Hearing Loss – Numbers and Costs

EVALUATION OF THE SOCIAL AND ECONOMIC COSTS OF HEARING IMPAIRMENT

A report for Hear-It AISBL

Bridget Shield

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CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

In 2006 Hear It published a report 'Evaluation of the Social and Economic Costs of Hearing Impairment' (Shield, 2006). The report reviewed literature concerning the prevalence of hearing loss; psychosocial effects of hearing loss and its impact on employment and earnings; ownership and use of hearing aids; satisfaction with hearing aids and their impact on various aspects of quality of life. The report concluded by evaluating the costs to Europe of hearing loss.

The report presented here is a continuation and update of the 2006 report. It reviews literature related to the same topics published between 2006 and December 2017. (Also included are a few significant papers published before 2006, or with a publication date of 2018 which were published online or otherwise available late in 2017.) An additional topic addressed in the current report is a comparison between self-reported and audiometric data on hearing loss; as will be seen, there have been many papers published on this subject in recent years.

1.2 SUMMARY OF 2006 REPORT

The main findings of the literature review carried out in 2006 were as follows:

- There was considerable variation in both qualitative and quantitative descriptions of deafness.
- Around 22% of the population of Europe were estimated to have some degree of hearing loss.
- It was estimated that after 20 years there would be 100 million hearing impaired people in Europe.
- Many studies showed that hearing loss had a major detrimental impact on overall quality of life, causing loneliness and social isolation, depression and low self-esteem among hearing impaired people, and affecting family and intimate relationships. Effects were exacerbated by the frequently long period of denial of a problem and consequent delay in seeing help.
- Around 3% of the population of Europe, or fewer than 1 in 3 of those who would benefit, owned a hearing aid, but around one third of hearing aids provided were not used.
- The proportion of hearing impaired people owning and using a hearing aid had not changed for around 40 years, despite improvements in technology and appearance of aids.
- The majority of hearing aid users were satisfied or very satisfied with the performance of their aids.
- The use of hearing aids benefitted many aspects of quality of life, including improving communication and other listening situations, and having a positive effect upon social, emotional, psychological and physical well-being.
- Hearing impairment and resulting discrimination caused problems in all aspects of working life.
- The employment rate of hearing impaired people was lower than that of the general population, and more hearing impaired than hearing persons were employed in lower status, and lower paid, jobs.
- The earnings of hearing impaired people were, on average, around 85% of those of the hearing population.
- The cost to the EU of reduced quality of life due to unaided hearing loss of 25 dB and above was estimated to be 224 billion euros; for Europe as whole (EU plus 14 other countries/ principalities) it was 284 billion euros (in 2004).

- The cost to the EU of reduced quality of life due to hearing loss of 25 dB and above, taking account of current hearing aid ownership, was estimated to be 168 billion euros; for Europe as whole (EU plus 14 other countries/ principalities) it was 213 billion euros (in 2004).
- There are significant costs to society of lost productivity due to unemployment and underemployment of hearing impaired people.

1.3 SOURCES AND METHODS

A systematic search of academic journals in the fields of audiology, hearing and hearing research, noise and health, has been carried out to identify relevant papers published since 2004. In addition to academic papers, articles in hearing and health publications have been reviewed where appropriate.

In recent years there have been many major reports published in the field, by regional, national and global bodies, which have also been included in the review. Some examples are listed in Table 1.1. Many of these reports concern the prevalence and impact of hearing loss and the feasibility and costs of providing hearing technology. It is interesting to note that similar work in this area has been carried out simultaneously in the UK, France, Australia, New Zealand and the USA, as well as by the World Health Organisation, suggesting increasing recognition of the social and economic burden of hearing loss around the world.

Table 1.1. Recent reports on hearing loss

Country	Date	Authors	Report title
UK	2007	Davis *et al*	Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models.
	2014	Commission on Hearing Loss	Commission on Hearing Loss Final Report
	2014	Archbold *et al*	The Real Cost of Adult Hearing Loss:
	2016	NHS/Dept of Health	Action Plan on Hearing Loss
France	2016	de Kervasdoue & Hartmann	Economic Impact of Hearing Loss in France and Developed Countries: a survey of academic literature 2005-2015
USA	2016	Blazer *et al*	Hearing healthcare for adults: priorities for improving access and affordability
Australia	2017	Deloitte Access Economics	The Social and Economic Cost of Hearing Loss in Australia
New Zealand	2017	Deloitte Access Economics	Listen Hear! New Zealand: Social and Economic Costs of Hearing Loss in New Zealand
World	2017	WHO	Global costs of unaddressed hearing loss and cost-effectiveness of interventions

There has been a wealth of literature concerning hearing loss published in the academic press in recent years. Many of the issues addressed in the original report are now covered in much more detail than previously, in particular the prevalence of hearing impairment worldwide and regionally; the psychosocial effects of hearing loss; the burden of hearing loss in relation to other diseases; and the true costs of hearing loss. A growing area of research is the investigation of relationships between hearing loss and other diseases, especially dementia, diabetes and cardiovascular disease.

Much of the recent research has been enabled by large scale population studies of health, particularly among the elderly, which have provided large data sets from which it has been possible to investigate the prevalence of hearing loss and links between hearing loss and other conditions. Population surveys which have been used by the papers cited in this report are listed in Table 1.2.

Table 1.2. Population health studies

Country	Survey
USA	National Health and Nutrition Examination Survey
USA	Health, Aging and Body Composition
Japan	Kurabuchi Study
Australia	Blue Mountains Study
Australia	Health in Men Study
Australia	Longitudinal Study on Women's Health
Iceland	Reykjavik Study of Aging
Netherlands	National Longitudinal Study of Hearing
Netherlands	Longitudinal Aging Study Amsterdam
Norway	Nord-Trondelag Hearing Loss Study
UK	English Longitudinal Study of Ageing

In terms of hearing health care there has been a particular focus on the needs of the ageing population, that is people in their 80s (Dubno, 2015). According to Dubno (2015), although this is the fastest growing segment of the population, hearing health care has not kept up in terms of assessing and addressing the complex needs of this age group. In addition to increasing hearing loss many in this age group experience multiple health needs including, as will be seen in this report, changes in cognition and physical frailty. They may also experience loneliness, social isolation and have a poorer quality of life. However, it is not just the older age group which is affected by the negative implications of hearing loss; many of the outcomes traditionally regarded as affecting the hearing impaired older generation are also found in young and middle aged adults with hearing loss.

There is also a wide range of data on prevalence of hearing loss. The Eurotrak surveys have been carried out in an increasing number of European countries since 2009, to provide data on the prevalence of (self-reported) hearing loss and its impact, and the ownership and use of hearing aids. Since 2010 hearing loss has been included in the Global Burden of Disease studies which evaluate all the available epidemiological data on disease to provide comparisons of prevalence of disease and loss of health over time and across age groups, countries and regions of the world.

1.4 SCOPE AND LIMITATIONS OF STUDY

This report is concerned only with the psychosocial and economic impact of hearing impairment in Europe. The literature reviewed and calculations involve only hearing loss and do not consider the impact of other types of hearing impairment such as tinnitus. Information and research concerning audiological examination and fitting of hearing aids is also outside the scope of the study, as is technical information on types and features of hearing aids.

The report uses the Global Burden of Disease (GBD) definition of Europe and includes within the definition of Europe all those countries which make up the GBD regions of Western Europe, Central Europe and Eastern Europe, as shown in Table 1.3.

Table 1.3. Global Burden of Disease (GBD) definitions of Western Europe, Central Europe and Eastern Europe

GBD Region	Countries
Western Europe	Andorra, Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy. Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom
Central Europe	Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Macedonia, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia
Eastern Europe	Belarus, Estonia, Latvia, Lithuania, Moldova, Russian Federation, Ukraine

It will be seen that, for many topics, it is difficult to draw comparisons between the reviewed studies or to draw definitive conclusions owing to different methodologies such as different survey techniques, subject groups, age ranges and definitions of hearing loss. However, where possible, some comparison is attempted in order to observe trends and draw general conclusions.

1.5 OUTLINE AND STRUCTURE OF REPORT

The body of this report has been organised into four sections as described below. Each section contains the references relating to that section, and sections A, C and D are followed by an Appendix.

Section A covers the prevalence of hearing loss. It includes chapters on the assessment of hearing loss and examines the differences between prevalence established by self-reported and audiometric surveys. Results of major surveys such as Global Burden of Disease studies and Eurotrak surveys are presented, plus data from smaller research studies carried out in specific European countries.

Section B is concerned with the effects of hearing loss and includes chapters on the psychosocial impact of hearing impairment; its effects on physical health and cognition; and its impacts on employment and earnings.

Section C reports data on the ownership and use of hearing aids; factors which affect ownership and use; and benefits of, and satisfaction with, hearing aids.

Section D contains the chapters relating to the costs of hearing loss. The first chapter reviews previous studies of costs of hearing impairment and the second chapter uses data presented in earlier chapters to estimate the current costs to Europe of hearing loss.

The final chapter of the report contains overall conclusions.

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SECTION A

ASSESSMENT AND PREVALENCE OF HEARING LOSS

CHAPTER 2 ASSESSMENT OF HEARING LOSS: COMPARISON OFSELF REPORTED AND AUDIOMETRIC DATA

2.1 INTRODUCTION

Different methods are used to define and assess hearing impairment in surveys aimed at estimating the prevalence and consequences of hearing loss in a population or population sample. Some surveys use subjective, self-reported data on hearing and hearing problems; other studies use data acquired objectively, usually through clinical audiometric testing; while others use a combination of subjective and objective information.

Each method has its advantages and disadvantages, depending in part on the exact purpose of a survey and the time and costs available. Obtaining data subjectively, through questioning of subjects, is usually simpler, cheaper and takes less time than carrying out full audiometric testing of subjects.

However, Davis *et al* (2007) consider that self-reporting is a poor indicator, leading to underestimation, of prevalence. This is due to the length of time, sometimes up to 10 years, that it takes for an individual to recognise that they have a hearing problem, which the authors state could result in an underestimate of the prevalence of the more severe levels of hearing loss.

On the other hand, audiometric testing does not fully represent or lead to understanding of the practical difficulties which an individual may experience in everyday situations and the consequent disability (Williams *et al*, 2015). This was a reason for the revised disability weightings and classifications of hearing loss in the 2013 Global Burden of Disease studies (Davis, 2014; Salomon *et al,* 2015), as reported in Chapter 3. Self-reporting assesses disability but is not a measure of impairment. Furthermore, subjective assessments of hearing loss and resultant difficulties reflect not only a subject's actual hearing impairment but also personal factors such as cognitive ability or psychological resources (Salonen *et al*, 2011).

A further complication can arise in comparing results based upon audiometric data as different organisations define disabling hearing loss and categories of hearing impairment differently, as discussed in section 2.2

2.2 DEFINITIONS OF DEAFNESS AND HEARING LOSS

A difficulty in reporting and comparing studies on the prevalence of hearing loss is that there are several different definitions and categorisations of deafness and hearing loss in use, which may invalidate comparisons (Duthey, 2013).

Many studies use the WHO classification which is unchanged from the Hear It '06 report (Shield, 2006). The WHO definition uses four grades of hearing loss, in categories of 20 dB as shown in Table 2.1 and defines disabling hearing loss as being a loss greater than 40 dB in the better hearing ear (see WHO website).

The 2010 GBD Hearing Loss Expert Group recommended a new classification, with disabling hearing loss starting at a loss of 35 dB in the better ear (Stevens *et al*, 2011), and with categories of width 15 dB, to more accurately reflect hearing perception (Olusanya *et al*, 2014). The modified classification also equated unilateral hearing loss with bilateral mild hearing loss. Although the proposed new classification (also shown in Table 2.1) has been used in the 2013 and subsequent GBD prevalence studies, it has not been adopted by the WHO. (See Chapter 3 for further discussion of GBD hearing loss classifications.)

Table 2.1. Grades of hearing loss: current WHO classification and proposed new GBD classification (Stevens *et al*, 2011)

Grade of hearing loss*	WHO classification	2010 GBD classification
Mild/slight	26 – 40 dB	20 – 34 dB
Moderate	41 – 60 dB	35 – 49 dB
Moderately severe	---------	50 – 64 dB
Severe	61 – 80 dB	65 – 79 dB
Profound	81 dB or greater	80 – 94 dB
Disabling hearing loss in adults	Greater than 40 dB in better ear	Greater than 35 dB in better ear

*Audiometric average of 500, 1000, 2000 and 4000 Hz

Organisations involved with hearing loss may use different classifications. For example, the American Speech-Language Hearing Association uses the classification shown in Table 2.2, while Action on Hearing Loss uses the definitions shown in Table 2.3.

Table 2.2. American Speech-Language Hearing Association classifications of hearing loss (American Speech-Language Hearing Association, 2015)

Degree of hearing loss	Hearing loss range (dB HL)
Normal	-10 – 15
Slight	16 – 25
Mild	26 – 40
Moderate	41 – 55
Moderately severe	56 – 70
Severe	71 – 90
Profound	91 or greater

Table 2.3. Action on Hearing Loss classifications of hearing loss (Action on Hearing Loss, 2015)

Degree of hearing loss	Quietest sound heard (dB)	Effects
Mild	25 – 39	Can sometimes make following speech difficult
Moderate	40 – 69	May have difficulty following speech without hearing aids
Severe	70 – 94	Usually need to lipread or use sign language, even with hearing aids
Profound	95 dB or greater	Usually need to lipread or use sign language

It should also be noted that, as stated by the WHO and other authors, using purely audiometric descriptors may not be sufficient to fully describe the extent of hearing disability, particularly in relation to communication in background noise. Furthermore, the better ear average of hearing threshold at 0.5, 1, 2 and 4 kHz tends to underrate the potential problems of someone with asymmetrical hearing (Davis *et al*, 2009).

2.3 STUDIES COMPARING SELF-REPORTED WITH AUDIOMETRIC DATA

Over the years there have been many attempts to investigate the validity of using self-reported data rather than audiometric data to identify those with impaired hearing, and the prevalence of different grades of hearing loss. In 2005 a review was published of ten studies carried out between 1990 and 2004 (Valete-Rosalino and Rozenfeld, 2005). Since then there have been an increasing number of similar studies, many of which have involved analysing data from earlier surveys of hearing loss and comparing individuals' self-reported

information with their audiometric data. However, the evidence for a strong relationship between self-reported hearing loss and measured hearing impairment remains equivocal (Kiely *et al*, 2012).

Comparing studies is not straightforward as there are substantial variations within both self-reporting and measurement methods. As will be seen, in subjective, self-reporting surveys, some rely on a single question such as 'Do you feel you have a hearing loss?' while others use a more detailed questionnaire involving questions concerning hearing difficulties in particular situations. The criteria for defining audiometrically measured hearing loss have also varied across studies. Some papers report average values across different frequency ranges (typically 0.5, 1, 2 and 4 kHz) or at a variety of individual frequencies; some authors have use averaged hearing loss for the better ear while others consider the worse ear or binaural hearing; and the cut off point for defining hearing loss also varies.

In addition, there are differences between subject groups in the various studies. Many of the studies are based upon data previously collected as part of larger studies of ageing and hence involve only elderly subjects; others have investigated noise exposed workers to see whether self-reporting identifies noise induced hearing loss (NIHL); some have specifically compared older and younger age groups; while others have involved a wider age range across a general population. Finally, the statistical methods that have been used to analyse the relationship between audiometric and self-reporting data vary.

Table 2.4 summaries the studies that are included in this review giving a brief description of the numbers and types of subjects, the subjective and audiometric surveys used, the results of the comparison between them and the conclusions of the authors. Throughout this chapter the term 'hearing loss' is used to refer to results obtained through self-reporting, subjective surveys while 'hearing impairment' refers to hearing loss as measured by audiometry.

2.4 ANALYSIS OF DIFFERENCE BETWEEN SELF-REPORTING AND AUDIOMETRY

The reviewed studies have used a variety of statistical techniques to analyse the differences between self-reporting and audiometry.

The majority of the studies have used systematic analytical techniques to test the reliability of self-reporting methods. These involve comparing each individual's subjective assessment of their hearing with their audiometric results. Various parameters related to the whole subject group are then calculated to determine how sensitive self-reporting is in correctly identifying the people who have hearing loss as measured by audiometry, and how specific it is in correctly identifying people who do not have hearing loss according to their audiometric measurement.

The *sensitivity* is defined as the proportion of those with measured hearing impairment who self-report that they have hearing loss; while the *specificity* is given by the proportion of those without hearing impairment who self-report no hearing problems. Ideally, to be regarded as a reliable method, a self-reporting survey needs to have both high sensitivity and high specificity; however, in practice, there tends to be a trade-off between the two with higher sensitivity in general being related to lower specificity.

Other studies have used different statistical techniques to investigate the reliability of self-reporting, such as correlation analysis or calculation of overall accuracy (the percentage of subjects who are correctly classified as having or not having hearing impairment).

Some papers report on the overall prevalence of hearing loss estimated by both audiometry and self-reporting, as discussed in section 2.8, but the overall conclusions on reliability and accuracy of a self-reporting method, summarised in Table 2.1, are mainly based upon the detailed statistical analysis of individual data as described above.

2.5 SELF-REPORTING METHODS

The studies reviewed here have compared subjective and objective data from surveys which have used a variety of self-reporting methods, including the following:

- One simple yes/no question (for example '*Do you feel you have a hearing loss?*')
- Several questions concerning various types of hearing problem (such as tinnitus or hypersensitivity to noise) and often including a simple question on hearing loss
- A more detailed questionnaire concerning hearing problems in different situations
- Questions where a scaled response or rating is required
- A questionnaire on noise induced hearing loss (NIHL) and noise exposure
- The Hearing Handicap Inventory for the Elderly – Screening questionnaire (described below)
- One or more questions on hearing which are part of a large scale general health survey

In studies where scaled responses or ratings have been used, these have subsequently been dichotomised to reduce them to the equivalent of yes/no answers for the purposes of comparison with the presence or absence of hearing loss according to audiometry. For example, in the study by McCullagh *et al* (2011) subjects were asked '*How good is your hearing?*', with possible responses *'excellent', 'good', 'fair'* and *'poor'.* In the analysis *'excellent'* and *'good'* were taken to indicate no hearing loss and *'fair'* and *'poor'* to indicate hearing loss.

Many of the subjective surveys used the Hearing Handicap Inventory for the Elderly – Screening questionnaire (HHIE-S). This is a shortened version of the Hearing Handicap Inventory for the Elderly (HHIE), developed by Ventry and Weinstein (1982, 1983). The HHIE is a 25 item questionnaire on hearing, which has responses 'always', 'sometimes' and 'never' to each question. In order to give a maximum score of 100, 'always' is scored as 4, 'sometimes' as 2 and 'never' as 1. The HHIE-S consists of ten questions on the emotional and social aspects of hearing loss, and uses the same scoring system as in the HHIE; hence the maximum score possible is 40. Both the HHIE and HHIE-S have been thoroughly validated and the HHIE-S is accepted as a robust test for identifying hearing impairment in the elderly (Salonen *et al*, 2011). An HHIE-S score greater than 8 is taken to indicate the presence of hearing handicap (Diao *et al,* 2014). It will be seen that in most of the studies reviewed in this chapter this is the cut off point used, although Chang *et al* (2009) used a cut off of 10 and other authors (Salonen *et al*, 2011; Diao *et al*, 2014) investigated the effects of several different cut off points.

The self-reporting methods used in each of the reviewed studies are included in Table 2.4.

2.6 AUDIOMETRIC MEASUREMENTS

The audiometric measures used in each study are also listed in Table 2.4. As can be seen, the audiometric measurements and cut off points for defining hearing impairment or grades of hearing impairment (for example mild, moderate, severe) vary between studies. Some surveys have used better ear measurements, others worse ear and some binaural hearing thresholds. Where pure tone averages (PTA) have been used, the usual frequency range averaged is 500 Hz to 4 kHz, in accordance with the WHO and other classifications of hearing loss (Stevens *et al*, 2011). However, in some cases different ranges are used.

Some surveys have investigated accuracy of self-reporting compared with audiometric data at individual frequencies and others have considered low, medium or high frequency ranges.

2.7 EARLY STUDIES

In 2005 Valete-Rosalino and Rozenfeld carried out a review of studies published between 1990 and 2004 that compared prevalence estimates of hearing loss obtained by both self-reporting and pure tone audiometry (Valete-Rosalino and Rozenfeld, 2005). They examined ten studies which involved between 63 and 12,495 subjects, all of which included subjects aged 60 years and older. Although there was variation between the studies in both the audiometric assessment of hearing impairment and the questions used for self-reporting, Valete-Rosalino and Rozenfeld compared the observed and estimated prevalence of hearing loss and the reliability of self-reporting in all the studies. Across the studies, sensitivity ranged from 14% to 100% and specificity from 50% to 95% and differences between observed (by audiometry) and estimated (by self-reporting) prevalence from -49% to +60% (observed – estimated). The review found that self-reporting was less able to identify those with milder, rather than moderate to severe, hearing loss. The authors concluded that, in general, if hearing loss is identified as a mean pure tone average loss of 40 dB or greater in the better ear, across frequencies of up to 2000 or 4000 Hz, then a single, simple, question (for example, *'Do you feel you have a hearing loss?'*) was an acceptable indicator of hearing loss, and more reliable than questions with multiple choice answers. They recommended that such a question could satisfactorily be used for an epidemiological study of hearing loss prevalence among older persons where it was not possible to perform audiometric measurements, even though self-reporting was less consistent at identifying those with milder hearing loss.

These findings have largely been replicated by the more recent studies reviewed in this chapter, as will be seen in the next section.

2.8 MORE RECENT STUDIES

Table 2.4 lists the studies published since 2005 which are included in this review. Also listed for information, although they were included in the review by Valete-Rosalino and Rozenfeld (2005), are two earlier studies (Nondahl *et al*, 1998; Sindhusake *et al*, 2001) as they are significant and important investigations which are frequently cited by subsequent surveys.

The studies listed in Table 2.4 involved between 55 and over 15,300 subjects aged from 19 to 92 or older. Four of the studies (McCullagh *et al*, 2011; Rosso *et al*, 2011; Hong *et al*, 2011; Fredriksson *et al*, 2016) concerned people of working age, and were focussed on identifying symptoms of noise induced hearing loss; the remaining studies involved more general cross sections of the population.

Results and conclusions across studies are somewhat inconsistent. Although some authors conclude that self-reporting is suitable for estimating the prevalence of hearing impairment, particularly moderate to severe hearing loss, or identifying adults in need of hearing rehabilitation (Salonen *et al*, 2011; Deepthi and Kasthuri, 2012; Diao *et al*, 2014; Fredriksson *et al*, 2016), others consider that it is a poor predictor of hearing impairment (McCullagh *et al*, 2011; Rosso *et al*, 2011; Hannula *et al*, 2011; Choi *et al*, 2016). Some authors consider that it may be suitable as a preliminary screening tool for hearing loss (Ferrite *et al*, 2011; Hong *et al*, 2011; Swanepoel *et al*, 2013), particularly when audiometry is not available. However, it is emphasised that self-reporting alone is not sufficient and should be supplemented by audiometry (Hietanen *et al*, 2005; Ramkissoon and Cole, 2011).

Nevertheless, it can be seen that, overall, despite the differences between definitions, methodologies and subject groups, the general findings of studies published since 2005 are consistent with the conclusions of the review by Valete-Rosalino and Rozenfeld. While self-reporting may provide a rough estimate of the prevalence of hearing loss, particularly in a younger population, it is not an accurate assessor of true prevalence and is likely to underestimate the actual prevalence of hearing impairment above 25 dB in a general population. Self-reporting is more reliable in identifying moderate and severe hearing loss than mild; it overestimates prevalence among younger age groups and underestimates prevalence among older people. These aspects are discussed in the following section which considers factors affecting self-perceived hearing loss which have been revealed by the studies.

2.9 FACTORS AFFECTING AGREEMENT BETWEEN AUDIOMETRY AND SELF-REPORTED HEARING LOSS

As explained in section 2.3, comparison of studies can be problematic owing to differences in survey techniques, subject groups and measurement methods. As Chang *et al* (2009) point out, results may also be affected by variations in self-perception of hearing problems which may be affected by non-audiometric factors related to a subject's physical and social environment. This section highlights certain factors which have emerged from the review of studies listed in Table 2.4.

2.9.1 Type of question

Those studies which have compared the performance of a single question with a more extensive questionnaire or the HHIE-S have concluded that a simple, single question performs as well as, or better than, a more extensive questionnaire. In addition, in comparing the performance of three differently worded questions, Ferrite *et al* (2011) confirmed the findings of the review by Valete-Rosalino and Rozenfeld (2005) that a question with a yes/no response is a more accurate indicator of hearing loss than a question with scaled responses. A similar observation was made in the review of data from several national health surveys in the USA by Ikeda *et al* (2009) in which the use of a scaled response question appeared to result in over reporting of hearing loss.

2.9.2 Degree of hearing impairment

Where studies have investigated accuracy of surveys across different degrees of hearing impairment, the findings of the review by Valete-Rosalino and Rozenfeld (2005) have been repeated in that self-reporting is a reasonable predictor of moderate to severe hearing loss but fails to identify those with mild hearing impairment (Ikeda *et al*, 2009; Rosdina *et al*, 2010; Salonen *et al*, 2011; Ramkissoon and Cole, 2011; Deepthi and Kasthuri, 2012; Diao *et al*, 2014; Fredriksson *et al*, 2016). This contributes to the relatively poor performance of self-reporting in predicting overall prevalence.

2.9.3 Frequency ranges of hearing impairment

Some studies have investigated the reliability of self-reporting across different frequencies or frequency ranges of hearing loss, but results are inconsistent. Among a group of factory workers, many of whom had NIHL, McCullagh *et al* (2011) found that self-reporting was more sensitive but less specific at lower frequencies (500 Hz to 2 kHz) than higher (3 to 8 kHz). Comparable results were reported by Hong *et al* (2011) in their study of construction workers. Similarly, in an Australian study of younger (on average) subjects who were members of the armed forces, and hence also potentially subject to NIHL, Kirk *et al* (2012) found that self-reporting was less reliable at identifying hearing impairment at high frequencies (3 to 8 kHz) compared with low and moderate frequencies. All these studies involved noise exposed subjects of mean age 33 to 44, so may not be typical of a more general population.

However, the results of a large scale study across an age range from 20 to 69 years (Agrawal *et al*, 2008) also found that self-reporting was less accurate at identifying individuals with high frequency loss (greater than 25 dB averaged across frequencies 3, 4 and 6 kHz) than those with a loss averaged across lower frequencies (0.5, 1, 2 and 4 kHz).

In contrast Hannula *et al* (2011) found that self-reporting was better able to predict hearing impairment at higher frequencies (4 to 8 kHz) than lower (below 4 kHz). Swanepoel *et al* 2013) also noted that 4 kHz was the most significant frequency in the reporting of self-reported hearing loss, the greatest agreement between self-report and measured hearing impairment occurring at this frequency.

2.9.4 Age

Studies which have compared the reliability of self-reporting across age groups have found that younger subjects tend to overestimate their hearing difficulties compared with their measured hearing ability, while older people under report problems with hearing. For example, Ikeda *et al* (2009) found that, in some of the US national health survey data which they reviewed, over reporting was highest in the 20 to 49 age group while under reporting was significant among people aged 60 to 69. Several possible explanations have been given for the under reporting by older people: they may regard loss of hearing as a normal part of ageing and therefore expect to have poorer hearing; they may deny their hearing loss completely due to the stigma of its being associated with age and disability; or they may have fewer communication needs after retirement (Ikeda *et al*, 2009; Kiely *et al*, 2012; Bainbridge and Wallhagen, 2014; Choi *et al*, 2016). Kamil *et al* (2015) found that the likelihood of overestimating of hearing impairment by younger subjects and underestimation by older participants was consistent across gender, race/ethnicity and education levels, the overall accuracy of self-reporting being significantly lower in older age groups.

Although hearing was assessed objectively by screening at 1 kHz and 3 kHz rather than full audiometric testing, data from the English Longitudinal Study of Ageing (ELSA) similarly demonstrates the increase with age in discrepancy between objective and self-reported hearing loss, as can be seen in Table 4.22 in Chapter 4 (Banks *et al*, 2016). Overall 36% of men and 31% of women were found to be hearing impaired when tested, compared with 26% of men and 17% of women who reported hearing problems. The differences between objective and self-reported prevalence varied from approximately zero at age 50 for both sexes to 38% for men and 42% for women among the over 80s.

2.9.5 Gender

Some studies have investigated differences in responses between genders but results are inconsistent. Kamil *et al* (2015) found that more women than men between the ages of 50 and 69 overestimated their hearing loss, and their rate of accuracy decreased with age while remaining stable for men. Engdahl *et al* (2013) found a stronger association between self-reporting and audiometry for men than women at high frequencies, and the reverse at low frequencies. This is consistent with the findings of Swanepoel *et al* (2013) that, among middle aged adults (aged 45 to 65) men with a high-frequency hearing loss were more likely than women to report a hearing difficulty, while women with a mid-frequency loss were more likely than men to report hearing difficulty. In a small study by Torre *et al* (2006), self-reporting was more reliable among women than men; the authors suggest that may be due to women being less inhibited than men about admitting they have a hearing loss.

2.9.6 Other demographic factors

Some authors have identified other factors which appear to influence responses in self-reporting surveys of hearing. In a Taiwanese study Chang *et al* (2009) found that perceptions of hearing loss were affected by marital status and general health while Kamil *et al* (2015) in the USA found that, in addition to age and gender, ethnicity and level of education affected differences between self-reported and measured hearing ability.

Accuracy rates in the latter study were higher among black and Hispanic, compared to white, participants, particularly in the 50 to 59 age group. Pierre *et al* (2015), in developing a model to relate objective and subjective hearing levels, found that it was necessary to take account of age, sex, the frequency under consideration and the presence of tinnitus.

Cultural and linguistic differences also cause variations between studies. Chang *et al* (2009), in a Taiwanese study, suggest that many elderly Chinese people do not regard themselves as disabled by hearing impairment, in part owing to the respect with which they are treated and a lack of stigma in being old. In their study, over 75% of those with moderate to severe hearing loss did not perceive themselves to have hearing problems. Similar underreporting of hearing loss occurred in the Chinese study by Diao *et al* (2013) who also point out that, because of respect for the elderly, younger family members adopt strategies to help communication with elderly relatives, who, as they mostly live with their children, are also familiar with their social and physical environments.

Linguistic characteristics of the Chinese language (Diao *et al*, 2013) and also of the Finnish language (Salonen *et al*, 2011), compared with other European languages and American English, may also contribute to differences in results across studies.

2.10 COMPARISON OF ESTIMATES OF OVERALL PREVALENCE

Some of the reviewed papers have provided estimates of overall prevalence of hearing impairment calculated from self-reported data. These are shown in Table 2.5 along with the prevalence figures derived from audiometric assessment. Unless otherwise stated hearing levels are averaged across frequencies 0.5, 1, 2 and 4 kHz.

It can be seen that the accuracy of self-reporting for predicting prevalence, whether by a single question or using the HHIE-S questionnaire, is poor in the majority of cases. In many cases the differences between prevalence estimates from self-reporting and audiometry are very large.

Results of the studies reporting the accuracy of prevalence data predicted using the HHIE-S are inconsistent. In comparing HHIE-S scores with hearing loss greater than 40 dB, prevalence was overestimated in the studies by Salonen *et al* (2011) and Deepthi and Kasthuri (2012) but underestimated in the studies by Chang *et a*l (2009) and Diao *et al* (2014). A possible explanation for the discrepancy between results is that the two latter studies involved Chinese subjects and, as both papers explain and was discussed in section 2.9.6, there is a particular lack of recognition by elderly Chinese subjects of problems caused by age related hearing loss.

It can be seen from Table 2.5 that, in the majority of studies where a single question was used, particularly when comparing with a criterion of 25 dBHL to define hearing loss, self-reporting underestimated, in some cases by a large error, the prevalence of hearing loss as measured using audiometry. This is to be expected, given the findings of section 2.9, which showed that self-reporting often fails to identify the presence of mild hearing loss, that is hearing loss of between approximately 25 and 40 dB. Furthermore, it can be seen that in all the studies of older people where a single question was used, self-reporting underestimated the objectively measured prevalence of hearing loss, whereas in the studies involving younger subjects, prevalence tended to be overestimated. This is again consistent with the findings discussed in section 2.9 that older people are inclined to under report their hearing loss, whereas younger age groups over report their self-perceived hearing loss.

The very low objectively measured prevalence in the study by Pierre *et al* (2015) should be noted. The authors suggest that this is due to their subjects being young (the majority were under 40, with a median age of 32), urban and middle class.

In the study by Kiely *et al* (2012), although overall prevalence rates from self-reporting and audiometric data differed by a relatively small amount, the difference increased sharply with age. For every 5-year increase in age the prevalence of self-reported hearing loss increased by 4.1% compared with 13.5% increase in measured hearing impairment. This is consistent with the differences in self-reporting between age groups discussed above. Although prevalence rates for adults aged between 65 and 74 were reasonably accurate, prevalence based upon self-reporting greatly overestimated measured prevalence for younger subjects (for example, 44% compared with 9% for men aged 55-59) and underestimated prevalence for older subjects (for example, 69% compared with 89% for men aged over 85). In this study the differences across the age groups balanced out so that overall prevalence based upon self-reporting was reasonably accurate although there were large discrepancies in individual age groups.

2.11 SUMMARY

The main findings of the review of the reliability of self-reported surveys of hearing loss carried out in this chapter are as follows:

- Self-reporting underestimates the individual occurrence and prevalence of mild hearing impairment, leading to a general underestimation of overall prevalence
- Younger individuals tend to overestimate their hearing loss in self-reporting surveys
- Older individuals underestimate their hearing problems in self-reporting surveys
- Using a single question is as reliable as using longer, more complex, questionnaires
- A simple yes/no question performs better than questions requiring scaled responses
- Results of studies into the reliability of self-reporting surveys related to frequency ranges of hearing loss are inconsistent
- Results of studies into the effects of gender on reliability of self-reporting are inconclusive
- Responses in self-reporting studies may be influenced by subjects' age, gender, marital status, general health, ethnicity, level of education and frequency as well as cultural and linguistic factors
- Self-reporting surveys underestimate the prevalence of hearing loss among older people and overestimate the prevalence among younger people
- Results of self-reporting surveys alone are not sufficient to identify individuals with hearing impairment and should be supplemented, where possible, with audiometry.
- A combination of self-reporting and audiometry is recommended for identifying individuals who may benefit from hearing aids.

2.12 DISCUSSION AND CONCLUSIONS

As many authors have pointed out, self-reporting and audiometry measure different aspects off hearing loss. Audiometry gives an objective measurement of an individual's hearing impairment while self-reporting assesses an individual's perceived disability due to hearing loss. The latter depends not just on the level of hearing impairment but also on personality, general health, environment and various demographic factors.

There are several circumstances in which it might be useful to be able to rely on self-reporting of hearing problems and acuity, rather than audiometry. These include situations where audiometry is not available for some reason, or where there is a need to reduce the costs of assessment of hearing. Possible purposes of self-reporting surveys include screening individuals in order to determine whether they are eligible for more detailed audiometric assessment, and possible hearing aid fitting; obtaining an approximate assessment of the level of hearing impairment of an individual; and roughly estimating prevalence of hearing impairment in a particular group or population.

The overriding conclusion of the review in this chapter is that self-reporting is not accurate as a clinical measure of hearing impairment, although it may be useful as an initial screening tool. Where a self-reporting survey is to be used, a single yes/no question is sufficient to determine the incidence of hearing loss. However, self-reporting is poor at identifying individuals with mild hearing loss.

These studies support the findings of Davis *et al* (2007) who carried out a detailed investigation in the UK into effective and acceptable screening procedures for identifying people aged 55 to 74 who could benefit from hearing aid fitting. They concluded that the best screening procedure consists of one simple question *'Do you have any difficulty with your hearing?*' followed by screening audiometry consisting of hearing a 3 kHz tone at 30 dB.

Furthermore, it has been shown that estimates of prevalence of hearing loss based upon self-reporting surveys are not reliable, either underestimating or overestimating objectively measured prevalence depending upon the age range of the subjects and their degree of hearing loss.

In addition, care needs to be taken in interpreting results of audiometry which refer to classifications of hearing impairment such as 'mild' or 'moderate', owing to different definitions of these categories by different organisations.

Table 2.4. Studies of comparison of self-reported hearing loss with audiometrically measured hearing impairment

Study/country	Subjects Number Age (mean)	Self-report	Audiometric meas/HI defn	Results	Author comments/ conclusions
Nondahl *et al*, 1998 USA	N: 3556 Age: 48-92	HHIE-S Q: *Do you feel you have a hearing loss?*	$WEHL_{0.5,1k,2k,4k}$ > 25 dB	Single question had higher sensitivity than HHIE; predicted HL prevalence within 3% of audiometric prevalence.	A simple question may be sufficient for prevalence surveys, depending on age and gender of subjects.
Sindhusake *et al*, 2001 Australia	N: 2015 Age: 55-99	HHIE-S Q: *Do you feel you have a hearing loss?*	$BEHL_{0.5,1k,2k,4k}$ > 25 dB (mild), 40 dB (moderate), 60 dB (severe/marked)	Both SR methods performed reasonably in identifying subjects with HI	Both SR methods recommended for use in epidemiological studies.
Hietanen *et al*, 2005 3 Nordic countries	N: 822 Age: 75	General health questionnaire including question on ease of hearing with 4 response options	$BEHL_{0.5,1k,2k,4k}$ and $WEHL_{0.5,1k,2k,4k}$ categorised into 5 HI groups	SR hearing disability broadly in accordance with measured degree of HI, but with some conflicting results.	In order to assess elderly peoples' hearing, both audiometry and SR are needed.
Torre *et al*, 2006 USA (Latino-American subjects)	N: 59 Age: 42-88 (62)	Questionnaire on hearing including Q: *Do you feel you have a hearing loss?*	$WEHL_{0.5,1k,2k,4k}$ > 25 dB	SR performance better for women than men.	Question is effective in identifying HL in older Latino-American adults.
Agrawal *et al*, 2008 USA	N: 5742 Age: 20-69	Q with 4 response options, dichotomised.	$PTA_{0.5,1k,2k,4k}$ ≥ 25 dB in one or both ears; $PTA_{3k,4k,6k}$ ≥ 25 dB in either ear	Overall, the sensitivity of SR was low (range, 41%-65%); but higher for bilateral than unilateral or high-frequency HI.	Prevalence estimates based on SR hearing loss may underestimate the true prevalence.
Chang *et al*, 2009 Taiwan	N: 1220 Age: ≥ 65	HHIE-S Score ≥ 10 ~ SR hearing handicap	$BEHL_{0.5,1k,2k,4k}$ > 40 dB (moderate HI)	Moderate association between hearing handicap and HI. Many (78.6%) with moderate to severe HI did not perceive themselves as hearing-handicapped.	Other factors (marital status, general health) affected self-perceived HL.
Ikeda *et al*, 2009 USA	N: 5299 Age: 20-69	Various graded questions: pooled SR and audiometric data from several previous US surveys	$BEHL_{0.5,1k,2k,4k}$ > 25 dB	Substantial variation between surveys in conclusions re SR and audiometry. Over reporting of HL highest in 20–49 age group, lowest in 60–69 age group.	Estimates of prevalence of HL from SR must be evaluated with caution.

Table 2.4 Studies of comparison of self-reported hearing loss with audiometrically measured hearing impairment (continued)

Study/country	Subjects Number Age (mean)	Self-report	Audiometric meas/HI defn	Results	Author comments/ conclusions
Rosdina *et al*, 2010 Malaysia	N: 111 Age: 60-93 (68)	Q: *Do you have hearing loss?*	$PTA_{0.25,0,5\ k,1k,2k,4k,5k}$ > 25 dB	Single question not good for predicting mild HI; better for moderate HI.	If patient denies HL family should be asked for signs of HL.
McCullagh *et al*, 2011 USA	N: 2691 Noise exposed workers (44)	Q: *How good is your hearing?* (4 response options, dichotomised)	3 methods based on different frequency ranges	Low agreement between SR and measured HI. Better at lower frequencies (500, 1k Hz) than higher.	SR is poor measure of actual hearing loss.
Ferrite *et al* 2011 Brazil	N: 188 Age: 30-65 (46)	3 questions including *Do you feel you have a hearing loss?*	$WEHL_{0.5,1k,2k,4k,5k}$ >25 dB	The yes/no question had good sensitivity and specificity.	All questions provided responses accurate enough for use in epidemiological studies when audiometry not available.
Salonen *et al,* 2011 Finland	N: 164 Age: 70-85	HHIE-S Q: *Do you feel you have a hearing loss?*	$BEHL_{0.5,1k,2k,4k}$ > 25, 35, 40 dB	Both SR methods perform well for moderate to severe HL (> 40 dB). Single question as good as HHIE-S.	Both methods reliable for BEHL of 35 dB or more. Either can be used to evaluate the need for audiological rehabilitation in an elderly population.
Rosso *et al,* 2011 Malta	N: 250 (88% male) Age: 19-64 (42)	NIHL questionnaire including Q: *Do you feel you have a hearing loss?*	HL defined across frequency range 0.25 to 8k Hz.	Sensitivity of both methods similar but neither accurate. enough for use for screening for NIHL.	Questionnaire not sensitive enough as screening tool for NIHL.
Hong *et al,* 2011 Canada	N: 403 Construction workers Mean age 43	Q: *How do you rate your hearing*' (5-point rating scale, dichotomised)	3 frequency ranges for PTA, WEHL > 25 dB	Agreement highest at lower frequency range (0.5-3k Hz).	SR useful and valid when audiometry not available but not adequate substitute.
Hannula *et al,* 2011 Finland	N: 850 Age: 54-66 (61)	4 questions including *Do you have any difficulty with your hearing?*	$BEHL_{0.5,1k,2k,4k}$ or $WEHL_{0.5,1k,2k,4k}$ >20 dB Different frequency ranges also investigated.	Relationship between SR and HI is frequency dependent. SR poor at frequencies < 4k, good at 4–8k kHz and at single frequency of 4 kHz.	Measured HL at 0.5 – 4 kHz does not agree well with SR results. Study does not support use of questions alone as screening tool

Table 2.4 Studies of comparison of self-reported hearing loss with audiometrically measured hearing impairment (continued)

Study/country	Subjects Number Age (mean)	Self-report	Audiometric meas/HI defn	Results	Author comments/ conclusions
Ramkissoon and Cole 2011 USA	N: 170 2 age groups: 19-30 (24) & ≥ 45 (62)	Q: *Do you have any hearing or communication difficulties?*	Binaural $PTA_{1k,2k,3k,4k}$ > 25 dB (mild), 40 dB (moderate), 60 dB (severe)	Overall SR prevalence close to measured. Younger subjects over reported HL; middle aged underreported. SR more reliable for moderate to severe HL.	SR suitable for screening in clinical context but should be supplemented by audiometry to identify mild HL.
Kiely *et al*, 2012 Australia	N: 23,001 Age: 45-103 (72)	Pooled data from 7 previous Australian surveys. SR responses dichotomised.	$BEHL_{0.5,1k,2k,4k}$ > 25 dB (mild), 40 dB (moderate), 60 dB (severe)	Moderate associations between SR and audiometric data.	SR not reliable for estimating prevalence of HL although may indicate perceived hearing disability.
Kirk *et al*, 2012 Australia	N: 3335 (defence force personnel) Age:≤64 (33)	Q: *Do you experience any problems with your hearing?*	$PTA_{0.5,1k,2k}$ > 25 dB $PTA_{1k,2k,3k,4k}$>25 dB $PTA_{3k,4k,6k,8k}$>25 dB	SR less effective at identifying high frequency HL.	Usefulness of SR is limited in identifying individuals with HI.
Deepthi & Kasthuri 2012 India	N: 175 Age >60	HHIE-S Q: *Do you feel you have a hearing loss?*	$BEHL_{0.5,1k,2k,4k}$ > 25 dB (mild), 40 dB (moderate), 55 dB (severe)	Both SR methods quite good at identifying those with moderate and marked HL. Single question better than HHIE-S for mild and moderate HL. Overall prevalence underestimated by both methods.	Both SR tools useful in identifying elderly with disabling HL but not mild HL.
Swanepoel *et al*, 2013 Australia	N: 947 Age: 45-65	Q: *Do you have a hearing impairment?*	BE, WE and binaural $PTA_{0.5,1k,2k,4k}$ and $PTA_{4k,8k}$ at various cut off values, plus individual frequencies.	4k Hz most important frequency related to SR. WE $PTA_{0.5,1k,2k,4k}$ > 25 and $PTA_{4k,8k}$ > 35 dB also important.	SR can be useful screen for hearing loss in middle aged people
Diao *et al,* 2014 China	N: 727 Age: 60-86	HHIE-S	$BEHL_{0.5,1k,2k,4k}$ > 25 (mild), 40 (moderate), 60 (severe)	Good correlation between HHIE-S and PTA for moderate to severe HL.	HHIE-S is reliable and valid screening tool for moderate hearing loss in older adults in China.

Table 2.4 Studies of comparison of self-reported hearing loss with audiometrically measured hearing impairment (continued)

Study/country	Subjects Number Age (mean)	Self-report	Audiometric meas/HI defn	Results	Author comments/ conclusions
Kamil *et al*, 2015 USA	N: 3557 Age: ≥ 50	Scaled response on hearing level, dichotomised	$BEHL_{0.5,1k,2k,4k}$ > 25 dB	Association between SR and measured hearing differs across gender, age, race/ethnicity, and education.	Those using SR methods need to be aware of the differences caused by demographic factors. SR may not be a good surrogate measure of objective hearing.
Pierre *et al*, 2015 Sweden	N: 15322 Age: 18-50	4 questions with scaled answers including *How is your hearing?*	In both ears: > 20 dBHL at one or more frequencies	Overall prevalence of PTA hearing loss was lower than that of subjective hearing. Increased association between SR and PTA at lower frequencies.	SR predicted PTA when age, sex, frequency and tinnitus accounted for.
Fredriksson *et el*, 2016 Sweden	N: 55 female obstetrics personnel Age: 22-63 (49)	Questions including *Do you have a hearing loss?*	In either ear: 40 dBHL: ≥1 pure tone threshold ≥40 25/30 dBHL: ≥2 pure tone threshold ≥25 dB or ≥1 pure tone threshold ≥30 dB (0.25 to 8 kHz)	Question on auditory fatigue had best performance in terms of sensitivity and specificity. All questions performed better for moderate than mild HL.	SR may identify moderate but not mild disorder
Choi *et al*, 2016 USA	N: 1669 Age: ≥ 70	Scaled question on hearing ability, dichotomised. Both audiometric & SR data compared with functional outcomes.	$BEHL_{0.5,1k,2k,4k}$ > 25 dB (mild), ≥ 40 dB (moderate or greater),	SR hearing may underestimate associations with objective outcomes (eg physical activity) and overestimate associations with subjective outcomes (eg SR problems).	Epidemiological studies using SR HL in older adults should be interpreted with caution. SR results should not be considered representative of audiometric testing.

Table 2.5 Prevalence estimated by self-reporting and audiometric surveys
(Unless otherwise stated hearing levels are averaged across frequencies 0.5, 1, 2 and 4 kHz)

Study		Audiometry		Self-report	
Authors	**Number Age (mean)**	**Criterion**	**Prevalence %**	**Criterion**	**Prevalence %**
Torre *et al*, 2006 USA	N: 59 Age: 42-88 (62)	$WEHL_{0.5,1k,2k,4k,5k}$ >25 dB	62.7	Single question	57.6
Chang *et al*, 2009 Taiwan	N: 1220 Age: ≥ 65	BEHL > 40 dB	45.5	HHIE-S score ≥ 10	11.6
Rosdina *et al*, 2010 Malaysia	N: 111 Age: 60-93 (68)	$PTA_{0.25k,0,5k,1k,2k,4k,5k}$ > 25 dB	36.9	Single question	24.3
McCullagh *et al*, 2011 USA	N: 2691 (44)	$PTA_{2k,3k,4k}$ > 25 dB in either ear	42	Single question	23.6
Ferrite *et al* 2011 Finland	N: 188 Age: 30-65 (46)	$WEHL_{0.5,1k,2k,4k,5k}$ >25 dB	16.5	Single question	33
Salonen *et al,* 2011 Finland	N: 164 Age: 70-85	BEHL > 25 dB	47.6	Single question	40.1
		BEHL > 40 dB	15.2	HHIE-S > 8	49.4
Rosso *et al,* 2011 Malta	N: 250 (88% male) Age: 19-64 (42)	Presence of NIHL defined across frequency range	68	Single question	26
Hong *et al,* 2011 Canada	N: 403 Construction workers Mean age 43	$WEHL_{0.5-2k}$ >25 dB	11	Single question	37
		$WEHL_{0.5-3k}$ >25 dB	19		
		$WEHL_{4k-6k}$ >25 dB	59		
Ramkissoon and Cole 2011 USA	N: 170 2 age groups: 19-30 (24) & ≥ 45 (62)	PTA > 25 dB	16.5	Single question	15.9
		PTA > 40 dB	5.9		
		PTA > 60 dB	1.2		
Kiely *et al*, 2012 Australia	N: 23,001 Age: 45-103 (72)	BEHL > 25 dB	59 Men 46 Women	Single question (pooled)	56 Men 43 Women
Deepthi & Kasthuri 2012 India	N: 175 Age >60	PTA > 25 dB	46.9	Single question	22.3
		PTA > 40 dB	13.1	HHIE-S score > 8	18.9
		PTA > 55 dB	12		
Swanepoel *et al*, 2013 Australia	N: 947 Age: 45-65	BEHL> 25 dB	5.9	Single question	16.6
		WEHL > 25 dB	14.3		
		BEHL> 20 dB	12		
		WEHL > 20 dB	23		
Diao *et al,* 2014 China	N: 727 Age: 60-86	BEHL > 40 dB	38.8	HHIE-S > 10	22.9
				HHIE-S > 8	34.1
Pierre *et al*, 2015 Sweden	N: 15322 Age: 18-50 (median 32)	HL > 20 dB in both ears at any frequency	4	Single question	16.7
Choi *et al*, 2016 USA	N: 1669 Age: ≥ 70	BEHL > 25 dB	68.3	Single question	50.4

CHAPTER 3 PREVALENCE OF HEARING IMPAIRMENT: GBD, WHO AND EUROTRAK DATA

3.1 INTRODUCTION

This chapter summarises results of large scale studies into the prevalence of hearing loss globally and in Europe, and of its contribution to the global burden of disease.

The first part of the chapter discusses the Global Burden of Disease studies and the contribution of hearing loss to disability adjusted life years and years lived with disability globally. Data from the WHO on the global and European prevalence of hearing loss are also presented. The second part of the chapter presents the most recent results on the prevalence of hearing loss among adults in ten European countries, from Eurotrak surveys.

3.2 GLOBAL BURDEN OF DISEASE STUDIES

Since 1990 the Global Burden of Disease (GBD) studies have been carried out at intervals, bringing together all currently available epidemiological data on disease to provide comparisons of death, prevalence of disease and loss of health over time and across age groups, countries and regions of the world. The GBD studies were initially funded by the World Bank and were carried out by researchers at Harvard and the WHO, with results being published by the WHO. Since 2010 the studies have been coordinated by the Institute for Health Metrics and Evaluation (IHME), based in Seattle and funded by the Bill and Melinda Gates Foundation. Results overall, at global, regional and national levels, and pertaining to particular diseases are published in medical journals, including The Lancet, and on the WHO website.

Detailed results on all diseases in all countries are published on the Institute for Health Metrics and Evaluation GBD website (ghdx.healthdata.org), which can be interrogated to provide data in various different categories (eg by disease, region, country, gender, age etc). Age related hearing loss is in the category 'sense organ diseases', which also includes vision problems. Hearing loss is categorised according to the classifications shown in Table 2.1 in the previous chapter.

The most recently published GBD study, involving around 300 diseases in 195 countries, took place in 2016, overall results and trends occurring since 1990 being reported in The Lancet in September 2017 (Hay *et al*, 2017; Vos *et al*, 2017). Data from the 2017 survey is currently available online on the GBD website.

Health losses are expressed in terms of Years Lived with Disability (YLD) and Disability Adjusted Life Years (DALY), which are defined in the following section.

3.2.1 Years Lived with Disability and Disability Adjusted Life Years

Years Lived with Disability (YLD) are a measure of the numbers of years lived in non-perfect health, due to a particular condition. The YLD figure for a particular condition is obtained by multiplying the prevalence of the condition by a 'disability weight' which reflects the severity of the condition in comparison with other conditions. A disability weight is a number between 0 and 1 where 0 represents a state equivalent to full health and 1 represents a state equivalent to death. Disability weights for various diseases, including hearing loss, have varied over the years of the studies to better reflect the disability caused by a particular condition (WHO, 2017; Salomon *et al*, 2012; 2015). Current disability weights have been based on populations surveys of over 60,000 people and are found to be consistent across locations, income and levels of educational attainment (Hay *et al*, 2017).

Disability Adjusted Life Years (DALY) are the sum of YLD and Years of Life Lost (YLL), that is years lost due to premature death as a result of a particular condition. Hearing loss is considered to be a non-fatal disease and hence the figures for YLD and DALY are the same.

3.2.2 Disability weightings for hearing loss

The different severities of hearing loss (mild, moderate etc) are given different disability weightings to reflect their relative impact upon overall health. The disability weightings for all diseases in the 2010 GBD study were estimated through a large scale empirical investigation involving household and web based surveys of over 30,000 individuals around the world (Salomon *et al*, 2012). However, the estimates of YLD generated by the GBD 2010 study proved controversial (Davis, 2014), with some commentators arguing that disability weights attached to hearing and visual, and other, impairments were underestimated and did not represent the disability caused (Salomon *et al*, 2015). Some disability weightings were therefore adjusted for the GBD 2013 study. To obtain weightings for the 2013 study the data from the 2010 disability weights study was combined with results of a new web based survey of over 30,000 respondents in four European countries (Netherlands, Sweden, Italy and Hungary). Hearing loss was among the diseases for which new weightings were used in the 2013 study (Salomon *et al*, 2015).

Table 3.1 shows the disability weightings for grades of hearing loss for the 2010 and 2013 GBD studies (Salomon *et al*, 2012; Salomon *et al*, 2015). Also shown are the higher weightings for when hearing loss is accompanied by tinnitus.

Table 3.1. Disability weightings for hearing loss for the 2010 (Salomon *et al*, 2012) and 2013 (Salomon *et al*, 2015) studies

Grade of hearing loss	Disability weighting	
	2010	2013
Mild	0.005	0.010
Moderate	0.023	0.027
Severe	0.032	0.158
Profound	0.031	0.204
Complete	0.033	0.215
Mild with tinnitus	0.038	0.021
Moderate with tinnitus	0.058	0.074
Severe with tinnitus	0.065	0.261
Profound with tinnitus	0.088	0.277
Complete with tinnitus	0.092	0.316

It can be seen from Table 3.1 that the disability weightings increased between the 2010 and 2013 studies. This resulted in increased ratings for hearing loss in relation to other diseases in 2013, compared with the 2010 GBD study, more accurately reflecting the impact of hearing loss as a contributory factor to the overall burden of disease. These weightings continued to be used for the 2015 (Vos *et al*, 2016; Kassebaum *et al*, 2016) and 2016 GBD (Vos *et al*, 2017; Hay *et al*, 2017) studies.

3.2.3 DALYs and YLDs due to hearing loss

The figures for global all-age and age-standardised DALYs for all diseases, all sense organ diseases and for age-related and other hearing loss in 2013 (Murray *et al*, 2015), 2015 (Kassebaum *et al*, 2016) and 2016 (Hay *et al*, 2017) are shown in Table 3.2. It can be seen that age related and other hearing loss accounts for 55 to 60% of the sense organ disease DALYs.

Table 3.2 shows that the number of DALYs due to hearing loss has increased since 2013. The 'sense organ disease' category was ranked as the 13th contributory cause of global DALYs in 2013, and 7th in both 2015 and 2016.

Globally, hearing loss was among the five leading causes of YLDs in 2015 (Vos *et al*, 2016) and 2016 (Vos *et al*, 2017).

Table 3.2. Global all-age and age standardised DALYs for all causes, all sense organ diseases and age related and other hearing loss

	All ages DALYs (1000s)			Age-standardised DALYs (per 100,000)		
	2013	2015	2016	2013	2015	2016
All causes	2449810	2464895	2391258	35524	34446	33641
Sense organ diseases	54428	68515	66702	839	1000	959
Age-related and other hearing loss	32580	40597	36288	507	596	524

The 2016 DALYs due to age related hearing loss for each European country (from the GBD website *www.ghdx.healthdata.org*) are listed in Table A1 of Appendix A, together with the 2013 and 2016 rankings of sense organ disease DALYs and hearing loss YLDs for each country.

In almost all European countries the rankings of sense order diseases and hearing loss as contributors to overall DALYs and YLDs increased between 2013 and 2016, as can be seen in Table A1 in Appendix A. In 2016 sense order diseases were ranked in the top five contributory factors to overall DALYs in 50% of European countries, and in the top ten factors in all European countries. Hearing loss was ranked in the top five leading causes of YLDs in 84% of European countries.

3.2.4 Prevalence of hearing loss

The GBD website (ghdx.healthdata.org) publishes prevalence data for all diseases for individual countries and regions. The numbers of people in different age groups, and with hearing loss of different severities, in each country are available. The 2017 online data have been used in Chapter 15 in the calculations of the costs of hearing loss. Prevalence of hearing loss (20 dB and greater) across all ages in each European country is shown in Table A2 in Appendix A.

3.3 WHO PREVALENCE DATA

Over the years, the WHO has published data on various aspects of hearing loss globally and regionally, the current data being based on the latest Global Burden of Disease studies.

3.3.1 Current WHO data

The current (2018) figures relating to global hearing loss on the WHO website (WHO, 2018a) are as follows:

- 466 million have disabling hearing loss (BEHL > 40 dB), that is 5% of the world's population
- 34 million of these are children (BEHL > 30 dB)
- By 2030 the number with disabling hearing loss will be nearly 630 million
- By 2050 it is possible the number could be over 900 million
- Nearly 1 in 3 people over the age of 65 have disabling hearing loss
- 72 million people could potentially benefit from use of a hearing device (eg hearing aid or cochlear implant)

The prevalence of disabling hearing loss among people of all ages and male and female adults (people aged 15 and above) in the WHO world regions is shown in Table 3.3.

Table 3.3 Global prevalence of hearing loss (WHO, 2018a)

	All ages, both sexes		Adults, males		Adults, females	
	Millions	%	Millions	%	Millions	%
High-income region	46.02	4.57	24	5.8	21	4.8
Central/E Europe & Central Asia	34.57	8.36	16	10.2	17	9.5
Sub-Saharan Africa	49.66	4.55	23	7.4	18	5.6
Middle East & North Africa	16.55	3.17	9	4.7	6	3.3
South Asia	131.67	7.37	70	10.7	50	8.0
Asia Pacific	47.04	6.90	24	9.6	19	7.4
Latin America & Caribbean	40.19	6.18	20	8.3	17	6.8
East Asia	100.76	6.85	56	9.1	41	6.9
World	466.46	6.12	242	8.5	190	6.7

3.3.2 Increase in prevalence of hearing loss

The consistent increase in the prevalence of worldwide hearing impairment has been noted by several authors and can be seen by comparing WHO data over the years.

Olusanya *et al* (2014) stated that the global prevalence of hearing impairment more than doubled between 1985 and 1995, from 0.9% of the world's population (42 million) to 2.1% (120 million). In 2012 the WHO estimated that globally there were 360 million people with disabling hearing loss (5.3% of the world's population) of whom 328 (91%) were adults (183 million males and 145 million females). This compares with the current figure of 432 million adults (242 million males and 190 million females) (WHO 2018b; 2018c).

Olusanya *et al* (2014) cite several factors that have contributed to the increase in global prevalence. These include increase in life expectancy, with associated occurrence of presbycusis; improvements in technology for early detection and diagnosis of hearing loss; use of ototoxic medications; diseases such as rubella which can cause hearing loss; and noise induced hearing loss arising from environmental and occupational noise.

Figure 1, reproduced from the WHO, shows global projections of disabling hearing loss until 2050, for all ages.

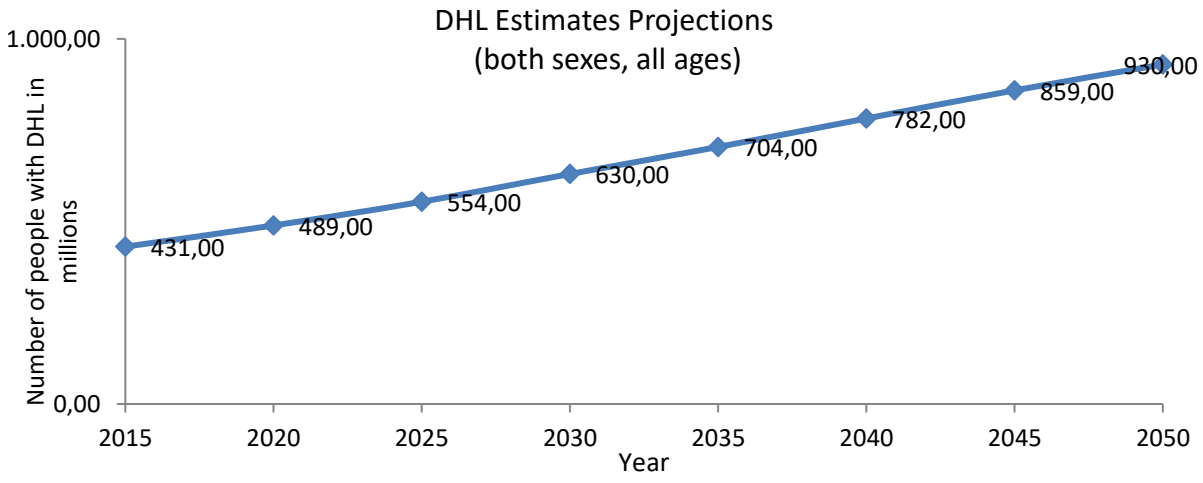

Figure 1. Predicted prevalence of global disabling hearing loss, all ages (WHO, 2018d)

It is likely that the prevalence of hearing impairment in Europe will increase significantly over the next 40 years. According to the WHO, the population of Europe is projected to increase only slightly (to 910 million) by 2020, and to return to current levels by 2050. However, during this period the number of working age people is expected to decline steadily and of older people to increase. The proportion of people aged 65 and over in 2050 is forecast to be almost double that of 2010. Furthermore, with increasing life expectancy, the number of over 85 year olds in Europe is expected to rise to 19 million by 2020, and to 40 million by 2050. It is to be expected that this increase in the ageing population will have a significant impact upon the prevalence of disabling hearing loss in Europe.

3.3.3 Development of WHO data bank on hearing impairment

A data bank recording the prevalence of hearing impairment was established by the World Health Organisation (WHO) under its Programme for the Prevention of Blindness and Deafness and Hearing Impairment (Pascolini and Smith, 2009). The purpose of the data bank was to maintain up to date information on the extent of the global and regional burden of hearing impairment.

The original data were provided by 53 studies in 31 countries in all six WHO regions. These studies were chosen from 3000 studies published since 1980, the majority of which were consistent with the inclusion criteria which are listed in Table 3.4. Only surveys in which the hearing loss data was obtained by audiometric testing, rather than self-reporting, were included. Only six studies in the European region (Denmark, Finland, Italy, Sweden and the UK), published between 1980 and 1998, were chosen for inclusion (Pascolini and Smith, 2009), all of which were discussed in the 2006 Hear It report (Shield, 2006).

Table 3.4. Criteria for inclusion of studies in WHO data bank (Pascolini and Smith, 2009)

Criteria for inclusion in WHO data bank
Studies should be cross –sectional surveys of representative populations
Studies should report results for ‘persons’ not ‘number of ears’
Definitions of hearing impairment should be clearly stated
Studies should report prevalence of bilateral hearing impairment
Study methods should be fully described
Sample should be sufficiently large to give appropriate level of accuracy
Type of audiometric testing, background noise etc should be fully described

Data from 42 of the studies in 29 countries, which were used to inform the 2010 GBD study, were analysed in more detail by Stevens *et al* (2011) to estimate the prevalence of hearing impairment at global and regional levels in 2008. Hearing impairment was defined as a hearing level of 35 dB or more in the better ear. The global figures for male and female adults are shown in Table 3.5, using the GBD hearing loss categories.

Table 3.5. Global prevalence of hearing impairment in 2008 (data from Table 2 in Stevens *et al*, 2011)

		Prevalence of degrees of hearing loss, %					
		Mild	**Moderate**	**Moderately severe**	**Severe**	**Profound**	**Complete**
Male	2444268	22.7	8.4	2.6	0.8	0.2	0.2
Female	2452325	19.0	6.8	2.0	0.6	0.2	0.2

The prevalence of hearing impairment in 2008 reported by Stevens *et al* (2011) in all WHO world regions is given in Table A3 in Appendix A.

In reporting the results of the 2013 GBD study Vos *et al* (2015) presented data on the global prevalence of all forms of hearing loss, including ‘age related and other hearing loss’ and

other types of hearing loss caused by, for example, congenital anomalies or disease, in 1990 and 2013. Table 3.6 shows the prevalence of age-related and other hearing loss, and all types of hearing loss, plus prevalence of different grades of hearing loss (extracted from Vos *et al*, 2015).

Table 3.6. Prevalence of all forms of hearing loss in total (1990 and 2013) and by severity (2013) (data from Table 6 of Vos *et al*, 2015)

	Total (1000s)		**Prevalence by severity in 2013 (1000s)**			
	1990	**2013**	**Mild 20-34 dB**	**Moderate-severe 35-79 dB**	**Profound 80-94 dB**	**Complete >= 95 dB**
Age-related & other hearing loss	726118	1130192	738006	383964	1943	6280
All types of hearing loss	807158	1226420	800710	414514	3209	7687

Table 3.6 enables a comparison to be made between prevalence in 1990 with more recent prevalence data, which further demonstrates the increase in prevalence of hearing loss over the years.

3.4 EUROTRAK SURVEYS

Since 2009 the European Hearing Instrument Manufacturers Association (EHIMA) has carried out surveys approximately every three years to determine hearing status and hearing aid usage in Europe, and to enable trends and comparisons to be made (Hougaard *et al*, 2013; EHIMA 2015). The surveys are carried out by questionnaire and are designed to be comparable with the MarkeTrak surveys carried out in the USA. In 2009 the countries surveyed were Germany, France and the UK; in 2012 surveys were carried out in these three countries and also in Switzerland, Italy, Norway and Denmark. Between 2015 and 2017 surveys were carried out in those seven countries and also in the Netherlands, Poland and Belgium. Surveys were also carried out in Japan in 2012 and 2015.

The surveys comprise questionnaire surveys of a large representative sample of the general population in each country (sample size of typically around 15,000 people in each country) to establish the (self-reported) prevalence of hearing loss, plus more in-depth interviews of smaller samples of people reporting difficulties in hearing (around 1300 in each country) to investigate hearing aid ownership, usage and benefits.

The EHIMA website (*www.ehima.com*) gives results of the surveys of the individual countries. Table A4 in Appendix A shows the number of people surveyed in the most recent survey in each country, plus the number who report being hearing impaired.
The prevalence of self-reported hearing loss in ten European countries and Japan, according to age, taken from the most recent individual country reports on the EHIMA website, is shown in Table 3.7.

It can be seen that there is relative consistency between countries both overall and in different age bands apart from Poland where the rates of self-reported hearing loss in all age groups is considerably higher than in the other nine countries. Conversely, self-reported prevalence in Japan is in general lower than that in all the European countries in all age groups except for the highest (74+).

Table 3.7. Prevalence (%) of self-reported hearing loss according to age, from EuroTrak surveys

	All (18+)	Age groups (years)						
		15-24	25-34	35-44	45-54	55-64	65-74	74+
Belgium****	11.5	2.9	3.7	6.0	9.8	11.7	18.6	33.7
Denmark***	12.1	3.2	5.7	6.2	8.1	12.9	22.5	33.9
France**	11.4	3.2	4.9	5.5	7.9	12.3	18.0	33.0
Germany**	13.9	3.7	5.3	7.2	9.7	15.0	22.3	36.9
Italy**	13.6	4.2	4.9	6.5	8.8	14.8	20.8	37.4
Netherlands***	11.8	3.5	5.2	6.6	9.4	11.8	18.4	35.0
Norway*	10.8	2.6	4.5	4.8	7.5	11.7	19.7	39.5
Poland***	18.3	7.8	9.3	10.4	16.5	21.8	29.6	48.4
Switzerland**	9.5	1.7	2.0	3.6	5.2	10.5	20.1	35.9
UK**	11.7	3.7	3.6	4.7	7.8	12.9	20.4	40.4
Average	**12.5**	**3.7**	**4.9**	**6.2**	**9.1**	**13.5**	**21.0**	**37.4**
Japan**	13.1	2.9	2.5	3.4	7.2	10.3	18.0	41.6

* 2012 ** 2015 ***2016 ****2017

The Eurotrak survey reports also present data on the percentages of those with hearing impairment who have mild, moderate severe or profound hearing loss. The data for all countries is shown in Table 3.8.

Table 3.8. Percentages of hearing impaired with different severities of hearing loss

	Total HI (%)	% of hearing impaired			
		Mild	Moderate	Severe	Profound
Belgium****	11.5	30	42	19	8
Denmark***	12.1	44	37	14	6
France**	11.4	21	52	22	4
Germany**	13.9	35	47	13	5
Italy**	13.6	30	49	18	4
Netherlands***	11.8	32	46	17	6
Norway*	10.8	26	53	16	5
Poland***	18.3	46	32	16	6
Switzerland**	9.5	31	51	14	4
UK**	11.7	30	52	15	4
Average	**12.5**	**33**	**46**	**6**	**5**
Japan**	13.1	40	49	10	2

* 2012 ** 2015 ***2016 ****2017

The UK, Germany and France were all included in the Eurotrak surveys for 2009, 2012 and 2015. The data for the three countries have been pooled in order to examine trends over the years (EHIMA, 2015). The numbers of respondents upon which the results are based in each year in all three countries varies between 43,000 and 45,000. Figures for prevalence over the three surveys, overall and broken down demographically, are given in Table 3.9. The data show that the overall prevalence of self-reported hearing loss has remained relatively stable since 2009.

Table 3.9. Prevalence (%) of self-reported hearing loss in UK, Germany and France (combined) from EuroTrak surveys of 2009, 2012 and 2015 (EHIMA, 2015)

	All (18+)	M	F	Age groups (years)						
				15-24	25-34	35-44	45-54	55-64	65-74	74+
2009	13.1	12.1	9.9	4.3	6.4	7.1	10.5	14.8	21.9	35.8
2012	12.2	11.2	9.4	3.4	4.8	5.7	9.0	13.2	20.6	36.8
2015	12.3	11.1	9.7	3.5	4.6	5.8	8.5	13.4	20.5	36.6

In a joint report for the European Association of Hearing Aid Professionals (AEA), the European Federation of Hard of Hearing (EFHOH) and the European Hearing Instrument Manufacturers Association (EHIMA), Laureyns *et al* (2016) found a strong correlation between the percentages of people reporting hearing loss in Eurotrak surveys and the percentages of populations aged 65 and over. Using this relationship they estimate the percentages and numbers of people with hearing loss in 29 European countries (all EU countries apart from Croatia, plus Norway and Switzerland). Overall, they estimate that 10% of people in these 29 countries of Europe, or 52.4 million people, have self-reported hearing loss. The estimated percentages and numbers for each country are shown in Table A5 in Appendix A.

3.5 CONCLUSIONS

This chapter has summarised results of global estimates of the prevalence of hearing loss and the disability due to hearing problems. It can be seen that, in terms of disability, the global prevalence of hearing loss is increasing and, in the majority of European countries hearing loss is among the top five contributory factors to the overall burden of disease.

The Eurotrak surveys show that, in ten European countries, an average of 12.5% of adults report being hearing impaired, the numbers increasing with age from around 4% in the 15 to 24 year age group to 37% among people aged 75 and over. The WHO predicts that the prevalence in Europe will increase significantly over the coming decades due to changes in the demographic profile of the population, with increasing numbers of elderly and corresponding decreasing numbers of younger citizens.

Research studies of prevalence of hearing loss in individual European countries are summarised in the following chapter.

CHAPTER 4 PREVALENCE OF HEARING IMPAIRMENT: EUROPEAN NATIONAL STUDIES

4.1 INTRODUCTION

This chapter describes studies published since 2005 which have aimed to identify the prevalence of hearing loss in individual European countries. Table 4.1 summarises the studies which are discussed.

As seen in the review of studies by Pascolini and Smith (2009), and also reported by Davis *et al* (2009), there were until recently few detailed and reliable studies of the prevalence of hearing loss in Europe. This was confirmed by Roth *et al* (2011) who, in a review of the literature on age related hearing loss in Europe, highlighted the paucity of information caused by a lack of consistently and well reported epidemiological knowledge and trends. Despite reviewing 24 studies in which both audiometrically assessed and/or self-reported hearing loss were reported, the authors concluded that it was not possible to provide a clear picture of the prevalence of age related hearing loss in Europe. Their broad conclusion from a crude average of the reviewed studies was that, on average, 30% of men and 20% of women in Europe had a hearing loss of 30 dB or more at 70 years of age, and 55% of men and 45% of women at age 80 years.

In recent years, however, as can be seen in Table 4.1, additional studies have been published of the prevalence of hearing loss among particular groups in several European countries, particularly in northern Europe.

Large scale studies have been reported in the UK and in France; studies of smaller samples of the population in some Nordic countries, Spain, Italy and Germany have also been published. Comparison of studies is difficult owing to variations in study samples and methodologies. Some studies assess prevalence using self-reported hearing loss while others use audiological testing including pure tone audiometry. Questionnaire survey methods to identify cases of self-reported hearing loss are also inconsistent, with numbers and details of questions differing between studies. The numbers and ages of subjects in the studies also vary, and some of the reported investigations have involved data originally collected up to 30 years ago. The studies cited in Spain, Italy and Germany report average thresholds of hearing across the frequency spectrum, whereas all the other studies described report the prevalence of hearing loss in terms of numbers and/or percentages of the study sample (sometimes extrapolated to the whole population) experiencing hearing loss.

4.2 PREVALENCE OF HEARING LOSS IN FRANCE

In France a survey of impairment caused by ill health (the 'Handicap-Sante' survey) is carried out every ten years, the most recent being in 2008, with results published in 2014. A more recently published report on the economic impact of hearing loss in France (de Kervasdoue and Hartmann, 2016) presented estimates of prevalence of hearing loss and hearing difficulties which were published by Haeusler and colleagues in 2014 (Haeusler and Mordier, 2014; Haeusler *et al*, 2014). The 2008 survey involved nearly 40,000 participants. The prevalence of hearing loss was estimated from self-reports of use of hearing aids or need of a hearing aid (options available to respondents: 'hearing aid user'; 'non-user but has need of hearing aid'; 'non-user and has no need of hearing aid') and from types of hearing disability reported (deaf/hard of hearing/single sided deafness/tinnitus etc). Those with hearing loss represented about 5% of the population although over 11% reported at least one type of hearing disability. In the 2008 survey disabling hearing was further estimated by assessing the degree of 'auditory functional limitation' (AFL) as defined in Table 4.2.

Table 4.1. European national studies and surveys of prevalence of hearing loss

Country	Authors	Date of data collection	Subjects		Type of testing	
			Number	Age	Self-report	Audiometry
Sweden	Bardel *et al* 2009	Not known	2991 Women	35-64	X	
	Hasson *et al* 2010	2008	11,441	19-70	X	
	Muhr & Rosenhall 2010	2002-2004	839 Men	19-22	X	X
	Rosenhall *et al* 2011	1986-1993	726	70, 75, 85		X
	Pierre *et al* 2012	2004-2008	19,045	20-64	X	
	Pierre *et al* 2015	2009-2012	15,322	18-50	X	X
	Statistics Sweden 2017	2016	>12,000	16+	X	
Finland	Hannula *et al* 2010	2003, 2004	850	54-66		X
Denmark	Burr *et al* 2005	1990, 1995, 2000	4766	18-64	X	
Sweden, Denmark & Finland	Hietanen *et al* 2005	1989-1991	1041/ 1409	75	X	X
France	Haeusler *et al* 2014	2008	~40,000	All ages	X	
	Amieva *et al* 2015	1989-1990	3670	>65	X	
Germany	Von Gablenz & Holube 2016	2010-2012	1752	18-97		X
Spain	Valiente *et al* 2015	2009-2013	175	5-90		X
Italy	Bedin *et al* 2009	Not known	1682	1-95		X
UK	Davis *et al* 2007	1998-1999	32,000	>14	X	X
	Akeroyd *et al* 2014	Estimated prevalence of HL > 35 dB in adults (aged 18-80) - update using prevalence data of Davis (1995)				
	Davis 2014	2012-2013	2 million	Adult	X	
	Dawes *et al* 2014	2006-2010	164,770	40-69	X	Speech in noise test
	ipsosMORI 2015	2014-2015	~850,000	Adult	X	
	Scholes & Mindell 2015	2014	8077	>16	X	X*
	Liljas *et al* 2015	2003	3981	63-85	X	
	Action on Hearing Loss 2015	Estimated prevalence of HL > 25 dB - update using prevalence data of Davis (1995)				
	Banks *et al* 2016	2014-2015	9666	50+	X	X*

*Screening measure at 1 kHz and 3 kHz

Table 4.2. Definitions of severity of auditory functional limitation (adapted from de Kervasdoue and Hartmann, 2016)

Level of AFL	Symptoms
Very severe or total	Subject cannot hear at all a conversation involving several people and reports being deaf in one or both ears or hard of hearing
Severe	Subject has many difficulties hearing a conversation involving several people or cannot hear it at all and declares a hearing impairment other than deafness or hard of hearing
Moderate	Subject has some difficulties hearing a conversation involving several people; or wears hearing aids and can follow conversation without difficulty; or is hard of hearing or deaf in one ear and in need of a hearing aid
Slight	Subject has some difficulties hearing a conversation but does not report a hearing impairment; or has no difficulties hearing a conversation and reports a hearing impairment such as tinnitus but does not use hearing aids

The 2008 survey concluded that 10 million people, that is 16.1% of the population of France, were affected by AFL to some degree, with 5.4 million (8.6% of the population) experiencing moderate to severe AFL. Among the over 50 age group this rises to 10%.

In a study examining use of hearing aids and cognitive decline among adults aged 65 and over in France, Amieva *et al* (2015) reported that, at baseline, of 3670 subjects aged 65 and over, 137 (4%) reported major hearing loss (mean age 81.7 years); 1139 (31%) reported moderate problems (mean age 76.7 years); and 2394 (65%) reported no hearing problems (mean age 73.8 years). Hearing loss was assessed by a short questionnaire which asked the question 'Do you have hearing trouble?' and gave the following possible responses: 'I do not have hearing trouble'; 'I have trouble following conversation with two or more people talking at the same time or in a noisy background'; and 'I have major hearing loss'.

Summary of French studies

The French studies reviewed show that 16.1% of the population of France, or approximately 1 in 6 persons, were hearing impaired in 2008, with 8.6% (10% among the over 50s) experiencing moderate to severe hearing difficulties. In the early 1990s, of those aged 65 and over, 35% reported having moderate to severe hearing problems.

4.3 PREVALENCE OF HEARING LOSS IN SWEDEN

There have been several studies published since 2009 of the prevalence of hearing loss in Sweden.

In 2009 Bardel *et al* published the results of a cross sectional postal questionnaire survey of over 4000 Swedish women aged 35 to 64, in which they asked about the prevalence of 30 symptoms related to well-being, using yes/no answers. Results, analysed across age bands, showed that hearing loss was one of five symptoms whose prevalence increased with age, as shown in Table 4.3.

Table 4.3. Prevalence of impaired hearing across age groups, after adjustment for various factors such as education, mood, smoking (data from Table 2 of Bardel *et al*, 2009)

	Age groups (years)					
	35-39	**40 - 44**	**45 - 49**	**50 - 54**	**55 - 59**	**60 - 64**
No of subjects	426	514	602	541	418	490
Prevalence of HL (%)	9.4	10.9	12.6	14.6	16.8	19.3

Hasson *et al* (2010) published data concerning the prevalence of hearing loss among the Swedish population following a survey of over 11,400 individuals aged 19 to 70. The aim of

the survey was to examine the prevalence of hearing problems, that is hearing loss and/or tinnitus, in relation to age, sex, noise exposure, socio-economic status and lifestyle factors. The survey consisted of a questionnaire which included one question on hearing difficulty: 'How difficult is it for you to (without hearing aid) hear what I said in a conversation between several persons?' to reflect difficulties in communicating. Four possible answers were provided: 'not difficult at all'; 'not very difficult'; 'quite difficult'; very difficult'). The presence of hearing loss was assumed to be represented by the answers 'quite difficult' or 'very difficult'.

The prevalence among working and non-working men and women in different age bands is shown in Table 4.4. Note that results on tinnitus are not discussed here.

Table 4.4. Prevalence (%) of hearing loss across age groups (data from Table 2 of Hasson *et al*, 2010)

	Age groups (years)			
	≤ 40	**41 - 50**	**51 - 60**	**61 +**
Women, working	5	8	12	17
Men, working	6	10	15	25
Women, non-working	4	9	12	15
Men, non-working	3	11	21	27

Muhr and Rosenhall in 2010 published a study of hearing impairment among 839 young Swedish men aged 19 to 22 reporting for military service, as part of an investigation into relationships between self-reported auditory symptoms, measured hearing impairment and noise exposure. A questionnaire asked four questions related to hearing problems, tinnitus and sensitivity to noise. The questions concerning hearing loss asked 'Do you have hearing problems?' and 'Do you experience hearing problems when many people talk simultaneously?'. All four questions had three response alternatives: 'No, not at all', 'Yes, sometimes' and 'Yes, often or always'. Overall, 51% of subjects reported one or more auditory symptoms, including tinnitus and sensitivity to noise. Self-reported rates of hearing problems are shown in Table 4.5.

Table 4.5. Prevalence of hearing problems (%) among young men (data from Table 1 in Muhr and Rosenhall, 2010)

Auditory symptom	**Often/always**	**Sometimes**
Hearing problems	1.7	19.0
Hearing problems when many people talk simultaneously	3.5	33.5

Audiometric testing was performed on all subjects, and hearing impairment was defined as a hearing threshold greater than 20 dB HL in one or both ears and at one or more frequencies between 0.5 and 8 kHz. The prevalence of hearing impairment among subjects was 14.5%.

Another study by Rosenhall and colleagues (Rosenhall *et al*, 2011) investigated types of hearing loss among younger and older subjects aged 70 and over. In total 726 subjects aged 70, 75 and 85 were included in the study, which included pure tone audiometric testing of all subjects. The prevalence of hearing impairment of different severities in the three age groups is shown in Table 4.6.

Table 4.6. Prevalence of hearing impairment among 70, 75 and 85 years olds (data from Figure 1 in Rosenhall *et al*, 2011)

Age	Degree of hearing loss, dB HL			
	26 - 40	41 - 60	61 - 80	> 80
70 years	33.3	5.8	1.1	0
75 years	40.9	21.7	1.5	0
85 years	36.1	40.9	10.7	2

Pierre *et al* (2012) carried out a cross sectional population based study of over 19,000 adults aged 20 to 64 years, in order to investigate the relationship between hearing loss and various socio-economic and demographic factors, using data from four consecutive years, 2004 to 2008, of an annual Swedish survey on living conditions. Self-reported hearing loss was identified through a yes/no question asking whether the respondent had difficulty hearing a conversation between several people. Table 4.7 shows the percentages of men and women across the age groups reporting hearing loss.

Table 4.7. Percentages of men and women across age groups reporting hearing loss (data from Table 1 of Pierre *et al*, 2012)

	Total number	Age group (years)				
		20-24	25-34	35-44	45-54	55-64
Men	9287	5.3	7.2	9.8	13.9	25.0
Women	9758	5.5	5.6	7.6	12.5	15.0

A more recent study by Pierre *et al* (2015) analysed data from surveys carried out between 2009 and 2012 of over 15,000 people aged 18 to 50, in which hearing loss was assessed by the three questions: 'How is your hearing?' (possible answers: 'good''/slightly impaired'/'very impaired'); 'Is it difficult for you to hear when talking with one person in a quiet room?' ('no, not at all'/'sometimes a bit difficult'/'yes, very difficult'); 'Is it difficult for you to hear when talking with several persons at the same time?' ('no, not at all'/'sometimes a bit difficult'/'yes, very difficult'). A fourth question related to tinnitus.

Tables 4.8 and 4.9 show the responses to the questions on hearing difficulties for men (N = 5809) and women (N = 9513).

Table 4.8. Prevalence (%) of self-reported hearing acuity (data from Table 1 of Pierre *et al*, 2015)

Question	Good		Slightly impaired		Very impaired	
	Men	Women	Men	Women	Men	Women
How is your hearing?	81	84.7	18.5	14.8	0.5	0.5

Table 4.9. Prevalence (%) of self-reported hearing difficulties (data from Table 1 of Pierre *et al*, 2015)

Question	No, not at all		Sometimes a bit difficult		Yes, very difficult		No response	
	M	W	M	W	M	W	M	W
Is it difficult to hear when talking with one person in quiet room?	69.6	69.2	2.8	3.7	0	0	27.6	27.1
Is it difficult to hear when talking with several persons at same time?	48.1	47.5	22.4	23.2	1.8	2.3	27.6	27.0

Pure tone audiometry was also performed on all subjects, and hearing loss was defined as a hearing threshold of 20 dB or above at one or more frequencies. The prevalence of hearing impairment was 6% in men and 2.9% in women. Hearing impairment was highly dependent on age and sex and was more common at the higher frequencies, with significant differences between men and women at 3, 4 and 6 kHz.

Data on hearing impairment from the 2016 Swedish survey of living conditions is available on the Statistics Sweden website (*www.scb.se*). The prevalence of hearing impairment is as shown in Table 4.10.

Table 4.10. Prevalence of hearing impairment in 2016 Swedish Living Conditions survey (data from Statistics Sweden)

	Age (years)									
	16-24	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75-84**	**85+**	**16-84**	**All 16+**
All	3.2	8.4	8.4	15.7	24.5	33.8	46.6	55.7	17.8	18.9
Men	2.6	9.3	8.0	19.8	28.0	42.7	53.2	-	20.3	21.1
Women	4.0	7.5	8.8	11.4	20.9	25.3	41.1	54.1	15.2	16.7

It can be seen that, apart from the younger age groups, more women than men report hearing impairment, the incidence for both sexes increasing with age.

Summary of Swedish studies

There have been many studies of hearing loss in Sweden in recent years. However, different survey and reporting techniques make comparison of studies difficult. All show that the prevalence of self-reported hearing loss increases with age, to around 20% among the over 60 age group and rising to 55% among those over the age of 85. In general, the prevalence is higher among men than women. The 2016 figures from the Swedish Living Conditions Survey show that the overall prevalence of self-reported hearing loss among adults (16+) is around 19%. Audiometric testing of subjects over the age of 70 confirmed the steep rise in prevalence in the older age group, with 40% of 70 year olds, 64% of 75 year olds and 88% of 85 year olds having hearing loss greater than 25 dB. Of these, 7% of 70 year olds, 23% of 75 year olds and 54% of 85 year olds have disabling hearing loss greater than 40 dB.

4.4 PREVALENCE OF HEARING LOSS IN FINLAND

A survey of 850 adults aged between 54 and 66 years of age in northern Finland was undertaken by Hannula *et al* (2010). It was found that the prevalence of hearing impairment, defined as a BEHL of 20 dB or greater (averaged over 0.5, 1, 2 and 4 kHz) was 26.7% overall. It was greater among men (36.8%) than women (18.4%); the prevalence for men and women of different degrees of hearing loss in the better ear is shown in Table 4.11.

Table 4.11. Prevalence (%) of BEHL among adults in Finland (data from Table 1 from Hannula *et al* (2010)

	N	**BEHL dB**				
		< 20	**20 - 39**	**40 - 69**	**70 - 95**	**≥ 95**
Men	383	63.2	32.6	3.7	0.5	0
Women	467	81.6	16.5	1.9	0	0
All	850	73.3	23.8	2.7	0.2	0

4.5 PREVALENCE OF HEARING LOSS IN DENMARK

Data from the Danish Work Environment Cohort Study was reanalysed by Burr *et al* in 2005 to investigate smoking and height as possible risk factors for hearing loss. Overall, 7221 employees were included in the study, 3702 men and 3519 women, aged 18 to 59. Hearing loss was assessed by one yes/no question relating to difficulty in following a conversation between several people. The prevalence of self-reported hearing loss among men and women in different age groups is shown in Table 4.12. It can be seen that above the age of 30 prevalence is higher among males than females.

Table 4.12. Prevalence (%) of self-reported hearing loss among employees in Denmark (data from Table 2 in Burr *et al*, 2005)

		Age group (years)			
	Total no.	**18 - 29**	**30 - 39**	**40 - 49**	**50 - 59**
Men	3702	4	7	12	20
Women	3519	4	3	8	10

The figures in Table 4.12 are reasonably consistent with the Swedish data of Pierre *et al* (2012) shown in Table 4.7 and similar to those of Hasson *et al* (2010) for working men and women shown in Table 4.4. The prevalence among men aged 50 to 59 in Table 4.12 is higher than that in Table 4.4, but this may be because the data dates from earlier studies when noise induced hearing loss may have been more common among men of working age.

4.6 PREVALENCE OF HEARING LOSS IN THREE NORDIC COUNTRIES

Hietanen *et al* (2005) report a comparative study of prevalence of hearing impairment and hearing difficulties among 75 year olds in three Nordic cities in Sweden, Denmark and Finland. In total over 1400 subjects participated, as part of the Nordic Research on Ageing (NORA) project. Assessment of hearing was undertaken through both audiometric testing and self-reporting by interviews of subjects. Self-reported hearing difficulties were reported by subjects answering a question on how well they could follow a conversation between three or more people ('with no difficulty'/'with some difficulty'/'with great difficulty'/'not at all'). The prevalence of different degrees of hearing impairment is shown in Table 4.13 and of self-reported hearing difficulties in Table 4.14.

Table 4.13. Prevalence (%) of hearing impairment among 75 year olds in 3 Nordic populations (data from Table 2 in Hietanen *et al*, 2005)

	BEHL dB									
	< 21		21 - 39		40 - 69		70 - 94		>94	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
Denmark	20.9	29.0	52.8	47.7	26.4	23.3	-	-	-	-
Sweden	8.0	33.9	58.0	49.5	34.1	16.5	-	-	-	-
Finland	10.2	24.5	57.1	56.4	30.6	18.1	2.0	1.1	-	-

Table 4.14. Prevalence (%) of hearing difficulties among 75 year olds in 3 Nordic populations (data from Table 4 in Hietanen *et al*, 2005)

	Total number		No difficulty		Minor difficulty		Considerable difficulty		Unable to hear	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
Denmark	198	213	58.1	62.9	35.4	30.0	6.1	7.0	0.5	-
Sweden	136	173	43.4	72.3	43.4	22.0	11.8	4.6	1.5	1.2
Finland	109	212	58.7	63.2	39.4	31.1	1.8	4.7	-	0.9

It can be seen from Table 4.13 that the prevalence of moderate hearing impairment varied between 26% and 34% in men, and between 17% and 23% in women. The corresponding figures reported by the authors for the prevalence of self-reported hearing difficulties were 41% to 57% for men, and 28% to 37% for women.

The authors concluded that the prevalence of hearing impairment among 75 year olds was fairly similar in the three countries and that self-reported hearing problems were broadly in agreement with the audiometric test results.

4.7 OTHER STUDIES IN GERMANY, SPAIN AND ITALY

Authors of studies of hearing loss in Germany (von Gablenz and Holube, 2016), Spain (Valiente *et al*, 2015) and Italy (Bedin *et al*, 2009) have published results as hearing thresholds across frequencies in different age groups. All three studies involved audiometric testing of subjects but the results are presented differently in each case. It is therefore difficult to compare these results with each other and with the prevalence data from other studies discussed above, so detailed results are not presented here.

An aim of the German study, involving over 1700 adult subjects aged 18 to 97, was to investigate the impact on results of restricting testing to an otologically normal subgroup. The study by Valiente *et al* (2015) was much smaller, involving 175 subjects aged 5 to 90; the authors comment on the lack of surveys in Spanish and other Mediterranean populations. The German study found that the decrease in hearing sensitivity at high frequencies was more pronounced in males than females, but the Spanish study found no statistically significant differences between males and females in any age group or at any frequency (this may be due to the relatively small sample number in the Spanish study).

The Italian study of hearing thresholds among four genetically isolated villages (Bedin *et al*, 2009), aimed to investigate the role of genetic factors in hearing loss. The number of subjects was similar to that in the German study (1682, all ages) but, as in the Spanish study, no significant difference was found between males and females over the age of 40.

4.8 PREVALENCE IN THE UK

4.8.1 Prevalence data from Davis and colleagues

Several large scale epidemiological studies on hearing loss have been carried out in the UK and have been reported by Davis and colleagues (Davis *et al*, 2007; Davis *et al*, 2009; Davis 2014). Data from these studies have been used in several reports published in recent years concerning the prevalence of hearing loss and the provision of hearing aids in the UK. The focus of many of these reports has been the prevalence of hearing impairment among the elderly population, and the corresponding impact of demographic changes on the required provision and support for hearing impaired people over the coming years.

As reported by Roth *et al* (2011) and Davis *et al* (2009), there have been few large-scale prevalence studies, the reason being that they are costly and complicated and hence more likely to be carried out in managed public health economies (Davis *et al*, 2009). However, Davis *et al* (2009) consider that data from recent well managed UK surveys will be applicable to populations in other developed health economies. It is therefore reasonable to assume that prevalence data from UK studies could be applicable elsewhere in Western Europe.

Much of the recent information on prevalence in the UK has been derived by updating, using current demographic data, the findings of the original National Study of Hearing (NSH) which

was carried out in the 1980s (Davis, 1995) and showed that around 20% of the population had a hearing loss in their better ear of 25 dB or more (Davis *et al*, 2009). Results of the NSH were summarised in the 2006 Hear It report (Shield, 2006). The threshold of impairment in these UK studies was taken to be a hearing loss of 25 dB or greater in the better ear (averaged over the frequencies 0.5, 1, 2 and 4 kHz). Davis *et al* (2009) concluded that one in six of the European population is affected by hearing loss and that this figure will rise to one in four by 2050.

The NSH data were updated in a National Health Service Health Technology Assessment (HTA) of the costs and benefit of early screening for hearing disability (Davis *et al*, 2007). The assessment included a large-scale population study involving around 34,000 people over the age of 14 and audiological screening of a smaller sample. Postal questionnaires were sent to over 26,000 randomly selected households in England, Wales and Scotland in 1998. The questionnaires contained around 50 questions relating to hearing difficulty in different situations, use of hearing aids, other ear, nose and throat problems and demographic information. Approximately 32,000 valid responses, weighted by age and gender to reduce bias, were available for analysis.

Almost one-fifth of the sample reported having difficulty with their hearing while, overall, 31% reported some degree of hearing difficulty in at least one listening situation; this figure increased to 45% among 55 to 74 year olds. The percentages reporting at least one hearing problem across age groups are shown in Table 4.15.

Table 4.15. Prevalence (%) of people reporting hearing problems across age groups (from Table 12 of Davis *et al*, 2007)

	Age group (years)			
	14-34	**35-54**	**55-74**	**≥ 75**
Male	14.4	33.3	54.1	68.2
Female	16.1	26.3	36.4	55.7
Overall	15.3	29.6	45.1	61.1

The HTA study focused on the 55 to 74 years age range. Within this age group 12% reported having a hearing problem that caused moderate or severe worry, annoyance or upset. Using a criterion of 35 dB hearing loss in the better ear as representing a significant hearing loss it was found that 14% of this age group (11% female, 17% male) were significantly impaired.

Table 4.16 shows the percentages of the population in different age groups within this age range with a hearing loss of 35 dB or greater in either ear. In terms of a criterion of 25 dB hearing loss, prevalence rates are small up to the age of around 45 years; after the age of 50 years prevalence is greater than 10%; and reaches nearly 50% in the 70 to 74 age range. The median better ear average increases by about 2.5 dB per decade in the 20 to 40 age range, and by up to 10 dB per decade in those aged 60 to 80 years (Davis *et al*, 2009).

Table 4.16. Prevalence (%) of population in 55 to 74 age group with hearing loss (average of 0.5, 1, 2 and 4 kHz) of 35 dB or more (from Figure 57 of Davis *et al*, 2007)

Overall			**Age group (years)**			
All	**Male**	**Female**	**55 – 59**	**60 – 64**	**65 – 69**	**70 -74**
14	17	11	4	6	15	25

Davis and Smith (2013) state that, in England, 10% of individuals aged 18–80 years, or 4.9 million, have a moderate level of hearing loss (>35 dB HL in the better hearing ear averaged across 0.5 to 4 kHz) that would greatly benefit from hearing aids or other forms of hearing

management. The breakdown of the numbers of adults (aged 18 to 80) in England with differing severities of hearing loss, and cumulatively, is shown in Table 5.17.

Table 4.17. Numbers of people in England with varying severities of hearing loss (from Table 1 of Davis and Smith, 2013)

	Severity of hearing loss			
	Mild	**Moderate**	**Severe**	**Profound**
Number	5804578	2735013	1847909	388082
Cumulative number	10775582	4971004	2235991	388082

The 1995 data on numbers of people with a hearing loss of 35 dB in their better ear (Davis, 1995) have also been updated by Akeroyd *et al* (2014) using the population estimates provided by the 2013 census of England, Wales and Scotland, as shown in Table 4.18.

Table 4.18. Expected numbers of adults (aged18-80) with hearing loss (better ear average of at least 35 dB) in England and Wales and Scotland (data from Akeroyd *et al*, 2014)

Age	**Prevalence (%)**		**England and Wales (number)**		**Scotland (number)**		**Total number**
	Females	**Males**	**Females**	**Males**	**Females**	**Males**	
18-30	0.6	0.1	29500	5000	3000	500	38000
31-40	1.2	1.7	45000	63000	4000	5500	117500
41-50	3.7	4.3	152500	173500	15500	17000	358500
51-60	5.3	10.7	178000	351500	18500	36500	584500
61-70	13.3	19.7	399500	563000	40000	55000	1057500
71-80	38.8	41.5	803500	732000	83500	70000	1689000
Total			**1608000**	**1888000**	**164500**	**184500**	**3845000**

The estimate of 3.8 million adults aged 18 to 80 with a hearing loss of at least 35 dB in their better ear corresponds to 1 in 12 of the population. The original calculation by Davis (1995) using 1994 population data was 3.4 million, suggesting an increase of around 12% over two decades. Akeroyd *et al* also estimate that 7.5 million people in England, Scotland and Wales have a hearing loss of at least 25 dB, and 2.7 million have greater than 40 dB hearing loss, that is 1 in 6 and 1 in 17 of the population respectively.

4.8.2 Prevalence data from Action on Hearing Loss

The Commission on Hearing Loss was set up to investigate the challenges posed by age related hearing loss in the UK. The final report of the Commission (Commission on Hearing Loss, 2014) quotes data from the 2011 Hearing Matters report published by Action on Hearing Loss (2011). This stated that in 2011 hearing loss (of 25 dB and above) affected 10 million people in the UK (that is, 1 in 6 of the population) and predicted that by 2031 14.5 million people would be affected, that is nearly 20% of the population. The Commission on Hearing Loss quotes corresponding figures for those with a hearing loss of at least 35 dB and predicts an increase from 6 million in 2014 to over 10 million by 2037.

In 2015 Action on Hearing Loss published a new edition of the Hearing Matters report with updated figures on the prevalence of hearing loss (Action on Hearing Loss, 2015). The report states that in 2015 11 million people in the UK had hearing loss, and predicted that by 2035 15.6 million people would be affected. That is the rate of hearing loss would increase from 1 in 6 to 1 in 5 of the population by 2035.

Table 4.19 shows the estimates of people with all levels of hearing loss (that is, hearing loss greater than 25 dB) in each age group. These figures have been derived by applying 2015 population estimates from the Office of National Statistics to the original prevalence data of Davis (Davis, 1995).

Table 4.19. Estimated numbers of adults with hearing loss of 25 dB and above in the UK using population estimates for 2014 (Action on Hearing Loss, 2015)

Age group	England	N Ireland	Scotland	Wales	UK
17-29	158000	5500	15500	9000	188000
30-39	199000	6500	18500	10000	234000
40-49	625500	21000	62500	34000	743000
50-59	1305000	44500	142500	77000	1569000
60-69	2101500	65000	221500	135500	2524000
70-79	2395500	75500	251000	157000	2879000
80+	2434500	68500	232000	152000	2887000
All ages*	**9235000**	**287500**	**945000**	**575500**	**11043000**

*includes those under the age of 17

Tables 4.20 and 4.21 show the 2010 and 2014 estimates respectively for hearing loss of 25 dB and above, and 35 dB and above estimated by Action on Hearing Loss (2011;2015).

Table 4.20. Prevalence of hearing loss in the UK across age groups in 2010 (data from Hearing Matters, Action on Hearing Loss, 2011)

Hearing loss	Age groups (years)				
	16-49	50-64	65-79	80+	Total
BEHL ≥ 25 dB	1,157,500	2,563,500	3,768,000	2,622,500	10,111,500
BEHL ≥ 35 dB)	522,000	1,017,000	2,293,500	2,288,000	6,120,500

Table 4.21. Prevalence (1000s) of hearing loss in the UK across age groups in 2014 (data from Hearing Matters, Action on Hearing Loss, 2015)

Hearing loss	Age groups (years)							
	17-29	30-39	40-49	50-59	60-69	70-79	80+	All*
BEHL ≥ 25 dB	188	234	743	1,569	2,524	2,879	2,887	11,043
BEHL ≥ 35 dB	44	117	362.5	647.5	1,080.5	1,909.5	2,518.5	6,699.5

*includes under 17 year olds

4.8.3 Patient surveys

More recent information on the prevalence of hearing loss in the UK has been provided by the GP Patient Surveys of England carried out in 2012 and 2013 and reported in the 2014 Chief Medical Officer's report (Davis, 2014). The paucity of data is again noted by Davis. The data provided by the GP surveys, from surveying nearly 2 million patients, showed that, among all adults 5% reported having been diagnosed with 'deafness or severe hearing impairment' or 'blindness or severe visual impairment'. This figure increased to 11% among those aged 55 or above, with around 9% of this age group reporting deafness, 2% blindness and 1% both. The survey showed considerable variation in the prevalence of deafness among the over 55s between the regions of England, the highest being in the north-east. It is purported that this may be due to the concentration of noisy industry in this area in the past. A relationship between deafness and socio-economic deprivation was also found.

The summary report on the 2015 GP surveys (ipsos MORI, 2015) gave the percentages of people who reported deafness or severe hearing impairment each year since 2012. The overall figure is consistent, varying between 3.9% and 4% of respondents.

4.8.4 Health Survey for England

Prevalence of hearing impairment in England was determined from the most recent health survey of England which is carried out every few years to monitor the nation's health (Scholes and Mindell, 2015). The survey investigates health, social care and lifestyles

among adults and children. The 2014 survey, which involved a questionnaire survey of 8077 adults, was the first to include questions on, and testing of, hearing loss. Respondents were asked about hearing aid use, and were asked to rate their hearing difficulty in the following three circumstances: conversing with one person in a quiet room; conversing with several people in a group; and following TV programmes at a volume acceptable to others. An objective hearing test, which consisted of screening hearing acuity at 1 kHz and 3 kHz, was conducted on 5339 participants during a home visit from a nurse.

Results of the self-reporting survey were as follows: 19% of men and 17% of women reported hearing difficulties, the prevalence increasing with age being 71% of men and 59% of women aged 85 and over. Occurrence of moderate or worse difficulty in the three situations was as follows: conversing with one person 4% men, 3% women; conversing in a group 9% men, 7% women; following TV programmes 7% men, 6% women.

In the objective survey 14% had hearing loss at 1 kHz: 10% were unable to hear a tone at 1 kHz at a level of 20 dB, while 4% were unable to hear the tone at 35 dB. At 3 kHz 13% had hearing loss. Prevalence at 3 kHz was similar for men and women except in the age group 65 to 84 where the it was higher for men than for women. 69% of subjects had some hearing loss at at least one frequency in at least one ear.

4.8.6 UK Biobank data

The UK Biobank is a health resource which recruited 500,000 people aged between 40 and 69 years in 2006-2010 to provide ongoing health and demographic data with the aim of investigating the development of diseases. A subset of almost 165,000 participants completed a speech in noise test to examine their hearing acuity which was classified as 'normal', 'insufficient' and 'poor' (Dawes *et al*, 2014). Overall 10.7% of participants had significant hearing impairment; the breakdown of prevalence of hearing disability in the better ear by age is shown in Table 4.22 (Dawes *et al*, 2014 (supplementary tables)).

Table 4.22 Prevalence (%) of hearing disability in the better ear by age (Dawes *et al*, 2014)

Hearing	Age group (years)						
	40-44	45-49	50-54	55-59	60-64	65-69	Overall
Normal	94.28	93.4	92.22	89.59	84.52	77.95	89.28
Insufficient	4.98	5.72	6.91	9.15	13.24	18.58	9.23
Poor	0.74	0.88	0.87	1.26	2.24	3.47	1.48

4.8.5 British Regional Heart Study (BRHS)

In analysing data from the BRHS to investigate associations between self-reported sensory impairments and various social and health factors, Liljas *et al* (2015) report the prevalence of self-reported hearing impairment by age among approximately 4000 British men aged 63 to 85 years, as shown in Table 4.23.

Table 4.23. Prevalence (%) of hearing impairment by age among British men aged 63 to 85 years (Liljas *et al*, 2015)

Age (years)	< 70	≥70 to < 75	≥75 to < 80	≥ 80	Total
% HI	21	26	37	40	27

The prevalence figures in Table 4.23 are considerably lower than the figures of Davis *et al* (2007) for self-reported hearing difficulties shown in Table 4.15. A possible reason is that the questions on hearing in the survey by Liljas *et al* were very much simpler than the more detailed probing provided by the questionnaire of Davis *et al* (2007).

4.8.7 English Longitudinal Study of Ageing (ELSA)

The ELSA has been collecting and analysing data on many aspects of life, including health, employment, income and social life among people aged 50 and over in England since 2002. Data collection is through interviews, physical measurements and self-assessment questionnaires. The most recently published ELSA data was that of Wave 7, collected in 2014/5, and published in 2016 (Banks *et al*, 2016). Wave 7 was the first to include an objective hearing screening test, as well as self-reported assessments of hearing. The objective test consisted of testing hearing acuity at 1 kHz and 3 kHz; performance of the better ear was used to classify hearing acuity as 'good', 'mild difficulty' or 'moderate to severe difficulty'. Self-reported hearing was classified in five categories, from 'poor' to 'excellent'.

Objective and self-reported hearing acuity by age group and gender in Wave 7 is shown in Table A5 in Appendix A. Results are summarised (by the author) in Table 4.24 in which 'hearing impairment' includes, for objective results, those with mild and moderate/severe difficulty, and, for self-reported assessment, those reporting their hearing as being 'fair' or 'poor'.

Table 4.24. Prevalence of objective and self reported hearing impairment by age group and gender from Wave 7 of ELSA (data from Banks *et al*, 2016)

Hearing impairment	Age in 2014-15							
	50-54	55-59	60-64	65-69	70-74	75-79	80+	All
MEN								
Objective screening	17.7	18.4	26.2	36.5	47.4	58.1	83.3	35.5
Self-reported	17.7	18.0	24.3	26.4	30.8	36.6	44.9	26.1
WOMEN								
Objective screening	13.2	16.4	17.6	26.6	37.0	52.1	75.8	31.1
Self-reported	12.5	8.7	11.0	16.5	15.8	23.5	33.8	16.7

It can be seen from the table that the prevalence of both self-reported and measured hearing impairment increases significantly with age, with around 80% of subjects over the age of 80 being objectively assessed as being hearing impaired. Fewer women than men are hearing impaired in all age groups. The self-reported prevalence for men is similar to that found by Liljas *et al* (2015) as seen in Table 4.23. Table 4.24 shows that the discrepancy between measured and self-reported hearing difficulty increases with age; comparisons of measured and self-reported hearing loss were discussed in Chapter 2, which showed that, in older age groups self-reporting underestimates the prevalence of hearing impairment.

Summary of UK data

As with other countries, comparison of surveys in the UK is difficult owing to different survey techniques, subject groups and reporting methods. However, some general conclusions can be drawn.

It has been estimated, by applying the original prevalence rates of Davis (1995) in different age groups to current and future population estimates, that there are currently around 1 in 6 people in the UK (that is, 16.7%) with hearing loss of 25 dB or greater, and that by the mid-2030s the rate will rise to around 1 in 5, or 20%. The prevalence rises steeply with age, being over 10% above the age of 50 and over 50% above the age of 70. Between 8% and 10% of adults are currently estimated to have hearing loss of 35 dB or greater. Rates of both self-reported and measured hearing impairment increase rapidly with age, as does the difference between prevalence based upon self-reporting and objective surveys

4.9 DISCUSSION

As shown in this chapter, in recent years there have been many European studies of the prevalence of hearing loss, most of which have involved populations in northern Europe. Many of the studies have focussed on particular subject groups, often restricting the analysis to specific age groups. Some studies have used self-reported data only, some have used audiometric data or other forms of objective measurement and some have been based upon both objective and subjective measures. Several UK authors have applied the prevalence rates from the UK National Study of Hearing (Davis, 1995) to population estimates to derive current and future prevalence figures for the UK.

The variations in methods used, types of subjects, ages of subjects and definitions of hearing loss make it difficult to make detailed comparisons of the results. However certain consistent patterns can be observed.

The results of the reviewed studies are summarised in Table 4.25. Results of objective measurement surveys are shown in italic.

Both self-reported and objective surveys show that prevalence of hearing loss and hearing difficulties increases significantly with age. The prevalence of self-reported hearing difficulties increases from around 4% to 5% at age 20 (Burr *et al*, 2005; Hasson *et al*, 2010; Pierre *et al*, 2012) to approximately 20% at age 60 (Bardel *et al*, 2009; Hasson *et al*, 2010; Pierre *et al*, 2012; Liljas *et al*, 2015; Banks *et al*, 2016). Figures for self-reported hearing impairment increase among the older age groups but are less consistent, with around 65% of those over the age of 85 reporting hearing difficulties in one survey (Scholes and Mindel, 2015). However, as discussed in Chapter 2, self-reporting of hearing difficulties as an indicator of actual hearing problems becomes increasingly unreliable as the age of subjects increases.

A similar pattern to that shown in the self-reporting surveys is demonstrated by surveys of objectively measured hearing loss, prevalence increasing with age to around 80% of people aged 80 and above. Those studies which have analysed data by gender have shown that the prevalence of hearing loss is higher among men than women, the difference in general increasing with age and being particularly evident in the over 50 age group.

Two large scale studies of hearing loss have been carried out in France (de Kervasdoue and Hartmann, 2016) and the UK (Davis *et al*, 2009). The results of both studies are consistent. It is estimated that 16.1% of the population of France is affected by auditory dysfunction; this figure agrees closely with the conclusion by Davis *et al* (2009) that one in six of the European population is currently affected by hearing loss.

However, as discussed by Pierre *et al* (2015) other data on hearing loss prevalence are in general conflicting. Several studies have found a continuous increase in the prevalence of audiometrically assessed hearing loss over the past 30 years with particular concern that hearing loss is increasing due to greater leisure time noise exposure. However other studies have shown that the prevalence of hearing loss is stable or less than it was in the past. Pierre *et al* (2015) cite two American studies published in 2010, one of which found that older adults had better hearing than in previous generations (Zhan *et al*, 2010) and the other that hearing thresholds of Americans aged 25 to 64 were equal to or better than they were 40 years ago (Hoffman *et al*, 2010). Suggested possible reasons are improved economic and social welfare, better medical care for children and reduced occupational noise exposure.

Table 4.25. Summary of results of European prevalence studies

Country	Author(s)	Age	Summary of results
Sweden	Bardel *et al* 2009	35-64	Overall prevalence 13.9%, from 9% (age 35-39) to 19% (age 60 -64)
	Hasson *et al* 2010	19-70	From 4.5% (age 19-40) to 21% (age >60)
	Muhr & Rosenhall 2010	19-22	21% have hearing problems
	Rosenhall *et al* 2011	70, 75, 85	*Prevalence of HL > 25 dB: 40% at age 70; 64% at age 75; 88% at age 85*
	Pierre *et al* 2012	20-64	From ~5.4% (age 20-24) to ~20% (age 55-64)
	Pierre *et al* 2015	18-50	~17% impaired (~16% slightly, 0.5% very impaired) *Prevalence of HL > 20 dB: 6% in men, 2.9% women*
	Statistics Sweden 2016	16+	Overall prevalence 19%, from 3% (age 16-24) to 56% (>84)
Finland	Hannula *et al* 2010	54-66	*Prevalence of HL > 20 dB: 27% (24% 20-39 dB HL; 3% HL > 40 dB)*
Denmark	Burr *et al* 2005	18-59	From 4% (age 18-29) to ~15% (age 50-59)
Sweden, Denmark & Finland	Hietanen *et al* 2005	75	Similar in all 3 countries: *26-34% of men and 17-23% of women had moderate HI (40-69 dB HL).* 41-57% men, 28-37% women had hearing difficulties.
France	Haeusler *et al* 2014	All ages	HL: 15%; At least 1 hearing disability: 11%; some degree of auditory disability: 16.1%; mod/severe auditory disability: 8.6% (10% of over 50s).
	Amieva *et al* 2015	>65	35% have moderate to severe hearing problems: 4% major, 31% moderate
UK	Davis *et al* 2007 (also Davis *et al* 2009)	>14	Difficulty hearing: 20%; in at least one listening situation: 31% (15% aged 14-34, 61% aged >74); 12% of 55-74 year olds have moderate-severe hearing difficulty. *Prevalence of HL > 35 dB: 14% aged 55 to 74 (4% aged 55-59 to 25% aged 70-74).* *Prevalence of HL > 25 dB: 10% over age of 50, nearly 50% aged 70 -74. Increases per age decade: ~ 2.5 dB from 20 to 40, up to 10 dB from 60-80.*
	Akeroyd *et al* 2014	18-80	1 in 12 adults have HL > 35 dB HL; 1 in 6 > 25 dB HL; 1 in 17 > 40 dB HL.
	Davis 2014	Adult	5% diagnosed with sensory impairment; 10% of those aged 55 and over diagnosed with hearing impairment. .
	Dawes *et al* 2014	40-69	*Overall 10.7% had significant hearing impairment, from 5.7% age 40-44 to 22% age 65-68*
	ipsosMORI 2015	Adult	Around 4% of respondents to GP surveys diagnosed with hearing impairment in each year 2012 to 2015.
	Scholes & Mindell 2015	>16	~18% have hearing difficulties; ~65% of those over 85. *14% had HL at 1 kHz, 13% at 3 kHz.*
	Liljas *et al* 2015	63-85	27% of men aged 63 to 85 have hearing impairment (21% of those < 70 years, 40% of those > 80 years)
	Action on Hearing Loss 2015	All	In 2014 11 million people in UK, 1 in 6, had HL of 25 dB and above. By 2035 the rate will be 1 in 5.
	Banks *et al* 2016	50+	~21% are hearing impaired (~16% aged 50-54 to ~40% aged 80+). *~34% have objective HL (~16% aged 50-54 to ~80% aged 80+)*

Nevertheless, in future, the changing age profile of the population, with a greater proportion of older citizens, means that the prevalence of hearing loss in Europe is likely to increase in the coming decades. Furthermore, although the prevalence of different severities of hearing loss may remain approximately constant in particular age groups, the increasingly ageing population means that there will be increasing numbers of people with the more severe grades of hearing loss, thereby increasing the economic and societal burden of hearing impairment.

4.10 SUMMARY OF PREVALENCE RATES FOR EUROPE

As has been seen some of the recent UK studies used the prevalence rates of Davis (1995), applied to recent population data, to calculate current and future prevalence of hearing loss in the UK. By examining the summary results shown in Table 4.25, and the survey results in the previous sections of this chapter, it can be seen that, in recent studies where audiometric surveys have been carried out, the results across age groups are in broad agreement with the prevalence rates for differing levels of hearing loss found by Davis (1995). Thus, it appears that the prevalence rates of Davis (1995), shown in Table 4.26, are still valid.

Table 4.26. Prevalence (%) of 20 dB, 25 dB and 35 dB BEHL (Davis, 1995)

Age range	BEHL		
	> 20 dB	≥ 25 dB	≥ 35 dB
18-30	2.6	1.8	0.4
31-40	5.6	2.8	1.4
41-50	13.5	8.4	4.0
51-60	28.8	18.9	7.8
61-70	50.8	36.8	16.2
71-80	74.0	60.3	40.0

Furthermore, as stated in section 4.8.1, as Davis *et al* (2009) consider that data from well managed UK surveys are applicable elsewhere with developed health economies, it is reasonable to assume that results of recent UK surveys are applicable elsewhere in Europe. Indeed, it has been shown in sections 4.2 and 4.8.1 that there is close agreement between current prevalence estimates in France and the UK, confirming that the prevalence rates of Davis (1995) may be applied to other European countries.

4.11 CONCLUSIONS

It has been seen that, although there have been several subjective surveys of hearing loss in European countries in recent years, there are few recent objective surveys. The surveys that have been carried out have varied in the subject groups involved and methodologies making it difficult to compare results and draw overall conclusions. Furthermore, the majority of surveys have been carried out in northern Europe and involved relatively small numbers of subjects. The Eurotrak surveys discussed in the previous chapter show that while there is general consistency between surveys in Western Europe, a different pattern is evident in the results of the Eurotrak survey of Poland.

All surveys show that prevalence of both self-reported and measured hearing impairment increases with age, with relative good consistency between results of objective surveys.

The data also show that the prevalence data of the UK National Study of Hearing by Davis (Davis, 1995) are still valid, and are relevant across Europe.

APPENDIX A

Table A1. Countries of Europe: 2016 DALYs due to age related hearing loss (WHO, 2018a), 2013 and 2016 rank orders of DALYs for sense order diseases (SOD) (Murray *et al*, 2015; Hay *et al*, 2017) and YLDs for hearing loss (HL) (Vos *et al*, 2015; 2017)

Country	2016 DALYs (1000s)	Rank order			
		SOD (DALYs)		HL (YLD)	
		2013	2016	2013	2016
Albania	24.5	8	4	6	4
Andorra	-	4	5	5	4
Austria	66.2	6	4	6	5
Belarus	85.3	8	5	3	4
Belgium	91.2	9	6	8	4
Bosnia & Herzogovina	37.8	8	6	4	4
Bulgaria	75.7	9	4	4	3
Croatia	42.6	5	6	2	3
Cyprus	5.9	6	7	8	5
Czech Rep	96.5	6	5	4	4
Denmark	29.0	-	10	9	7
Estonia	13.3	6	5	3	4
Finland	34.9	8	8	6	7
France	538.7	6	5	6	4
Germany	872.7	4	3	2	2
Greece	105.1	7	6	5	3
Hungary	94.0	7	6	4	4
Iceland	2.0	5	6	9	5
Ireland	26.8	8	6	9	7
Israel	44.7	8	4	6	5
Italy	613.4	4	4	5	3
Latvia	20.7	4	4	2	4
Lithuania	29.5	5	6	3	3
Luxembourg	3.5	8	7	7	7
Macedonia	16.9	7	7	4	4
Malta	3.3	6	5	7	4
Moldova	33.4	6	4	3	3
Montenegro	5.3	6	5	4	4
Netherlands	122.7	8	6	7	5
Norway	29.0	-	8	7	7
Poland	348.8	7	6	4	4
Portugal	91.9	7	5	5	5
Romania	187.6	6	5	4	4
Russia	1246.5	8	7	3	4
Serbia	86.3	7	6	3	4
Slovakia	44.1	6	5	4	4
Slovenia	18.7	6	5	3	4
Spain	413.0	9	4	6	3
Sweden	66.8	7	7	5	6
Switzerland	58.2	7	5	6	4
Ukraine	447.7	6	4	3	4
UK	510.5	7	6	6	3

Table A2. Countries of Europe: prevalence of hearing loss ≥ 20 dB, all ages: 2017 GBD data (1000s, to nearest 1000)

Country	Prevalence
Albania	636
Andorra	15
Austria	1849
Belarus	2341
Belgium	2360
Bosnia & Herzogovina	867
Bulgaria	1995
Croatia	1169
Cyprus	219
Czech Rep	2809
Denmark	1164
Estonia	353
Finland	1138
France	13871
Germany	19002
Greece	2430
Hungary	2616
Iceland	59
Ireland	819
Israel	1318
Italy	14467
Latvia	537
Lithuania	778
Luxembourg	106
Macedonia	510
Malta	93
Moldova	876
Montenegro	147
Netherlands	3493
Norway	995
Poland	9758
Portugal	2443
Romania	5130
Russia	34924
Serbia	2247
Slovakia	1318
Slovenia	562
Spain	10047
Sweden	2021
Switzerland	1762
Ukraine	11377
UK	13368

Table A3. Prevalence (%) of adult (> 14 years) hearing impairment in 2008 by region and impairment category (data from Table 2 in Stevens *et al*, 2011)

		Grade of hearing loss* (dBHL)					
	Total (1000s)	**Mild (20-34)**	**Mod (35-49)**	**Mod. severe (50-64)**	**Severe (65-79)**	**Prof (80-94)**	**Comp (≥ 95)**
Male							
High-income region	387609	16.8	5.8	1.6	0.4	0.1	0.1
Central/E Europe & Central Asia	155901	23.8	9.6	3.1	0.9	0.3	0.2
Sub-Saharan Africa	232208	24.1	8.3	2.5	0.7	0.2	0.2
Middle East & North Africa	154985	16.4	4.9	1.3	0.4	0.1	0.1
South Asia	543896	26.9	10.2	3.2	1.0	0.3	0.3
Asia Pacific	212693	25.5	9.4	2.9	0.9	0.3	0.2
Latin America & Caribbean	200837	22.5	8.2	2.6	0.8	0.2	0.2
East Asia	556140	22.7	8.2	2.5	0.7	0.2	0.2
World	2444268	22.7	8.4	2,6	0.8	0.2	0.2
Female							
High-income region	408794	15.0	5.3	1.4	0.4	0.1	0.1
Central/E Europe & Central Asia	178626	21.6	9.2	3.0	0.9	0.3	0.2
Sub-Saharan Africa	238564	19.6	6.4	1.8	0.5	0.2	0.1
Middle East & North Africa	148927	12.8	3.7	0.9	0.2	0.1	0.1
South Asia	515635	22.3	7.8	2.4	0.7	0.2	0.2
Asia Pacific	219241	21.2	7.5	2.3	0.7	0.2	0.2
Latin America & Caribbean	210768	18.5	6.6	2.0	0.6	0.2	0.2
East Asia	531769	18.6	6.4	1.9	0.5	0.2	0.1
World	2452325	19.0	6.8	2.0	0.6	0.2	0.2

*Mild, Moderate (Mod), Moderately severe (Mod.severe), Severe, Profound (Prof), Complete (Comp)

Table A4. Numbers surveyed and reporting hearing loss in Eurotrak surveys

	Number in whole sample	**Number with self reported hearing loss**
Belgium****	14245	1307
Denmark***	13434	1304
France**	14824	1320
Germany**	13775	1304
Italy**	15641	1343
Netherlands***	14339	1350
Norway*	14866	1309
Poland***	15344	1451
Switzerland**	14570	1301
UK**	14473	1325
Japan**	14316	1306

* 2012 ** 2015 ***2016 ****2017

Table A5. Prevalence of self-reported hearing loss in 29 European countries of (Laureyns *et al*, 2016)

Country	% age > 65	% HI	No HI (millions)
Austria	18.3	9.9	0.8
Belgium	17.8	9.6	1.1
Bulgaria	19.6	10.6	0.8
Cyprus	13.9	7.5	0.1
Czech Republic	17.4	9.4	1.0
Denmark	18.2	9.8	0.6
Estonia	18.4	9.9	0.1
Finland	19.4	10.5	0.6
France	18.0	9.7	6.4
Germany	20.8	11.2	9.1
Greece	20.5	11.1	1.2
Hungary	17.5	9.5	0.9
Ireland	12.6	6.8	0.3
Italy	21.4	11.6	7.0
Latvia	19.1	10.3	0.2
Lithuania	18.4	9.9	0.3
Luxembourg	14.1	7.6	0.0
Malta	17.9	9.7	0.0
Netherlands	17.3	9.3	1.6
Norway	15.9	8.6	0.4
Poland	14.9	8.0	3.1
Portugal	19.9	10.7	1.1
Romania	16.5	8.9	1.8
Slovakia	13.5	7.3	0.4
Slovenia	17.5	9.5	0.2
Spain	18.1	9.8	4.5
Sweden	19.4	10.5	1.0
Switzerland	17.6	9.5	0.8
UK	17.5	9.5	6.9
Total	**18.5**	**10.0**	**52.4**

Table A6. Results from English Longitudinal Study of Ageing (ELSA), Wave 7 (Banks *et a*l, 2016)

	Age in 2014-15 (years)							
	50-54	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80+**	**All**
MEN								
Objective hearing								
Good	82.3	81.6	73.8	63.6	52.6	41.8	16.6	64.5
Mild difficulty	17.2	16.2	25.2	34.5	42.6	48.9	61.4	31.1
Moderate/severe difficulty	0.5	2.2	1.1	2.0	4.8	9.2	21.9	4.4
Self reported hearing								
Excellent	25.3	16.1	13.7	12.8	8.8	8.0	3.4	14.2
Very good	30.4	32.2	29.0	25.6	22.5	19.4	17.3	26.5
Good	26.5	33.7	33.9	35.2	38.0	36.0	34.3	33.3
Fair	15.0	14.0	17.8	21.0	22.8	27.1	30.6	19.9
Poor	2.7	4.0	5.5	5.4	8.0	9.5	14.3	6.2
WOMEN								
Objective hearing								
Good	86.8	83.7	82.3	73.5	63.0	47.9	24.2	68.9
Mild difficulty	12.6	15.7	16.8	25.1	33.5	45.1	56.6	26.9
Moderate/severe difficulty	0.6	0.7	0.8	1.5	3.5	7.0	19.2	4.2
Self reported hearing								
Excellent	35.9	26.8	22.1	20.8	16.6	14.6	6.9	21.8
Very good	31.6	33.9	34.4	29.6	30.7	24.7	21.2	29.9
Good	20.1	30.6	32.5	33.1	37.0	37.3	38.2	31.7
Fair	9.7	7.3	8.7	14.4	12.3	18.2	21.8	12.7
Poor	2.8	1.4	2.3	2.1	3.5	5.3	12.0	4.0

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SECTION B

EFFECTS OF HEARING LOSS

CHAPTER 5. PSYCHOSOCIAL EFFECTS OF HEARING LOSS

5.1 INTRODUCTION

In the 2006 Hear It report (Shield, 2006) it was shown that from the 1970s onwards there were many publications concerning the psychosocial impact of hearing loss on adults. Table 5.1 lists the areas affected by hearing loss which were discussed in the 2006 report.

Table 5.1. Categories of adverse effects of hearing impairment

Overall quality of life
Loneliness/social isolation/exclusion
Psychiatric disturbance and depression
Family relationships
Stigma and low self esteem
Education
Denial
Difficulties in particular environments
General health/visiting the doctor
Cognitive skills and dementia
Memory loss
Intimate relationships
Prejudice and abuse
Employment

There has continued to be a body of literature published concerning many of these effects, in particular relationships between hearing loss and depression, hearing loss and loneliness of social isolation and the impact of hearing loss upon family members and spouses, which are the topics covered in this chapter. The impact of hearing loss on employment and earnings is examined in Chapter 8.

Much of the research on depression and loneliness has been undertaken by analysing data acquired as part of wider surveys concerning the wellbeing of the elderly population in various countries. Other surveys have been undertaken specifically to investigate whether the use of hearing aids is able to alleviate any of the psychosocial disadvantages due to hearing loss; these will be reviewed in a later chapter. The research into the impact of hearing loss on family and personal relationships has, on the whole, been conducted through small scale qualitative studies.

As in the 2006 report, this review includes only those studies involving subjects with partial hearing loss; surveys which relate to totally or profoundly deaf subjects only (for example Hallam *et al*, 2006; Kvam *et al*, 2007) are not included

5.2 STUDIES INTO THE IMPACT OF HEARING LOSS ON LONELINESS AND DEPRESSION

There have been many studies undertaken of possible links between depression and hearing loss in the past 12 years; some of these studies also investigated loneliness and social isolation among hearing impaired subjects as it is it known that depression is strongly related to loneliness (Glass *et al*, 2006; Hawthorne, 2008).

Tables 5.2 and 5.3 summarise the studies of depression and loneliness, respectively, which have been reviewed. The majority of studies, particularly those using data from large scale questionnaire studies, have relied on self-reporting of hearing problems through questions relating to difficulties in hearing. Some studies have been able to use audiometric data

Table 5.2. Summary of studies on depression

Country	Authors	Subjects		Type of testing		Results
		No	Age	SR	Audiom	
Norway	Tambs, 2004	>49,000	20-101 Mean 50	X	X	Measured HL related to anxiety, depression, self-esteem and wellbeing. Effects greater for young and middle aged; strongest effects for young men and low frequency HL.
US	Capella-McDonnall, 2005	9832	> 55	X (vision & hearing)		Those with dual sensory loss significantly more likely to experience depression than those with HL alone.
US	Abrams *et al*, 2006	123 HI 370 NHI	Mean 74	X		Strong association between HL and depression.
Norway	Helvik *et al*, 2006	343 All HI	21-94 Mean 69	X	X	No association between psychological wellbeing and hearing severity.
Japan	Ishine *et al*, 2007	434 HI 2170 NHI	> 65 Mean 77	X		Rate of depression significantly higher in those with HL.
UK	Chou, 2008	3782	> 65	X (vision & hearing)		Vision loss but not hearing loss associated with onset and persistence of depression.
Japan	Harada *et al*, 2008	843	≥ 65		X (vision also)	Dual sensory loss increased odds of depression 3-fold. HL only increased odds of depression in males but not females.
Italy	Monzani *et al*, 2008	73 HI 96 NHI	35-54 Mean 47	X	X	HI group showed significantly higher levels of overall psychological distress, and of depression and anxiety.
Australia	Gopinath *et al*, 2009a	1328	> 60		X	HL associated with depressive symptoms, especially among women under 70.
NL	Nachtegaal *et al*, 2009a	1511	18-70 Mean 46		Speech in noise test	Significant relationship between HL and depression, particularly in middle aged subjects. Increase in severity of HL increases odds of depression.
Japan	Saito *et al*, 2010	112 HI 436 NHI	> 60	X	X (at 1 kHz)	Longitudinal study over 3 years. After 3 years 19.6% of HI group and 8% of NHI group had developed depressive symptoms. Audiometric HI not associated with depression.
China	Lee *et al*, 2010	914 313 HI	≥ 60	X	X	Depression associated with measured HL but not self-reported HL.
NL	Garnefski *et al* 2012	119, all with HL	> 18 Mean 60		X	Degree of HL not related to depression scores; small significant relationship between anxiety and severity of HL.
Japan	Yamada *et al*, 2012	197 HI 1057 NHI	65-98 Mean 75	X		Longitudinal study over 3 years Feelings of depression significantly higher in those with HL.
Australia	Gopinath *et al*, 2012a	811	≥ 55	X	X	Longitudinal study over 5 years Those with SR hearing handicap had increased odds of developing depressive symptoms.

Table 5.2 Summary of studies on depression (continued)

Country	Authors	Subjects		Type of testing		Results
		No	Age	SR	Audiom	
US	Mener *et al*, 2013	1029 602 HI	70-79 Mean 74		X	HL not associated with greater odds of having depressive symptoms
NL	Pronk *et al*, 2011 Pronk *et al*, 2013	1826	63-93 Mean 75	X	Speech in noise test	Longitudinal study over 4 years No significant relationships between hearing status and depression
US	Li *et al*, 2014	18,318	≥ 18 Mean 50	X	X (aged ≥70)	Self-reported and measured HI were significantly associated with depression, particularly in women. Prevalence of depression increased with severity of HI.
UK	Keidser *et al*, 2015	101,099 Approx 10% HI	39-70 Mean 57	X	Hear in noise test	Significant relationships between all hearing measures, depressive symptoms and depressive episodes. Relationships stronger for younger and female subjects.
France	Amieva *et al*, 2018	3777 1289 HI	≥ 65 Mean 75	X		Longitudinal study over 25 years. Men with HI had increased risk of depression.

Table 5.3. Summary of studies on loneliness

Country	Authors	Subjects		Type of testing		Results
		No	Age	SR	Audiom	
Australia	Hawthorne, 2008	3015	> 15 Mean 45	X		Hearing difficulties significantly associated with social isolation.
Italy	Monzani *et al*, 2008	73 HI 96 NHI	35-54	X	X	HI group had lower levels of social functioning than control group.
NL	Nachtegaal *et al*, 2009a	1511	18-70 Mean 46		Speech in noise test	Significant relationship between HL and loneliness, particularly among youngest age group (18-29).
Japan	Yamada *et al*, 2012	1254	65-98	X		Longitudinal study over 3 years. HL associated with decline in daily activities but not decline in social participation.
NL	Pronk *et al*, 2011 Pronk *et al*, 2013	1826	63-93	X	Speech in noise test	Longitudinal study over 4 years. Hearing status measured by a speech in noise test was associated with emotional loneliness but not social loneliness.
US	Mick *et al*, 2014	1453	60-84		X	In 60-69 age group those with BEHL > 25 dB had higher level of social isolation than those without HL. Increase in HL increased risk of isolation for women but not men.
Finland	Mikkola *et al*, 2015	848	75-90	X		Those with more severe HL participated less in some social activities than those with normal hearing; those with fewer hearing problems were as socially active as those with normal hearing.
US	Sung *et al*, 2015	145 HI	50-94		X	Greater HL and younger age significantly associated with loneliness.

instead of, or in addition to, self-reported information on hearing. Three studies, those of Nachtegaal *et al* (2009a), Pronk *et al* (2011; 2013) and Keidser *et al* (2015), used a hearing in noise or speech in noise test to give an objective measure of hearing.

The numbers of subjects given in the tables refer to the total number included in the study; unless otherwise stated this number includes both hearing and hearing impaired subjects.

It can be seen that the majority of studies have concerned subjects over the age of 60. This reflects the fact that many of the studies have been part of wider studies into the general wellbeing of the older population.

5.3 DEPRESSION

The majority of the studies reviewed here have found an association between hearing impairment and symptoms of depression, although there are some conflicting results where a relationship between depression and hearing loss has not been demonstrated.

One of the most extensive and comprehensive investigations into the relationship between hearing loss and mental health is that reported by Tambs (2004), who analysed data from around 50,000 adult participants of all ages in the Norwegian Nord-Trondelag Hearing Loss Study. This study produced several important results which have subsequently been confirmed by other studies. Audiometric testing was carried out of all participants, who also completed questionnaire surveys which included items on hearing loss, disability due to hearing loss, anxiety, depression and subjective well-being. Data for three age groups was analysed separately: young (20 to 44 years); middle-aged (45 to 64 years); and older (over 64 years), as was the impact of hearing loss at low, middle and high frequencies. The results showed a moderate but definite overall effect of measured hearing loss on depression and anxiety, as well as on self-esteem and well-being. However, no effect of hearing loss was found in the older age group, while the strongest effects were for depression and low self-esteem among young men. The effects were strongest for low frequency hearing loss, although they decreased significantly with age. Effects were also stronger for men than for women across all age groups, but particularly in the young and middle aged groups. The author suggests that this may be related to career expectations for men and a sense of being disabled at work. It was also found that self-reported hearing loss was more strongly related to mental health than measured hearing loss. The decrease in impact of hearing loss with age may be explained by hearing loss being regarded as a 'normal' condition of ageing, while hearing impaired younger people may feel different to, and more disabled than, their peers.

Subsequent studies have, in general, repeated these findings although there have been some inconsistencies in results.

Huang *et al* (2010), in a meta-analysis of studies into the relationship between depression and chronic diseases among people aged 60 and over, found a clear association between poor hearing and vision and depression. Individuals with impaired hearing or vision were more likely to experience disability, limitations to daily activities and poor social support, all of which are known to be risk factors for depression in old age. They therefore concluded that poor hearing and vision (together with stroke, cardiac disease, and chronic lung disease) are definite risk factors for depression.

This conclusion is mainly supported by the results summarised in Table 5.2 which show that the majority of studies, including ones published since the review by Huang *et al* (2010), have similarly demonstrated an association between hearing loss and depression. However, there are some exceptions, the inconsistencies between studies being commented upon by several authors, for example Gopinath *et al* (2009a) and Keidser *et al* (2015).

Two studies that investigated the effects of both vision and hearing loss found that vision loss alone or dual loss were more likely to be associated with depression than hearing loss alone (Capella-McDonnall, 2005; Chou, 2008).

Two more recent studies in the United States (Mener *et a*l, 2013) and the Netherlands (Pronk *et al*, 2011; 2013) also found no significant associations between hearing loss and depression. The study by Mener *et al* analysed data from the US National Health and Nutrition Examination Survey and the authors suggest that the reason for the discrepancy between their results and those of other surveys may be due to the small number of subjects exhibiting (self-reported) symptoms of depression. (However, they did find that the use of hearing aids mitigated the likelihood of suffering from depression, this is discussed further in Chapter 12). Pronk *et al* (2011; 2013) carried out a four year longitudinal study using data from the Longitudinal Aging Study Amsterdam. The authors express surprise that the results of their study do not agree with findings of other studies, suggesting that this may be due to the fact that they compared hearing status at baseline with depressive symptoms at follow up, and that symptoms of depression may have weakened during that period due to coping mechanisms. Another study which failed to find any association between hearing loss and depression is that of Helvik *et al* (2006). A further possible explanation for the negative findings of these studies is suggested below. In a smaller study of 119 subjects with moderate to profound hearing loss Garnefski *et al* (2012) found that self-reported hearing loss characteristics were not related to depression scores, although there was a small significant relationship between anxiety and severity of hearing loss.

The remaining studies have all demonstrated a definite association between depression and hearing loss; however, the nature and strength of the association varies between studies.

Studies in which a group of hearing impaired subjects have been compared with a control group of normal hearing subjects (Abrams *et al*, 2006; Ishine *et al*, 2007; Monzani *et al*, 2008; Gopinath *et al*, 2009a; Saito *et al*, 2010; Yamada *et al*, 2012; Li *et al*, 2014; Amieva *et al*, 2018) have found higher rates of depression, psychological distress, and anxiety among the hearing impaired groups. In the longitudinal study by Saito *et al* (2010) it was found that after 3 years 19.6% of the subjects who had a hearing handicap (measured subjectively) at baseline had developed symptoms of depression, compared with 8% of the subjects who did not have a hearing handicap at the start of the study. Similarly, Gopinath *et al* (2012a) found that self perceived hearing handicap at baseline was related to increased odds of developing depressive symptoms over a 5 year follow up period. In the three year longitudinal study by Yamaha *et al* (2012) feelings of depression at baseline were significantly higher in those with self-reported hearing loss, and, although depression was not directly measured at follow up, those with hearing loss had a greater decline in daily activities, which may be related to depression. Amieva *et al* (2018), in their longitudinal study, followed subjects for an exceptionally long time period of 25 years. They found that the risk of depression was increased in men with hearing loss over that time period, compared with normal hearing subjects. However, as in the study by Mener *et al* (2013), it was found that, for those men using hearing aids, there was no increased risk, as discussed in Chapter 12.

Li *et al* (2014), in analysing a large cohort from the 2005-2010 National Health and Nutrition Examination Survey (NHANES) in the US, found that the prevalence of both mild and moderate to severe depression among adults with self-reported hearing loss was significantly higher than among those without hearing loss, and increased with the severity of hearing loss. For those with hearing loss the prevalence of moderate to severe depression was 11.4%, compared to 5.9% for those without hearing loss.

Yiengprugsawan *et al* (2012) in a study of a Thai national cohort of over 87,000 subjects aged between 15 and 97, also found, despite a rather crude definition of self-reported

hearing loss, that hearing impairment was associated with poor psychological health, depression and anxiety.

The UK Biobank, a collection of epidemiological data on people aged 40 to 70, includes information on hearing loss and on depression. Keidser *et al* (2015) recently published an analysis of data from over 100,000 subjects. Hearing was measured by a hearing in noise test and by a self-reported functional hearing (that is ability to hear in different situations) questionnaire. Around 10% of the subjects showed a lower than normal ability to understand speech in noise. Participants answered a range of questions related to mental health, including topics associated with depression. A significant relationship was found between all measures of functional hearing (both self-reported and measured) and higher levels of depressive symptoms and the duration and frequency of depressive episodes. Associations were stronger for the younger subjects (in their 40s), with female subjects reporting higher levels of depression.

5.3.1 Effects of age and gender

As can be seen some of the studies discussed above have found that the effects of hearing loss are related to age and/or gender. Gopinath *et al* (2009a), in investigating the prevalence of depressive symptoms among adults over the age of 60, found that depressive symptoms were more common among hearing impaired women than men. Furthermore, depressive symptoms were more prevalent in women under the age of 70. This result agrees with the findings of Keidser *et al* (2015) who reported higher levels of depression among women, and stronger associations for the younger subjects in their study (that is, subjects in their 40s). However, Harada *et al* (2008) found that hearing impairment was associated with depression among male, but not female subjects over the age of 65. The earlier study by Tambs (2004) also found that effects were stronger among men than women of all ages, but particularly among the young and middle aged groups; this study found no significant effect of hearing loss in the over 65 age group for either sex. Similar results were found by Nachtegaal *et al* (2009a) who examined associations between hearing loss and various psychosocial health indicators across age groups from 18 to 70. Significant associations were found between distress and/or depression and hearing loss for people in their 30s and 40s, but there were no associations for the older age groups. Li *et al* (2014), in comparing the prevalence of depression among those aged 18 to 69 with those aged 70 and above, found that the association between hearing loss and depression was strongest for the 18 to 69 age group whereas there was no significant association for those aged 70 and above.

Overall, it therefore appears that depression may be more common among young and middle aged people with hearing loss than among the older hearing impaired population. It is generally thought that the lower rate of depression among older subjects could be explained by an acceptance of loss of hearing as being a normal part of the ageing process.

It is also possible, when considering the age ranges of the subjects in the studies of Helvik *et al* (2006), Mener *et al* (2013) and Pronk *et al* (2011; 2013), that a lack of depression in their older subjects explains why, overall, they found no significant relationship between hearing loss and depression.

The evidence for differences between male and female subjects in occurrences of depression is inconclusive with some studies finding hearing impaired men are more susceptible to depression than women (Tambs, 2004; Harada *et al*, 2008; Amieva *et al*, 2018) while others have found the reverse (Gopinath *et al*, 2009a; Li *et al*, 2014; Keidser *et al*, 2015).

Li *et al* (2014) found that depression was more prevalent among women than men (for those both with and without hearing loss); of those with hearing loss 9% of men and 14.7% of

women experienced depression. They also found that, for those aged 70 and over, moderate hearing loss (BEHL between 35 and 50 dB) was associated with increased risk of depression for women, but not for men. In contrast, in their 25 year longitudinal study, Amieva *et al* (2018) found that men, but not women, with hearing loss were at greater risk of depression than those without hearing loss.

5.3.2 Assessment of hearing loss

Differences also emerge between results of studies when considering whether hearing loss is measured or self-reported. Lee *et al* (2010), in studying a Chinese population aged 60 and over, found a relationship between measured hearing loss and depressive symptoms, but not between self-reported hearing loss and depression. However, Saito *et al* (2012) found the reverse: self-reported hearing handicap was associated with depression but hearing loss as measured by audiometry was not. Tambs (2004) also found that self-reported hearing loss related more closely than audiometric data with mental health. Saito *et al* suggest that this is because audiometry assesses only the sound level that can be heard, but does not assess the hearing difficulties that people experience as a result of their hearing loss. This could be a further explanation for the lack of an association in the study by Mener *et al* (2013).

5.4 LONELINESS AND SOCIAL ISOLATION

The 2006 report (Shield, 2006) showed that loneliness and social isolation were recognised as major effects of hearing loss and were the consequences of hearing loss cited most frequently in the literature. Fewer papers on this topic appear to have been published in recent years, as can be seen from Table 2.2. However, all except one of the reviewed studies show an association between hearing loss and loneliness, social isolation or social functioning.

In a study of social isolation among Australians aged 15 and over, Hawthorne (2008) compared self-perceived social isolation with several common health conditions. Hearing difficulties were one of only three conditions which were significantly associated with social isolation (the other two were depression and severe incontinence).

The Dutch study by Nachtegaal *et al* (2009a), which investigated the relationship between hearing loss and a range of psychosocial factors among different age groups from 18 to 70 found a significant association between hearing loss and loneliness, particularly in the youngest age group (18 to 29) of their subjects. The authors suggest this may be due to greater stigma being attached to hearing loss among young people, or to difficulties in communicating with friends and family. This is consistent with the findings of Tambs (2004) and others, cited in the previous section, who found that depression was more common among younger people with hearing impairment than in older age groups.

The other reviewed papers have specifically investigated hearing loss and its impact in relation to social participation or loneliness.

Monzani *et al* (2008) found that a group of hearing impaired individuals (average 39.6 dB HL) had significantly reduced social activities compared with a non-impaired matched control group. However, this result disagrees with that of the study by Yamada *et al* (2012), discussed above, who found in a longitudinal study over three years that hearing loss was associated with a decline in daily activities over the study period, but not with a decline in social participation.

Pronk *et al* (2011; 2013), in their four year longitudinal study, considered two different types of loneliness: emotional loneliness, that is lack of an intimate attachment such as a partner or close friend, and social loneliness, that is a lack of social integration. They found that both

self-reported hearing status and hearing ability measured by a speech in noise test were significantly associated with emotional loneliness, but only for male subjects. In addition, poorer baseline hearing was significantly associated with greater emotional and/or social loneliness scores at follow-up for certain subgroups of the subjects: those living with a partner in the household, those with a medium or high income, those without cardiovascular conditions, those with one or more chronic diseases, and those with higher educational status.

Two recent studies have found that the extent of loneliness or social participation is related to the severity of the hearing loss. Mikkola *et al* (2015) concluded that self-reported hearing difficulty causes a reduced level of participation in social and leisure activities in adults with normal cognitive ability; however, this mainly related to those who reported major difficulties. Subjects with fewer self-reported hearing problems were as socially active as subjects who reported good hearing. The study of audiology patients by Sung *et al* (2015) also found an association between the degree of hearing loss and loneliness: the more severe the hearing loss the greater the degree of loneliness. Mick *et al* (2014) in a larger study of subjects taken from the NHANES between 1999 and 2006 found differences between the younger (60 to 69 years) and older (70 to 84 years) age groups. In the younger group there was a significant difference between the numbers of socially isolated people with and without hearing loss (20.6% and 11.9% respectively). In the younger group increase in hearing loss was associated with greater prevalence of social isolation for women only. Among older subjects there was no association between level of hearing loss and social isolation.

5.5 EFFECTS OF HEARING IMPAIRMENT ON FAMILY RELATIONSHIPS

The 2006 Hear It report (Shield, 2006) showed that it is not just hearing impaired individuals who are affected by their loss; hearing impairment can also have significant negative effects upon family members and relationships. In the US National Hearing Health Poll of people aged 50 and over, carried out by the AARP and ASHA in 2011 (Geraci, 2011), of around 1500 people who reported having hearing difficulties, 44% agreed or strongly agreed with the statement ‘Hearing difficulties can negatively impact my relationships with my family and friends’. The impact of a disability on close family and friends is now recognised by the WHO as causing an additional disability, known as a ‘third person disability’ (Scarinci *et al*, 2012).

Kamil and Lin (2015) carried out a review of 24 studies into the impact of hearing impairment on the ‘communication partners’, including spouses, partners, close family members, or caregivers, of hearing impaired individuals. They concluded that, overall, the studies were in broad agreement and showed that hearing impairment affects the quality of life of communication partners. A subsequent review and meta-synthesis (Barker *et al*, 2017) confirmed that hearing loss affects both the hearing impaired person and their communication partner, and further suggested that the relationship between the two people and the coping strategies they use could affect their subsequent adjustment to the hearing loss.

This section reports results of studies into the impact of hearing loss upon both significant others and children of hearing impaired individuals.

5.5.1 Significant others

The majority of studies into the impact of hearing loss on the spouse or partner of hearing impaired individuals have involved couples of the opposite sex. Some differences have been found between the reactions of male and female partners (Anderson and Noble, 2005) as described below, and a small study comparing different sex and same sex couples (Kelly and Atcherson, 2011) also found differences in the impact of hearing loss.

Anderson and Noble (2005), in an Australian study of 66 couples aged from 35 to 86 years, found that female partners were more likely to attribute blame for situations arising from their partner's hearing impairment to personal failings rather than to the hearing impairment per se. However, female partners were more accommodating towards their male partners' hearing impairment than male partners to their female partners' hearing loss, and took greater responsibility to maintain communication within the relationship. Anderson and Noble also found that couples were happier where the hearing impaired person acknowledged their hearing difficulty and took responsibility for hearing related behaviours, such as employing effective coping strategies, which reduced the impact on the partner. Where the person with impaired hearing rated their loss as more severe than did their partner, the couple was more satisfied with the relationship than couples where the partner rated the loss as more severe.

Detailed studies of the impact of having a partner with age related hearing loss have been carried out by Scarinci and colleagues (Scarinci *et al*, 2008; 2009; 2012), also in Australia. In their first study (Scarinci *et al*, 2008) they conducted in depth semi-structured interviews with ten partners (five male, five female) of people whose hearing had deteriorated gradually with age, the ages of subjects and partners ranging from 60 to 83 years. They found that having a hearing impaired partner affected almost every aspect of everyday life, with almost all tasks and activities being affected. There was a general trend for female spouses to express greater feelings of frustration and distress over their partners' hearing loss, than male partners, and also to take greater responsibility for maintaining communication with their partner.

Table 5.4 summarises the impacts on spouses elicited by the interviews by Scarinci *et al* (2008).

Based upon the results of their qualitative study, Scarinci and colleagues developed a scale to assess quantitatively third party disability as a result of hearing impairment (Scarinci *et al*, 2009). The scale was used to further investigate the factors that affected the extent of disability in spouses through a study of 100 retired couples aged 50 and over where one partner was hearing impaired (Scarinci *et al*, 2012). The main areas contributing to third party disability were changes in communication and use of communication strategies, and emotional problems such as feeling frustrated or angry. Fewer problems were reported in terms of relationship changes and social activities, but this may have been because the majority of hearing impaired participants had mild to moderate hearing loss. Greater third party disability was associated with lower satisfaction with the relationship, greater hearing disability perceived by the spouse and a greater age difference between the partners. Interestingly, the actual degree of hearing impairment and the presence or absence of hearing aids did not have a significant relationship with third-party disability.

Another study of couples was that by Preminger and Meeks (2010) which investigated personal characteristics which both influenced hearing loss related quality of life among hearing impaired people and their partners, and were related to discrepancies between perceptions within a couple. Of the 52 couples studied, 26 couples demonstrated a difference in their perception of the impact of hearing loss on their quality of life, with the hearing impaired partner reporting a poorer quality of life than their spouse. In both partners perception of hearing related quality of life was significantly related to negative measures of mood.

The RNID carried out a survey of hearing impaired people and their normal hearing partners in order to examine the impact of hearing loss on personal relationships (Eschalier, 2010). Twenty-three people with hearing loss and their partners were interviewed and their comments recorded and transcribed. The themes that emerged in relation to the experience of the partners are summarised in Table 5.5. It can be seen that they are very similar to the views expressed in the interviews by Scarinci *et al* (2008) shown in Table 5.4.

Table 5.4. Summary of impacts of partner's hearing impairment on spouses (extracted from Scarinci *et al,* 2008)

Effect on everyday life	
Effect on communication	Increased time and effort
	Less spontaneous conversation
	Frustration at having to repeat
Effect on everyday activities	Negative impact of high volume of TV
	Separate watching of TV
	Spouse unable to hear telephone
	Having to make telephone calls for spouse
	Worry about safety – eg spouse not hearing traffic
Effect on emotions	Frustration and embarrassment at partner's behaviour
Effect on the relationship	Increase in tension
	Impact on intimate/sexual relationship
Effect on social life	Staying at home, not going out to restaurants, movies, theatre etc
	Avoiding social gatherings
Need to adapt to partner's HI	
Use of communication strategies	Need for different techniques eg face to face, loud voice, writing note, correcting/answering for spouse
Need to think of HI all the time	Having to take account of HI in all situations
Need to protect HI partner	Need to consider and protect partner in group situations
Imbalance of adjustment	Spouses feeling they had done all the adaptation
	HI partner expected others to accommodate HI
Acceptance of situation	
Effect of acceptance by HI partner	
Denial by HI partner	Denial by partner adds to frustration
Denial by spouse	Spouses also deny and blame themselves eg for not speaking loudly enough
Acceptance by HI partner	Positive effect on spouse
	Easier to adapt
	Increased willingness to help partner
	Decrease in tension
Impact of ageing and retirement	
HI as consequence of ageing	Acceptance of HI as part of ageing process
	Related to other changes, eg memory loss, physical changes
Effect of age on ability to adapt to HI	'Too old to change now'
Effect of retirement	Hearing difficulties more apparent with increase in time spent together
	Increase in frequency of communication difficulties
Comparison with other people/conditions	Spouses compare hearing difficulties with others
	Males consider wives' HI less severe compared with other health conditions

In the study by Kelly and Atcherson (2011), which investigated differences in reactions to hearing loss between same sex and different sex couples, all of the hearing impaired participants and their significant others reported some emotional and social consequences of hearing impairment. In the different sex couples the hearing impaired partner reported more emotional consequences of hearing loss than those in same sex relationships, and than their their partner; in the same sex couples there were no differences in the perceived consequences of hearing loss between the two partners.

Ask *et al* (2010) used data on around 17,000 Norwegian couples aged 44 and over, collected as part of the Nord-Trøndelag Health Study, to investigate the effect of hearing impairment on the mental health of spouses. They found that there was no association between audiometrically assessed hearing and spousal mental health, although there was a small effect on spouses' mental health of self reported hearing loss.

Table 5.5. Summary of issues arising from RNID survey of effects of hearing loss upon partners (extracted from Echalier, 2010)

Experiences of partners	**Description**
Awareness and diagnosis	Partners played critical role in making HI person aware of HL and seeking diagnosis
Expectations	Partners expected HI person to minimise impact of HL, eg accepting HL, wearing HA and telling others about HL
Frustration	If above steps not taken or if partner communicated with HI person assuming they were wearing HA when they were not.
Adjustments in communication	Partners tried to minimise impact of HL eg by speaking more clearly, positioning themselves appropriately
Difficulty in understanding challenges to HI person	Partners found it difficult to understand nature of HL and its implications, especially fatigue and problems caused by background noise
Encouragement in choosing assistive technology	Partners often research the most suitable HA and other technology for their partners
Mediating communication	Facilitating communication with others in social, family and other settings
Providing practical assistance	eg by answering the telephone, encouraging confidence in HI partner
Changes in activities	Some partners stopped doing activities eg watching TV, listening to music, that the HI partner had difficulty with; group activities curtailed
Worries	Partners worried about what might happen to their partner in their absence, eg not hearing alarms, doorbell, road traffic
Taking more responsibility	Some partners take on more responsibility, eg dealing with banks etc. Others do not as they wish HI person to retain independence
Changes in communication	Couples experience sense of loss and isolation due to limitations in communication (loss of small talk, jokes etc); loss of companionship; frustration
Loneliness	Hearing partners experience feelings of loneliness and frustration and lack of companionship

5.5.2 Children

Preminger and colleagues also investigated the impact of hearing loss upon adult children of hearing impaired people (Preminger *et al*, 2015). They interviewed twelve subjects between the ages of 22 and 58, each of whom had a hearing impaired parent and found that, although they also experienced third party disability, their restrictions and activity limitations were not as great as those experienced by spouses. However, they did describe the detrimental negative impact of hearing impairment upon family relationships, with the use of disagreeable coping strategies (for example yelling or having to make extra effort) leading to

negative feelings such as frustration, anger, annoyance and fatigue. Parents' unwillingness to use hearing aids or the apparent ineffectiveness of hearing aids also led to frustration. Many participants also experienced a feeling of loss at the reduced communication and relationship with their parent.

In the study by Preminger *et al* (2015), children of hearing impaired persons reported very few positive feelings. This is in contrast with the findings of studies by Stephens and colleagues, reported by Pyykko *et al* (2014), in which family members described some positive experiences in relation to coping with a hearing impaired person, such as increased patience and tolerance, better understanding and awareness of hearing problems, and improved communication skills. However, it was noted that younger family members (children and grandchildren) were more likely to report positive experiences than older people (spouses or partners).

Participants in the 2010 RNID survey (Echalier, 2010) reported mixed experiences of how their children adjusted to their hearing loss, but were much more positive about how their grandchildren reacted.

5.5.3 Intimate relationships

Two studies of younger (in their 20s to 50s) married men with hearing loss (Ozler and Ozler, 2013; Bakir *et al*, 2013), found that hearing loss had a detrimental effect upon their sex lives, regardless of the severity of the hearing loss. In developing a new questionnaire to assess the impact of hearing loss on quality of life, Stika and Hays (2016) found that younger adults in focus groups and those completing the pilot testing of the questionnaire often identified 'intimacy' and 'dating' as areas significantly impacted by their hearing loss, and expressed concerns about the difficulty of socializing in large groups and meeting potential life-partners. Effects of spouses' hearing loss on intimate and sexual relationships were also commented upon in the interviews held by Scarinci *et al* (2008).

5.6 CONCLUSIONS

This chapter has reviewed the main psychosocial impacts of hearing loss that have been discussed in the literature over the past decade. The majority of studies are concerned with the association of depression and hearing loss. There is a body of evidence showing that hearing impairment can lead to depression, loneliness and social isolation. The effects appear to be greater among younger hearing impaired subjects, with some evidence that men are more affected by loneliness than women. It has also been shown that hearing loss has multiple effects upon personal and family relationships.

Depression and loneliness are serious consequences of hearing loss. As well as reducing quality of life, it is known that these conditions increase the likelihood of death in the elderly population. Holwerda *et al* (2007; 2012) used data from the Amsterdam Study of the Elderly to investigate the relationship between depression, anxiety and loneliness and death over a 10 year period. They found that both depression (Holwerda *et al*, 2007) and feelings of loneliness (Holwerda *et al*, 2012) were associated with excess mortality among men. In a meta-analysis of results from nearly 150 studies Holt-Lunstad *et al* (2010) found that individuals with adequate social relationships have a 50% greater likelihood of survival compared to those with poor or insufficient social relationships. The magnitude of this effect is comparable with giving up smoking and exceeds that of many well-known risk factors for mortality such as obesity or physical inactivity. Fernia *et al* (2001) also showed how the extent of disability in people over the age of 80 is affected by the psychosocial variables depression, subjective health, and social integration.

CHAPTER 6. EFFECTS OF HEARING LOSS ON PHYSICAL HEALTH

6.1 INTRODUCTION

The investigation of links between hearing loss and other health conditions appears to be a growing area of research, in many cases prompted by considerations of the impact of the ageing demographic on society and the need for health care. Weinstein (2015), in a review of hearing and health in the elderly related refers to the 'daunting' effect of increasingly widespread age-related hearing loss on other health problems.

Since the 1990s there have been several extensive and comprehensive surveys of health in many countries including the UK, USA, Norway and Australia. Many of these have been national surveys, while others have focussed on a particular region but have used a typical sample of the population. This has provided a wide range of demographic and health data which has facilitated studies into associations between different health factors. Many of the papers reviewed in this chapter have used data provided by these surveys to investigate associations between hearing loss and other factors relating to physical health.

This chapter considers only those papers which have considered hearing loss as a risk factor for other physical health conditions. There are also many studies which have aimed to establish whether concurrent diseases or lifestyle factors are risk factors for hearing loss; these are not reviewed as this topic is beyond the scope of the current report.

Health conditions which are considered in this chapter in relation to hearing loss are cardiovascular disease, stroke, falls, decline in general physical activity and reduction in activities of daily living. There has also been increasing interest in links between hearing loss and mortality and the co-morbidity of hearing loss and other diseases, plus the overall impact of hearing impairment on general health and wellbeing. Another growing area of research is the association between hearing loss and cognitive decline and dementia; this topic is discussed in Chapter 7.

6.2 MORTALITY

Longitudinal surveys of health such as those listed in Chapter 1 have enabled studies to be made into links between sensory impairment and mortality. Loss of vision, loss of hearing and dual vision and hearing loss, have all been investigated in relation to mortality.

This section considers the impact of hearing loss on mortality. The reviewed studies have used data from the following longitudinal studies: American National Health and Nutrition Examination survey (Contrera *et al*, 2015), Health, Aging and Body Composition (Genther *et al*, 2015) and Epidemiology of Hearing Loss Study (Schubert *et al*, 2017); the Kurabuchi study in Japan (Michikawa *et al*, 2009); the Australian Blue Mountains study (Karpa *et al*, 2010) and Health in Men and Longitudinal Study on Women's Health (Lopez *et al*, 2011); and the Icelandic Reykjavik Study of Ageing (Fisher *et al*, 2014).

All studies have used similar methods in comparing the rates and causes of mortality of subjects who were hearing impaired at baseline with those of non-hearing impaired subjects. All subjects, except those in the study by Lopez *et al* (2011), had an audiometric assessment but there are slight differences between the studies in the definition of hearing loss and numbers and ages of subjects. The time periods over which mortality rates were investigated also vary, from three years to ten years.

In the studies by Karpa *et al* (2010), Genther *et al* (2015), Contrera *et al* (2015) and Schubert *et al* (2017) hearing loss was defined as a pure tone average (0.5, 1, 2 and 4 kHz)

greater than 25 dB HL, while Fisher *et al* used a PTA of 35 dB HL (that is, moderate-severe) hearing loss in their analysis. In the smaller study by Michikawa *et al* (2009) hearing impairment was defined as the failure to hear a 30 dB signal at 1 kHz in the better ear.

All the studies took into account a wide range of other health conditions. Where other conditions were found to relate to hearing loss the data were adjusted for these confounding factors, and for demographic and other characteristics.

Michikawa *et al* (2009) investigated the relationship between sensory impairments and adverse health outcomes which included death and dependence in activities in daily living (ADL), whereas the other studies examined relationships between impairment and mortality only. The study by Michikawa *et al* also had the shortest follow up period, three years, of the studies. During this period they found that of 796 subjects over the age of 65, 86 had adverse health outcomes, of whom 34 had died. The authors investigated gender differences in the risk of adverse health outcomes due to vision and hearing impairment. They concluded that vision impairment was related to an elevated risk of adverse health outcomes in men and women, but for hearing impairment the risk was increased for men only. Men with hearing impairment were three times more likely than those with normal hearing to develop adverse health outcomes, including death.

The Australian study by Karpa *et al* (2010) involved 2815 participants aged 50 and over, of whom 929 were hearing impaired. After five years, hearing loss was associated with increased risk of death from cardiovascular disease and from all causes, but the association was not significant when adjusted for multiple demographic and health factors. However, there was an indirect significant effect of hearing loss, with a greater risk of mortality for those with hearing impairment; the association was attributed to the effect of hearing loss on cognitive impairment and walking disability. (These two conditions are discussed in later sections.) The authors suggest this may be due to affected persons being less likely to see their doctor, and having poorer understanding of their own health issues, poorer diets and less exercise (also discussed later in this chapter). The study also found that the association was independent of degree of hearing loss; the risk factor was as great for those with mild hearing loss as for those with moderate/severe hearing loss.

However, in the other Australian study by Lopez *et al* (2011), which involved 5354 subjects aged 76 to 81, no association was found between hearing impairment and mortality.

In Iceland, the Reykjavik study (Fisher *et al*, 2014) provided data on nearly 5000 subjects aged 67 and older, of whom 25% were hearing impaired (HI) (that is, had BEHL greater than 35 dB), 9% vision impaired (VI) and 7% had dual sensory loss (DSI). After adjusting the data for age and sex and known risk factors, after a five year follow up period it was found that hearing impairment was associated with a higher risk of death from cardiovascular disease. The authors also found that, as in the Japanese study by Michikawa *et al* (2009), men were at greater risk than women for whom risk due to hearing impairment was increased but not significantly. Table 6.1 shows the percentages of deaths due to all causes and to cardiovascular-related causes according to impairment, overall and by gender (unadjusted data). Cardiovascular disease is discussed further in section 6.4.

Table 6.1. Percentages of deaths due to all causes and cardiovascular related, by gender and type of sensory impairment (data from Table 2 of Fisher *et al*, 2014)

Impairment	All cause mortality			CVD related mortality		
	Overall	Men	Women	Overall	Men	Women
No/mild SI	12.3	15.4	10.3	4.7	5.4	4.3
VI only	17.4	24.1	13.7	7.5	10.5	5.8
HI only	23.2	25.6	20.8	10.9	11.8	9.9
DSI	35.9	44.8	25.6	15.7	20.8	10.0

A more recent study, by Genther *et al* (2015), used data on nearly 2000 participants aged between 70 and 79 at baseline. The authors compared the rate of death over a 10-year period between subjects who were hearing impaired (N = 1146) and those who were not (N = 812). Of the hearing impaired group 43% died, compared with 31% of the normal hearing group. After adjusting for demographics and cardiovascular risk factors it was found that hearing impairment was associated with a 20% increased mortality risk compared with normal hearing.

The study by Contrera *et al* (2015) took into account the severity of hearing loss. They studied 1666 adults aged 70, of whom 1139 were hearing impaired (that is, had BEHL greater than 25 dB) and 527 had normal hearing. Table 6.2 shows the occurrences of death from all causes across the hearing categories in the follow up period (between 1 and 5 years).

Table 6.2. Occurrences of death across categories of hearing impairment (data from Table 1 of Contrera *et al*, 2015)

	Hearing impairment		
	None (BEHL < 25 dB)	Mild 25 dB ≤ BEHL < 40 dB	Moderate/severe (BEHL ≥ 40 dB)
Number of subjects	527	589	550
Number (%) of deaths	55 (10.4)	85 (14.4)	112 (20.4)

After adjusting the data for age, mild hearing impairment was associated with a 27% increased risk of mortality and moderate/severe hearing loss with a 54% increased risk compared with individuals without hearing loss. With further adjustment for demographic characteristics and cardiovascular risk factors, the increased risk reduced to 21% and 39% for mild hearing loss and moderate/severe hearing loss respectively,

Thus all studies discussed above, except that of Lopez *et al* (2011), have demonstrated an association between hearing impairment and mortality. However, the study by Lopez *et al* differed from the other studies in that hearing loss was assessed by one simple question on difficulty hearing a conversation, rather than by audiometry, and the age range of participants was very much smaller than in the other studies. It can therefore be concluded from the above studies that hearing impairment increases the risk of death among older adults by at least 20%. The increase in risk is greater for men than for women.

However, two recently published longitudinal studies carried out over longer time periods (17 and 25 years) found that when corrected for confounding factors the association between hearing impairment and mortality was no longer significant. Schubert *et al* (2017) followed over 2,400 participants in the US for up to 17 years, and found that initially hearing loss was associated with mortality when the data were corrected for age and sex, and also for other demographic and health factors. However, when taking account of additional risk factors for cardiovascular and other diseases which are a common cause of death in the US, the association between hearing loss and mortality was no longer significant. The authors observe that the additional risk factors which they considered (preclinical atherosclerosis and

inflammation) had not been considered in previous studies. They also found that participants who developed hearing impairment during the follow up period did not have an increased risk of mortality. Similarly, Amieva *et al* (2018), in a 25 year longitudinal study in France, found no difference in risk of mortality between subjects with and without self reported hearing loss.

It is therefore difficult to draw any definitive conclusions regarding the links between hearing loss and increased risk of mortality.

6.3 CO-MORBIDITY: CO-EXISTENCE OF HEARING LOSS AND OTHER DISEASES

The large scale longitudinal surveys of health undertaken in recent years have enabled investigations into the presence of a range of other chronic diseases and medical conditions among hearing impaired people.

Stam *et al* (2014) analysed data from the Netherlands National Longitudinal Study on Hearing, an internet based survey of adults aged 18 to 70 to investigate the occurrence of 27 medical conditions among groups of differing hearing ability. Participants' hearing was assessed as 'good', 'insufficient' and 'poor' using a national hearing in noise test. The authors found that having any chronic medical condition was more frequent in the group with insufficient and poor hearing than in the group with good hearing. Of the participants with poor hearing ability 78.5% reported one or more other chronic medical conditions, 50% had at least two other chronic conditions and 15% reported having four or more additional chronic medical conditions (compared with 68.6%, 38% and 10% respectively of the normally hearing group). After adjusting for age and gender the following three conditions were significantly associated with poor hearing ability: diabetes, arthritis other than osteoarthritis or rheumatoid arthritis, and dizziness causing falling. No significant association was found between cardiovascular conditions and hearing ability. An interesting feature of this study is that it includes hearing impaired individuals across the adult age range, rather than just older adults experiencing age related hearing loss as in many of the other studies.

In contrast, in their study of a Thai national cohort of over 87,000 subjects aged between 15 and 97 Yiengprugsawan *et al* (2012) found that self-reported hearing loss was associated with cardiovascular conditions (high blood pressure, stroke). They also found associations between hearing loss and high cholesterol and, in agreement with the results of Stam *et al*, diabetes.

The 2017 report into the social and economic costs of hearing loss in Australia (Deloitte Access Economics, 2017) quotes data from the 2015 Australian demographic survey examining the 12 most common comorbidities in people with hearing loss, as shown in Table 6.3. However, the data do not necessarily imply a causal link between hearing loss and other conditions, for example hearing loss and arthritis are both related to ageing.

A recent study in the USA analysed data from the National Health Interview Survey (NHIS) to investigate associations between hearing loss and other, common, medical conditions (McKee *et al*, 2018). The study involved over 53,000 people aged 65 and over who self-reported both hearing loss and diagnosis of other conditions. Hearing loss prevalence was nearly 37%. After adjusting for sociodemographic and other confounding data, the authors found that hearing loss was independently associated with arthritis, cancer, cardiovascular disease, diabetes, emphysema, high blood pressure and stroke. There was also an association with worse health status over the year prior to the survey. However, as the

authors note, causality and the mechanisms underlying these associations cannot be determined from this study

Table 6.3. Most common morbidities in people with hearing loss: prevalence in people with and without hearing loss (data approximated from Chart 5.3 in Deloitte Access Economics, 2017a)

Condition	Prevalence %	
	With HL	No HL
Back problems	27	8
Arthritis and related disorders	24	6
Hypertension	21	7
Head injury/brain damage	17	5
Depression/mood affective disorder	14	5
Asthma	11	6
Diabetes	9	3
Phobias and anxiety disorders	7	3
Nervous tension/stress	7	2
Migraine	7	3
Leg/knee/foot/hip damage	6	2
Arm/hand/shoulder damage	5	1

Thus, there is evidence that people with hearing loss are more likely to suffer from other chronic conditions such as diabetes, but there is conflicting evidence regarding links between cardiovascular conditions and hearing loss, as discussed further in the following two sections.

6.4 CARDIOVASCULAR HEALTH

There have been several studies in the past which have examined possible links between hearing loss and various cardiovascular risk factors such as hypertension, smoking, and high cholesterol. Some of the more recent studies have investigated links between cochlear function and cardiovascular health using otoacoustic emissions (Torre *et a*l, 2005; Hutchinson *et al*, 2015), while others have used audiometric data in their analysis (Helzner *et al*, 2011; Nash *et al*, 2011, Engdahl *et al*, 2015, Lohi *et al*, 2015). An aim of these studies was to identify cardiovascular factors which might also prove to be risk factors for hearing loss. As such a detailed review of these papers is beyond the scope of this report, the purpose of which is to examine consequences, rather than causes, of hearing impairment. Furthermore, the results of the majority of these studies are inconclusive, showing only small effect sizes, as reported by Engdahl *et al* (2015). However, Engdahl *et al* also suggest that if such a link were proved it might suggest that hearing loss is an additional stressor which increases the risk of cardiovascular disease. Nevertheless, in their own study which utilised data on over 31,000 participants in the Nord-Trøndelag health study, including audiometric data, they found that, although many cardiovascular risk factors were associated with hearing loss, the effects were small and of doubtful clinical relevance. Similarly, in the smaller study by Lohi *et al* (2015) of 850 subjects aged between 54 and 66 years in Finland, no significant relationship was found between cardiovascular disease and hearing impairment.

There is thus not yet sufficient evidence to conclude that there are strong links between hearing loss and cardiovascular health, or that, in particular, hearing loss may contribute to increased risk of cardiovascular disease.

6.5 STROKES

Two studies have investigated associations between hearing loss and the risk of strokes, with conflicting results.

In 2008 Lin *et al* published the results of a study into the relationship between sudden sensorineural hearing loss and risk of a stroke. They compared a group of over 1400 patients, of all ages, who had experienced sudden hearing loss with a control cohort matched for age and found that those with sudden hearing loss had a significantly greater risk of stroke in a five year follow up period than those in the control group. They concluded that sudden sensorineural hearing loss could be an early indicator of a stroke. However, while Gopinath *et al* (2009b) found a reported increase in strokes at baseline among those with gradual or sudden hearing loss, the number of reported strokes being higher among those with moderate to severe hearing impairment, they did not find that hearing loss increased the risk of stroke during a five year follow up period.

6.6 FALLS AND GAIT

There have been several studies in the past which have investigated possible links between sensory impairments and falls, but, as explained by Grue *et al* (2009) in a brief review of previous work, findings have been inconsistent. However, more recent studies have been in agreement in establishing a link between falls and slower gait and hearing loss. Possible explanations given for the observed association are direct and indirect effects of hearing loss: coexistent cochlear and vestibular dysfunction affecting both hearing and balance; poor awareness of the auditory and spatial environment; reduced attention to balance; and reduced balance as a result of a decline in physical and social activities (Grue *et al*, 2009; Viljanen *et al*, 2009; Lin and Ferrucci, 2012). Similar explanations are given for the relationship found between a slower gait, which is a recognised indicator of health status, and hearing loss (Li *et al*, 2013).

In the study by Li *et al* (2013) of data from the NHNES 1180 participants ages 50 to 69 years underwent audiometric and gait speed assessments. Hearing loss greater than 25 dB was prevalent in 23% of subjects with only 5.2% having moderate or greater hearing loss. After adjusting for demographic and cardiovascular risk factors it was found that hearing loss was associated with slower gait speed. The reduction in speed associated with a 25 dB hearing loss was equivalent to the reduction expected from an age difference of approximately 12 years. It was also found that a 25 dB increase in hearing loss doubled the risk of having a gait speed less than 1 metre per second, a known risk factor for major health problems including hospitalisation and death (Li *et al*, 2013).

All of the remaining studies reviewed in this section have shown an association between hearing impairment and the risk of falls, despite differences between the studies regarding subjects and methodologies.

Grue *et al* (2009), in a study of older patients in hospital in the five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) explored relationships between falling and sensory impairments. In total 770 patients, aged 75 and over, from five hospitals were included in the study. Hearing loss was assessed subjectively with 48.4% of the subjects being classified as hearing impaired, 40.8% with a mild loss and 7.7% with a moderate loss. Hearing loss was compared with falls reported in the previous three months. It was found that hearing loss was associated with falling; mild hearing loss increased the risk of falls with moderate hearing loss leading to a greater risk.

Another Nordic study (Viljanen *et al*, 2009) was part of a Finnish study of female twins aged 63 to 76. Hearing was assessed by audiometry and the subjects' balance was also

measured; subjects also recorded information about any falls over a 12 month period. The subjects were grouped into quartiles of hearing impairment defined by BEHL (PTA of 0.5, 1, 2, 4 kHz). Table 6.4 shows the percentages of falls in each quartile; it can be seen that the occurrence is relatively stable across the first three quartiles. However, owing to the unusual grading of hearing loss in this study it can be seen that the first three quartiles will involve people with no or very mild hearing loss on the whole so it is difficult to draw any detailed conclusions regarding a relationship between severity of hearing loss and falls. Nevertheless, it can be seen from Table 6.4 that the occurrences of falls increase for people with hearing loss greater than 27 dB. The research also found that people with poorer hearing acuity had poorer postural balance which may explain the increased risk of falling.

Table 6.4. Occurrences of falls across hearing quartiles (data from Table 2 of Viljanen *et al*, 2009)

	BEHL quartiles			
	< 11.5 dB	**11.5 – 17.5 dB**	**18-27 dB**	**>27 dB**
At least 1 fall	43	49	49	53
At least 2 falls	17	18	25	30
At least 1 injurious fall	25	29	27	37

The Australian study by Lopez *et al* (2011) included falls in their investigation into the relationship between vision and hearing impairment and general health related quality of life among 76 to 81 year olds (N = 5354). Hearing was assessed by self-report and compared with reported numbers of falls in the previous 12 months. Men had a higher incidence of hearing impairment than women (30% for men, compared with 13% for women) but the numbers of falls were similar (20% men, 19% women). Hearing impairment was associated with an increased risk of having a fall.

Further evidence of a link between hearing impairment and falls is provided by a recent study by Criter and Honaker (2016). The authors compared the incidence of falls between a group of audiology clinic patients aged 61 to 77 with a matched control group. In the 12 months prior to the study 68% of the audiology patients had had at least one fall, compared with 28% of the control group. The number of falls between the two groups was significantly different (averages of 1.83 and 0.84 falls/person for the audiology and control groups, respectively). In addition, of the audiology patients 64.7% reported multiple falls in the previous year, compared with 42.9% of the control group. However, as the authors state, although audiology patients appear to be more at risk of falls it cannot be concluded that this is directly due to their hearing impairment.

The above studies into falling have involved adults in their 60s and 70s and older. However, the increased risk of falling as a result of hearing impairment is not confined just to the older age groups. The incidence of falls among younger subjects was analysed by Lin and Ferrucci (2012) using data from the American NHANES survey. Hearing of 2017 subjects aged 40 to 69 was assessed by audiometry. Hearing loss greater than 25 dB was prevalent in 14.3% of participants, and 4.9% of participants reported falling over in the preceding 12 months. The researchers found that, for every 10 dB increase in hearing loss, there was a 1.4-fold increase in the odds of an individual reporting a fall. This association remained after adjusting for demographic, cardiovascular and balance factors, and when those with moderate to severe hearing loss were excluded from the analysis. A 25 dB hearing loss was associated with a nearly three-fold increase in the odds of having a fall in the preceding year.

In section 6.3 it was reported that the investigation by Stam *et al* (2014) into the co-morbidity of hearing impairment with other chronic diseases in adults between the ages of 18 and 70 found a significant relationship between dizziness causing falling and poor hearing ability,

suggesting that the likelihood of falling is greater for hearing impaired adults of all ages, not just older subjects.

There is thus increasing evidence that hearing loss increases the risk of falling among hearing impaired adults of all ages; the greater the hearing loss the greater the risk.

6.7 PHYSICAL ACTIVITY

Two studies published in 2014 investigated the extent of physical activity and frailty associated with hearing loss. Both studies involved subjects in the US aged 70 and older, Gispen *et al* (2014) investigating around 700 subjects while the study by Kamil *et al* (2014) was larger with 2100 subjects. However, the study by Gispen *et al* was more detailed using audiometric data on hearing and assessing physical activity both subjectively, by questionnaire, and objectively by body-worn accelerometers, while Kamil *et al* compared self-reported hearing impairment with self-reports of frailty. Both studies found that hearing impairment was associated with physical activity or frailty, although Kamil *et al* found that the association between self-reported hearing loss and self-reported frailty was only significant for male subjects. Gispen *et al,* on the other hand, found that although mild hearing impairment was not associated with the level of physical activity, moderate or severe hearing loss (40 dB or greater) was associated with lower levels of physical activity independent of demographic and cardiovascular risk factors. The authors suggest this may be because individuals with moderate or greater hearing impairment may perform less physical activity because they are socially isolated, and therefore less likely to exercise in a social setting than individuals with normal hearing. Other possible reasons suggested are that hearing loss may impact upon attentional and cognitive resources that are important for maintaining posture and balance, or may restrict an individual's ability to effectively monitor their auditory environment (for example, by hearing auditory cues such as footsteps) and hence reduce their likelihood of performing physical activities.

In an examination of fatigue and vigour among adults seeking help for hearing loss Hornsby and Kipp (2015) found that, compared with adults with normal hearing, they reported significantly more fatigue and less vigour plus increased reports of severe vigour/fatigue problems. However, the increased risk appeared to be unrelated to the degree of hearing loss.

6.8 ACTIVITIES OF DAILY LIVING

Several studies have considered the impact of hearing loss on subjects' ability to perform activities of daily living (ADL). The exact activities assessed vary between studies but in general include 'functional activities' (or 'personal activities') such as dressing, eating, personal hygiene, or getting in and out of bed and 'instrumental activities' (IADL) such as cooking, housework, shopping, or travelling.

The six studies reviewed here have taken place in the UK (Jagger *et al*, 2005), Japan (Ishine *et al*, 2007; Harada *et al*, 2008; Yamada *et al*, 2012), the Nordic countries (Grue *et al*, 2009), Australia (Gopinath *et al*, 2012b) and France (Amieva *et al*, 2018).

In the UK study (Jagger *et al*, 2005) hearing and vision problems were self-reported at baseline for 643 persons aged 75 and over, and only functional activities of daily living were assessed after 11 years.

Table 6.5 shows the percentages of subjects with vision and/or hearing impairment at baseline who had restrictions in their daily activities (that is difficulty performing alone, needing help or aids, or not doing any one of seven ADLs) after 11 years (unadjusted data).

Table 6.5. Percentages of those with and without onset of restrictions in daily activities according to sensory impairment (data from Table II in Jagger *et al*, 2005)

Onset of activity restriction	Sensory impairment at baseline			
	None	Hearing only	Vision only	Both
None (N = 143)	86.0	10.3	3.5	0
Onset (N = 305)	80.7	13.8	4.3	1.3

It can be seen that the group who developed restrictions in ADLs had greater sensory impairment at baseline than the group who remained unrestricted. However, when the data were adjusted for confounding factors (socio-demographic, psychosocial, physical health and physical functional limitations) only those with dual sensory impairment had significantly increased risk of restricted ADLs, with a doubling of the risk.

Similar results were found in the Japanese study by Harada *et al* (2008). Dual sensory impairment and vision impairment but not hearing impairment were significantly associated with reduced functional activity. In this study of 843 people aged 65 years and older, hearing impairment was defined as the inability to hear a tone of 30 dB at 1 kHz. The functional activities assessed included items on social and intellectual functioning as well as more personal activities.

However, two other Japanese studies of over 65 years olds found relationships between hearing loss and reduction in ADLs. Ishine *et al* (2007), in a study of over 2,500 adults, found that self-reported hearing function was significantly associated with reductions in both personal and instrumental ADLs. In a 3-year longitudinal study of 921 adults by Yamada *et al* (2012) which compared self-reported hearing loss with five items of IADL, 45% of those with hearing loss at baseline declined in IADL over the follow up period, compared with 23% of those without hearing loss, resulting in a statistically significant difference in the likelihood of reduction in IADL due to hearing loss.

Grue *et al* (2009), in a study of 770 patients aged 75 and over in five medical wards in the five Nordic countries, found that hearing impairment, vision impairment and dual sensory impairment were all significantly associated with reduction in IADL. The likelihood of IADL loss was greater for those with moderate hearing impairment than for those with mild hearing impairment (assessed subjectively).

The most detailed, and largest, study into restriction in ADL was that carried out by Gopinath *et al* (2012b), in analysing data on 1572 subjects aged 60 and over in the Blue Mountains study in Australia. Baseline audiometric data was compared with functional status of subjects after a 10 year follow up period, as measured by a 14 item ADL scale. Table 6.6 shows the percentages of subjects with and without hearing loss (that is hearing loss greater than 25 dB) who needed help with, or were unable to perform, the 14 activities of daily living. It can be seen that a significantly higher proportion of hearing-impaired than non-impaired adults reported difficulties in performing three out of the seven personal ADL tasks and six out of the seven instrumental ADL tasks. After adjusting for demographic and health factors it was found that increasing severity of hearing loss was associated with increased risk of impaired ADL; those with moderate to severe hearing loss were almost three times as likely to report difficulties with ADL as persons without hearing loss. The authors also stratified the subjects by age group and found that those under 75 years of age with a hearing loss were twice as likely to experience impaired ADL as those without impaired hearing. However, significant associations were not observed in the 75 years and over age group, suggesting that for older subjects hearing loss is not the most important cause of reduction in ADL.

The French study (Amieva et al, 2018) involved a 25 year longitudinal study of around 3000 participants aged 65 and over at baseline. The study found an increased risk of disability in both ADL and IADL for those with self-reported hearing loss who did not use hearing aids.

In conclusion, despite some inconsistencies in results, the more detailed studies suggest that hearing impairment has a significant impact upon activities of daily living, the greater the hearing loss the greater the impact. This obviously has important consequences for the support required in society for the older population in terms of their independent living, caring needs and so on.

Table 6.6. Percentages of subjects with and without hearing loss who need help with, or are unable to carry out, daily activities (data from Table 2 of Gopinath *et al*, 2012b)

Activity	Without HL	With HL
Eating	0.7	0.9
Dressing and undressing	0.9	1.8
Taking care of appearance	0.4	0.7
Walking	1.5	3.9*
Getting in and out of bed	0.3	0.9
Bathing or showering	1.3	3.0*
Getting to bathroom on time	9.7	14.2*
Using telephone	1.7	4.9*
Travelling to places not in walking distance	3.8	11.8*
Shopping for groceries or clothes	3.8	13.3*
Preparing meals	5.7	11.3*
Doing housework	20.0	34.5*
Taking medication	1.5	3.8*
Managing money	2.5	4.1

*Significant difference ($p<0.05$)

6.9 HEARING RELATED QUALITY OF LIFE

There have been several studies which have considered the overall impact of hearing impairment upon general health. Some of these studies have been undertaken in the context of examining the impact or cost effectiveness of treating hearing loss through provision of hearing aids.

Most of the studies involved patients at audiology clinics or volunteers with previously diagnosed hearing loss; thus audiometric data for subjects was available in the majority of cases. Only three studies (Hogan *et al*, 2009a; Lopez *et al*, 2011; Yiengprugsawan *et al*, 2012), which used data from large epidemiological surveys, relied on self -reported hearing levels.

Ciorba *et al* (2012) carried out a review of papers published between 2000 and 2011 which reported studies of the impact of hearing loss, specifically presbycusis, on the quality of life of elderly adults. They concluded that 39% of the hearing impaired population consider that they have an excellent global quality of life, compared with 68% of those without hearing loss, and that almost two-thirds of those with hearing loss report being in fair or poor health, compared with 9% of people without hearing loss. Furthermore, people with hearing loss are less satisfied with life in general than people without hearing loss.

Results of individual studies which are reviewed in this section are summarised in Table 6.7.

One of the most commonly used scales for assessing health related quality of life is the Medical Outcomes Study Questionnaire Short Form Health Survey, SF-36, which is widely used in medical and healthcare research. It can be seen in Table 6.7 that the majority of studies reviewed here used the SF-36 scale. The SF-36 consists of 36 items, grouped into eight subscales that assess eight health domains: 'physical functioning', 'role limitations due to physical problems', 'bodily pain', 'general health perceptions', 'vitality', 'social functioning', 'role limitations due to emotional problems', and 'mental health'. The subscales are combined to give a physical composite score (PCS) and a mental composite score (MCS). All components of domain scores are weighted so that the overall scores on each domain, and the PCS and MCS, range from 0 (maximum disability) to 100 (no disability); thus a higher value indicates better health. Shortened versions of the SF-36 (eg SF-6D and SF-8) are also in use. Another generic health related quality of life survey, which was used in one study, is the Veterans-RND, VR-12, which assesses similar domains to those of the SF-36.

Other scales have been developed specifically to assess hearing handicap and associated quality of life. The most commonly used in the studies shown in Table 6.7 are the Hearing Handicap Inventory for the Elderly (HHIE) and its adaptation, the Hearing Handicap Inventory for Adults (HHIA). These are self-assessment tools designed to measure the effects of hearing impairment on emotional and social adjustment. Both the HHIE and HHIA consist of 25 items, 13 items which assess the emotional consequences of hearing impairment, and 12 items that assess social and situational effects.

Two of the studies shown in Table 6.7 used health utility index (HUI) scales. The HUI is a number ranging from 0 (death) to 1 (full health), which is commonly used in health economic evaluations to reflect the impact on general health of various conditions. The HUI scale currently used is the Health Utilities Index Mark III (HUI3) which assesses a person's ability to function in eight different domains (vision, hearing, speech, mobility, dexterity, emotion, cognition and pain). Figures given in the table refer to scores pre hearing aid fitting.

It can be seen that, overall, whatever the measure used, all the studies indicate that hearing impairment reduces quality of life. (However, some care must be taken in interpreting results of some studies as it is difficult to control for differences in quality of life that may have preceded the onset of hearing loss.)

Studies which report effects on individual domains of the SF-36 show that social functioning and physical role domains are particularly affected by hearing impairment which is consistent with the effects of hearing loss reported in the preceding sections of this chapter and in Chapter 2. Some, but not all, studies have found that the quality of life decreases with increasing severity of hearing loss. However, Hallberg *et al* (2008) concluded that it is coping skills, such as the use of communication strategies, in addition to hearing ability, which determine the extent of the impact of hearing impairment on wellbeing.

Two studies (Hawkins *et al,* 2012; Simpson *et al,* 2015) compared the decrease in HRQoL scores associated with (self-reported) hearing loss with the decrements due to other chronic conditions and found that hearing loss caused a greater loss than several other conditions such as diabetes, hypertension, angina, sciatica and congestive heart failure.

Table 6.7. Summary of studies on impact of hearing impairment on quality of life

Authors	Subjects		Hearing handicap & QoL assessments	Results
	No	Age		
Barton *et al*, 2005	915 HI	20-95 Mean 68.5	EQ-5D HUI3 SF-6D	Measured health utility using three different scales: mean values EQ-5D 0.79; HUI3 0.56; SF-6D 0.77
Ozler and Ozler, 2005	45 HI 40 NH (all M)	20-50 Mean 35	SF-36 HHIE	Poorer social functioning and physical role domains of SF-36
Chia *et al,* 2007	1084 HI 1347 NH	Mean 67	SF36 Self reported hearing difficulties	Measured bilateral and S-R HL associated with poorer HRQoL. Impact increases with increasing severity of HL. High frequency loss alone and unilateral loss not associated with QoL scores.
Hallberg *et al*, 2008	79	48-92 Mean 68.7	3 tests of hearing handicap; psychological well being and communication strategies	HI subjects scored lower scores on PWB scale than general population; women's scores significantly lower than men's. QoL affected by ability to understand speech.
Monzani *et al*, 2008	73 HI 96 NH	35-54 Mean 46	SF-36 HHIA Social functioning quest	HI subjects scored lower in social functioning and emotional areas.
Hogan *et al*, 2009a	>43,000 14.6% hearing disabled	≥ 55	Self-reported hearing disability SF-12	Hearing disabled group had significantly poorer scores on physical and mental health scales. Decrease in Qol greater with increased hearing disability.
Preminger and Meeks, 2010	52 HI 52 NH spouses	34-84 Mean 66	HHIE/A	HRQoL decreased with increasing HL
Lopez *et al*, 2011	5354 20% HI	76-81 Mean 78	SF-36 Self-reported HL	Reduction in MCS and PCS scores for HI men and women compared with normal hearing subjects.
Bakir *et al*, 2012	36 HI 40 NH (all M)	24-57 Mean 36	SF-36	Poorer social functioning and physical role domains of SF-36
Gopinath *et al,* 2012c	829 (10 year study)	≥ 55 Mean 65.8	SF-36 HHIE/A	Measured baseline HI associated with lower MCS after 10 years. Self-reported baseline hearing handicap associated with lower scores on most domains of SF-36 and PCS. Incident HL in 10 years led to lower scores on PCS, general health and 2 other domains.
Hawkins *et al*, 2012	573 HI 4942 NH	≥ 65	VR-12	HI strongly related to reduced QoL related to physical and mental health. Impact of HL is greater than that of many other chronic conditions.
Swan *et al*, 2012	4442 HI 947 SNHL	Mean 54	HUI3 and GBI	Average HUI all hearing problems 0.65; SNHL 0.57

Table 6.7. Summary of studies on impact of hearing impairment on quality of life (continued)

Authors	Subjects		Hearing handicap & QoL assessments	Results
	No	Age		
Wong & Cheng, 2012	64 HI	≥ 65	SF-36 HHIE	HI subjects had poorer HRQoL than general older population. QoL lower among those with HL > 40 dB
Yiengprugsawan *et al,* 2012	7376 HI 79640 NH	15-87 (82% 20-40)	SF-8 Questionnaire	Self-assessed poor health and poor psychological health strongly associated with HL
Niemensivu *et al*, 2015	949 HI 4685 NH	33-95 Mean 73.8	15 item questionnaire	HI subjects scored significantly lower on most dimensions of QoL scale.
Simpson *et al,* 2015	421 HI 2146 NH	60-90 Mean 71.0	EQ-5D	Mild HL is associated with small decrement in QoL, mod/severe HL with larger decrement. Reduction in QoL caused by mod/severe HL is greater than for several other chronic conditions.
Stika and Hays, 2016	409 HI	22-91 Mean 63	New scale IHEARIT SF-36 HHIE/A	Greater HL associated with poorer HRQoL. Women and younger subjects reported poorer HRQoL than men and older subjects.

6.10 SUMMARY

This chapter has shown that research published in the past twelve years has provided increasing evidence of links between hearing loss and several other physical health conditions, as well as detrimental effects of hearing impairment on overall health. In particular, it has shown that

- The earlier studies suggested that hearing impairment increases the risk of death among older adults, particularly men, by at least 20% However, two recently published studies found that, after controlling for confounding factors, there was no significant association between hearing loss and mortality.
- People with hearing impairment are more likely to have other chronic diseases than people with normal hearing.
- To date results are inconclusive regarding links between hearing loss and cardiovascular disease.
- Hearing loss is associated with lower gait speed, an indicator of poorer health status.
- Hearing impairment increases the risk of having a fall in adults of all ages.
- The risk of a fall increases with increasing severity of hearing loss.
- Hearing impairment is associated with frailty and reduction in physical activity, particularly among those with moderate to severe hearing loss.
- Hearing loss is associated with disability as measured by reduction in activities of daily living; the more severe the hearing loss the greater the reduction.
- Hearing loss has a negative impact upon overall health related quality of life.
- Hearing loss has more of an impact on quality of life than many other chronic conditions.

6.11 CONCLUSIONS

Hearing impairment has a very detrimental effect upon health and wellbeing, particularly for older adults. This has important consequences for the social and practical care needed to support the people with hearing impairment in society.

CHAPTER 7 HEARING LOSS AND COGNITION

7.1 INTRODUCTION

There have been many studies since the 1960s which have investigated links between hearing loss and cognitive performance, with increasing interest in this area in the past 25 years as a result of growing concern about the ageing population and corresponding increase in the prevalence of dementia. The 2006 Hear It review (Shield, 2006) showed that, at that time, there was inconclusive evidence regarding the relationship between hearing loss and cognitive performance, dementia, or memory loss. Some research had found links between hearing impairment and dementia, confusion or decline in cognitive function; however, in some of the studies any association was lost when age was taken into account (McKenna, 2001).

However, as will be seen, studies undertaken in the past 14 years have tended to show a definite link between hearing loss and cognitive decline, although there is still some inconsistency between results. In 2016 Taljaard *et al* published a meta-analysis of results from 33 previous studies into the relationship between hearing and cognition; although their overall conclusion is that hearing impairment is associated with cognitive problems, they considered that this assumption might be premature given the diverse nature of the studies. However, Humes and Young (2016) in reviewing research into the relationship between age-related changes in vision and/or hearing and changes in cognition concluded that there was increasing evidence for a link between decline in sensory function and cognitive decline although the exact nature of the link was still unknown.

7.2 RECENT RESEARCH STUDIES

The changing demographic profile of the population, with an increasing proportion of the population being elderly, has led to a significant amount of research in recent years into the effects of ageing and the mental and physical well-being of the elderly. Much of the research into hearing loss and its impact upon memory, cognition and dementia has been carried out as part of these wider studies. Table 7.1 summarises some of the studies that have been undertaken in the past 14 years, plus two significant earlier studies. It can be seen from the table that much of this research has been published in the past five years, highlighting the increasing interest in the area.

In the past ten years there have also been several reviews of research into the relationship between hearing, hearing loss and cognition (Akeroyd, 2008; Tun *et al*, 2012; Pichora-Fuller, 2015; Taljaard, 2016; Humes and Young, 2016). A major review in 2009 by Arlinger *et al* traced the history of research in both hearing and cognition since the mid 20th century, describing the convergence of the two disciplines around the end of the millennium, which is demonstrated by the upsurge in the number of publications in the field since the early 2000s.

Many of the studies reported here, and additional studies, have investigated the impact of hearing aids on cognition, and whether their provision improves cognitive function and/or slows the rate of cognitive decline; this particular potential benefit of hearing aids is considered in Chapter 12.

7.3 DIFFICULTIES IN INTERPRETING RESULTS

The relationship between hearing loss and cognitive ability is complex. While early studies reported a link between hearing loss and dementia, more recent authors have postulated that there may not be a direct causal link between the two conditions as there are many confounding factors involved. Furthermore, while some studies have found that hearing loss is associated with poorer cognitive functioning, others have found that individuals with

hearing loss perform normally in cognitive tests. Inconsistent and conflicting results from various studies have been noted by many authors (for example, Zekveld *et al*, 2007; Tun *et al*, 2012; Lin *et al*, 2013; Taljaard *et al*, 2016) so that it is still not possible to say definitively what the exact relationship is between hearing loss and cognitive decline. Many of the inconsistences could be due to different study populations, in particular in terms of age or degree of hearing loss (Zekveld *et al*, 2007; Lin *et al*, 2013; Taljaard *et al*, 2016); the types of cognitive testing used and methods of presentation (Zekveld *et al*, 2007; Pichora-Fuller, 2015); and the type of hearing assessment undertaken (Lin *et al*, 2013). These factors are discussed in more detail in section 7.4.

A further difficulty in interpreting results may arise from the overlap of symptoms of hearing loss and dementia. In most of the studies, particularly those related to research into ageing, the subjects are elderly. Given the prevalence of both hearing loss and cognitive decline among older individuals it is likely that some of the participants in the research will be suffering from at least one of the conditions. However, many of the symptoms of dementia are similar to those of hearing loss which may make identifying direct effects of hearing loss or dementia, and the nature of the association between them, difficult. Jorgensen *et al* (2014) list the following overlapping symptoms which are common to both hearing loss and dementia: social isolation; decreased comprehension; repeating questions; short-term and working memory problems; stereotyped or inappropriate word use; difficulty following conversation.

7.4 COMPARISON OF STUDIES

As mentioned briefly above, the differences between the methods used in the various studies, plus potential difficulties in dissociating symptoms of hearing impairment from those of cognitive decline, make comparison of results and drawing of any definitive conclusions from the results of all the studies problematic. Some of these difficulties are discussed below.

7.4.1 Types of study

There are many variations in the methodologies that have been used to study links between hearing loss and cognition. Some studies have compared a group of hearing impaired with a group of non hearing impaired subjects, while others have taken the severity of hearing loss into account; others have considered people with dual sensory impairment (hearing and vision); and some studies have been longitudinal over several years and have compared rates of decline in hearing acuity with rates of cognitive decline.

7.4.2 Cognitive testing

Various different types of cognitive tests have been used. Some studies have used just one test, such as the Mini-Mental State Examination (MMSE), a commonly used screening test of memory and cognition, or the similar Montreal Cognitive Assessment (MoCA). Both of these tests are quite short, consisting of around 30 items designed to assess mental status. Other studies have used longer versions of these tests with around 100 items; while others have used a battery of tests to examine many different aspects of cognition such as memory, mental status, executive function (behaviour and reasoning required to adapt to one's environment), speed of processing and verbal functioning.

7.4.3 Presentation of cognitive test material

It is suggested in some of the more recent papers that the results of previous research which appeared to prove a link between hearing loss and cognitive decline could have been influenced by the methodologies used for the cognitive testing, particularly if hearing loss is not taken into account (Pichora-Fuller, 2015). Cognitive tests often require the patient to listen to instructions or respond to auditory stimuli, so people with hearing loss may underperform, especially if the tests are not carried out in a sufficiently quiet environment or

with appropriate listening technology (Pichora-Fuller, 2015). Their performance may then be incorrectly interpreted as being due to poor cognitive abilities, hence underestimating their true ability. However, Allen *et al* (2003) believe that the simple explanation that hearing loss reduces the patient's ability to hear and respond to spoken test instructions is probably not true as some studies have found lower scores in cognitive tests when patients were given written rather than verbal test instructions. Nevertheless, although Gussekloo *et al* (2005) found that both hearing and visual impairment were associated with lower MMSE scores, there was no association between hearing impairment and cognitive functioning in tests that were presented visually (memory and cognitive speed), whereas there was an association between visual impairment and visual test results. Gussekloo *et al* therefore assumed that the association between sensory impairment and cognitive functioning is, at least partly, based on the practical disadvantages of elderly people with sensory impairment during cognitive assessments. This is further suggested by the study of Zekveld *et al* (2007) which used non-verbal cognitive tests of memory and attention; in this study hearing loss was not associated with lower performance and the authors emphasised the importance of using non-verbal tests when testing hearing impaired individuals.

7.4.4 Audiological assessments

Table 7.1 shows that the majority of studies have used pure tone audiometric testing to assess the hearing acuity of subjects. However, the detailed testing has varied both in the frequency range tested and/or reported and in the definition of hearing loss. Lin *et al* (2011a) cite the variability in how hearing loss is measured and how audiometric data are analysed in defining hearing loss as explaining some of the inconsistencies between studies. Not all studies have used audiometric measurements; some have used self-reported data on hearing loss instead of (Wallhagen *et al*, 2008; Gurgel *et al*, 2014; Amieva *et al*, 2015, 2018) or in addition to (Zekveld *et al*, 2013) measured audiometric data.

Table 7.1 illustrates both the variation in definitions of hearing loss and the wide range of hearing loss encountered across the studies.

7.4.5 Subjects

There has been a very great range in the numbers of subjects used in the various investigations, and in the ages of subjects tested. Most of the studies have involved middle aged or elderly participants over the age of 50 but some (Teasdale and Sorenson, 2007; Zekveld *et al*, 2007) have used subjects who are very much younger. One study involved only women (Lin *et al*, 2004) while the study by Teasdale and Sorenson (2007) concerned young men registering for military service in Denmark. It can be seen from Table 7.1 that some studies have included participants over the age of 100.

A further confounding factor is that, in some studies hearing impaired subjects used hearing aids for some of the tests, whereas in others participants did not use their hearing aids.

7.5 OVERALL RESULTS OF RECENT STUDIES

The results of recent studies are summarised in Table 7.1. It can be seen that the majority of studies have shown a relationship between decline in hearing acuity and reduction in various aspects of cognitive performance.

Two studies which examined the effects of both visual and auditory impairment (Lin *et al*, 2004; Valentijn *et al*, 2005) found that sensory impairment is related to cognitive decline but that the relationship is stronger for visual impairment than for hearing loss. However dual impairment was strongly correlated with reduction in cognitive performance. These results were consistent with those of an earlier study (Lindenberger and Baltes, 1994) in which both visual and hearing acuity were examined in relation to intellectual ability.

Of those studies which examined the role of hearing impairment alone in cognitive functioning and decline, the majority found a link between hearing loss and cognitive abilities, with more severe hearing loss being associated with lower performance in cognitive tests (Tay *et al*, 2006; Teasdale and Sorenson, 2007; Lin *et al*, 2011a; Lin *et al*, 2011b; Dupuis *et al*, 2015; Deal *et al*, 2015), even among a group of young subjects (Teasdale and Sorenson, 2007). Other studies showed no direct relationship between cognition and hearing acuity (Valentijn *et al*, 2005; Zekveld *et al*, 2007; Amieva *et al*, 2015). The longitudinal studies also showed conflicting results. Valentijn *et al* (2005) found that, while auditory acuity at baseline was not associated with any cognitive variable, it was associated with changes in cognition over a six year period, while changes in auditory acuity were related to changes in memory. Similarly, Wallhagen *et al* (2008) and Lin *et al* (2011b) found that baseline hearing level was related to increased risk of cognitive decline or dementia after a follow up period of five or 12 years respectively. Other longitudinal studies also showed that an increase in hearing loss over time was related to a corresponding decrease in some aspect of cognitive performance (Valentijn *et al*, 2005; Lin *et al*, 2013; Gurgel *et al*, 2014) and an increased risk of developing dementia (Gurgel *et al*, 2014). However, Lin *et al* (2004) and Amieva *et al* (2015) found that, after correcting for psychosocial and demographic characteristics the association between decrease in hearing acuity and decline in cognitive function was no longer present, although the later study by Amieva *et al* (2018) found a small increase in risk of dementia for those with self reported hearing problems at baseline.

Most of the studies have involved middle aged or elderly subjects, and it has generally been assumed that the association between hearing loss and cognitive decline is particularly prevalent among older adults. However, Teasdale and Sorenson (2007), in studying a large group of young men, found that even among a younger age group hearing loss was associated with a general reduction of cognitive ability. The authors postulate that this may have been due to difficulties in hearing in the classroom. More recently, research by Humes and Young (2016) has suggested that the linkage between sensory processing and cognition is independent of age.

7.6 LANCET COMMISSION ON DEMENTIA

As mentioned in section 7.1, two recent reviews of studies into the relationship between hearing loss and cognition concluded that hearing impairment is associated with cognitive problems, although it was not possible to establish the exact nature of the link between hearing loss and dementia or cognitive decline (Taljaard *et al*, 2016; Humes and Young, 2016).

However, the 2017 report of the Lancet Commission on dementia prevention, intervention, and care identified risk factors for dementia which could be modified or controlled (Livingston *et al*, 2017). The authors concluded that around 35% of dementia is attributable to a combination of nine modifiable risk factors including hypertension, obesity and hearing loss in mid-life. The majority of studies which they considered found that even mild hearing loss increased the long-term risk of cognitive decline and dementia, the risk increasing with severity of hearing loss. The authors estimated the reduction in cases of dementia that could be achieved if the modifiable risk factors were controlled. Table 7.2 shows the nine main modifiable risk factors and their relative contributions. It can be seen that, of the nine main modifiable risk factors, hearing loss in middle age made the greatest contribution (9%) to dementia risk, that is if hearing loss in middle age could be managed or eliminated, 9% of cases of dementia in later life would be prevented.

Table 7.2. Risk factors for dementia (Livingston *et al*, 2017)

	Risk factor	Relative contribution
Early life	Less education	8%
Mid life	Hearing loss	9%
	Hypertension	2%
	Obesity	1%
Late life	Smoking	5%
	Depression	4%
	Physical activity	3%
	Social isolation	2%
	Diabetes	1%

7.7 RELATIONSHIP BETWEEN HEARING LOSS AND COGNITION

It is generally agreed that the relationship between hearing loss and cognitive ability is complex, with hearing loss having the potential to negatively influence cognitive performance both directly and indirectly (Tun *et al*, 2012). Several theories have been proposed to explain the interaction between hearing loss and cognitive performance or cognitive decline.

In reviewing previous studies, Valentijn *et al* (2005) listed four hypotheses that had been suggested to explain the link between sensory and cognitive functioning. Subsequent authors have also suggested one or more of these as possible explanations for their results:

- A prolonged lack of adequate sensory input will result in cognitive deterioration due to neuronal atrophy (the 'sensory deprivation' hypothesis).
- Sensory-impaired individuals have to allocate more attentional resources to perceive and interpret sensory information, resulting in fewer resources available for other cognitively demanding tasks (the 'resource allocation' hypothesis).
- Sensory functioning and cognition may both decline as the result of age-related changes in a common factor, such as degeneration of central nervous structures.
- Sensory-impaired individuals are disadvantaged in their performance on tests as a direct result of difficulties in sensory perception. (This aspect has been discussed above and it has been seen that some authors have attempted to investigate this factor by presenting test material in different ways.)

Increased engagement in social, physical or intellectual pursuits is associated with increased cognitive ability and decreased risk of dementia (Marioni *et al*, 2015). Hence the loss of social contacts and activities, which is known to be a consequence of hearing impairment (Shield, 2006), is increasingly being suggested as a possible cause of cognitive decline and dementia (Allen *et al*, 2003; van Hooren *et al*, 2005; Pichora-Fuller, 2015; Amieva *et al*, 2015). Allen *et al* (2003) also suggest that depression, which is linked to hearing loss, may contribute to apparent cognitive impairment.

Theories have also been suggested to explain the results of studies where no association was found between hearing loss and cognitive test results. For example, Zekveld *et al* (2007) suggest that working memory, which is known to be important in language understanding, is used to compensate when hearing loss is present and indeed appears to improve among individuals with more severe hearing loss.

It is also thought by some authors that age related decline in certain aspects of cognitive processing, such as speed of information processing and some memory tasks, can be compensated for by age related gains in cognitive knowledge, such as vocabulary and expertise (Pichora-Fuller, 2015).

7.8 CONCLUSIONS

It can be seen that, although increasingly, research continues to find a link between cognition and hearing loss, the nature of the association is still by no means clear. The effectiveness of hearing aids in restoring, or preventing decline in, cognitive function is examined in Chapter 12.

Table 7.1. Summary of studies into relationship between hearing loss and cognitive ability

Study/country	Subjects			Tests		Results	Comments/ conclusions
	Number	Ages (yrs)	Hearing	Cognition	Hearing		
Lindenberger and Baltes 1994 Germany	156	70-103 Mean 84.9	Mean $BEHL_{0.5,1k,2k}$: 46.3 dB	14 tests of intellectual ability	Audiometry Visual acuity also measured	Sensory functioning correlated with intellectual functioning in old age (vision more than HL).	Authors suggest several possible interpretations of results
Thomas *et al* 1983 USA	239	60-89 Mean 72	46% hearing impaired	Cognitive tests plus psychosocial and memory tests	Audiometry	Those with HL performed less well on verbal but not non-verbal tests of cognition.	Hearing acuity affects measured mental status
Lin *et al* 2004 USA	5345 (all women)	≥ 69 Mean 76.1 at baseline	19.9% had HL (defined as ≥ 40 dB BEHL at 2000 Hz)	3MS (testing of concentration, language and memory) and assessment of functional status at baseline and after 4-5 years	Audiometry (using hand held audiometer) Visual acuity also measured	15.7% had cognitive decline; 10.1% functional decline. After adjusting for sociodemographic etc characteristics HL not associated with cognitive or functional decline but combined visual and hearing impairment was.	Sensory impairment is associated with cognitive and functional decline in older women.
Valentijn *et al* 2005 Netherlands	418	≥ 55 Mean 65.9 at baseline	At baseline: 7.7% HI (BEHL ≥ 35 dB) Mean $BEHL_{1k,2k,4k}$ = 16 dB After 6 years: 32.7% HI Mean $BEHL_{1k,2k,4,}$ = 29.2 dB	Cognitive tests at baseline and after 6 years	Audiometry Visual acuity also measured	Auditory acuity at baseline not associated with any cognitive variable but associated with change in some cognitive tests over 6 years. Change in auditory acuity associated with change in memory performance. Changes in visual acuity more closely associated with cognitive changes.	There is a strong connection between sensory acuity and cognitive performance measures.

Table 7.1 Summary of studies into relationship between hearing loss and cognitive ability (continued)

Study/country	Subjects			Tests		Results	Comments/ conclusions
	Number	Ages (yrs)	Hearing	Cognition	Hearing		
Gussekloo *et al* 2005 Netherlands	459	≥ 85	15% no HL ($BEHL_{1k,2k,4k}$ < 35 dB) 70% BEHL 35 to 64 dB 15% BEHL > 64 dB	Battery of tests including mental status, memory and cognitive speed	Audiometry Visual acuity also measured	HL associated with lower scores on MMSE (presented verbally and visually). No association between HL and tests of cognitive functioning presented visually.	Association of sensory impairment and cognition at least partly due to practical problems during cognitive testing
Tay *et al* 2006 Australia	3509	≥ 50	89% no or mild HL (defined as $BEHL_{0.5,1k,2k,4k}$ ≤ 40 dB) 11% moderate to severe HL ($BEHL_{0.5,1k,2k,4k}$ > 40 dB)	Mental status (MMSE)	Audiometry Visual acuity also measured	Significant correlation between MMSE score and hearing threshold in all age groups. After adjusting for age, sex, education etc HL associated with doubling of likelihood of cognitive impairment.	Correlation between sensory and cognitive function increased with age.
Teasdale & Sorenson 2007 Denmark	>22,000 (all men)	Young men >18	4.6% severe* 19.7% mild 75.7% normal	4 cognition tests, results standardised to give IQ metric	Audiometry	HL associated with general reduction of cognitive abilities	May result from difficulties hearing in the classroom
Zekveld *et al* 2007 Netherlands	30	24-72 Mean 53	Mean $BEHL_{0.5,1k,2k}$ = 28.8 dB	Battery of IQ and memory tests, presented non-verbally	Audiometry	HL not associated with decreased performance in memory and attention tests.	Non-verbal tests essential. Those with severe HL use working memory to compensate.
Wallhagen *et al* 2008 USA	2061	50-94 Mean 63 at baseline	At baseline: 17% reported trouble hearing 47% reported some difficulty understanding conversation	Self-reported cognitive functioning at baseline and 5 year follow up. (13% poor at baseline; 15% poor at follow up)	Self-reported	After adjusting for demographic and medical factors hearing at baseline was associated with poor cognitive functioning at follow up.	Both prevalence (existing cases) and incidence (new cases) of cognitive impairment associated with HL.

Table 7.1 Summary of studies into relationship between hearing loss and cognitive ability (continued)

Study/country	Subjects			Tests		Results	Comments/ conclusions
	Number	Ages (yrs)	Hearing	Cognition	Hearing		
Lin 2011 USA	605	60-69 Mean 64.1	Mean $BEHL_{0.5,1k,2k,4k}$ = 20.9 dB 29% BEHL>25 dB 7.3% BEHL > 40 dB	Non-verbal test of executive function and processing speed	Audiometry	Hearing loss negatively associated with cognitive scores. Results same after adjustment for demographic and medical factors and when restricting data to those with HL < 40 dB.	Reduction in cognitive performance due to 25 dB HL corresponds to reduction associated with increase in age of 7 years.
Lin *et al* 2011a USA	347	≥ 55 Mean 71	Mean $BEHL_{0.5,1k,2k,4k}$ = 25.5 dB No HL 59.1%** Mild HL 28.5% Moderate HL 11.5% Severe HL 0.9%	Battery of tests including mental status and memory	Audiometry	Greater HL associated with lower scores on MMSE, memory and executive functioning test	Reduction in cognitive performance associated with 25 dB HL is equivalent to reduction associated with increase in age of 6.8 years.
Lin *et al* 2011b USA	639	36-90	No HL 71%** Mild HL 20% Moderate HL 8% Severe HL 1%	Battery of tests for cognitive decline, dementia and Alzheimer's disease at 12 year follow up	Audiometry	After adjusting for demographic and medical factors risks of incident dementia and of Alzheimer's disease increased with severity of baseline hearing loss	Hearing loss may be an indicator of early stage dementia or a modifiable risk factor for dementia.
Lin *et al* 2013 USA	1984	70-79, mean 77.4 at baseline	41% no HL ** 59% HL (of which 65.6% mild, 33.2% moderate, 1.2% severe)	Tests administered 4 times over 6 years, include memory, mental status, concentration	Audiometry	Those with HL showed 30% to 40% accelerated rate of cognitive decline and 24% increased risk of incident cognitive impairment over 6 years compared with normal hearing group	HL is associated with accelerated cognitive decline and incident cognitive impairment

Table 7.1 Summary of studies into relationship between hearing loss and cognitive ability (continued)

Study/country	Subjects			Tests		Results	Comments/ conclusions
	Number	Ages (yrs)	Hearing	Cognition	Hearing		
Zekveld *et al* 2013 Netherlands	32	48-83 (mean =66.4)	Av PTA 15-64 dBHL	Memory and attention tests	Audiometry Self reported (re speech perception)	Cognitive abilities related to subjective hearing disability factors	Large working memory related to more reported hearing difficulties
Gurgel *et al* 2014 USA	4545	65-102 Mean 75.4	18% HI at baseline	Cognitive tests at baseline and 3 year intervals over 12 years	Self reported and observed at baseline and 3 year intervals over 12 years	Of those with HL at baseline 16.3% developed dementia compared with 12.1% of those without. Mean times to developing dementia were 10.3 years for the HL group and 11.9 years for non-HL group	HL is independent predictor of developing dementia. HL is associated with higher incidence and faster rate of developing dementia.
Amieva *et al* 2015 France	3670	> 65 at baseline	4% major HL 31% moderate HL 65% no HL at baseline	Test of mental status 10 times over 25 years	Self reported	HL associated with accelerated cognitive decline Relationship not significant when controlled for psychosocial factors	No direct effect of HL. Restoring communication abilities through use of HA attenuates cognitive decline
Dupuis *et al* 2015 Canada	301	Mean 71	165 no HL *** 136 HL	Test of mental status/memory	Audiometry	More of normal hearing group passed memory test (66%) than of HL group (38%)	HL affects performance on memory test. Sensory impairments need to be considered when cognitive screening conducted

Table 7.1 Summary of studies into relationship between hearing loss and cognitive ability (continued)

Study/country	Subjects			Tests		Results	Comments/ conclusions
	Number	Ages (yrs)	Hearing	Cognition	Hearing		
Deal *et al* 2015 USA	253	45-64 at baseline Mean 77 at time of final testing (2013)	At final follow up: 29% no HL 37% mild HL 34% moderate/ severe HL	Battery of tests at 20 year follow up Tests of memory, language, processing speed administered 3 times over 20 years	Audiometry only at final follow up	Subjects with moderate/severe HL performed worst in memory tests at follow up and had fastest rate of cognitive decline.	HL may be a risk factor for cognitive decline in older adults; HA use could possibly reduce risk.
Marioni *et al* 2015 France	2854	> 65 at baseline	–	Battery of cognition tests + lifestyle questionnaire	–	–	Increased engagement in social etc activities related to decreased risk of dementia.
Fritze *et al*, 2016 Germany	~155,000	≥ 65	-	Hearing and cognitive status determined from insurance records		Bilateral and side-unspecified HL increased risk of incident dementia (bilateral by 16%). No effect of unilateral HL	Bilateral HL increases risk of dementia.
Amieva *et al*, 2018 France	3588	≥ 65 at baseline	36% with hearing difficulty at baseline	11 cognitive assessments over 25 years	Self reported	24% of those without hearing loss had dementia; 26% of those with HL not wearing HA; 16.5% of those with HA	HL associated with increased risk of dementia. HA reduce risk.

* Normal: Normal hearing 20 dB; Mild – not worse than 25 dB in both ears at frequencies < 3000 Hz and not worse than average of 45 dB at freq > 2000 Hz; Severe -greater than mild

** No HL: BEHL ≤ 25 dB; Mild HL: BEHL between 26 and 40 dB; Moderate HL: BEHL between 41 and 70 dB; Severe HL: BEHL ≥ 71 dB

*** HL: $WEHL_{0.5, 1k, 2k}$ ≥ 26 dB

CHAPTER 8 IMPACT OF HEARING LOSS ON EMPLOYMENT AND EARNINGS

8.1 INTRODUCTION

There have been many studies in the past ten years concerning the impact of hearing impairment on occupational performance and wellbeing at work, to add to the body of knowledge which was reviewed in the 2006 Hear It report (Shield, 2006). The studies reviewed then showed that hearing impairment caused problems in all aspects of working life including obtaining work, functioning at work, communicating with colleagues and being stigmatised by co-workers. The original report also reviewed data, obtained mainly from studies carried out in the UK by the RNID, and from American studies, on the incidence of underemployment and unemployment among deaf and hard of hearing people, and typical earnings of people with hearing impairment in relation to those of the general population. There was a consistent pattern of lower employment rates among the hearing impaired population than in the general population, employment rates decreasing with increased severity of impairment. More hearing impaired than hearing people were employed in jobs with lower status and lower earnings. Studies of relative earnings showed that, on average, the earnings of hearing impaired people were approximately 85% of those of the hearing population.

The first part of this chapter considers the negative effects of hearing loss on working life by reviewing papers that have been published in the past 12 years describing studies which have been undertaken in the Netherlands (Kramer *et al*, 2006; Nachtegaal *et al*, 2009b; 2012; Stam *et al*, 2013), Sweden (Pierre *et al*, 2012; Hua *et al*, 2013; 2015), Denmark (Christensen, 2006) and the USA (Tye-Murray *et al*, 2009; Blazer *et al*, 2016). In the second part of the chapter the impact of hearing loss on income, unemployment and underemployment, and its links to social deprivation, are discussed.

8.2 NEGATIVE IMPACT OF HEARING LOSS ON WORKING LIFE

Studies investigating the impact of hearing loss in the work place have taken different forms: some have been based upon focus group discussions or semi-structured interviews with a relatively small number of people, while other authors have carried out surveys or used data from larger population surveys to compare hearing impaired with non-impaired subjects. In general, similar findings have been found among the various studies concerning the impact of hearing loss on daily working life. Effects that have been identified among hearing impaired employees include fatigue, stress, lack of control at work, reduced social integration at work and reduced productivity.

8.2.1 Overall impact

In 2009 Tye-Murray *et al* published the outcomes of focus group discussions with 46 hearing impaired professionals aged 29 to79, who worked in offices or office-like environments. The aim of the study was to gauge how hearing loss affects self-perceived job performance and the psycho-emotional status of professionals in the workforce (Tye-Murray *et al*, 2009). The focus group discussions were transcribed and comments relating to psycho-emotional reactions analysed. The percentages of occurrences of particular psycho-emotional topics are listed in Table 8.1. It can be seen that approximately 75% of the comments relate to negative psycho-emotional reactions.

In a more recent study Hua *et al* (2015) carried out semi-structured interviews with 15 participants aged 18 to 65, all of whom had mild-moderate hearing loss, used hearing aids, and were employed for between 80% and 100% of full time in a variety of occupations. From these they identified four main categories of the impact of hearing loss, as shown in Table 8.2, together with common factors within each category.

Table 8.1. Occurrences of comments (%) on different psychosocial reactions at work (data from Table 1 in Tye-Murray *et al*, 2009)

Reaction	Percent of all comments
Embarrassment/self-consciousness/shame	23
Equanimity/acceptance/self-assurance	22
Frustration/sense of being misunderstood	16
Anxiety/fear	15
Resentment/anger	10
Self-doubt	9
Other	3

Table 8.2. Impact of hearing loss at work (Table 2 in Hua *et al*, 2009)

Category of impact	Subgroups
Difficulties in daily work	Communication in groups
	Loud non-verbal noise
	Inconvenience with hearing aids
	Tinnitus
Communication strategies	Guessing/making sense of missing words using contexts
	Asking for repetition
	Move closer to speaker
	Avoid challenging listening situations
	Inform colleagues about hearing impairment
	Adjust hearing aids
	Speech reading
Facilitating factors in work environment	Support and understanding from colleagues
	Assistive listening devices
	Adjustment of room acoustics
Impact on daily life	Sense of exclusion
	Withdrawal
	Fatigue

The majority of participants in the study by Hua *et al* (2015) found that hearing impairment caused difficulties at work which had a direct negative impact on their daily life, both during working hours and afterwards. Many of the impacts described have been found in other studies as will be seen below.

Action on Hearing Loss also investigated the impact of hearing loss in the workplace, through interviews with 27 hearing impaired people, plus a questionnaire survey of over 4000 members (Matthews, 2011). In the questionnaire survey over two thirds of respondents said that losing their hearing while of working age affected their working life. Table 8.3 shows the percentages of respondents agreeing with various statements relating to their situation at work. As in the study by Tye *et al* (2009) the majority of responses reflect negative experiences at work due to hearing impairment.

All three studies suggest various negative impacts of hearing loss on working life. Individual impacts addressed by other studies are discussed in the following sections.

Table 8.3. Numbers of respondents agreeing with statements about experiences at work (from Matthews, 2011)

Statement	Number agreeing	% of respondents
Losing my hearing made me less confident in my abilities	1627	40
Losing my hearing made me less confident in taking on new work or responsibilities	1396	34
Losing my hearing made no difference to me at work	1299	32
My colleagues were supportive when I lost my hearing	1112	27
When I lost my hearing I felt isolated at work	694	17
My employer made every effort to help me	553	14
My employer made some effort to help me, but not enough	503	12
After losing my hearing I felt less valued at work	472	12

8.2.2 Control of work environment

In the study by Kramer *et al* (2006) 150 audiology patients who were in work were compared with 60 employees with normal hearing using a questionnaire to identify particular difficulties of those with hearing loss. The study found that hearing impaired employees felt less able to control their work environment (for example by organising their own work schedule or arranging a break after demanding auditory tasks). Similar results were reported by Christensen (2006) in a Danish study of around 2400 working adults aged 50 to 64. Those with functional hearing problems felt, more than those with normal hearing, that they had no influence on their job assignments and were less often consulted by management about their work. In the Dutch study by Nachtegaal *et al* (2009b), among employees with moderate to severe (but not milder) hearing impairment, a perceived lack of job control increased with decreasing hearing acuity

8.2.3 Type of work/underemployment

Many employees with hearing loss felt that their hearing loss restricted the type of work they were able to undertake. Hogan *et al* (2009b), in an analysis of an Australian survey of disability and ageing, found that nearly two out of three employees who had hearing loss and communication difficulties reported that their disability restricted their type of employment. Those with hearing loss were over represented in lower socio-economic occupations, particularly men who were employed in unskilled to semi-skilled jobs. This may be because people with hearing loss gravitate towards jobs with fewer communication demands. Similar results were found in the Dutch study by Nachtelgaal *et al* (2012) who found that hearing ability influenced the type of work undertaken, in particular poorer hearing increased the odds for experiencing limitations in the type or amount of work done. This restriction on the type of work undertaken by people with hearing loss of course affects their income relative to people with normal hearing; underemployment of people with hearing loss and its effect on income are discussed further in section 8.3.

8.2.4 Performance and productivity

Employees with hearing impairment have expressed concern about their own performance and productivity. In focus group discussions with 46 hearing impaired working professionals Tye-Murray *et al* (2009) found that there was general concern about hearing loss affecting their ability to perform their jobs competently, and their competitive edge. However, perceived productivity appears to be related to support received from colleagues. Nachtegaal *et al* (2012) found that among hearing impaired respondents who received good social support from colleagues and supervisors there was no relationship between hearing ability and productivity, while among those receiving little support productivity decreased significantly with poorer hearing ability in noise. It has also been found that working in a noisy office environment can affect the performance of hearing impaired more than normal hearing employees. An experimental study in which a group of hearing impaired subjects

and a control group of normal hearing subjects performed various tasks in a simulated open plan office environment found that the hearing impaired group were more distracted by high levels of office noise than the control group (Jahncke and Halin, 2012).

8.2.5 Fatigue and need for recovery

Several authors have reported on the fatigue caused by hearing loss at work (Kramer *et al*, 2006; Christensen, 2006; Nachtegaal *et al* 2009b; Hua *et al*, 2015) and on the increased need of hearing impaired people to recover from the extra concentration and effort required for them to communicate (Nachtegaal *et al*, 2009b). Table 2 shows that in the study by Hua *et al* (2015), fatigue was cited as a negative impact of hearing loss. In the interviews, participants with mild to moderate hearing impairment reported both physical and mental fatigue after work (Hua *et al*, 2015), with a need for rest, peace and quiet to recover after a day's work. In some cases, family members were asked not to make any noise. Similarly, the Danish study by Christensen (2006) found that employees with functional hearing problems felt mentally fatigued when they got home from work more often than persons without hearing problems.

Many of the participants in the 2015 study by Hua *et al* stated that their fatigue was due to listening and participating in challenging listening conditions at work. This confirmed results of an earlier study by Hua *et al* (2013) who compared the effort required by a group of 20 workers with mild to moderate hearing loss with that of a matched group with normal hearing. The perceived effort of performing a work related task in typical office noise was significantly higher in the hearing impaired group than in the normal hearing group.

The experimental open plan office study by Jahncke and Halin (2012) also found that hearing impaired participants were more fatigued by high noise exposure than participants with normal hearing,

The effort required to hear, interpret and react appropriately in a work environment is also cited as the cause of fatigue and the need for recovery after work by Nachtegaal *et al* (2009b). In their study of over 900 subjects they found a significant relationship between hearing status and the need for recovery after work, the worse the hearing the greater the need for recovery.

8.2.6 Stigma, discrimination and social integration at work

Although there is some evidence that stigma in relation to hearing loss may have declined in recent years (Tye-Murray *et al*, 2009) other reports suggest that it remains an ongoing concern (Blazer *et al*, 2016). The hearing-impaired employees in the study by Christensen (2006) did not have as positive an experience of their social working environment as those with normal hearing, for example a number of those with reduced hearing had experienced unpleasant teasing. They also, in comparison with normal hearing employees, felt lonelier at work and that they received less support and encouragement from colleagues. However, the study by Tye-Murray *et al* (2009) found that occurrences of stigmatisation due to hearing loss were fewer than were found in earlier studies, for example those of Hetu and colleagues (Hetu et al, 1990; Hetu, 1996), which were reviewed in the 2006 Hear It report (Shield, 2006).

There is evidence that revealing a hearing impairment increases support at work from colleagues and managers, although discrimination at work may continue. Christensen (2006) found that telling superiors about hearing impairment improved relations with management and led to more support and encouragement from superiors. Seventy percent of the hearing impaired participants in the study by Tye-Murray *et al* (2009) had revealed their hearing loss to others in the workplace and several said that they often drew attention to it to remind colleagues to speak clearly and understand the reason for potential communication

difficulties. Nevertheless, several mentioned occurrences of embarrassment, self-consciousness or shame due to communication difficulties.

In a survey of 24 hearing aid users carried out by the RNID, several subjects had experienced discrimination at work (RNID, 2009). Some participants were unwilling to tell their colleagues about their hearing loss for fear of being seen as less capable, suggesting, as surmised by Blazer *et al* (2016), that stigma is of continuing concern, in contrast to the findings of Tye-Murray *et al* (2009).

Withdrawal from social contact with colleagues, both during and after work, was another consequence of hearing loss mentioned by participants in the study by Hua *et al* (2015). A sense of exclusion was observed by all subjects in all occupation settings, regardless of age and gender.

8.2.7 Mental distress at work

Kervasdoue and Hartmann (2016) quote the analysis by Sitbon *et al* (2015) of data from a survey of deaf and hard of hearing people in France, which found that 34% of the French working population with hearing impairment experience psychological distress due to working conditions, in contrast with 5.4% of the general working population. Furthermore, 10.3% of them had thought of suicide during the previous 12 months because of their working situation, compared with 1.4% of the general population, and 3.5% had attempted to kill themselves at some point in their lives for the same reasons (0.6% for the general population).

8.2.8 Sick leave

There is evidence that employees with hearing loss take more sick leave than workers with normal hearing. Friberg *et al* (2012), in a systematic review concluded that, although there were remarkably few robust studies of the relationship between hearing difficulties and sick leave, and despite large variations between study design and methods, all the reviewed studies reported positive associations

Hua *et al* (2013) cite a Swedish report which found that sick leave was more common among workers with hearing loss than in the general population. In the study of Dutch workers by Kramer *et al* (2006) a significant difference was found between the proportion of hearing impaired employees reporting sick in the previous 12 months (77%) and the corresponding number in the normal hearing group (55%). It was also found that the number of those citing stress related complaints (fatigue, mental distress, strain) as the reason for their sick leave in the hearing impaired group (26%) was significantly higher than in the normal hearing group (7%).

Nachtegaal *et al* (2012) followed up their study of fatigue in the workplace and the need for recovery (Nachtegaal *et al*, 2009b) by an investigation into the association between hearing ability and sick leave. The percentages reporting one or more days of sick leave in the preceding four months were 47.4% for those with good hearing, 50.5% for those with mild hearing loss and 51.5% for those with poor hearing. However, after adjusting for confounding factors there was no significant relationship between sick leave and hearing ability although there was a significant association between the need for recovery and sick leave among those with poorer hearing, which is consistent with the finding of Kramer *et al* (2006) regarding the stress related causes of sick leave. Nachtegaal *et al* (2012) suggest that the lower incidence of sick leave among their hearing impaired subjects compared with that in the study by Kramer *et al* (2006) could be explained by the fact that in the latter study the majority of subjects had moderate to severe hearing loss whereas in the study by Nachtegaal *et al* (2012) hearing impaired subjects were equally divided between those with mild and poor hearing. Also, Kramer *et al* (2006) considered sick leave in the previous 12

months whereas Nachtegaal *et al* (2012) were concerned with only the previous four months.

Associations between hearing impairment and long term sick leave have been suggested by Pierre *et al* (2012) and Davis (2014). Several of the studies which have considered the effects of gender have found that the association between hearing loss and sick leave tends to be stronger for women than men (Pierre *et al*, 2012, Friberg *et al*, 2012).

8.2.9 Summary of negative impact of hearing loss on working life

The papers and reports reviewed in this section have shown that having a hearing loss while in employment can cause many negative impacts, both during the working day and after work. A major problem is fatigue both during and after work, and the need for recovery, which in some cases has an effect upon family members as well as the hearing impaired individual. The fatigue caused by hearing loss is one of the contributory factors to a greater incidence of sick leave among hearing impaired employees compared with those with normal hearing. The situation at work can also lead to negative feelings including a lack of confidence in ability and productivity, and a perceived lack of control in the work situation, as well as practical problems with communication and relationships with colleagues. Discrimination and stigma, although less often reported than previously, remain ongoing concerns. Many of the negative effects of hearing loss may be mitigated by support from employers and colleagues.

It is thought that the adverse effects of hearing loss may be responsible for the higher rates of early retirement and underemployment, leading to lower incomes, that are observed among hearing impaired employees, compared with non-impaired workers. These issues are explored in the following section.

8.3 EARNINGS AND EMPLOYMENT

Chapter 11 of the 2006 report (Shield, 2006) reviewed data, obtained mainly from studies carried out in the UK by the RNID, and from American studies, on the incidence of underemployment and unemployment among deaf and hard of hearing people, and typical earnings of people with hearing impairment in relation to those of the general population.

In the past 12 years there have been several more studies published which have been undertaken in Australia, Sweden, Denmark, the USA and the UK; these are reviewed in this section. Lost productivity caused by unemployment and early retirement has been considered in calculations of the economic burden of hearing loss in Europe (Shield, 2006), Denmark (Christensen, 2006), Australia (Access Economics, 2006; Deloitte Access Economics, 2017a); New Zealand (Deloitte Access Economics, 2017b) and the UK (Commission on Hearing Loss, 2014; Archbold *et al*, 2014).

The studies reviewed here provide further evidence of hearing impairment leading to unemployment, underemployment and early retirement, and to lower status occupations and lower earnings than among the general population.

There are several issues that contribute to the lower earnings of people with hearing loss, including underemployment and over representation of hearing impaired people in lower paid occupations. There is also increasing evidence of higher rates of prevalence of hearing loss in areas of greater social deprivation and among people with lower socio-economic status.

8.3.1 Household Income

A report on the economic impact of hearing loss in Australia, published in 2006 (Access Economics, 2006) quotes figures from 1990s health data in South Australia. People with hearing loss were 25% less likely to be earning higher incomes than people without hearing loss. Of the people in paid work, 72.1% of people with hearing loss reported incomes greater than $40,000 per annum compared with 77.9% of people without hearing problems, a net difference of 5.8%. Similar results were found by Hogan *et al* (2009b) who analysed data from the 2003 Australian survey of disability, ageing and carers. Over a quarter (26%) of those with hearing loss and communication difficulties were in the lower three income brackets (A$224 per week) compared with 16.1% of people without hearing loss. Conversely, fewer than a quarter of those with hearing loss (23.6%) reported being in the top three income brackets (A$700 per week) compared with 31.8% of those without hearing loss.

In the USA Kochkin analysed data from the 2004/5 and 2008/9 surveys of households across the country, comparing the income of households where the head of the household or spouse reported having a hearing loss with households where neither the head of household nor spouse is hearing impaired (Kochkin, 2007a; 2010a). Around 40,000 households were included in each analysis. Various subjective measures of hearing were used and hearing loss was graded into ten categories from mild to severe. In the earlier survey it was found that individuals with the most serious hearing loss (decile 10) earned $12,000 less per year than an individual with a mild (decile 1) hearing loss (Kochkin, 2007a). The later survey showed a differential of $14,100 per year between those with mild hearing loss and the most severe hearing loss (Kochkin, 2010a). In both surveys, these figures show that people with the most severe hearing loss earn approximately 77% of those with the mildest hearing loss. (These figures are for all hearing impaired individuals, including those with hearing aids; the differential is greater for those with unaided hearing loss as is discussed in Chapter 12.)

The analysis by Kochkin (2010a) is consistent with that of another American study in which data from the Medical Expenditure Panel Survey were analysed with respect to earnings of individuals with hearing loss (Jung and Bhattacharyya, 2012). The average annual earnings of the population with hearing loss was estimated to be $23,281, compared with $31,272 for the normal hearing population (a difference of $7,791). Thus the average earnings of hearing impaired people were 75% of those who are not hearing impaired.

A more recent US study involving adults aged 20 to 69 who had participated in the National Health and Nutrition Examination Survey (NHANES) found that hearing loss was significantly associated with low income and unemployment/underemployment (Emmett and Francis, 2015). The odds of hearing impaired individuals being on low income (defined as family income less than $20,000 per year) was 1.6 times higher than for individuals with normal hearing. The authors also found that hearing loss was significantly related to low educational attainment but, even after controlling for education and other sociodemographic factors, the association between hearing loss and low income remained significant.

In 2010 the RNID (now Action on Hearing Loss) published a cost benefit analysis of hearing screening at ages 55 and 65 years (London Economics, 2010) which included figures, based upon the UK Office of National Statistics Labour Force Survey, comparing the annual income of men and women in this age group with and without hearing impairment, as shown in Table 8.4. (The population with hearing impairment includes people with and without hearing aids.)

Table 8.4. Annual income (£) of older male and female employees (data from Table 16, London Economics, 2010)

	Aged 53 - 57		Aged 63 - 67	
Average annual earnings, £	**Men**	**Women**	**Men**	**Women**
General population	33,901	19,615	22,986	11,840
Population with hearing impairment	-	14,933	21,737	11,220

For men in the 53 to 57 age group there was no statistically significant difference between earnings of those with and without hearing impairment, but hearing impaired women in this age group earned 76% of women in the general population. For both men and women and women in the older age group there was a small difference in earnings between those who are hearing impaired and the general population, the earnings of those with hearing impairment being approximately 95% of those of the general population. The authors comment that this is probably due to a higher proportion of this age group wearing hearing aids. The impact of hearing aids on relative incomes is discussed in Chapter 12.

Two subsequent reports published in the UK provide further evidence of the disparity in pay between those with hearing impairment and those with normal hearing. Archbold *et al* (2014), using data from the 2009 British Household Panel Survey, and controlling for factors such as age, education and gender, estimated lost earnings due to hearing impairment to be £2,136 per individual per year. (However, without further information relating to the average earnings for 2009 it is not possible to calculate the relative loss of earnings due to hearing impairment.)

In the 2014 Health Survey England report levels of measured hearing loss were reported in relation to household income (Scholes and Mindell, 2015). The authors found that higher levels of hearing loss occurred among those with lower household incomes; for both men and women, objective hearing loss at 1 kHz and 3 kHz increased with decreasing household income. Table 8.5 shows the percentages of men and women with objective hearing loss at 1 kHz and 3 kHz according to quintile of household income.

Table 8.5. Percentages of men and women with objective hearing loss across quintiles of household income (data from supplementary Table 4.22, Scholes and Mindell, 2015)

Quintile of household income	**1 kHz**		**3 kHz**	
	Men	**Women**	**Men**	**Women**
1 (highest)	10	12	14	10
2nd	10	12	12	7
3rd	11	13	13	13
4th	18	17	18	13
5 (lowest)	23	18	19	13

Thus data from Australia, the USA and the UK show that hearing impaired people are over represented in low income groups, and that household income decreases as the severity of hearing loss increases. Reasons for this are that in general people with hearing impairment work fewer hours and for lower rates of pay than people with normal hearing; they are thus over represented in lower status and lower paid jobs. The following section reviews evidence, consistent with these findings, which shows that the prevalence of hearing impairment increases with levels of social deprivation.

8.3.2 Relationship between hearing impairment and socioeconomic status

In recent years there has been interest in links between hearing loss and socio-economic status. Hasson *et al* (2010) examined the prevalence of hearing problems (hearing loss and tinnitus) among different socioeconomic groups of different ages within working and non-

working populations in Sweden, hearing and socioeconomic status being self-assessed. The results regarding hearing loss are shown in Table 8.6.

Table 8.6. Prevalence (%) of hearing loss by gender, age group and socioeconomic status in the working population (data from Table 3 of Hasson *et al*, 2010)

Age	Socioeconomic status					
	Low		Medium		High	
	Men	Women	Men	Women	Men	Women
Under 41	11	7	5	5	2	2
41-50	12	10	9	7	7	5
51-60	18	16	15	12	14	8
Over 60	24	23	28	16	19	12
All	14		11		9	

It can be seen that in all age groups hearing loss is more prevalent in the lowest social status group, the gradient from low to high status being particularly pronounced for those under 40. For non-working people the association between hearing loss and socioeconomic status was significant only for women, there being no statistically significant difference in the prevalence of hearing problems between different socioeconomic groups overall.

The study by Emmett and Francis (2012), which analysed data from the NHANES in the USA, found that hearing loss was independently associated with several indicators of socioeconomic status, and concluded that hearing loss has substantial socioeconomic implications.

Two reports in the UK have provided evidence of the increase in prevalence of hearing loss with increase in social deprivation. Scholes and Mindell (2015) in the 2014 Health Survey England report found that objective hearing loss at 1 kHz and 3 kHz increased as household deprivation, as measured by the Index of Multiple Deprivation, increased, as shown in Table 8.7.

Table 8.7. Percentages of men and women with objective hearing loss across quintiles of deprivation (data from supplementary Table 4.23, Scholes and Mindell, 2015)

Quintile of deprivation	1 kHz		3 kHz	
	Men	Women	Men	Women
1 (least deprived)	9	14	12	11
2nd	13	11	13	10
3rd	12	14	14	10
4th	17	15	18	12
5 (most deprived)	19	22	16	16

Davis (2014), in reporting the GP survey of England in the Chief Medical Officer's report for 2012, also found that, for all age groups, there was a substantial and significant trend for higher prevalence of hearing loss in areas with a higher level of socio-economic deprivation, the effect being more prominent among younger people.

Potential reasons have been suggested to explain the link between socioeconomic status and hearing loss. Emmett and Francis (2015) postulated that, in contrast to suggestions of other authors, the relationship between socioeconomic status and hearing impairment is due to factors other than, or in addition to, low educational attainment. They suggest that the low social status itself might be the driver behind development of hearing loss, owing to possible noise exposure at work, or that impaired hearing might be the result of recreational noise exposure or increased perinatal risk factors in lower socioeconomic groups.

Davis also found significant regional variations in prevalence of hearing loss in England for all age groups. Prevalence was highest in the north-east of England (10%) and lowest in London (6%). The north-east also had the largest difference in prevalence between the most deprived quintile (13%) and the least deprived quintile (8%), while in London there was no difference between the least and most deprived quintiles. It is suggested by Davis (2014) that the higher prevalence in the north of England could be due to the very noisy industries in the last century where many of the older respondents may have worked. (It is also noted, although not commented upon by the authors, that the summary data presented by Jung and Bhattacharyya (2012) show large variations in prevalence of hearing loss across regions of the USA, ranging from 20.9% in the mid-west to 31.5% in the south.)

8.3.3 Lower status employment of hearing impaired people

Reasons for the lower earnings of hearing impaired people when compared with the normal hearing population include their underemployment and over representation in lower paid occupations.

In their analysis of Australian survey data Hogan *et al* (2009b) found that people with hearing loss were less likely to be in high skilled jobs and were overrepresented among low income earners. This can be observed in Table 8.8 which shows the percentages of men and women aged 20 to 64 with hearing loss in different occupations, compared with the general population. Two out of three people in the labour force with hearing loss and communication difficulties reported that their disability restricted their employment, both in the type of work they did and with difficulties changing jobs or getting preferred jobs.

Table 8.8. Percentages in different occupations by hearing status and gender (Table 7 from Hogan *et al*, 2009b)

Occupation	Male		Female	
	Hearing loss	General pop	Hearing loss	General pop
Managers and administrators	11.6	11.6	9.1	5.1
Professionals	16	17.1	24.1	24.5
Associate professionals	10.2	14.2	9.5	12.9
Tradespersons & related workers	22.6	20.2	0	2.9
Advanced clerical, sales & service workers	0.2	1	7.6	8.4
Intermediate clerical, sales & service workers	9.1	9.5	21.2	26.4
Intermediate production & transport workers	15	12.7	4.3	2.1
Elementary clerical, sales & service workers	2.7	5.3	13.2	10.9
Labourers & related workers	12.6	8.5	11.1	6.7

Pierre *et al* (2012), in analysing data on over 19,000 respondents to the Swedish Living Conditions survey, found that there was a higher prevalence of people with hearing difficulties in manual work than in other types of work. Table 8.9 shows the prevalence of people with hearing difficulties in different types of job, as the percentage of the total number in each occupation type. It can be seen that hearing impaired men constitute 32.2% of those in manual occupations; the corresponding figure for women is 24.2%.

The papers by Hogan *et al* (2009b) and Pierre *et a*l (2012) both suggest possible reasons for the higher incidence of people with hearing problems in lower status occupations: a tendency for people with hearing difficulties to get work that makes fewer communication demands; or the possibility that the occupations themselves in which they are employed give rise to noise exposure which increases the likelihood of hearing difficulties. Pierre *et al* postulate that it might also be due to lower educational attainments among people with hearing problems.

Table 8.9. Percentages of people with hearing difficulties in different types of occupation (data from Table 1 of Pierre *et al*, 2012)

Occupation	Men	Women
Professional	8.7	6.7
Intermediate non-manual	12.0	8.6
Assistant non-manual	11.0	10.0
Self-employed non-professional	14.3	7.8
Skilled manual	16.7	11.0
Unskilled/semi-skilled manual	15.5	13.2
Students	6.7	6.8

8.3.4 Early retirement

Another contributory factor to lower earnings of hearing impaired people, and also to some of the psychosocial problems discussed in Chapter 5, is the higher incidence of early retirement among people with hearing loss.

Several authors have found, or cite statistics that show, that reduced hearing contributes to early retirement (Christensen, 2006; Kramer, 2008; Pierre *et al*, 2012; Hua *et al*, 2013). Pierre *et al* (2012), in a cross-sectional study involving over 19,000 subjects, found that people with hearing difficulties were more likely to be dependent on unemployment benefits, sickness benefits, or disability pension than their normal-hearing counterparts. However, after adjusting for demographic and socio-economic variables, a significant relationship between hearing difficulties and long term unemployment was found only for women and not for men.

In the 2010 annual survey of members of Action on Hearing Loss (Matthews, 2011), 36% of respondents who had taken early retirement said that it was related to their hearing loss. This figure rose to 41% in a later AHL survey (Arrowsmith, 2014).

In the Dutch study by Stam *et al* (2013), the employment status of participants with 'good' hearing was compared with that of participants with 'insufficient' or 'poor' hearing. Table 8.10 shows the percentages overall, and of male and female subjects, who reported to have taken early retirement. It can be seen that a greater percentage of the subjects with impaired hearing had taken early retirement than of those with good hearing.

Table 8.10. Percentages of participants taking early retirement (data from Stam *et al*, 2013)

	Hearing ability	
	Good	Insufficient/poor
Males	11.5	19.1
Females	1.8	3.3
All	5.5	8.2

Fischer *et al* (2014), in a longitudinal study of hearing loss and retirement found that hearing impairment was associated with a higher rate of retirement over 15 years (77% for hearing impaired subjects compared with 74% of those without hearing impairment) but the association was not significant when the data were corrected for confounding factors such as age and health. However, as the average age of subjects was 58 at baseline, retirement among this cohort could not necessarily be considered as early retirement.

8.3.5 Employment, underemployment and unemployment

Unemployment and underemployment (that is, part time employment) among hearing impaired people are further contributory factors to their lower earnings.

The most comprehensive data on the impact of hearing loss on rates of employment and unemployment have been derived from Australian surveys (Access Economics, 2006; Hogan *et al*, 2009b; Deloitte Access Economics, 2017a). The report by Access Economics (2006) on the economic impact of hearing loss in Australia used data from a 1994 study (the South Australia Omnibus Study); Hogan *et al* (2009b) analysed later data from the 2003 Survey of Disability, Aging and Carers (SDAC) carried out by the Australian Bureau of Statistics; and the 2017 Australian report (Deloitte Access Economics, 2017a) used employment data derived from the 2015 SDAC. Information on various aspects of unemployment and retirement has also been published in the USA by Kochkin (2007a; 2010a) and in the UK by Action on Hearing Loss (2007; 2015; London Economics, 2010) and in the reports by the Commission on Hearing Loss (2014), Archbold *et al* (2014) and the Chief Medical Officer (Davis, 2014).

Australian data

The report by Access Economics (2006) presented the employment outcomes for over 2,500 people aged 15 to 64 years with different grades of hearing loss, and none, as shown in Table 8.11. Hearing status was determined by self-reported responses to a question concerning difficulties hearing conversation. (Note that some of the numbers are incorrect; the numbers which are inconsistent with other entries are in italic.)

Table 8.11. Employment outcomes for people aged 15 to 65 years with and without hearing loss (data from Table 5-2 in Access Economics, 2006)

Hearing status	Work full time	Work part time	At home	Unemp-loyed	Retired	Student	Other	Total
Severe	3	0	4	2	4	0	2	15
Moderate	25	6	5	3	10	3	10	62
Borderline	102	47	34	18	26	15	12	*252*
No problems	983	373	365	118	93	206	35	2173
Total	1113	*435*	408	141	133	224	*57*	*2502*

The report states that, in total, 55.6% of people with hearing problems reported being in paid work (full or part time) compared with 62.4% of people with no hearing problems, a difference of 6.8%. Seven per cent of hearing impaired subjects were unemployed, compared with 2.7% of those with no hearing problems. Overall 5.3% of respondents were retired; but 12.2% of people with hearing problems were retired compared with 4.3% of people without hearing problems, suggesting a possibility of early retirement due to hearing difficulties. (These figures appear to be based on the incorrect numbers in the above table but as the errors are relatively small there would not be large changes in the percentages quoted.)

The authors investigated employment outcomes for the younger (15-44) and older (45-64) age groups, according to gender, as shown in Table 8.12.

Table 8.12. Percentages of older and younger age groups in paid work, according to gender and hearing status (data from Table 5-3 of Access Economics, 2006)

	% in paid work			
	15-44 years		45-64 years	
Hearing status	**Men**	**Women**	**Men**	**Women**
Hearing problems	79.6	50.6	47.4	30.2
No hearing problems	74.9	54.7	67.9	46.7

For the younger age group, there were no significant differences in employment rates between those with and without hearing problems although there was a slightly smaller percentage of hearing impaired women in employment than among those with no hearing problems. For the older age group, however, there were significant differences in employment rates between those with and without hearing loss, again suggesting the likelihood of early retirement.

The 2017 report (Deloitte Access Economics, 2017a) states that analysis of the 2015 SDAC data showed that 80% of males of working age (15-64) without hearing loss were in full or part time employment, compared with 67% of males with hearing loss, while 71% of females without hearing loss were employed compared with 56% of those with hearing loss. The difference in employment rates of hearing and hearing impaired people of working age is thus greater than it was in the 2006 report. The 2017 figures show that the employment rates of hearing impaired males and females were 84% and 79% respectively of the rates for those without hearing loss.

The employment rates of males and females with and without hearing loss across the age ranges are shown in Table 8.13. (Note that in the published report the columns 'with' and ''without' hearing loss have been incorrectly labelled.)

Table 8.13. Employment rates (%) of males and females with (HL) and without (NHL) hearing loss (data from Table 5.2 and 5.3 in Deloitte Access Economics, 2017a)

Age	Males		Females	
	HL	NHL	HL	NHL
15-19	1	42	35	48
20-24	50	74	33	74
25-29	51	87	68	77
30-34	74	90	67	76
35-39	92	89	76	75
40-44	77	92	75	78
45-49	80	89	59	80
50-54	74	88	57	77
55-59	70	81	62	70
60-64	53	65	39	49
65-69	26	38	15	21
70-74	20	22	8	9

It can be seen that the employment gap is considerably larger for young people under the age of 30 than for older adults. (It is suggested that the slightly higher employment rates for hearing impaired people aged 35-39, compared with their hearing counterparts, might be due to an early educational intervention programme of this age group (Deloitte Access Economics, 2017a)). The differences in employment for the younger age groups is in contrast to the finding in the 2006 report (Access Economics, 2006) that the employment rates for 15-44 years olds with hearing loss were not significantly different to those of the hearing population in this age group, as shown in Table 8.12.

The more recent finding of the greater differences in employment rates for people under the age of 30 is, unlike the earlier finding shown in Table 8.12, consistent with the findings of Parving and Christensen (1993), cited by Kramer (2008), who found a significant difference in the employment rates of younger adults with 30% of hearing impaired adults aged 20 to 35 years being unemployed, compared with 12% of those with normal hearing.

In the analysis of the 2003 data on 20 to 64 year olds (Hogan *et al*, 2009b), hearing loss was again associated with an increased rate of non-participation in employment. As in the 2006 study (Access Economics, 2006), and in contrast to the more recent study (Deloitte Access

Economics, 2017a,) the difference in employment rates increased with age and with the existence of other health conditions. The impact was greater for women, and for those with a lower level of education and communication difficulties.

Table 8.14 shows the employment status of those with self-reported hearing loss (HL) and with hearing loss and communication difficulties (HLCD) , compared with the general population.

Table 8.14. Percentages in employment categories by hearing loss (data from Table 2 of Hogan *et al*, 2009b)

Employment status	General population	HL	HLCD
Working full time	56.5	52.7	48.3
Working part time	21	14	13.1
Unemployed looking for full time work	2.5	3.6	3.9
Unemployed looking for part time work	1	1.8	2.6
Not working	18.5	27.6	31.4

Table 8.14 shows that 77.5% of the general population are currently working, compared with 66.7% of those with hearing loss and 61.4% of those with hearing loss and additional communication difficulties. The average for the two hearing loss categories is 64.1% in work (note that this is merely an arithmetic average of the figures in the above table and not a weighted average taking account of the numbers in each category, which are not reported). The average figure differs from the rate for the general population by 13.4%. The difference of 13% in employment rates is consistent with that found in the 2017 study by Deloitte Access Economics (2017a).

Hogan *et al* (2009b) analysed employment rates by age for men and women with hearing loss (HL) and with hearing loss together with communication difficulties (HL & CD), as shown in Table 8.15.

Table 8.15. Employment rates in different age groups (data from Tables 3 and 4 in Hogan *et al,* 2009b)

Age	Male			Female		
	General population	With HL	With HL & CD	General population	With HL	With HL & CD
< 45	95.3	95.3	85.7	70	60.2	55.7
45 – 54	98.6	94.4	78.9	92.4	72.8	60.4
55 - 64	81.9	75.7	48.6	53.5	48.2	27.5

It can be seen that for those under the age of 55, there are greater differentials for women than men between the percentages of those with hearing loss and of the general population in paid employment. For men under the age of 45 the employment rate for those with hearing loss only is the same as that of the general population. Overall the results suggest that hearing loss has a greater impact upon women than men in terms of their likelihood of employment. The difference in employment rate between those with hearing loss and the general population increases with age for men, and is greatest for middle aged women.

There are considerable differences between the figures for the different age groups quoted by Access Economics (2006), Hogan *et al* (2009b) and Deloitte Access Economics (2017a). These may reflect different age ranges and different categories of employment considered. Furthermore, the three surveys upon which the data analyses were based were conducted over a period of 20 years (1994, 2003 and 2015; therefore the results may reflect changes in the economic climate and employment patterns over that period.

New Zealand data

A similar study to the 2017 Australian study was carried out in New Zealand by Deloitte Access Economics (2017b). The authors used employment data derived by Jensen *et al* (2005) from the 2001 Disability Survey of New Zealand to estimate current productivity losses. Jensen *et al* found that 63% of hearing impaired people were in full or part time employment, whereas in the absence of their hearing disability their expected employment rate was 73%. No more detailed or more recent employment data are presented in the report.

US data

The findings of the Australian reports are in contrast with those of Kochkin (2010a) who found no evidence, overall, that hearing loss was related to unemployment for any age group. However, when considering aided and unaided individuals separately, while there was no significant relationship between hearing loss and unemployment rates for individuals with hearing aids, there was a highly significant relationship for unaided subjects, the unemployment rate increasing significantly with increase in severity of hearing loss. Table 8.16 shows the unemployment rates of aided and unaided subjects across quintiles of hearing loss severity.

Table 8.16. Unemployment rates in the US for aided and unaided subjects with hearing loss, according to quintile of severity of hearing loss (Kochkin, 2010)

Quintile of hearing loss	Percent unemployed	
	Aided	Unaided
1 (least severe)	0	4.9
2nd	0	6.1
3rd	5.4	10.7
4th	1.8	11.8
5 (most severe)	8.3	15.6

The table shows that for those with unaided hearing loss, the unemployment rate of those with the most severe hearing loss is almost three times that of those with the mildest hearing loss. For all grades of hearing loss, the unemployment rate of those with hearing aids is very much lower than that of those who do not use aids. The effects of hearing aids on employment are discussed in more detail in a future chapter on the benefit of hearing aids.

Kochkin (2010a) also published data on unemployment in different age bands. These are shown in Table 8.17.

Table 8.17. Unemployment (%) in different age bands (data from Table 5 in Kochkin, 2010a)

Age	Normal hearing households	Hearing loss households	
		Aided	Unaided
20 - 44	8.1	6.8	6.8
45 - 64	7.6	4.4	8.1
65+	6.9	4.7	7.7

There was no evidence of an association between hearing loss and unemployment for any age group. The author comments on the unexplained finding that subjects with hearing aids (and non-aided subjects in the youngest age group) tended to be employed more often than normal-hearing subjects, although the relationships were not significant.

Emmett and Francis (2015), in their analysis of data from the NHANES, also found that hearing loss was associated with unemployment and underemployment; the odds of

individuals with hearing loss being unemployed or underemployed being almost twice those of the odds for people with normal hearing.

UK data

In the UK the Royal National Institute for the Deaf (RNID), now Action on Hearing Loss (AHL), have published many reports on problems faced by people with hearing loss in the workplace, and employment statistics for hearing impaired people. The figures on unemployment have been derived both from their own surveys and also from analysis of annual national statistics published by the Office of National Statistics (ONS) from their annual Labour Force Survey.

In 2007 the RNID surveyed 870 deaf and hard of hearing people and found that 63% of those surveyed were in employment, compared with 75% of the population as a whole. Furthermore, 20% of people in the survey were unemployed and looking for work, compared to 5% in the UK labour market at the time (RNID, 2007). The employment rate of 63% is in close agreement with those of the Australian studies discussed above.

A report for the RNID on the cost benefits of hearing screening for older people (London Economics, 2010) cited data on employment rates from the ONS Labour Force Survey in their calculations. Table 8.18 shows the percentages of women and men in the general population and with hearing impairment in employment in their mid-50s and mid-60s.

Table 8.18. Percentages of men and women in employment (data from Table 16, London Economics, 2010)

Percentages in employment	Aged 53 - 57		Aged 63 - 67	
	Men	Women	Men	Women
General population	79.8	71.3	35.0	21.8
Population with hearing impairment	60.0	44.1	22.7	9.0

Unpublished data by Action on Hearing Loss, derived from the 2013 Labour Force Survey, is cited by the Commission on Hearing Loss report (Commission on Hearing Loss, 2014). The employment rate for the hearing impaired population of working age (16-64) was 64%, compared with 77% for people who do not have a long term health issue or disability. The most recent employment rates published by AHL, from the 2015 Labour Force Survey, are 65% for people with hearing loss and 79% for those without health problems or disability (Action on Hearing Loss, 2015). These overall employment figures are again in broad agreement with the Australian data presented above and with the earlier RNID findings (RNID, 2007).

Employment statistics for England, comparing employment rates of those with sensory impairment to those without any sensory impairment, were also provided in the Chief Medical Officer's report for England, derived from the 2012-13 GP Patient Survey of England (Davis, 2014). The data showed that between the ages of 18 and 65, those with deafness or blindness were significantly less likely to be in full-time employment than those without deafness or blindness. Around 53% of those without sensory impairment were in full-time employment, compared with 38% of those with deafness, and 22% of those with blindness. In the 25 to 54 year age group, around 60% of those without deafness of blindness were in full-time employment, whereas between 45% and 50% of those with hearing impairment worked full time.

Regarding unemployment or long-term sickness absence, 10% of the adult population without sensory impairment compared with 12% of those with hearing loss reported not working.

Table 8.19 shows the percentages of patient survey respondents with hearing loss who were in full time employment compared with those without any sensory impairment, across the age ranges from 18 to 64. (Note that the figures are estimated from Figure 4.9 of the Chief Medical Officer's report.)

Table 8.19. Percentages (approximate) of those with hearing loss and with no sensory impairment in full time employment (data estimated from Figure 4.9 of Davis, 2014).

	Age group				
	18 - 24	**25 - 34**	**35 - 44**	**45 - 54**	**55 - 64**
No sensory impairment	37	62	58	60	38
Hearing loss	23	46	48	45	30

It is difficult to compare the age related data shown in Table 8.19 with results of other studies owing to the differences in presentation of data in other papers.

8.3.6 Other studies of unemployment of hearing impaired people

Two other European studies, in the Netherlands and Spain, examined the unemployment and employment rates of hearing impaired people. In their analysis of data from the Dutch National Longitudinal Study on Hearing Stam *et al* (2013) compared average employment rates (where employment was defined as being in work for more than 12 hours per week), working hours per week, and length of time being unemployed and looking for work among people with 'good' hearing and those with 'insufficient' or 'poor' hearing. The results for all subjects and for male and female subjects, aged 18 to 64, are shown in Table 8.20. It can be seen that overall employment rates and number of working hours per week were higher (by 7% and two hours per week respectively) for those with good hearing compared with those with poorer hearing. Furthermore, the average period of unemployment and looking for work was approximately one year longer for participants with poorer hearing than for their normally hearing peers.

Table 8.20. Employment data in the Netherlands for those with good hearing (good) and with insufficient or poor (poor) hearing (data from Stam *et al*, 2013)

	All subjects		**Males**		**Females**	
Hearing status	**Good**	**Poor**	**Good**	**Poor**	**Good**	**Poor**
Number of subjects	996	892	381	277	615	615
% employed	67.6	61.2	72.4	60.6	64.6	61.5
No. of working hours	32	30	37	36	29	28
% unemployed & looking for work	1.9	3.1	1.8	3.2	2.0	3.1
Length of unemployment (yrs)	1.4	2.1	1.2	2.6	1.1	1.9

In the Spanish study, Garramiola-Bilbao and Rodriguez-Alvarez (2016) analysed data from the 2002 Health Survey of Asturias to examine the impact of hearing impairment on employment. Among 1599 subjects aged from 15 to 70, they found that being hearing impaired reduced the probability of being unemployed by 18.4%.

8.3.7 Summary of employment rates

Table 8.21 summarises the figures extracted from the studies discussed above, where possible, which compare overall employment rates of hearing impaired people with either the general population or people without a disability. All refer to people of working age. The table includes the ratio of the employment rate of hearing impaired people to that of people without hearing loss.

Table 8.21. Summary of employment rates

Country	Study	Date of data collection	HL	No HL	Ratio
Australia	Access Economics, 2006	1994	55.6	62.4	0.89
	Hogan *et al*, 2009b	2003	64.1	77.5	0.83
	Deloitte Access Economics, 2017	2015	62[a]	76[a]	0.82
UK	RNID, 2007	2007	63	75	0.84
	Commission on Hearing Loss, 2014	2013	64	77[b]	0.82
	Davis, 2014	2012-13	45-48[c,d]	60[d,e]	0.80
	AHL, 2015	2015	65	79[b]	0.82
Netherlands	Stam *et al*, 2013	From 2006	61	68	0.90
New Zealand	Jensen *et al*, 2005	2001	63	73	0.86

[a] overall figures extrapolated by author from M/F data [b] people with no health problems or disability
[c] people with hearing and/or visual impairment [d] working full time [e] no sensory impairment

It can be seen from Table 8.21 that overall rates of employment, and the ratios of the employment rates of hearing impaired people to those of non hearing impaired persons, are reasonably consistent, particularly for the more recent studies. It appears that, on average, the employment rate of people with hearing loss is around 83% of that of those without hearing loss.

8.3.8 Summary of impact of hearing loss on earnings and employment

The main findings of this section are follows.

- There is considerable evidence that hearing impaired people earn, on average, significantly less than people with normal hearing. It is somewhat difficult to determine an exact ratio for the earnings of those with hearing impairment compared with the rest of the population as the analysis of earnings has been presented differently by different authors. However, the data presented by Kochkin (2007a; 2010a) show that people with severe hearing loss earn 77% of those with very mild hearing loss, while the results of Jung and Bhattacharyya (2012) show that earnings of hearing impaired people are 75% of those with normal hearing. There is nothing to suggest that these figures are inconsistent with the data presented by other authors. It can therefore be assumed that hearing impaired individuals earn around 75% of those without hearing impairment.
- Data from the UK, Sweden and the USA show that hearing impairment is related to socio-economic status; the greater the social deprivation, the higher the prevalence of hearing loss. There is also significant variation in prevalence of hearing loss across regions of the UK and USA, possibly reflecting the differences in social deprivation in different areas and/or the past or current presence of noisy industries.
- Hearing impaired people are over represented in lower status, lower paid, occupations.
- Hearing impairment is a contributory factor in people taking early retirement.
- A higher proportion of hearing impaired people are unemployed than in the general population.
- Data from several sources suggest that around 64% of hearing impaired people of working age are in full or part time employment, compared with around 77% of the general population. The employment rate of hearing impaired people is approximately 83% of that of the non-hearing impaired population.

8.4 CONCLUSIONS

This chapter has shown that hearing impairment has many significant detrimental effects in the workplace and on the employment and earnings of hearing impaired people relative to those of people with normal hearing. Negative feelings induced by being hearing impaired at

work, especially when not supported by colleagues and management, contribute to employees seeking early retirement or less demanding jobs. Fatigue both during and after work is a major problem affecting many hearing impaired workers, which in some cases has a direct impact on their home life and can also lead to increased incidence of sick leave.

Early retirement and less demanding jobs mean that the average income of hearing impaired people is below that of people with normal hearing. Hearing impaired people in work tend to be in lower status occupations with correspondingly lower levels of income than the general population, and hearing impairment has been shown to be significantly related to social deprivation.

The employment rate of hearing impaired people is significantly less than that of the general population, being around 83% of that of those without hearing impairment.

It can thus be seen that hearing impairment has a major negative impact on many aspects of working and family life.

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SECTION C

OWNERSHIP AND USE OF HEARING AIDS

CHAPTER 9 OWNERSHIP OF HEARING AIDS

9.1 INTRODUCTION

This chapter reviews evidence concerning the numbers of hearing impaired people in different countries around the world who do not possess hearing aids. Surveys of hearing aid ownership have taken place in Europe, the USA and Asia. Some of the survey data comes from large, general studies of health while other authors have investigated hearing aid ownership as an independent topic.

As with many of the other topics covered in the project, study designs vary in terms of methodology, subject demographics, definitions of hearing impairment and loss and so on, making comparison of results between studies difficult. Furthermore, in some studies the terms 'use' and 'ownership' of hearing aids appear to be used interchangeably; it is therefore possible in these cases that the results may underestimate ownership if the subjects have interpreted questions as referring to the use of aids rather than actual ownership.

An additional confusion may arise owing to different definitions of people who would benefit from wearing hearing aids; where there is objective, audiometric, data some authors report results as percentages of people with a hearing impairment greater than 35 dB while others use a criterion of 25 dB. Others consider that only about 50% to 60% of people who report hearing problems are suitable for hearing aid fitting, owing to very minor hearing deficits or the presence of conditions such as hyperacusis or tinnitus (Godinho, 2016).

The following sections summarise reports and papers on hearing aid ownership which present data from both large scale and small scale studies in different countries. Factors which affect people's attitude towards ownership of hearing aids will be discussed in a later report.

9.2 SURVEYS OF HEARING AID OWNERSHIP AND USE

The most comprehensive surveys of hearing aid ownership and usage in Europe are the Eurotrak surveys, initiated by EHIMA in 2009 and carried out approximately every three years by Anovum on behalf of EHIMA and/or national organisations representing the hearing aid industry. The original surveys in 2009 were conducted in England, Germany and France. Since then other countries have been added, so that there is currently data available for ten European countries. In 2012 and 2015 the same survey was carried out in Japan, on behalf of the Japan Hearing Instruments Manufacturers Association (JHIMA). Results of Eurotrak surveys are available on the EHIMA website *www.ehima.com.*

The Eurotrak surveys were designed to be comparable to the MarkeTrak surveys which have been carried out at in the USA regular intervals since 1989 (Kochkin, 2009). The most recent MarkeTrak survey, MarkeTrak IX, took place in 2014 (Abrams and Kihm, 2015).

Both MarkeTrak and Eurotrak surveys investigate various facets of hearing aid ownership and usage among different age groups and hearing abilities, and explore routes to obtaining hearing aids, reasons for not owning or using aids, and perceived benefits from hearing aids. By being conducted every few years they enable patterns and trends in the hearing aid markets over time to be observed.

In addition to these large, wide scale surveys, studies of hearing aid ownership and use in individual countries have been published; results of such studies published since 2006 are included in this chapter. Many of these studies have been carried out as part of wider health studies such as the National Health and Nutrition Examination Survey (NHANES) in the

USA. In other cases smaller scale studies are reported. In some countries, for example the UK and France, surveys of hearing aid ownership and use have been conducted in recent years in order to inform the development of hearing health policies.

9.3 EUROTRAK SURVEYS OF HEARING AID OWNERSHIP

The Eurotrak surveys each involved around 14,000 subjects who completed questionnaires concerning various aspects of hearing and hearing aid use. From these subject groups, in each country a balanced sample of around 1300 hearing impaired subjects was selected, consisting of hearing aid owners and non-owners. The sample sizes involved in the surveys reported in this section are shown in Table C1 in Appendix C.

9.3.1 Overall ownership of hearing aids

Table 9.1 shows the percentages of those with hearing loss who own hearing aids for the ten European countries, plus Japan, included in the most recent Eurotrak surveys. Figures are given for all ages, and for adult subjects only, that is people aged 18 and over. Also shown are reported prevalence of hearing loss overall and among adults, and the percentages of owners fitted with binaural aids.

Table 9.1. Summary data from Eurotrak surveys including percentages of hearing impaired subjects who own hearing aids

Country	Prevalence of hearing loss %		% of hearing impaired with aids		% of owners with binaural aids
	All	≥18	All	≥18	All
Belgium****	9.6	11.5	30.7	30.6	80
Denmark***	10.3	12.1	53	54.1	78
France**	9.3	11.4	34.1	33.6	69
Germany**	12.1	13.9	35.0	34.9	76
Italy**	11.7	13.6	25.2	23.9	58
Netherlands***	10.1	11.8	41.1	41.8	74
Norway*	8.8	10.8	42.5	43.3	73
Poland***	16.0	18.3	17.8	17.8	32
Switzerland**	8.0	9.5	41.4	41.9	72
UK**	9.7	11.7	42.4	42.7	61
Average Europe	**10.6**	**12.5**	**36.3**	**36.5**	**67.3**
Japan**	11.3	13.1	13.5	12.8	46

* 2012 ** 2015 ***2016 ****2017

It can be seen from Table 9.1 that the country with the highest percentage of hearing impaired people who have hearing aids is Denmark, with over 50% of hearing impaired people being aided. In contrast, in Poland under 20% of those with hearing loss have hearing aids which means that more than four out of five hearing impaired people are unaided, while in Italy approximately three out of four are unaided.

As Godinho (2016) has shown, three of the four countries with the highest fitting rates (Denmark, Norway and the UK) are those where the hearing aids are either supplied free of charge, or the owners are reimbursed in full for the cost of the aids. In the UK around 82% of hearing aid owners obtain their hearing aids free on the National Health Service (Davis *et al*, 2007). In Switzerland also either all or a substantial portion of the cost of amplification is paid by social insurance (Bertoli *et al*, 2009). The countries with the highest percentages of

owners who have binaural fitting are Belgium, Denmark and Germany; the lowest binaural fitting occurs in Poland (32%).

Although the prevalence of hearing loss is reportedly considerably higher in Poland than in the other countries, the rate of hearing aid ownership is very much lower. Switzerland, on the other hand, has low prevalence of self-reported hearing loss but a comparatively high rate of hearing aid fitting.

It can also be seen from Table 9.1 that the rate of hearing aid fitting is very much lower in Japan than in the European countries. This may reflect the low self-reporting of hearing problems in eastern societies which was discussed in Chapter 2; it is possible that fewer elderly people seek help for hearing difficulties in Japan than in Europe.

9.3.2 Ownership across age groups

The percentages of hearing impaired subjects who own hearing aids in different age groups are shown in Table 9.2, from which it can be seen that the pattern of hearing aid ownership according to age differs between countries.

Table 9.2. Percentages of hearing impaired subjects with hearing aids across age groups.

Country	Age range (years)		
	≤ 44	**45-64**	**≥ 65**
Belgium****	15.8	16.1	45.7
Denmark***	37	42.4	66.3
France**	29.5	23.2	42
Germany**	25.4	24	44.9
Italy**	33.4	18.1	25.9
Netherlands***	27.9	26.5	57.3
Norway*	18.1	34.2	58.3
Poland***	11.7	9.8	29
Switzerland**	17.5	24.5	54.2
UK**	29.4	33.7	51.6
Average Europe	**27.9**	**26.5**	**47.5**
Japan**	-	5	15

* 2012 ** 2015 ***2016 ****2017

In all countries except Italy the highest percentage of hearing aid ownership occurs in the oldest age group (65 years and older). In Belgium, Denmark, Norway, Switzerland and the UK ownership increases with age, the highest percentage of owners being in the oldest age group. The lowest percentages fitted in the under 45 age group occur in Belgium, Norway, Poland and Switzerland where fewer than 20% of hearing impaired people have aids. In France and Italy and, to a lesser extent, Germany, the Netherlands and Poland, the rate of hearing aid fitting drops in the middle age group.

9.3.3 Ownership according to severity of hearing loss

The relationship between hearing aid ownership and severity of hearing loss has been examined in the Eurotrak surveys in two different ways.

Table 9.3 shows hearing aid adoption rates across different severities of impairment, where the hearing impaired subjects have been divided into six equal sized groups of severity.

It can be seen that, in all countries, hearing aid ownership increases with the severity of hearing loss, with between 52% and 91% of those in the most severe group being aided. The lowest rates are again those of Poland (57%) and Japan (52%); for the other countries between 67% and 91% of those in the most severe hearing loss category have hearing aids.

Table 9.3. Hearing aid adoption rates (%) across equal groups of severity of hearing loss

Country	Severity of hearing loss					
	1 (low)	2	3	4	5	6 (high)
Belgium****	4	16	21	35	51	80
Denmark***	31	48	52	59	74	91
France**	13	14	31	42	49	69
Germany**	14	17	25	35	54	78
Italy**	9	9	17	24	37	67
Netherlands***	11	29	43	43	61	73
Norway*	22	30	38	45	52	72
Poland***	1	6	10	16	33	57
Switzerland**	13	19	32	57	70	81
UK**	19	31	31	52	52	84
Average Europe	**13.7**	**21.9**	**30**	**40.8**	**53.3**	**75.2**
Japan**	3	2	12	15	25	52

* 2012 ** 2015 ***2016 ****2017

Using the more common categories of mild, moderate and severe hearing loss, Table 9.4 also shows the percentages of hearing impaired subjects with different degrees of (self-reported) hearing loss who own hearing aids, plus the percentages of the hearing impaired subjects who are in the different categories.

Table 9.4. Adoption rates across grades of hearing loss

Country	Grade of hearing loss					
	Mild		Moderate		Severe/profound	
	% of HI	% HA	% of HI	% HA	% of HI	% HA
Belgium****	30	7	42	29	27	61
Denmark***	44	31	37	73	20	82
France**	21	10	52	31	26	56
Germany**	35	10	47	41	18	72
Italy**	30	10	49	23	22	51
Netherlands***	32	13	46	46	23	65
Norway*	26	26	53	40	21	60
Poland***	46	4	32	21	22	45
Switzerland**	31	14	51	50	18	68
UK**	30	18	52	46	19	70
Average Europe	**32.5**	**14.3**	**46.1**	**40**	**21.6**	**63**
Japan**	40	7	49	17	12	37

* 2012 ** 2015 ***2016 ****2017

The adoption rates in Table 9.4 are consistent with those shown in Table 9.3 and with the data on overall ownership shown in Table 9.1, as is to be expected. As with the overall data, it can be seen that there is considerable variation between countries, for example Poland has the lowest adoption rates across all grades of hearing loss with only 4% of those with mild hearing loss being fitted with aids.

In 2016 EHIMA published an analysis of trends since 2009 by pooling the data from the three countries which had surveys in 2009, 2012 and 2015: France, Germany and UK (Ruf *et al*, 2016). They found that, while the prevalence of hearing loss remained stable, the rate of hearing aid adoption for adults increased, from 33% in 2009 to 37% in 2015. Increases were seen in all age groups, the largest increase occurring in the 65 and over age bracket (from 42.8% to 46.2%).

9.3.4 Ownership according to gender

The Eurotrak survey reports provide demographic data for each country surveyed. Table 3.5 shows the percentages of men and women reporting hearing difficulty, and the percentages of hearing impaired men and women who own hearing aids.

Table 9.5. Percentages of men and women reporting hearing difficulty and with hearing aids

Country	Prevalence of hearing difficulty %		% of hearing impaired with aids	
	Men	**Women**	**Men**	**Women**
Belgium****	?	?	51.2	48.8
Denmark***	11.6	9.0	51.5	55.0
France**	10.1	8.5	32.0	36.3
Germany**	12.7	11.6	33.1	36.7
Italy**	12.2	11.3	25.8	24.6
Netherlands***	11.0	9.3	40.1	42.3
Norway*	10.3	8.2	36.5	49.9
Poland***	17.9	14.1	16.3	19.5
Switzerland**	9.2	6.9	38.6	45.1
UK**	10.5	8.9	37.8	47.8
Average Europe	**11.7**	**9.8**	**36.3**	**40.6**
Japan**	10.9	11.6	13.8	13.2

* 2012 ** 2015 ***2016 ****2017

In all European countries except Belgium and Italy the rate of hearing aid ownership is higher among women than men.

9.4 OWNERSHIP OF HEARING AIDS IN THE UK

There have been several reports and surveys in the past ten years examining costs, affordability and efficiency of screening for hearing loss and provision of hearing aids in the UK. These form part of continuing research to inform the development and improvement of hearing aid services culminating in the 2016 publication of the Action Plan on Hearing Loss, (NHS England and Department of Health, 2016) which sets out the actions required to improve services to meet hearing needs in England.

In two of the reports discussed in this section, the Health Technology Assessment report (Davis *et al*, 2007) and the Health Survey for England report (Scholes and Mindell, 2015) there is no distinction between 'use' and 'ownership' of hearing aids. It is assumed in this chapter that the two words are synonymous in this context; further information on usage of hearing aids by those who own them is presented in Chapter 10.

9.4.1 Hearing Technology Assessment (HTA) report

In their study of the benefits and costs of potential screening methods in the UK, Davis *et al* (2007) carried out a large scale population survey to determine prevalence of hearing loss and use of hearing aids. Of around 25,000 postal survey respondents aged 14 and over, 31% reported hearing problems but only 3.4% of the sample reported using a hearing aid.

Table 9.6 shows the percentages of people reporting hearing problems, and using hearing aids, according to gender and age. It can be seen that the percentages of people wearing hearing aids increase with age, although the numbers wearing aids are very much smaller than the number reporting hearing problems in all age groups. The proportion of those with hearing problems who have aids is very much greater in the oldest age group (75+), where it is approximately 36%, than in the younger age groups. It can also be seen from the table

that, in those above the age of 55, the rate of hearing aid wear among those with hearing problems in greater for men than for women.

The study focussed on subjects in the 55 to 74 year age range. In this age range 12% of people reported having a problem that caused moderate or severe worry, annoyance or upset. The percentage using aids rose steadily across the age group, with 2.8% of people aged 55 using hearing aids, compared with 11.5% of those aged 74.

Table 9.6. Percentages of study sample with hearing problems and using hearing aids according to age and gender (data from Tables 12 and 17 of Davis *et al* 2007)

	Age range (years)											
	14-34			**35-54**			**55-74**			**75+**		
	M	**F**	**All**	**M**	**F**	**All**	**M**	**F**	**All**	**M**	**F**	**All**
With hearing problems	14.4	16.1	15.3	33.2	26.3	29.6	54.1	36.4	45.1	68.2	55.7	61.1
Wearing HA												
Tried in past	0.1	0.3	0.2	0.5	0.5	0.5	2.3	1.3	1.8	3.8	3.9	3.8
Some of time	0.1	0.2	0.2	0.5	0.4	0.5	3.4	1.9	2.6	11.4	6.6	8.7
Most of time	0.2	0.2	0.2	0.5	0.6	0.5	3.9	2.3	3.1	15.6	11.1	13.0
Total wearing some or all of time	0.3	0.4	0.4	1.0	1.0	1.0	7.3	4.2	5.7	27.0	17.7	21.7

Of 506 subjects aged 55 to 74 who were interviewed, 86 (17%) reported no hearing difficulties, 95 (19%) reported hearing difficulty and possessed a hearing aid and 325 (64%) reported difficulty but did not own a hearing aid. Thus, only 23% of those with hearing difficulties in the 55 to 74 year age range owned a hearing aid.

In a subsequent paper, Davis and Smith (2013) updated the original figures of Davis (1995) using current population demographics. They reported that, in England, 10% of individuals aged 18–80 years, or 4.9 million, have a moderate level of hearing loss (>35 dB HL in the better hearing ear averaged across 0.5 to 4.0 kHz) and would benefit from hearing aids or other forms of hearing management. However, 76%, or 3.8 million, of those who would benefit from aids do not have them or any other clinical management of their hearing loss.

9.4.1 Health Survey for England, 2014

The Health Surveys for England (HSE) are annual surveys which have been undertaken for the past 25 years to monitor trends in the nation's health. Hearing was included in the survey for the first time in 2014 and results related to hearing are summarised in Chapter 4 of the 2015 report (Scholes and Mindell, 2015).

The survey related to hearing involved a questionnaire survey of over 8000 adults (people aged 16 and over) which included questions on hearing difficulties and hearing aid use. Over 5000 participants also had an objective hearing screening test, which consisted of testing hearing at 1 kHz and 3 kHz, as recommended by the 2007 Health Technology Assessment report (Davis *et al*, 2007) as a suitable method for identifying people who might benefit from hearing aids.

In the questionnaire survey 19% of men and 17% of women reported hearing difficulties, of whom 6% of men and 5% of women reported using hearing aids. Overall 28% of participants with self-reported hearing difficulties wore hearing aids.

The questionnaire asked about past, as well as current, use of hearing aids. Current and previous use of aids increased with the self-reported degree of hearing difficulty, for example

46% of men and 45% of women who reported great difficulty were using aids. However, 42% of men and 45% of women with great difficulty had never used a hearing aid, and around 1 in 10 had used them in the past but were not currently using them.

Use of hearing aids also increased as measured hearing loss increased, but of those aged 55 and over with hearing loss of 35 dB or worse at 3 kHz, only 31% were currently using aids.

Table 9.7 shows the percentages of men and women currently wearing hearing aids across age groups.

Table 9.7. Percentages of sample currently wearing hearing aids (data from supplementary Table 4.12, Scholes and Mindell, 2015)

	Age range (years)								
	16-24	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75-84**	**>85**	**All**
Men	0	1	0	2	6	15	25	45	6
Women	0	0	1	1	5	8	20	37	5
All	0	0	1	2	5	11	22	40	5

Table 9.8 shows the percentages of men and women currently wearing, and who have never worn, hearing aids across grades of self-reported hearing difficulty.

Table 9.8. Percentages of currently wearing, and never worn, aids, according to gender and hearing difficulty (data from supplementary Table 4.15, Scholes and Mindell, 2015)

HA use	**Gender**	**Self-reported hearing difficulty**			
		None	**Slight**	**Moderate**	**Great**
Never used	Men	99	91	76	42
	Women	99	93	73	45
Current use	Men	0	5	12	46
	Women	0	3	13	45

It can be seen that over two in five adults reporting great hearing difficulty had never used a hearing aid, and over half were not currently using one. The survey also found that around one in ten of this group (12% of men and 9% of women) who had tried aids in the past did not currently use them.

The figures in Table 9.8 are considerably less than those for ownership of aids in the UK reported by the Eurotrak survey; this could be due to different classification of grades of hearing loss or the questions asked, or it may be that the numbers reflect the actual usage of aids, rather than ownership. However, as in the Eurotrak survey, prevalence of hearing aid use increased as hearing loss increased.

The survey results also showed that the use of hearing aids increased as measured hearing impairment increased. Table 9.9 shows the wearing of hearing aids according to objective hearing level in the better ear at 1 kHz and 3 kHz for adults aged 55 and over.

It can be seen that only 20% of people aged 55 and over with moderate hearing loss wear aids. The survey also found that, of those with at least moderate loss (35 dB or worse) at 3 kHz, only 31% were currently using a hearing aid and 60% had never used hearing aids. Table 9.9 also shows that, as in the HTA survey (Davis *et al*, 2007), over the age of 55 prevalence of hearing aid use among subjects with hearing impairment is greater for men than women.

Table 9.9. Hearing aid use among the 55+ age group according to measured hearing level (data from data from supplementary Table 4.31, Scholes and Mindell, 2015)

HA use	Gender	Hearing level at 1 kHz, dBHL			Hearing level at 3 kHz, dBHL		
		< 20 dB	20-35 dB	≥ 35 dB	< 35 dB	35-55 dB	≥ 55 dB
Never used	Men	90	66	23	94	73	39
	Women	95	80	35	97	69	44
	All	92	73	30	95	71	41
Current use	Men	6	26	72	3	18	52
	Women	3	17	49	2	22	45
	All	4	21	59	2	20	49

Table 9.9 shows that only 20% of people aged 55 and over with moderate hearing loss wear aids. The survey also found that, of those with at least moderate loss (35 dB or worse) at 3 kHz, only 31% were currently using a hearing aid and 60% had never used hearing aids. Table 9.9 also shows that, as in the HTA survey (Davis *et al*, 2007), over the age of 55 prevalence of hearing aid use among subjects with hearing impairment is greater for men than women.

The report concludes that there is potentially considerable unmet need, with approximately four million unaided adults in England who could benefit from hearing technology.

9.4.2 Action on Hearing Loss (AHL)

The estimate of four million adults who could benefit from hearing aids but do not have them, from the 2014 HSE report (Scholes and Mindell, 2015) is consistent with data reported by Action on Hearing Loss (2011) and quoted in the report by the Commission on Hearing Loss (2014) (see Chapter 4). The AHL data is based upon the original prevalence data by Davis (1995), updated by current population demographic information.

The report 'Hearing Matters' (Action on Hearing loss, 2011) stated that 10 million people in the UK had a hearing loss of 25 dB or more in the better ear. Of these, four million had hearing loss between 25 dB and 34 dB and would benefit from using a hearing aid if their hearing in the other ear was significantly worse. The remaining six million had hearing loss of 35 dB or more in their better ear, of whom most would benefit from using hearing aids. However only two million of these six million currently possessed hearing aids, thus AHL estimated that around four million people in the UK who could benefit from hearing aids did not have them.

In a subsequent report, AHL updated the figures on hearing loss in the UK and estimated that in 2014 the number with hearing loss of 25 dB and above was 11 million, of whom around 6.7 million had hearing loss of at least 35 dB in the better ear, and hence would benefit from wearing hearing aids (Action on Hearing Loss, 2015).

9.4.3 British Regional Heart Study

Another UK survey of vision and hearing impairment among men aged 63 to 85 years was carried out as part of the British Regional Heart Study (Liljas *et al*, 2013). The subjects were men who had taken part in the original heart survey around 25 years previously. The prevalence of self-reported hearing impairment and use of hearing aids among almost 4000 respondents, in 5 year age bands, are shown in Table 9.12.

Table 9.12. Prevalence (%) of hearing loss and hearing aid use among British men aged 63 to 85 (data from Table 1 of Liljas *et al*, 2013)

	Age range (years)				
	<70	**70-74**	**75-79**	**80+**	**Total**
Could hear	80	74	63	60	73
Could hear, used aid	7	11	20	23	12
Could not hear, no aid	11	11	11	10	11
Could not hear, used aid	3	4	6	7	4
Overall hearing impaired	21	26	37	40	27
Overall use of hearing aids	10	14	25	29	16

Overall, 59% of those who were hearing impaired wore hearing aids; this is a significantly higher rate of hearing aid use/ownership than found in other UK studies. However, the definition of hearing was based on a single question concerned with listening to television so those subjects who identified themselves as 'hearing impaired' may not correspond to those identified in other surveys. It can be seen from the table that the percentage of hearing impaired men using hearing aids increased with age; however, the percentage of subjects who reported not being able to hear and not using an aid was approximately constant at 10% to 11% in all age bands.

9.4.4 English Longitudinal Study of Ageing (ELSA)

ELSA provides a data set on the English population over the age of 50. The most recent report, on Wave 7 of ELSA (Banks *et al*, 2016) included questions on hearing as well as an objective hearing test (see Chapter 4, section 4.8.7). The study found that the percentage of men and women wearing a hearing aid increases with age and nearly doubles between those aged 75–79 and those aged 80 and over.

Table 9.13 shows the percentages of men and women over the age of 50 who wear hearing aids compared with the percentages of those with objectively measured hearing difficulty (mild/moderate/severe) and self-reported fair or poor hearing.

Table 9.13. Percentages of men and women wearing hearing aids (data from Table H4a in ELSA Wave 7 report (Banks *et al*, 2016)

	Age (years) in 2014-2015							
	50-54	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80+**	**All**
MEN								
Wear hearing aid	2.4	1.7	6.2	10.4	18.5	26.9	43.1	12.3
Hearing difficulty (mild/mod/severe)	17.7	18.4	26.3	36.5	47.4	58.1	83.3	35.5
Self-reported fair or poor hearing	17.7	18.0	23.3	26.4	30.8	36.6	44.9	26.1
WOMEN								
Wear hearing aid	3.3	2.0	4.3	7.5	11.6	17.0	30.4	9.8
Hearing difficulty (mild/mod/severe)	13.3	16.4	17.6	26.6	37.0	52.1	75.8	31.1
Self-reported fair or poor hearing	12.5	8.7	11.0	16.5	15.8	23.5	33.8	16.7

Table 9.13 shows that between the ages of 50 and 60, more women than men wear hearing aids but over the age of 60, considerably more men than women use aids.

9.4.5 Summary of hearing aid ownership in UK

Comparison between surveys is difficult owing to different survey methods, different subject groups and variation in categorisation of hearing loss.

Table 9.14 summarises the figures on ownership of hearing aids (as a percentage of those who are hearing impaired and the numbers of those who would benefit from aids but do not have them) from the UK studies discussed above, where possible, plus the 2015 Eurotrak survey.

Table 9.14. Summary of figures on ownership of hearing aids in UK

Survey/authors	Age of subjects	Ownership of hearing aids	
		% owning	Number without HA
Health Technology Assessment Davis *et al,* 2007	55-74	23	
Action on Hearing Loss, 2011	≥ 16		4 million
Davis and Smith, 2013	> 60	24	3.8 million
British Regional Heart Study Liljas *et al*, 2013	63-85	59	
Health Survey for England Scholes and Mindell, 2015	≥ 16	28	4 million
Action on Hearing Loss, 2015	≥ 17		>4 million
Eurotrak 2015	≥ 18	43	

Table 9.14 shows the large discrepancies between the rates of hearing aid adoption reported by the various surveys. The results of surveys by Davis and colleagues (Davis *et al*, 2007; Davis and Smith, 2013) and the Health Survey for England are reasonably consistent, estimating a hearing aid ownership rate of between 23% and 28% of those who need them, which is considerably lower than the rates found in the Eurotrak and British Regional Heart surveys. However, as discussed, the surveys reported in the Health Technology Assessment report (Davis *et al*, 2007) and the Health Survey for England (Scholes and Mindell, 2015) used the term 'use' of hearing aids rather than ownership. It is therefore possible that the rates of ownership in these surveys are higher than those reported in Table 9.14.

9.5 OWNERSHIP OF HEARING AIDS IN FRANCE

In 2016 a major report on an economic assessment of addressing the hearing needs of the French population was published (de Kervasdoue and Hartmann, 2016). As part of the study de Kervasdoue and Hartmann reviewed literature published between 2005 and 2015 on the extent of hearing loss and use of hearing aids in France and other developed countries. They included results of Eurotrak surveys as well as large scale French health surveys carried out by French national statistics institutes in recent years. They found some variation between studies in estimating the prevalence of hearing loss in France but concluded that around 16% of the population have some difficulty hearing, while between 8.6% and 11.2%, or over 6 million people, have disabling hearing loss. Of those with disabling hearing loss between 30% and 35% are equipped with hearing aids, that is around 2 million people. Thus around 65% of those eligible do not have hearing aids.

The Handicap-Sante survey is conducted every 10 years; the most recent survey, in 2008, was reported in 2014. In 2008 it was established that only 20% of those with moderate or greater hearing difficulties (as assessed by 'auditive functional limitation' (AFL), as described in Chapter 2) wore hearing aids, although the percentage of wearers had increased from 13% in the previous survey in 1998. De Kervasdoue and Hartmann suggest that the increase in hearing aid fitting could be due to the improved quality of hearing aids.

Table 9.15 shows the responses to the question 'Are you a hearing aid user?' in the survey, extrapolated to the whole population of France.

Table 9.15. Responses to question 'Are you a hearing aid user?' (data from Table 3 of de Kervasdoue and Hartmann, 2016)

	Number	% of population
Yes	1,112,000	1.8
No, but I need them	2,043,000	3.2
No and I don't need them	59,875,000	94.9
Total	63,084,000	99.9

Table 9.16 shows rates of hearing aid ownership and need across age groups, according to the severity of AFL from moderate to total. The authors note that the relatively high fitting of people under the age of 20 is probably due to the better social support for that age group, and their better response to equipment in terms of its effectiveness.

De Kervasdoue and Hartmann cite several other surveys including the Alcimed-DSS survey, published in 2011, which estimated that in 2009, of 6,300,000 hard of hearing people, half were eligible for hearing aids but only 1.25 million (31.7%) of those eligible, possessed them.

Table 9.16. Hearing aid equipment rate according to age and severity of AFL (data from Table 8 of de Kervasdoue and Hartmann)

	Severity of AFL	Age group (years)					
		< 20	20-44	45-59	60-74	75+	Overall
% of population owning hearing aids	Moderate		13	8	17	31	18.4
	Severe		9	8	20	30	21.8
	Very severe to total		25	19	26	41	33.5
	Moderate to total	37	14	8	15	32	20.4
% of population without but needing hearing aids	Moderate		22	28	32	41	32
	Severe		35	45	51	51	47
	Very severe to total		32	51	63	49	51
	Moderate to total	9	26	34	38	45	37

A further series of health and social welfare surveys, the ESPS (Sante et Protection Sociale/Health and Social Welfare Survey) surveys, have been carried out biennially since 1992. These have shown an increase in hearing aid ownership over the years, particularly since 2002. In 1992 1% of the total population were fitted with aids; this figure was relatively stable until 2002 when it increased to 1.9% and, in the most recently reported survey of 2012 it was 3.7%. Among those aged 65 and over, the rate increased from 6% in 1992 to 11.4% in 2012.

The authors give a table summarising the rates of hearing aid provision according to the various surveys in France since 2008; this table is reproduced below as Table 9.17.

From the data shown in Table 9.17 the authors concluded that the access rate for hearing aids in France is between 30% and 35% of the population affected by disabling hearing loss. However, they also refer to lower figures given by two other recent surveys, one of which in 2014 estimated the number of hearing impaired people in France to be 7 million, of whom only 15% were equipped with hearing aids; while the other, published in 2015, estimated there to be 6 million impaired people, 25% of whom were equipped with aids. It is possible that these surveys may consider those with mild hearing impairment in their calculation of the percentages with hearing aids, rather than just those with moderate to severe hearing loss as in other surveys.

Table 9.17. Summary of estimated rates of hearing aid provision in France (data from Table 10 in de Kervasdoue and Hartmann, 2016)

Year	Survey	Access rate to hearing aids %	Prevalence of hearing loss
2008	Handicap-Sante (disabling hearing loss)	15.8	11.2
2008	Handicap-Sante (moderate to total AFL)	20.4	8.6
2008	ESPS	23.0	10.0
2009	Eurotrak	29.8	10.4
2009	Alcimed-DSS	31.7	10
2010	ESPS	23.0	10
2012	Eurottrak	30.4	9.4
2012	ESPS	37.0	10
2015	Eurotrak	34.1	9.3

De Kervasdoue and Hartmann also show that the figure of 30% to 35% hearing impaired people being unequipped is consistent with the figure of 32.6% given by an alternative method of calculation, which takes account of the numbers of hearing aids sold in France.

9.6 OWNERSHIP OF HEARING AIDS IN NORDIC COUNTRIES

Apart from the Eurotrak surveys there are few reports of hearing aid ownership in Nordic countries, although there have been some investigations into the use of hearing aids among owners which are discussed in Chapter 10. This section reviews a study in Sweden which was mainly concerned with investigating outcomes of hearing aid use and factors affecting the uptake of hearing aids (Oberg *et al*, 2012), and a large scale study of an elderly population in Iceland (Fisher *et al*, 2015).

9.6.1 Ownership of hearing aids in Sweden

In a study by Oberg *et al* (2012) of people aged over 85, of 346 adults 124, or 36%, had self-reported hearing difficulties and a hearing aid; 85 (25%) had hearing difficulties and no hearing aid; and 133 (39%) reported normal hearing. Thus of those who reported hearing difficulties, 59% owned a hearing aid. The authors point out that this is a higher uptake than that reported in many other studies but may be due to the fact that it is based on self-reported hearing problems rather than audiometric measurements. As shown in Chapter 2, there is a tendency for older adults to underreport hearing problems so it is possible that, in reality, fewer than 133 had normal hearing, in which case the percentage of those with hearing difficulties who possessed hearing aids would be lower. However, the figure of 59% agrees with that found in the British Regional Heart Study (Liljas *et al*, 2013) discussed in section 9.4.3. The study also found that men were more likely than women to report hearing difficulties and to own hearing aids.

9.6.2 Ownership of hearing aids in Iceland

In a study of over 5000 people aged from 67 to 96 years (mean age 76.5) in Iceland, Fisher *et al* (2015) found that, overall, 19% of the subjects used hearing aids with more men (23%) than women (15.9%) using them. The prevalence of hearing aid use varied according to age and severity of hearing loss, as shown in Tables 9.18 and 9.19.

Table 9.18. Prevalence (%) of hearing aid use in Iceland according to age and gender (from Table 2 of Fisher *et al*, 2015)

Gender	Age group (years)					
	67-69	70-74	75-79	80-84	85+	Overall
Men	7.3	13.9	22.9	33.5	44.2	23.0
Women	4.5	8.9	11.9	26.4	42.4	15.9
All	5.5	11.1	16.9	29.4	43.2	19.0

Table 9.19. Prevalence (%) of hearing aid use in Iceland according to severity of hearing impairment and gender (from Table 2 of Fisher *et al*, 2015)

Severity of HI (BEHL)	Gender		
	Men	Women	All
None	0	0	0
Unilateral*	3.1	1.3	2.0
Mild (20-35 dB)	8.0	4.4	6.0
Moderate (35-50 dB)	37.9	39.7	38.8
Moderately severe (50-65 dB)	76.3	85.7	80.3
Severe-profound (65+ dB)	95.5	93.8	94.7

*Better ear < 20 dB HL and worse ear ≥ 35 dB HL

Of those with hearing loss greater than 35 dB in the better ear, the prevalence of hearing aid use was 49.9%.

9.7 OWNERSHIP OF HEARING AIDS IN THE UNITED STATES

There have been several studies in recent years of ownership of hearing aids in the USA, including the MarkeTrak surveys and analyses of responses to larger health surveys.

9.7.1 MarkeTrak surveys

The MarkeTrak surveys have been conducted in the USA at regular intervals since 1989 to investigate various aspects of the hearing aid market from the consumer's perspective (Abrams and Kihm, 2015). The most recent survey, MarkeTrak IX, was carried out in 2014. Unlike the previous eight surveys, which were postal questionnaire surveys, MarkeTrak IX used an online survey technique. Results of MarkeTrak IX are reported by Abrams and Kihm (2015) and by Ruf *et al* (2016).

In total 17,000 households in the USA were initially surveyed, and 3000 respondents who reported a hearing difficulty were followed up in more detail; of these 1000 were hearing aid owners, and 2000 non-owners.

There were over 13,000 respondents to the initial survey. Overall 10.6% respondents had self-reported hearing difficulty (compared with 11.3% in the previous survey of 2008) and 3.2% owned hearing aids (compared with 2.8% in 2008). 74% of the subjects reported that they had bilateral hearing loss. Of those with hearing difficulty, 30.2% owned hearing aids (compared with 24.8% in 2008), of whom 72% had bilateral aids.

Table 9.20 shows the percentages of participants who are hearing impaired and who own hearing aids across age groups, while Table 3.21 shows the hearing aid adoption rate in three age bands.

Table 9.20. Percentages of subjects in US who are hearing impaired (HI) and who own hearing aids (HA) across age groups (data from Figure 3 of Abrams and Kihm, 2015)

	Age range (years)								
	<18	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75-84**	**>85**
HI	3	3	5	7	11	17	22	34	62
HA	1	1	1	1	2	3	9	14	26

Table 9.21. Hearing aid adoption rate in different age ranges (data from Abrams and Kihm, 2015).

	Age range (years)		
	≤ 34	**35-64**	**> 65**
Hearing aid adoption rate	31	20	42

Table 9.21 shows a similar, though more pronounced, pattern of hearing aid adoption to those of Italy and France (and, to a lesser extent Germany, the Netherlands and Poland) shown in Table 9.2, in that, rather than a general increase in hearing aid ownership with age, there is a drop in the numbers possessing hearing aids in the middle age group. Abrams and Kihm suggest that this may reflect the relatively low incidence of hearing difficulty among younger age groups which could distort the figures. In addition, the introduction of newborn hearing screening and early intervention could explain the higher adoption rates among children and young people.

The MarkeTrak IX survey also found that incidence of both hearing loss and hearing aid ownership were higher for men than for women (12.2% men reported hearing loss, compared with 9.2% women, and 3.7% of men owned hearing aids compared with 2.7% of women).

In examining overall trends from the early Marketrak surveys, plus the Hearing Aid Industry survey of 1984, Kochkin (2009) observed that prevalence of hearing loss had increased from 10% in 1989 to 11.3% in 2008, giving an estimated 34.25 million people with hearing difficulties in 2008. Hearing aid adoption rates decreased from 23.8% of the hearing impaired population in 1984 to 20.4% in 1997, but then increased with each survey to 24.6% in 2008, the highest rate of increase being for those aged 85 and above (from 58.6% in 1984 to 64.3% in 2008).

9.7.2 Hearing Health Care for Adults report

The MarkeTrak IX figures are broadly in agreement with the summary figures in the 2016 report on hearing health care for adults in the USA (Blazer *et al*, 2016). After reviewing current data on prevalence of hearing loss and ownership of hearing aids the report concludes that 30 million Americans have hearing loss, including 12.7% of those aged 12 and over. The prevalence rises steeply with age, from 3% of 20 to 29 year olds to 45% of those aged 70 to 74 and over 80% in the 85+ age group. The report estimates that between 67% (from Bainbridge and Ramachandran, 2014) and 86% (from Chien and Lin, 2012) of adults who might benefit from hearing aids do not use them (see section 9.7.3 for further discussion of these surveys).

9.7.3 National Health and Nutrition Examination Survey (NHANES)

Three papers (Lin *et al*, 2011c; Chien and Lin, 2012; Bainbridge and Ramachandran, 2014) have analysed data from the NHANES to investigate the prevalence of hearing aid use in Americans over the age of 70 (Lin *et al*, 2011c; Bainbridge and Ramachandran, 2014) and over the age of 50 (Chien and Lin, 2012). Hearing aid use was based on whether an individual reported wearing a hearing aid either at least once a day or for at least 5 hours per

week (depending on the particular questionnaire). Among the over 70s, Lin *et al* (2011c) found that, overall, 19.1% of those with hearing loss used hearing aids, but that the rate of use varied according to the severity of the hearing loss. Of those with mild hearing loss (25-40 dB) loss, 3.4% used aids; of those with moderate hearing loss (40 – 70 dB) 40% used them; and for severe hearing loss greater than 70 dB 76.6% wore aids.

In another analysis of subjects aged over 70, Bainbridge and Ramachandran (2014) identified 601 potential hearing aid users from the survey, that is people with moderate hearing loss (defined as pure tone average of 0.5, 1 and 2 kHz better ear hearing loss ≥ 35 dB) and self-reported hearing difficulty, of whom only 33.1% (38% of men and 28% of women) wore hearing aids. The use of hearing aids according to age is shown in Table 9.22.

Table 9.22. Use of hearing aids among people over 70 with moderate hearing loss (data from Table 2 of Bainbridge and Ramachandran, 2014)

	Age range (years)			
	70-74	**75-79**	**≥ 80**	**Overall**
Hearing aid adoption rate	24.2	41.1	33.6	33.1

The figures in Table 9.22 show that Bainbridge and Ramachandran found considerably fewer people with moderate and greater hearing loss failing to use hearing aids (67%) than was found in the analysis by Lin *et al* (2011c) (80.9%). The authors suggest that this is due to different definitions of grades of hearing loss severity in the two analyses. Bainbridge and Ramachandran included self-reported hearing difficulties as well as audiometric measurements in their definition of hearing impairment; as shown in Chapter 11, hearing aid use is more strongly associated with self-reported hearing difficulties than with objective hearing acuity.

More detailed information concerning hearing aid use across all ages above 50 years was provided by Chien and Lin (2012). The authors state that this was the first national US estimate of hearing aid prevalence based upon audiometric data and a large representative sample of the US population (N = 2605). Table 9.23 shows the use of hearing aids according to age, gender and severity of hearing impairment.

Table 9.23. Prevalence of hearing aid use among over 50 year olds in the US (data from Chien and Lin, 2012)

Age group	**Gender (%)**		**Severity of BEHL (%)**		**Total**		**Number with BEHL ≥ 25 dB (millions)**
	M	**F**	**Mild (25-40 dB)**	**Moderate or greater (> 40 dB)**	**Overall prevalence of HA (%)**	**Number with HA (millions)**	
50-59	4.3	4.5	2.7	11.8	4.3	0.2	4.5
60-69	7.3	7.2	2.6	23.9	7.3	0.4	6.1
70-79	21.1	12.7	3.4	47.8	17.0	1.5	8.8
80+	28.1	17.9	3.4	35.7	22.1	1.6	7.3
Total					14.2	3.8	26.7

It can be seen that hearing aid use is low for all age groups who have mild hearing loss but is greater among those with more severe hearing loss, usage in general increasing with age for this group. Overall, of people aged 50 and over in the US who have hearing loss, only 1 in 7 uses a hearing aid; for adults of working age, fewer than 1 in 20 have aids The authors estimate that 3.8 million, or 14.2%, of the hearing impaired American population aged 50 years and older own hearing aids, while 26.7 million have hearing loss. Thus, nearly 23

million Americans over the age of 50 have untreated heating loss. It can also be seen from Table 9.23 that, over the age of 70, a greater proportion of men than women with hearing loss use hearing aids.

To summarise, there are differing estimates of the rate of hearing aid ownership derived from the same study data, depending on definitions of hearing loss and the particular cohorts of subjects studied.

9.7.4 Epidemiology of Hearing Loss Study and Beaver Dam Offspring Study

A longitudinal study of hearing, the Epidemiology of Hearing Loss Study (EHLS). was carried out in Beaver Dam from 1993 to 2005, participants with hearing loss being followed over a 10 year period. Fischer *et al* (2011) found that close to two thirds of the individuals with hearing loss (64%) who were followed for 10 years did not acquire a hearing aid, even though their hearing worsened over this period. The Beaver Dam Offspring Study which took place between 2005 and 2008 involved adult children, aged 21 to 84, of participants in the EHLS (Nash *et al*, 2013). Hearing aid ownership among those with both measured and self-assessed hearing impairment was low: the prevalence of use among those with mild hearing impairment (25 to 40 dB HL) was 3.9%, while 22.5% of those with moderate to severe hearing loss (> 40 dB) used aids. Over all grades of hearing impairment greater than 25 dB HL, 10.3% of those under the age of 70 wore hearing aids, compared with 11.6% of those over 70. Among those with self-reported hearing loss, only 1.4% of people aged under 54 wore aids, and 8.1% of those aged 55 to 84. The authors also reported that, of participants who had ever worn a hearing aid, 41.3% were not currently using them.

9.7.5 AARP/American Speech-Language-Hearing Association (ASHA) survey

A national poll of 2232 members of the AARP (formerly American Association of Retired Persons) was carried out jointly with ASHA in 2011, to determine the state of hearing health among US adults aged 50 years and above (Geraci, 2011). The survey found that 47% of respondents reported having untreated hearing problems, meaning that around 46 million US adults aged 50+ are likely to have hearing problems that are untreated.

Table 9.24 shows the percentages of men and women across the age groups who have untreated hearing difficulties, while Table 3.25 shows the percentages of men and women who own hearing aids.

Table 9.24. Percentages of men and women with untreated hearing problems (Geraci, 2011)

Gender	Age group (years)					
	50-54	54-59	60-64	65-69	70-74	75+
Men	57	45	59	56	51	42
Women	48	45	52	41	47	37
All	52	45	55	50	49	39

Table 9.25. Percentages of men and women who own hearing aids (Geraci, 2011)

Gender	Age group (years)					
	50-54	54-59	60-64	65-69	70-74	75+
Men	2	4	15	17	26	44
Women	5	3	5	10	11	28
All	4	4	10	14	18	37

Thus, the poll showed that men are more likely than women to have untreated hearing problems but are also more likely to own hearing aids.

9.7.6 Summary of ownership of hearing aids in USA

Table 9.26 summarises the figures on ownership of hearing aids (as a percentage of those who are hearing impaired) from the USA studies discussed above, plus the 2014 MarkeTrak survey.

Table 9.26. Summary of figures on ownership of hearing aids in the USA

Survey/authors	Age of subjects	Ownership of hearing aids	
		% owning	Number without HA
Lin *et al*, 2011c	>70	19.1	
Fischer *et* al, 2011	48-89 (at baseline)	36	
Geraci, 2011	≥ 50	20	46 million
Chien & Lin, 2012	>50	14.2	23 million
Nash *et al*, 2013	21-69	10.3	
	70-84	11.6	
Bainbridge & Ramachandran, 2014	>70	33.1	
MarkeTrak 2014	All	30.2	

As with the several surveys of hearing aid ownership in the UK, it can be seen from Table 9.26 that there is wide variation in US studies of ownership. Again, the discrepancies between study results are probably due to different definitions of hearing impairment and the questions asked. However, even analysis of data from the same study leads to different results (Lin *et al*, 2011c; Bainbridge & Ramachandran, 2014). As explained in section 9.7.3 these are probably due to different descriptions of hearing loss. In particular, the results of Lin *et al* (2011c) and Chien and Lin (2012) are based upon those with hearing loss greater than 25 dB, whereas Bainbridge & Ramachandran (2014) used a cut off of 35 dB HL. The figure of 36% in the paper by Fischer *et al* (2011) represents the cumulative acquisition rate after following the subjects for five or ten years in a longitudinal study.

9.8 OWNERSHIP OF HEARING AIDS IN AUSTRALIA

The Blue Mountains Hearing Study (BMHS) is a population-based survey of age-related hearing loss among a representative group of older Australians. People over the age of 49 have been surveyed every five years since 1992. Chia *et al* (2007) and Hartley *et al* (2010) have reported on various aspects of hearing aid ownership and use determined from analysis of different cohorts of the study.

Chia *et al* (2007) reported the rates of ownership across age groups of those with bilateral hearing loss (that is, BEHL, averaged across 0.5, 1 and 2 kHz, greater than 25 dB), as shown in Table 9.27.

Table 9.27. Percentages of ownership of hearing aids among Australian subjects with bilateral hearing loss (data from Table 1 of Chia *et al*, 2007)

	Age range (years)				
	< 60	60-69	70-79	80+	Total
Prevalence (%) of bilateral hearing loss	7.2	21.0	48.9	77.5	31.3
% of those with bilateral HL who have aid	16.7	23.5	31.5	40.1	33.3

As in the other reviewed studies, the percentages of hearing impaired individuals who own a hearing aid increase with age.

Hartley *et al* (2010) reported similar findings in that 31% of those with over 25 dB hearing loss in the better ear owned a hearing aid. When considering only those with moderate or greater hearing loss the percentage of hearing aid owners increased to 61.2%. Specifically, the proportions of hearing aid owners for those with mild (26 - 40 dB), moderate (41 - 60 dB) and marked (> 60 dB) hearing loss were 16.4%, 55.8% and 91.3% respectively.

9.9 OWNERSHIP OF HEARING AIDS IN ASIA

There appears to be little data on rate of hearing aid ownership in Asia, apart from the studies mentioned below.

9.9.1 Ownership in Japan

As was discussed in sections 9.2 and 9.3, in 2012 and 2015 Eurotrak surveys were carried out in Japan. Sample sizes were similar to those in the European surveys. The data for Japan is included in Tables 9.1 to 9.4. It can be seen that the figures for hearing aid fitting were much lower than in Europe: in 2015, of all individuals with hearing loss 13.5% had hearing aids (an increase from 11.3% in 2012) and of over 18 year olds, 12.8% of those with hearing loss had hearing aids (increased from 10.9 % in 2012). Around three times as many people over the age of 65 were fitted as younger subjects, although Table 9.4 shows that fewer than 2 in 5 of those with severe hearing loss are fitted with aids.

9.9.2 Ownership in China and India

Zhao *et al* (2015), in examining the influence of cross-cultural factors to explain differences in attitudes to hearing loss and hearing aid uptake, present comparative data for the UK, Sweden, India and China, related to healthcare provision in those countries. After examining data from a variety of sources for the four countries, Zhao *et al* summarised the prevalence of hearing loss and adoption of hearing aids in each country as shown in Table 9.28.

Table 9.28. Prevalence of hearing loss, hearing aid uptake, and health care information in four countries (Table 1 from Zhao *et al,* 2015)

	UK	Sweden	China	India
Population	62 million	9.6 million	1.4 billion	1.2 billion
Number with HL	10 million (16.1%)	1.3 million (13.5%)	27.8 million (2.0%)	63 million (5.3%)
Hearing aid adoption rate	20% - 25%	25% - 30%	1% - 8%	1% - 2%
Main healthcare service provision	Public healthcare (NHS)	Public healthcare	Basic medical insurance plus rural co-operative medical schemes	Private healthcare
Hearing aid provision by government	Free BTE HA	Free or subsidised BTE/ITE HA depending on region	No free HA in general	Free body-worn HA only provided in national institutes

Table 9.28 shows that provision of hearing aids is very low in China and India, compared with European countries. It is possible that, in addition to economic reasons, cultural attitudes as discussed in Chapter 2, may also contribute to the low uptake of hearing aids.

9.10 OWNERSHIP OF HEARING AIDS IN LATIN AMERICA

Two studies have examined the ownership and use of hearing aids in Brazil (Cruz *et al*, 2013) and Chile (Fuentes-Lopez *et al*, 2017). In Brazil, a survey by Cruz *et al* (2013) of over

1100 individuals aged 65 and over found that over 330 would benefit from hearing aids, of whom only 10% owned an aid.

Similar results were reported in a larger survey of nearly 5000 people aged 60 and above which was carried out in Chile in 2009 (Fuentes-Lopez *et al*, 2017). Of the 30% who reported having hearing difficulties (hearing fair, poor or very poor), only 9% wore hearing aids. The prevalence of hearing aid use increased with age from 3% for people in their 60s to 19% for people aged 80 and over. When considering only those who reported their hearing as poor or very poor, the proportion of hearing aid use increased to 21.5% over all ages.

9.11 DISCUSSION

Table 9.29 summarises the studies reviewed in this chapter which have estimated overall rates of hearing aid ownership among those with hearing impairment. The table includes the dates of the surveys from which the data were obtained, the ages of subjects, and the definitions of hearing loss in the studies). It can be seen from the table that, even within countries, there is large variation between results depending on the study.

Comparison between studies is complex owing to variations in methodologies and analysis. Factors that affect results and make comparison difficult include assessment of hearing loss, numbers and age ranges of subjects, other demographic characteristics of subjects and national policies regarding provision of hearing aids. An additional cause of inconsistency may be the specific wording of questions concerning ownership or use of hearing aids, and possible misunderstandings by respondents.

It is similarly not possible to carry out direct comparisons between hearing aid ownership rates across age groups or hearing severity owing to different methods of reporting results and variations in the definition of hearing loss. However, all studies which have investigated these aspects have shown that the rate of hearing aid ownership increases with age, and with severity of hearing loss.

Nevertheless, some general observations can be made. Table 9.29 illustrates the very wide range of results found in studies investigating the numbers of those with hearing loss who own hearing aids. The lowest rates are reported in Asian and South American countries, and the highest in some European countries. (Note that the figure of 61% from the study by Hartley *et al* (2010) refers only to those with hearing loss greater than 40 dB.) Taking into account all the rates shown in Table 9.29, it appears that at least 40% of hearing impaired people who could benefit from hearing aids do not own them, and some studies show that the percentages of people needing but not owning aids in some countries is very much higher than 40%.

Among the surveys which are based upon audiometric testing of subjects, for those surveys which use a hearing loss of 25 dB as indicating a need for hearing aids, the percentages of those with aids ranges from 10% to 36%; where 35 dB HL is the criterion between 31% and 50% own hearing aids. This general pattern, and the figure of 61% (Hartley *et al*, 2010), is consistent with the finding that hearing aid ownership increases with severity of hearing loss.

It can also be seen that, in general, the higher rates of ownership occur in those studies which have concerned older subjects, in their 80s or 90s. This is similarly consistent with the findings of increasing rates of ownership with age. The much lower rates reported in the analyses of NHANES data by Lin *et al* (2011c) and Chien and Lin (2012) probably reflect the fact that the question asked concerned use rather than ownership of aids.

Table 9.29. Summary of studies into hearing aid ownership

Country	Study	Dates of surveys	Subject ages (years)	Definition of HL		Rate of HA %
				SR	Aud (BEHL)	
Australia	Chia *et al*, 2007	1997-2000	≥ 50		>25 dB	33
	Hartley *et al*, 2010	1997-2003	49-99		>25 dB	31
					> 40 dB	61
Brazil	Cruz *et al*, 2013	2006	≥ 65	x		10
Chile	Fuentes-Lopez, 2017	2009	≥ 60	x		9
China	Zhao *et al*, 2015		All			2
Denmark	Eurotrak	2016	≥ 18	x		54
France	Eurotrak	2015	≥ 18	x		34
	de Kervasdoue & Hartmann, 2016	2008-2015	All	x		30-35
Germany	Eurotrak	2015	≥ 18	x		35
Iceland	Fisher *et al*, 2015	2002-2006	67-96		>35 dB	50
India	Zhao *et al*, 2015		All			5
Italy	Eurotrak	2015	≥ 18	x		24
Japan	Eurotrak	2015	≥ 18	x		13
Norway	Eurotrak	2015	≥ 18	x		43
Poland	Eurotrak	2015	≥ 18	x		18
Sweden	Oberg *et al*, 2012	2007-2009	>85	x		59
	Zhao *et al*, 2015		All			25-30
Switzerland	Eurotrak	2015	≥ 18	x		42
UK	Davis *et al*, 2007	1998-1999	≥ 14	x		11
			55-74	x		23
	Liljas *et al*, 2015	2003	63-85	x		59
	Scholes & Mindell, 2015	2014	≥ 16	x		28
			≥ 55		≥ 35 dB at 3 kHz	31
	Eurotrak	2015	≥ 18	x		43
USA	Fischer *et al*, 2011	1993-2005	48-89*		>25 dB	36
	Lin *et al*, 2011c	2005-2006	>70		>25 dB	19
	Geraci, 2011	2011	≥ 50	x		20
	Chien & Lin, 2012	1999-2006	>50		>25 dB	14
	Nash *et al*, 2013	2005-2008	21-69		>25 dB	10
			70-84			12
	Bainbridge & Ramachandran, 2014	2005-2010	>70	x	≥35 dB	33
	MarkeTrak	2014	All	x		30

*At baseline

In summary, although there are discrepancies and inconsistencies between the reviewed studies, certain key points emerge:

- Ownership of hearing loss increases with age
- Ownership of hearing loss increases with severity of hearing loss (both measured and self-reported)
- Rates of ownership in western European countries are comparable
- Rates of ownership in Australia are, in general, comparable with those in Europe
- Rates of ownership in the USA are, in general, lower than those in Europe
- Rates of ownership in Asia are very low compared with those in the USA and Europe
- At least 40% of the hearing impaired population who would benefit from hearing aids do not have them.

The individual studies in which gender has been considered show that more men than women own hearing aids, the difference in general increasing with age. The same is true in the MarkeTrak survey of the USA. However, the Eurotrak surveys show a contradictory picture: in all European countries except Belgium and Italy the rate of ownership is higher for women than men. (In Japan the rate of ownership for men and women is almost the same.) It is not clear what causes this discrepancy between results.

9.12 CONCLUSIONS

The review in this chapter has shown, despite inconsistences in detailed results of individual studies, that there continue to be large numbers of people around the world with untreated hearing loss.

In view of the adverse effects and social and economic consequences of untreated hearing loss, as reported in Section B, there is an urgent need to widen ownership of hearing aids, and for countries to introduce policies that will make provision of hearing aids more widely available and easier to access.

CHAPTER 10 PATTERNS OF USE OF HEARING AIDS

10.1 INTRODUCTION

Although surveys repeated every few years, such as the Eurotrak and MarkeTrak surveys, have found that ownership of hearing aids is gradually increasing over time, there is evidence of continued low usage among hearing aid owners, some of whom never wear their aids or only use them for short periods of time. In a review of papers examining the reasons why people do not wear their hearing aids, McCormack and Fortnum (2012) comment on the fact that, despite improvements in hearing aids since the early studies of the 1970s and 80s, usage is still low and underuse of hearing aids among older adults is still a matter of significant concern.

The non-use or limited use of hearing aids has been examined in the Eurotrak and Marketrak surveys and also, increasingly, in other large and small national studies. These have been accompanied by many studies aimed at determining the reasons why people do not seek help for hearing loss in the first place, and why they are reluctant to purchase and/or use hearing aids. This chapter reports data on the usage, including the non-use, of hearing aids among owners, while factors which affect the ownership and use of aids are discussed in Chapter 11.

In a systematic review of studies of hearing aid usage, published between 1999 and 2011, Perez and Edmonds (2012) commented on the lack of consistency and robustness in the way that usage is assessed and categorised. This is partly due to the absence of a standardised method of reporting hearing aid use. Some studies report proportions of time for which an aid is worn (for example, half the time, a quarter of the time etc); some assess the average amount of time per day in hours that hearing aids are worn; and others report the frequency of use (for example, daily or monthly). In their review of 64 studies, Perez and Edmonds identified 15 different metrics which have been used for evaluating the usage of hearing aids. The three most commonly used scales were the International Outcome Instrument – Hearing Aids (IOI-HA) (Cox *et al*, 2000), the Abbreviated Profile for Hearing Aid Benefit (APHAB) (Cox and Alexander, 1995) and the Glasgow Hearing Aid Benefit Profile (GHABP) (Gatehouse, 1999). All assess many different aspects of hearing aid use but all include questions on the amount of usage. The IOI-HA asks for the average number of hours per day that a hearing aid is worn, with five possible responses (zero, less than 1, 1 to 4, 4 to 8, more than 8); the GHABP asks for what proportion of time an aid is worn, also with five responses (never, about ¼ of the time, about ½ the time, about ¾ of the time, all the time); and the APHAB has a four point scale to determine daily use (less than 1 hour, 1 to 4 hours, 4 to 8 hours, 8 to 16 hours). Perez and Edmonds also comment on the fact that in some surveys distinction is not made between ‘do not own’ and ‘own but do not use’ a hearing aid, as was found in reviewing the studies of ownership of aids in Chapter 9.

Other surveys have investigated ‘regular’ and ‘irregular’ use of hearing aids, although the definitions of regular and irregular differ. For example, in the studies by Vuorialho *et al* (2006a, 2006b, 2006c) ‘regular users’ are those who report using a hearing aid for over 2 hours per day; ‘occasional users’ are those who use an aid less than 2 hours daily, for 2 to 6 hours almost every day, or at least once a week); and ‘non-users’ are those who use an aid seldom or never. Bertoli *et al* (2009), for the purpose of analysis, define ‘regular’ use as daily, most days or some days per week and ‘irregular’ use as occasionally or never. Hickson *et al* (2014) consider hearing aid owners as ‘successful’ or ‘unsuccessful’, successful owners being those who use their aids for at least one hour per day and report moderate benefit from them.

10.2 DAILY USE OF HEARING AIDS

Table 10.1 summarises the numbers of hours per day that have been estimated in surveys carried out since 2006 which have used the IOI-HA scale. Some of the figures, which are indicated in the table, were not stated in the original publications but are provided in the review by Aazh *et al* (2015) which was included in their investigation into non-adherence to hearing aid use in the UK. The numbers of subjects in the table refer to the number of hearing aid users analysed in each study, which is not necessarily the total number of subjects in the whole survey.

Table 10.1. Summaries of studies of daily hearing aid usage

Study/ country	Subjects		% binaural fitting	Daily hours of use of aid(s): % respondents				
	N	Age range (mean/median)		0	<1	1-4	4-8	>8
Takahashi *et al*, 2007 USA	164	36-96 (73)	Not reported	0	4	19	12	65
Bertoli *et al*, 2009 Switzerland	8707	18+ (74)	61	2	3	20	26	49
Williams *et al*, 2009 USA	64	22-94 (73)	91	0	3	14	22	61
Hartley *et al*, 2010 Australia	322	49-99 (67)	68	32**	7	23	13	24
Hickson *et al*, 2010 Australia*	1575	>20 93% >50	78	4	6	17	23	51
Brannstrom & Wennerstrom, 2010 Sweden*	224	27-94 (66)	40	3	9	21	27	40
Liu *et al*, 2011 China*	1049	18-93 (61)	33	1	2	20	34	43
Solheim *et al*, 2012 Norway	90	≥ 65 (81)	Not reported	***	22	21	29	28
Aazh *et al*, 2015 UK	1023	75	84	10	5	13	17	54

* Data from Aazh *et al* (2015)
** 24.3% never plus 7.4% less than 1 hour per week
*** Only figure for ≤ 1 hr daily reported

It can be seen that the number of subjects who reported never using their aids (0 hours of use per day) is very low in most cases. However, this should not be considered as a reliable estimate of the number of non-users in a particular country as those who never use their aids may not have volunteered, or been selected, for a survey investigating hearing aid use. It is to be expected that the majority of subjects in the surveys included in Table 10.1 would have used their aids for at least some of the time.

10.3 EUROTRAK SURVEYS OF HEARING AID USE

The Eurotrak surveys ask hearing aid owners to specify for how many hours a day (from 0 to 18) they wear their hearing aids. The mean figures from the most recent surveys for each country are shown in Table 10.2. Also shown are the percentages of owners who report wearing their aids for 0 hours per day, that is who never wear their aids.

Table 10.2. Average numbers of hours of use, and percentages of owners reporting no use, of hearing aids, from Eurotrak surveys

	Belg ****	Den ***	Fra **	Ger **	It **	Neth ***	Nor *	Pol ***	Switz **	UK **	Jap **
Mean no of hrs aids worn daily	9.4	9.1	8.6	8.7	8.4	9.1	7.9	6.3	9	8.1	6.8
% reporting 0 hrs wear daily	5	8	4	3	5	5	10	4	2	11	7

* 2012 ** 2015 ***2016 ****2017

It can be seen that, on average, hearing aids are worn for between six and nine hours per day, the average use exceeding eight hours per day in all countries except Poland and Japan. However, in all countries a certain percentage of hearing aid owners report that they never wear their hearing aids. In Denmark, Norway and the UK, around 10% of owners never use their aids. These are the countries where aids are provided free of charge to the consumer, and which have the highest rates of ownership (see Chapter 9, section 9.3.1). Otherwise, in all other countries, apart from Japan, between 2% and 5% report not wearing their aids, which is consistent with most of the surveys shown in Table 10.1. There may be more motivation to use hearing aids when owners have committed their own money to purchase of the aids. Possible reasons for non-use of aids are explored in Chapter 11. Additional data on non-use of aids is presented in section 10.5.

In analysing trends in Eurotrak surveys, by examining pooled data for France, Germany and the UK, no significant changes were observed in wearing times between 2009 and 2015 (Ruf *et al*, 2015).

The Eurotrak survey reports give the percentages of owners who wear their aids for different lengths of time each day. Some reports give figures for each number of hours daily from 0 to 18. To be consistent with the majority of studies of use, which employ the five IOI-HA categories of 0, less than 1, 1 to 4, 4 to 8 and more than 8 hours, and to enable comparison with the data shown in Table 10.1, this information has been reclassified by the author using the categories shown in Table 10.3. Other reports give the usage times in a form which is consistent with the IOI-HA categories. The daily times of wear for each country are shown in Table 10.4.

Table 10.3. Reclassification of Eurotrak data on hours of use of hearing aids

Eurotrak categories (hours)	**IOI-HA categories (hours)**
0	0
1	< 1
2,3,4	1-4
5,6,7,8	4-8
>8	>8

Table 4.4 shows that, in Belgium, France, Italy, Germany, Netherlands and Switzerland hearing aids are worn by around 75% of owners for over 4 hours a day, while in the other European countries between 60% and 70% of owners wear them for this length of time. In Japan around half of hearing aid owners wear their aids for more than four hours per day. The results are broadly consistent with the results of studies cited in Table 10.1. Information on patterns of use of hearing aids is examined further in section 10.4.

Table 10.4. Percentages of population wearing their hearing aids for different lengths of time

Country	Daily hours of use of aid(s): % respondents				
	0	<1	1-4	4-8	>8
Belgium****	5	8	10	15	61
Denmark***	8	8	15	26	43
France**	4	6	13	26	50
Germany**	3	7	14	17	58
Italy**	5	5	14	26	49
Netherlands***	5	9	7	25	53
Norway*	10	13	14	19	43
Poland***	4	11	20	34	29
Switzerland**	2	10	13	18	57
UK**	11	8	14	20	44
Japan**	7	17	24	15	38

* 2012 ** 2015 ***2016 ****2017

10.4 MARKETRAK SURVEYS

The MarkeTrak IX survey in the US, rather than specifying daily hours of use of hearing aids, asked owners how frequently they used their aids (Abrams and Kihm, 2015). The results for adult users (aged 20 and over) are shown in Table 10.5.

Table 10.5. Frequency of use of hearing aids in MarkeTrak IX survey (data from Table 3 of Abrams and Kihm, 2015)

Frequency of use	% adults, N=2,084
Daily	71
Weekly	15
Monthly	3
Less than monthly	2
Varies with situation	6
Never	3
Not yet worn	0.2

The figure of 3% for never using aids (aids being 'in the drawer') is considerably lower than that found in the previous MarkeTrak survey of 2008, when 12% of aids were reported to be 'in the drawer'. Data from the previous surveys published by Kochkin (2010b) have shown that, between 1991 and 2008, this number was relatively constant, varying from 12% to 18%, as shown in Table 10.6. Kochkin examined the use of hearing aids relative to their age and Table 10.6 also presents the data on unused aids which are less than five years old. It can be seen that, the older the aids, the higher the number that are unused. However, Kochkin considers the number of unused aids under five years old to be perplexing, especially given the cost of hearing aids in the USA.

Table 10.6. Percentages of owners reporting non-use of aids in previous MarkeTrak surveys (data from Kochkin, 2010b)

	1991	1994	1997	2000	2004	2008
Overall	12.0	17.9	16.2	11.7	16.7	12.4
Aids ≤ 1 year old	3.0	3.5	4.6	3.1	3.8	5.2
Aids ≤ 4 years old	7.7	11.1	8.8	6.8	10.0	7.5

In the previous MarkeTrak survey of 2008, MarkeTrak VIII, the average number of hours that hearing aids were worn was 9.5 (Kochkin, 2010b). This figure was almost constant over the

previous surveys since 1994, fluctuating between 8.7 and 9.6 hours, which is consistent with the average hours of use reported in Eurotrak surveys (see Table 10.2). Another survey of hearing aid outcomes among older adults in the USA (Humes *et al*, 2009) found that aids were used, on average, for 7 to 8 hours a day (see section 10.5 and Table 10.7).

10.5 PATTERNS OF USE AND NON-USE OF HEARING AIDS

In addition to studies of hourly or daily usage there have been other studies which have examined typical use and non-use of hearing aids. Some of the studies cited in Table 10.1 have covered other aspects of usage, including factors affecting use and non-use which are discussed in Chapter 11. Table 10.7 summarises the findings of studies on usage and non-usage of hearing aids published since 2006.

Table 10.7. Studies on usage and non-usage of hearing aids

Study/country	Subjects		Summary of results
	N	Age	
Vuorialho *et al*, 2006a Finland	98	61-87 (77)	58% > 2 hrs per day; 32% occasional use (< 2 hrs per day, 2-6 hrs almost every day or at least once a week); 10% seldom or never
Vuorialho *et al*, 2006b Finland	76	73.8	56.6% regular users; 36.8% occasional users; 5.3% non-users
Chia *et al*, 2007 Australia	233	74-76 (75)	77% of those with hearing aids usually use them
Bertoli *et al*, 2009 Switzerland	8707	18+ (74)	85% regular use (1-7 days per week); 12% occasional use; 3% non-use
Humes *et al*, 2009 USA	213	74.6	Average use 7-8 hours per day
Hartley *et al*, 2010 Australia	322	49-99 (67.4)	24% non-users
Geraci, 2011 USA	406	50+	11% wear aids rarely or never; 28% when needed; 61% most or all of time.
Oberg *et al*, 2012 Sweden	124	85+	47% used aids > 8hrs per day; 12% non-users
Solheim *et al*, 2012 Norway	90	≥ 65 (81)	22% use aid for < 1 hr per day; 28% > 8 hrs per day
Davis & Smith, 2013 UK	~140	60+	80% of owners used their aids
Nash *et al,* 2013 USA	3130	21-84 (49)	Among those who had ever used an aid, 41.3% no longer used them
Hickson *et al*, 2014 Australia	160	60-91 (73)	85 successful owners (use > 1 hr per day + moderate benefit. Of 75 unsuccessful owners, 24 never use aids; 24 minimal use and low benefit; 15 use > I hr per day and low benefit; 12 use < 1 hr per day and moderate benefit
Laplante-Levesque *et al*, 2014 Netherlands, Denmark	228	≥ 18 (72)	Comparison of objective and self-reported daily use: objective 10.5 hrs; self-reported 11.8 hrs. average difference 1.2 hrs.
Aazh *et al*, 2015 UK	1023	17-105 (74)	29% < 4 hrs per day; 71% > 4 hrs per day 39.5% new users & 10.7% existing users < 4 hrs 22.6% new users < 1 hr per day. 27% new users unsuccessful.
Solheim & Hickson, 2017 Norway	181	≥ 60 (79)	Comparison of objective and self-reported daily use 6 months after fitting: objective 6.1 hrs; self-reported 8.4 hrs. 15.5% < 30 minutes per day.

As Table 10.7 shows, there is a range of results concerning hearing aid use depending on the study, the survey methods used, the participant group and so on. It is therefore difficult to draw any definitive conclusions concerning hearing aid use. Some studies (Chia *et al*, 2007; Hartley *et al*, 2010; Davis and Smith, 20013) suggest that around 20% to 25% of hearing aid owners do not use their aids, while Nash *et al* (2013) found that 41% of people who had previously used a hearing aid no longer used one. However, other studies report much smaller numbers of non-users. It can be seen that where hours of use have been recorded by data logging and compared with self reported data (Laplante-Levesque *et al,* 2014; Solheim and Hickson, 2017), HA wearers over reported their use (by an average of 1.2 hours in the study by Laplante-Levesque *et al* and by 2.3 hours in the study by Solheim and Hickson).

10.5.1 Use according to age

In the Blue Mountains Hearing Study of over 2,400 people aged 49 and over, Chia *et al* (2007) reported the rates of use of hearing aids across age groups of those with bilateral hearing loss (that is, BEHL, averaged across 0.5, 1 and 2 kHz greater than 25 dB), as shown in Table 10.8.

Table 10.8. Rates of use (%) of hearing aids among Australian subjects with bilateral hearing loss (data from Table 1 of Chia *et al*, 2007)

	Age range (years)				
	< 60	**60-69**	**70-79**	**80+**	**Total**
% who have aid	16.7	23.5	31.5	40.1	33.3
% of owners who usually use aid	71.4	72.7	78.8	78.3	77.3

Thus the study by Chia *et al* (2007) shows that the percentage of hearing aid owners who use their aids increases with age.

However, in the Norwegian study by Solheim *et al* (2012), no relationship was found between hours of use and age.

10.5.2 Daily use for greater than or less than four hours

The data shown in Tables 10.1 and 10.4 have been further summarised according to country and use less than or greater than four hours daily, as shown in Table 10.9. (Note that in some cases percentages do not add up to 100 owing to rounding or missing data in the original papers.)

Table 10.9 shows close agreement between the results of Eurotrak and other surveys in the three countries where comparison is possible (Norway, Switzerland, UK) giving confidence in the results of Eurotrak surveys for the other countries.

It appears from Table 10.9 that, in the majority of countries, over 70% of hearing aid owners use their aids for more than four hours per day.

Table 10.9. Studies showing daily use for less than and greater than 4 hours

Country	Study	No of owners	Daily hours of use of aid(s) % respondents	
			< 4 hours	> 4 hours
Australia	Hartley *et al,* 2010	322	62	37
	Hickson *et al*, 2010	1575	27	74
Belgium	Eurotrak 2017	502	23	76
China	Liu *et al*, 2011	1049	23	77
Denmark	Eurotrak 2016	711	31	69
France	Eurotrak 2015	501	23	76
Germany	Eurotrak 2015	505	24	75
Italy	Eurotrak 2015	492	24	75
Japan	Eurotrak 2015	416	48	53
Netherlands	Eurotrak 2016	555	21	78
Norway	Eurotrak 2012	691	37	62
	Solheim *et al*, 2012	90	43	57
Poland	Eurotrak 2016	475	35	63
Switzerland	Bertoli *et al*, 2009	8707	25	75
	Eurotrak 2015	619	25	75
UK	Aazh *et al,* 2015	1023	29	71
	Eurotrak 2015	605	33	64
USA	Takahashi *et al*, 2007	164	23	77
	Williams *et a*l, 2009	64	17	83

10.6 DISCUSSION

The studies reviewed in this chapter demonstrate significant variation in patterns of use of hearing aids, making it difficult to draw any detailed comparisons or definitive conclusions regarding usage. However, the discrepancies between study results could be related more to the methodologies of the individual surveys rather than to different patterns of behaviour among the various cohorts of hearing aid owner studied.

The Eurotrak surveys of hearing aid owners have found that hearing aids are used, on average, for between 6 and 9 hours per day. Nevertheless it is clear from individual studies by various authors that a certain percentage of owners never wear an aid, or wear them for a very short time, typically less than one hour per day on average. The figures for the number of owners who never or rarely wear their aids range from 2% to 41%, with several surveys suggesting that around 20% to 25% of owners do not use their aids.

Some key points which emerge from this chapter are:

- There is good agreement between the results of Eurotrak and other surveys.
- Eurotrak surveys show that hearing aids are worn, on average, for around eight hours per day.
- Eurotrak surveys show that the use of hearing aids is very much lower in Japan than in European countries.
- Some hearing aid owners never use their hearing aids or use them for a very short time.
- The most recent MarkeTrak survey shows that the rate of non-use of hearing aids in the USA has decreased.
- The hours of use of hearing aids increase with age.
- In many countries over 70% of hearing aid owners wear their aids for more than four hours per day, on average.
- Self-reports of daily hearing aid use over estimate the number of house worn.

10.7 CONCLUSIONS

The review of studies of hearing aid use in this chapter has shown different patterns of use of hearing aids among owners. However, although, on average, aids are used for around eight hours per day, and over 70% of owners use their aids for over four hours per day, there is a substantial proportion of owners who never use their aids or use them only rarely. This information, combined with the findings of the previous chapter concerning the high numbers of hearing impaired people who do not possess hearing aids, show that many hearing impaired people around the world continue to live with untreated hearing loss.

CHAPTER 11 FACTORS AFFECTING OWNERSHIP AND USE OF HEARING AIDS

11.1 INTRODUCTION

Chapters 9 and 10 showed that, although the prevalence of hearing loss is high, there are still large numbers of hearing impaired people who do not own hearing aids. Furthermore, of those who have been fitted with aids, many do not use them or use them only occasionally. This chapter reviews many studies that have been undertaken in the past ten years exploring reasons for non-ownership and under use of hearing aids.

Many researchers and organisations have attempted to identify those factors which determine whether a person with hearing loss a) seeks help for hearing loss, and if so, when; b) accepts or purchases a hearing aid if recommended; c) uses or does not use a hearing aid if they own one. These issues have been addressed in large scale surveys such as the Eurotrak and Marketrak surveys, and in smaller scale research studies. This chapter summarises the information that is available to date. Review papers and their main conclusions are listed, and findings of the most recent Eurotrak and Marketrak surveys are summarised, together with those of individual research studies. The chapter concludes by discussing some of the more important factors that have emerged from the investigations.

11.2 REVIEWS

Table 11.1 lists the major literature reviews, published since 2006, of studies investigating factors which influence the acquisition and use of hearing aids, plus their overall conclusions.

The most commonly found factor which encourages people to seek help for hearing problems and to acquire hearing aids is self-perceived hearing difficulties. Self-reported hearing loss appears to be more strongly related than measured hearing impairment to hearing aid ownership. Results regarding age and gender in relation to the acquisition of hearing aids are inconsistent, some studies finding relationships and others not. A review by Barker *et al* (2016) comments on the difficulties of comparing results of different studies and also on the poor quality of some of the evidence. Stigma has been found to be a factor preventing people from considering wearing of hearing aids in some studies; however McCormack and Fortnum (2013) concluded that it is not now as great a deterrent as it was in the past, although Clements (2015) found that it was the main reason for the delay in seeking help. Stigma is discussed further in section 11.6.2.

11.3 EUROTRAK AND MARKETRAK SURVEYS

The largest datasets concerning reasons for not owning or not using hearing aids, and the drivers for purchasing hearing aids, are provided by the Eurotrak and Marketrak surveys.

11.3.1 Eurotrak data on ownership and non-ownership of hearing aids

In the Eurotrak surveys, hearing impaired respondents without hearing aids were asked to indicate their reasons, from a list of 27 possible reasons, for not owning hearing aids. Table 11.2 shows the top five reasons from the most recent surveys, with the percentages (averaged across 10 European countries) of respondents who marked each as ‘a reason’ or ‘somewhat a reason’ for their non-ownership of hearing aids. For each of these reasons the score was greater than 50% in the majority of countries surveyed. The full list of reasons, in order of priority, is shown in Table C2 of Appendix C.

Table 11.1. Reviews of studies of factors affecting hearing aid (HA) acquisition and use

Authors	Ownership/ Use of HA	Period covered by review	No of studies	Main conclusions
Knudsen *et al*, 2010	Uptake, use and satisfaction	1980-2009	39	Self-reported hearing disability is most important factor in aural rehabilitation, affecting help-seeking, HA uptake, HA use and satisfaction. Gender and age not relevant.
Jenstad and Moon, 2011	Ownership	1990-2010	50 in total, 14 reported	Most common predictors of HA uptake are self-reported HL, stigma and degree of HI. Contradictory results re age.
Perez and Edmonds, 2012	Use	1999-2011	64	Results re age, design/technological advances and affordability are inconsistent. Degree of HI not related to HA use.
McCormack and Fortnum, 2013	Use	2000-2012	10	Most common reasons for not using HA relate to HA effectiveness, fit, comfort, care, maintenance, cost and also manual dexterity. Stigma not as great a deterrent as previously. No evidence re age or gender.
Meyer and Hickson, 2014	Ownership	1990-2010	22	Help-seeking and HA adoption more likely once communication difficulties acknowledged and/or experienced. HA adoption not associated with gender but with increased age. Positive expectations, perceived benefits of HA and attitudes of significant others encourage adoption of HA.
Ng and Loke, 2015	HA adoption and use	2001-2014	22	4 audiological factors (severity of HL, type of HA, background noise tolerance and insertion gain) and 7 non-audiological factors (self-perceived hearing problems, benefit and satisfaction with HA, expectation, demographics, group consultation and support from significant others) affect HA adoption and use. Self-perceived hearing problem most important determinant of use. Regular use related to self-perceived benefit.
Clements 2015	Ownership (delay in help seeking)	1973-2014	17	Stigma main reason for delay; also attitudes and opinions of others; emotional and psychosocial barriers; and patient/clinician interaction.
Barker *et al,* 2016	Use	Up to 2016	37	Difficult to compare data from different studies. Interventions that deliver self-management support improve some outcomes but evidence is of low quality.

Table 11.2. Average (of 11 countries) percentages of respondents citing reasons for non-ownership of hearing aids ('reason' or 'somewhat reason')

Reasons for non-ownership	%
Hear well enough in most situations	64.3
Hearing loss not severe enough	61.8
Uncomfortable	56.0
They do not restore your hearing to normal	54.2
They do not work well in noisy situations	54.2

The same top five reasons were given in the 2012 surveys. However, as Hougaard *et al* (2013) pointed out, there were some country specific anomalies. This is also true of the latest results. In the most recent surveys cost was the main factor in France, and also in the top five factors in Poland and Italy; embarrassment and/or not wanting to admit to hearing loss in public were in the top five reasons in Poland and the UK; having more serious priorities was in the top five factors in several countries (France, Poland, Italy, UK); and the opinion of the ENT specialist was in the top five in France, Germany and Netherlands.

The Eurotrak surveys also asked hearing aid owners to indicate which of around 30 factors finally made them decide to obtain hearing aid(s). The top five reasons, with percentages of respondents averaged across the 10 European countries surveyed, are shown in Table 11.3.

Table 11.3. Top five factors leading owners to acquire hearing aids

Factors	**%**
Hearing loss got worse	50.5
ENT doctor	40.9
Audiologist	38.0
Spouse	32.6
GP/family doctor	24.6

Non-owners were also presented with the same factors and asked which might influence them to acquire a hearing aid. The top five factors are shown in Table 2.4.

Table 11.4. Top five factors which might influence non-owners to acquire a hearing aid

Factors	**%**
Hearing loss got worse	62.1
ENT doctor	46.4
Price of hearing aids	31.0
GP/family doctor	30.6
Spouse	27.9

For both hearing aid owners and non-owners worsening hearing loss is the main driver in obtaining hearing aids. Professionals and spouses are also important influences.

11.3.2 Eurotrak data on non-use of hearing aids

The same list of factors suggested as possible reasons for non-ownership of hearing aids were also presented to owners who said that they owned, but did not use, their aids. The top six factors, cited by over 50% of respondents in most countries and averaged over 10 European countries, are shown in Table 11.5.

Table 11.5. Top six reasons for non-use of hearing aids among owners

Reasons for non-use	%
They do not work well in noisy situations	71.7
Hear well enough in most situations	67.6
Uncomfortable	65.9
They do not restore your hearing to normal	64.3
Hearing loss not severe enough	58.7
Have tried hearing aid and they do not work	57.9

It can be seen from Tables 11.2 and 11.5 that the most important reasons for non-ownership and non-use of hearing aids are the same.

11.3.2 MarkeTrak and AARP-ASHA data on ownership of hearing aids

In their summary of the 2014 MarkeTrak IX survey in the USA, Abrams and Kihm (2015) found that the most common barriers to the adoption of hearing aids were financial constraints and lack of perceived need. Stigma effects, such as respondents feeling they were too young to wear hearing aids or too embarrassed to wear them, or that aids were unattractive, were also cited as reasons for non-ownership of aids. The authors state that non-owners with more severe hearing loss often have more financial constraints than those with milder loss. Non-owners were asked what factors would motivate them to purchase an aid. Over 50% said increased insurance that would cover some of the cost of an aid, and 36% said having a hearing test that made it clear that a hearing aid was needed. From a psychological point of view Abrams and Kihm (2015) consider that those with more potential for hearing aid adoption include optimistic problem solvers who feel socially supported; those who are motivated to communicate through social and other activities; and those who are not embarrassed to admit that they have hearing loss.

In a detailed analysis of reasons given for not acquiring hearing aids in the 2005 MarkeTrak survey Kochkin (2007b) found that the most common reasons were financial; they do not restore hearing to normal; and do not work in noise. However, the importance given to various reasons varied with the severity of hearing loss. Among those intending to acquire a hearing aid in the near future, the most important influences were reported to be that their hearing loss had got worse (67%) and pressure or recommendation from a family member (62%). These two factors were in fact the most important influences among new hearing aid users in all the Marketrak surveys from 1989 to 2008 (Kochkin, 2009).

Thus, ignoring financial aspects which vary from country to country, the main reasons found in MarkeTrak surveys for not owning a hearing aid, and the important influences that would encourage hearing aid adoption, are similar to those reported in the Eurotrak surveys.

In another American survey, of over 2000 people aged 50 and over, carried out by the AARP (formerly the American Association of Retired Persons) and ASHA (American Speech-Language-Hearing Association) in 2011, of those with untreated hearing loss the foremost reason (57% of respondents) was that the hearing loss was not severe enough to need a hearing aid (Geraci, 2011). However, around 70% said that they would seek help if they felt their relationships with family and friends were being affected.

11.4 STUDIES OF FACTORS AFFECTING OWNERSHIP OF HEARING AIDS

Table 11.6 summarises studies published since 2006 which have examined factors affecting help-seeking for hearing loss and ownership of hearing aids. It can be seen that the most common factor motivating people to acquire hearing aids, as concluded by the majority of reviews discussed in section 11.2, is self-perceived hearing loss, as well as others' perceptions of hearing difficulties. It appears that a person is more likely to seek help for

Table 11.6. Studies investigating factors affecting hearing aid acquisition

Study/Country	Subjects	Results
Meister *et al*, 2008 Germany	100 ENT patients not previously fitted with HA Age:32-92 (68.6)	Willingness to try HA was significantly related to expectations of improvement in quality of life, lack of stigmatisation, and self-rated hearing ability.
Uchida *et al*, 2008 Japan	2355 general population of whom 260 HI Age:40-84	HA possession influenced by age, BEHL, WEHL, education in men and by age, BEHL and HL pointed out by others in women. Possession decreased with age.
Helvik *et al*, 2008 Norway	173 audiology patients Age:30-94 (67.6)	Higher degree of activity limitation and participation restriction increased likelihood of accepting use of HA. Patients who felt they had fewer hearing difficulties rejected HAs more often.
Palmer *et al*, 2009 USA	840 HI adults Age:18-95	When asked to rate hearing on scale of 1(very poor) to 10 (very good): those rating 1 – 5 very likely to accept HA; 8-10 very unlikely; and 6 or 7 need more information. Thus perceived hearing ability strongly related to acquisition of HA.
Wong & McPherson, 2010, China (HK)	95 HI non-owners Age: ≥ 65	Main reasons for non-adoption of HA: perceived hearing impairment not severe enough and is normal aspect of ageing.
Solheim, 2011 Norway	174 HI waiting for HA Age: 65-93 (80)	Those with greater HL had higher expectations of HA than those with mild HI. Men reported fewer barriers to getting/using HA than women.
Fischer *et al*, 2011 USA	718 HI Age: (70.5)	HA acquisition was related to perceived hearing ability by self and friends/relatives, education level and measured HI. Reasons for non-acquisition: need, cost, inconvenience and poor experience of others.
Gopinath *et al*, 2011 Australia	2015 total Age: ≥ 65	Main reasons for not owning HA: too expensive; no need; experience of others
Laplante-Levesque *et al,* 2012a Australia, Denmark, UK, USA	34 HI with range of HA experience Age: > 18	Experiences similar across countries. Self-assessment central to experiences and expectations.
Laplante-Levesque *et al*, 2012b	95 HI, 1st time help seekers Age: ≥ 65	Self assessment of hearing ability is important predictor of uptake and success of intervention.
Abdellaoui & Huy, 2013 France	184 HI patients Age:55-92 (74)	3 main criteria in HA purchase: advice of HA fitting specialist; price; effectiveness when tried.
Ekberg *et al*, 2014 Australia	63 consultations with 26 audiologists	Audiologists often don't address psychological concerns of patients, which affects likelihood of acquiring and using HA.
Meyer *et al*, 2014a Australia	307 HI Age: ≥ 60	Similar, mainly non-audiological, factors affect decision to seek help and/or adopt hearing aids.
Bainbridge and Ramachandran, 2014 USA	601 HI Age: ≥ 70	Low income adults less likely to use HA.
Lee & Noh, 2015 Korea	119 with unilateral HL Age: (58)	Social and/or work activities predictor of HA uptake.
Fisher *et al*, 2015 Iceland	5172 Age: ≥ 67 (79.5)	Main factors affecting HA use were measured HI and self-perceived hearing ability. Age not a factor.
Rolfe & Gardner, 2016 UK	22 HA owners Age: 66-88 (74)	Stigma is a major barrier to help-seeking; knowledge of benefits is a factor in seeking support

hearing loss and to accept hearing aids once hearing loss begins to limit social, leisure and/or work activities. Stigma rarely featured in these studies as being a contributor to the lack of ownership of hearing aids, although it is still considered by some authors to be a factor influencing ownership and use of hearing aids, as discussed in section 11.6.2. Other relevant factors that have been considered in some studies are also discussed in more detail in section 11.6.

11.5 STUDIES OF FACTORS AFFECTING USE OF HEARING AIDS

Table 11.7 summarises studies published since 2006 which have examined factors affecting use of hearing aids among those who own them. The results are consistent with those of the reviews listed in Table 11.1. A common factor causing use of hearing aids to be discontinued is a problem of excessive noise. Another major factor cited in many of the studies is low perceived need for their use, which was also a major reason for people not seeking help or acquiring aids in the first instance. Those with more social and/or work activities (and hence greater perceived need), and with support from significant others, were found to be more successful users. Discomfort of aids is also a common problem, and difficulties in handling aids has been found to be a reason for low use in some studies, as discussed further in section 11.6.3. Results are inconsistent between studies regarding effects of gender and age.

Table 11.7. Studies of factors affecting use of hearing aids

Study/Country	Subjects	Results
Takahashi et al, 2007 USA	~200 fitted with HA 6 yrs previously Age:36-96 (73)	Non-users perceive less difficulty hearing than users. Difficulty hearing speech is most common reason for discontinued use of HA.
Bertoli *et al*, 2009 Switzerland	8707 HA users Age: > 18	Most common reasons for no/irregular use: cause noisy situations to be disturbing (52%); no need (24%); no/poor benefit (23%). Frequency of use depends on communication needs. Dissatisfaction with aid and difficulty in handling strongly associated with non-regular use. Subjects aged 65-74 and men at higher risk of non-regular use.
Bertoli *et al*, 2010 Switzerland	6027 HA users Age: > 18	Hours of use greater among those with more severe HL. Most common reason for non-use in both bilateral and unilateral HA users: disturbance in noisy situations.
Hartley *et al*, 2010 Australia	322 HA owners Age: 49-99 (67)	Increasing age, HL and handicap associated with HA use. Main reasons for non-use: does not help (30%), too noisy (28%), discomfort (28%).
Brannstrom & Wennerstrom, 2010 Sweden	224 new HA users Age: 27-94 (66.1)	HA use increases with increasing degree of HL
Solheim, 2011 Norway	174 HI waiting for HA Age: 65-93 (80)	Low expectations, problem-oriented preconceptions, low estimated need and modest plans for regular use in those with milder HL (≤ 40 dB) may contribute to non-use.
Solheim *et al*, 2012 Norway	90 HA owners Age: : ≥ 65 (81)	Acceptance of HL, subjective assessment of need and follow up support associated with use of HA.
Staehelin *et al*, 2011 Switzerland	8389 HA owners	Women used HA more frequently and for longer than men. Poor handling and low satisfaction were associated with non-regular use for both sexes.
Gopinath *et al*, 2011 Australia	2015 total Age: ≥ 65	Main reasons for not using HA: does not help; too uncomfortable; unable to fit.

Table 11.7 Studies of factors affecting use of hearing aids (continued)

Study/Country	Subjects	Results
Laplante-Levesque *et al*, 2012a Australia, Denmark, UK, USA	34 HI	HA use is not necessarily related to HA satisfaction.
Oberg *et al*, 2012 Sweden	346 (55% with HL) Age: 85	Greater proportion of non-users among 85 year olds than younger owners; hours of use decrease over time. Reasons for non-use: handling problems & disappointment with aid.
Kelly *et al*, 2013 UK	240 HI: long term and new users Age: ≥ 70	Information provision and attention to the psychosocial aspects of care are key to enabling older people to benefit from HA.
Saunders *et al,* 2013 USA	223 Hearing and HI Age: 22-90	Gender and age related to help-seeking. Regular users perceived HL to be more problematic, had fewer barriers, and greater self-efficacy than non-regular users.
Linssen *et al*, 2013 Netherlands	11 non-users Age: 50-80	Found negative emotional consequences of non-use.
Bainbridge & Ramachandran,2014 USA	601 HI Age: ≥ 70	Low-income adults and those who have not had recent hearing test are less likely to report hearing aid use.
Dawes *et al,* 2014 UK	16 fitted with HA in previous 2 years Age: 63-89	Getting used to HA is a challenging multi-factorial process with both psychosocial and practical difficulties, plus demands of adjusting to HA input.
Solheim *et al*, 2014 Norway	90 HA wearers Age: ≥ 65	HA use is associated with acceptance of HL; subjective assessment of need for aid; and follow up support. Use not related to degree of HI, gender or age.
Hickson *et al*, 2014 Australia	160 fitted with HA in previous 2 years: Age: ≥ 60	Those who perceive greater hearing handicap, who have more positive attitudes to hearing aids, greater confidence in their ability to use them, and support from significant others are more likely to be successful users.
Kelly-Campbell & Lessaway, 2015 New Zealand	123 HI: 73 HA users, 50 non-users	Perceived social consequences of HI distinguished users from non-users – users had poorer hearing and poorer quality of life (when not using aids) than non-users.
Lee & Noh, 2015 Korea	119 with unilateral HI, fitted with HA	Those with social and/or work activities are more likely to be successful users
Aazh *et al*, 2015 UK	1023 with HA Age: (75)	Most common reasons for non-regular use: noisy situations being disturbing (60%); no need (39%); negative side effects (27%); discomfort (23%)
Solheim *et al*, 2017 (online) Norway	181 HA users (new and experienced), 6 months after fitting Age: ≥ 60 (79)	Hours of use decreased with increase in number of reported issues; report of at least 1 issue resulted in 3.3 hr/day less use. Most common issues: handling, earmould and sound quality. Non-use most strongly associated with no perceived need.

11.6 INDIVIDUAL FACTORS AFFECTING OWNERSHIP AND USE OF HEARING AIDS

Some of the common factors that emerge from the studies summarised above are discussed in this section.

11.6.1 Delay in seeking help

There is disagreement in the literature over the typical length of time someone with a hearing problem waits before seeking help.

A commonly quoted figure is that of Davis *et al* (2007) who found that in the UK people typically wait for between eight and fifteen years between the onset of hearing difficulties and help seeking, with an average delay of ten years. The authors point out that this delay is likely to reduce the benefit derived from wearing a hearing aid as it means the average age for someone attending a hearing aid clinic for the first time is around 70 years, and older people find it more difficult to adapt to wearing hearing aids (Davis *et al*, 2007).

Other studies have found similar delay times which are consistent with the average figure of ten years found by Davis *et al* (2007). In a study of 173 patients referred for hearing aid fitting for the first time, Helvik *et al* (2008) found that the average duration of the hearing loss prior to the fitting was 11 years. In a qualitative interview study with 18 hearing impaired adults, Wanstrom *et al* (2014) examined the psychological process from avoidance to acceptance of hearing loss. Participants reported having waited between three and 44 years from first experiencing hearing difficulties and seeking professional help, with approximately half having waited for over 10 years. They described reaching awareness, and acceptance, of their hearing impairment as a slow and gradual process. Meyer *et al* (2014b) in a study involving over 300 hearing impaired subjects including hearing aid owners and non-owners, found that the average duration of hearing loss was ten years for owners and twelve years for non-owners.

However, shorter delay times have been found in other studies and surveys. For example, Meister *et al* (2008) found that, of 100 new hearing aid candidates, most had sought help within two to five years of recognising that they had a problem with their hearing. However, the span of delay times was very large, ranging from a few months to 57 years, which, according to the authors, gave a comparatively high mean value of 6.5 years, compared with a median value of three years.

The Eurotrak surveys also report shorter delay times on average. In most countries the average length of time between the onset of hearing problems and receiving an aid is two to three years, as shown in Table 11.8 (no data was available for Norway). The longer period of four to six years in Japan may reflect the fact that hearing loss is often not recognised as a problem in some far eastern countries, as discussed in Chapter 2. Despite the relatively short average times it can be seen that, in most countries, around one third of hearing aid owners waited for more than four years before receiving an aid.

In a recent study by Rolfe and Gardner (2016), which was a qualitative interview study involving 22 hearing aid wearers, all participants had waited for between one and five years from first noticing their hearing loss and acquiring aids. However, all the subjects in the study were volunteers who had been recruited via a hearing loss charity. They were therefore likely to be highly motivated to seek help and may not be representative of the general hearing impaired population.

Table 11.8. Number of years after awareness of hearing loss before getting aid (% of respondents) (data from Eurotrak surveys)

Country	Number of years before receiving hearing aid					
	1	2	3	4-6	>6	Average
Belgium****	24	21	28	15	12	3
Denmark***	26	24	18	17	15	3
France**	20	20	23	21	16	3
Germany**	26	28	23	16	7	2-3
Italy**	35	25	20	16	4	2-3
Netherlands***	23	31	20	13	13	2-3
Poland***	16	19	26	22	17	3
Switzerland**	24	29	17	17	13	2
UK**	18	25	26	14	18	3
Japan**	14	14	21	27	24	4-6

** 2015 ***2016 ****2017

Some authors have explored reasons why people wait before seeking help for their hearing loss. Interviews with 24 hearing aid users presented in a report by the RNID (Echalier, 2009) gave reasons reported by participants for delays in seeking help. They included having other priorities, a previous unsatisfactory attempt at wearing aids or consulting a hearing specialist, not perceiving a need, and denial of the ageing process. The report also points out that people living alone may become aware of their hearing problems later than other people, particularly if they are not working.

Clements (2015) carried out a review of reasons for delays in seeking help for hearing loss, and concluded that the time when a person seeks help is influenced by multiple factors including stigma, social, psychological and physiological factors, and the relationship between a patient and clinician.

11.6.2 Stigma

Although stigma does not seem to be such a major issue as in the past, as discussed in Chapter 8, it does still feature frequently as a reason for people not seeking help for hearing loss. Clements (2015) concluded that it continues to be a very prevalent problem with the fear of being regarded as old, stupid or unemployable still influencing the decision to seek help in many cases.

The issue of stigma related to hearing loss was explored in depth by Wallhagen (2010) through interviews with 91 couples where one had hearing loss, and had never worn, or was not currently wearing, a hearing aid. The study revealed that stigma affected many decisions concerning treatment for hearing loss: initial acceptance, whether to be tested, type of hearing aid selected, and when and where hearing aids were worn. Stigma was related to three areas – self-perception (and perception by the hearing partner), ageism and vanity. The author states that hearing aid advertisements contribute to the stigma by emphasising their small nature and minimal visibility, and also highlights the influence of the media in perpetuating the stigma of hearing loss and hearing aids.

McCormack and Fortnum (2013), in their review of papers on the non-use of hearing aids, found a very low incidence of stigma and appearance of aids being cited as reasons for non-use, which they considered noteworthy as stigma is often given as a major reason for people not wearing aids. However, they comment that appearance might be more of a barrier to initial acquisition of an aid. They consider that a possible reason for the stigma of hearing loss not being as great as previously could be the considerable changes in appearance of aids over the past 30 years so that they are now much more discrete and unnoticeable.

In focus group discussions involving 16 hearing aid users, aimed at eliciting views on getting used to hearing aids, some participants reported the need to manage the stigma attached to hearing loss and felt embarrassed at having to wear a hearing aid (Dawes *et al*, 2014). However, for other participants, the impact of hearing aids on self-image was positive and resulted in increased self-confidence.

The RNID (Echalier, 2009) also found, in interviews with hearing aid users, that some had delayed getting aids because they did not fit with their view of themselves, being seen as associated with age and/or disability.

The later Eurotrak surveys asked respondents whether they have ever been made fun of or rejected because of wearing a hearing aid (in the case of owners) or because of their hearing loss (in the case of non-owners). The distribution of responses is similar in all countries, as can be seen in Table C3 in Appendix C. The averages of the nine European countries for which data are available are shown in Table 11.9.

Table 11.9. Percentages of Eurotrak respondents reporting being made fun of as a result of wearing a hearing aid (HA) or hearing loss (NHA)

	Never		Rarely		Occasionally		Regularly	
	HA	NHA	HA	NHA	HA	NHA	HA	NHA
Average of 9 countries	70	31.8	14.8	35.6	11.1	29.5	4.0	2.8

It can be seen that most hearing aid wearers never or rarely experienced being rejected because of their hearing aids while over 30% of those not wearing hearing aids felt that they had been teased or rejected because of their hearing loss.

These figures are reasonably consistent with results of an American survey of hearing (Geraci, 2011) which found that around 70% of respondents (which included those with and without hearing difficulties) did not recognise any stigma attached to hearing loss. Nevertheless, Blazer *et al* (2016), in their report on hearing healthcare in the USA, although regarding recent findings on the reduced stigma of hearing loss to be encouraging, consider that it still a concern among some hearing impaired individuals, and hence needs to be addressed.

However, in the recent survey of hearing aid owners in Norway (Solheim *et al*, 2017) cosmetic concerns were barely mentioned, being an issue for only two out of the 181 participants, and were not found to be a reason for non-use of aids. The authors suggest that attitudes to HA have changed in recent years, in part as a result of improved technology.

11.6.3 Dexterity and handling of hearing aids

The issue of dexterity and the difficulties of handling increasingly small hearing aids as a factor affecting their use has been addressed by some authors. Table 11.7 shows that handling problems were cited as a main reason for not using aids in several of the studies (Bertoli *et al*, 2009; Staehlin *et al*, 2011; Oberg *et al*, 2012; Saunders *et al*, 2013; Hickson *et al*, 2014; Solheim *et al*, 2017).

From their review examining factors responsible for non-use of hearing aids McCormack and Fortnum (2013) concluded that manual dexterity, and its implications for the care and maintenance of the hearing aid, was an important issue, stating “If the hearing aid user cannot properly insert, remove, and manipulate their hearing aids, they are less likely to wear them”.

As Solheim *et al* (2017) point out, it is not surprising that handling can be problematic given the high prevalence of arthritis among elderly people, and the precision, dexterity and visual

acuity required to manipulate hearing aids. Meyer *et al* (2014b) found that poor vision was affected people's confidence in their ability to manage both basic and more advanced features of a hearing aid.

The area of self-efficacy in hearing aid use, that is self-confidence in the ability to handle, use and care for hearing aids, and the importance of its contribution to successful hearing aid use, has become of increasing interest in recent years. Studies by Hickson and Meyer and colleagues (Hickson et al, 2014; Meyer *et al*, 2014a; Meyer *et al*, 2014b) have found that it is related to all aspects of hearing aid use: initial help-seeking, adoption of hearing aids and their successful use.

A questionnaire was developed by West and Smith (2007) to assess hearing aid self-efficacy and a further test was developed to determine how well hearing aid users can manipulate their hearing aids (Desjardins and Doherty, 2009). Desjardins and Doherty found that participants who performed better in the test tended to use their hearing aids for more hours per day than those who performed poorly.

It is thus important that both hearing aid fitting and follow up appointments consider the wider aspects of users' health, and take account of problems such as visual difficulties and manual dexterity, to ensure optimal use of hearing aids (Meyer *et al*, 2014b; Solheim *et al*, 2017).

11.6.4 Provision of information and design of user guides

The importance of a holistic approach to adult aural rehabilitation was discussed by Boothroyd (2007). Use of technology alone to enhance auditory function is not sufficient; adults need to know and understand the nature of their hearing loss; potential benefits of hearing aids and other devices, and their limitations; and how to maintain and operate their devices effectively. Yet there is criticism by some authors of the amount and quality of information provided to hearing aid users. Atcherson *et al* (2013) found that there was relatively low understanding among audiologists and speech-language pathologists of the potential low levels of health literacy among patients, and that this could affect communication between professionals and patients.

Questionnaire surveys and interviews with long term, new and waiting hearing aid users were used to explore the experiences of older adults in the hearing aid fitting process (Kelly *et al,* 2013). Participants reported a general lack of information about wearing, maintaining and optimal use of their aids, as well as a need for more psychosocial support.

It is recognised in other medical fields that, in consultations, the use of patient centred communication techniques improves outcomes with patients more likely to follow the professional advice they are given (English and Archbold, 2014). The need for audiologists to address the psychosocial needs of patients in this way is increasingly being addressed through counselling workshops (English and Archbold, 2014).

Caposecco *et al* (2014) assessed 36 printed hearing aid user guides for their suitability for older (over 60 years of age) adults with hearing loss. The content, design and readability of each guide was analysed. They found that 69% of the guides were unsuitable, and 31% adequate, with none scoring highly in all aspects. The authors emphasise that these findings are of concern as it is known that poorly designed user guides may negatively affect successful use of hearing aids. In a subsequent paper Caposecco *et al* (2016) showed how the use of a modified guide designed to comply with the best practice principles of health literacy improved performance on a hearing aid management test.

Ferguson *et al* (2016) examined the use of interactive video tutorials among first time hearing aid users. Although there was no difference, post fitting, between the group who

used the video and the control group in overall hearing aid use, there was significantly greater use among those more reluctant to use them in the tutorial group than the control group. The tutorial group also had better practical hearing aids skills and understanding of practical and psychosocial issues than the control group, and were very positive about the benefits of the tutorials.

11.6.5 Adaptation to hearing loss and hearing aids

The various stages involved in decision making at all stages of acquiring hearing aids, from initial help seeking to using hearing aids, have been investigated by some authors (Laplante-Levesque *et al*, 2012; Benova *et al*, 2014) and the need for a client-centred approach emphasised (Laplante-Levesque *et al*, 2012). The need for more follow up care and support following hearing aid fitting has been highlighted by many participants in focus group studies (for example, Kelly *et al*, 2013).

Several authors highlight the length of time and effort required to adapt to wearing a hearing aid (Solheim *et al*, 2011). In reporting focus group studies with relatively new hearing aid users, Dawes *et al* (2014) demonstrate that getting used to hearing aids is a multi-factorial process which represents a significant challenge to new users, audiologists and manufacturers. They highlight the psychosocial and practical difficulties, including issues of handling as discussed in section 11.6.3, which might be encountered. The need for audiologists to address the psychosocial concerns of patients regarding the use of hearing aids are also emphasised by Handscomb (2009) and Ekberg *et al* (2014).

Some recent studies have applied health psychology models such as ‘health behaviour’, ‘health belief’ or ‘theory of planned behaviour’ models to investigate factors involved in help seeking and choice of intervention for hearing loss (Laplante-Levesque *et al*, 2013, 2015; Saunders *et al*, 2013; Meister *et al*, 2014, Meyer *et al*, 2014a). The results are generally consistent with the findings of other studies

11.7 SUMMARY

The most important points arising from the above review are as follows.

- There have been many studies investigating reasons for the low occurrence of hearing aid ownership and non-use of hearing aids.
- The most commonly found factor which encourages people to seek help for hearing problems and to acquire hearing aids is self-perceived hearing difficulties.
- Self-reported hearing loss is more strongly related than measured hearing impairment to hearing aid ownership.
- The main reasons reported in Eurotrak surveys for not owning hearing aids are lack of need; discomfort; hearing aids not restoring hearing to normal; and not working well in noisy situations.
- The main influences for acquiring hearing aids reported in Eurotrak surveys are worsening hearing loss; advice of professionals; and influence of spouses.
- The main reasons reported in Eurotrak surveys for not using hearing aids are that they do not work well in noisy situations; discomfort; they do not restore hearing to normal; and lack of need.
- Lack of need is also the main reason for not adopting hearing aids reported in the most recent MarkeTrak survey in the USA, together with financial constraints and hearing aids not working in noise.
- In repeated Marketrak surveys in the USA the most important reported influences for acquiring hearing aids have been worsening hearing loss and pressure from a family member.

- Individual research studies in many countries have found self perceived hearing loss to be the most common factor for motivation to acquire hearing aids.
- Individual studies have found self perceived hearing loss, problems of wearing hearing aids in noise and discomfort to be common factors for non-use of hearing aids.
- Many people delay for several years before seeking help for hearing loss. Reported delays range from a few months to over 50 years. The average reported time is around 10 years although several studies and surveys have reported that the majority of subjects have a shorter delay of two to three years.
- Although stigma is not as common a reason for non-ownership or non-use of hearing aids as it was in the past, it is still a problem in some cases and needs to be addressed.
- Confidence in the ability to manipulate and maintain hearing aids is an important factor which affects all aspects of hearing aid ownership and use.
- Visual problems and arthritis can reduce the dexterity required to manipulate hearing aids.
- Information provided to hearing aid users is in general inadequate.
- The use of interactive video tutorial on hearing aid use would be a valuable additional resource for new hearing aid users.
- The psychosocial needs of hearing aid users need to be addressed.
- More follow up support is needed for hearing aid users.

11.8 CONCLUSIONS

This chapter has shown that there are many factors which affect people's decisions to seek help for hearing loss, to accept and to use hearing aids. Many of these factors relate to technical aspects of hearing aids, such as causing problems of hearing in noise. The small size of hearing aids, apparently designed to reduce the stigma associated with hearing loss, leads to practical difficulties in handling and maintaining aids. The marketing of such aids, emphasising how their small size means they cannot be seen, is reinforcing the stigma associated with hearing loss. Information provided to hearing aid users, both in clinics and in user guides, appears to be inadequate leading to lack of confidence in practical aspects of hearing aid use. Other factors affecting hearing aid ownership and use are caused by psychosocial aspects of hearing loss which do not appear to be currently addressed by hearing professionals. There is a need for more follow up support for hearing aid users regarding psychosocial and practical aspects of hearing loss and hearing aid use, as well as the technical aspects of improving hearing.

An aspect of hearing aid use that does not appear to have been addressed in any of the studies is to further investigate a potential reason for apparently low usage: it is possible that owners may be quite happy with their aids but only use them when the need arises. For example, people living on their own might only want to wear their aids when they have visitors or wish to listen to the radio or television, or when they go out. Thus a low number of hours of use might not necessarily imply dissatisfaction with, or no benefit from, hearing aids.

CHAPTER 12 BENEFITS OF HEARING AIDS

12.1 INTRODUCTION

The 2006 Hear It report (Shield, 2006) found remarkable consistency between the reviewed studies examining the benefits of hearing aids. It was shown that the use of hearing aids significantly improved the overall quality of life of hearing impaired people, with particular benefits demonstrated in psychological well being, health, social, emotional and family life.

In the past ten years there have been many more surveys and studies published which have provided further evidence of the benefits to hearing impaired people of wearing aids. Surveys such as the Eurotrak and Marketrak surveys have asked hearing aid users to indicate the extent of benefits and advantages arising from the use of hearing aids. Research studies have examined the impact of hearing aid use on particular psychosocial conditions known to be affected by hearing loss, such as cognition and depression, as discussed in Chapter 5. This chapter summarises the results of the benefit data provided by Eurotrak and Marketrak surveys, and reviews research studies into the impact of hearing aids which have been published in the past 12 years. Psychosocial areas covered include cognition, depression, loneliness, family life and physical health. The chapter concludes by presenting evidence concerning the impact of hearing aids on employment and earnings. Discussion of audiological consequences of hearing aid use is beyond the scope of this report.

12.2 EUROTRAK SURVEYS OF BENEFITS OF HEARING AIDS

The Eurotrak surveys asked respondents about various aspects of their lives and compared the responses of those who wore hearing aids (HA) with those who did not have hearing aids (NHA). For the non-hearing aid owners only those in the upper 50% of hearing impairment were considered, in order to compare groups (HA and NHA) with similar degrees of hearing loss. Hearing aid owners only (between 400 and 700 in each country, total 6652) were asked about certain areas in order to investigate perceived changes in those areas as a result of wearing aids.

The areas investigated by the surveys included physical and mental health, performance in various listening scenarios, work, general health, and general quality of life. The impact of hearing aids on the hearing impaired person's work and personal relationships were also explored.

In the following sections, which present results for different categories of effect, in addition to data for individual countries, average figures across all countries are given. It should be noted that these averages are simply the arithmetic averages of the percentages of all countries, and are not the actual percentages of responses of all the subjects from all countries, which would be derived by weighting the individual country results by the total numbers of respondents in each country.

12.2.1 Impact of hearing aids upon stigma

Section 11.6.2 showed how the stigma of hearing loss continues to be a reason for people how seeking help for hearing loss. However there is evidence that use of hearing aids reduces stigma. The percentages of hearing aid owners and non-owners reporting being made fun off or rejected because of hearing aids or hearing loss never, rarely, occasionally or regularly in ten countries, are shown in Table C3 in Appendix C.

Table 12.1 shows the percentages of those with (HA) and without (NHA) hearing aids who are made fun of occasionally or regularly because of their hearing aids or hearing loss. (Note that no data is available for Norway.)

Table 12.1. Percentages made fun of occasionally or regularly because of hearing loss or hearing aids

Made fun of	Belg ****	Den ***	Fra **	Ger **	It **	Neth ***	Pol ***	Switz **	UK **	Average Europe	Jap **
HA	10	10	12	21	29	10	18	5	21	**15.1**	9
NHA	20	18	36	44	46	23	39	21	44	**32.3**	9

** 2015 ***2016 ****2017

It can be seen that approximately half as many of those who wear hearing aids as of those who do not wear them are stigmatised. In some countries, notably France and Switzerland, the ratio is even lower. In Japan fewer hearing impaired people experience stigma than in the European countries, and the percentage is the same whether or not hearing aids are worn.

12.2.2 Impact of hearing aids upon quality of life

Table 12.2 shows the percentages of those with hearing aids who reported that aids improved their quality of life occasionally or regularly. (Note that no data is available for Norway.)

Table 12.2. Percentages of hearing aid wearers reporting improvements in their quality of life occasionally or regularly

Improved QoL	Belg ****	Den ***	Fra **	Ger **	It **	Neth ***	Pol ***	Switz **	UK **	Av Europe	Jap **
Occasional	27	36	36	39	33	34	36	35	38	**34.9**	34
Regular	59	39	50	43	51	41	48	58	41	**47.8**	50
Total	86	75	86	82	84	75	84	93	79	**82.7**	84

** 2015 ***2016 ****2017

In most countries between 75% and 86% of hearing aid wearers observe improvements in their quality of life due to the use of hearing aids, the figure rising to 93% in Switzerland. Overall, around 83% of hearing aid wearers in Europe reported that the use of hearing aids improved their quality of life.

12.2.3 Impact of hearing aids upon others in household

Table 12.3 shows the percentages of other people in the household, or relatives of a hearing aid user, who reported that certain aspects of their interaction with the hearing impaired person were better or a lot better since the latter started wearing hearing aids. (Note that no data is available for Japan.)

Table 12.3. Percentages reporting improvements ('better' or 'a lot better') in certain activities since a hearing impaired person started wearing hearing aids

Activity	Belg ****	Den ***	Fra **	Ger **	It **	Neth ***	Nor *	Pol ***	Switz **	UK **	Av Europe
Communication	59	53	52	52	66	46	42	59	60	48	**53.7**
Social activities	39	36	44	35	59	27	26	38	42	35	**38.1**
Personal relationships	30	23	40	29	54	22	21	39	23	27	**30.8**
Quarrels/ disputes	21	20	28	27	53	20	17	33	20	24	**26.3**

* 2012 ** 2015 ***2016 ****2017

There is some variation between countries in responses to this aspect of the impact of hearing aids, with Norway, Switzerland and the Netherlands reporting relatively little improvement in family relationships due to hearing aid use, while respondents in Italy report high levels of improvement in all aspects. Overall the only area where over 50% of respondents report improvements is communication, as would be expected.

12.2.4 Impact of hearing aids upon general health

The Eurotrak surveys included various items related to general health, for example quality of sleep, physical and mental exhaustion, symptoms of depression and forgetfulness.

Tables 12.4 and 12.5 show the percentages of respondents with (HA) and without (NHA) hearing aids agreeing or strongly agreeing with the statements 'In the evenings I often feel physically exhausted' (Table 12.4) and 'In the evenings I often feel mentally exhausted' (Table 12.5).

Table 3.4. Percentages with (HA) and without (NHA) hearing aids agreeing or strongly agreeing that they often feel physically exhausted in the evenings

	Belg ****	**Den *** **	**Fra ** **	**Ger ** **	**It ** **	**Neth *** **	**Nor * **	**Pol *** **	**Switz ** **	**UK ** **	**Av Europe**	**Jap ** **
HA	27	31	35	44	37	28	33	50	44	46	**37.5**	41
NHA	46	48	43	55	54	51	47	66	50	54	**51.4**	52

* 2012 ** 2015 ***2016 ****2017

Table 12.5. Percentages with (HA) and without (NHA) hearing aids agreeing or strongly agreeing that they are feel mentally exhausted in the evenings

	Belg ****	**Den *** **	**Fra ** **	**Ger ** **	**It ** **	**Neth *** **	**Nor * **	**Pol *** **	**Switz ** **	**UK ** **	**Av Europe**	**Jap ** **
HA	18	24	27	35	48	21	23	37	29	33	**29.5**	36
NHA	35	39	37	47	58	38	42	52	46	47	**44.1**	44

* 2012 ** 2015 ***2016 ****2017

Tables 12.4 and 12.5 show that in all countries hearing impaired people without hearing aids feel more physically and mentally exhausted in the evenings than those using hearing aids.

Respondents were also asked about the quality of their sleep. Table 12.6 shows the percentages of respondents with and without hearing aids who report that they are generally satisfied with the quality of their sleep. (Note that no data is available for Norway.)

Table 12.6. Percentages of respondents with (HA) and without (NHA) hearing aids who are generally satisfied with their sleep

	Belg ****	**Den *** **	**Fra ** **	**Ger ** **	**It ** **	**Neth *** **	**Pol *** **	**Switz ** **	**UK ** **	**Av Europe**	**Jap ** **
HA	78	68	60	52	50	71	55	85	59	**64.2**	70
NHA	61	39	53	47	40	55	46	69	34	**49.3**	56

** 2015 ***2016 ****2017

In all countries, a higher percentage of respondents with hearing aids were satisfied with their sleep than of those without hearing aids.

The Eurotrak surveys also compared responses of hearing aid users and non-owners regarding symptoms of depression, and forgetfulness. Based on their responses, Table 12.7 shows the percentages of those with no or very low probability of depression among hearing aid owners and non-owners, and Table 12.8 compares the percentages who reported that they had been more forgetful in the previous year. (Note that no data is available for Italy.)

Table 12.7. Percentages of respondents with (HA) and without (NHA) hearing aids with no or very low probability of depression

	Belg ****	**Den *** **	**Fra ** **	**Ger ** **	**Neth *** **	**Nor * **	**Pol *** **	**Switz ** **	**UK ** **	**Av Europe**	**Jap ** **
HA	54	49	39	32	46	91	22	59	49	**49.0**	85
NHA	39	35	36	23	29	79	19	39	33	**36.9**	81

* 2012 ** 2015 ***2016 ****2017

Table 12.8. Percentages of respondents with (HA) and without (NHA) hearing aids who reported being more forgetful in the previous year

	Belg ****	**Den *** **	**Fra ** **	**Ger ** **	**Neth *** **	**Nor * **	**Pol *** **	**Switz ** **	**UK ** **	**Av Europe**	**Jap ** **
HA	53	48	53	66	55	45	63	56	50	**54.3**	56
NHA	57	59	65	65	65	58	67	58	75	**63.2**	65

* 2012 ** 2015 ***2016 ****2017

Table 12.7 shows that in all countries there is a higher percentage of hearing impaired people with hearing aids with zero likelihood of depression, than of non-hearing aid owners. Furthermore, Table 12.8 shows that fewer hearing aid owners than non-owners report being more forgetful in the past year (although the differences are small in some countries), possibly indicating a beneficial effect of hearing aids in reducing the rate of cognitive decline.

12.2.5 Impact of hearing aids on psychosocial factors

Hearing aid users were asked to indicate, for 12 areas, changes that they had experienced which they believed were due to wearing hearing aids. There were five categories of response: ‘a lot worse’, ‘worse’, ‘the same’, ‘better’, ‘a lot better’.

Table 12.9 shows the percentages responding ‘better’ or ‘a lot better’ in each country, plus the average percentage of all 11 countries, in all 12 categories. The categories in the table are arranged in decreasing average order of improvement.

In all countries respondents rated the greatest improvement due to hearing aids to be in the ability to communicate effectively, with 65% of hearing aid owners on average reporting this activity to be better or a lot better with hearing aids. The second most improved area is participation in group activities. It can be seen that although rankings and ratings across countries are relatively consistent, there are some noticeable differences. For example, Poland scores more highly than other countries in almost all areas, while the UK and Japan generally have the lowest improvement scores.

12.2.6 Summary of Eurotrak data

The Eurotrak surveys have shown that hearing aid owners in all countries surveyed recognise significant perceived benefits due to their use. Over 80% of owners report improvements in overall quality of life, and in various areas related to health such as sleep, tiredness, depression and forgetfulness. Improvements are also noted in family relationships, in reduction of stigma, and in many other psychosocial areas. The results of Eurotrak surveys are compared with data from the most recent Marketrak survey in the following section.

Table 12.9. Percentages of hearing aid owners reporting changes for the 'better' or 'a lot better' in different situations, due to hearing aids

	Belg ****	**Den *** **	**Fra ** **	**Ger ** **	**It ** **	**Neth *** **	**Nor***	**Pol *** **	**Switz ** **	**UK ** **	**Av Europe**	**Jap ** **
Ability to communic-ate more effectively	75	59	65	67	74	66	69	82	74	54	**68.5**	40
Ability to participate in group activities	60	52	56	62	67	57	59	71	68	45	**59.7**	27
Sense of safety	48	44	45	64	67	47	54	70	61	37	**53.7**	41
Social life	63	50	57	52	68	53	61	64	55	39	**56.2**	26
Relation-ships:home	50	48	52	44	71	51	54	71	52	37	**53.0**	26
Sense of indepen[ce]	48	35	50	54	66	50	48	67	50	37	**50.5**	24
Confidence in yourself	48	39	45	54	62	45	50	69	45	39	**49.6**	29
Feelings about self	48	39	38	47	64	45	50	76	44	35	**48.6**	38
Mental/emot-ional health	37	42	38	44	67	37	51	68	46	28	**45.8**	31
Relation-ships:work	42	42	44	36	64	43	52	57	50	29	**45.9**	25
Mental ability	32	33	35	39	57	36	38	56	36	25	**38.7**	27
Physical health	28	43	31	32	58	33	32	46	31	22	**35.6**	21

* 2012 ** 2015 ***2016 ****2017

12.3 MARKETRAK SURVEYS OF BENEFITS OF HEARING AIDS

Some results from the most recent Marketrak survey, Marketrak IX, in the USA were presented by Ruf *et al* (2016).

The results are largely consistent with those of the Eurotrak surveys although they are not directly comparable as the results published by Ruf *et al* (2016) refer only to owners who acquired hearing aids in the past five years.

12.3.1 Impact of hearing aids on quality of life

Regarding overall quality of life 88% of hearing aid users said that their quality of life had improved since acquiring hearing aids (48% regularly and 40% occasionally). This figure is slightly higher than those reported in most of the countries in the most recent Eurotrak survey (see Table 12.2) which showed that on average 83% of hearing aid users reported an increase in quality of life. However, this discrepancy may be due to the inclusion of only more recent hearing aid owners in the Marketrak survey.

12.3.2 Impact of hearing aids on memory, depression and stigma

Table 12.10 shows the percentages of hearing aid owners and non-owners responding to some of the same areas as examined in the Eurotrak survey. Where possible the (European) average Eurotrak percentages from section 12.2 are included for comparison.

Table 12.10. Percentages of hearing aid owners and non-owners in Marketrak (MT) and Eurotrak (ET) surveys responding to questions relating to memory, depression, and stigma

	More forgetful in past year		No depressive symptoms in past 2 weeks		Made fun of/rejected regularly or occasionally		Feel embarrassed	
	MT	ET	MT	ET	MT	ET	MT	ET
HA	55	54	65	49	14	15	14	-
NHA	62	63	48	37	25	32	49	-

The results of the Marketrak survey show the same trends as those of the Eurotrak survey.

The Marketrak survey also reported change, following the wearing of hearing aids, in various areas, similar to those in the Eurotrak surveys which are listed in Table 12.9. Table 12.11 shows the percentages of respondents in the Marketrak survey replying 'better or 'a lot better' in the various categories. Where there is a comparable category in the Eurotrak survey the average figure taken from Table 12.9 is also shown in Table 12.11 for comparison.

Table 12.11. Percentages of hearing aid owners in Marketrak (MT) and Eurotrak (ET) surveys reporting changes for the 'better' or 'a lot better' in different situations, due to hearing aids

Situation	MT	ET
Ability to communicate effectively	61	69
Work performance	59	
Relationships at work	55	46
Ability to participate in group activities	54	60
Overall quality of life	52	
Confidence in yourself	44	50
Relationships at home	44	53
Social life	43	56
Sense of safety	41	54
Feelings about yourself	41	49
Sense of independence	39	51
Emotional health	34	46
Sense of humour	32	
Physical health	28	36
Mental ability/memory	26	39

It can be seen that the Marketrak scores are lower than the average Eurotrak scores in all areas. This is surprising given that the Marketrak survey concerns more recently acquired hearing aids, and is inconsistent with the higher percentage of Marketrak respondents reporting improved overall quality of life. However, it can be seen that the percentage reporting improvement in quality of life in Table 12.11 (52%) is very much less than the 88% reporting regular or occasional quality of life improvements. It is possible that these inconsistencies are due to different wording and/or response scales between questions.

12.4 RESEARCH STUDIES

Research studies published in the past 12 years which have examined the effects of hearing aids on psychosocial impacts of hearing loss are summarised in Table 12.1. It can be seen that nine of these studies have considered the effect of hearing aids on cognition, memory or dementia; eight have investigated depression or mental health; eight health related quality of

life; and four loneliness or social isolation. These aspects are considered in the sections below.

Many studies are longitudinal studies in which groups are assessed before and after hearing aid fitting. The majority of these have a relatively short follow up period of a few months. However, several studies have examined the impact of hearing aids over a much longer follow up period, of up to 25 years.

Other authors have reported cross sectional studies in which groups of hearing aid users are compared with non-users, and in some cases also with normal hearing control groups. The data for these studies are usually taken from larger health surveys.

The following sections discuss the findings of the research studies in various areas and, where appropriate, also consider the results of the most recent Marketrak and Eurotrak surveys in relation to these findings.

12.4.1 Impact of hearing aids on cognition

A review of papers published between 1990 and 2011 on the impact of hearing aids on cognition was published in 2012 (Kalluri and Humes, 2012). The review concluded that there was an increasing body of evidence concerning an interaction between immediate or short term hearing aid use and cognition, but less evidence on long term effects. However, the association found does not necessarily mean that hearing aids themselves improve cognition. The review authors explain that there are two ways in which cognition may be a factor in the outcomes of hearing aid fitting: better cognitive skills may lead to greater success in wearing hearing aids; alternatively, the use of hearing aids may lead to improved cognitive function.

It can be seen from Table 12.1 that the majority of studies reviewed here have also found an association between hearing aids and cognition, the use of hearing aids being related to better cognitive skills. Long term (over 20 years or more) longitudinal studies by Amieva *et al* (2015; 2018) and Deal *et al* (2015) have shown that aids reduce the rate of cognitive decline associated with hearing loss. Studies carried out over a few months (Acar *et al*, 2011; Choi *et al*, 2011) have shown an increase in cognitive function associated with use of hearing aids. However, another longitudinal study (Dawes *et al*, 2015a) found no difference between hearing aid users and non-users in the occurrence of cognitive impairment and performance over an 11 year period. Cross sectional studies using data from the UK Biobank survey (Ronnberg *et al*, 2014; Dawes *et al*, 2015b) and from the NHANES in the USA (Lin, 2011) also found that hearing aid use was associated with higher levels of cognition and some improvements in memory, although there was no evidence in another US survey that it reduced the risk of dementia (Lin *et al*, 2011b).

Several authors of cross sectional studies emphasise that, where they have found an association between hearing aid use and improved cognitive performance, this could be due to improved audibility or increased self-efficacy, or it may be, as suggested by Kalluri and Humes (2012), that more cognitively able people seek and use hearing aids (Lin, 2011; Dawes *et al*, 2015b). However, the finding by Amieva *et al* (2015; 2018) and Deal *et al* (2015) which show that hearing aid use reduces the rate of decline in cognitive ability over a long time period suggest that hearing aids do help to maintain cognitive function. The results of the Marketrak and Eurotrak surveys comparing forgetfulness among hearing aid users and non-users are consistent with the conclusions of Amieva *et al* (2015; 2018) and Deal *et al* (2015).

12.4.2 Impact of hearing aids on depression

Table 12.1 shows that results concerning the impact of hearing aids on depression are contradictory. In cross sectional studies using data from the Blue Mountains study (Gopinath

et al, 2009) and the NHANES (Mener *et al*, 2013) it was found that the use of hearing aids was associated with lower prevalence of depressive symptoms. However, using more recent data from the UK Biobank resource, two further cross sectional studies (Dawes *et al*, 2015b; Keidser *et al*, 2015) found no association between hearing aid use and depression. Similarly, Nachtegaal *et al* (2009a) in a national internet survey of hearing in the Netherlands found use of hearing aids did not affect psychosocial health. Longitudinal studies have also produced conflicting results: two studies with short follow up period of 6 months or less (Acar *et al*, 2011; Boi *et al*, 2012) found that use of hearing aids decreased depressive symptoms and improved mental health, whereas a study with a follow up period of one year (Metselaar *et al*, 2009) found no effect of hearing aids on depression, although in a smaller group of older hearing aid users Lee *et al* (2010) found a slight trend towards fewer depressive symptoms after one year of hearing aid use. However, Amieva *et al* (2018), in a 25 year longitudinal study, found that use of hearing aids reduced the risk of developing depression which was found only in male subjects with impaired hearing.

A possible reason for the lack of consistency in results may be the age ranges of the subjects in the different studies. Keidser *et al* (2015) suggest that a reason for the lack of association between hearing aid use and depression in their study could be because the UK Biobank subjects are younger than the subjects in many of the other studies, and that in this age group the negative effects of wearing hearing aids may balance out positive effects. Other studies which found no effect (Metselaar *et al*, 2009; Nachtegaal *et al*, 2009a; Dawes *et al*, 2015b) also involved younger subjects. Keidser *et al* (2015) further point out that older subjects who have chosen to wear hearing aids will be more accepting of their hearing loss, which itself reduces symptoms of depression, while Mener *et al* (2013) suggest that individuals who are more health conscious and/or without depression may be more likely to obtain hearing aids. In the study by Vuorialho *et al* (2006c) it was found that the emotional status of hearing impaired people improved after hearing aid fitting, even when they chose not to accept or use their aids, implying that merely having their problems addressed helped hearing impaired people to cope with them.

Nachtegaal *et al* (2009a) also emphasise that lack of an association does not necessarily mean that hearing aids are ineffective; without hearing aid use the psychosocial status of subjects might be much worse than it is.

The results of the Eurotrak and Marketrak surveys, which involved subjects of all ages, suggest that the likelihood of suffering from depression may be lower among hearing aid users than non-users. Thus, overall, the results of research and surveys concerning the impact of hearing aids on depression are contradictory and inconclusive, although the overall trend in results suggests that the use of aids may be associated with reduced depressive symptoms.

12.4.3 Impact of hearing aids on quality of life

A review of previous studies into the impact of hearing aids on health-related quality of life was published in 2007 (Chisolm *et al*, 2007). The authors reviewed 16 papers published between 1988 and 2004 and concluded that hearing aids improve adults' health-related quality of life by reducing the psychological, social, and emotional effects of hearing loss.

The studies shown in Table 12.1 are, in general, consistent with the conclusions of Chisolm *et al* (2007). They demonstrate that hearing aids mitigate the reduction in quality of life which is associated with hearing loss. In some cases the change was marginal and/or only applied when hearing aids were worn regularly, but only one study (Metselaar *et al*, 2009) found that hearing aids had no effect on quality of life. The study by Davis *et al* (2007) also found small positive changes in several quality of life measures, in particular in the social life component of the Health Utility Index. The average HUI3 increased by 0.075 overall following hearing aid fitting, the increase being higher among those with a hearing loss of 35

dB and above than for those with less severe hearing loss. Similar results were reported by Swan *et al* (2012) who found that the HUI3 increased by 0.084 post fitting with hearing aids.

Niemensivu *et al* (2015) found that self-reported hearing ability was a better predictor than audiometric data of the change in quality of life due to hearing aid use.

A recent systematic review of evidence on the effects of hearing aids also concluded that they improve both hearing specific and general health related quality of life (Ferguson *et al*, 2017)

Surveys have also found that hearing aid users report improvements in their overall quality of life since wearing aids. As seen in the previous sections 88% of hearing aid users in the Marketrak survey and 83% in the Eurotrak surveys perceive improvements. In another survey of over 400 hearing aid owners in the USA carried out in 2011 by the American Association of Retired Persons (AARP) and American Speech-Language-Hearing Association (ASHA) (Geraci, 2011) 73% of respondents reported that their quality of life was much or somewhat better since they had been wearing hearing aids.

Thus the evidence from both research studies and consumer surveys suggest that the use of hearing aids improves quality of life, by reducing the detrimental impact of hearing loss.

12.4.4 Impact of hearing aids on loneliness and social isolation

Only four of the reviewed studies have specifically investigated the effects of hearing aids on the loneliness and social isolation that may result from hearing impairment, and the results of these studies are inconsistent. In a short time after fitting Weinstein (2016) found that hearing aid use led to reduced perceptions of loneliness. There was disagreement between the conclusions of the two longitudinal studies which used longer follow up periods: Pronk *et al* (2013) found that worse hearing loss was associated with greater loneliness in non-hearing aid users, suggesting that hearing aids reduce the impact of hearing loss on loneliness. However, Dawes *et al* (2015a) found that, 11 years after fitting, there was no difference between hearing aid users and non-users in social engagement, after adjusting for age, gender and hearing loss. An interesting result was also observed by Dawes *et al* (2015b), in examining data from the UK Biobank: they found that hearing aid use was associated with increased social isolation. The authors suggest this may be because hearing aids discourage participation in social events by amplifying unwanted background noise. A further explanation may be the lack of sensitivity in the measure of social isolation which consisted of a single Yes/No question. This result may be peculiar to the UK as it can be seen that the UK had the lowest score (apart from Japan) for improvement in social life (39%). In contrast, Davis *et al* (2007) in their UK survey found that the most noticeable factor affecting improvements in quality of life measures was the element relating to social life; however, the follow up time in this study was short, 3 months. In the majority of countries involved in the most recent Eurotrak surveys over 50% of hearing aid owners report positive changes in their social life (see Table 12.9).

12.4.5 Impact of hearing aids on family life and relationships

Boi *et al* (2012) found that, as well as having a positive impact on the quality of life of hearing impaired individuals, hearing aids also reduced stress amongst their families and caregivers. This is consistent with the positive effects of hearing aids on the household reported in the Eurotrak and Marketrak surveys. Davies *et al* (2007) also found a small increase in a Quality of Family Life (QoFL) measure following fitting of hearing aids.

12.4.6 Impact of hearing aids on physical health

Two studies have noted that use of hearing aids was associated with better physical health (Chia *et al*, 2007; Dawes *et al*, 2015a). However, the cause of the association is not understood. According to Chia *et al* (2007) it may be a reflection of the dexterity and better

physical functioning required to use hearing aids, or it may be that people who are more physically active are more in need of aids to help them in their activities. Alternatively, hearing aids, by reducing hearing handicap, may promote a more active, engaged lifestyle (Dawes *et al*, 2015a). Amieva *et al* (2018) in their 25 year study found that using hearing aids reduced the risk of developing disability, as assessed by ADL and IADL scales.

12.4.7 Discussion

The reviewed studies have shown that, overall, the use of hearing aids helps to mitigate some of the negative psychosocial impacts of hearing loss. The most conclusive studies are those longitudinal studies carried out over a period of years which can observe differences in the rate of change of conditions between hearing impaired people using hearing aids and those not using them. Dawes *et al* (2015a) have pointed out that the impact of hearing aid use may only be observable after a period of several years.

There is also some evidence that individuals' opinions of benefits may vary with time. Vestergaard (2006) investigated responses to five different benefit and satisfaction scales after one, four and 13 weeks and found that hearing aid users assessments changed over time. This means that, for some outcomes, early self-report assessment may be misleading further highlighting the importance of longer term assessments to fully understand the true impact of hearing aid use.

The positive effects of hearing aids in the studies reviewed above are, in general, consistent with the findings of large scale consumer surveys of hearing aid users such as the Eurotrak and Marketrak surveys.

12.5 IMPACT OF HEARING AIDS ON EMPLOYMENT AND EARNINGS

The information in this section comes from the Eurotrak and Marketrak consumer surveys.

12.5.1 Usefulness of hearing aids at work

The Eurotrak surveys asked respondents with and without hearing aids how useful their aids were in their job. Table 12.12 shows the percentages of respondents in the most recent surveys stating that they were of no, some and significant use.

Table 12.12. Percentages of respondents reporting hearing aids to be of no, some or significant use at work

Country	No use	Some use	Significant use	Some or significant use
Belgium****	16	24	60	84
Denmark***	10	31	60	91
France**	9	20	70	90
Germany**	5	39	56	95
Italy**	4	37	59	96
Netherlands***	10	35	55	90
Norway*	14	27	59	86
Poland***	8	35	57	92
Switzerland**	5	34	61	95
UK**	19	33	48	81
Average Europe	**10**	**31.5**	**58.5**	**90**
Japan**	10	57	33	90

* 2012 ** 2015 ***2016 ****2017

It can be seen that a high percentage of hearing aid users find them useful at work.

Respondents were also asked for their perceptions of opportunities in work. Table 12.12 shows the percentages of hearing aid owners and non-owners who 'rather' or 'strongly' agreed that people with an untreated hearing loss tend to be less promoted in their job, to not get the job that they deserve and to receive a lower salary.

Table 12.12. Percentages of hearing aid owners and non-owners agreeing with statements about work and salaries

Country	People with untreated hearing loss tend to be:					
	less promoted		not in the job they deserve		under salaried	
	HA	NHA	HA	NHA	HA	NHA
Belgium****	40	12	41	11	21	6
Denmark***	24	11	29	8	19	5
France**	40	25	42	26	25	18
Germany**	47	23	48	26	36	19
Italy**	53	29	54	31	51	24
Netherlands***	28	16	36	16	21	12
Norway*	35	20	42	19	23	10
Poland***	44	23	46	26	42	22
Switzerland**	41	19	45	20	32	12
UK**	34	21	34	21	30	17
Average Europe	**38.6**	**19.9**	**41.7**	**20.4**	**30**	**14.5**
Japan**	39	17	36	16	22	13

* 2012 ** 2015 ***2016 ****2017

Thus more people with hearing aids than without believe that hearing aids increase the probability of hearing impaired people to get promoted, to get an appropriate job and to earn more.

12.5.2 Impact of hearing aids on earnings and income

It was shown in Chapter 8 that previous Marketrak surveys, analysed by Kochkin (2007a, 2010a), indicate that people with the most severe hearing loss earn approximately 77% of those with the mildest hearing loss. (These figures are for all hearing impaired individuals, including those with hearing aids.)

In analysing the results of the 2004 Marketrak survey Kochkin (2007a) found that, although hearing loss was shown to reduce household income by up to $12,000 per year on average, depending on the degree of hearing loss, the use of hearing aids mitigated the effects of hearing loss by 50%.

Figure 12.1 (figure 2 from Kochkin, 2007a) shows the decline in household income for hearing aid users and non-users, across 10 deciles of hearing loss. A similar pattern was shown in the 2008 Marketrak V!!! survey (Kochkin, 2010a).

It can be seen that the decline in income per hearing loss decile is greater for those without hearing aids than for hearing aid users. The unaided decline in income is $2.25 per decile, while for aided households it is $1.13, leading to a difference between decile 1 (mild hearing loss) and decile 10 (profound hearing loss) of $20,300 for unaided subjects, and $10,200 for subjects using hearing aids.

In further analysis of the Marketrak VIII survey Kochkin (2010a) showed a greater differential in income between hearing aid users and non-users. Figure 12.2 shows the loss of income

for hearing aid users and non-users across the 10 deciles of hearing loss from 1 (mild) to 10 (profound), compared with households with no hearing loss.

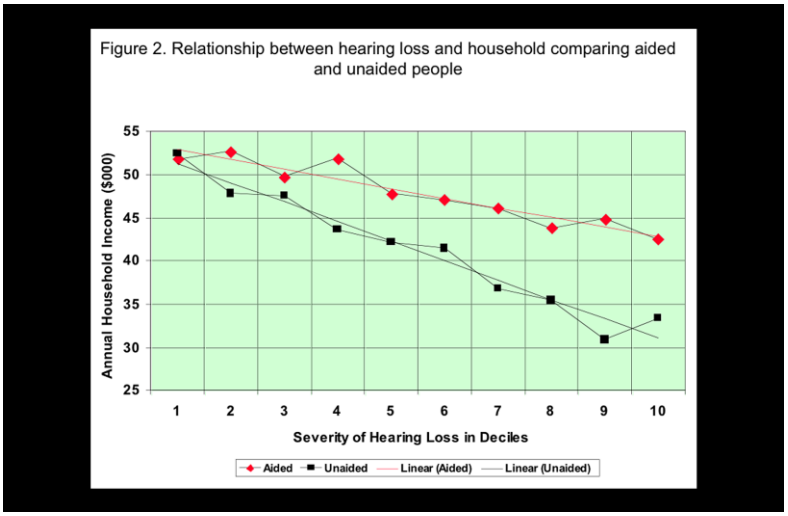

Figure 12.1. Relationship between household income and severity of hearing loss for hearing aid users and non-users (Kochkin, 2007a).

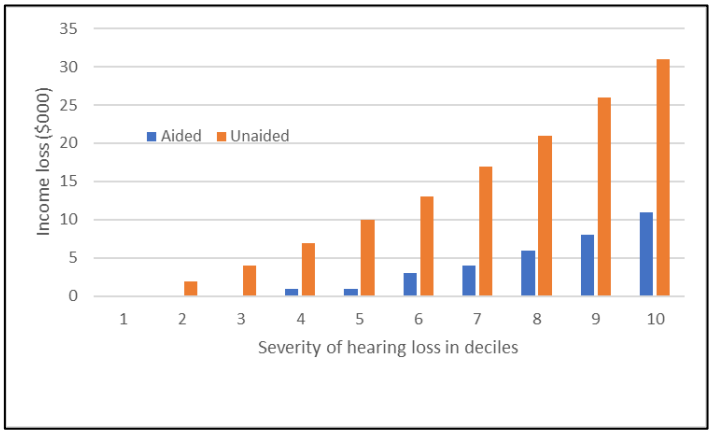

Figure 12.2. Comparison of loss of income of households with hearing aid users and non-users, compared with normal hearing households (adapted from Figure 3 in Kochkin, 2010a)

It can be seen that for hearing aid users there is no loss of income compared with the normal hearing population in the lower 30% of hearing loss, after which there is a reduction of up to $11,000 in decile 10. However, for non hearing aid users there is a steady increase in loss of income compare with normal hearing households, from $2000 per year in decile 2 to £31,000 per year in decile 10. Thus the use of hearing aids can mitigate the amount of income loss by up to $20,000, depending on the degree of hearing loss.

In the most recent Marketrak survey, Marketrak IX, Abrams and Kihm report that hearing aid owners had higher median incomes ($66,000) than non-owners ($54,000), even though more of the owners were retired.

It is not possible to directly compare the results of Eurotrak surveys with Marketrak surveys in relation to income. However, in pooling data for the 2009, 2012 and 2015 surveys for Germany, France and the UK, Ruf *et al* (2016) show that 30% of employed (full or part time) hearing aid users earn over 40,000€ compared with 21% of non-users. Furthermore, 37% of

non-users believe that they earn less than their peers, compared with 23% of hearing aid users.

12.5.3 Impact of hearing aids on unemployment

Chapter 8 presented evidence from several countries that the percentage of hearing impaired people who are unemployed is higher than that of the general population. However, there is little data on the impact of hearing aids on employment status, apart from that of Kochkin (2010a) shown in Chapter 8 and repeated here. Table 12.14 presents Kochkin's analysis of data from the MarkeTrak VIII survey.

Table 12.14. Unemployment rates in the USA for aided and unaided subjects with hearing loss, according to quintile of severity of hearing loss (data from Kochkin, 2010a)

Quintile of hearing loss	Percent unemployed	
	Aided	Unaided
1 (least severe)	0	4.9
2nd	0	6.1
3rd	5.4	10.7
4th	1.8	11.8
5 (most severe)	8.3	15.6

For those with hearing aids, there was no significant relationship between unemployment rates and severity of hearing loss, while, for those with unaided hearing, the unemployment rate increased with hearing loss. The rate for those with the most severe hearing loss is three times that of those with the mildest hearing loss. For all grades of hearing loss, the unemployment rate of those with hearing aids is very much lower than that of those who do not use aids. In the 45 to 64 age group the unemployment rate of those without hearing aids (8.1%) is approximately twice that of those with hearing aids (4.4%).

12.6 SUMMARY

The most important points arising from the evidence presented in this chapter, comparing hearing aid users with hearing impaired non-users, are as follows.

- Over 80% of hearing aid users report improvements in their overall quality of life.
- Hearing aids help to mitigate the detrimental effects of hearing loss on quality of life.
- Twice as many non hearing aid users experience stigma as hearing aid users.
- Hearing aids have a positive impact upon family relationships.
- Hearing aids have a positive impact upon various aspects of general health: hearing aid users in Eurotrak surveys report less physical and mental exhaustion, better sleep, less depression and better memory than non-users.
- Hearing aid owners report improvements in many situations: over 60% in Europe and the USA report improvements in the ability to communicate effectively and over 50% in the ability to participate in group activities.
- There is an association between hearing aid use and reduction in cognitive ability; recent research suggests that hearing aid use reduces the rate of cognitive decline.
- There has been conflicting research evidence concerning the impact of hearing aids on depression but there is a suggestion that the use of hearing aids may reduce depressive symptoms.
- Results of studies concerning the impact of hearing aids on loneliness and social isolation are inconclusive.
- Hearing aid users earn significantly more than non-users, the differential between the two groups increasing with the severity of hearing loss.
- Unemployment rates of non-users are approximately twice those of hearing aid users.

12.7 CONCLUSIONS

This chapter has outlined the many direct and indirect benefits that arise from the use of hearing aids. The results of research studies into the benefits are consistent with those of consumer surveys of hearing aid users. It is likely that hearing aid users will be happier, healthier and wealthier, with a better overall quality of life, than hearing impaired people who do not use aids.

Table 12.1. Summary of studies on benefits of hearing aids

Authors	Subjects		Areas considered	Assessment methods	Follow up period	Results
	No	Age				
Vuorialho *et al*, 2006c	98 HA	≥ 60	QoL	HHIE-S EQ-5D	6 months	40%-60% of 1st time HA users reported fewer social or emotional problems. Health status improved for regular users but not for occasional and non users.
Davis *et al*, 2007	~200 HA	55-74	QoL	SF-36 SF-6D QoFL HUI3	3 months	Small but robust positive changes in all QoL measures, most significantly in HUI relating to social life
Chia *et al*, 2007	~ 800 HI	Mean 67	QoL	SF-36	N/A	Regular HA users had slightly better score than non-users and irregular users, but not statistically significant.
Gopinath *et al,* 2009	1328 total	≥ 60	Depression	SF-36 CES-D-10	N/A	Use of HA associated with lower prevalence of depressive symptoms
Metselaar *et al*, 2009	254	29-95	QoL Depression	EQ-5D GDS	1 year	No effect of HA on quality of life or depression
Nachtegaal *et al*, 2009a	1511	18-70 Mean 71	Psychosocial health	Various incl DG loneliness scale	N/A	Psychosocial health similar for those with and without HA
Hogan *et al*, 2009	>43,000 14.6% HD	≥ 55	QoL	SF-12	N/A	People with hearing disability who used HA reported better QoL than non-users, although it was still less than that of general population.
Lee *et al*, 2010	37 HA	> 60	Depression	GDS	1 year	Tendency for depressive symptom scores to reduce after using HA
Acar *et al*, 2011	34	65-82	Depression Cognition	GDS MMSE	3 months	Statistically significant decrease of depressive symptoms and increase of cognitive functions
Choi *et al*, 2011	18 HA 11 NHA	Mean 67	Cognition		6 months	Use of HA led to improvement in working memory and learning ability.
Lin, 2011	605	60-69	Cognition	DSST	N/A	HA use associated with higher cognitive scores
Lin *et al,* 2011b	639	36-90	Dementia		N/A	No evidence that HA use associated with reduction in dementia risk
Boi *et al*, 2012	15	70-85	Depression QoL Caregiver burden	Various incl MMSE, ADL, SF-36	1, 3, 6 months	Use of HA improved general and mental health, social functioning and emotional stability. Caregiver stress decreased.
Gopinath *et a*l, 2012	829		QoL	SF-36	10 years	HA use reduced adverse effects of HL on QoL
Swan *et al*, 2012	9005	Mean ~ 55	HR QoL		6 months	Otolaryngology patients fitted with a HA reported an overall improvement in health-related QoL

Table 12.1. Summary of studies on benefits of hearing aids (continued)

Authors	Subjects		Areas considered	Assessment methods	Follow up period	Results
	No	Age				
Mener *et al*, 2013	1029	70-79	Depression		N/A	HA use associated with lower odds of depression
Pronk *et a*l, 2013	1826	63-93	Loneliness	DG loneliness scale	4 years	Worse hearing lead to more loneliness in HA non-users but not in users – suggesting a protective effect of HA use.
Ronnberg *et al,* 2014	138,098		Memory		N/A	HA use benefits short term/working memory for those with poorer hearing.
Amieva *et al*, 2015	1276 HI 2394 controls	≥ 65	Cognition	MMSE	25 years	Difference in rate of change in MMSE score between non HA users and controls; no difference between HA users and controls. HA use attenuates cognitive decline associated with HL.
Dawes *et al*, 2015b	Total: 164,770	40-69	Depression Cognition Social isolation	Battery of tests		HA use associated with better cognition. No association between HA use and depression; increased social isolation associated with HA use.
Dawes *et al*, 2015a	666 HI	Mean 68	Cognition Physical and mental health Social engagement	HHIE-S Various cognitive tests SF-12	5, 11 years	No difference between HA users and non-users in cognitive performance, incidence of cognitive impairment, social engagement, perceived mental health. HA users scored slightly better than non-users on physical health component of scale.
Deal *et al*, 2015	253		Cognition	Battery of tests	> 20 years	Decline in cognitive function greater in those not using HA. For HA users decline only slightly greater than for normal hearing population.
Keidser *et al*, 2015	>100,000 total	39-70	Depression			No evidence that use of HA mitigates depression
Niemensivu *et al*, 2015	949 HI 4685 NH	33-95 Mean 73.8	QoL	15 item questionnaire	6 months	HA fitting gave significant improvement on hearing dimension and marginal improvement overall
Weinstein *et al,* 2016	40	62-92	Loneliness	DG Loneliness scale	4-6 weeks	HA use led to reduction in perceptions of loneliness, especially among those with moderate to severe HL
Amieva *et al*, 2018	1289 HI	≥ 65	Dementia Depression Disability	Clinical diagnosis, CES-D, ADL/IADL scales	25 years	Increased risks of disability, dementia and depression (men only) in those with HI. No increased risk in those using HA who had same risk of developing dementia, depression or disability as control group.

CHAPTER 13 SATISFACTION WITH HEARING AIDS

13.1 INTRODUCTION

The Hear It report of 2006 report (Shield, 2006) showed that over 70% of hearing aid users were satisfied or very satisfied with their aids, the greatest satisfaction being for one to one conversations and the least for conversations in large groups or in noisy situations.

Many of the studies into the outcomes of hearing aid fitting, plus surveys of hearing aid users, have investigated overall user satisfaction with hearing aids, and the factors that contribute to satisfaction or dissatisfaction. This chapter summarises the findings of large and smaller scale consumer surveys and research projects regarding overall satisfaction with hearing aids, satisfaction with the performance of aids in different listening environments, satisfaction with various features of hearing aids and factors that affect satisfaction.

13.2 OVERALL SATISFACTION WITH HEARING AIDS

Overall, consumer surveys and studies have found that there is a high level of satisfaction with hearing aids, and that satisfaction rates are increasing.

In the Eurotrak surveys hearing aid owners were asked to indicate their satisfaction with their hearing aids on a 7-point scale (very dissatisfied, dissatisfied, somewhat dissatisfied, neutral, somewhat satisfied, satisfied, very satisfied).

Table 13.1 shows the responses in the most recent surveys where 'satisfied' includes somewhat satisfied, satisfied and very satisfied and 'dissatisfied' includes somewhat dissatisfied, dissatisfied and very dissatisfied.

It can be seen that the satisfaction rate for Japan is very much lower, and dissatisfaction very much higher, than for the other countries. This is also true of satisfaction rates for different aspects of hearing aids discussed in subsequent sections of this chapter. Godhino (2016) discusses the low level of satisfaction in Japan compared with other countries and concludes that it, together with the low rate of fitting in Japan (14.1%), is due to the widespread use of non-professional hearing health services. Therefore, as in previous chapters and as the focus of this report is the situation in Europe, only European countries are included in any averaging of results.

Table 13.1. Satisfaction with hearing aids in Eurotrak surveys

	Bel ****	**Den ***	**Fra **	**Ger **	**It **	**NL ***	**Nor *	**Pol ***	**Switz **	**UK **	**Av Eur**	**Jap **
Satisfied	79	71	84	77	79	73	71	80	80	70	**76.4**	38
Dissatisfied	13	13	10	10	8	11	18	10	10	18	**12.1**	30

* 2012 ** 2015 ***2016 ****2017

It can be seen in Table 13.1 that the country with the highest rate of satisfaction is France. However, de Kervasdoue and Hartmann (2016) point out that care is needed when interpreting the satisfaction scores and comparing between countries as they may reflect socio-cultural differences and preferences. In all countries, apart from Japan, over 70% of hearing aid owners are satisfied with their aids.

In the USA, the most recent Marketrak survey found that 81% of hearing aid owners were satisfied with their aids (Abrams and Kihm, 2015). A very similar rate of satisfaction was found in a survey carried out in 2011 by the American Association of Retired Persons (AARP

and the American Speech-Language-Hearing Association (ASHA) in the USA (Geraci, 2012) in which 82% of owners reported being somewhat, very or extremely satisfied with their aids. A survey of hearing aid owners in England, carried out as part of the 2014 Health Survey for England (HSE), reported satisfaction rates among adults in different age bands, as shown in Table 13.2 (Scholes and Mindel, 2015). 'Satisfied' refers to those reporting being fairly or very satisfied, while 'dissatisfied' includes those reporting being fairly or very dissatisfied. It can be seen that the figures for all ages agree very closely with the Eurotrak results for the UK.

Table 13.2. Satisfaction with hearing aids in the UK (data from Table 4.19 of Scholes and Mindel, 2015)

	16-64 years			**65-74 years**			**75+ years**			**All ages**		
	M	W	All	M	W	All	M	W	All	M	W	All
Satisfied	69	69	69	75	77	75	68	70	69	70	71	71
Dissatisfied	20	16	18	18	15	17	23	20	21	21	18	19

The HSE survey found no significant variation in satisfaction with age or gender (see section 13.7.2 for further discussion of effects of age and gender).

A large scale study of over 8700 hearing aid users in Switzerland (Bertoli *et al*, 2009) found that 85.7% of respondents were satisfied (that is, very or rather satisfied) with their aids, although this was corrected to 79.7% to allow for potential bias caused by non-response to the survey. This figure agrees closely with the percentage of satisfied owners (80%) in Switzerland found in the Eurotrak survey, as shown in Table 13.1. Interestingly the French speaking respondents were more satisfied than the German and Italian speaking respondents, which the authors suggest may be due to cultural differences as hearing aid provision is the same in all regions of the country. This reinforces the point made by de Kervasdoue and Hartmann (2016) concerning different cultural preferences

Similarly high satisfaction ratings were found in a consumer survey (EARtrak) of over 1600 hearing aid users in Australia which was carried out between 2005 and 2007 (Hickson *et al*, 2010): 78% of participants were satisfied or very satisfied with their hearing aids

13.3 INCREASES IN SATISFACTION RATINGS

The Marketrak and Eurotrak surveys have shown that satisfaction with hearing aids has increased over the years.

Kochkin (2010b), in analysing the results of Marketrak surveys from 1989 to 2008, found that satisfaction increased from 60% to 74%, as can be seen in Table 13.3. The satisfaction rate for the most recent Marketrak survey (Abrams and Kihm, 2015) is also included which confirms the increasing satisfaction trend. It can also be seen that the satisfaction rate was relatively stable between 1989 and 2000, with a large increase in 2004. This may be partly due to a change in scale from 5 points to 7 points (including 'somewhat satisfied' and 'somewhat dissatisfied' scale points) but may also reflect improvements in hearing aid design and performance/technology.

Table 13.3. Satisfaction rates (%) from 1989 to 2014 (data from Kochkin, 2010b and Abrams and Kihm, 2015)

	1989	**1991**	**1994**	**1997**	**2000**	**2004**	**2008**	**2014**
% satisfied	59.6	58.2	53.5	53.9	54.7	67.9	74.0	81.0

Ruf *et al* (2016), in pooling Eurotrak data for the UK, France and Germany for 2009, 2012 and 2015, also demonstrate that satisfaction with product features, product performance and use of hearing aids in difficult listening situations, has increased over the years.

13.4 SATISFACTION IN DIFFERENT LISTENING SITUATIONS

The Eurotrak and Marketrak surveys ask respondents about their levels of satisfaction with hearing aids in different listening situations

The most recent Eurotrak data for all countries (except Norway for which there is no data) is shown in Table C4 in Appendix C. The data is reasonably consistent across countries, with the rankings in particular being very similar. Switzerland has the highest satisfaction ratings in most situations, while figures for Japan are again being very much lower than those of the other countries in all situations.

The average European ratings are shown in Table 13.4, together with the corresponding satisfaction ratings (where available) from the 2008 Marketrak survey (Kochkin, 2010b). It can be seen that the results of both surveys are similar, with slightly higher satisfaction ratings being reported in most situations in the Marketrak survey. In both surveys the situation in which aids are reported to provide most satisfaction is one to one conversation.

Table 13.4. Average Eurotrak and Marketrak (2008) satisfaction ratings for hearing aids in different listening situations

	Eurotrak average	**Marketrak average**
Conversation with one	84	91
At home with family	80	-
Outdoors	78	79
In a store, when shopping	78	77
Watching TV	77	80
Conversation in small groups	77	85
Listening to Music	76	78
When riding in a car	76	77
When talking to children	76	-
Leisure activities	71	78
At a movie theatre	71	72
On the telephone	71	73
Conversation in large groups	68	68
In the workplace	67	65
In a larger lecture hall	66	-
In school or a classroom	62	59
Use in noisy situations	60	-

The EARtrak survey in Australia (Hickson *et al*, 2010) also presented participants with a similar (but shorter) range of listening situations. The results are not directly comparable with Eurotrak and Marketrak data as EARtrak used a 5 point scale, whereas the other surveys currently use a 7 point scale. In general satisfaction scores (representing 'satisfied/very satisfied) in the EARtrak survey are lower than those in the other surveys. However, there are consistencies in the results: one to one conversation was the situation in which the greatest number of respondents were satisfied (84.9%) in the EARtrak survey, while the four situations in which they were least satisfied were listening in large groups

(33.5%), in the workplace (43.4%), in restaurants (43.2%) and on the telephone (44.3%) (Hickson *et al*, 2010).

The problem of listening in large groups was also highlighted by the AARP/ASHA survey (Geraci, 2012) in which the most common reason given for dissatisfaction with hearing ads was that they could not hear as well as expected in a crowded room with many conversations going on (cited by 79% of dissatisfied owners).

13.5 SATISFACTION WITH HEARING AID ATTRIBUTES

Table 13.5 shows the average European satisfaction rates with various features of hearing aids from the Eurotrak surveys and, where applicable, from the 2008 Marketrak survey (Kochkin, 2010b). The results for individual countries in the Eurotrak surveys are shown in Table C5 in Appendix C.

Table 13.5. Satisfaction with sound quality and product features in Eurotrak and Marketrak surveys

		Percentage somewhat satisfied, satisfied and very satisfied	
		Eurotrak average	**Marketrak (Kochkin, 2010b)**
Sound quality	Clearness of tone and sound	74	77
	Natural sounding	73	71
	Richness or fidelity of sound	72	68
	Comfort with loud sounds	67	67
Product features	Ease of changing battery	86	88
	Reliability	81	80
	Overall fit/Comfort	80	87
	Visibility to others	78	78
	Managing whistling/feedback/buzzing	70	69
	Battery life	70	73
	Value (performance versus money spent)	67	66

It can be seen that, although scores for some features vary, the ranking of satisfaction with the various characteristics in both surveys is very similar.

The EARtrak survey also asked about satisfaction with certain features of hearing aids (Hickson *et al*, 2010). Again direct comparison is not possible owing to the different rating systems and differences in the list of features presented for rating. However, the results are consistent with the Eurotrak and Marketrak rankings, the highest satisfaction scores being obtained for overall fit/comfort and reliability. The attributes with the lowest levels of satisfaction were comfort with loud sounds; ease of adjusting volume control; whistling/feedback; and ability to locate sounds.

The high satisfaction rating for fit/comfort in the consumer surveys is in direct contrast with a detailed survey of 27 hearing aid users carried out for the RNID (now AHL) (Matthews, 2011). During in depth interviews comfort of aids was one of the main problems that was repeatedly raised, leading the report to highlight the importance of supporting people in adjusting to wearing aids and ensuring that they are comfortable, which will in turn have a positive impact on the amount of time people will wear them.

In a recent review of evidence concerning the impact of background sound on hearing aid users Gygi and Hall (2016) concluded that around one third of hearing-aid users still find particular features dissatisfying in the presence of background sounds, the most common causes of dissatisfaction concerning listening in noisy environments; conversations in large groups; and amplification of unwanted background sounds.

Discomfort with loud sounds was also the most highly rated problem in a survey of new Hong Kong Chinese hearing aid users (Wong *et al*, 2009).

13.5.1. Contribution of hearing aid characteristics to overall satisfaction

Relationships between satisfaction with individual product features and overall satisfaction have been investigated in some surveys through correlation analysis (Eurotrak and Marketrak surveys) and multiple regression analysis (EARtrak survey). (The significance of the correlations in the Eurotrak and Marketrak surveys is not known.)

Analysis of results to the EARtrak survey found that the factors most strongly associated with positive outcomes were higher levels of satisfaction with overall fit/comfort, clarity of tone and sound, and comfort with loud sounds, of which the strongest factor was clarity (Hickson *et al*, 2010).

Correlation coefficients between hearing aid attributes and overall satisfaction in the most recent Eurotrak surveys are shown in Table C6 in Appendix C. The corresponding correlation coefficients in the 2008 Marketrak survey (Kochkin, 2010b) are also presented. The factor that is most closely related to satisfaction in 50% of countries, including the USA, is clarity of tone and sound, in agreement with the findings of the EARtrak survey. In most countries, the three factors most closely associated with overall satisfaction are clarity, natural sounding and richness or fidelity of sound. However, in Belgium and the Netherlands value for money (performance versus money spent) is also highly correlated with satisfaction.

13.6 SATISFACTION WITH DIFFERENT TYPES OF HEARING AID

Several studies, as well as the Eurotrak surveys, have considered satisfaction with different types of aid.

Table 13.6 shows the Eurotrak results for overall satisfaction with behind the ear (BTE), in the ear (ITE) and in the canal (ITC) aids, from the most recent surveys and, where available, from the 2012 surveys, for comparison. The table shows that, in 2012, BTE aid owners in all countries were more satisfied than owners of ITE or ITC aids. However, in the most recent surveys, although on average BTE aids lead to most satisfaction, in half of the countries surveyed (Belgium, Germany, Italy, Netherlands, Switzerland) ITE or ITC aids were reported to be more satisfactory than BTE aids.

Some authors have examined the effect of hearing aid technology on hearing aid outcomes. Humes *et al* (2009) found there was no difference in satisfaction rates between four different technologies varying from simple analogue to more complex digital aids. Similarly, in the large scale survey by Bertoli *et al* (2010), six different categories of hearing aid were identified and the owners of the simpler aids were reportedly more satisfied with their aids than those with more complex devices. The authors suggest that this could indicate the limitations of hearing aid technology in compensating for hearing loss, and also potentially higher and possibly unrealistic expectations of owners of complex devices, compared with those with simpler hearing aids.

Table 13.6. Satisfaction with different types of hearing aid in Eurotrak surveys

	BTE		ITE		ITC	
	Recent	**2012**	**Recent**	**2012**	**Recent**	**2012**
Belgium****	81	-	73	-	86	-
Denmark***	77	75	54	65	68	64
France**	86	85	77	81	83	77
Germany**	77	83	82	69	79	73
Italy**	77	77	81	71	76	71
Netherlands***	75	-	63	-	79	-
Norway*	-	78	-	64	-	69
Poland***	80	-	75	-	86	-
Switzerland**	79	86	84+	78+		
UK**	72	76	72	66	60	72
European average	**78**	**80**	**73**	**71**	**77**	**71**
Japan**	48	46	36+	33+		

+ITE/ITC combined
* 2012 ** 2015 ***2016 ****2017

However, in contrast, the authors of a small scale study of 64 new hearing aid owners (Williams *et al*, 2009) suggest that the high satisfaction rate found in their study (86%) compared with earlier studies means that more advanced hearing aid technology results in better outcomes and higher satisfaction scores. Kaplan-Neeman *et al* (2012) also consider that advances in technology account for the high level of satisfaction found among the 109 HA users in their study, of whom 92% were very satisfied, satisfied or moderately satisfied with their aids.

13.7 OTHER FACTORS WHICH AFFECT SATISFACTION RATES

This section considers some other factors which have been addressed in various studies and surveys in relation to users' satisfaction with their hearing aids.

13.7.1 Age of hearing aids

Both Eurotrak and Marketrak surveys have considered satisfaction with aids according to the age of the aids.

In the most recent Marketrak survey the satisfaction rates with aids of varying age were as shown in Table 13.7 (Ruf *et al*, 2016).

Table 13.7. Satisfaction rates according to age of hearing aids in Marketrak IX survey (figures from Ruf *et al*, 2016)

Age of aid (years)	Somewhat satisfied	Satisfied	Very satisfied	Total satisfied
≤ 1	15	33	43	91
2 to 5	20	30	27	77
≥ 6	20	35	19	74

The satisfaction responses in the most recent Eurotrak surveys are categorised by age of hearing aid as less than or equal to two years and over two years. The responses for each country and averaged are shown in Table 13.8.

Table 13.8. Satisfaction rates in Eurotrak surveys according to age of hearing aid

Age of HA	Bel ****	Den ***	Fra **	Ger **	It **	NL ***	Nor *	Pol ***	Switz **	UK **	Av Eur	Jap **
≤ 2 years	83	76	87	85	83	79	79	82	84	72	**81**	42
> 2 years	75	71	83	71	74	67	67	77	79	71	**73.5**	33

* 2012 ** 2015 ***2016 ****2017

Tables 13.7 and 13.8 both show that satisfaction is greater among owners of newer aids. The earlier Eurotrak and Marketrak (Kochkin, 2010b) surveys similarly showed greater satisfaction with newer aids.

These results are consistent with the findings of the Swiss survey of hearing aid users which found a greater risk of dissatisfaction with aids among people who had owned their aids for at least two years (Bertoli *et al*, 2009), and significantly higher satisfaction for hearing aids less than one year old compared with aids between one and five years old (Bertoli *et al*, 2010).

13.7.2 Age and gender of hearing aid owners

A review of literature on various aspects of hearing aid use by Knudsen *et al* (2010) found that age and gender were not related to satisfaction with hearing aids in the majority of studies in which they were considered. As shown in section 13.1 and Table 13.2, this was also the finding of the HSE survey (Scholes and Mindel, 2015). However, some studies have found a relationship between age and satisfaction, in which satisfaction decreases with age (Oberg *et al*, 2007; Kaplan-Neeman *et al*, 2012). Kaplan-Neeman *et al* (2012) suggest that this may be due in part to detrimental effects of age-related central processing changes on speech understanding. Oberg *et al* (2007) also found that women were more satisfied than men with their hearing aids.

13.7.3 Appearance/visibility of hearing aids

The Eurotrak and Marketrak surveys showed that owners were in general satisfied with the appearance of their hearing aids, as can be seen in Table 13.5. The results of the EARtrak survey (Hickson *et al*, 2010) are consistent with these findings, with 77.5% of respondents satisfied with the visibility of their hearing aids. Kaplan-Neeman *et al* (2012) also found that participants in their study were satisfied with the style and appearance of their hearing aids, which the authors consider could result from continuous improvement in the aesthetic appearance of aids.

The survey by Davis *et al* (2007) also found that most participants (over 80%) considered the appearance of all types of smaller hearing aid (BTE, ITE etc) acceptable.

These findings are consistent with the discussion in Chapter 8 concerning a reduction in recent years in the negative image and stigmatisation of hearing aid wearers.

13.7.4 Hours of use

Several studies and surveys have found that overall satisfaction with aids is related to the hours of wear per day, which might be expected: if someone is satisfied with their aid they are likely to wear it for longer. Alternatively, the longer a hearing aid is used the more an owner is likely to acclimatise to the aid; there is increasing evidence that use of a hearing aid can lead to perceptual and/or physiological changes in the adult human auditory system thereby modifying the deprived auditory associated with hearing loss (Munro, 2008)

Table 13.9 shows the satisfaction rates related to hours of use in each country in the Eurotrak surveys. It can be seen that average satisfaction increases from 56% for those aids used for less than 4 hours per day to 86% for those worn for more than 8 hours per day.

Research studies have also found relationships between satisfaction and regular use of aids, with those who use their hearing aids more frequently being more satisfied (Oberg *et al*, 2007; Bertoli *et al*, 2009; Kaplan-Neeman *et al*, 2012).

Table 13.9. Satisfaction rates (% somewhat satisfied, satisfied, very satisfied) in Eurotrak surveys related to hours of wear

	Hours of use per day		
	< 4	**4-8**	**> 8**
Belgium****	67	73	86
Denmark***	49	70	81
France**	61	83	93
Germany**	51	80	86
Italy**	52	82	88
Netherlands***	48	70	85
Poland***	56	87	91
Switzerland**	69	82	84
UK**	48	73	82
Average Europe	**56**	**78**	**86**
Japan	25	46	52

13.7.5 Degree of hearing loss

There is some disagreement in the literature regarding the extent to which satisfaction with hearing aids is related to degree of hearing loss. Oberg *et al* (2007) found that when users were categorised as having mid or moderate hearing loss, those with the greater hearing loss were more satisfied with their aids, in agreement with some previous studies. Kaplan-Neeman *et al* (2012) also found that degree of hearing loss was associated with enhanced satisfaction. However, in their analysis of the large scale Swiss survey Bertoli *et al* (2010) found no relationship between satisfaction and degree of hearing loss.

Extrapolating from the data provided by Ruf *et al* (2016) in their pooling of Eurotrak responses for Germany, France and the UK for the three years 2009, 2012 and 2015 gives the satisfaction rates for differing degrees of self-reported hearing loss shown in Table 13.10.

Table 13.10. Satisfaction rates for differing degrees of hearing loss (extrapolated from Ruf *et al*, 2016)

	Degree of hearing loss (self-reported)			
	Mild	Moderate	Severe	Profound
% satisfied	69	82	75	77

While there does not appear to be a clear relationship between degree of hearing loss and satisfaction, the figures in Table 13.10 are consistent with the finding of Oberg *et al* (2007) that those with mild hearing loss are less satisfied with their aids than those with greater hearing loss.

13.7.6 Expectations of hearing aids

It has been shown that positive expectations of hearing aids encourage their use (Meister et al, 2008). However, it is important that expectations are realistic in order to maximise benefit; too high expectations can lead to disappointment with aids and consequent reduction in their use. The audiology departments therefore need to provide patients with full information about what may be expected from their aids (Matthews, 2011). A study of 30 new hearing aid users found that positive expectations were related to satisfaction, although there had been conflicting results in previous studies (Ferguson *et al*, 2016). Another study, of first time users (Wong *et al*, 2009), found that the difference between performance and

expectation was more highly related to satisfaction than expectation alone: participants were more satisfied when the ability to hear with hearing aids was better than expected, when problems were fewer than expected, and when service was better than expected.

Recent Eurotrak surveys also asked about hearing aid owners' expectations of hearing aids and whether they had been met. Table 13.11 shows the results for each country in answer to the question 'How have the expectations you had towards hearing aids before trying them on for the first time been met?'

Table 13.11. Respondents to Eurotrak question on expectations

	% answering in each category		
	Better than expected	**As expected**	**Worse than expected**
Belgium****	21	53	27
Denmark***	26	59	15
France**	20	52	27
Germany**	28	59	13
Italy**	31	56	13
Netherlands***	27	57	15
Poland***	22	54	24
Switzerland	26	54	20
UK**	27	54	19
Average Europe	**25**	**55**	**19**
Japan**	40	50	10

It is interesting to note that Japan has the highest percentage of respondents for whom their aids were better than expected, and the lowest percentage for whom they were worse than expected.

13.7.7 Handling of aids

Only two recent studies have examined the contribution of the ability to handle hearing aids to satisfaction.

In the Swiss survey (Bertoli *et al*, 2009) 90.5% of respondents indicated that they were able to handle their aids well (that is, very or rather well). The authors state that this may be due to continuous support and counselling from the hearing aid dispenser in case of problems. Difficulties in handling aids were found to be very strongly associated with dissatisfaction with aids.

In a more recent study Ferguson *et al* (2016) examined the impact of self-efficacy (that is, self confidence in the ability to handle and use hearing aids) prior to fitting among new hearing aid users, and found that it was related to overall satisfaction with aids.

13.8 SUMMARY

The main points arising from the review of evidence of satisfaction with hearing aids presented in the chapter are as follows.

- Consumer surveys of hearing aid owners show high levels of satisfaction with hearing aids in all countries except Japan.
    - In European countries between 70% and 84% of owners are satisfied with their aids
    - In the USA over 80% of users are satisfied with their aids
    - In Australia 72% to 78% of users are satisfied with their aids
- Satisfaction with hearing aids has increased significantly over the past 30 years.

- The listening situation in which hearing aids provide the greatest rate of satisfaction is in one to one conversation.
- The listening situations in which owners are least satisfied with their aids include conversation in large groups and in the workplace.
- The sound attribute with which users are most satisfied is clarity.
- The sound attribute with which users are least satisfied is comfort with loud sounds.
- The factor which has most impact on overall satisfaction is clarity of sound.
- Satisfaction with aids decreases with the age of the aids.
- The majority of owners are happy with the appearance of their aids.
- Satisfaction is related to amount of wear, increasing with hours of use.
- It is important that new hearing aid users have realistic expectations of their benefits.

13.9 CONCLUSIONS

This chapter has shown that the majority of hearing aid owners are satisfied with the performance of their hearing aids, although satisfaction varies depending upon the listening situation. The 2006 report (Shield, 2006) showed that satisfaction with aids was generally high, around 70% of users being satisfied with their aids. It has been seen in this chapter that satisfaction with aids has further increased over the years, probably due to advances in technology which have improved their performance. The aspect of performance with which users are most satisfied, and which is the most closely related to overall satisfaction, is clarity of the sound. The use of hearing aids is the most satisfactory when users are engaged in one to one conversation; they perform less well during conversation with large groups. The newer the aid, the greater the satisfaction. It is important that users are provide with sufficient information pre fitting so that they know what to expect from their hearing aids, and with sufficient support post fitting to enable them to manipulate and manage their aids to provide maximum benefit.

APPENDIX C

Table C1. Sample sizes for most recent Eurotrak surveys

	Whole sample	Hearing impaired sample	Hearing impaired with HA	Hearing impaired without HA
Belgium****	14245	1307	502	805
Denmark***	13434	1304	711	593
France**	14824	1320	501	819
Germany**	13775	1304	505	799
Italy**	15641	1343	492	851
Netherlands***	14339	1350	555	795
Norway*	14866	1309	691	618
Poland***	15344	1451	475	976
Switzerland**	14570	1301	619	682
UK**	14473	1325	605	720
Japan**	14316	1306	416	890

* 2012 ** 2015 ***2016 ****2017

Table C2. Average (of 10 European countries) percentages of respondents citing reasons for non-ownership of hearing aids ('reason' or 'somewhat reason')

Reason	%
Hear well enough in most situations	64.3
Hearing loss not severe enough	61.8
Uncomfortable	56
They do not restore your hearing to normal	54.2
They do not work well in noisy situations	54.2
Have more serious priorities	48.4
Ear doctor's opinion (ENT)	46.5
Cannot afford a hearing aid	44.9
Have tinnitus	43.1
Have hearing loss only with high pitch sounds	42
Do not admit I have a hearing loss in public	40.1
Would be embarrassed to wear a hearing aid	38.6
Family doctor's opinion (GP)	38.4
Have hearing loss in only one ear	36.1
Bad design	34.8
Have hearing loss only with low frequency sounds	34.1
Hearing aid dispenser/audiologist's opinion	33.9
Have tried hearing aid and they do not work	32.9
Another hearing aid owner's opinion	31.2
Have not had hearing tested yet	31.1
Social/family opinion such as child, spouse, friend	28.6
Have sensor-neural hearing loss (nerve deafness)	28.5
I have vision or dexterity problems	23.9
Hearing problem requires surgery	22.1
Do not trust hearing aid dispenser/audiologist	21.6
Had surgery – hearing aids won't help	17.9
Do not know where to get hearing aids	16.3

Table C3. Percentages of owners (HA) and non-owners (NHA) reporting being made fun off or rejected because of hearing aids or hearing loss

Country	Never		Rarely		Occasionally		Regularly	
	HA	NHA	HA	NHA	HA	NHA	HA	NHA
Belgium****	76	45	13	34	7	19	3	1
Denmark***	70	36	19	46	5	16	5	2
France**	72	32	15	31	9	34	3	2
Germany**	68	21	12	35	16	41	5	3
Italy**	53	18	18	36	23	39	6	7
Netherlands***	76	48	14	29	7	17	3	6
Poland***	62	21	20	40	13	38	5	1
Switzerland**	85	44	10	34	4	21	1	0
UK**	68	21	12	35	16	41	5	3
Average Europe	**70**	**31.8**	**14.8**	**35.6**	**11.1**	**29.5**	**4.0**	**2.8**
Japan**	68	55	23	35	8	9	1	0

** 2015 ***2016 ****2017

Table C4. Percentages of hearing aid owners in Eurotrak surveys satisfied (somewhat satisfied/satisfied/very satisfied) with their aids in different listening situations

	Bel ****	Den ***	Fra **	Ger **	It **	NL ***	Pol ***	Switz **	UK **	Av Eur	Jap **
Conversation with one	87	84	83	86	81	87	82	88	79	**84.1**	43
At home with family	82	76	83	78	76	81	80	89	75	**80.0**	26
Watching TV	73	73	80	80	81	77	79	75	73	**76.8**	34
When talking to children	78	73	77	76	74	77	78	83	70	**76.2**	27
Conversation in small groups	73	73	80	76	79	76	79	84	70	**76.7**	32
Outdoors	75	74	82	78	75	81	76	88	70	**77.7**	26
Listening to music	75	75	83	79	76	77	73	81	69	**76.4**	30
In a store, when shopping	77	75	76	81	76	82	77	86	69	**77.7**	25
When riding in a car	75	79	76	80	71	78	74	87	68	**76.4**	29
Leisure activities	61	68	77	70	76	69	75	78	67	**71.2**	28
At a movie theatre	66	75	71	72	74	69	67	80	64	**70.9**	24
Conversation in large groups	63	66	75	65	74	65	76	66	63	**68.1**	28
On the telephone	68	71	75	74	76	71	74	74	60	**71.4**	31
In a larger lecture hall	60	69	73	65	72	67	70	62	59	**66.3**	25
In the workplace	57	72	58	73	72	68	65	79	57	**66.8**	29
Use in noisy situations	53	58	68	59	67	62	62	59	55	**60.3**	27
In school or a classroom	55	69	52	63	68	66	64	72	51	**62.2**	32

** 2015 ***2016 ****2017

Table C5. Satisfaction rates with hearing aid features from Eurotrak surveys

	Bel ****	**Den ***	**Fra **	**Ger **	**It **	**NL ***	**Nor***	**Pol ***	**Switz **	**UK **	**Av Eur**	**Jap **
Clearness of tone and sound	75	75	78	72	75	73	66	74	81	68	**73.7**	35
Natural sounding	78	72	78	72	74	73	63	73	83	65	**73.1**	32
Richness or fidelity of sound	75	71	78	74	73	72	62	70	78	62	**71.5**	33
Comfort with loud sounds	68	69	77	65	72	64	57	62	73	65	**67.2**	37
Ease of changing battery	90	87	87	84	84	87	84	79	92	83	**85.7**	50
Reliability	87	80	84	79	79	81	76	75	91	76	**80.8**	46
Overall fit/ Comfort	85	76	82	76	77	84	77	77	89	75	**79.8**	38
Visibility to others	84	82	78	78	79	79	75	65	90	70	**78**	48
Managing whistling/feedback/ buzzing	74	72	77	69	71	70	57	64	78	66	**69.8**	26
Battery life	71	76	75	67	75	75	52	65	66	71	**69.3**	33
Value for money	69	76	60	61	72	75	65	67	57	68	**67**	28

* 2012 ** 2015 ***2016 ****2017

Table C6. Correlation coefficients between satisfaction with hearing aid attributes and overall satisfaction in Eurotrak and Marketrak surveys

	Bel ****	**Den ***	**Fra **	**Ger **	**It **	**NL ***	**Nor***	**Pol ***	**Switz **	**UK **	**Jap **	**USA +**
Clearness of tone and sound	.80	.79	.74	.74	.79	.78	.72	.75	.59	.80	.80	.70
Natural sounding	.83	.77	.76	.74	.80	.74	.72	.72	.56	.79	.81	.66
Richness or fidelity of sound	.76	.80	.75	.76	.82	.74	.71	.69	.65	.78	.81	.65
Comfort with loud sounds	.6	.73	.73	.72	.78	.67	.66	.62	.52	.71	.75	.63
Ease of changing battery	.58	.54	.58	.55	.60	.54	.51	.50	.41	.58	.43	
Reliability	.71	.71	.75	.63	.80	.71	.66	.68	.51	.76	.76	.65
Overall fit/ Comfort	.62	.62	.74	.62	.72	.53	.60	.45	.49	.68	.72	
Visibility to others	.53	.55	.65	.56	.71	.51	.47	.44	.39	.60	.56	
Managing whistling/feedback/ buzzing	.59	.70	.66	.60	.76	.69	.58	.60	.56	.68	.67	
Battery life	.41	.46	.50	.48	67	.38	.40	.46	.38	.46	.39	
Value for money	.78	.72	.53	.58	.66	.79	.63	.65	.56	.65	.72	.68

* 2012 ** 2015 ***2016 ****2017 + Marketrak

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SECTION D

COSTS OF HEARING LOSS

CHAPTER 14 REVIEW OF PREVIOUS STUDIES OF COSTS OF HEARING LOSS

14.1 INTRODUCTION

At the time of writing the Hear It 2006 report (Shield, 2006) there were very few previous studies which estimated the total costs of hearing impairment, and none which took account of the cost of the personal and social impact of hearing loss. While there have been some publications in this area in the past 12 years, the continuing lack of studies of the overall costs of hearing impairment of all grades has been noted in recent reviews of the economic impact of hearing loss (Hjalte *et al*, 2012; Huddle *et al*, 2017).

This chapter reviews and summarises those studies which have been carried out to date. Publications reviewed include research papers in peer reviewed journals, and detailed national reports aimed at guiding government policies on health expenditure, and emphasising the relative importance of addressing hearing loss.

In the 2006 report, it was estimated that the annual cost of hearing loss in Europe was 284 billion euros (€224 billion in the EU; €60 billion for the rest of Europe). Taking account of the numbers of people wearing hearing aids reduced the costs, so that the annual cost of untreated hearing loss in Europe was estimated to be €213 billion (€168 billion in the EU; €45 billion for the rest of Europe). These estimates were based upon a quality of life approach, which has since been used in other studies (London Economics, 2010; de Kervasdoue and Hartmann, 2016).

As noted in the 2006 report, although there was very little previous work estimating the financial costs of hearing loss in general, there was a relatively large body of literature concerning the cost-effectiveness of cochlear implants. This work provided some useful guidance in evaluating the reduction in quality of life associated with different degrees of hearing loss.

The main study of societal costs associated with adult hearing loss reviewed in the 2006 report was that of Mohr *et al* (2000), which was concerned only with the costs of severe to profound deafness. In estimating lifetime costs the authors considered costs due to lost productivity, special education, vocational rehabilitation, assistive devices and medical costs. They estimated that the additional cost to US society, due to severe to profound hearing loss, was, on average, $297,000 over the lifetime of an individual (in 1998 dollars). They also found that, up to the age of 65, medical costs were a relatively minor proportion of the total costs, the major one, for people of working age, being due to lost earnings or productivity.

Another significant study was that of Ruben (2001), who estimated the costs of various communication disorders, including hearing difficulty, in terms of unemployment, underemployment and lost productivity. He estimated the annual costs to the US economy of all communication disorders to be between $154 and $186 billion, depending on prevalence, of which $122.6 billion was due to unemployment or underemployment (in 1999 dollars).

The only study included in the 2006 review which addressed the socio-economic benefits of treating moderate hearing loss was that of Joore *et al* (2003) (the ‘Maastricht study’), but results were not translated into monetary costs.

However, since 2006 there have been several studies and reports published into the costs of hearing loss and/or the cost-effectiveness of interventions including screening for hearing

loss, and fitting with hearing aids or cochlear implants. Many of these have arisen as a result of concerns about the ageing population, and the consequent expected increase in the prevalence of hearing loss. However, as will be seen, there is considerable variation in methodologies between studies making comparisons between studies or the drawing of overall conclusions difficult.

14.2 REVIEWS OF STUDIES OF COSTS OF HEARING LOSS

In recent years there have been two systematic reviews of the literature on the socio-economic costs of hearing loss. Hjalte *et al* (2012) reviewed studies published between January 1995 and January 2012; the review was restricted to studies written in English or Swedish which included societal costs as well as direct costs. They concluded that (in 2012) the most comprehensive study was still that of Mohr *et al* (2000), although it considered only severe to profound hearing loss; the lifetime cost estimated by Mohr *et al* was updated to 2011 prices of $410,000. The review highlighted the lack of information concerning the costs of less severe degrees of hearing impairment. The review authors found it difficult to compare studies owing to variations in the methodologies employed, for example different populations (adult/child/lifetime/particular age groups), different levels of hearing loss, different methods of assessment of hearing loss (self-reported/audiometric). However, it confirmed that, in terms of costs of hearing loss, social welfare systems are impacted more than health care systems, with indirect costs, due for example to lost productivity, being a major component of the societal cost of hearing loss. The authors also recognised the need to consider the other health care costs associated with conditions that are related to hearing loss.

A more recent review (Huddle *et al*, 2017) of papers published before August 2015 reached similar conclusions concerning the lack of rigorous, comprehensive studies of the economic impact of hearing loss, and the significant variance between published studies in terms of methodology and outcome measures, making it impossible to perform a meaningful meta-analysis of the data. The authors found that estimates of the cost of lost productivity in the USA varied from $1.8 to $194 billion, and direct medical costs from $3.3 to $12.8 billion (2015 USD). The authors again suggest that a comprehensive economic estimate of other negative health effects, related to hearing loss, such as falls, cognitive decline or depression, is needed for a full evaluation of the costs of hearing loss.

14.3 PREVIOUS STUDIES OF COSTS OF HEARING LOSS

This section reviews studies and reports on the economic costs of hearing loss published since 2004. The studies are summarised in Table 14.1 which gives overall costs of hearing impairment and, where available, costs per person. The costs have been updated to 2017 costs, based upon inflation rates in the relevant country, but it should be noted that the updated costs do not reflect the actual costs of hearing loss in 2017 as they do not take account of increases in prevalence. For example, the 2005 figure for Australia, updated to 2017 (AU$ 30.4) differs from the figure estimated for 2017, which was based upon exactly the same calculations (AU$33.3). The table underlines the findings of Hjalte *et al* (2012) and Huddle *et al* (2017) regarding differences between studies in terms of age groups, hearing loss and types of costs considered, and hence the difficulties of comparing studies.

The majority of studies have calculated the costs of lost productivity due to unemployment or underemployment of hearing impaired people. Five of the reviewed reports calculate the monetary equivalent of reduced quality of life. Many studies have included an estimate of the health care costs associated with hearing loss but the items of expenditure included vary between studies. (As the funding mechanisms of hearing health care differ from country to country, this aspect of expenditure is beyond the scope of this report.)

Table 14.1. Studies of costs of hearing loss

Authors	Country	Age	Costs included	Definition of HL	Total cost (year)		2017 cost[+]
					Total	Per person	
Mohr *et al*, 2000	USA	Lifetime	Direct medical, special education, rehabilitation, lost productivity	Severe-profound (self-reported)		$297,000 (1998)	$446,021
Ruben, 2001	USA	Adult*	Lost productivity	All communication disorders	$122.6 billion (1999)		$180.1 billion
Honeycutt *et al*, 2004	USA	Lifetime	Direct medical; direct non-medical; lost productivity	Identification of children with hearing loss	$2.1 billion (2003)	$417,000 (2003)	$2.8 billion total $554,800 pp
Christensen, 2006	Denmark	50-64	Lost productivity	Mild to severe (self-reported and audiometry)	DKK 2.7 billion ~ €360 million (2006)		€423.8 million
Access Economics, 2006	Australia	All	Health system, lost productivity, informal care, QoL	BEHL > 25 dB	AU$23.05 billion (2005)		AU$30.4 billion
Stucky *et al*, 2010	USA	≥ 65	Direct medical costs in 1st year of treatment, lost productivity	Mild to severe hearing difficulty (self-reported)	$9.6 billion (in 2002) $60.4 billion (in 2030)		$13 billion N/A
Kochkin, 2010a	USA	>20	Loss of income	Mild to severe (self-reported)	$176.3 billion (2008)	Depends on severity of HL	$200.4 billion
			Loss of taxes		$26.4 billion (2008)		$30 billion
Foley *et al*, 2014	USA	≥ 65	Excess medical expenditure due to HL	Mild to severe (self-reported)	$3.1 billion (2012)	$392 (2012)	$3.3 billion total $418 pp
ILC-UK, 2014	UK	16-64	Lost productivity	All grades	£24.8 billion (in 2013) £38.6 billion (in 2031)		$26 billion N/A
Archbold *et al*, 2014	UK	16-64	Lost earnings, GP visits, social care, QoL	Any grade (self-reported)	£30.1 billion (2013)		£31.8 billion

Table 14.1 Studies of costs of hearing loss (continued)

Authors	Country	Age	Costs included	Definition of HL	Total cost (year)		2017 cost+
					Total	Per person	
de Kervasdoue & Hartmann, 2016	France	> 20	Intangible/QoL	Moderate to severe (self-reported)	€23.4 billion (2014)		€23.9 billion
Simpson *et al,* 2016	USA	55-64	Excess medical expenditure due to HL	Diagnosed HL		$3168 over 18-month period (2010-2013)	$3329-$3556 depending on year
WHO, 2017	Global	Adults and children	Healthcare, education, lost productivity, societal/QoL	BEHL > 35 dB	I$728-812** billion (2017)		I$728-812 billion**
	High income region				I$316 – 347** billion (2017)		I$316-347 billion**
	Central Europe				I$66-73** billion (2017)		I$66-73 billion**
Deloitte Access Economics, 2017a	Australia	All	Health system, lost productivity, informal care,QoL	BEHL > 25 dB	AU$33.3 billion		AU$33.3 billion
Deloitte Access Economics, 2017b	New Zealand	All	Health system, lost productivity, informal care, QoL	BEHL > 20 dB	NZ$4.9 billion		NZ$5.0 billion

*Report addressed adults and children – only adults reported here
**Figures corrected by author
+ Costs for USA, Denmark, France, UK, Australia updated to 2017 equivalent using website *www.in2013dollars.com* and for New Zealand *www.rbnz.govt.nz.* Inflation rates based upon data from US Bureau of Labour Statistics, European Central Bank, UK Office of National Statistics, Reserve Bank of Australia, Reserve Bank of New Zealand

The following sections briefly describe individual studies which are grouped according to the country or region to which they apply.

14.3.1 Global costs of hearing loss

In 2017 the World Health Organisation published an analysis of the global cost of moderate and greater hearing loss (defined as hearing loss greater than 35 dB in the better ear) in adults and children. The estimated annual costs were based upon reviews of previous studies of costs of hearing loss, and excluded costs associated with interventions such as screening and provision of hearing devices. Costs were reported in international dollars (denoted here as I$), a hypothetical currency defined by the World Bank which would purchase in a particular country the same amount of goods or services as could be purchased in the USA for the equivalent amount of US dollars. Component and overall global costs were estimated, and also presented for each of the WHO regions; western European countries are included in the high income region, while central and east European countries are included in the Central/eastern Europe and central Asia region (referred to as 'Central Europe' for brevity in this section). In the following discussion, global costs and costs for the two regions relevant to Europe are shown.

In estimating costs the following contributions were taken into account: direct costs to health care systems (excluding the costs of providing hearing devices such as cochlear implants and hearing aids); costs to education systems of additional support for children with hearing loss greater than 50 dB in the better ear; indirect costs consisting of productivity losses due to unemployment; and societal or intangible costs resulting from the psychosocial effects of hearing loss, and based upon disability adjusted life years (DALYs).

Because of widely differing estimates of health care costs in the studies reviewed by the WHO, two different scenarios for each of child and adult estimates of health care costs were used. The estimates of health care costs for children (aged 0-14 years) are shown in Table 14.2 and for adults are shown in Table 14.3.

The costs to the education system of children aged 5 to 14 with at least moderately severe hearing loss (BEHL > 50 dB) were also calculated and are included in Table 14.2.

Table 14.2. Health care and education costs for children (WHO, 2017)

	Prevalence (2015 GBD study)	Health care costs (I$, thousands)		Education costs (I$, thousands)
		Scenario A1	Scenario B1	
High income region	938,451	9,031,351	4,733,435	658,944
Central Europe	784,206	2,937,270	1,539,457	233,620
World	22,469,896	45,860,499	24,036,016	3,914,681

Table 14.3. Health care costs for adults (aged 15 years and over) (WHO, 2017)

	Prevalence (2015 GBD study)	Costs (I$, thousands)	
		Scenario A2	Scenario B2
High income region	68,898,706	9,208,295	35,935,014
Central Europe	36,764,655	2,190,543	8,548,508
World	422,223,343	21,485,488	83,846,285

The total health care costs have been calculated incorrectly in the WHO report, which states that the health care costs range from I$67 to I$107 billion globally; from I$18.2 to I$40.7 billion for the high income region; and from I$5.1 to I$10.1 billion for Central Europe. The correct figures are shown in Table 14.4, in which the amounts in Tables 14.2 and 14.3 have been correctly combined.

Table 14.4. Total health care costs for adults and children (WHO, 2017, corrected)

	Minimum (I$, thousands)	Maximum (I$, thousands)
High income region	13,941,730	44,966,365
Central Europe	3,730,000	11,485,778
World	45,521,504	129,706,784

The analysis of annual productivity losses took account only of losses due to unemployment and premature retirement (and not underemployment), and considered only those with moderately severe or worse hearing loss. The authors point out that this therefore leads to a conservative estimate of productivity losses as it does not include those with mild or moderate hearing loss. Table 14.5 shows the productivity losses due to unemployment among 15 to 64 year olds.

Table 14.5. Productivity losses due to hearing loss among adults of working age with moderate/severe and greater hearing loss (WHO, 2017)

	Prevalence (2015 GBD study)	Productivity costs (I$, thousands)
High income region	5,773,196	30,115,025
Central Europe	3,243,370	8,585,116
World	65,119,976	104,922,293

Finally, societal costs were estimated from net costs of DALYs due to hearing loss, after excluding productivity losses, and were found to be approximately I$573.5 billion globally, I$270.8 billion in the high income region and I$53 billion in the Central Europe region.

The total costs have been estimated by adding the health care, productivity and societal costs. The error in calculating the total health care costs has therefore led to an error in the calculation of the total costs, which are stated in the report to vary between I$750 and I$790 billion globally, I$320 and I$342 billion in the high income region, and I$67 and I$72 in the Central Europe region.

The correct figures are shown in Table 14.6 from where it can be seen that the estimated costs for hearing loss vary from I$728 to I$812 billion globally, I$316 and I$347 billion in the high income region, and I$66 and I$73 in the Central Europe region.

Table 14.6. Total costs of hearing loss for adults and children (WHO, 2017, corrected by the author)

	Minimum costs (I$, thousands)	Maximum costs (I$, thousands)
High income region	315,527,706	346,552,341
Central Europe	65,592,569	73,348,347
World	727,855,916	812,041,196

The WHO authors point out that there will be additional costs due to, for example, informal care and communication technologies, but that there is insufficient information available concerning these costs which are highly country specific.

14.3.2 Costs of hearing loss in USA

A major report on hearing loss in the USA was published in 2016, with the aim of improving accessibility and affordability of hearing care for adults (Blazer *et al*, 2016). The report briefly discusses the economic consequences of hearing loss through citing individual

studies in which different aspects of consequences of hearing loss have been evaluated, but no further analysis of costs is carried out by the authors of the report.

Table 14.1 shows that many of the recent studies have concerned the costs of hearing loss in the USA. The early studies by Mohr *et al* (2000) and Ruben (2001), which were described in detail in the 2006 Hear it report (Shield, 2006), highlighted the high costs to society of hearing loss, mainly due to lost productivity as a result of unemployment or underemployment of working age adults.

In 2004 Honeycutt *et al* published a comparison of the lifetime costs associated with four long term conditions: mental retardation, cerebral palsy, hearing loss, and vision impairment. In estimating the costs they included many components of the total costs associated with the conditions: direct medical costs (due to physician visits, prescription medications, hospital inpatient stays, assistive devices, therapy and rehabilitation, long-term care); direct non-medical costs (due to home and vehicle modifications, special education); and indirect costs (including productivity losses due to inability to work or limitations in the type of work performed).

Table 14.7 shows the estimated total lifetime costs, and lifetime costs per person with the condition, for the four disabilities, for persons born in 2000 (costs in 2003 dollars). The authors note that special education formed a major part of the direct non-medical costs for all conditions. The components of costs for hearing loss are shown in Table 14.8.

Table 14.7. Estimated lifetime costs for four long term conditions (Honeycutt *et al*, 2004)

Disability	**Total $ (millions)**	**Average per person $**
Mental retardation	51,237	1,014,000
Cerebral palsy	11,470	921,000
Hearing loss	2,102	417,000
Vision impairment	2,484	566,000

Table 14.8. Components of lifetime costs of hearing loss (Honeycutt *et al*, 2004)

Component of costs	**Lifetime cost**
Direct medical costs	$132 million
Direct non-medical costs	$640
Indirect costs	$1330 million
Total costs	**$2102 million**
Average per person	**$417,000**

Table 14.8 shows that the major component of the costs of hearing loss is indirect costs, which is consistent with the findings of the study by Mohr *et al* (2000).

In 2010 Stucky *et al* (2010) examined the economic impact of age related hearing loss among people aged 65 and older in the US. Their calculations were carried out at a national level and also local levels for the state of California and Los Angeles County. They calculated direct medical costs incurred during the first year of treatment and costs attributable to low productivity (based upon the data of Mohr *et al*, 2000), for the years 2002 and 2030. Details of the calculations are not reported. The national results are shown in Table 14.9.

Table 14.9. Costs of hearing loss in USA in 2002 and 2030 (Stucky *et al*, 2010)

	2002	2030
Total population, n	287,726,647	363,584,435
Adults aged 65 and older with hearing loss, n	6,357,942	12,764,377
Direct medical costs for first year of treatment	$8,215,923,722	$51,406,229,193
Lost productivity attributable to hearing loss	$1,432,825,867	$8,965,059,909

Another study which considered the medical costs associated with hearing loss was that of Foley *et al* (2014), who found that, among the US population aged 65 and over in 2010, self-reported hearing loss was associated with additional medical costs of $392 per person compared with those with normal hearing, equivalent to a total of $3.1 billion (2012 USD). The calculations were based upon a survey of 35,000 individuals and included costs for individual items such as outpatient visits, inpatient hospital stays, medical supplies, equipment and drugs, and home health care. Not all the costs were directly related to hearing health care; it is possible that some of the excess expenditure is due to hearing related health conditions.

Another study examined the differences in health care costs between middle aged people (aged 55 to 64) with hearing loss and those without (Simpson *et al*, 2016). Medical costs associated with 16 chronic conditions were evaluated over a period of up to 18 months, between 2009 and 2013, using records of private insurance payments. After adjusting for hearing related medical costs, the mean cost for patients with untreated hearing loss was $13,797, compared with $10,629 for patients without hearing loss. Thus the excess medical costs associated with hearing loss was $3168 per person over 18 months.

The costs due to lost productivity and earnings have been examined by Kochkin (2007a, 2010a) in his analyses of data from Marketrak surveys, in which he estimated the loss of income due to untreated hearing loss, and to hearing loss of different grades of severity (see Chapter 8). In his most recent analysis, of the 2009 Marketrak VIII survey of over 40,000 households, Kochkin (2010a) showed that someone with a severe hearing loss could earn around $14,000 per annum less than someone with mild or no hearing loss. The total amount of lost income resulting from underemployment due to untreated hearing loss was calculated as $176 billion, with resulting loss in federal taxes of $26 billion. As discussed in Chapter 12, Kochkin further examined the role of hearing aids on salary profile and found that the loss in income is mitigated by up to $20,000 per year by use of hearing aids, depending on the severity of the loss.

14.3.3 Costs of hearing loss in Denmark

In 2006 a report was published by the Danish National Institute of Social Research in which the socio-economic cost of hearing loss due to lost productivity among 50 to 64 year old Danes was estimated (Christensen, 2006). Data for the whole population were extrapolated from a survey of 2400 people. The calculation was based upon the potential increases in employment probabilities and working hours for hearing impaired men and women if their hearing loss did not exist. The resulting loss of productivity was calculated as 2.7 billion DKK, equivalent to €360 million.

14.3.4 Costs of hearing loss in France

Following an extensive review of literature concerning the prevalence, implications and economic impact of hearing loss published between 2005 and 2015, de Kervasdoue and Hartmann (2016) calculated the economic impact of hearing loss in France, and hence showed the cost effectiveness of intervention, the cost savings that would result from fitting more people with hearing aids, and the resulting implications for the hearing aid sector in

France. They assessed the annual economic burden of hearing loss in France by calculating the intangible costs related to the reduction in quality of life due to hearing loss. The calculation method was based upon that of Shield (2006), and involved applying the health utility indices proposed by Shield (2006) for different grades of hearing loss to the hearing impaired population of France, see Table 14.10. Using this method, with a reference value of €40,000 for an additional QALY (as opposed to €44,000 used by Shield (2006)) they calculated the economic burden to France of untreated hearing loss to be €23.4 billion per annum.

Table 14.10. Calculation of costs of hearing loss in France (2014 figures) (de Kervasdoue and Hartmann, 2016)

Grade of hearing loss	Moderate	Severe	Very severe to total	Overall
Average HUI for adult in good health	0.85	0.85	0.85	
HUI associated with hearing loss	0.80	0.7	0.6	
HUI reduction due to hearing loss	0.05	0.15	0.25	
Value of reduction in QoL per QALY (€40,000)	€2,000	€6,000	€10,000	
Number of HI people in France	4,044,514	1,940,495	368,348	6,353,357
Cost (billion €)	8.09	11.64	3.68	23.4

Assuming that aids restore 75% of the degraded quality of life, de Kervasdoue and Hartmann further calculate the reduction in cost burden achieved by use of hearing aids, Using Eurotrak data on current hearing aid use in France, they calculate that the economic burden is reduced by 30% (€6.6 billion) with current hearing aid supply and use, and would be reduced by 40% (€8.8 billion) if hearing aids were supplied to, and used by, 50% of hearing impaired people.

The authors also estimated additional health care costs in France as a result of hearing loss to be 400 euros for moderate loss, 1200 euros for severe hearing loss and 2000 euros for very severe loss per person per year. If 50% of hearing impaired people had been provided with hearing aids in 2014, the saving in health care costs would have been 290 million euros.

14.3.5 Costs of hearing loss in the UK

There have been several studies in recent years of the implications and costs to the UK of hearing loss.

The final report of the Commission on Hearing Loss, established by the International Longevity Centre-UK to consider the implications of age related hearing loss in the UK, was published in 2014 (Commission on Hearing Loss, 2014). The report estimated that the cost to the UK economy of hearing loss due to unemployment alone was £24.8 billion in 2013, which, if nothing is done to improve employment rates of hearing impaired people, will increase to £38.6 billion in 2031. This figure would be higher if levels of underemployment of those with hearing loss were also accounted for. The calculation method used was adapted from that of Shield (2006), the main difference being that, rather than basing the calculation upon average earnings, average economic output per worker was used, and the age range was restricted to 16 to 64 years of age. Also. the proportion of those with hearing loss in employment was compared with that of those without a long term health issue or disability, rather than with the overall UK employment rate, as in the calculations of Shield (2006).

A report published by the Ear Foundation (Archbold *et al*, 2014) examined additional health and social service use, reduced income and reduction in health related quality of life arising from hearing impairment, using data from over 13,000 respondents to the 2009 British Household Panel Survey. The authors extrapolated from the 2006 Australian report (Access Economics, 2006) to provide an estimate of the value of reduced health related quality of life

in the UK in 2013. The estimated costs of GP services, social worker services, lost earnings and reduced quality of life are shown in Table 14.11. It can be seen that the total economic burden due to these factors in the UK is over £30 billion per year (2013 prices). As the authors point out, this is a conservative estimate given that it does not include several additional factors such as costs of informal care, and costs associated with the treatment of conditions related to hearing loss.

Table 14.11. Financial burden of hearing loss in UK in 2013 (Archbold *et al*, 2014)

Item	Estimate (£)
GP services	76 million
Social worker services	59 million
Lost earnings	4 billion
Reduced quality of life	26 billion
Total	**30.13 billion**

14.3.6 Costs of hearing loss in Australia

A major report was published in 2006 which evaluated in detail both the real financial costs and the cost of loss of well-being in Australia in 2005 due to hearing loss (Access Economics, 2006). The financial cost was estimated to be $11.75 billion (Australian dollars), representing an average cost of $3,314 per hearing impaired person per annum, or $578 per person when considering the whole population. The greatest component of the costs was lost productivity costs of $6.7 billion, and second was the cost of informal care at $3.2 billion. Direct health system costs of $674 million formed a relatively small percentage of the total financial costs. Additional costs due to loss of wellbeing were calculated as $11.3 billion. (All costs in 2005 Australian dollars.)

The Hearing Care Industry Association (HCIA) recently commissioned an update of the 2006 report (Deloitte Access Economics, 2017a) in which a further detailed assessment was carried out of many direct and indirect costs associated with hearing loss in Australia. The calculated costs include direct health care costs; indirect costs arising from items such as lost productivity, informal care and lost taxes; and the monetary value of the loss of well-being.

Direct health care costs relating to diagnosis, treatment and management of hearing loss were estimated to be $881.5 million in 2017, or $245 per hearing impaired person.

A breakdown of the estimated indirect costs, totalling $15 billion, is shown in Table 14.12.

Table 14.12. Estimated indirect financial costs of hearing loss in Australia in 2017 (Deloitte Access Economics, 2017a)

	Total	Per person
Productivity losses	$12.8 billion	$3566
Informal care costs	$141.6 million	$39
Deadweight losses	$1.6 billion	$440
Other	$480.3 million	$134
Total	**$15 billion**	**$4179**

In analysing the costs by age and gender it was shown that the highest proportions of the costs occurred for males in the 50 to 64 age range.

The individual components of lost productivity costs are shown in Table 14.13.

Table 14.13. Estimated costs of productivity losses due to hearing loss in Australia in 2017 (Deloitte Access Economics, 2017a)

	Total	Per person
Reduced employment	$9.26 billion	$2579
Absenteeism	$1.58 billion	$440
Presenteeism (underemployment)	$1.96 billion	$547
Premature mortality	$1.1 million	$0.3

The costs associated with reduced employment were calculated by applying the differences in employment rates between those with and those without hearing loss to average weekly earnings in different age groups. The costs of absenteeism were based upon the average days sick leave due to hearing loss reported by Nachtegaal *et al* (2012) and average weekly earnings according to age and gender. The authors also used the study by Nachtegaal *et al* (2012) to calculate the average decrease in productivity due to 'presenteeism' (that is, underemployment) of employees with hearing loss to be 2.8%, relative to employees without hearing loss. Based upon average weekly earnings, this results in a loss of approximately $2 billion for 2017. The costs associated with premature mortality applied only to 75 to 79 year olds, and took account of lost earnings and administrative costs.

The costs of informal care for those with hearing loss, shown in Table 14.12, were based upon the additional number of hours per week of care needed for people with hearing loss, and the lost earnings of carers. Deadweight losses included lost taxes (from consumers, companies and carers) and welfare benefits. The 'other' costs include items such as education and support services, communication aids and services.

The report also estimated the cost of loss of well-being due to hearing loss by calculating the disability adjusted life years (DALYs) due to hearing loss according to age and gender, using the disability weights proposed by Salomon *et al* (2015) for the Global Burden of Disease study (see Chapter 3). In total, hearing loss in Australia accounted for 90,223 DALYs in 2017. To translate this to a financial cost the number of DALYs was multiplied by the value of a statistical life year (VSLY) for 2017 of $193,821 giving a total value of $17,441 billion for loss of well-being.

Thus, the report concludes that the total cost of hearing loss in Australia in 2017 was $33.3 billion, or $9,280 per person with hearing loss. This includes health system costs ($881.5 million), indirect financial costs ($15 billion, see Table 2.12), and the cost of lost wellbeing ($17.4 billion).

This figure compares with the 2006 estimate (Access Economics, 2006) of $11.75 billion financial costs, plus an additional $11.3 billion representing loss of wellbeing, giving a total of $23.05 billion. Hence the figures in the 2017 report suggest that the overall cost of hearing loss increased by 44% between 2005 and 2017.

14.3.7 Costs of hearing loss in New Zealand

Deloitte Access Economics carried out a similar analysis to that of the Australian study, to estimate the overall costs of hearing loss in New Zealand in 2016 (Deloitte Access Economics, 2017b). The details of the analysis will not be repeated here as they were very similar to those described above for the Australian case. The total cost of hearing loss in New Zealand in 2016 was estimated to be $4.9 billion, comprising $957.3 million in financial costs and $3.9 billion in loss of well-being. This equates to approximately $5,556 per person with hearing loss. The financial costs include $132 million health system costs and $552.4 in lost productivity. (Note error in Table 10.1 of report: $129.8 million health system costs

should be $131.8 million, and $147 per person should be $150 per person, but total costs are correct.)

14.4 OVERVIEW OF COSTS

This section gives an overview of the costs reported in the previous section, and discusses additional costs that may occur as a result of hearing loss.

14.4.1 Comparison of costs

Table 14.1 and section 14.3 show that the majority of the reviewed studies have involved a calculation of lost earnings or lost productivity. The second most commonly occurring factor in the estimation of costs of hearing loss is medical costs. (Detailed discussion of direct medical costs associated with screening for hearing loss and supply of hearing technologies are beyond the scope of this report.) Financial estimates for the reduced quality of life associated with hearing loss are calculated in four national reports and globally (WHO, 2017), and are added to the indirect financial costs to give an overall figure for the total costs of hearing loss in different areas

Table 14.14 shows the most commonly occurring elements (health care, lost productivity, reduced quality of life) contributing to the overall costs in the reviewed studies (original, not updated figures). Note that Table 14.14 includes only the most recent, 2017, Australian study, not the 2006 study which it superseded.

It can be seen that, in studies where both health costs and costs arising from lost productivity have been estimated, in general the costs of lost productivity greatly exceed the health care costs. The only study where the reverse is true is that of Stucky *et al* (2010). The reasons for this are not clear from the paper which gives little detail of the calculation methods. In studies where the monetary value of reduced quality of life has also been calculated, this is greatly in excess of the costs of lost productivity. Thus, the health care costs appear to be a minor factor in the overall costs of hearing loss, which are dominated by lost productivity among those of working age and, even more, by the cost of reduced quality of life due to hearing loss.

Table 14.14 also shows that, consistent with the findings of the reviews by Hjalte *et al* (2012) and Huddle *et al* (2017), there is very great variation in estimated costs, even within the same countries. This is especially true of the costs of lost productivity; the estimated figures for the costs of reduced quality of life are more consistent, with the differences reflecting the different sizes of populations in the various countries.

14.4.2 Additional costs

In addition to the costs discussed above and shown in Table 14.14, there will be many additional costs associated with hearing loss. Some of the studies have estimated costs resulting from items such as lost taxes (Kochkin, 2010a), informal or social care (Honeycutt, 2014; Access Economics, 2006; Archbold *et al*, 2014; Deloitte Access Economics 2017a, 2017b), special education and rehabilitation (Honeycutt *et al*, 2014; WHO, 2017) and technological/communication aids for hearing impaired people (Access Economics, 2006; Deloitte Access Economics 2017a, 2017b). There will also be costs associated with unemployment and underemployment such as welfare payments (Kochkin, 2010a; Clinkard *et al*, 2015). However, all these additional costs have been estimated to be relatively small compared with the costs of lost productivity and reduced quality of life.

In addition to these costs there will be further medical costs as a result of treatment for the various related conditions that were outlined in Chapter 7. Although there are few definitive estimates of the likely costs involved, several authors note that they make a substantial

Table 14.14. Costs of health care, lost productivity and reduced quality of life

Authors	Country	Age	Health care	Lost productivity	QoL
Mohr *et al*, 2000	USA	Lifetime	$223,800	$1,505,500 (1998)	
Ruben, 2001	USA	Adult*		$122.6 billion (1999)	
Honeycutt *et al*, 2004	USA	Lifetime	$132 million	$1.3 billion (2003)	
Christensen, 2006	Denmark	50-64		€360 million (2006)	
Stucky *et al*, 2010	USA	≥ 65	$8.2 billion (2002) $51.4 billion (2030) (cost of 1st year of treatment)	$1.4 billion (2002) $9.0 billion (2030)	
Kochkin, 2010a	USA	>20		$176.3 billion (2008)	
Foley *et al*, 2014	USA	≥ 65	$3.1 billion (2012) (excess medical expenditure)		
ILC-UK, 2014	UK	16-64		£24.8 billion (in 2013) £38.6 billion (in 2031)	
Archbold *et al*, 2014	UK	16-64	£76 million (GP visits)	£4 billion (2013)	£26 billion
de Kervasdoue & Hartmann, 2016	France	> 20			€23.4 billion (2014)
WHO, 2017**	Global	Adults and children	I$45.5 -129.7 billion	I$104.9 billion (2017)	I$573.5 billion
	High income region		I$13.9-45 billion	I$30.1 billion (2017)	I$270.8 billion
	Central Europe		I$3.7-11.5 billion	I$8.6 billion (2017)	I$53 billion
Simpson *et al,* 2016	USA	55-64	$3168 excess medical expenditure per HI person over 18-month period (between 2010 and 2013)		
Deloitte Access Economics, 2017a	Australia	All	AU$881.5 million	AU$12.8 billion (2017)	AU$17.4 billion
Deloitte Access Economics, 2017b	New Zealand,	All	NZ$132million	NZ$552.4 million (2016)	NZ$3.9 billion

*Report addressed adults and children – only adults reported here
**Figures corrected by author

contribution to the overall economic burden to society of hearing loss. As can be seen in Tables 14.1 and 14.14, and discussed in section 14.3.2, total medical expenditure for people with hearing loss has been compared with that of people with normal hearing in two studies in the USA (Foley *et al*, 2014; Simpson *et al*, 2016). Estimates for excess expenditure per

hearing impaired person vary from $392 per person in 2012 (Foley *et al*, 2014) to $3148 per person over an 18 month period between 2009 and 2013 (Simpson *et al*, 2016). However, these findings disagree with those of a Dutch study (Nachtegaal *et al*, 2010) which found that, once health care costs had been adjusted to exclude those related to hearing, there was no difference in the costs between those with and without hearing loss. The main differences between the studies are that the Dutch study relates to a shorter time period (6 weeks) than the American studies, and includes adults aged between 18 and 65, whereas the American studies concern older age groups. It is likely that there will be greater occurrence of other conditions associated with hearing loss among older, rather than younger, hearing impaired persons, which may account for the discrepancy.

Regarding costs of particular conditions associated with hearing loss, there have been some estimates of the costs of dementia related to hearing loss, which are discussed in the following section, together with potential savings in such costs which could result from interventions to treat hearing loss.

14.5 POTENTIAL COST SAVINGS DUE TO TREATMENT FOR HEARING LOSS

There is now a large body of evidence confirming the associations between hearing loss and other long term conditions, as discussed in Section B. Hearing loss has been shown to be related to overall health status and to many and multiple chronic conditions including cardiovascular disease, stroke and arthritis (McKee *et al*, 2018) and strong links have been demonstrated with dementia (Livingston *et al*, 2017). A report published by the Ear Foundation (Archbold *et al*, 2014) quotes data from the 2012 survey of GPs in the UK which showed that 83% of those with severe hearing loss have an additional long term condition, and 33% have more than two additional long term conditions. The costs of treating these other conditions represent a further indirect economic burden of hearing loss. Hence treating hearing loss may have the potential to reduce some of the additional financial burden associated with related diseases.

The cost of treating dementia related to hearing loss in the UK was calculated by Action on Hearing Loss, in a report which discussed the costs of treating other conditions associated with hearing loss, and potential savings due to management of hearing loss (Echalier *et al*, 2013). The report examined issues relating to the provision of health and social services to hearing impaired and deaf people who also have long term conditions such as diabetes, cardiovascular disease or dementia. The only actual costs calculated are those related to dementia among hearing impaired people. The report estimated that better management of hearing loss in people with severe dementia in England would lead to potential savings of at least £28 million per year.

Further information confirming the association between hearing loss and dementia, and the role of hearing loss in the global costs of dementia, was recently published in the major report of the Lancet Commission on Dementia (Livingston *et al*, 2017). The report states that the estimated global cost of dementia in 2015 was $818 billion, a figure that will increase as the number of people with dementia continues to increase. In a meta-analysis of several studies it was demonstrated that, of nine potentially modifiable risk factors for dementia, hearing loss was the highest. Hearing loss in middle age and older was found to increase the risk of dementia, and therefore management of hearing loss is a possible strategy that could contribute to the prevention of, or delay the onset of, dementia (Livingston *et al*, 2017). If the onset of dementia were delayed by five years, the authors report that its prevalence would be halved, thereby significantly reducing the societal and economic burden.

Other reports have estimated the potential reductions in the number of doctor consultations and use of social care as a result of treating hearing loss. Archbold and colleagues examined the reduction in GP consultations and social worker visits among hearing impaired

people in the UK over the period from 1992 to 2009, which they assumed was due to increased access to, and improvements in, hearing technologies over that period (Archbold *et al*, 2014; Lamb *et al*, 2015; O'Neill *et al*, 2016). They calculated that this represented savings of between £52 and £92 million per year, giving a total saving of up to £1.5 billion over the 17 year calculation period (2014 prices). The authors recognise that other technological changes, for example in communication technologies such as texting and email, would also have contributed to changes in behaviour, possibly resulting in less need for health and social services. Nevertheless, they consider that it is reasonable to assume that reduction in need is at least partially attributable to the increase in access to new technologies for managing hearing impairment.

In a cost benefit analysis of screening for hearing loss in the UK, published in 2010 by the RNID (now Action on Hearing Loss), an estimation was made of the savings that would have been made in the 10 year period from 2010 to 2019 if hearing screening was introduced for 55 year olds and 65 year olds (London Economics, 2010). The calculations assumed that a certain number of people in each age group would be fitted with hearing aids as a result of the screening. The savings included avoided costs related to personal and social welfare, employment, health care services and health care efficiency, and are summarised in Table 14.15 (2010 prices).

Table 14.15. Costs (2010-2019) of hearing loss potentially avoided as a result of interventions (London Economics, 2010)

Avoided costs	**55 year olds (£ million)**	**65 year olds (£ million)**
Personal and social	335.6	1,480.9
Employment related	339	493.6
Health care services	21.2	92.9
Health care service efficiency	3.9	17.2
Total	**699.6**	**2,084.6**

The calculation of personal and social costs was based upon the quality of life calculation method of Shield (2006). The employment related costs include earnings of previously unemployed hearing impaired people, plus increased income of hearing impaired people earning more after being fitted with hearing aids. The costs of health care services are based upon an evaluation of GP visits involved in treating various conditions that are known to be associated with hearing loss, such as depression and stress.

As reported in section 14.3.4, de Kervasdoue and Hartmann, in estimating the economic impact of hearing loss in France in 2014, calculated that if 50% of hearing impaired people in France had been provided with hearing aids, the health care costs would have been reduced by €290 million, and the reduction in cost burden due to reduced quality of life by €8.8 billion.

Increasing employment and earnings among hearing impaired people as a result of interventions to improve hearing would also reduce welfare payments and other benefits (Kochkin, 2010a; Clinkard *et al*, 2015).

14.6 SUMMARY

The main findings of the review of published data on the economic burden of hearing loss in this chapter are as follows.

- The issue of the economic costs of hearing loss has become of increasing importance in the past decade, with several countries carrying out national studies to estimate the costs and the WHO estimating global and regional costs.
- Comparison between studies is difficult because of different contributing factors considered and the wide range of methods used in estimating costs.
- The greatest cost of hearing loss arises from the monetary costs of reduced quality of life caused by hearing loss.
- The second greatest contribution to costs of hearing loss results from lost productivity as a result of unemployment and underemployment of hearing impaired people.
- Additional costs will arise as a result of treatment of conditions associated with hearing impairment.
- Costs of hearing loss could be reduced if a greater percentage of people with hearing loss were provided with hearing technology: costs of lost productivity, reduced quality of life and health care for associated conditions would all be significantly reduced.

14.7 CONCLUSIONS

This chapter has reviewed studies and reports which have contained estimates of the costs of hearing loss in different countries. It can be seen that there are many variations in methods used and economic factors accounted for in the calculations. There are also variations in the age ranges and degrees of hearing loss included in the various studies. It is thus difficult to draw any general conclusions regarding exact costs of hearing impairment. However, the majority of studies show that the greatest contributions to the costs of hearing loss to society are the costs associated with lost productivity and quality of life. In studies where both of these elements have been calculated the higher figure is that due to reduction in quality of life.

Furthermore, it has been shown that the economic burden of hearing loss could be substantially reduced if more people were fitted with hearing aids.

The results of the review in this chapter suggest that, in calculating the costs of hearing loss in Europe, the focus should be on both lost productivity and reduction in quality of life, as in the 2006 report (Shield, 2006). The following chapter describes the methodology which has been used for the calculation of these two elements of the costs of hearing loss in Europe, and presents the resulting estimated costs.

CHAPTER 15 CALCULATION OF COSTS OF HEARING LOSS IN EUROPE

15.1 INTRODUCTION

This chapter presents the methods used for, and the results of, calculations of the costs of hearing loss in Europe. The calculation methods used are similar to those used in the 2006 Hear It report (Shield, 2006) but have been adapted and informed by material presented in earlier chapters of this report.

The calculations have been carried out for each country in the Global Burden of Disease categories of Europe (Western Europe, Central Europe and Eastern Europe), apart from Andorra. Results for individual countries are presented in Appendix D. In this chapter results are presented for Europe as whole, the European Union (28 countries) and non-EU countries of Europe (13 countries) as shown in Appendix D.

15.2 COMPONENTS OF COSTS

As was seen in Chapter 14, several authors have made estimates of the costs of hearing loss in different countries, and globally. Different components of costs have been considered, the most common being lost productivity due to lack of employment of hearing impaired people, reduction in quality of life of hearing impaired people, and the health costs associated with assessing hearing and fitting with hearing aids or cochlear implants.

As the health costs vary between countries owing to different financial models of health care, this report considers only the two components related to quality of life and lost productivity.

The data required to estimate the costs for each country, for each component, are listed in Table 15.1, together with the sources for the data used in this study.

Table 15.1. Data for estimation of costs of hearing loss in each country

	Data	**Source**
QUALITY OF LIFE	Number of adults (15+ years) with each grade of hearing loss	Extrapolated from GBD 2017 data
	GDP per capita	IMF website July 2018 data
	Health utility indices for each category of hearing loss	Estimated by author
LOST PRODUCTVITY	Number of adults of working age (15-64 years) within each grade of hearing loss	Extrapolated from GBD 2017 data
	Economic output per person (GDP per employed person)	Calculated from data (July 2018) on GDP and number of employed persons on Trading Economics website
	Employment rate for 15 to 64 age group	Trading Economics website, except for 4 countries: data for Albania, Bosnia and Herzogovina and Montenegro from World Bank (2018); for Belarus extrapolated from data on belstat.gov website.

The prevalence data from the 2017 GBD study were released towards the end of 2018 and are available at http:// vizhub.healthdata.org/gbd-compare (Institute for Health Metrics and Evaluation). The data used for the calculations in each category of hearing loss in each country have been rounded to the nearest 1000.

The GBD 'mild' category refers to hearing loss between 20 and 34 dB. In calculating costs due to reduced quality of life and lost productivity, three categories of hearing loss are considered: hearing loss of 20 dB and greater, of 25 dB and greater and of 35 dB and greater. To estimate the numbers of people in the 25 dB to 34 dB category it was assumed that the number of people with hearing loss between 20 and 25 dB is 45% of those with hearing loss between 20 and 35 dB, based upon the prevalence data of Davis (1995).

All GDP data, which were in US dollars, have been converted to euros using an exchange rate of $1 = €0.85 which was the exchange rate on 20th July 2018.

15.3 COSTS OF REDUCED QUALITY OF LIFE DUE TO HEARING LOSS

In the 2006 report (Shield, 06) an innovative method using a health utility approach was used to estimate the overall costs of reduced quality of life (QoL) caused by hearing loss. Shield applied health utilities indices (HUI), with values derived from cost effectiveness studies of cochlear implants, to the prevalence of hearing loss at different grades; this enabled the calculation of the costs to Europe of the reduction in quality of life due to hearing loss in terms of lost quality adjusted life years (QALYs).

15.3.1 The health utilities index (HUI)

As has been seen in previous chapters, there are several quality of life measures that are commonly used in hearing and hearing aid studies to evaluate the perceived detriment in quality of life caused by hearing loss, and benefits obtained from the use of hearing aids.

The HUI remains a valid means of estimating quality of life and continues to be used in cost benefit analyses and assessments of interventions related to hearing loss such as screening (Barton *et al*, 2005; Davis *et al*, 2007), fitting with cochlear implants (Bond *et al*, 2009; Chen *et al*, 2014; Smulders *et al*, 2016) and fitting with hearing aids (Davis *et al*, 2007; RNID, 2010; Swan *et al,* 2012; de Kervasdoue and Hartmann, 2016). Furthermore, the method of Shield (2006), or an adaptation of it, has been used in subsequent studies and the HUI values assigned by Shield to different levels of hearing loss considered valid and used in other calculations of the cost effectiveness of hearing aids (RNID, 2010; de Kervasdoue and Hartmann, 2016). Alternative health state valuations between 0 and 1, similar to the HUI, have been used in other studies of the effectiveness of hearing aids (Chao and Chen, 2008; Baltussen and Smith, 2009).

The health utilities index, HUI, focuses on a person's ability to function in eight different domains (vision, hearing, speech, mobility, dexterity, emotion, cognition and pain), but does not assess the implications of impairments in those areas. It therefore differs from other scales such as the EQ-5D or SF-36 which focus more on the implications of impairments, and how they affect a person's day to day performance. Barton *et al* (2005) compared the use of three quality of life measures, the HUI, EQ-5D and SF-36, for assessing the quality of life of hearing impaired adults and concluded that the HUI was more able than the other two measures to detect the expected quality of life deficits associated with hearing impairment.

15.3.2 Values of HUI corresponding to hearing loss

The values of HUI associated with different grades of hearing impairment which were used in the report by Shield (2006) and in subsequent calculations of the costs of lost quality of life due to hearing loss (RNID, 2010; de Kervasdoue and Hartmann, 2016) are shown in Table 15.2.

In these studies it was assumed that the average HUI for the population who are not hearing impaired is 0.85, which was the value determined by Sorri *et al* (2001). This is close to the average value of the matched control group, 0.83, in the study by Swan *et al* (2012). Table 15.2 also shows the losses in HUI due to hearing impairment, assuming the average HUI for the population who are not hearing impaired is 0.85.

Table 15.2. Health utility indices assigned to grades of hearing loss (Shield, 2006)

Grade of HL	**Mild 25-39 dB**	**Moderate 40-69 dB**	**Severe/ Profound >70 dB**
Health utility index	0.8	0.7	0.6
Loss in HUI due to HL	0.05	0.15	0.25

The values shown in Table 15.2 can be compared with the values of HUI shown in recent studies of hearing aids and cochlear implants which are described briefly below and summarised in Tables 15.3 and 15.4.

Barton *et al* (2005), in their analysis of the use of three different QoL measures in relation to hearing loss, found that, in a group of 915 new referrals for hearing aids, with average age of 69.5 years and average BEHL 38 dB, the mean HUI was 0.56. In their assessment of the costs and benefits of early screening for hearing loss Davis *et al* (2007) used the HUI to assess the benefits of hearing aids in terms of QoL and calculate the costs of increased QALYs following hearing aid fitting. In a group of 156 subjects with mean age 66 years and mean BEHL of 31 dB, the average HUI increased from 0.713 before fitting to 0.788 three months after fitting. It was also found that the HUI increased more for those with greater hearing loss: the increase in HUI was 0.063 for those with BEHL less than 35 dB, and 0.099 for those with BEHL of 35 dB and above, suggesting that after hearing aid fitting the quality of life is similar for those with differing degrees of hearing loss. These figures suggest the HUI values shown in Table 15.3 for different degrees of hearing loss in the study by Davis *et al* (2007), assuming that the average HUI for all subjects is 0.788 after hearing aid fitting

A smaller increase in the HUI after hearing aid fitting was found in the study by Swan *et al* (2012), although a direct comparison with the figures presented by Davis et al (2007) is not possible as the hearing losses involved are not given. Swan *et al* used the HUI to assess the quality of life of over 4000 (mean age 54) patients at otolaryngological clinics of whom 947 (mean age 60) had sensorineural hearing loss. The average HUI for these patients pre-management of their condition was 0.56, which increased by 0.044 after management. For those fitted with hearing aids (N=534, mean age 58), the average value pre-fitting was 0.452; the HUI increased by 0.084 post fitting.

The HUIs evaluated in studies of hearing aids are summarised in Table 15.3.

Table 15.3. HUI values associated with hearing loss in studies of hearing aids

Study	**Subjects**			**HUI**	
	N	**Age**	**Hearing loss**	**Pre- HA fitting**	**Post HA fitting**
Barton *et al*, 2005	915	70	38 dB	0.560	-
Davis *et al*, 2007	156	66	31 dB	0.713	0.788
			< 35 dB	0.725	
			≥ 35 dB	0.689	
Swan *et al*, 2012	4422	54	All patient	0.650	-
	947	60	SNHL	0.566	-
	534	58	Fitted with HA	0.452	0.536

The HUI values shown in Table 15.3 suggest that the values used previously may be too high and may not sufficiently account for the loss in quality of life caused by hearing loss.

Table 15.4 summarises the HUI values found in recent studies of the effectiveness of cochlear implants. It lists the reported HUI values pre-implantation and following implantation with one or two implants.

Table 15.4. HUI values associated with hearing loss in cochlear implant studies

Study	Subjects			HUI		
	N	Age	Hearing loss	Pre-implant	Unilateral implant	Bilateral implants
Bichey & Miyamoto, 2008	23	6-79	Severe/ profound	0.33	0.69	0.81
Bond *et al*, 2009	311	16-82	Profound	0.433	0.633	-
Chen *et al*, 2014	90		Severe/ profound	0.54	0.77	0.79
Smulders *et al*, 2016	38	≥ 70	≥ 70 dB	0.58	0.68	0.71

The values shown in Table 15.4 are in general consistent with those in Table 15.3, again suggesting that the values used previously were too high.

For the current estimation, the costs of the loss in quality of life are based upon the prevalence data of the 2017 GBD study, using the GBD grades of hearing loss. Therefore, it is necessary to assign HUI values to the grades of hearing loss used in the GBD studies. Based upon the values shown in Tables 15.3 and 15.4 the HUI values shown in Table 15.5 have been assigned to the five grades of hearing impairment from mild to profound (note that complete hearing loss is not included as it is beyond the scope of this report). The loss in HUI due to hearing loss again assumes an HUI of 0.85 for the general, unimpaired, population.

Table 15.5. HUI values assigned to grades of hearing loss

Grade of HL	Mild 20-34 dB	Moderate 35-49 dB	Moderate /severe 50-64 dB	Severe 65-79 dB	Profound 80-94 dB
Health utilities index	0.8	0.7	0.6	0.5	0.4
Loss in HUI due to HL	0.05	0.15	0.25	0.35	0.45

15.3.3 Value of a full QALY year

In the 2006 report (Shield, 2006) the value of a full QALY year was that assigned by the UK Department of Transport to the Value of Preventing a Fatality (VPF): £40,000 or €44,000 (at 2006 exchange rates). In 2010 the UK Department of Health estimated the value of a full QALY as £60,000 based upon Department of Transport calculations (Glover and Henderson, 2010); however this figure is considerably greater than that used in the recent studies in France (de Kervasdoue and Hartmann, 2016) (€40,000) and for the RNID (London Economics, 2010) (£42,000) and is not easily available for other countries. Hence, in the current study the value of a full QALY is assumed to be the GDP per capita for each country, as used in the WHO report on the global costs of hearing loss (WHO, 2017).

15.3.4 Calculated costs of loss in quality of life

The cost of lost quality of life has been calculated for each country by multiplying the number in each category of hearing loss by the relevant loss in HUI from Table 15.5 to give the total

number of QALYs lost due to hearing loss. The value is then calculated by multiplying the number of lost QALYs by the GDP per capita for each country.

The costs have been worked out for three scenarios: considering all adults with hearing loss of at least 20 decibels; at least 25 decibels and at least 35 decibels. The costs shown in Table 15.6 assume that all those who are hearing impaired are unaided, and thus represent the costs in Europe of untreated hearing loss. The costs for individual countries are shown in Table D1 of Appendix D.

Table 15.6. Costs of lost quality of life due to untreated hearing loss (euros, to nearest 1000)

Hearing loss	Area	All unaided
≥35 dB	EU28	205,204,065,000
	Other	31,065,925,000
	Total	236,269,990,000
≥25 dB	EU28	273,698,427,000
	Other	44,551,386,000
	Total	318,249,813,000
≥20 dB	EU28	329,739,268,000
	Other	55,584,945,000
	Total	385,324,213,000

15.3.4 Costs assuming current rates of hearing aid ownership

The figures in Table 15.6 assume that no hearing aids are worn. However, various surveys and studies have shown that in Europe, around 30% - 35% of those with impaired hearing are supplied with hearing aids, as discussed in Chapter 9. Thus, in estimating current costs of treated and untreated hearing loss it is necessary to calculate the prevalence in each country of those currently owning hearing aids, in each category of hearing loss.

To do this the average rates of hearing aid ownership found in the Eurotrak surveys (see Table 9.3 in Chapter 9) have been used, and rates of ownership assigned to the GBD hearing loss categories of interest, as shown in Table 15.7.

Table 15.7. Rates of ownership of hearing aids (HA) in different categories of hearing loss

Grade of HL	Mild 20-34 dB	Moderate 35-49 dB	Moderate /severe 50-64 dB	Severe 65-79 dB	Profound 80-94 dB
Rate of HA ownership	22	30	41	53	75
% unaided	78	70	59	47	25

Table 15.8 shows the costs of untreated hearing loss in Europe assuming current rates of hearing aid ownership as in Table 15.7.

The corresponding figures for individual countries are shown in Table D2 in Appendix D.

Note that the figures shown in Table 15.8 will be an underestimate of costs of hearing loss for several reasons. The calculations assume that all those who are provided with hearing aids will wear them and obtain maximum benefit from them, but the literature reviewed in Chapter 10 shows that this is unlikely to be the case. It is also assumed that there is no loss of quality of life for those who own aids. Furthermore, as discussed in section 15.3.2, the HUIs upon which the calculations are based may be too high and hence underestimate the loss in quality of life due to hearing loss in each grade.

Table 15.8. Costs to Europe of currently untreated hearing loss (euros)

Hearing loss	Area	Currently unaided
≥35 dB	EU28	129,913,136,000
	Other	19,376,176,000
	Total	149,289,312,000
≥25 dB	EU28	183,338,738,000
	Other	29,894,836,000
	Total	213,233,574,000
≥20 dB	EU28	227,050,595,000
	Other	38,501,012,000
	Total	265,551,607,000

15.4 COSTS OF LOST PRODUCTIVITY DUE TO HEARING LOSS

The productivity costs have been calculated using a method similar to that used in the 2006 report (Shield, 2006) and subsequently adapted by the Commission on Hearing Loss (2014) for their calculation of the costs of lost productivity in the UK.

There were two differences between the calculation method used in the 2006 report by Shield and the Commission on Hearing Loss report. In the latter the employment rate of hearing impaired people of working age was compared with that of people without disabilities, whereas Shield compared it with the employment rate of the general population of working age. This same method has been used again here as the employment rates for people without disabilities for all countries in Europe are not readily available. In the current report the calculations are restricted to people of working age (15 to 64 years).

In the 2006 report the costs of lost productivity were based upon average earnings of individuals, whereas the Commission on Hearing Loss report used economic output per worker, that is the GDP per employed person. This latter approach has been used here.

The 2017 GBD prevalence data were used to estimate the numbers of hearing impaired people of working age (15 to 64) in each country, the numbers being extrapolated from age related data on the GBD data website (Institute for Health Metrics and Evaluation, 2018). The productivity losses have been calculated for two groups: those with hearing loss greater than 35 dB and those with hearing loss greater than 25 dB in the 15 to 64 years age group.

The employment rate for each country was used to calculate the number of hearing impaired people who would be employed if their employment rate was the same as that of the general population. The employment rate for hearing impaired people was based upon the review of the impact of hearing loss on work in Chapter 8. It was found that, for those countries where relevant studies have been carried out, the employment rate of hearing impaired people is approximately 83% of the employment rate of the general population. It has therefore been assumed that for each country the employment rate of people with hearing loss is 83% of that of the general population.

To estimate the lost productivity in each country, the number of people who are not working due to hearing loss has been calculated by estimating both the number who would be in work if they were employed at the same rate as the general population, and the number who are likely to be employed if their rate of employment is 83% of that of the general population. The difference between these two numbers in each country thus gives the number of people lost to the work force as a result of hearing impairment.

This number has been multiplied by the average economic output of each employed person (that is the GDP per employed person) to give the total loss to the economy in each country.

The results for each country are shown in Table D3 in Appendix D. The results for the EU and other European countries considered are shown in Table 15.9.

Table 15.9. Productivity losses due to hearing loss

Hearing loss	Area	Productivity loss (euros)
≥ 35 dB	EU28	55,513,829,000
	Other	11,368,451,000
	Total	66,882,280,000
≥ 25 dB	EU28	216,932,529,000
	Other	46,151,968,000
	Total	263,084,497,000

Tables 15.6 and 15.8 showed that the costs of lost quality of life due to hearing loss can be reduced by the wearing of hearing aids. The studies reviewed in Chapter 8 do not state whether or not the hearing impaired subjects included in the employment data wear hearing aids. It is therefore assumed that the figures for employment of hearing impaired people in those studies include people with and without hearing aids. Therefore, no further analysis is undertaken regarding the influence of hearing aids on productivity loses

15.5 TOTAL COSTS OF HEARING LOSS IN EUROPE

The costs due to lost quality of life in Tables 15.6 and 15.8 have been combined with the costs of lost productivity in Table 15.9 to give the overall costs of hearing loss of 25 dB and greater and 35 dB and greater, assuming all those with hearing loss are untreated (Table 15.10) and assuming current rates of hearing aid ownership (Table 15.11). It should be recognised that adding together the two sums is not entirely valid as the figures in Table 15.9 refer to the total hearing impaired population, which includes both those who wear hearing aids and those who are unaided.

Combining the results in Table 15.6 with those in Table 15.9, Table 15.10 shows the total costs of hearing loss of 25 dB and greater, and of 35 dB and greater, assuming no hearing aid ownership.

Table 15.10. Total costs of hearing loss in Europe, assuming no hearing aid ownership

Hearing loss	Area	Total costs
≥ 35 dB	EU28	260,717,894,000
	Other	42,434,376,000
	Total	303,152,270,000
≥ 25 dB	EU28	490,630,956,000
	Other	90,703,354,000
	Total	581,334,310,000

Combining the results in Table 15.8 with those in Table 15.9, Table 15.11 shows the total costs of hearing loss of 25 dB and greater, and of 35 dB and greater, assuming current rates of hearing aid ownership.

Table 15.11. Total costs of hearing loss in Europe, with current rate of hearing aid ownership

Hearing loss	Area	Total costs
≥ 35 dB	EU28	185,426,965,000
	Other	30,744,627,000
	Total	216,171,592,000
≥ 25 dB	EU28	400,271,267,000
	Other	76,046,804,000
	Total	476,318,071,000

15.6 CONCLUSIONS

This chapter has shown that the current costs to the EU of hearing loss of 25 dB or more range from approximately 400 to 491 billion euros, depending upon whether or not current usage of hearing aids is taken into account. When other European countries (according to the GBD definition of Europe) are also considered, the total cost ranges from around 476 to 581 billion euros.

Restricting the calculations to hearing loss of 35 dB and above, the cost to the EU ranges from approximately 185 to 261 billion euros, and to the wider European community from approximately 216 to 303 billion euros, depending on whether or not the use of hearing aids is accounted for.

APPENDIX D

Table D1. Costs of lost quality of life due to hearing loss (all unaided) (1000 €)

	Hearing loss		
EU	**≥ 20 dB**	**≥ 25 dB**	**≥ 35 dB**
Austria	7,263,379	5,942,194	4,327,411
Belgium	8,916,146	7,415,080	5,580,443
Bulgaria	1,318,436	1,059,123	742,184
Croatia	1,237,664	993,840	695,833
Cyprus	447,336	360,124	253,531
Czech Rep	4,661,294	3,711,068	2,549,681
Denmark	5,135,283	4,115,958	2,870,116
Estonia	622,124	506,077	364,243
Finland	4,471,295	3,687,315	2,729,116
France	48,593,592	40,678,707	31,004,957
Germany	73,200,195	60,659,276	45,331,486
Greece	4,167,011	3,526,192	2,742,968
Hungary	3,098,216	2,478,182	1,720,363
Ireland	4,589,021	3,685,268	2,580,682
Italy	42,586,387	36,126,546	28,231,185
Latvia	732,382	594,619	426,241
Lithuania	1,128,834	917,800	659,870
Luxembourg	903,151	726,348	510,255
Malta	231,470	191,876	143,484
Netherlands	13,827,165	11,234,835	8,066,432
Poland	11,155,746	8,909,503	6,164,095
Portugal	4,585,420	3,824,205	2,893,832
Romania	4,577,139	3,665,293	2,550,815
Slovakia	1,846,208	1,454,346	975,404
Slovenia	1,088,519	868,884	600,441
Spain	25,867,373	21,709,539	16,627,741
Sweden	8,148,869	6,502,852	4,491,054
UK	45,339,615	38,153,379	29,370,201
Total	**329,739,268**	**273,698,427**	**205,204,065**
NON EU	**≥ 20 dB**	**≥ 25 dB**	**≥ 35 dB**
Albania	235,596	187,369	128,425
Belarus	1,044,225	834,095	577,269
Bosnia & Herzegovina	353,350	281,124	192,848
Iceland	331,099	264,699	183,544
Israel	3,957,911	3,218,421	2,314,599
Macedonia	223,304	176,795	119,952
Moldova	162,214	129,644	89,837
Montenegro	85,485	66,761	43,877
Norway	6,032,040	4,959,560	3,648,752
Russian Federation	28,957,001	22,975,097	15,663,881
Serbia	1,096,169	876,319	607,614
Switzerland	10,821,132	8,751,757	6,222,520
Ukraine	2,285,420	1,829,744	1,272,807
Total	**55,584,945**	**44,551,386**	**31,065,925**

Table D2. Costs of lost quality of life due to hearing loss (currently unaided) (1000 €)

	Hearing loss		
EU	**≥ 20 dB**	**≥ 25 dB**	**≥ 35 dB**
Austria	5,058,593	4,028,068	2,768,538
Belgium	6,131,326	4,960,495	3,529,479
Bulgaria	906,995	704,730	457,518
Croatia	850,556	660,373	427,928
Cyprus	313,696	245,671	162,528
Czech Rep	3,221,259	2,480,083	1,574,201
Denmark	3,627,604	2,832,530	1,860,774
Estonia	422,010	331,494	220,864
Finland	3,092,790	2,481,286	1,733,891
France	33,276,070	27,102,459	19,556,935
Germany	50,633,152	40,851,236	28,895,560
Greece	2,827,108	2,327,269	1,716,354
Hungary	2,134,785	1,651,158	1,060,059
Ireland	3,213,514	2,508,587	1,647,010
Italy	28,817,832	23,779,156	17,620,774
Latvia	498,726	391,271	259,937
Lithuania	762,038	597,431	396,246
Luxembourg	628,940	491,034	322,481
Malta	156,939	126,056	88,310
Netherlands	9,673,011	7,650,994	5,179,639
Poland	7,673,287	5,921,217	3,779,799
Portugal	3,147,982	2,554,235	1,828,543
Romania	3,148,260	2,437,020	1,567,727
Slovakia	1,279,767	974,115	600,540
Slovenia	752,623	581,308	371,922
Spain	17,632,269	14,389,158	10,425,355
Sweden	5,742,671	4,458,778	2,889,575
UK	31,426,791	25,821,527	18,970,649
Total	**227,050,595**	**183,338,738**	**129,913,136**
NON EU	**≥ 20 dB**	**≥ 25 dB**	**≥ 35 dB**
Albania	161,630	124,013	78,036
Belarus	716,614	552,713	352,388
Bosnia & Herzegovina	243,001	186,665	117,810
Iceland	237,635	185,844	122,543
Israel	2,740,357	2,163,554	1,458,573
Macedonia	153,522	117,246	72,908
Moldova	110,721	85,316	54,267
Montenegro	59,363	44,758	26,909
Norway	4,204,501	3,367,967	2,345,536
Russian Federation	19,945,582	15,279,697	9,576,948
Serbia	753,131	581,648	372,058
Switzerland	7,609,079	5,994,966	4,022,162
Ukraine	1,565,876	1,210,449	776,038
Total	**38,501,012**	**29,894,836**	**19,376,176**

Table D3. Costs of lost productivity due to hearing loss (€)

	Hearing loss		
EU	**≥ 20 dB**	**≥ 25 dB**	**≥ 35 dB**
Austria	9,055,214	5,575,803	1,323,189
Belgium	11,127,504	6,902,212	1,737,967
Bulgaria	1,281,435	793,835	197,879
Croatia	1,660,990	1,028,135	254,647
Cyprus	615,098	378,934	90,290
Czech Rep	6,013,540	3,713,262	901,811
Denmark	5,333,403	3,260,420	726,774
Estonia	643,732	398,884	99,625
Finland	4,356,616	2,683,490	638,558
France	48,187,469	29,942,263	7,642,566
Germany	68,137,970	42,132,292	10,347,574
Greece	5,659,913	3,527,382	920,956
Hungary	3,515,453	2,173,042	532,317
Ireland	5,764,598	3,539,229	819,334
Italy	38,683,003	24,135,747	6,355,768
Latvia	828,183	512,499	126,663
Lithuania	1,343,256	832,033	207,204
Luxembourg	700,185	427,517	94,256
Malta	246,798	152,825	37,969
Netherlands	15,511,556	9,568,574	2,304,930
Poland	15,998,058	9,906,596	2,461,477
Portugal	3,425,644	2,125,820	537,147
Romania	10,120,947	6,267,609	1,557,974
Slovakia	2,680,215	1,656,511	405,319
Slovenia	1,577,230	971,404	230,951
Spain	26,216,227	16,290,221	4,158,436
Sweden	8,133,081	4,867,842	876,995
UK	52,185,056	33,168,145	9,925,254
Total	**349,002,374**	**216,932,529**	**55,513,829**
NON EU	**≥ 20 dB**	**≥ 25 dB**	**≥ 35 dB**
Albania	355,020	221,071	57,357
Belarus	1,301,475	807,680	204,153
Bosnia & Herzegovina	679,337	421,737	106,894
Iceland	27,288	16,763	3,898
Israel	8,692,781	5,369,030	1,306,668
Macedonia	2,362,545	1,469,358	377,686
Moldova	203,928	126,865	32,676
Montenegro	163,195	102,144	27,527
Norway	6,229,642	3,884,914	1,019,135
Russian Federation	37,619,202	23,311,759	5,824,884
Serbia	1,195,004	741,697	187,654
Switzerland	11,718,540	7,156,680	1,581,073
Ukraine	4,063,251	2,522,269	638,847
Total	**74,611,208**	**46,151,968**	**11,368,451**

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CHAPTER 16 OVERALL CONCLUSIONS

16.1 INTRODUCTION

This report has updated the review of literature relating to definitions, prevalence and effects of hearing loss, and ownership and use of hearing aids, which was contained in the 2006 Hear It report (Shield, 2006). It has used findings of the current review to update the calculations of the costs of hearing loss to Europe.

There is now a very large body of literature in many of the areas addressed. However, as shown repeatedly throughout the preceding sections, there is such variation in methodologies between studies that in many areas it has proved difficult to reach definitive conclusions. Variations include differences between definitions of hearing loss, assessment of hearing loss, populations and subject groups studied (for example, in terms of gender and age) and survey techniques used (for example, objective or subjective, type of question in subjective surveys, frequency range in audiometric surveys).

Nevertheless, some patterns and trends can be observed and general conclusions drawn. The main findings of the current review are presented below.

16.2 MAIN FINDINGS OF REVIEW

16.2.1 Assessment of hearing loss

There have been many papers published which have compared results of surveys conducted using audiometric data with those obtained using self-reporting surveys. Differences occur in estimations of prevalence using the results of the two different survey techniques. Audiometry gives an objective measurement of an individual's hearing impairment while self-reporting assesses an individual's perceived disability due to hearing loss. The latter thus depends not just on the level of hearing impairment but also on personality, general health, environment and various demographic factors.

It has been found that the reliability of self-reporting varies with age: younger people tend to overestimate their hearing problems while older individuals underestimate their difficulties. Self-reporting is also poor at identifying individuals with mild hearing loss. Thus, estimates of prevalence of hearing loss based upon self-reporting surveys are not reliable, either underestimating or overestimating objectively measured prevalence depending upon the age range of the subjects and their degree of hearing loss. Furthermore, it has been found that where a self-reporting survey is used, a single yes/no question is sufficient to determine the incidence of hearing loss, although

There continue to be, as discussed in the 2006 report, differences between organisations in definitions of disabling hearing loss, and of different grades of hearing loss. Care therefore needs to be taken in interpreting results of audiometric surveys which refer to classifications of hearing impairment such as 'mild' or 'moderate'

16.2.2 Prevalence of hearing loss

The Global Burden of Disease studies show that the global prevalence of hearing loss is increasing and, in the majority of European countries hearing loss is among the top five contributory factors to the overall burden of disease. All the reported surveys, both objective and subjective, have found that the prevalence of hearing loss and hearing difficulties increases with age. The Eurotrak surveys show that, consistent with other self-reported surveys, an average of 12.5% of adults report being hearing impaired, the numbers increasing with age from around 4% in the 15 to 24 year age group to 37% among people aged 75 and over. Research using audiometric surveys has found that over 80% of people

aged 80 and above are hearing impaired; the difference in this number and that found in self-reporting surveys is probably due to the under reporting by older people of hearing difficulties discussed above. The changes in the demographic profile of the European population, with increasing numbers of elderly people and longer life expectancy, means that the prevalence of hearing loss in Europe will increase significantly over the coming decades, and that both the actual and relative numbers of those with the more severe grades of hearing loss will increase.

16.2.3 Effects of hearing loss on health

The focus of research on the psychosocial effects of hearing loss in recent years has been to show, as reported in the 2006 report (Shield, 2006), that hearing impairment can lead to depression, loneliness and social isolation, the effects appearing to be greater among younger subjects. However, there is less evidence than there was in 2006 of stigma associated with hearing loss.

There has been far more research than previously into links between hearing impairment and other physical health conditions, and into the relationship between hearing loss and cognitive decline and dementia. The research shows that people with hearing impairment are more likely to have other chronic diseases than people with normal hearing. In addition, hearing loss is associated with lower gait speed (an indicator of poorer health status), increased risk of falling, frailty, reduction in physical activity and general disability. It has also been shown that hearing loss has a greater negative impact on quality of life than many other chronic conditions.

The 2006 report (Shield, 2006) showed that there had been little research into links between hearing impairment and dementia, and that results were inconclusive. In the past decade this has become an expanding area of research which, increasingly, provides evidence of a link between cognition and hearing loss, although the nature of the association is still unclear. A recent major report on dementia found that hearing loss in middle age was the most important of several modifiable factors that are associated with dementia in later life.

Thus, overall, in the past 12 years there has been increasing and consistent evidence that hearing impairment has a very detrimental effect upon health and wellbeing, particularly for older adults. This has important consequences for the social and practical care needed to support people with hearing impairment in society.

16.2.4 Effects of hearing loss on work and income

Many studies have examined the impact of hearing loss on work and income. It has been shown that hearing impairment has significant detrimental effects in the workplace, including negative feelings and fatigue, which often contribute to absence or early retirement. However, it appears that stigma at work is less of a problem than it was in the past.

Several studies have shown that hearing impaired people are over represented in lower status, lower paid, occupations, and that a higher proportion of hearing impaired people are unemployed than of the general population. Early retirement and less demanding jobs mean that the average income of hearing impaired people is below that of people with normal hearing, being around 75% of those without hearing impairment. In the 2006 report (Shield, 2006) it was estimated that, on average, hearing impaired people earned approximately 85% of the earnings of the hearing population; this conclusion was based upon considerably fewer studies than in the current report.

Data from several sources suggest that around 64% of hearing impaired people of working age are in full or part time employment, compared with around 77% of the general population. The employment rate of hearing impaired people is thus approximately 83% of that of the hearing population. In the previous report by Shield (2006) it was found that 65%

of hearing impaired people were employed, compared with 75% of the general population; thus the employment rate of people with hearing loss was then 87% of that of the general population.

The current differences between hearing impaired and hearing people in terms of income and employment rates, compared with those in 2006, suggest that the position of hearing impaired people in the workplace is worse than it was in 2006.

16.2.5 Ownership and use of hearing aids

The 2006 report found that around 2.5% of the population of Europe owned a hearing aid, and that only around 25% of people who needed a hearing aid owned one; the rate of ownership had not increased over the previous 40 years despite advances in hearing aid technology. Furthermore, a high percentage of aids (from 12% in the US to 30% in the UK) were not worn owing to discomfort, poor performance, stigma and handling difficulties.

The present study has found that, although the rate of ownership has increased in the past 12 years, at least 40% of hearing impaired people who could benefit from hearing aids still do not own them. Similarly, although in general the usage of aids has increased with over 70% of owners using their aids for over four hours per day, there remains a substantial proportion of owners who never use their aids or use them only rarely, several studies suggesting that around 20% to 25% of aids are not used.

There is often still a long delay before people seek help for hearing loss, with reported delays ranging from a few months to over 50 years; on average the delay is around 10 years. The most common factor which encourages people to seek help for hearing problems and to acquire hearing aids is self-perceived hearing difficulties and the influence of spouses and professionals.

The main reasons for not owning/using hearing aids are perceived lack of need, discomfort, hearing aids not restoring hearing to normal, and aids not working well in noisy situations. Confidence in the ability to manipulate and maintain hearing aids is another important factor which affects all aspects of hearing aid ownership and use. This problem may increase among elderly patients as visual problems and arthritis can reduce the dexterity required to manipulate hearing aids. Information provided to hearing aid users, and follow up support, is in general inadequate. The small size of hearing aids, apparently designed to reduce the stigma associated with hearing loss, leads to practical difficulties in handling and maintaining aids. The marketing of such aids, emphasising how their small size means they cannot be seen, reinforces the stigma associated with hearing loss.

16.2.6 Benefits of, and satisfaction with, hearing aids

The still relatively low rate of hearing aid ownership and use is particularly disappointing given the positive reports of the benefits provided and users' satisfaction with their hearing aids. The 2006 report (Shield, 2006) showed that satisfaction with aids was generally high, around 70% of users being satisfied with their aids. Surveys have shown that satisfaction with aids has increased significantly over the past 30 years, the European average (from Eurotrak surveys) of users who are currently satisfied being around 76%. This further increase in satisfaction is probably due to advances in technology which have improved the performance of aids.

Surveys of hearing aid users show that over 80% experience improvements in their overall quality of life: they report less physical and mental exhaustion, better sleep, less depression and better memory than non-users, and improved family relationships. Importantly, recent research suggests that hearing aid use reduces the rate of cognitive decline which has been shown to be related to hearing loss.

It has also been found that hearing aid users earn significantly more than non-users, the differential between the two groups increasing with the severity of hearing loss, and unemployment rates of non-users are approximately twice those of hearing aid users.

Thus, it is likely that hearing aid users will be happier, healthier and wealthier, with a better overall quality of life, than hearing impaired people who do not use aids.

16.2.7 Costs of hearing loss

The current costs of hearing loss in Europe due to reduced quality of life and lost productivity have been estimated. The calculations were based upon evidence reported in earlier chapters, including the GBD prevalence data on different grades of hearing loss, the effects of hearing loss on quality of life and employment, and rates of ownership of hearing aids. The estimated costs of hearing loss of 25 dB or more, and 35 dB and above, for the EU and the rest of Europe are shown in Table 16.1.

Table 16.1. Total costs of hearing loss in Europe (euros)

Hearing loss	Area	Total costs assuming no ownership of hearing aids	Total costs assuming current ownership of hearing aids
≥ 35 dB	EU28	260,717,894,000	185,426,965,000
	Other	42,434,376,000	30,744,627,000
	Total	303,152,270,000	216,171,592,000
≥ 25 dB	EU28	490,630,956,000	400,271,267,000
	Other	90,703,354,000	76,046,804,000
	Total	581,334,310,000	476,318,071,000

Thus, hearing loss of 25 dB and above represents an annual cost to Europe of between 476 and 581 billion euros, depending on ownership of hearing aids, while hearing loss of 35 dB and above costs between 216 and 303 billion euros.

16.3 SUMMARY

The review carried out in this report, an update of the 2006 Hear It report by Shield, has found that there has been a very substantial increase in the amount of literature published on many topics related to hearing loss; the numbers of academic papers, national reports, policy documents and reports by organisations involved in hearing loss have increased greatly in the past 12 years. While this provides a wealth of information on many topics, and an increasing body of evidence concerning prevalence of hearing loss, its effects and management, it also causes some difficulties in arriving at definitive conclusions owing to the many different methodologies used in the research. A particular problem is created by the differing definitions of hearing loss used by various organisations and different authors.

However, the evidence concerning the prevalence of hearing loss is far more wide ranging and robust than it was in the past, largely due to studies such as the Global Burden of Disease studies and subjective surveys such as the Eurotrak surveys. Hearing loss is shown to be a major contributor to the burden of disease in Europe, and the prevalence and consequences of hearing loss will increase over the coming decades as the population of Europe ages.

There is increasing evidence of links between hearing loss, psychosocial conditions and other diseases and, importantly, dementia. Hearing loss has also been shown to have a detrimental impact upon employment and income; the differentials between hearing impaired people and the general population appear to be increasing. However, some of the negative effects of hearing loss can be mitigated by the use of hearing aids.

Despite reports of many positive benefits of hearing aids, and overall satisfaction of those who use them, there are still large numbers of hearing impaired people who are unaided.

It has again been shown, as in 2006, that hearing loss represents a very large cost to society in terms of reduced quality of life and lost productivity. It is therefore important, for the sake of both the hearing impaired individual, and society as a whole, that hearing loss is identified early and appropriate treatment and support provided.

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