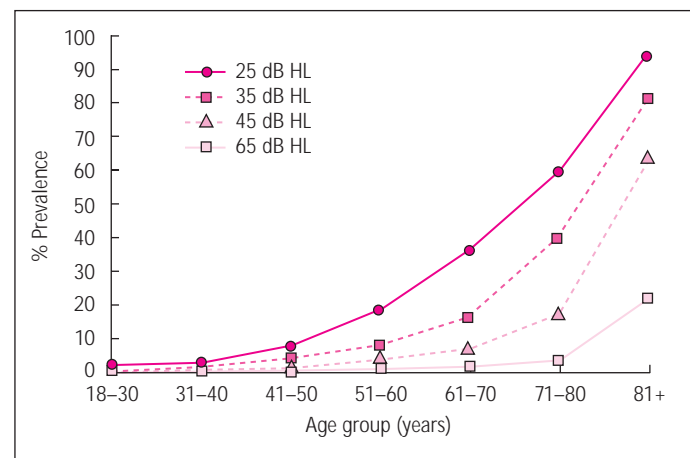


Figure 4.2 The prevalence (%) of different degrees of hearing impairment as a function of age in the Great Britain population.

## 36 Basic science

a major issue in terms of the numbers of people involved. The UK National Study of Disability estimated that hearing disability was the third most prevalent disability, and the figures from the National Study of Hearing show that it is in fact the most prevalent disability in the aged (see Davis<sup>2</sup> for a discussion of this difference) and should be given a greater priority than at present. While there is no doubt that hearing impairment and disability are major chronic problems for the population at present,<sup>1</sup> with probably 8.759 million people in the UK with a hearing impairment as described above, the situation may deteriorate due to demographic changes in the population.<sup>10,32</sup> Figure 4.3 shows an extract of the predictions for the number of people with hearing impairment in the UK, USA, developed countries and developing countries in 1995 and 2015.

Figure 4.3 is derived from the National Study of Hearing in Great Britain by convolving the age and sex distribution of different countries (in 5-year bands) with the prevalence of hearing impairment. The increase seen in the overall prevalence is therefore due to the structure of the population alone and assumes no change in aetiology or risk factors over the time period. However, as most of the people who will be contribut-

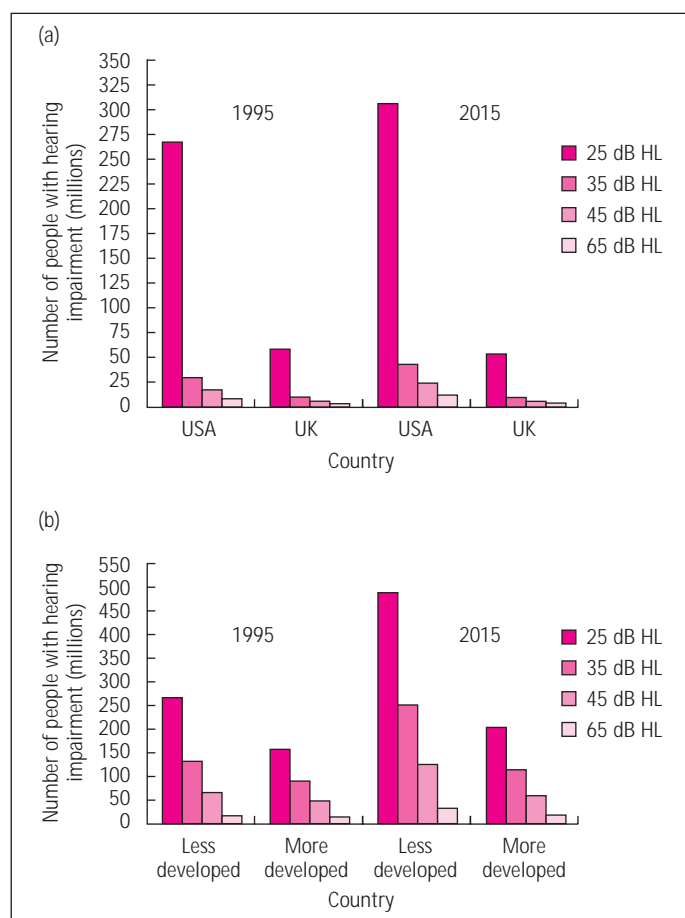


Figure 4.3 Predictions for the number of people with hearing impairment as a function of country and severity of hearing impairment using the 1994 revision of the UN projected world populations in 1995 and 2015. (a) USA and UK; (b) Less and more developed countries.

ing to the statistics are already in middle age, they have had their most dangerous time for noxious exposure. There will probably be a more rapid growth in those with hearing problems in the less developed countries as life-expectancy increases over the next 20 years. However, it is noticeable that the proportion of people who have hearing problems is greater in the more developed countries, where life-expectancy is already high. Another key factor for health/hearing services planning is that the expected number of hearing-impaired people in the UK will rise by over 20% in the next 20 years. Using the data for Great Britain, of 8.580 million hearing-impaired people in 1994, 2.131 million were aged 18–60, 4.486 million were aged 61–80 years and 1.963 million were aged over 80. At  $\geq 45$  dB HL, there were 0.471 million, 1.132 million and 1.337 million, and at  $\geq 65$  dB HL, there were 0.136 million, 0.294 million and 0.469 million respectively for the 18–60, 61–80 and over-80 age groups.<sup>1</sup> Thus, as the severity criterion increases, there is a larger proportion of the very elderly in the hearing-impaired group. Figure 4.4 shows the prevalence of reported hearing disability in the population<sup>1</sup> in the 1980s. The question 'How well

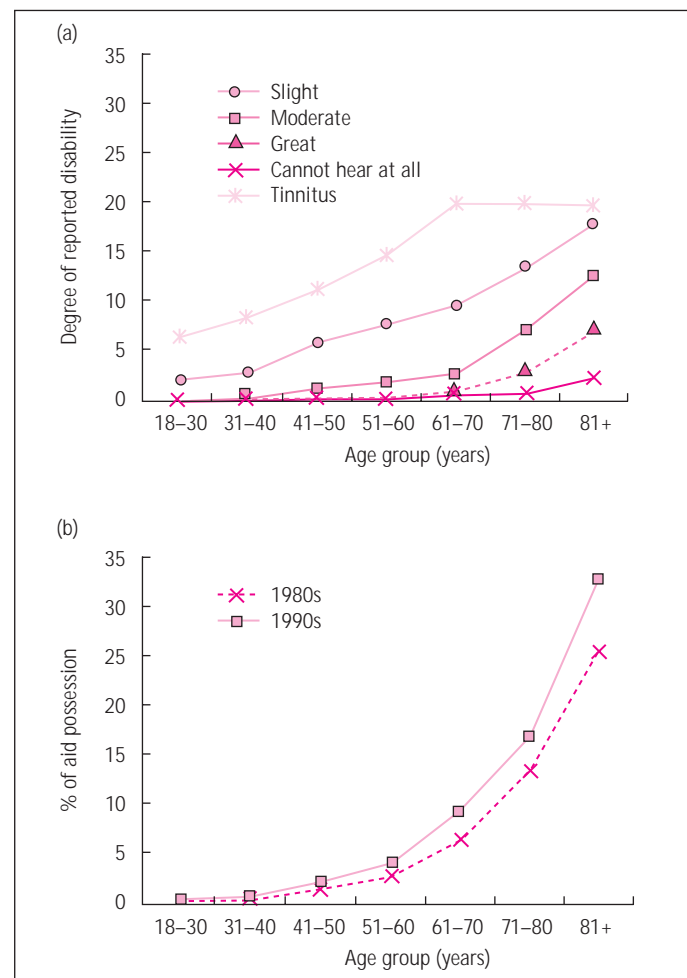


Figure 4.4 Prevalence (%) of different degrees of (a) reported hearing disability, tinnitus and (b) hearing aid possession as a function of age in the Great Britain population.

can you hear someone talking to you when that person is sitting on your left/right hand side in a quiet room' was used, with responses 'No, slight, moderate and great difficulty' and an option for 'Cannot hear at all'. A response of slight difficulty in an ear relates to a median hearing impairment of 35 dB HL, moderate and worse to 50 dB HL, and great and worse to 75 dB HL (averaged over 0.5, 1, 2 and 4 kHz). Figure 4.4 shows that, at all degrees of reported hearing disability, there is an increase with age. Thus, at 61–70 years, about 15% report some difficulty with the better ear, about 25% at 71–80, and 40% for the over-80s. Comparing the reported hearing disability with the measured hearing impairment, it is noticeable that far fewer people have a reported better-ear hearing disability compared to a measured hearing impairment. Furthermore, the ratio of reported problem to measured impairment is not constant across age, showing fair correspondence up to 50 years and then progressive discrepancies. Thus older people are far less likely to report a hearing disability for a given level of hearing impairment. However, it could be argued that they are less likely to benefit from rehabilitation unless they recognize that problem.

Figure 4.4 also reports the prevalence of tinnitus that lasts for 5 min or more and not only after loud sounds, adjusted for the proportion of the sample who did not complete all three parts of the question (this was particularly so in the elderly). It is noticeable that the prevalence of tinnitus increases with age until 60 years, when it reaches a peak of one in five people. The factors that influence tinnitus report are systematically explored in Davis et al.<sup>26</sup> Davis and Roberts<sup>11</sup> explore the quality of life implications for those with prolonged spontaneous tinnitus and/or a reported hearing disability. They examined the scores on the SF-36 and showed that both reported hearing disability and tinnitus affect the scores on the SF-36 in a differential way, with severe tinnitus giving the largest deficits, particularly in terms of vitality, social function and mental health. Using the 1990s sample, the largest effect of reported hearing disability was concerned with the social function score (Figure 4.5).

The terms 'hearing difficulty' and 'disability/handicap' were obtained from the subject and situation specific hearing questionnaire devised by Gatehouse<sup>31</sup> and the factor effect shown

here is for a shift in 10% of the scores on this questionnaire that only uses items that are relevant to individual patients/hearing aid users. Figure 4.5 shows that the effect of a slight reported hearing disability is a deficit in 6 points of the social function score (range 0–100%), and that a moderate reported disability gives a deficit of 14% with about 30 points for a great disability (using the question in Figure 4.4). However, those who use their hearing aids most or all of the time do get this deficit from the hearing disability offset by up to 12%. Those who only use the hearing aid some of the time do not get a significant benefit. This may be for a number of reasons including the fact that there needs to be a reasonable amount of time to adapt to the input from the aid (cognitive plasticity). Also there were significant beneficial effects of 'using a hearing aid most or all of the time' for body pain and mental health scores.

## Vestibular dysfunction

Not a great deal is known about the epidemiology of vestibular dysfunction, in terms of balance or dizziness. A recent UK survey (personal communication) of the prevalence of ear, nose and throat (ENT) symptoms was conducted in 1998 as the first strand of the Health Technology Assessment Project, entitled 'Acceptability, Benefit & Costs of Early Screening for Hearing Disability', the broad aim of which is to investigate screening of people aged 55–74 in order to predict the potential ability to benefit from a hearing aid. A postal questionnaire was sent to 26 100 randomly selected households in targeted areas of England, Scotland and Wales. Everybody over the age of 14 was asked to give details of the occurrence of hearing, balance, throat and nose problems and the disabling effects of these problems. Questionnaires were returned from 34 362 individuals (a response rate of 60.5%). Three questions were asked about the experience of vestibular problems: attacks of dizziness in which things seem to spin around you; unsteadiness, light-headedness or feeling faint; and attacks of dizziness in which you seem to move.

Overall, 22.2% of responders reported attacks of dizziness

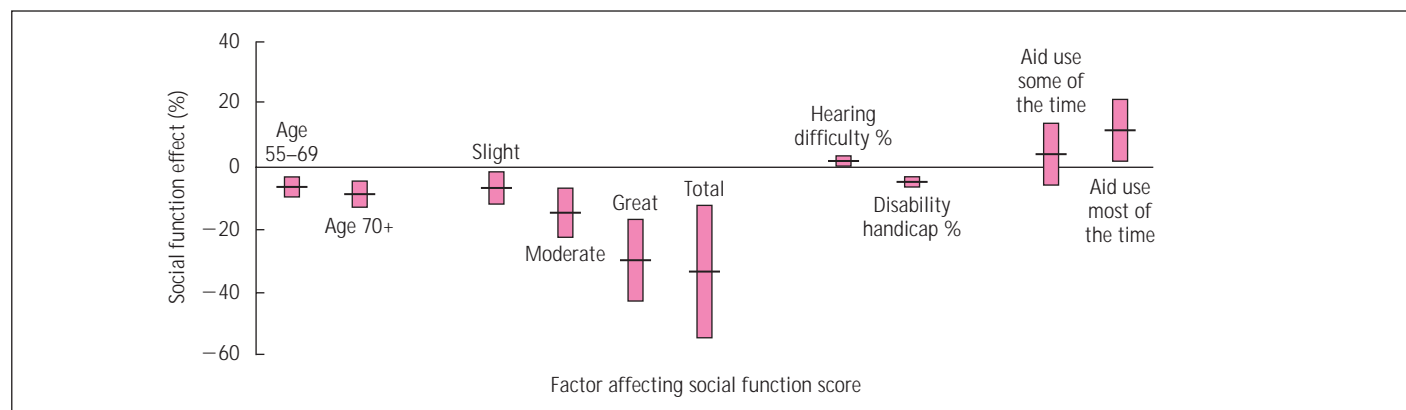


Figure 4.5 The effect (with confidence interval) of age, hearing disability, difficulty handicap and hearing aid use on the social function score of the SF-36 using a general linear model to estimate the effects.

## 38 Basic science

**Table 4.1** The prevalence of self-reported dizziness as a function of age ( $n = 31\ 085$ ), gender ( $n = 31\ 643$ ) and occupational group ( $n = 31\ 409$ ): attacks of dizziness in which things spin around you.

Age group (years)	Prevalence (%)	Gender/ Occupational group	Prevalence (%)
14–30	17.6	Male	16.4
31–40	19.9	Female	27.7
41–50	23.1		
51–60	24.8		
61–70	25.4	Non-manual	21.7
71–80	27.2	Manual	20.4
81+	32.2	Other*	24.4

\* Other = housewife/student/unemployed.

**Table 4.3** The prevalence of self-reported dizziness as a function of age ( $n = 30\ 944$ ), gender ( $n = 31\ 492$ ) and occupational group ( $n = 31\ 266$ ): attacks of dizziness in which you seem to move.

Age group (years)	Prevalence (%)	Gender/ Occupational group	Prevalence (%)
14–30	12.3	Male	11.1
31–40	14.7	Female	18.5
41–50	16.0		
51–60	15.9	Non-manual	14.0
61–70	15.9	Manual	14.4
71–80	15.6	Other	16.3
81+	20.4		

in which things spun around them (and 6.9% of responders reported symptoms within the last year) (Table 4.1); 30.2% reported unsteadiness, lightheadedness or feeling faint (6.7% reported experiencing symptoms in the last year) (Table 4.2); and 14.8% of people who responded reported attacks of dizziness in which they seemed to move (3.3% of responders reported symptoms within the last year) (Table 4.3).

The prevalence of all three vestibular problems increased with age, and women reported more symptoms than men.

People were also asked whether they had been to their general practitioner (GP) or had been referred to a hospital about any vestibular problems. Consultations for balance and dizziness increased with age, particularly for respondents aged 81 and over visiting their GP about dizziness problems. The general consultation pattern for vestibular problems by reported hearing difficulty was an increase with worsening hearing in the

**Table 4.2** The prevalence of self-reported dizziness as a function of age ( $n = 31\ 023$ ), gender ( $n = 31\ 570$ ) and occupational group ( $n = 31\ 343$ ): unsteadiness, lightheadedness or feeling faint.

Age group (years)	Prevalence (%)	Gender/ Occupational group	Prevalence (%)
14–30	27.9	Male	22.4
31–40	31.0	Female	37.5
41–50	31.6		
51–60	31.1	Non-manual	31.3
61–70	29.6	Manual	26.0
71–80	30.5	Other	32.4
81+	39.2		

**Table 4.4** Prevalence per 100 000 live births of permanent hearing impairment  $\geq 40$  dB HL, for birth cohorts from 1985 to 1990, for all impairments, for congenital impairments only, for three degrees of severity of congenital impairment (moderate, 40–69 dB HL; severe, 71–95 dB HL; and profound,  $\geq 95$  dB HL), and for congenital sensorineural impairments.

Impairment type and severity	Prevalence per 100 000	95% confidence interval
All		
$\geq 40$ dB HL	133	122–146
Congenital		
$\geq 40$ dB HL	112	101–123
40–69 dB HL	64	56–73
70–94 dB HL	23	19–28
$\geq 95$ dB HL	24	20–30

better ear, particularly for hospital referrals. The patterns for reported tinnitus were similar.

## Prevalence of hearing impairment in children

This section is concerned only with permanent childhood hearing impairment (PCHI) and not with fluctuating impairments due to otitis media with effusion (OME or glue ear; for a description of the epidemiology of OME see Haggard and Hughes<sup>33</sup>). A major study of PCHI was conducted in the Trent Region of the UK. This region has about 4.8 million people and a typical distribution of ethnic minorities as well as occupational groups.

Fortnum et al<sup>16</sup> report the prevalence of hearing impairment shown in Table 4.4, which presents data on the prevalence rate per 100 000 live births for all impairments  $\geq 40$  dB HL (i.e. including acquired, progressive and late-onset losses) and for congenital losses alone (i.e. equivalent to incidence) for four degrees of severity of impairment,  $\geq 40$  dB HL, 40–69 dB HL (moderate), 70–94 dB HL (severe) and  $\geq 95$  dB HL (profound). The confidence intervals have been calculated according to the logistic distribution model, because of the very low values of the prevalences.

The prevalence of all PCHI  $\geq 40$  dB HL is 133 per 100 000, and for congenital impairments only is 112 per 100 000. The prevalence of profound impairments that are congenital is of the order of 1 in 4 000 births.

For congenital impairments, the incidence is equivalent to the prevalence. However, there are a number of children, 21 per 100 000, who have either a progressive or an acquired hearing impairment. By the age of about 5 years, the proportion of profoundly hearing impaired who have acquired impairments, mostly through meningitis, is about 20%. The proportion of children with a progressive hearing impairment is not known very accurately, and may be up to 15–25% of those who have a PCHI at the age of 5 years;<sup>34</sup> however, the present study finds only about 10% of PCHI to be progressive.

## Aetiology of childhood hearing impairments and major risk factors

The major aspect concerning the aetiology of congenital PCHI is that there are a considerable number of cases with no ascribed aetiology (43%). The major proportion of children who do have an aetiology comprises the approximately 39% who have been given a genetic aetiology. Of those with a genetic aetiology, the dominant genetic inheritance is only about 6%, and children with a stated syndrome comprise about 30%.

There were three major risk factors associated with the hearing impairments. The first and most important was the history of staying in the neonatal intensive care unit (NICU) (26%). The second was a family history of hearing impairment (after excluding those who had an NICU history) (23%), and the third the presence of a craniofacial abnormality noticeable at birth (after excluding those with an NICU or a family history) (4%). Altogether, just over 50% of those with PCHI had a risk factor that might be used as the basis of a targeted screen. Others have found a higher proportion,<sup>13,15,35</sup> so this may be something that varies over districts/regions/countries.<sup>14</sup>

## Service indicators for PCHI

Very few studies have looked at the overall benefit derived from finding children with congenital hearing impairments and undertaking a programme of habilitation. The major focus over

the last 20 years has been on reducing the age of identification and hearing aid fitting. The National Deaf Children's Society (NDCS) quality standard guidelines<sup>36</sup> apply to children with bilateral  $\geq 50$  dB HL average hearing impairment (0.5, 1, 2 and 4 kHz) and suggest that 40% of the children with PCHI should be identified by 6 months of age and 80% by 12 months of age.<sup>36</sup> In the current study, only 14% (95% confidence interval 8–18%) were identified by the age of 6 months and only 42% by the age of 12 months.

Table 4.5 shows the distribution of ages for significant events in the rehabilitative chain: referral, confirmation of the hearing impairment and age at hearing aid fitting. For overall severities, the age at referral was 10 months at the median, with 30% having an age at referral of less than 8 months and 10% having an age at referral of 2 months. It can be seen that the severe and profound impairments are referred earlier and 'diagnosed' earlier than moderate impairments, where the median age at referral is 18 months, and age at hearing aid fitting is 43 months. The data are reasonably encouraging, but regarding the higher percentiles, there are still 30% of children with hearing impairments who have not been referred before about 23 months, and a similar number who are almost 4 years of age before they are fitted with a hearing aid. The delays between referral and fitting are indicative of the long time it takes for some children to be 'diagnosed'. Some of these delays are inevitable. However, many children are kept without amplification while a conductive impairment is ruled out, and inevitably this leads to considerable delays that could be reduced substantially by having a hearing aid while waiting for the operation.<sup>16</sup> The age at referral reflects the service realities that during 1985–90 the targeted neonatal screening services in the region were starting up and that the mainstay for identifying children with permanent childhood hearing impairment was the health visitor distraction test (HVDT). The performance of these tests is discussed elsewhere,<sup>37,38</sup> with the yield coming from the HVDT being much lower than expected and the sensitivity being very dependent on the severity of the hearing impairment.<sup>16</sup> The more systematic use of neonatal hearing screening may substantially improve the age at referral, 'diagnosis' and fitting of hearing aids to those with congenital PCHI. Children with other substantial risk factors, e.g. parental anxiety concerning language development or meningitis, should seek a diagnostic appointment at the first opportunity.<sup>39</sup>

## Summary and implications for service provision

The public health priority of hearing impairments and tinnitus in adults should be substantially higher than at present, because hearing disorders comprise the most prevalent chronic impairment in the population, with over 8 million people in the UK (i.e. about 20%) having an impairment. The major factor associated with this high prevalence is age, with noise being the

## 40 Basic science

**Table 4.5** The mean and selected percentiles of the distribution of the age (months) of referral, confirmation of hearing impairment ('diagnosis') and hearing aid fitting, as a function of severity of the hearing impairment, for birth cohorts between 1985 and 1990 who have a congenital hearing impairment.<sup>16</sup>

Age at key points in identification and rehabilitation	Severity group	Mean	Percentiles				
			10	30	Median	70	90
Age at referral	Overall	19	2	8	10	23	47
Age at 'diagnosis'	Overall	26	5	11	17	37	59
Age at aid fitting	Overall	32	9	16	27	44	63
Age at referral	40–69 dB HL	25	3	9	18	39	55
Age at referral	70–94 dB HL	13	3	7	9	12	34
Age at referral	95+ dB HL	9	1	5	8	10	19
Age at 'diagnosis'	40–69 dB HL	35	9	16	35	46	65
Age at 'diagnosis'	70–94 dB HL	17	3	8	11	19	42
Age at 'diagnosis'	95+ dB HL	11	3	7	10	13	21
Age at aid fitting	40–69 dB HL	42	14	29	43	51	70
Age at aid fitting	70–94 dB HL	24	8	14	18	29	50
Age at aid fitting	95+ dB HL	14	6	9	12	17	24

major preventable factor, especially in young people. Because age is the major factor, the whole population prevalence of hearing impairments will increase over the next 20 years by up to 20%, due to the demographics of the population.<sup>23</sup>

Early identification of chronic, but progressive, impairment is not currently being achieved, even for those with substantial impairments, by the mainly reactive hearing services, and hence provision of services substantially lags behind need. Furthermore, the service is not inspiring people to use their hearing aids as only about 40–50% are used for most of the time.

The implications of this global epidemiology are that in the UK, and almost certainly in every developed country, there is a substantial underprovision of services for hearing-disabled people. This could be met by the use of a proactive screening service.<sup>13,28,40</sup> People with hearing disability and tinnitus have a significantly worse quality of life,<sup>11</sup> which can be ameliorated by the appropriate use of rehabilitation such as the use of a hearing aid for most of the time.<sup>41</sup>

For children, the public health priority stems, on the one hand, from the high burden that the condition confers on a relatively small number of the population (about 700–800 children per year in England), with a prevalence of 112 per 100 000 births for the congenital hearing impaired with average thresholds of 40 dB HL or greater, and on the other, from the very high cost of interventions, e.g. cochlear implants and educational training for the profoundly impaired, who comprise 24 per 100 000 births.

We are still considerably in the dark with respect to the full story of the aetiology of hearing impairments in children; however three risk factors (NICU history, family history of childhood deafness and craniofacial abnormalities) cover over 50%

of the population of congenitally hearing-impaired children. There are very few children with rubella as an aetiology (<5%), and so the main scope for prevention may be in understanding why children with an NICU history develop hearing impairment. The understanding of genetic impairments should also be a major priority.

In terms of service development, the wider use of neonatal screening to identify and habilitate hearing-impaired children with the least delay should be given urgent public health attention.

While both adult and child epidemiology support systematic screening of the population for congenital and then later acquired hearing impairment, the precondition for this screening to be successful is that an appropriately staffed and cost-effective service is available for those who do not pass the screen.

## Acknowledgements

We would like to thank Vicki Owen for help with the statistics.

## References

1. Davis AC. *Hearing Impairment in Adults*. London: Whurr, 1995.
2. Davis AC. The prevalence of hearing impairment and reported hearing disability among adults in Great Britain. *Int J Epidemiol* 1989; **18**: 911–17.
3. Salomon G. Hearing problems and the elderly. *Dan Med Bull* 1986; **33**(suppl): 1–22.

4. Brooks D. *Adult Auditory Rehabilitation*. London: Chapman & Hall, 1989.
5. Alpiner JG. Audiological problems of the aged. *Geriatrics* 1963; **18**: 19–27.
6. Martin D, Peckford B. Hearing impairment in homes for the elderly. *Social Work Service* 1978; **17**: 52–62.
7. Schow RL, Norbonne MA. *Introduction to Aural Rehabilitation*, 2nd edn. Pro. Ed., 1989. Texas.
8. Tolson D, McIntosh J, Swan IRC. Hearing impairment in elderly hospital residents. *Br J Nursing* 1992; **1**(14): 705–10.
9. Reich GE, Vernon JA (eds). *Proceedings of the Fifth International Tinnitus Seminar*. Portland: American Tinnitus Association, 1995.
10. Davis AC. Epidemiology. In: Stephens SDG, ed. *Scott-Brown's Otolaryngology* 6th edn, Vol. 2, Ch. 5, *Adult Audiology*. Oxford: Butterworth-Heinemann, 1997, pp. 4–38.
11. Davis AC, Roberts H. Tinnitus and health status: SF-36 profile and accident prevalence. In: Reich GE, Vernon JA (eds) *Proceedings of the Fifth International Tinnitus Seminar*. Portland: American Tinnitus Association, 1996, pp. 257–65.
12. Bench R, Bamford J. *The Spoken Language of Hearing Impaired Children*. London: Academic Press, 1979.
13. Davis AC, Wood S. The epidemiology of childhood hearing impairment: factors relevant to planning of services. *Br J Audiol* 1992; **26**(2): 77–91.
14. Davis AC, Parving A. Towards appropriate epidemiological data on childhood hearing disability: a comparative European study of birth cohorts 1982–88. *J Audiol Med* 1994; **3**: 35–47.
15. Davis A, Wood S, Rowe S, Webb H, Healey R. Risk factors for hearing disorders: epidemiological evidence of change over time in the UK. *J Am Acad Audiol* 1995; **6**: 365–70.
16. Fortnum HM, Davis A, Butler A, Stevens J. *Health Service Implications of Changes in Aetiology and Referral Patterns of Hearing-impaired Children in Trent 1985–93*. Report for Research and Development Trent RHA. MRC Institute of Hearing Research, 1996.
17. Stephens D, Davis A, Read A. *Audiological, Epidemiological and Genetic Definitions*. In: Martini A, Mazzoli M, Stephens D, Read A (eds). *Definitions, Protocols & Guidelines in Genetic Hearing Impairment*. London: Whurr, 2001.
18. Gardner MJ, Altman DG. *Statistics with Confidence*. London: British Medical Journal, 1989.
19. World Health Organisation. *World Health Organisation International Classification of Impairments, Disabilities and Handicap*. WHO: Geneva, 1980.
20. Davis AC. Hearing disorders in the population: first phase findings of the MRC national study of hearing. In: Lutman ME, Haggard MP (eds). *Hearing Science and Hearing Disorders*. London: Academic Press, 1983.
21. Stephens D, Hetu R. Impairment, disability and handicap in audiology: towards a consensus. *Audiology* 1991; **30**: 185–200.
22. Summerfield AQ, Marshall DH. *Cochlear Implantation in the UK 1990–1994: A Report by the MRC Institute of Hearing Research of the Evaluation of the National Cochlear Implant Programme*. London: HMSO, 1995.
23. Doyal L, Gough I. *A Theory of Human Need*. Basingstoke: MacMillan Education, 1991.
24. Coles RRA, Smith P, Davis AC. The relationship between noise induced hearing loss and tinnitus and its management. In: Berglund B and Lundvall T (eds). *Noise as a Public Health Problem*. Stockholm: Swedish Council for Building Research, 1990, pp. 87–112.
25. Haggard MP, Gatehouse SG. Candidature for hearing aids: justification for the concept and a two-part audiometric criterion. *Br J Audiol* 1993; **27**: 303–18.
26. Davis A, Stephens D, Rayment A, Thomas K. Hearing impairments in middle age: the acceptability, benefit and cost detection (ABCD). *Br J Audiol* 1992; **26**: 1–14.
27. Stephens SDG, Callaghan DE, Hogan S, Meredith R, Rayment A, Davis AC. Hearing disability in people 50–65: effectiveness and acceptability of early rehabilitative intervention. *BMJ* 1990; **300**: 508–11.
28. Davis AC, Thornton ARD. The impact of age on hearing impairment: some epidemiological evidence. In: Jenson JH, ed. *Proceedings of 14th Danavox Symposium. Presbycusis and Other Age-related Aspects*. Copenhagen: Danavox Jubilee Foundation, 1990, pp. 69–89.
29. Hart FS. *The Hearing of Residents in Homes for the Elderly—South Glamorgan (Report)*. University of Wales, Cardiff, 1980.
30. Soucek S, Michaels L. *Hearing Loss in the Elderly*. London: Springer-Verlag, 1987.
31. Gatehouse SG, Davis AC. Clinical pure-tone vs three-inferred forced choice thresholds: effects of hearing level and age. *Audiology* 1992; **31**: 30–44.
32. Davis AC. Epidemiological profile of hearing impairments: the scale and nature of the problem with special reference to the elderly. *Acta Otolaryngol (Stockh) Suppl* 1991; **476**: 23–31.
33. Haggard MP, Hughes EG. *Screening Children's Hearing*. London: HMSO, 1991.
34. Stevens J, Webb H. Targeted hearing screening in neonates—comparison of follow-up with neonatal results. *Audiens (BACDA Newsletter)* 4 April 1995.
35. Sutton G, Rowe S. Risk factors for childhood sensorineural hearing loss in the Oxford Region. *Br J Audiol* 1997; **31**: 39–54.
36. National Deaf Children's Society. *Quality Standards in Paediatric Audiology*, Vol. 1. London: NDCS, 1994.
37. Wood S, Davis AC, McCromick B. Changing performance of the health visitor distraction test when targeted neonatal screening is introduced into a health district. *Br J Audiol* 1997; **31**: 35–61.
38. Lutman ME, Davis AC, Fortnum HM, Wood S. Field sensitivity of targeted neonatal hearing screening by transient otoacoustic emissions. *Ear Hear* 1997; **18**: 265–76.
39. NDCS. *Quality Standards in Paediatric Audiology*, Vol. 2. London: NDCS, 1996.
40. Cochrane AL. *Effectiveness and Efficiency. Random Reflections on Health Services*. London: The Nuffield Provincial Trust, 1971.
41. Davis A. The epidemiology of hearing in an ageing population. In: M & J Pathey (eds). *Principles and Practice of Geriatric Medicine*. John Wiley and Sons Ltd, 1998, pp. 1087–92.

