HEARING IN SOUTH AUSTRALIA : DISABILITY, IMPAIRMENT AND QUALITY-OF-LIFE

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In memory of my mother and father.

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ABSTRACT

Hearing is a function at the very core of human existence affecting our ability to communicate with and relate to others. Despite this importance, and the potential affect that hearing impairment may have on people's lives, we know very little about hearing ability for the Australian population. To date there have been few well designed population studies and none that have assessed hearing threshold levels, and related disability and impairment, from a representative population sample. This study reports on the prevalence of hearing impairment and the quality-of-life of hearing impaired adults in South Australia. The study group comprised of a representative population sample of n=926 South Australians aged 15 years or older who were recruited to an audiological study through the South Australian Health Omnibus Survey. Hearing threshold levels (0.5, 1, 2, 4, 6 & 8 kHz) were established for the sample by a team of audiologists. Hearing impairment was measured at ≥21dBHTL and ≥25dBHTL averaged across the frequencies 0.5, 1, 2, 4kHz. The first of these levels is the level conventionally used by South Australian audiologists to report a hearing impairment. The second level conforms with that used to report the prevalence of hearing impairment in the Medical Research Council's Institute of Hearing Research's National Study of Hearing in the United Kingdom and provides a useful reference point for the South Australian study. At this second level the prevalence of hearing impairment in South Australia was found to be 22.2%. This compares with 26.1% for the British population using the same criteria.

Previous estimates of hearing ability in Australia have largely been based on self-reported disability. A second dimension of the study was, therefore, to compare measured hearing threshold levels of hearing impairment with self-reported prevalence estimates of hearing disability. The level of agreement between the two estimates of prevalence was declared to be slight. This finding seriously questions the value of previous Australian hearing studies based on self-report.

The study also measured the quality-of-life of the hearing impaired across the eight health dimensions of the SF-36 (short form) questionnaire. The quality-of-life scores for the hearing impaired were compared firstly, with the quality-of-life scores for people suffering other chronic conditions (asthma and diabetes). A second comparison was made with a control group who reported none of the chronic diseases and had hearing levels within the normal range, and a third comparison was made with the quality-of-life

population norms for the South Australian population. The results of the study show that the severe hearing impaired group had quality-of-life scores below that of the control group and the norm for the population. In addition, a mild/moderate hearing impaired group who believed their hearing was worse than their measured threshold level had one of the lowest quality-of-life scores of any hearing impaired group on the summary physical health scale. The impact on the quality-of-life of this mild/moderately impaired group compared with that of the asthma group on the quality-of-life physical summary dimension. These findings are of considerable interest given that hearing impairment has a very low public health priority in Australia, compared with other chronic diseases, and that few resources are available to deal with the rehabilitative needs of a large segment of the population.

STATEMENT

This work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except when due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

David Hugh Wilson

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1. BACKGROUND TO THE STUDY

This thesis reports on an epidemiological study of hearing impairment and handicap in a random sample of South Australians, who had their hearing threshold levels measured audiologically and their quality-of-life assessed by questionnaire. It arises from the observation in a routine general health survey that a far higher proportion of South Australians were reporting a hearing disability than previous Australian estimates would have suggested.

This work began in 1990 when a population survey of self-reported hearing disability was incorporated within the South Australian Health Omnibus Survey (SAHOS). The SAHOS is a representative annual health survey of 3000 or more South Australians, aged 15 years or older, who are interviewed at home. The results of this Australian study questioned the validity of previous population assessments of hearing, by providing an estimate of hearing disability at least twice that of previous studies. Since 1990, this study has been replicated in successive SAHOS with comparable results identifying that the self-report questions used are reliable. A second and more important issue is how valid these studies are in providing prevalence estimates of hearing disability since they are based on a self-report question. If prevalence is incorrectly stated from self-report studies the public health importance of hearing morbidity may be devalued. Valid estimates of hearing impairment were therefore the focus of this study. In addition, the health related quality-of-life of the hearing impaired was assessed to enable inferences to be drawn about hearing impairment in the broader context.

The 1990 survey of self-reported hearing disability in this population was an initiative of Better Hearing Australia (BHA South Australia). This is a consumer based organisation involved in the education and rehabilitation of the hearing impaired. It has also been an advocate for the provision of increased resources and services for hearing impaired people throughout Australia. The survey reported here was undertaken because previous studies in Australia had been questioned about their ability to provide reliable estimates of the prevalence and severity of hearing impairment and disability. Because these early surveys pointed to a low prevalence and severity of hearing impairment it was not considered to be an important public health issue by health authorities. This was reflected in the small annual health budget allocated in South Australia for education and rehabilitation of the hearing impaired: $57,000 in 1994/95 & 1995/96 (South Australian Health Commission, 1996(b)). BHA (SA) had an impression these gaps in awareness and funding would be corrected if more specific information were obtained from the SAHOS.

Developmental work for the first South Australian survey was conducted in collaboration with the Medical Research Council's (MRC) Institute of Hearing Research in Nottingham. This organisation had been responsible for conducting the MRC National Study of Hearing during the 1980's. This was the first major epidemiological study of hearing impairment that used a large representative population sample and measured hearing threshold levels.

In the first SAHOS in South Australia, 19 per cent of the population (Wilson et al, 1992 (b)) aged 15 years or older, were reported to have a hearing disability (Appendix 1). This proportion far exceeded any prior Australian estimate and was more akin to British estimates (Davis, 1989). Notably, the highest previous Australian prevalence estimate of 7.4 per cent had been reported in 1978 by the Australian Bureau of Statistics (Australian Bureau of Statistics, 1978). This new evidence from the SAHOS strengthened the presumption that hearing impairment was more widespread in Australia than previous surveys had estimated.

Since the first survey in 1990, the same prevalence question has been asked in other SAHOS. Subsequent estimates were not statistically significantly different from the first estimate, and the self-report question indicates high level of reliability if not validity. Validity in self-assessment of hearing has been questioned previously by a number of authors and is well described in the review of Schow & Gatehouse (1990).

Although SAHOS have shed light on questions related to prevalence they have not been able to address other related issues such as the impact of hearing impairment on those who experience it and its relative priority as a public health problem. These issues would need to describe the effects on the individual's activities of daily living and how these compare with the effects of other chronic conditions. An audiological study was designed to address these aspects and was funded by the National Health and Medical Research Council of Australia (NHMRC) in 1994. The data reported here were collected as part of this study.

The main aim of the audiological study was to describe the measured prevalence of hearing impairment, by type of impairment, for an Australian population. This included conductive, sensori-neural and mixed hearing impairment. A second aim was to assess the quality-of-life of the hearing impaired and compare them with the corresponding factors of people without hearing impairment, and with other chronic disease groups.

Different sub-groups within the hearing impaired population also were described and compared, and specific hypotheses examined in an effort to advance knowledge about hearing impairment in Australia.

Without an appreciation of the epidemiological features of hearing impairment, resources cannot be allocated and used in a cost effective manner. Moreover, if this health problem is under-estimated, problems of lower magnitude will be given a greater relative public health priority. The data contained in this thesis are therefore important in providing a proper assessment of the public health importance of hearing impairment, as well as for precise targeting of health programs and specific interventions, and research.

At this stage an explanation is required about terminology. The World Health Organisation has promulgated four classifications of disease: pathology, impairment, disability and handicap, adapted by Davis (1987) to hearing. **Pathology** is seen as the abnormality of the hearing mechanism or structure (eg. the middle ear, cochlea etc.). **Impairment** refers to an abnormality of function of the auditory system which is normally measured by psychoacoustic or physiological function. **Disability** is used to indicate the problems experienced by the individual who suffers the impairment (eg. difficulty hearing in noise, difficulty identifying the source of sounds etc.). **Handicap** refers to the disadvantage arising from the hearing impairment or disability that limits the individual in achieving the "normal" role or function for that person (eg. social isolation or effects on quality-of-life etc.).

Throughout this thesis the term "impairment" is used to refer only to hearing function that has been determined according to hearing threshold levels. The term "disability" refers only to self-reported estimates of hearing ability. This occurs because of the nature of the self-report question which asks: "Do you have difficulty hearing what someone says to you in a quiet room a) when they speak loudly to you? b) when they speak normally to you? c) if they whisper to you? or d) none of these?" When the individual responds to this question they are reporting a difficulty which conforms with the WHO disability category above. As will be shown in this report there have been a number of self-reported studies of hearing. The estimates they provide are a substitute for prevalence measures determined by hearing threshold levels. When reference is made in this thesis to self-reported studies the term "self-reported disability" is used. When reference is made to studies in which hearing ability was determined by hearing threshold levels the term "hearing impairment" is used.

2. INTRODUCTION AND SCOPE OF THE STUDY

OVERVIEW

This chapter reviews previous studies of hearing in Australia and internationally. From these it is concluded that previous estimates of hearing impairment for Australia are questionable and not suitable for policy development. It is then argued that an epidemiological approach to assessing hearing impairment is required. The chapter then discusses the impact of hearing impairment and the notion of functional limitation. It assesses the quality of previous studies that have looked at the impact of hearing impairment.

2.1 Assessment of the Prevalence of Hearing Disability and Impairment In Australian and Other Populations

Is hearing impairment a public health problem? Except in extreme circumstances, it does not make people feel ill, does not require use of hospital beds, has no immediately apparent disability and mainly affects older people. Furthermore, its visibility as a public health problem is diminished when people with hearing difficulties try to conceal their problem to avoid appearing different (Hetu & Getty, 1993).

To fully assess the public health importance of hearing impairment it is necessary to review some of the literature on prevalence and impact. First, it should be pointed out that many studies have targeted different age groups and used different survey designs and methods. Nevertheless, there is enough commonality to allow initial conclusions about the size and distribution of the problem in Australia. It is, however, questionable as to how useful these initial data would be for planning purposes.

The study presently regarded as a "gold standard" of hearing studies, because of its epidemiological quality, comprehensive study design and methods, is the MRC National Study conducted by the Medical Research Council's Institute of Hearing Research in Nottingham (Davis, 1989). It used a multi-stage clustered area sample of 48,313 people, selected at random from electoral registers. After completion of a self-report questionnaire at stage one, 2,910 people were selected for audiological assessment. Using the criteria of a hearing threshold of ≥25 dBHTL across the frequencies of 0.5, 1, 2 and 4 kHz in the better ear, 16% of the British population were considered to have a hearing impairment in the better ear. Consensus of opinion would accept that the public health burden of hearing loss is indicated by prevalence in the better ear. The study showed that hearing impairment increased dramatically with age and that 90% of those impaired were over 50 years of age (Davis, 1989). Although there have been other studies of measured hearing impairment, Davis's study was an important landmark in assessing hearing, because of its full population focus, the rigour in sampling, measurement of hearing thresholds and analyses of data. It was also important in that it seriously questioned earlier population estimates based on self-report. Today it is still the best model in the design of population studies of hearing impairment.

Since 1978 there have been six Australian population surveys of hearing (Australian Bureau of Statistics, 1978, 1984, 1990(b); Wilson et al 1992(c); Trumble & Piterman,

1992; Ward et al, 1993). Table 2.1 shows the scope of these studies and resulting prevalence estimates. All of the estimates are based on self-reported hearing disability. The earliest population study in 1978 yielded an estimate of 7.4% (Australian Bureau of Statistics, 1978). In terms of the other information on hearing impairment or disability available at that time, this could be considered to be a reasonable estimate of the problem (National Center for Health Statistics, 1971; Reis P, 1982; Milne, 1976). Table 2.2 shows that results of United States assessments conducted during the 1970's were largely consistent with this figure. The National Health Interview Surveys of 1971 and 1977 provided US prevalence estimates of 7.6% and 7.4% respectively (National Center for Health Statistics, 1994; Reis, 1982). Another estimate provided by British investigators, a little earlier, also concurred with the Australian figure (D'Sousa et al, 1975).

Table 2.1: Estimates of prevalence of hearing impairment in the Australian population based on self assessment or audiometry*

Author	Date	Prevalence (%)	n	Age Group	Study Design
Australian Bureau of Statistics	1978	7.4	30,000 households	> 15 years	Self-report
Australian Bureau of Statistics	1984	0.1	18,000 households	>15 years	Self-report
Australian Bureau of Statistics	1990(b)	2.1	73,700	All age groups	Self-report
Wilson D et al	1992(c)	19.4	2559	>15 years	Self-report
Trumble SC et al	1992	37.3	201	>60 years	Audiometry
Ward JA et al	1993	33.7	496	>65	Self-report

* Audiometric measures are for the better ear

With one exception these early studies (D'Sousa et al, 1975), were based on self-reported hearing disability. By the early 1980's, however, quite different estimates were beginning to emerge when more comprehensive audiological measures were used in English and some American studies. Herbst & Humphrey (1980) for an elderly London population of 70 years and older, produced a prevalence of 60% (Herbst & Humphrey, 1980). This was much higher than the estimated 21.5% obtained for subjects aged 65 years and older in the 1978 Australian survey of self-reported hearing disability

(Australian Bureau of Statistics, 1978). The first stage of the British National study provided an estimate of 20% for the population aged 17 years and older (MRC Institute of Hearing Research, 1981). In the late 1980's Davis (1989), using a large audiological sample, obtained a prevalence estimate of 16.1% for Britain. Meanwhile, other Australian population estimates in the 1980's continued to produce prevalence estimates that were at considerable variance with the international information, without questioning the differences. The 1984 and 1990 studies conducted by the Australian Bureau of Statistics produced population estimates of 0.1% and 2.1% respectively. Further evidence to the contrary came from the United States Framingham cohort (Mosciki et al, 1985). This study, although again using an older population, confirmed the fact that hearing impairment was much more prevalent than suggested by the 1984 and 1990 Australian studies, there being an estimated prevalence of 83% for the Framingham population over 57 years of age.

Table 2.2: Estimates of prevalence of having a hearing impairment in various international studies, based on self assessment, audiometry* or audiology*

Author	Date	Prevalence (%)	n	Age Group	Study Design
D'Sousa M et al	1975	5.8	2,278	40-64 years	Self-report Audiometry
National Centre for Health Statistics	1971	7.6	191,602	>3 years	Self-report
Milne JS	1976	39.5	958	>62 years	Self-report Audiometry
Reis P (NCHS)	1977	7.4	202,936	>3 years	Self-report
MRC Institute of Hearing Research	1981	19.9	6,804	>17 years	Self-report
Herbst KG et al	1980	60.0	253	>70 years	Audiometry
Browning GG et al	1983	19.0	759	>17 years	Audiology
Moscicki EK et al	1985	83.0	2,293	57-89 years	Audiology
Martin J et al	1988	5.3			Self-report
Davis AC	1989	16.1	2,708	18-80 years	Audiology
National Centre for Health Statistics	1990	8.6	235,688	>3 years	Self-report
Gates GA et al	1990	29.0	1,662	>60 years	Audiology

* Audiometric and audiological measures are for the better ear in each study

In the 1980's some consistent criteria of hearing impairment were beginning to emerge from the international literature. The earliest measure by Herbst used ≥35dBHTL averaged across the frequencies 1, 2 and 4kHz (Herbst & Humphrey, 1980). Both Browning & Davis (1983) and Gates et al (1990), used ≥25dBHTL across the frequencies 0.25-8kHz, whereas later in the 1980's Davis used the ≥25dBHTL across the speech frequencies of 0.5, 1, 2 and 4kHz. The frequencies used in this latter study cover the important speech frequencies.

Meanwhile, the Australian studies of the 1980's continued to be based on self-report (Australian Bureau of Statistics, 1984 & 1990(b)). In subsequent studies, the survey questions asked varied from each other and also from the 1978 questions. As a consequence, varying prevalence estimates were produced. Not only were these estimates different from each other, they were also inconsistent with international findings. It also becomes clear from reviewing these studies that the international experience was not considered in their design. In 1992(c), Wilson et al, after reviewing the British approach to measuring hearing impairment, used the self-report questions from the first stage of the MRC National Study of Hearing (MRC Institute of Hearing Research, 1981) in a representative population survey of the South Australian population. This study provided two prevalence estimates of hearing impairment of 15% and 19%, depending on the definition used. The larger estimate was reasonably consistent with the first stage self-report assessment for the British population, as reported by the Medical Research Council in 1981 (MRC Institute of Hearing Research, 1981). In 1992, more evidence that hearing impairment in Australia was more prevalent than previously suggested, was provided by Trumble & Piterman (1992). They measured the hearing of general practice patients and showed that 37% of those over 60 years were impaired at the threshold level of ≥30dBHTL across the frequencies 1kHz to 4kHz. The most recent Australian study, although again based on self-report and only including women aged 65 years or older, estimated the prevalence of hearing disability to be 33.7% (Ward et al, 1993).

The first conclusion which can be drawn about hearing data in Australia is that the three most recent studies are more likely to provide valid estimates, because these estimates are more consistent with prevalence data from overseas studies. They have used either audiometric measures or research designs that are consistent with the overseas work. The second conclusion which must be drawn is that Australian studies have varied in their approach to assessing hearing disability and, consequently, the data are inconsistent and generally invalidated. From a public health perspective, this is a

serious shortcoming. In this study it has been hypothesised that the best estimate for Australia to date is the self-reported hearing disability study by Wilson et al (1992(c)). This is based on the fact that it used a large representative population sample and hearing disability was determined by the self-report question used in the first stage of the MRC National Study of Hearing. It is an important aim of this thesis to test the hypothesis of no difference between this estimate of self-reported disability and audiologically assessed hearing impairment.

2.2 The Need for an Epidemiological Approach to Measuring Hearing Impairment

Epidemiology, in conjunction with other disciplines, has an important contribution to make in providing valid and reliable data for planning of programs and services. Davis (1987) points out that the epidemiology of hearing is important for three reasons. First, it shows the scale of the problem in terms of prevalence, disability and handicap. Second, it shows the factors that are responsible for the deterioration of hearing, and third, it shows the effectiveness of existing services in dealing with the problem.

Epidemiology is a principal scientific method of public health. Its function is to show the distribution and determinants of disease and health problems within a defined population. It has well established principles for guiding decisions on selection of the study population, sample size, and the avoidance of measurement bias. In the analysis of data and in the investigation of prevalence rates, epidemiological theory helps to identify confounding, interactions and multi-collinearity between variables that may influence the interpretation of data. Epidemiology uses the discipline of biostatistics in data analysis. Biostatistics may also be orientated towards model building, ie. determining the best set of variables which explain the data or testing hypotheses which might yield a better understanding of the problem. While good *survey* methodology was used in the early Australian studies of hearing impairment, many of the *epidemiological* considerations listed above were not followed. Employment of epidemiological principles in the MRC Study of Hearing is consistent with its overall high quality and should be followed in studies of hearing impairment and disability in Australia.

The Australian population is ageing rapidly, which will increase the prevalence of hearing impairment and age-related conditions. The relative priority of hearing alongside other morbidity should be established using reliable population estimates. However, valid and reliable epidemiological data are important not just in assessing opportunity cost for health decisions, but also in establishing the characteristics of segments of the hearing impaired population, their needs, and the relative priority of primary and secondary prevention, treatment and service issues. There is much talk today of quality in health services (Hall & Masters, 1986; Garrat et al, 1993; Hadorn et al, 1994), but improving quality requires more precise data that can be used to develop policy and target interventions. Reliable data is necessary to confirm the extent of hearing impairment for the population overall and for major sub-problems such as sensori-neural, conductive and mixed impairments. There is also the need for better data on aetiological factors that influence the distribution of hearing impairment and disability. In addition, it is important to assess the potential for improving health. The current Australian data are not up to these tasks. It will be argued in the next section that in the first instance, surveys related to improving health should involve quality-of-life measures.

The value of epidemiological studies of hearing is well established in Britain, primarily through the work of the Medical Research Council's Institute of Hearing Research. This organisation provides population data on a range of hearing morbidity issues. These data are beginning to flow to health care planners, purchasers and providers of services in the British health care system, and are changing perspectives on the importance of hearing impairment as a public health problem and how it should be dealt with in the health care system (Davis, 1987; Haggard, 1993; Davis et al, 1991; Davis, 1991; Davis et al, 1992(b); Stephens, 1991).

Against that background this thesis sets out to report on an epidemiological study of measured hearing levels in a representative sample of South Australians and to compare the prevalence estimate with a previously published estimate of self-reported hearing disability (Wilson, 1992(c)). This estimate is used because it is one of the three studies most likely to provide a reasonable estimate of prevalence in an Australian population having used questions designed for use in the MRC National Study of Hearing. A second task of the study involves a more thorough investigation of the self-report questions used to date. Because of the expense of measured epidemiological studies of hearing impairment, it is important to assess whether the self-reported questions, as adapted from the British studies, are predictive of the measured prevalence of hearing

impairment across the categories of mild, moderate and severe hearing impairment. If the self-report questions prove to be predictive of hearing impairment, it may be possible to use them strategically for public health monitoring, thereby avoiding the need for expensive audiological data. The two null hypotheses that will be examined are those of:

- no difference between the prevalence estimate of hearing impairment determined by hearing threshold levels and the prevalence determined by self-reported hearing disability (Wilson et al, 1992 (c)).
- no difference in the level of agreement in mild, moderate and severe hearing disability obtained from self-report and audiologically assessed threshold levels of hearing impairment.

2.3 Impact and Severity of Hearing Impairment

What does it matter if hearing impairment is common? It is not enough to identify that a condition is prevalent without showing that it has a severe impact on the individual, the health care system and society. There is now an extensive literature on the impact of hearing impairment on the individual and society, including the impact on family members and social and work groups. It is emphasised, however, that many of these studies are small scale and of limited design. Most of them are overseas studies and can, therefore, only serve as a guide to Australian public health policy. From the perspective of planning services for the hearing impaired in Australia, population information on the impact of the problem to the individual and to the health care system is limited (Taylor et al, 1993). The current research will address the impact of the problem to the individual and will go some way towards assessing the use of health services by the hearing impaired compared with the non-hearing impaired population.

Many studies in many countries now point to the pervading effects of hearing impairment on the lives of those affected. Hearing impairment has been associated with effects on the individual as wide ranging as speech and voice problems (Higgins et al, 1994), maladaptive communication (Hallberg & Carlsson, 1991), isolation (Lichtenstein, 1992; Lalande et al, 1988), self esteem (Lalande et al, 1988; Erikson-Mangold & Carlsson, 1991), stress (Erikson-Mangold & Carlsson, 1991), internalised speech problems (Lyxell et al, 1994), communication difficulties (Mulrow et al, 1990),

impaired cognition (Robin & Røyer, 1989), a lack of independence (Herbst, 1980), feelings of inferiority and avoidance of others (Hallberg & Carlsson, 1991), somatic distress (Erikson-Mangold & Carlsson, 1991), difficulty of diagnosis and management of other health problems (Lichtenstein, 1992), compliance with health care regimes (Lichtenstein, 1992), limitations in employment (Hetu & Getty, 1993), speech recognition (Sutter, 1985; Slawinski et al, 1993), and elevated rates of cardiovascular disease (Gates et al, 1993). In addition, there are well-documented studies of the effects of hearing impairment on the individual, and on others close to them, in terms of psycho-social disturbance (McKenna et al, 1991; Hetu et al, 1987; Hallberg & Carlsson, 1991; Hallberg et al, 1993; Brooks, 1978; Noble, 1983; Ireys et al, 1994; Noble & Atherley, 1983; Hetu et al, 1993; Hetu et al 1987), and quality-of-life (Lalande et al, 1988; Mulrow et al, 1990(a); Noble, 1983; Hetu et al, 1993(b); Hetu et al, 1987; Bade, 1991; Bess et al, 1989; Magilvy, 1985; Carabellese et al, 1993; Stephens et al, 1990; Mulrow et al, 1990(b)). Only one study showed no effect of hearing impairment on health (Lindgren et al, 1994).

Although these studies have identified a multiplicity of health problems associated with hearing impairment, the concept of impact must consider not only the range of problems but also the severity of the problem. Severity of the associated hearing difficulties has not been measured well across these studies. Some of the studies were qualitative (Hetu & Getty, 1993; Hetu et al, 1988; Hallberg & Carlsson, 1991) whereas others were concerned with theoretical development (Noble 1983): however, a number have measured severity in various ways using validated quality-of-life and mental health scales. Some of these studies compared the performance of the hearing impaired with a reference group, thus gaining comparative measures of impact (or severity). Bess et al (1989), used the Sickness Impact Profile to compare the functioning of hearing impaired elderly subjects with other subjects experiencing chronic disease. They concluded that the impact of hearing impairment fell between that experienced one year after a heart transplant and that experienced by chronic obstructive pulmonary patients. This indicates a clinically significant level of impaired functioning and severity. Mulrow et al (1990(b)) showed that the functional handicap of the hearing impaired, compared to those without impairment, as measured by the Hearing Handicap Inventory for the Elderly, was significantly related to hearing impairment, as were communication difficulties, as measured by the Quantified Denver Scale of Communication. In this study, functional difficulties were associated with hearing impairment even though individuals had only a mild to moderate detectable impairment. Carabellese et al (1993), using a range of quality-of-life measures, found a significant negative impact of

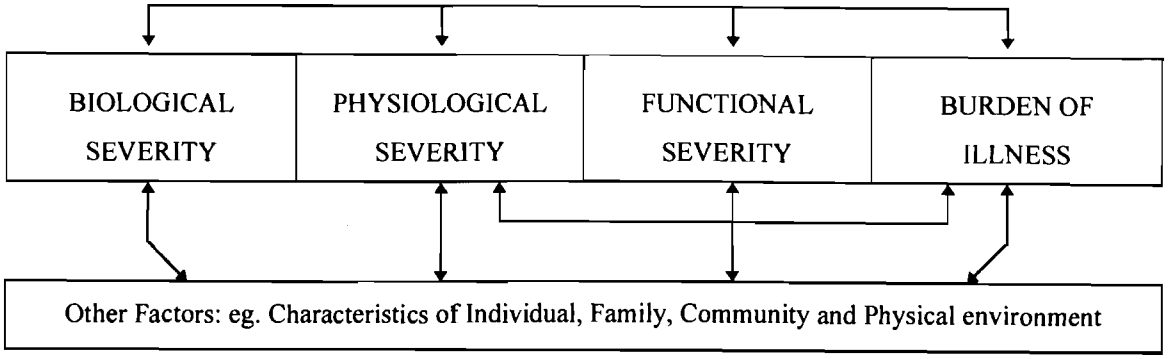
hearing impairment on most scales, but in particular on self-sufficiency. Ireys et al (1994), in a study of young adults with various chronic disease conditions, assessed mental health using the Psychiatric Symptom Index and found that hearing problems had a significant impact on the mental health of this group. Other studies have shown that impact of hearing impairment can be reduced considerably by fitting effective hearing aids (Stephens et al, 1991; Mulrow et al, 1990(b); Kreeger et al, 1995), with consequential (and statistically significant) gains on physical, cognitive, emotional, behavioural and social functioning. Many studies on the effects of hearing impairment have been small scale and there have been few representative population studies of the impact. There are now more comprehensive measures to assess impact across a number of health dimensions. One of these approaches (SF-36) has been used in this study to provide an assessment of impact and severity.

2.4 The Notion of Severity

The concept of severity has been used in many different ways to describe biological incapacity, the amount of illness or disability caused by a condition, the impact on quality-of-life, and the financial, social or emotional burden imposed by the illness (Stein et al, 1987). For the purposes of this research, and in establishing the relative priority of hearing impairment and its sequelae, it is important that the impact is discussed within a framework that includes illness severity. Such a framework will also be important in identifying where the present research can best make a contribution to the overall problem of hearing impairment.

Stein et al (1987) has produced a framework of illness which includes the notion of severity. This is a more comprehensive approach for assessing the effects of illness than the WHO framework of impairment, disability and handicap (World Health Organisation, 1980) and encourages a wider perspective of the overall impact of disease. The framework (Figure 2.1) shows severity as a comprehensive concept which can be defined: first, in terms of the disease itself, through biological and physical severity; second, in terms of functional limitations to the individual; and; third, to other people or the community in terms of the extended burden of disease. The arrows in Figure 2.1 indicate the interrelationship of various aspects of disease and its interaction with the social and physical environment. The arrows also indicate the dynamic nature of disease.

Figure 2.1: A framework for assessing the severity of chronic illness (adapted from Stein et al. 1987)



Stein's framework subsumes the WHO notion of hearing **impairment** (loss of auditory function), **disability** (impact of that loss on such specific tasks as communication), and **handicap** (social, economic, and psychological impact of the disability on a person's health and quality-of-life) as described by Davis for hearing impairment (Davis, 1987). Hallberg et al (1993) has argued the limitations of the WHO notion of handicap and has proposed a broader milieu-related definition. This was first proposed by Soder (1988). For Hallberg et al, the WHO definition implies that handicap is a consequence of defects affecting the individual. That is hearing handicap is seen as a disadvantage tied to the individual (Hallberg et al, 1993). Accordingly, if we use the WHO notion of handicap to assess the severity and impact of disease, we may fail to identify the full consequences of the disease, (especially in terms of the burden of the handicap) on the community. Stein et al's model (1987) is more comprehensive and enables an assessment of the impact in a wider social and economic context.

In Stein's model, three types of severity are addressed to characterise the impact of disease. Biological severity refers to the disease itself. Physiological and functional severity refer to the individual and are akin to the WHO notion of impairment, disability and aspects of handicap. Burden of illness may also apply to the individual, but this notion goes beyond the individual to the broader economic and social unit. Burden of the illness on others is additional to the WHO model. There are also a number of conceptual differences between the work of Stein and the WHO framework, which are important to highlight, since this modified framework helped to direct the present research. First, the Stein concept of handicap is more extensive than that proposed by WHO and bridges both functional severity and burden of illness. This is achieved by including the effects of the hearing impairment on others in the individual's social and

economic environment. Second, the framework is much less discrete than the WHO framework, and more realistically reflects the inter-dependence of impairment, disability and handicap. Stein defines the construct of functional severity as the impact of the disorder on an individual's ability to perform appropriate activities for their age in different circumstances. This definition not only covers the WHO definition of disability, but by relating performance to different circumstances, also immediately includes the issue of handicap. Stein's model also highlights the interdependence of impairment, disability and handicap. Disability not only leads to handicap, but handicap can also further affect disability. Furthermore, if the quality-of-life of a person is affected by hearing impairment, as found by many other investigators (Hetu et al, 1993; Hetu et al, 1987; Bade et al, 1991; Bess et al, 1989; Magilvy, 1985; Carabellese et al, 1993; Stephens et al, 1990; Mulrow et al, 1990(a)), then, it can affect the environment in which a person lives and works, and thereby compound the direct effects of the initial disability. These inter-relationships are shown in Stein's model. For Stein, functional severity also contains quality-of-life effects, which are also considered as part of the definition of hearing handicap included in Davis's application of the WHO framework as mentioned above (Davis, 1987).

Stein goes on to describe a number of quality-of-life measures that are appropriate for measuring his notion of functional severity, which include Activities of Daily Living, the Sickness Impact Profile and the Rand Health Status Index. In recommending these quality-of-life measures for assessing severity Stein operationalises his notion of **severity.** There are still aspects of Stein's notion of severity which are difficult to compare across disease categories. This is most evident when comparing biological severity across disease categories, a difficulty also pointed out by Ireys et al (1994), in a study of the mental health of young adults. For these reasons, Ireys then modified Stein's notion of functional severity in favour of functional limitations[1] . The concept of functional limitation is generic and allows assessments and comparisons across different disease categories, using generic quality-of-life measures. In addition, the semantics of "functional limitation" is more consistent with terms used in various quality-of-life measures.

In the present study, quality-of-life instruments were used to assess functional limitations experienced by the hearing impaired and also by people without measured hearing impairment. The study provides one of the first opportunities to use a

[1] Functional limitation in this quality of life context may be equated with handicap in the WHO classification.

representative population sample to examine major hypotheses regarding the associations of hearing impairment, severity and functional limitations, as measured by quality-of-life instruments.

Further support for Stein et al's (1987) milieu approach to assessing severity and burden of disease comes from the work of Soder (1988) who proposes that a handicap, at least in part, occurs in the encounter between the individual and his/her environment and can be attributed to deficiencies in the physical and social environment. This helps again to reinforce the inter-relationships of the multiple constructs of Stein's framework. Functional limitations may lead to burden of illness, but there may also be a feedback effect from burden of illness to further functional limitations. The quality-of-life instrument used in this study will assess functional limitations over a range of health dimensions and indicate the extent of the burden to the impaired person through measures of effect size.

To complete this description of the model, it should be noted that Stein also defines burden of illness as the impact of the disease on service utilisation and medical costs, and also on the family, the community in which the person lives and functions, and society at large. In Stein et al's (1987) wider context, hearing impairment and its consequences may (or may not) score high in terms of service utilisation and health care costs, but other sources of cost would be identified and counted as part of the overall burden. The value of Stein's model is that it that it can be used in the analysis of any acute or chronic disease and, in addition, it facilitates a comprehensive assessment of severity, in terms of function and burden wherever it occurs. For example, a person with an acute medical problem, such as appendicitis, is likely to incur most health costs through the use of medical resources, which will be dependent on the biological and physiological severity of the problem. Conversely, a person with a major developmental or acquired disability may not require a great deal in terms of medical resources, but the functional severity of the problem may place considerable demands on the educational system or the workplace, and a burden on family members who suffer psychosocial effects and may have to modify their own lifestyle because of the disability. In this study, some questions have been included which investigate the effect of the hearing impairment on some of these aspects of life from the point of view of the person affected. This has also created the opportunity to assess the association of functional limitations with aspects of the burden of illness.

The implicit notion of a framework of disease, such as that proposed by Stein is that it can facilitate a broad understanding of the problem under investigation and identify opportunities to modify functional limitations and reduce the burden of illness. According to Ireys, dealing with chronic illness can be interpreted as the ability to deal with, or overcome, handicap on a daily basis. In reviewing the literature, Ireys et al (1994) identify that coping with a chronic illness will vary considerably for people with approximately the same physiological condition according to four main groups of variables: (a) the condition characteristics or parameters (eg, type and severity of hearing impairment); (b) additional life stressors imposed on the individual; (c) resources or protective factors available to the individual; and (d) the individual's strengths, dispositions and perceptions (Ireys et al, 1994). If, in the first instance, the functional limitations of the hearing impaired can be assessed, and compared with limitations affecting individuals with normal hearing on a population basis, then it may be possible to develop rehabilitation priorities and programs based on the groups of variables identified by Ireys et al (1994).

The main preoccupation in previous population studies has been the measurement of audiological impairment and disability in terms of hearing threshold levels. With the exception of the National Study of Hearing in Britain, no population studies, using an epidemiological framework, have dealt with functional limitations of the population of hearing impaired people. Despite the work done in the MRC National Study of Hearing, Davis points out that little scientific research has been directed at handicap (Davis, 1987). The National Study of Hearing asked what activities people had to curtail or give up, but again Davis acknowledged that it was difficult to quantify handicap through a postal questionnaire (1987). These difficulties were overcome in the National Study of Hearing by conducting the more complex quality-of-life instruments through home interview and the less complex questions by postal questionnaire. Before proceeding to the instruments used in this study, there is a need to look again at the studies which have dealt with functional limitations, because there are other lessons that can be learnt to inform the design of this study.

2.5 Functional Limitations of Hearing Impairment

Most of the papers listed in the previous section on severity were obtained in a review of the literature obtained from a search of the Medline computerised database. No published systematic assessments or reviews of the literature concerned with hearing impairment limitations were found. It is important in understanding the problem of hearing impairment to make an assessment of the available literature. None of the 36 studies identified, most of which are listed in the previous section, had an overall assessments of the literature in their bibliographies. (Milne, 1976; Herbst & Humphrey, 1980; Higgins et al, 1994; Hallberg & Carlsson, 1991(a)(b); Lalande et al, 1988; Erikson-Mangold & Carlsson, 1991; Lyxell et al, 1994; Mulrow et al, 1990(a)(b); Robin & Royer, 1989; Herbst 1983; Sutter, 1985; Slawinsky et al, 1993; Gates et al, 1993; McKenna et al, 1991; Hetu et al, 1987; Hallberg et al, 1993; Brooks, 1978; Ireys et al, 1994; Noble & Atherley, 1970; Bess et al, 1989; Magilvy, 1985; Carabellese et al, 1993; Stephens et al, 1990; Mulrow et al, 1990(a); Lindgren et al, 1994; Kreeger et al, 1995; Vesterager et al, 1988; Uhlman et al, 1989; Cooke, 1989; Heidrich, 1993; Abutan et al, 1993; Lutman, 1991; Evenhuis, 1995). An overall assessment of the literature is important for a number of reasons. First, it should provide an overview of the range of hearing limitations identified and the concepts and factors involved in their occurrence. Second, the literature review should identify the conceptual and design problems of previous studies, and suggest where further research can best make a contribution. The public health researcher should be able to use the literature to guide decisions on appropriate health goals and targets, and relevant means of achieving them. We shall deal with the first two of these in this section. Health goals and targets will be considered in the concluding section of this thesis as a public health approach to hearing impairment.

The range of hearing limitations were discussed in the previous section, but there are some important conclusions to draw in this section. First, many of these studies were directed at a single interest issue, from which it is difficult to assess the true public health impact of hearing impairment. A feature of these studies, and the first point of public health interest, is the diversity and pervading nature of the effects reported. The second point of interest is that the bulk of studies reporting limitations associated with hearing impairment were concerned with psycho-social disturbances (McKenna et al, 1991; Hetu et al, 1988; Hallberg & Carlsson, 1991(b); Hallberg et al, 1993; Brooks, 1978; Noble, 1983; Ireys et al, 1994; Noble & Atherley, 1970; Hetu et al, 1993; Hetu et

al, 1987) and quality-of-life (Lichtenstein, 1992; Lingren et al, 1994; Mulrow et al, 1990(a); Noble, 1983; Hetu et al, 1993; Hetu et al, 1987; Bade, 1991; Bess et al, 1989; Magilvy 1985; Carabellese et al, 1993; Stephens et al, 1990; Mulrow et al, 1990(b)). With two exceptions (Lindgren, et al 1994 & Carabellese et al, 1993) none of these latter studies used a representative population sample which included both a hearing impaired group and a comparison or control group without this impairment. This is a major deficiency which the present study aims to fill. With the exception of Bess et al (1989), none of the quality-of-life studies compare their findings on hearing limitations to limitations associated with other chronic disease groups. Such an exercise would help to establish the relative priority of hearing impairment. In the present study population comparisons were made with other chronic disease groups.

A third feature of prior studies is that most were conducted in other countries, and some of the concepts may not transfer directly to an Australian population because of impairment, cultural or other differences. In addition, many of the studies had design deficiencies and it is, therefore, difficult to generalise their findings to the overall hearing impaired population. Studies which are methodologically unsound will produce results of questionable validity and reliability and should not be used as a basis for decisions on public health policy or in determining goals and targets. The design faults identified in these studies reinforce the need for a representative population study in an Australian population. It is important at this point to review the shortcomings of previous studies and identify how their aspects were considered in the present study design.

In assessing the literature, it was considered necessary to adopt a systematic approach that would provide a comparative overview of design strengths and limitations. This was achieved by developing a list of criteria that were used to assess each hearing study. Research design standards developed by Haynes (1979), and further modified by Windsor and Orleans (1986), provide a framework for assessing the quality of studies and their study designs. Haynes' original standards were developed from an extensive review of 1,400 published research reports. The standards contained in his framework were originally developed to assess the efficacy of compliance intervention studies and are not entirely appropriate for evaluating the descriptive and explanatory studies on hearing impairment that have been mentioned above. Supplementary standards were obtained from the instructions and guidelines for writing papers published by the British Medical Journal (Appendix 2). This is basically a checklist of important study design and analysis features that can be used by authors and reviewers in relation to peer-

reviewed journals. By including some of these with the standards retained from the work of Windsor and Orleans, a more comprehensive list of criteria for assessing descriptive and explanatory studies was produced. As a further check, the work of Campbell and Stanley (1966) and Cook and Campbell (1979), who have published general guidelines for designing experimental and quasi-experimental research studies, were also reviewed. The modified criteria are shown in Table 2.3. They are considered appropriate for assessing descriptive and explanatory studies, and are reflective of the process that would be followed in the peer review of studies for publication.

In assessing each study, one scoring point was allocated for each of the criteria that was met in Table 2.3. In determining the score for standards that were not relevant to particular study designs, a pro-rata or percentage score was provided. For example, if a study obtained a score of 50 per cent for the criteria that it should have applied, it also was allocated a score of 50 per cent for the aspects that were not relevant.

It can be argued that the list of criteria developed could be extended and this is not in dispute. The criteria listed in Table 2.3 are considered to be those which are basic to a reasonable study design. The quality of study design is reflected by the number of criteria that have been met. A description of these standards or criteria follows.

The criteria listed under the heading of research design in Table 2.3 are concerned with study development. There are few studies that are unable to draw on experience described in the literature when deciding the research focus. Formulation of the problem being investigated should emerge from the collective experience of the literature and the intended contribution of the proposed research should be identified in this context. Where appropriate, a statistical hypothesis, supported by the literature, should be used as the basis for computing sample size that will include sufficient statistical power. If conclusions are to be drawn about internal and external validity, it is also necessary to provide a clear description of the study group, and where necessary, the equivalence of the control group used. Assessments of any differences between groups should be based on their baseline equivalence, and this should be underscored in the methods section of the study.

The heading of representativeness is relevant to decisions on the extent to which study findings can be generalised. The sample frame and demographic characteristics of the sample identifies the population from whom the study group was drawn, and the characteristics of those who were excluded. Again, this information is critical to the

generalizability and utility of the results obtained. The sample frame also provides information about the number in the target population and is important in determining the sample fraction and sample-size calculation. If inappropriate recruitment methods are used, the study may be biased. A clear statement of recruitment methods, and description of included and excluded subjects will allow reviewers to assess potential bias. Investigators should consider both type 1 and type 2 errors in the calculation of sample sizes and the rationale for the sample calculation should account for these aspects. Identification of potential confounders is important. For example, in a hearing study assessing functional limitations, it would be important to identify the hearing levels of both the study and control group and the hearing thresholds of the latter should not be assumed to be normal.

The final category of criteria deals with issues of measurement quality and statistical analysis. An important aspect of explaining relationships and associations between variables in descriptive and explanatory studies will depend on accurate assessment of both hearing impaired and hearing normal groups at baseline. Artefactual errors may arise from diagnostic inaccuracies and misclassification. In some cases, people may consider their hearing to be normal even though they have a measurable hearing impairment. The opposite could also apply. If hearing impairment is used as a dependant variable the strength of associations with explanatory variables may be modified if it is not assessed accurately. It is also important in drawing conclusions from the study that the research instruments used to measure any differences between groups are of known validity and reliability and that this is identified by the investigators. Equal care must also be taken in the analysis and presentation of results, from the rationale through to the final analysis, if appropriate conclusions and extrapolations of the information are to be made by other investigators and policy decision makers. In assessing any study, the reviewer must be able to follow the statistical methods used and assess the effects of any decisions made by the investigators. Finally, it is important to identify any collinearity between variables which may affect the decisions in multivariate modelling.

Table 2.3: Criteria for research design

Criterion # 1: Research Design	
Appropriate review of the literature	1 point
Problem stated clearly and hypotheses specified	1 point
Clear description of the study method	1 point
Use of a representative sample and control group if necessary	1 point
Baseline equivalence of group/s assessed	1 point
Criterion #2: Representativeness	
Sample frame size and demographics defined	1 point
Recruitment criteria explained and justified	1 point
Pre-study calculation of required sample size conducted	1 point
Power calculations specified	1 point
Description and number of non-participants	1 point
Demographic characteristics identified in each sub-group	1 point
Identification of potential study confounders	1 point
Criterion #3: Measurement Quality and Statistical Analysis	
Self reported prevalence and/or measures of hearing impairment at baseline	1 point
Source of tests and instruments identified	1 point
Statement of validity and reliability of tests	1 point
Assessment methods standardised for all study participants	1 point
Confidence intervals given for main results	1 point
Appropriate statistical tests used	1 point
Satisfactory presentation of data	1 point
Multi-collinearity examined	1 point
TOTAL SCORE	**20 POINTS**

As indicated earlier, 37 studies were identified that had dealt with functional limitations associated with hearing impairment. Any other important papers contained in the bibliographies of these study reports that were considered important were also included in this review if they dealt with limitations or issues not already covered. The papers reviewed are considered to be a good cross-sectional sample of the literature concerned with hearing limitations and show approaches to research in this area.

Using the assessment criteria shown in Table 2.3, the research designs of the studies were evaluated. Each paper was assessed according to how well it met each of the criteria. Scores were then cumulated for each criteria and are presented in Table 2.4. A mean score was computed for the papers overall as well as for each section. Scores ranged from 3 to 16 points out of possible total of 20 and the overall mean was 10.8. For research design criteria the mean score was 3.3 out of a possible of 5. For representativeness the mean score was 2.1 out of a possible 7 and for measurement quality and statistical analysis the mean score was 5.3 out of a possible 8. It should be remembered that some of these studies were given a pro-rata score for some features in overall score, but this pro-rata score was not included in the section mean score, only in the overall score. This usually applied to qualitative studies which are obliged to follow different design rules.

These data show that, in general, studies were very strong on measurement quality and statistical analyses, less strong on research design, and poor in terms of representativeness. Some used representative population samples (Milne, 1976; Mulrow et al, 1990(a); Gates et al, 1993; Carabellese et al, 1993; Stephens et al, 1990; Lindgren et al, 1994; Kreeger et al, 1995; Heidrich, 1993; Abutan et al, 1993; Lutman, 1991). Many used convenience samples taken from hospitals, clinics or family practices, (Herbst & Humphrey, 1980; Hallberg & Carlsson, 1991(b); Erikson-Mangold & Carlsson, 1991; Herbst, 1983; McKenna et al, 1991; Hallberg et al, 1993; Brooks, 1978; Ireys et al, 1994; Mulrow et al, 1990(b); Vesterager et al, 1988; Uhlman et al, 1989; Cooke, 1989; Evenhuis, 1995), university campuses (Robin & Royer, 1989), the armed forces (Sutter, 1985), factories (Lalande et al, 1988; Hetu et al, 1988; Hetu et al, 1993; Hetu et al, 1987; Bess et al, 1989) other sources through advertising (Slawinski et al, 1993), or it was not stated where or how the samples were recruited (Higgins et al, 1994; Lyxell et al, 1994; Magilvy, 1985; Kreeger et al, 1995; Townsend & Bess, 1980). These sampling deficiencies probably reflect the limited resources available to most investigators, who are consequently restricted to sub-optimum samples. In addition to this, however, a number of studies failed on other basic criteria.

Table 2.4: Criteria for research design (applied)

Criterion # 1: Research Design	
Appropriate review of the literature	31 points
Problem stated clearly and hypotheses specified	30 points
Clear description of the study method	30 points
Use of a representative sample and control group if necessary	8 points
Baseline equivalence of group/s assessed	12 points
Mean section score	**3.3 points**
Criterion #2: Representativeness	
Sample frame size and demographics defined	20 points
Recruitment criteria explained and justified	9 points
Pre-study calculation of required sample size conducted	2 points
Power calculations specified	2 points
Description and number of non-participants	15 points
Demographic characteristics identified for each sub-group	13 points
Identification of potential study confounders	5 points
Mean section score	**2 points**
Criterion #3: Measurement Quality and Statistical Analysis	
Self reported prevalence and/or measures of hearing impairment at baseline	23 point
Source of tests and instruments identified	28 point
Statement of validity and reliability of tests	24 point
Assessment methods standardised for all study participants	26 point
Confidence intervals given for main results	21 point
Appropriate statistical tests used	26 point
Satisfactory presentation of data	26 point
Multi-collinearity examined	0 point
Mean section score	**5.3 points**
POSSIBLE SCORE	**20 POINTS**

For example, often they did not provide a clear description of the sample frame or an adequate description of the demographic characteristics of the groups studied. Having already omitted to provide adequate information on sample characteristics, it is not surprising that the study also failed to provide adequate data on non-participants, sample calculations, sub-group demographics and recruitment criteria. In two cases, sample size data was available from prior reports in earlier published papers.

Apart from a lack of sample size information, the greatest omission was the absence of discussion on potential study confounders. There were, however, some notable exceptions. Bess et al (1989), in a study of hearing and functional impairments in the elderly, recognised the potential confounding effects of case-mix variables in his primary care sample. Herbst & Humphrey (1980), recognised the connection between ageing, dementia and hearing impairment and, by controlling for age in the analysis, showed that deafness and dementia were contiguous conditions, both functions of ageing, and not otherwise related to each other. Cooke (1989), in a study of mental handicap and hearing impairment identified the potential confounding effects of measurement bias when assessing hearing. Cooke pointed out that this group may inadequately report conditions which could affect assessments of hearing thresholds. Sutter (1985), in a study of speech recognition in noise, recognised the potential confounding effects of presbycusis after 60 years of age, as a contributing variable to degradations in speech recognition, despite controlling for actual hearing level. Uhlman et al (1989), recognised the artefactual problems of verbal Mini-Mental State Examinations, when assessing geriatric persons with unidentified mild to moderate hearing impairment, and their possible misclassification in diagnosis and treatment. His study was designed to demonstrate the artefact.

Criteria concerned with measurement quality and statistical analysis were generally well covered, with the exception of multi-collinearity. For those studies that conducted multi-variate modelling, it is appropriate to examine the data for multi-collinearity as this can affect decisions in more complex modelling of the data.

A major conclusion to be drawn from this review of study designs that affect this study is that there are few representative population studies which deal with functional limitations associated with hearing impairment. Of the five population studies cited above only Carabellese et al (1993) and Mulrow et al (1990(a)) dealt with quality-of-life per se, but no audiometric measures of hearing impairment were obtained. Hearing was assessed using free-field voice testing. In this test, an examiner stands behind the person's line of vision and speaks three random numbers in a whispered voice. Impaired hearing was defined as the inability to repeat all of the numbers or to obtain a score of greater than 50 percent over three triplet numbers. Apart from the fact that it is difficult to control the volume of whispering, this test gives no indication of the level of hearing impairment, thereby limiting the opportunity to show the relationship of quality-of-life measures with hearing impairment and other variables, except in a crude sense. Davis (1987), in the British study used a large representative sample to investigate

aspects of handicap by asking people what activities they had to curtail or give up. Davis (1987) himself acknowledges the difficulty of measuring handicap by postal questionnaire and the limitations of the data so obtained.

The conclusion which must be reached is that there is little information on a population level regarding the impact of hearing impairment on the quality-of-life of the individual that can be used to assess the relative priority of hearing as a public health priority and for setting health goals and targets for this disability. It is a primary aim of this study to fill this gap by providing a reliable Australian prevalence estimate for different types of hearing impairment and, in addition, to assess the impact of hearing impairment using a quality-of-life measure.

2.6 Summary and Research Objectives

This chapter has shown that hearing impairment is a widespread disability, but that there is a paucity of reliable population data to demonstrate the extent of the problem in Australia. It would also appear from the literature that hearing impairment affects many aspects of life, but again there are no studies that have measured these effects on a representative population sample in an Australian setting. The remainder of this study will fill these gaps by addressing the following objectives[1]:

- Defining the prevalence of conductive, sensori-neural and mixed hearing impairment in a representative sample of the South Australian population.

- Comparing audiometric measures of hearing impairment with the self-reported hearing disability question.

- Assessing and comparing the quality-of-life of the hearing impaired population, other chronic disease groups without hearing impairment and a control group who have no chronic disease and no hearing impairment.

[1] The first two objectives are related to the null hypotheses on page 26

3. QUALITY-OF-LIFE

Overview

This chapter presents a justification for using a generic quality-of-life measure to examine and compare the impact of hearing impairment with that of other chronic disease problems (such as asthma and diabetes). Hearing impairment does not score highly on traditional morbidity indices (hospital morbidity and mortality data) and a more appropriate measure of its impact would be via a quality-of-life measure that incorporates a range of health dimensions. This chapter looks first at the concept of quality-of-life, distinguishing between disease-specific and generic measures. It is argued that the latter is valuable in assessing the impact of chronic diseases such as hearing impairment. The chapter then addresses the validity and reliability of generic quality-of-life measures and reviews their use in Australian studies to date. The best instrument for use in this study is identified.

3.1 Quality-of-Life: The Concept

There has always been some acknowledgment by health professionals of the status of well being or quality-of-life of their clients, although this has rarely been quantified. There have been such questions as "how are you feeling?"; "have you had any side effects?"; "are you able to cope with work?". Questions such as these target aspects of functioning that relate to the individual's quality-of-life. In this context quality-of-life is taken to mean health related quality-of-life.

Although there is not a comprehensive definition of quality-of-life, and it has meant different things to different people, there is enough of a consensus to identify its necessary conceptual elements. Olweny (1993) provides a good working definition that reflects these ideas whereby quality-of-life: "...is perceived and described as a personal evaluative state of the current vis-a-vis the expected lifestyle, and at any one time represents the functioning of an individual within his or her unique and time variable milieu." This definition brings out a number of conceptual aspects. Firstly, that quality-of-life clearly relates to a person's ability to function. Secondly, that quality-of-life is impaired when the reality of life falls below expectations, hope or ambition. Thirdly, because quality-of-life is evaluated personally the dimensions covered must be comprehensive enough to capture the range of personal considerations and individual impacts, hence it is multi-dimensional. Fourthly, there is a subjective aspect inherent in a personal evaluation of health that can only be adequately assessed by the person who experiences the problem. Ware (1992) also emphasises this subjective aspect in his notion of the centrality of the patients point of view in monitoring medical care outcomes. Other investigators support these four key aspects of quality-of-life: functional ability, comparative expectations, multi-dimensionality, and subjectivity (Ware, 1992; Geigle & Jones, 1990; Hadorn et al, 1994; Butow et al, 1991; Spitzer et al, 1981).

Quality-of-life is still not a concept that is universally accepted and/or used by health professionals. Some would consider it axiomatic that a valid measure of health outcome is only attributable to health care or a health intervention. It is now fairly clear, however, that health outcomes are multi-factorial and may occur not only as a result of health intervention but from other influences (Ware, 1992; Geigle & Jones, 1990; Hadorn et al, 1994; Butow et al, 1991; Spitzer et al, 1981). What exactly comprises quality-of-life is to some extent debatable and is reflected in the dimensions examined

in different quality-of-life instruments. It could be argued that quality-of-life influences are all encompassing and include housing, type of occupation, education level, standard of living etc. Kaplan and Bush (1982) point out that the term quality-of-life has surplus meaning and for some time the term "wellness" was used to provide a more direct linkage to health conditions. Ware (1987) too has argued that the term quality-of-life can be all encompassing and can cause some confusion. In its wider sense, quality-of-life encompasses effects of housing, occupation etc., and goes far beyond what is reasonable as a measure of health. More proximate measures are given by Ware and Shelbourne (1992) as *(1)* limitations in physical activities because of physical health problems; *(2)* limitations in social activities because of physical or emotional problems; *(3)* limitations in usual role activities because of physical health problems; *(4)* bodily pain; *(5)* poor mental health; *(6)* limitations in usual role activities because of emotional problems; *(7)* vitality (fatigue); and *(8)* poor general health perceptions. It is argued that Ware & Shelbourne's dimensions are more proximate measures of health because once basic needs have been met by housing, education and general living standards, further improvements in these features may not be associated with improving quality-of-life and cannot be used as measures of this quality. We can, however, measure quality-of-life along the dimensions developed by Ware and Shelbourne (1992) and assess the impact of illness on each dimension.

3.2 Approaches To Measuring Quality-of-Life

Two broad approaches have been developed for measuring quality-of-life. These are known as the disease specific and the generic approach. Although distinctions between the two are not always clear, a number of fundamental differences can be identified. Disease specific methods are usually used by clinicians to guide or evaluate treatment choices (Schipper et al, 1984; Schipper & Levitt, 1985; Wilson, 1995; Morrow et al, 1992). The disease specific questionnaire invariably contains questions on both disease symptoms and functional activities that are largely affected by that disease. The method is primarily concerned with the association between clinical features and the specific limitations on life activities imposed by the disease. For example, in chronic obstructive lung disease, the investigator may be concerned about the effect of showering, dressing, and doing housework on shortness of breath, or, alternatively, about how the treatment prescribed may have changed the performance of these activities (Guyatt et al, 1987). In another disease condition, such as diabetes, the effects

on the activities of daily living may change, with more emphasis on activities affected by poor circulation or impaired vision, such as exercising, socialising or driving. In summary, the aims of the disease specific assessments are to identify limitations in relation to specific health dimensions such as pain, suffering, loss of function and psychological distress on treatment, or conversely, how treatment affects these dimensions. The disease specific approach is particularly useful for comparing the effects of medical interventions (eg chemotherapy v's radiotherapy) and in tailoring specific treatments to the life needs of the patient. With information obtained from disease specific questionnaires, clinicians can involve the patient in choices of therapy that are acceptable to them. Disease specific assessments rarely produce information that is comparable across disease categories. Development of disease specific instruments for measuring quality-of-life have, however, added to the clinician's diagnostic skills and prognostic assessments. In well developed instruments the dimensions investigated are comprehensive and provide a standardised basis for making treatment decisions that can also be related to recommended treatment or best practice guidelines. Through quality-of-life information and guidelines for treating the disease, the clinician is in a better position to design therapeutic interventions. Although some doctors have always recognised the need to assess patient functioning, empirical studies show that they are not accurate in subjective assessments (Bech, 1993). The use of standardised instruments are therefore likely to improve patient diagnosis, reduce serendipity in patient care, and improve the performance of the health care system in assisting individuals to normalise their lives.

The second application of quality-of-life assessment is known as the generic approach. As implied by the name, the generic method is concerned with dimensions of disease outcomes or effects that are common across disease categories (Garrat et al, 1993; Vincent et al, 1994; Fillenbaum, 1985; Jette et al, 1986). The generic method does not focus on symptoms of disease and is more concerned with defining the range of functional dimensions (multi-dimensionality) that comprises a reasonable definition of health. The dimensions contained in generic quality-of-life instruments might, therefore, be used for assessing the outcomes from any disease. This allows comparison of diseases in terms of their impact on activities of living and provides information that facilitates a relative prioritisation of health problems. Because it addresses universal aspects of disease, the generic approach is a useful method for health planners. In addition to comparing the impact of different disease groups, generic quality-of-life measures can be used to assess the general health of population groups along a range of dimensions and provide planning information for public health programs or

interventions. These instruments can also be used prospectively to assess how people compensate for, or adjust to, illness and rehabilitation efforts, or maintain and adjust lifestyle in physical, social and emotional terms. The generic quality-of-life instrument, therefore, promises to be useful in assessing the effects of chronic disease, whereas the disease specific instrument has more utility in acute illness events.

In recent years the concept of quality-of-life has been incorporated into the measurement of quality adjusted life years (QALYs) (Schwarz et al, 1993). QALYs purport to combine, in a single index, the effect of health interventions or programs on both the quality and quantity-of-life and are another way to think about health effects or health outcomes. They are expressed as the number of life years lost or gained, adjusted for their quality, as assessed by a generic quality-of-life instrument. If, for example, a health intervention adds 0.2 quality adjusted life years to each of 100 people, it will have produced 20 life years (100 people x 0.2 life years = 20 life years). The effectiveness of health programs can be compared in terms of the number and cost of the QALYs they produce. Dividing the cost of a program by the number of QALYs produced will provide a measure of efficiency or cost effectiveness. If the program which adds 0.2 quality adjusted life years to each of 100 people costs $100,000, then the cost per QALY is $5,000 ($100,000 / 20 = $5,000).

The notion of QALYs has been included here to show one application of the quality-of-life concept. However, QALYs will not be used in this study because the costs of associated treatments or interventions have not been assessed. Instead the concept of quality-of-life will be used to compare hearing impaired subjects with those with other chronic disease problems (ie. asthma, diabetes, arthritis) along the dimensions identified by Ware (1992). This will allow a comparison of the relative impact of hearing impairment with impacts of disease problems that have a higher public health profile and are generally accepted as public health priorities. If more rational or "fairer" funding allocation rules are to prevail in the health services then they should, in part, be based on an understanding of the effects of a health problem and the expected benefits that could result from improved target funding. To date, the relative impact of hearing impairment, compared with the impact of other diseases, is not well documented in the literature.

A large number of generic quality-of-life instruments are available to measure quality-of-life. These will be reviewed in more detail later to justify the choice of instrument for this study. More recently there has been increasing emphasis in the literature on

quality-of-life data to inform or monitor health planning decisions (Verbrugge et al, 1994). Many of the instruments that will be reviewed include similar dimensions of health, showing the common ground used in their development. However, there is also enough difference to merit a review to justify the choice of instrument.

In summary, quality-of-life instruments have been used to assess the outcomes of treatment (Morrow et al, 1992; Guyatt et al, 1987; Bech, 1993) to assess health status (Garrat et al, 1993; Vincent et al, 1994; Fillenbaum, 1985), as part of cost utility analysis (Jette et al, 1986), and to study adaptation following illness (Verbrugge et al, 1994; Davis, 1995). Such instruments may also be particularly useful in assessing the long-term effects of chronic diseases, which are not measured by traditional morbidity data bases.

3.3 Quality-of-Life and Hearing Impairment

Chronic conditions, such as hearing impairment can be regarded as "icebergs" of the health system, because the true impact of these conditions is assessed and explained inadequately for a number of reasons. A recent United States study looked at the impact of seven chronic conditions including hearing impairment on adults 18 years or older (Verbrugge & Patrick, 1995). The study found that hearing impairment featured high in terms of prevalence, but low in terms of physician visits and length of time in hospital. However, the importance of hearing impairment as a health problem will be undervalued if assessed solely according to physician visits or hospital stay. In Australia, adult hearing impairment is most often assessed, treated and managed by audiometrists, audiologists, hearing aid companies, and voluntary organisations. Only in the more acute or severe cases is a hearing problem likely to be seen by a medical specialist. This means the problem is not adequately rated by traditional morbidity information systems that largely depend on hospital admission or general practice sentinel data to provide estimates. The first way in which the iceberg theory applies is, therefore, by underestimating the problem. The second way in which the iceberg theory applies relates to the dimensions of life affected by hearing impairment. Notably little information generally is collected on these enduring structural, social and personality effects. Verbrugge & Patrick (1995) point out that after people cross symptomatic and diagnostic thresholds, chronic conditions become a permanent feature of their lives. Medical regimes can sometimes control chronic conditions but rarely cure them. The

pervasive and long term nature of chronic health problems means that other data need to be collected if the problems are to be explained adequately. This is done most appropriately with quality-of-life instruments investigating a range of health dimensions. The third iceberg effect occurs because of the compelling nature of mortality and acute medical statistics and their powerful influence on health decision making. The effect of these statistics on the prioritisation of health issues and the allocation of health resources, including research resources, is considerable and as Verbrugge et al (1994) points out, non-fatal health conditions like hearing impairment are less likely to secure resources commensurate with their frequency and impact on daily life. Generic quality-of-life research now provides a way to document the true impact of chronic issues like hearing impairment and disability and strengthens the case for more appropriate prioritisation.

To date, the main evidence for hearing impairment as a public health priority has come from prevalence studies and/or studies that characterise the clinical aspects of hearing impairment and related disabilities (Chapter 1). Yet this does not provide a comprehensive picture of impact. Davis (1997), in a comprehensive review of the epidemiology of hearing impairment, indicates that hearing disability has been measured in a variety of ways, but goes on to identify that little has been done on hearing handicap. This is an important omission. The public health perspective of hearing impairment is incomplete without information on the handicapping effects and its health prioritisation is also likely to be misplaced as a result. This is especially the case for problems where the effects of handicap can be modified thus reducing the burden of disease as discussed earlier. If we now accept that handicap is better expressed as functional limitations across a range of health dimensions, then we can measure it using generic quality-of-life questionnaires. By way of example, the quality-of-life dimensions identified by Ware & Sherbourne (1992), and outlined above, describes aspects of life that could be affected by hearing impairment. Each of these dimensions could also be contained under the WHO definition of handicap. Ware & Sherbourne (1992), and other quality-of-life investigators, have now provided us with the means to describe more comprehensively the impact of hearing impairment and to compare this with other chronic disease groups.

There is also now a strong theme in the literature that chronic disease issues should be assessed via quality-of-life studies. This is part of the drive for greater accountability on how the health dollar is spent. With increasing emphasis on justifying resource use it is

important to demonstrate outcomes[2] as related to inputs (Geigle & Jones, 1990). This is especially so in health systems using casemix or purchaser-provider arrangements which attempt to make explicit judgements about cost-effectiveness. Traditional indicators of health such as mortality, morbidity, survival and remission rates, are by themselves of limited value for decision making in a system that is concerned with value for the health dollar. They reflect only the extremes of outcomes and fail to capture whole of life health information that occurs between birth and death. Information on quality-of-life and cost utility analyses will be increasingly important determinants of future health investment. Geigle & Jones (1990) argue that the traditional measures of health are too narrow and that the ideal outcome measure is the patient's quality-of-life. The changing nature of disease is also a factor. Olweny (1993) points out that the realisation that some chronic conditions, including some cancers, could be cured underscored the need for the restoration of functional health (rehabilitation). It is evident that the health system needs instruments for assessing longevity, disease symptoms, functional state, psychological and social status, compliance and satisfaction with care, and other subjective experiences of the patients. These are all necessary for assessing the full impact of disease and care and informing the optimum rehabilitation of the patient. The assessments may not re-establish functional health on their own, but may be a necessary factor in doing so.

The belief that quality-of-life measures can contribute to the drive for increased efficiency in the use of health resources, is now health policy of some influential health organisations. The American College of Physicians believes that the fundamental outcome of medical practice is functional well being, and also that the assessment of the impact of illness on physical, mental and psychosocial functioning are essential aspects of good practice (Olweny, 1993). The United States Agency for Health Care Policy and Research believes that health-related quality-of-life is of primary importance (American College of Physicians, 1988). Further, it has also been recommended as a routine measure of patient health outcome for the British National Health Service (McDowell & Newell, 1987). Part of the impetus for this movement does relate to more efficient use of the health dollar but within this objective is also the need to establish more clearly who is to be helped and how they are to be helped. More appropriate targeting of resources is an essential aspect of health service efficiency. Given the high prevalence of hearing impairment, it is necessary to question its current priority as a public health

[2] A strong trend in thinking about outputs and accountability in health services is discussed by Mooney (1994). He identifies a range of thinking and current opinion that incorporates community values in priority setting exercises concerned with outputs.

problem, identify the dimensions of health that are affected by it and the solutions that may be appropriate. At the same time, it is important to consider the current investment in such solutions and how relevant this investment is.

This chapter shows that the functional health status of people with a hearing impairment may be affected in ways that are not measured by existing information systems and that the use of a quality-of-life measure will ask new questions and uncover additional aspects of the problem. For a chronic disease like hearing impairment the questions may be: to what extent does the condition produce pain or suffering, reduce mobility and socialisation, and affect mental health and daily activities, when compared with the profiles of those who do not suffer from the condition, or compared with those affected by other diseases? In comparing with other disease groups we are able to draw on their standing as a public health priority, and by comparison along quality-of-life dimensions, provide a better informed perspective of the relative priority of hearing impairment.

Many of the quality-of-life instruments that have been developed for hearing studies are disease specific in nature and have largely been concerned with issue related to communication (Giolas et al, 1979; Lutman et al, 1987; Ventry & Weinstein, 1982; Newman et al, 1990; Gatehouse, 1994). Communication difficulties may also affect other aspects of daily functioning and therefore quality-of-life? In addition there may also be aspects of hearing impairment that are not captured by the disease specific instruments and are better identified using generic instruments.

3.4 Choosing a Quality-of-Life Instrument

This section is concerned with the adequacy of quality-of-life indices; ie., do the available indices reflect a clear and acceptable definition of quality-of-life. Many quality-of-life instruments reviewed in the literature do not provide a clear conceptual explanation of what they measure (McDowell & Newell, 1987). Yet it is important they should do so because this takes us to the heart of the issue of validity: the assessment of what an instrument measures, and its interpretation. The provision of a conceptual framework first, relates to a broader body of theory and experience and provides a logical developmental framework for the instrument. Secondly, a precise conceptual framework narrows the range of questions that could be asked to cover the dimensions included in the instrument. Thirdly, it helps us interpret the results. The conceptual framework of an index of health can be distinguished from the purpose of the index.

While the latter tells us what the index is meant to do, such as assess the activities of daily living, the former explains what approach is used to achieve the purpose and why. The two broad approaches that can be used in developing an index of health are empirical or theoretical. The empirical approach is appropriate in developing instruments for practical issues such as predicting which patients may be re-admitted to hospital after discharge. A large number of questions may be asked of the target group and substantial statistical analyses conducted to identify the questions that best predict the outcome. The alternative method is to select questions that are based on a specific theory of health. For example, the development of the Sickness Impact Profile (SIP) (Bergner et al, 1981) was based on the theory that the ultimate aim of health care was to reduce sickness. "Sickness" was then defined as the individual's experience of illness as distinct from disease, which was seen as the professional's view of illness, based on observation and clinical data. It was also hypothesized that the individual's health care outcome could best be measured through their performance of daily activities and that these data would be reliable, and sensitive to change over time. Thus, the SIP's conceptual base determined not only the focus of questions but also the content. In addition, the conceptual basis indicated the appropriate validity tests. In the case of the SIP validity was based on demonstrating the relationship between sickness impact and behavioural dysfunction in daily activities. In field trials of the instrument efforts were made to determine the relationship between the questions and independent measures of sickness. An understanding of the conceptual basis also indicates the type of additional external information that can be drawn on to provide evidence that the instrument actually does measure what it purports to measure. In the case of the SIP, Katz's Index of Activities of Daily Living (Katz et al, 1963) was used as an external comparison. For the purposes of this study, the conceptual basis of available instruments and their validity were fundamental considerations in assessing the quality-of-life instruments that would be most appropriate.

As already indicated, the validity of a questionnaire depends on what it actually measures and how well it does so (McDowell & Newell, 1987; Anastasi, 1968). If the questionnaire is intended to measure aspects of quality-of-life, it should be assessed in relation to some external information or criterion that confirm the test is measuring quality-of-life. The external information, or independent facts, can be referred to as the "gold standard" (validation) against which performance of the questionnaire is compared. Reliability is concerned with the consistency of an instrument in obtaining the same responses in an unchanged population, at different times or under variable testing conditions. Various aspects of both validity and reliability are appropriate in

assessing the value of a questionnaire, but only the important ones used in deciding choice of instrument for this study will be dealt with here.

First, the face validity of the questionnaire is important. This relates to whether the content of the questionnaire appears relevant or appropriate to those who complete it. If the questionnaire does not seem credible to its users, there may be poor co-operation. An important aspect of face validity with questionnaires imported to one country from another relates to the cultural expressions and language used. Face validity is a major consideration of questionnaire designers and the relevance and plausibility of the instrument should be assessed in the context of, and with, the people with whom it will be used.

Second, content validity should be considered. Many different dimensions of quality-of-life could be examined by a questionnaire and similarly, many questions could be included to explore those dimensions. The content validity of a questionnaire relates to how adequately the sampling of dimensions and questions reflect the intention of the instrument, as specified by a conceptual definition. Often content validity is not formally evaluated and a common method is to ask experts to comment on the clarity and completeness of the test, and/or to use the experience contained in the literature regarding the concept being examined.

Following content validation, more formal statistical methods may be used to determine how well the items in the questionnaire measure dimensions of quality-of-life. This may involve testing individual questions, sections of the instrument, or the instrument as a whole. If the overall instrument was shown to lack validity, then individual questions would be examined and altered appropriately to improve validity. An initial validity test could be comparing the performance of the questions against some external criterion (criterion validity). For example, to establish how well questions predict hearing impairment, they may be compared with audiometric measures. The questions which correlated least well with the audiometric criterion would be eliminated or changed.

The next stage of validity testing is construct validity. This is most applicable with abstract concepts such as quality-of-life or health. Often, because "gold standards" are difficult to find for complex conceptual issues, construct validity will assemble (or construct) evidence from several different sources. Construct validity also concentrates on establishing more enduring evidence of validity and will draw from any source that

throws light on the trait being validated. It may be compared with previous tests, if any are available, or use statistical techniques such as factor analysis that analyse the interrelationships of the data. A common method of construct validation is to test how well answers from the questionnaire correlate with variables with which it should correlate, and with variables from which it should differ (convergent and discriminant validation).

In addition to validity, reliability is also an important concept in establishing the merits of a quality-of-life instrument. Three types of reliability have been identified by researchers: consistency over time (test/retest reliability); consistency between different users (inter-rater reliability); and the extent to which items measure the same dimension (internal consistency).

Other types of validity that will be of less interest in this study are concurrent and predictive validity. Concurrent validity may also be synonymous with criterion validity when a criterion measure is obtained at approximately the same time as the questionnaire is administered. The predictive validity of a test refers to the ability of the test to predict a future outcome. For example, the ability of a job aptitude test to predict job performance. In many cases, however, a concurrent validity test is used in place of predictive validity because it is often impractical to extend the time of a study long enough to establish the outcome.

3.5 Hearing Studies That Have Used Quality-of-Life Measures

A number of studies have investigated the quality-of-life of hearing impaired people. In reviewing these, as to their appropriateness for the current study, it was important to ask: which questionnaire, if any, had demonstrated adequate validity and reliability for an Australian population? As a consequence of this question, it was also important to decide which validity and reliability concepts were appropriate in assessing quality-of-life instruments that are valid for Australian use.

Many of the quality-of-life instruments used in hearing studies and identified in this literature review were developed in the United States or the United Kingdom. Table 3.1 shows the range of quality-of-life instruments used in hearing studies (Noble & Atherley, 1970; Herbst & Humphrey, 1980; Weinstein & Ventry, 1982; Ventry &

Weinstein, 1982; Magilvy, 1985; Demorest & Erdman, 1987; Vesterager et al, 1988; Uhlman et al, 1989; Bess et al, 1989; Mulrow et al, 1990(a)(b); McKenna et al, 1991; Hallberg & Carlsson, 1991; Erikson-Mangold & Carlsson, 1991; Lindgren et al, 1994; Carabellese et al, 1993; Gatehouse, 1994). The purpose of Table 3.1 is to identify the range of instruments used, not to identify all hearing studies that have investigated quality-of-life status. With the exception of Noble's Hearing Measurement Scale there are also other instruments that touch on quality-of-life issues that have not been reviewed in Table 3.1 (High et al, 1964; Alpiner et al, 1971). These are more specifically concerned with disease specific communication issues and would not be appropriate for comparing health dimensions across disease categories which is the main quality-of-life aim of this study.

Noble's Hearing Measurement Scale was developed almost three decades ago before much of the current thinking on quality-of-life had developed. Although including some generic questions the instrument is also largely disease specific. It was therefore, not considered appropriate for this study.

Of the remaining instruments identified in Table 3.1 only the General Health Questionnaire has been validated for use in Australia (Tennant, 1977). The issue of Australian validation is an important point of emphasis, because instruments that have been validated on other populations should be re-validated on an Australian population before being used more extensively for local studies. In accepting an instruments' suitability for use in this study the pertinent validity issues of concern are: face validity of cultural and language aspects for each item; and construct (or convergent and discriminant validity) to show the dimensions and items included in the questionnaire are relevant in an Australian context. In addition, it is advisable to check the internal consistency of the instrument to demonstrate the inter-item correlations of the test, its homogeneity, and the ability of the test to produce consistent responses in the Australian context. For these reasons, and because there were no Australian hearing studies that had used validated quality-of-life instruments, it was considered important to review whether any quality of life instruments had been validated in other Australian studies that could be considered for this study.

Table 3.1: Hearing studies using quality-of-life measures (study aims, validity and reliability tests conducted)

AUTHOR	STUDY AIM	QoL INSTRUMENT	VALIDITY TEST	RELIABILITY TEST
Noble WG & Atherley GRC, 1970	Develop a new measure of hearing disability	The Hearing Measurement Scale	Criterion validity	Test/retest
Herbst KG & Humphrey C, 1980	Study of dementia and depression among hearing impaired	Comprehensive Assessment and Referral Evaluation	Convergent validity. Construct validity. Criterion validity	Internal consistency
Weinstein BE & Ventry IM, 1982	Hearing impairment and social isolation	Hearing Measurement Scale	Criterion validity	Test/retest
Ventry IM & Weinstein BE, 1982	Hearing impairment and emotional and social adjustment	The Hearing Handicap Inventory for the Elderly (HHIE)	Content validity Construct validity	Internal consistency
Magilvy JK, 1985	Hearing impairment and quality of life	HHIE	See above	See above
Demorest ME & Erdman SA, 1987	Development of a new measure of communication ability	Communication Profile for the Hearing Impaired	None	Internal consistency
Vesterager V et al, 1988	Influence of hearing impairment on socio/psycho profile & behaviour	Unnamed 300+ item questionnaire	None	None
Uhlman RF et al, 1989	Effect of hearing impairment on cognitive tests	Mini-Mental State Examination	Criterion Validity. Concurrent validity	Test/retest. Inter rater reliability
Bess FH et al, 1989	Hearing impairment & functional & psychological impairment	Sickness Impact Profile	Criterion validity	Test/retest Internal consistency
Mulrow et al, 1990(b)	Hearing aids & quality-of-life improvement	HHIE. Self Evaluation of Life Function	See above	
McKenna L et al, 1991	Hearing impairment and psychological disturbance	60 Item General Health Questionnaire	Criterion validity Convergent validity	Test/retest Internal consistency
Hallberg LRM & Carlsson SG, 1991	Audiological & psychological factors affecting handicap	The Hearing Measurement Scale. Subjective assessment	None (subjective assessment)	Subjective assessment-none
Erikson-Mangold M et al, 1991	Hearing impairment and psychological and somatic stress	The Symptoms Check List (SCL-90)	Convergent validity	Test/retest
Lindgren AM, et al., 1994	Hearing impairment and quality-of-life	Subjective instrument	None	None
Carabellese C et al, 1993	Sensory impairment and quality-of-life	Activities of daily living Mental Status Questionnaire	(ADL) Predictive validity (MSQ) Construct validity	(ADL) Inter rater. (MSQ) Test/retest. Internal consistency
Gatehouse S, 1994	Hearing aid candidates & perceived disabilities & handicaps	Crown-Crisp Experiential Index	Discriminant validity, Criterion validity, predictive validity	Test/retest Internal consistency

3.6 Other Australian Studies That Have Used Quality-of-Life Measures

Table 3.2 shows the Australian studies identified from the literature, other than those concerned with hearing, that have used quality-of-life measures (Tennant, 1977; Hall et al, 1987; Baum & Cooke, 1989; Munro et al, 1990; Dunne et al, 1990; Butow et al, 1991; Guinan et al, 1991; Vaughan et al, 1992; Kamien et al, 1995; McCallum, 1994; Vincent et al, 1994). Only the Nottingham Health Profile, the General Health Questionnaire series, and the Rand Corporation Medical Outcomes Survey (36 item) SF-36 questionnaire have been validated for use on Australian populations. As can be seen from the table only the SF-36 has also adequately tested reliability. Baum did conduct validity studies of the Nottingham Health Profile on an Australian population by comparing self reported health status with scores on each of the dimension of the instrument. However this was a limited study which did not conduct reliability testing (Baum & Cooke, 1989). The Nottingham Health Profile has also been criticised for its lack of sensitivity for use with ostensibly healthy adults and for its limited validity testing (Garrat et al, 1993). The GHQ instrument is generally regarded principally as a measure of mental health (Hall & Masters, 1986), and in this sense is too narrow in its dimensionality to use in a hearing study.

Only the SF-36 contains an adequate range of health dimensions and has been thoroughly validated and tested for reliability on an Australian population (McCallum, 1994). The original validation studies of the SF-36 were conducted in the United States (Ware et al, 1980) and the instrument was re-validated for use on an English population (Brazier, 1994). Together with the Australian studies, the US and English validation studies provide strong evidence of the instrument's universality.

The conceptual development of the SF-36, and the health dimensions it contains, emerged from the Rand Health Insurance Experiment (HIE) (Ware et al, 1980) and the Medical Outcomes Study (MOS) (Ware & Sherbourne, 1992). Both studies were designed to assess the health status of population groups and primarily with the construction of scales that were capable of measuring a broad array of functional and well being concepts. Following on from the HIE and the MOS, the question was asked whether quality-of-life data could be collected more efficiently with smaller questionnaires without compromising efficacy. In the HIE, for example, 25 items were

required to collect information on physical functioning. This was reduced to 10 items in the MOS study. The final result of this work was the development of a number of short form instruments: the SF-12, SF-20, and the SF-36. The items selected for these "new generation" instruments were drawn from the full-length MOS scale which also provided the initial validity criterion ("gold standard").

Table 3.2: Other health studies using quality-of-life measures: (study aims, validity and reliability tests conducted)

Author	Study aim	QOL instrument	Validity test	Reliability test
Tennant C, 1977	Quality-of-life in general practice	60 Item General Health Questionnaire	Yes	No
Hall J et al, 1987	Quality-of-life in general practice patients	Rand Health Battery Sickness Impact Profile GHQ 20	No No Yes	No No No
Baum F & Cooke RD, 1989	Community health needs assessment & validation study	Nottingham Health Profile	Yes	No
Munro JM et al, 1990	In vitro fertilisation and psychiatric morbidity	GHQ 60	Yes	No
Dunne MP et al, 1990	Health effects of chemical waste	GHQ 28	Yes	No
Butow P et al, 1991	Breast cancer and quality of life	FLIC HAD POMS PAC	No No No No	No No No No
Guinan JJ et al, 1991	Stress amongst AIDS support volunteers	GHQ 28	Yes	No
Vaughan JC et al, 1992	Service utilisation following an earthquake	GHQ 12	Yes	No
Kamien M et al, 1995	Diabetes patients satisfaction with GP care	Dartmouth COOP	No	No
McCallum J, 1994	Validation study	SF-36	Yes	Yes
Vincent C et al, 1994	Health study	Mental Health Inventory	Yes	Yes

The earlier HIE and MOS studies investigating the dimensions of self-reported health confirmed distinct mental and physical components. To test for these major dimensions

of physical and mental health within the SF-36, these principal components were extracted from the correlations among the eight scales of the questionnaire. The pattern of correlations between the scales, and the two rotated components, were then used to test the validity of each scale in relation to the hypothesised physical and mental health components. From these data it was hypothesised, and shown, that there were specific scales which correlated strongly with the physical health component, and scales which did not correlate well with the physical component, but did correlate highly with the mental health component.

Further US tests on the validity of each scale were conducted by comparing the questionnaire results with mutually exclusive adult patient groups differing in physical and/or mental health status. Scales shown in the principal components analysis to primarily measure physical health (physical functioning and role limitations-physical) distinguished best between groups varying in chronic medical conditions. Conversely, scales shown to primarily measure mental health best distinguished groups differing in the presence and severity of mental health disorders. Together the principal components analysis and the comparisons with different medical groups established United States criteria for the external validity of the instrument, that is whether the SF-36 truly measures health in acceptable terms.

McCallum (1994) followed a similar validation procedure for Australia, conducting a principal components analysis and then validating further by comparing the scores for groups differing in physical and mental health status and severity. For this analysis four mutually exclusive health groups similar to the US groups were formed as follows:

Group 1 no current medical condition and not depressed.

Group 2 minor (uncomplicated) medical conditions only and not depressed.

Group 3 depressed but with no serious medical conditions.

Group 4 serious medical conditions with most depressed as well.

Table 3.3 presents data from the principal components analysis and examines hypothesised associations between the principal components and each of the SF-36 scales for both the American and Australian validation studies. It can be seen that the results of the Australian principal components analysis are very similar to the American results, thus increasing confidence in the use of the SF-36 for Australian studies. The

correlations between the rotated components and the SF-36 scales confirm the hypothesised associations. The scales of physical functioning, role-physical and bodily pain correlated most highly with the physical health component. The scales of mental health, role-emotional, social functioning and vitality correlated most highly with the mental health component.

Table 3.3: Hypothesised associations between SF-36 scales and results from psychometric tests for Australia and United States

	ROTATED PRINCIPAL COMPONENTS		AUSTRALIA		UNITED STATES	
	Physical	Mental	Physical	Mental	Physical	Mental
Physical Functioning	+	-	0.76	0.09	0.88	0.04
Role-physical	+	-	0.72	0.21	0.78	0.30
Bodily pain	+	-	0.76	0.11	0.77	0.24
Mental Health	-	+	0.19	0.85	0.12	0.90
Role Emotional	-	+	-0.04	0.81	0.19	0.81
Social Functioning	*	+	0.33	0.72	0.44	0.71
Vitality	*	*	0.47	0.64	0.59	0.57
General Health	*	*	0.64	0.20	0.68	0.32

Adapted from McCallum, 1994; Ware & Sherbourne, 1992

+ Strong association

- Weak association

* Moderate to substantial association

Duckworth (1983) argues that attention needs to be focussed on the disabling aspects of disease since these reflect the chronic nature of much suffering. In the eight dimensions of the SF-36, a clear attempt has been made to focus on these disabling aspects. It should, however, be pointed out that, being a generic instrument, there are some items of the SF-36 that, at first appearance, may not be associated with hearing impairment (eg, lifting or carrying groceries or walking more than a kilometre). These are, however, the likely effects of the other diseases (asthma, diabetes) which were also measured in the present study using the SF-36. The diversity of the SF-36 items again attests to the generic nature of the instrument and supports its use in this study.

The choice of instrument for measuring quality-of-life associated with hearing impairment and disability in this study was therefore the SF-36. Many other instruments were mentioned in the literature that have been shown in other countries to be valid and reliable, but have not been assessed here because they have never been validity tested in the Australian context.

It should also be emphasised that no disease specific questionnaires were reviewed for this study because of the need to compare the hearing impaired with people experiencing other chronic diseases (ie, asthma, diabetes) in order to provide a clearer understanding of the relative public health importance of hearing impairment. This consideration necessitated the use of a generic instrument. It is also worth repeating that the range of dimensions of quality-of-life covered in disease specific measures are often too narrow to capture the range of disease effects that may be experienced with a chronic disease. Even in the most advanced disease specific work (Gatehouse, 1994), interest in quality-of-life is limited to specific outcomes, such as the range of hearing improvement in different hearing environments, and the psycho/social and other benefits gained, following the fitting of a hearing aid. While this work is important for other reasons, this study needs to focus on the valid range of quality of life dimensions that represent health. This is important in the case of hearing because the effects of this problem may not score highly on disease specific disability scales, especially in the lower range of hearing impairment. The key study question for this study is, therefore: are there effects on any of the recognised health dimensions of different levels of measurable hearing impairment? The reviews conducted in this chapter suggest the SF-36 is the most appropriate instrument to answer this question.

4. STUDY METHOD

OVERVIEW

This chapter explains the methodology of the South Australian Hearing Study. Study participants were recruited from the South Australian Health Omnibus Survey into the South Australian Hearing Study in which they were examined by a study audiologist who measured their hearing levels. The recruitment process, sample size concerns, data collection, approaches to statistical analyses and audiological methods are dealt with in detail under their respective headings.

4.1 The Health Omnibus Survey

The South Australian Health Omnibus Survey (SAHOS) was the primary method of sampling and data collection for this study. This survey is an annual household interview survey which samples 4200 people from the South Australian population and has a historical response rate of approximately 73% (±3%). The Survey was first conducted in 1990 and has operated each year since (Wilson, 1992(b)). It is now used by a wide range of government and non-government health organisations, providing them with relevant and timely data for planning, developing and monitoring health services, and programs. The Survey is demand driven and organisations purchase questions according to their needs. A quality control committee led and chaired by epidemiologists is convened each year to oversee survey development, implementation and data analyses. The aim of this committee is to maintain high quality control of the Survey and to provide advice to users as appropriate.

In 1993 previous client users of the SAHOS were surveyed to assess how the data obtained in the 1991 and 1992 surveys had been used (Taylor, 1995). A wide range of health and welfare applications were reported including: peer reviewed publications, conference presentations, program planning, policy development, lobbying and advocacy, successful research grant applications, program monitoring, theses work, describing health service patterns, baseline disease rates, recruitment to clinical studies, media releases, legislation, and epidemiological studies. A number of these applications attest to the high quality of SAHOS data, especially those applications that are peer reviewed. Exemplary output from the SAHOS has included: 1) Wakefield et al's (1996) research demonstrating changes in workplace smoking policy over time; 2) A study of the prevalence of cardiovascular risk factors among South Australians with diabetes (Phillips et al, 1994); 3) A study of the use and cost of alternative medicines in Australia (McLennan et al, 1996); and 4) Wilson et al's (1992(a) & 1995) continuing research on the characteristics of heavy smokers.

Apart from the South Australian component of the National Health Surveys, there are no other population health surveys in the state of South Australia that address a range of health issues simultaneously and provide a comprehensive list of demographic variables. The National Health Surveys conducted by the Australian Bureau of Statistics are conducted infrequently and could not be used for this hearing study which required a large sample of hearing impaired people. To provide an adequate sample for

the South Australian Hearing Study people were recruited from three SAHOS, each six months apart in October 1994, April 1995 and October 1995.

4.2 Survey Method

The SAHOS methodology involves a multistage, clustered, self-weighting, systematic area sample of persons aged 15 years or older who live in metropolitan Adelaide and major country centres of over 1000 persons. A constant sampling fraction is used for both metropolitan and country regions. Hotels, motels, hospitals, nursing homes and other institutions are excluded. There are no replacements for non-respondents. Up to five call backs are made to each household in an attempt to interview selected persons.

Explanation of the terminology used in the SAHOS method that provided the sample for the South Australian Hearing Study is as follows:

CLUSTERED: In both the metropolitan and South Australian country areas the Australian Bureau of Statistics collector districts (CD's) comprised the sample frame. A CD is selected with the probability of selection proportional to its size (PPS sampling). In the country areas the sample only includes towns with a population of 1000 or more. This is due to the fact that the bulk of the country population live in towns of this size and inclusion of smaller towns would considerably increase survey costs.

MULTISTAGE: The sample is obtained in three stages. First, CD's are selected randomly. Within each CD a number of households are selected proportional to the size of the CD from a random starting point. Within each household one person, aged 15 years or older, whose birthday is next, is chosen for interview by trained health interviewers.

SYSTEMATIC: Households are selected using a fixed skip interval from the random starting point. In addition, a random number is chosen for each CD to determine the skip interval.

SELF-WEIGHTING: The method of selecting the sample ensures that every unit has an equal chance of selection even though different probabilities of selection apply at each stage of selection. The process of selecting CD's and dwellings and the way in which the self-weighting method applies is as follows:

1. A skip interval is determined for sample selection:

$$\frac{N(\text{number of dwellings in the state})}{\text{n(number of CD's required)}}$$

2. A random starting point is selected between 1 and the skip interval.

3. CD's are listed as in Table 4.1. CD's are selected using the skip interval. The probability that a CD is selected is:

$$\frac{\text{cumulative number of dwellings in the state}}{\text{skip interval}}$$

4. Ten dwellings are then selected in each CD. The probability of selecting a dwelling in the CD, given that CD has been selected is:

$$\frac{10}{\text{n of dwellings in the CD}}$$

5. The probability of a dwelling being selected for the survey is:

$$\frac{\text{cumulative n of dwellings in the CD's}}{\text{skip interval}} \div \frac{10}{\text{cumulative n of dwellings in the CD's}} = \frac{10}{\text{skip interval}}$$

The recruitment of a representative sample is the first stage in assessing the prevalence of a population problem such as hearing impairment. Following the recruitment of the SAHOS sample, people were then asked if they would consent to take part in a National Health and Medical Research Council (NHMRC) South Australian Hearing Study. Further detail on the recruitment response rates at each of these stages is given below.

4.3 Sample Selection

In sampling for SAHOS from the population using the PPS sampling method identified above, all CD clusters in the population are listed first as shown by the example in Table 4.1. CD's are then selected as described under the self-weighting procedure above.

Table 4.1: Scheme for selecting CD's with probability proportional to size

CD	N of households in each CD	Cumulative N of households	CD's selected in sample *
1	500	500	
2	750	1250	*
3	920	2170	*
4	650	2820	
5	1075	3895	*
6	890	4785	*
7	1220	6005	**

Within each CD a fixed number of dwellings are selected, each time the CD is selected, commencing from a randomly chosen starting point within the CD. As some CD's are larger than others, and based on the theory of selection with probability proportional to size, it stands to reason that larger CD's have a greater probability of being selected, or of being selected more than once. The principle of listing and selecting from CD's is demonstrated in Table 4.1. It can be seen from this that if a skip interval of 1000 was determined in sampling of CD's, then CD's 2, 3, 5, 6 and 7, would be chosen from the CD's listed in the Table. It can also be seen that based on the skip interval CD number 7 is selected twice for this theoretical sample.

Using the sample frame and sample methodology detailed above people were recruited to the Stage 2 South Australian Hearing Study, in which hearing threshold levels were measured by an audiologist. Stage 1 of the recruitment process involved the collection of data on self-reported hearing disability, the collection of biomedical and demographic information and, in the first two Health Omnibus Surveys, the administration of the SF-36 (Short Form) quality of life questionnaire. Stage 2 involved measurement of hearing threshold levels and administration of the second questionnaire.

The SAHOS asked a preliminary screening question (also used in the MRC National Study of Hearing (Davis 1983). This asked: "Do you usually have trouble hearing what people say to you in a quiet room (a) when they speak loudly to you, (b) if they speak normally to you, (c) if they whisper to you, and (d) none of the above?" As previously stated, this question is regarded as self-reported hearing disability. Respondents were coded as reporting a hearing disability if they answered "yes" to any of the first three categories, and coded as not having a hearing disability if they answered "yes" to the fourth category. In the Stage 2 South Australian Hearing Study people were recruited for audiological assessment from each of the groups who reported a hearing disability and reported no hearing disability.

Table 4.2 shows the cumulative SAHOS samples for 1994/95 and the recruitment process for the Stage 2 South Australian Hearing Study. It can be seen from Table 4.2 that the overall response rate for the three SAHOS was 75.2%. Of these n=1378, or 15.3% of SAHOS respondents, reported a hearing disability and were available for recruitment to Stage 2. From those who reported a hearing disability n=689, or 50.0% finally took part in the Stage 2 South Australian Hearing Study and provided useable audiograms. To obtain the overall population response rate for this group (reported hearing disability) the response rate of 50.0% must be multiplied by the response rate of 75.2% obtained in the SAHOS. This gives a population response rate of 38%.

In addition to those recruited to the South Australian Hearing Study who reported a hearing disability, a random sample of n=300 people was selected from those who reported no hearing disability in the second of the three SAHOS recruitment studies. This group was necessary to measure the false positive rate of the self-report screening question ie. those who reported no hearing disability, but on audiological assessment had a measurable hearing impairment. This estimate was used to adjust the final population estimate for hearing impairment. Of the n=300 people recruited in the random sample 79% took part in the Stage 2 South Australian Hearing Study providing useable audiograms. This response rate of 79% must be multiplied by 75.2% which was the proportion of people in the SAHOS who reported normal hearing and agreed to take part in the survey. This gives an overall population response rate of those who reported no disability of 59%. It should be pointed out that these response rates, involving multi-stage recruitment of population groups, are respectable when compared with response rates for the British Study of Hearing (Davis, 1983; Davis, 1989).

The data reported in Table 4.2 were used as the basis for calculating the standard errors for the population prevalence rates reported in Chapter 5. The method used in calculating the standard errors is reported in detail later in this chapter.

It should also be pointed out at this stage that the differential recruitment process and the differential non-response rate introduced complex weighting and standard error computations. Assistance in weighting of data and calculation of the standard errors for the prevalence estimates was sought from an expert population statistician who has analytical experience of complex survey designs in population studies conducted by the Australian Bureau of Statistics and other South Australian Government departments.[3]

Individuals who were recruited to Stage 2 of the study were asked to complete a second questionnaire at home prior to attending the audiologist for a full audiological assessment (Appendix 3). The audiological procedure is explained in a subsequent section.

Table 4.2: Recruitment from the 1994/95 SAHOS to the South Australian Hearing Study

	RECRUITMENT CATEGORIES	n	Response Proportions %
a	n of respondents to the 1994/95 SAHOS	9027	75.2
b	n in the 1994/95 surveys reporting a hearing disability	1378	15.3
c	n in the 1994/95 surveys reporting a hearing disability and finally took part in Stage 2	689[4]	50.0
d	n in the 1994/95 surveys reporting no hearing disability	7754	84.7
e	random sample of those reporting no hearing disability and agree to take part in Stage 2	300	100.0
f	proportion of the random sample who finally took part in Stage 2	237	79.0

[3] Personal communication with Graham Tucker, Statistical Manager, Family and Community Services, South Australian Health Commission

[4] The SF-36 was only administered in the first two SAHOS resulting in n=483 being avialable for the Quality-of-Life analyses.

4.4 Sample Size Calculations

The sample size computations for the South Australian Hearing Study were determined by the main study objectives. These are as follows:

1. Describe the prevalence and severity of measured hearing impairment for the South Australian population.
2. Test the efficacy of the self-reported hearing disability question used in previous SAHOS of hearing and assess the value of its continued use in future studies.
3. Describe the quality-of-life of the hearing impaired population.
4. Compare the quality-of-life of the hearing impaired population with those who were not impaired as assessed by audiology.

The final study sample size was determined by the largest computation based on these objectives.

In determining the sample size for the South Australian Hearing Study information on hearing disability from previous SAHOS made an important contribution. In previous SAHOS the final sample size was approximately n=3000. In these surveys the self-reported estimate of hearing disability ranged from 14% to 19%. This meant that, at the lower of these estimates, approximately 400 people would report a hearing disability in each SAHOS and be available for audiology. Given this information an important question for the South Australian Hearing Study was: would the final sample of hearing impaired people recruited in three consecutive SAHOS be enough to achieve the objectives of the study, especially as there would be sample loss in recruiting from the SAHOS into the Stage 2 South Australian Hearing Study? The first part of the answer to this question involved calculation of the sample size required to estimate the population prevalence of hearing impairment.

Two important considerations were inherent in this calculation of sample size. These were:

- the clustered nature of the SAHOS sampling method, and:
- the need to sample not only those who reported a hearing disability, but also to take account of the false negative self-report rate and sample those who reported no disability.

Kish (1965) provides formulae for clustered (PPS) sampling methods that were faced in this study. He also provides a method for simplifying the complexity of PPS formulae by calculating the design effect of the survey from previous experience, if available. Given the known self-reported rate of hearing disability from previous SAHOS, it was possible to compute a design effect based on the ratio of the actual variance of the SAHOS estimates of hearing disability to the variance of the estimate of the same number of elements that did not take account of the design effect (simple random sampling). The estimate of the actual variance was computed for two previous SAHOS using SUDAAN, (Shah et al, 1995) which adjusts the simple random sample estimate according to the multistage sampling methodology used in the SAHOS. The highest design effect computed from the ratio given by Kish was 1.2. This ratio meant that it was possible to use a simple random sample formula, inflated by the design effect, to calculate the sample size required to estimate the population prevalence estimate of hearing impairment. Epi-Info Version 6.2 (Dean et al, 1994) was used to calculate a simple random sample to detect a prevalence rate for hearing impairment of 16.4% with 95% confidence that the true prevalence lies within 4% (ie 12.4% to 20.4%). The estimate of 16.4% was used because this was the self-reported hearing disability rate in the 1994 November SAHOS: the first survey used to recruit for the audiological study. The overall estimate of 15.3% from all recruitment SAHOS (Table 4.2) could have been used for the sample size calculation, however, it was considered that the highest estimate from the three recruiting surveys should be used so as to maximise survey sample size. The estimate of 16.4% was also more consistent with the range of South Australian estimates reported earlier in Chapter 2. The sample size given by Epi-Info was n=327. This was multiplied by 1.2 to account for the design effect giving a final sample size of n=360. The final response rate for the study providing useable audiograms, yielded from three SAHOS was well in excess of this number at n=926.

The second sample size consideration was related to the measure of agreement between self-reported hearing disability and audiologically measured impairment. Agreement between the measures is important because the question on self-reported hearing disability can be used in future studies, if it accurately identifies those with a hearing impairment. Any major difference between the two rates may seriously question the continued use of the self-report question. The self-report hearing question has now been used in a number of population studies of hearing impairment in the United States (National Centre for Health Statistics, 1994), England (Medical Research Council Institute of Hearing Research, 1981) and in South Australia (Wilson, 1992(c)). It cannot be assumed that assignment of a subject to a hearing impaired, or non-hearing

impaired category is made without error using the self-report question. The second sample size calculation, therefore, was based on hypothesised misclassification rates of the self-report question.

Fleiss (1981) provides a comprehensive treatment of the effects of misclassification and Donner & Eliasziw (1992) provides a method of sample estimation. First, it was necessary to determine an estimate of the magnitude of possible misclassification error using the self-reported hearing disability question classifying people with hearing impairment or no hearing impairment. Table 4.3 represents the problem of reported disability and measured hearing impairment for a population sample. Cells a and c are the groups who would be classified with hearing impairment by audiological measure and cells b and d those who would be classified with no hearing impairment. Cells a and d contain those people who would be correctly classified by both self-report and audiological thresholds and represent the level of agreement of both measures. Totalling the frequencies in cells a and d (that is the diagonal) gives the number of cases similarly classified by the two measures. Dividing this by the total (n) gives the proportional agreement (P) of the two measures.

Table 4.3: Level of agreement between self-reported hearing disability and threshold measures of hearing impairment

		AUDIOLOGY		
		Impairment	*No Impairment*	Total
SELF	*Disability*	a	b	r
REPORT	*No Disability*	c	d	r
	Total	c	c	n

The Kappa statistic (K) provides a better measure of agreement than the proportional agreement alone by incorporating a correction for chance agreement (P) (Donner et al, 1992).

$$K = \frac{P_o - P_c}{1 - P_c}$$

P_c is calculated using the standard chi-square procedure for finding expected frequencies in any joint cell $r \times c/n$.

$$P_c = \left(\frac{r_1 \times c_1}{1 - P_c} + \frac{r_2 \times c_2}{n} \right) / n$$

The theoretical basis of agreement in Table 4.3 is applied to best estimates of hearing impairment in Table 4.4 to further progress the sample size calculation. Table 4.4 provides estimates of agreement based on previous self-reported SAHOS data and information from the British Study of Hearing on measured hearing impairment. An estimate of 16.4% for reported disability is taken from the 1994 SAHOS. Information from the British Study of Hearing, however, suggests that measured hearing impairment could be as high as 25% of the population in the worse ear (ie. an increase of 9% over the self-report rate). These data were used together to provide estimates for the cells in Table 4.4. Although the British Study of Hearing suggests an increase in the prevalence of hearing disability when people are measured (ie false negatives on self-report), this is only one possible scenario which can result from self-reported hearing status. Another is that some people who reported hearing disability in fact have normal hearing (ie false positives on self-report). Therefore, both gains and losses will change the self-report rate when people are assessed audiologically. No data are available to estimate the false positives to the self-report question. However, for this theoretical exercise it was not considered unreasonable to hypothesise that if an additional 9% of the population who report no hearing impairment are impaired then a slightly lower proportion (say 6%) of the population are incorrect in reporting a hearing impairment and do not have one. Combining this information and applying it to a theoretical sample of n=900 as shown in Table 4.4 it is possible to estimate the level of agreement between self-reported disability and measured hearing impairment.

Table 4.4: Estimate of the level of agreement between self-reported disability (SAHOS) and threshold measures of impairment (MRC Hearing Study)

		AUDIOLOGY		
		Impairment	*No Impairment*	Total
SELF	*Disability*	148 (0.16)	54 (0.06)	202 (22.4)
REPORT	*No disability*	81 (0.09)	617 (0.69)	698 (77.6)
	Total	229 (25.4)	671 (74.6)	900 (100.0)

Computing the Kappa statistic for the data in Table 4.4, using the equation above, the estimate of the coefficient of agreement is 0.58, based on self-reported SAHOS data and MRC Audiological data.

Using the Kappa statistic Donner & Eliasziw (1992) provides a sample formula to compute the sample size needed to conduct a two-sided test of a hypothesis with significance level α and power $1-\beta(1,\lambda,\alpha)$. This incorporates the observed coefficient of agreement (K_O) as calculated above and an estimated coefficient (K_I) representing substantial agreement. This formula is:

$$n = l(1,1-b,a)\left\{\frac{p(1-p)(K_1-K_o)^2}{p^2+p(1-p)K_o}+\frac{2\left[p(1-p)(K_1-K_o)\right]^2}{p(1-p)(1-K_0)}+\frac{\left[p(1-p)(K_1-K_o)\right]^2}{(1-p)^2+p(1-p)K_o}\right\}^{-1}$$

In this study it is of interest to test the hypothesis Ho: K=0.4 versus Ho: K≠0.4, where K_o=0.4 corresponds to the value of Kappa characterised by Landis and Koch (1977) as representing moderate agreement. To ensure with 80% probability a significant result at α=0.05 and p=0.164 (the prevalence of self-reported hearing disability) when K_I=0.58, as computed earlier, we can calculate the required number for the sample from the equation above as n=637.

The effect of misclassification also has implications for the sample size required to establish the population prevalence of hearing impairment calculated earlier. This was based on an estimate of 16.4% from self-report and produced the sample size of n=360. If however the real prevalence is 25% as suggested by the British audiological study then this sample size needs to be reviewed. Re-calculating the sample for a population prevalence rate of 25%, with a ninety five percent confidence interval of 4% and inflated for a design effect of 1.2, gives a final sample size of n=540. Given that n=926 people provided useable audiograms the sample size of the study was considered adequate for the first two study objectives.

The third, and final study objective that had to be considered in relation to adequacy of sample size is the comparison of the quality-of-life of the audiologically measured hearing impaired with the non-impaired using the SF-36 Quality-of-Life measure. This comparison represents a test of the difference in the mean scores for the two groups on

each health dimension of the SF-36. Colton (1974) provides a formula for estimating sample size for a comparison of two means as follows:

$$n = 2\left[\frac{(Z_\alpha - Z_\beta)\sigma}{u_1 - u_2}\right]^2$$

Information on which to base this sample calculation was also available from a previous study (Behavioural Epidemiology Unit, 1995) using the SF-36 quality-of-life questionnaire. This measured the difference on the eight dimensions of the instrument for self-reported hearing disability and self-reported normal hearing. The smallest difference between the dimension means was for the mental health dimension where the mean score for the hearing impaired group was 5.6 points lower than the group with normal hearing. Using this information with α=0.05, a power of 80% and an estimate of the standard deviation of the difference in the population means of 17.7 (computed from the standard deviation of both estimates) a sample size of n=350 would be required.

In comparing the hearing impaired with the normal hearing group, SF-36 data were only available from the first two SAHOS. This resulted in n=483 hearing impaired people and n=237 with normal hearing being available for the quality-of-life analysis. The overall sample to compare the hearing impaired and the non-impaired was clearly adequate, but may not be adequate for sub-groups of both categories. This problem will be discussed further in the chapter dealing with quality-of-life.

4.5 Data Collection

Demographic Variables

As already mentioned, some of the data in the analyses of this study were collected in three SAHOS. In addition a supplementary questionnaire was completed at home, and an audiological examination was performed by trained audiologists in six audiological practices.

From the SAHOS a number of demographic variables were obtained and these are shown in Table 4.5. The categories of these demographic variables are largely self-explanatory and are shown in the Table. For socio-economic status (SES), however, the categories are not self-explanatory and were derived from occupational status as determined by ASCO codes (Australian Bureau of Statistics, 1990(a); Kelley & Evans, 1988), using a conventional method of aggregation to categorise respondents into high medium or low socio-economic status. Area of residence was determined from Australian Bureau of Statistics Collector Districts based on regional divisions of South Australia. In addition to these demographic variables data were also collected in all three SAHOS recruitment surveys on asthma, diabetes, alcohol consumption, body mass index and smoking status.

Diabetes status was determined if the respondent had ever been told by a doctor they had diabetes (asked in SAHOS 1990 - 1994). Asthma was determined if the respondent had ever been told by a doctor they had asthma and still had asthma (Abramson et al, 1992). Alcohol risk levels of consumption were computed according to the criteria developed by the National Heart Foundation of Australia (National Heart Foundation of Australia, 1990). In the 1994 and autumn 1995 SAHOS data was also collected, by interview, for the SF-36 quality of life instrument. The eight dimensions of health that are computed from the 36 questions in this study are listed in Table 4.6. Variables in the SF-36 quality-of-life questionnaire were coded and scaled according to the instructions in the manual developed for analysis and interpretation (Ware, 1993(b)).

Table 4.5: Questions included in the SAHOS and used in the South Australian Hearing Study

VARIABLE	VARIABLE CATEGORIES/DIMENSIONS
Gender	Male Female
Age	15 to 30 years 31 to 40 years 41 to 50 years 51 to 60 years 61 to 70 years 71 to 80 years 80 + years
Area of Residence	Metropolitan Area Country Area
Country of Birth	Australia United Kingdom & Ireland Other
Highest Education Level	High School only Still at school Trade Qualifications Certificate/Diploma Degree
Marital Status	Married Never Married
Annual Household Income	<$20,000 $20,000-$40,000 $40,001+ Not Stated
Socio-Economic Status	High Medium Low
Asthma	Diagnosed by a doctor (yes/no)
Diabetes	Diagnosed by a doctor (yes/no)
Smoking status	Smoker Ex-smoker Non-smoker
Body Mass Index	Normal weight Overweight
Alcohol risk	Drink at risk levels Do not drink at risk levels

Table 4.6: SF-36 dimensions assessed in the November 1994 and May 1995 SAHOS

VARIABLE	DIMENSIONS
Quality-of-Life	Physical functioning
	Role physical
	Body pain
	General Health
	Vitality
	Social functioning
	Role emotional
	Mental health

4.6 Variables in the Self-Completion Questionnaire

The self-completion questionnaire was administered to both those groups who reported hearing disability and the control group who reported no hearing disability in the Stage 2 South Australian Hearing Study. The variables examined in the self-completion questionnaire are shown in Table 4.7. The questionnaire is contained in Appendix 3.

For information on use of hospitals, people were asked about admissions to hospital, length of stay and casualty visits in the previous twelve months. Visits to a general practitioner were recorded for both the previous six and twelve months. Support for activities of daily living were assessed by asking about health professional visits to the home in the previous twelve months. For the "sick days" variable respondents were asked to state: "the time they had taken off from work, school or place of study in the last two months and in the last two weeks". For the health professionals seen about hearing disability in the last twelve months, the response categories were: "audiologist, GP, ear nose and throat specialist, hearing aid company, Better Hearing Australia, pharmacist, other, or none of these". The most serious difficulty experienced from hearing disability provided the choice of: "effects on study life, working life, social life, family life, personal depression, physical pain or suffering, and other (specified), or none of these". The choice of health professionals contacted in relation to this most serious difficulty provided the same list as health professionals seen in the previous twelve months. Frequency of hearing aid use was given in hours the aid is used each

day: "less than two hours, two but less than four hours, four but less than eight hours, do not use every day, and varies". The choice of responses for benefit obtained from a hearing aid were: "hearing aid made things worse, hearing aid is no use at all, hearing aid is some help, hearing aid is a great help, or can't say." In addition, respondents were asked how helpful their aid had been compared to what they had expected before they obtained it. Response categories for this question were: "much less helpful than expected, a bit less helpful than expected, what was expected, a bit more helpful than expected, and much more helpful than expected." Respondents were also asked how satisfied they had been with the aid. Response categories were: "not at all satisfied, not very satisfied, fairly satisfied, very satisfied, and delighted." Aid performance was examined in relation to a number of every day hearing situations in which aid performance was rated as: "very good, good, average, poor, useless". Finally a number of descriptive words and phrases describing the persons feelings about their aid were provided. Respondents could circle as many of these as individuals felt were appropriate to describe their experience. The definition of prolonged spontaneous tinnitus was taken from Davis (1996) and is described as noises in the head such as ringing, buzzing or whistling that lasts for five minutes or more, and occur not following exposure to loud noise. Tinnitus suffering which fitted this definition was computed from a series of questions. Noise exposure history was computed from the length of time respondents had worked in a noisy industry, exposure to firearms, or regular attendance at live concerts, or discos, and listening to amplified music. Medication use was examined via a range of conditions and people were asked if they took any medications for sleeping, to keep calm, water, blood pressure, heart, depression, pain relief or something else (specified).

Table 4.7: Health questions asked in the self-completion questionnaire

VARIABLE	VARIABLE CATEGORIES/DIMENSIONS
Hospital	Admissions in previous twelve months
	Length of hospital stay
	Visits to casualty in last twelve months
GP	Visits in last twelve months
	Visits in last six months
Health Services	Frequency of domestic care visits last twelve months
	Frequency of district nurse visits last twelve months
	Frequency of visits of other home service last twelve months
Sick Days	Time away from work, school, place of study in last twelve months
Hearing Disability	Most serious difficulty experienced
	Health professionals seen for hearing in the last twelve months
	Health professionals used for most serious difficulty
Hearing Aid Use	Length of time owned hearing aid
	Frequency of using aid
	Benefit obtained from aid
	Level of satisfaction with aid
	Expectations from aid
	Value of aid in everyday situations
	Current feelings about aid
	Overall satisfaction with aid
Tinnitus	Prolonged spontaneous tinnitus
	Side of head tinnitus experienced
	Level of annoyance
	Length of time tinnitus experienced each day
Noise Exposure	Worked in noisy job
	Length of time worked in noisy industry
	Served in armed services
	Exposure to firearms
	Other sources of noise exposure
	Concert/disco exposure
Medications	Purpose for which medications are used
Hearing related difficulty	Study life/working life/social life/family life
	recreational life/depression/physical pain
Sought help for the difficulty	Audiologist
	General practitioner
	Ear nose & throat specialist
	Hearing aid company
	Pharmacist
	Cannot remember
	Other
Require domestic help	Domiciliary care
	District nurse
	Other service

4.7 Audiological Methods

Eight private practice audiologists were used in the South Australian Hearing Study. They completed a three hour briefing workshop which covered the study protocols including: the necessity for all equipment to be re-validated to Australian standards; history taking; the sequence of audiological examination; recording of data on the study audiogram; translation of the data to computer codes for entry; and appropriate referral of patients with significant morbidity.

To ensure that high standards of audiological practice were maintained a test/retest protocol was invoked. 32 (3.5%) of the 926 people who were audiologically assessed were randomly selected for retesting by one of the audiologists who was blind to the client being retested. These data were compared with the original audiograms. Comparative agreement was assessed across the important speech frequencies 0.5, 1, 2 & 4kHz. If the reading for any one of the four frequencies varied by $\pm$ 10dBHTL or more then that frequency was considered to disagree with the original reading. From a total of 256 frequency readings the level of test/retest agreement was 96%. In addition, one audiologist was asked to review the original audiograms to determine whether hearing impairment was apparent at $\geq$21dBHTL $\geq$25dBHTL and to determine type of hearing impairment (conductive, sensorineural or mixed). This audiologist was blind to the recorded opinion of the original audiologist. Of the 926 audiograms the reviewing audiologist agreed with the original assessment in 98% of cases. The audiologist was then also asked to determine whether hearing impairment was unilateral or bilateral for the total sample and whether the audiogram showed a significant noise component. Because of the high level of agreement between audiological opinions, this audiologist's opinion was used for part of the analyses.

All appointments with audiologists were arranged following completion of the home questionnaire. An audiological history and examination consent form (Appendix 4) was signed by each participant prior to interview and assessment. A standardised comprehensive audiological history (Appendix 5) was then taken by the audiologist prior to otoscopic examination. If significant cerumen was detected which obscured a good view of the tympanic membrane (or were considered enough to effect the audiometric results) the participant was given a letter for their general practitioner for removal of the cerumen and a further appointment was arranged to complete the audiological assessments. Otoscopic examination also allowed observation of the

potential for collapse of the canal walls when earphones are placed on the head, a problem prevalent in audiometric assessment (Creston, 1965; Schow & Goldbaum, 1980). Canal collapse was managed by the audiologist including the use of EAR TONE 3A insert earphones with appropriate adjustments to calibration.

All audiological assessments were performed in sound-attenuated booths, conforming to Australian Standard 1269-1989 (Standards Australia, 1989) for measurement of air conduction thresholds of 0 dBHTL. A firm calibration protocol conforming to Australian Standards AS 2586-1983 (Standards Australia, 1995) for air conduction and Australian Standards AS 1591.4:1995 for bone conduction (Standards Australia, 1995) was maintained through out the study.

The method of audiological assessment was explained to each participant as follows:

> "I am going to test your hearing by measuring the faintest sounds that you can hear. I will test one ear at a time. As soon as you hear a sound, press the button. It is important to keep as quiet as possible in order to hear the faintest sounds. No matter how faint the sound, press the button when you hear it. I am going to test your left/right ear first. The sounds will be mid-pitched at first, then I will test the higher pitches and then the lower pitches."

An otoscopic check for the likelihood of collapsed ear canals under headphone pressure was taken. If positive, EAR TONE 3A insert earphones were used.

Air conduction thresholds were measured at 250Hz, 500Hz, 1kHz, 2kHz, 3kHz, 4kHz, 6kHz and 8kHz. Bone conduction thresholds were obtained at 500Hz, 1kHz, 2kHz and 4kHz.

Air conduction thresholds were first measured in the ear which the participant indicated to be the better ear, or the right ear if he/she felt there was no difference. The order of testing was: 1kHz, 2kHz, 3kHz, 4kHz, 6kHz, 8kHz, 0.5kHz, 0.25kHz. Re-testing was conducted on the first ear only at 1kHz. If the re-test value was more than $\pm$ 5dB from the original value, the next frequency was assessed. The contralateral ear was tested in the same sequence. Audiometric measurements were performed down to -10dB HTL if present.

Bone conduction thresholds were measured at 1kHz, 2kHz, 4kHz and 0.5kHz bilaterally. Standardised audiometric symbols were used throughout. Insert masking was used where appropriate. All results were recorded on a pro-forma. Audiograms were converted for computer input by the audiologist (on the same form) to eliminate possible conversion errors by data processors.

Home visits were conducted for 51 people in the sample who could not attend for audiology. Many of these were South Australian country visits for people who did not normally come to the city. In these cases EAR TONE 3A insert ear phones were used in conjunction with a portable audiometer conforming with the Australian Standard. The test was conducted in the quietest part of the home with other sources of home noise silenced.

A copy of the audiometric results and the audiologists recommendations was given to the participant for their general practitioner. A payment of $20.00 was made to each client post assessment to cover any expenses that may have been incurred in attending.

4.8 Equipment

All assessments were performed using two channel air and bone conduction clinical audiometers. MX41AR/MX51AR Supra aural cushions for noise exclusion were used.

4.9 Ethics Approval

Ethics approval for this study was obtained from the Ethics Committee, Royal Adelaide Hospital, North Terrace, Adelaide 5000.

4.10 Re-weighting of the hearing data set

Re-weighting of the data was necessary because of the two stage design of the study in which people were first asked about their hearing in the SAHOS then recruited to the Stage 2 South Australian Hearing Study.

Although detailed information has already been provided on the study methodology it is necessary here to describe the method used to re-weight the data for the Stage 2

analyses to determine prevalence estimates of hearing impairment, level of agreement between reported disability and measured impairment, and assessment of quality of life.

Data on self-reported hearing disability were collected in the SAHOS conducted in October 1994, April 1995 and October 1995. These data were first weighted to South Australian census data by age, sex, geographic region and household size to provide self-report estimates of hearing disability. Those reporting hearing disability in the three surveys were asked if they would agree to take part in the Stage 2 South Australian Hearing Study. Subjects for the South Australian Hearing Study were thus recruited from the SAHOS. A supplementary questionnaire was also administered to each participant prior to the audiological assessment. In addition, in the 1995 (April) SAHOS a control group was recruited by taking a sample of those reporting no hearing disability. Audiological data was also collected from this control group sample and the supplementary questionnaire was again administered. The design of the study therefore required the data from the three separate surveys to be concentrated into one file for both case and control groups for the South Australian Hearing Study. It was felt that whilst the original weights could reasonably be used for the analysis, their use would overlook the possible effect of differential non-response across strata (sex, age, part of state, and year) in the second stage of recruitment. The data were therefore re-weighted to provide a weight which took account not only of differing probabilities of selection and response rates in the initial collection of SAHOS data, but also allowed for differing response rates in the Stage 2 South Australian Hearing Study.

The original SAHOS sample was stratified by the part of state (metropolitan/country). The sample was self-weighting, with CD's selected with probability proportional to their size, and an equal number of dwellings selected from each CD. As discussed in section 4.2 the survey method in the metropolitan area was based on CD's. In the country, towns were the first stage of selection, selected with probability proportional to size, then CD's were selected with probability proportional to size, preserving the self-weighting properties of the sample design. Dwellings were thus selected with equal probability, and one person was chosen from each dwelling at random.

In the original weighting of the SAHOS sample, account was taken of the differing probabilities of selection of the sample by first weighting by the household size. The sample was post stratified by sex and five year age groups, and weighted to Australian Bureau of Statistics derived benchmarks for the part of state, sex and five year age groups (Australian Bureau of Statistics, 1992).

In re-weighting the data for the Stage 2 South Australian Hearing Study age groups were required for output to allow direct comparisons with the British study. The age groups used for comparison were:

15 - 50 years
51 - 60 years
61 - 70 years
71 years or more.

It should be noted that these age groups do not map exactly to the original post stratification by age used for the SAHOS. Official statistics in Australia are generally produced in five years age ranges from 0 - 4 years, 5 - 9 years, etc., and these were therefore the five year age ranges used in the original weighting of the data. This process of re-weighting therefore contains an approximation in that the average correction for non-response is one year out. For example, the 60 - 69 year age group has been applied to the 61 - 70 year age group on re-weighting. Frequency data showed that this one year dislocation would have had a negligible effect on the analysis.

This re-weighting of the data therefore took into account the differing probabilities of selection and response rates experienced in each SAHOS. To re-weight the survey data it was necessary to stratify the sample by the survey in which it was collected (October 1994, April 1995, October 1995), the part of state, sex, and age group, and also whether the respondent reported a hearing disability or not, since the method of sample selection differed for cases and controls. Re-weighting is first explained for those respondents reporting a hearing disability (cases).

In each survey, it is possible that the response rate for any survey/area/sex/age cell is different. This can be adjusted for by multiplying the existing (SAHOS) weight by the sum of the weights of those reporting hearing disability, divided by the sum of the weights of those reporting hearing disability who took part in the South Australian Hearing Study.

Let n_h be the number of SAHOS respondents reporting a hearing disability in stratum h (defined by the combination of survey, area, sex & age).

Let n_h' be the number of respondents in the Stage 2 South Australian Hearing Study reporting a hearing disability in stratum h.

Thus the sample size over all strata for the audiological study is $n' = \sum_h n_h'$

Let wt_{hi} be the original case weight from the SAHOS for the ith case in stratum h.

Then $$wt2_{hi} = wt_{hi} * \frac{\sum_{i=1}^{n_h} wt_{hi}}{\sum_{j=1}^{n_h'} wt_{hj}}$$

This new weight ($wt2_{hi}$) will sum over all those included in the South Australian Hearing Study to the sum of the original weights of those reporting hearing disability in the SAHOS. It is desirable for these weights sum to the sample size of the South Australian Hearing Study over all strata. This is achieved by dividing the calculated weight ($wt2_{hi}$) by the total sum of the weights in the SAHOS, so that the weights all add to 1, then multiplying by the sample size of the South Australian Hearing Study (n=926). Thus the weight for the Stage South Australian Hearing Study is :

$$wt3_{hi} = wt2_{hi} * \frac{n'}{\sum_h \sum_{i=1}^{n_h} wt_{hi}}$$

$$= wt_{hi} * \frac{\sum_{i=1}^{n_h} wt_{hi}}{\sum_{j=1}^{n_h'} wt_{hj}} * \frac{n'}{\sum_h \sum_{i=1}^{n_h} wt_{hi}}$$

This weight will sum to the sample size of the South Australian Hearing Study.

For those respondents who did not report a hearing disability (controls), the same process could have been followed, however this would not have taken account of all available information, since a sample of controls (those not reporting a hearing disability) was only drawn from the April 1995 SAHOS. Repeating the above correction for non-response would have ignored data collected about the profile of persons not reporting a hearing disability in the October 1994 and October 1995 SAHOS.

Another way to view the correction for non-response above is to consider that we are estimating a profile of persons reporting (and not reporting) hearing disability from the SAHOS data, for use as benchmarks in re-weighting the Stage 2 South Australian Hearing Study data. In the example above the survey of collection was used as another stratification variable, to account for different response rates between surveys. For those not reporting a hearing disability, using the profile of those not reporting hearing disability over the three years of SAHOS data available is bound to be more accurate since it is based on more observations. Accordingly, data for controls were re-weighted to the benchmarks derived for all three years of SAHOS data for those not reporting a hearing disability. Essentially the mechanics of the re-weighting process (and the algebra) are not changed by this adjustment, except that the stratification variable "survey" is ignored.

4.11 Variance Estimation

The sample for the SAHOS is a clustered, self-weighting, multistage area sample, stratified by the part of state, and post stratified by age and sex. It is a complex design. As with all complex sample designs, the most appropriate variance estimator is the ultimate cluster variance estimator (Kish, 1965). This estimator has the remarkable property in that it calculates the total variance of an estimate derived from a multistage sample, based solely on the variation occurring in the estimates of totals of selected first stage units, regardless of the selection methods employed in the subsequent stages of selection.

The general form of the **ultimate cluster** variance estimator is :

$$\hat{\sigma}^2_{x'} = \frac{1}{m} * \frac{1}{m-1} * \sum_{i=1}^{m} (\hat{x}_i - x')^2$$

where m is the number of clusters

$\hat{x}_i$ is an estimate of the population total based solely on the sample in the ith selected first stage cluster .

x' is the estimate of level over all clusters, which is generally taken to be = $\frac{1}{m}\sum_{i=1}^{m} \hat{x}_i$

In fact, in this instance we want $x' = N * \bar{x} = N\left(\frac{\sum_{i=1}^{m}\sum_{j=1}^{n'_i} wt_{ij}x_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n'_i} wt_{ij}}\right)$

It is legitimate to substitute this estimator of x' in the above formula to calculate the variance of it (Wolter, 1985).

Let m be the number of Primary Sampling Units (PSU's)

N_{ih} be the population of the ith PSU for any age sex stratum h

N_h be the total population of the age sex stratum over all PSU's $= \sum_i N_{ih}$

n'_i be the number of observations in the ith PSU

p_i be the probability of selecting the ith PSU

x_{ij} be the jth observation in the ith PSU

Dealing first with the metropolitan sample, where CD's were selected with a single draw probability p_i proportional to size (PPS), with:

$$p_i = \frac{\text{Number of dwellings in the CD}}{\text{Total dwellings in the Metropolitan area}}$$

In any age/sex stratum, the best estimate of the number of people with a characteristic in PSU i is:

$x'_{ih} = N_{ih}\left(\frac{\sum_{j=1}^{n'_i} wt_{ij}x_{ij}}{\sum_{j=1}^{n'_i} wt_{ij}}\right)$. Note that weights are not constant within strata.

$= N_{ih}\bar{x}_{ih}$ where $\bar{x}_{ih}$ is the weighted mean for PSU i.

This formula takes into account the fact that units within PSU i have differing probabilities of selection, and also accounts for differential non-response, as these factors have been allowed for in the weighting.

Thus the estimate of the population total based on PSU i is $\hat{x}_{ih} = \frac{N_{ih}\bar{x}_{ih}}{p_i}$

The ultimate cluster variance estimator for level is then:

$$\hat{\sigma}^2_{x_h'} = \frac{1}{m} * \frac{1}{m-1} * \sum_{i=1}^{m} \left(\hat{x}_{ih} - x'_{ih}\right)^2$$

Since $x'_h = N_h \bar{x}_h$, the variance estimator for $\bar{x}_h$ is:

$$\hat{\sigma}^2_{\bar{x}_h} = \frac{1}{N_h^2} * \frac{1}{m} * \frac{1}{m-1} * \sum_{i=1}^{m} \left(\hat{x}_{ih} - x'_{ih}\right)^2$$

Since strata are independent, the variance estimator of the level estimate over the whole metropolitan sample is:

$$\hat{\sigma}^2_{x'} = \sum_h \hat{\sigma}^2_{x_h'} = \sum_h \left(\frac{1}{m} * \frac{1}{m-1} * \sum_{i=1}^{m} \left(\hat{x}_{ih} - x'_{ih}\right)^2 \right)$$

and the variance of the mean over the whole metropolitan sample is:

$$\hat{\sigma}^2_{\bar{x}} = \frac{1}{N^2} \sum_h \hat{\sigma}^2_{x_h'} = \frac{1}{N^2} * \sum_h \left(\frac{1}{m} * \frac{1}{m-1} * \sum_{i=1}^{m} \left(\hat{x}_{ih} - x'_{ih}\right)^2 \right)$$

The country sample was based on towns as PSU's. Therefore the same process was followed to calculate variances using towns as the PSU rather than CD's. The variance components for the metropolitan and country areas were calculated separately, and amalgamated to produce overall variance estimates.

5. STUDY RESULTS

OVERVIEW

This chapter discusses the main study results for the prevalence of hearing impairment in the South Australian population. Estimates are given for overall hearing impairment and type of impairment. The prevalence estimates are compared with those from the MRC National Study of Hearing. Finally, the chapter compares the characteristics of the hearing impaired and the non-impaired as defined by hearing threshold levels.

5.1 Introduction

This chapter covers the prevalence of hearing impairment in the South Australian population as assessed by audiological measurement of hearing threshold levels. Prevalence is given for two threshold levels ≥21dBHTL and ≥25dBHTL. The first level is consistent with the level that Australian audiologists would consider as the working level of concern regarding the individual's hearing thresholds. It is also consistent with the lower level of mild impairment as described by the British Society of Audiology (1988). In addition, thresholds greater than 20 dBHTL are considered out of range of young normal, and therefore indicate a hearing impairment of some degree (Ballantyne et al, 1993). The second level (≥25dBHTL) was the level used to report the prevalence of measured hearing impairment in the adult population of Great Britain (Davis, 1989) and provides a useful point of comparison for the South Australian prevalence estimates. This chapter will also compare the characteristics of the hearing impaired population in a case control study with those people whose hearing was classified as unimpaired at ≥25dBHTL when averaging the thresholds across the frequencies 0.5, 1, 2, and 4kHz. This level was selected for the case control study because of the opportunity to compare South Australian findings with the British Study results. In comparison with the British data[4] the 71+ age group for South Australia covers all ages above 71 years, however, the British Study data is only for people aged 71-80 years. As the number of people older than 80 years in the South Australian study was small it is likely to only effect marginal changes to the South Australian estimate for the 71-80 age group.

[4] The British data were re-analysed to provide the age groups shown in the Tables of this chapter. Special thanks are due to Dr Adrian Davis for this work.

5.2 Prevalence of Hearing Impairment

The hearing threshold levels for the South Australian population are first summarised in Table 5.1 and Table 5.2. The ears are classified as better or worse as determined by the average score across the across the frequencies 0.5, 1, 2 and 4kHz for the threshold levels ≥25dBHTL and ≥21dBHTL. As already stated, the first of these threshold levels was used in the MRC National Study of Hearing and the second is that used on a day to day basis by Australian audiologists. The frequencies 0.5 1, 2 and 4kHz are the important speech frequencies and impairment measured at this level is taken to affect communication ability (Davis, 1989). Table 5.1 shows the prevalence of hearing impairment at a threshold level ≥25dBHTL and Table 5.2 at a threshold level of ≥21dBHTL. Figures in brackets are the 95 percent confidence intervals for the estimates.

Table 5.1: Prevalence (%) of hearing impairment (dB hearing threshold level averaged over 0.5, 1, 2, 4kHz at ≥25dBHTL) in the WORSE and BETTER ear for the South Australian population, by age group and sex (n=926)

	WORSE EAR ≥25dBHTL			BETTER EAR ≥25dBHTL		
Age Group	**Persons**	**Males**	**Females**	**Persons**	**Males**	**Females**
15-50 years	5.2 (0.7 - 9.7)	7.7 (0.0 - 16.2)	2.5 (0.0 - 5.2)	2.8 (0.0 - 6.2)	3.7 (0.0 - 10.0)	1.8 (0.0 - 4.5)
51-60 years	28.3 (13.4 - 43.2)	42.6 (18.8 - 66.4)	16.3 (0.7 - 32.0)	16.3 (3.5 - 29.0)	26.1 (3.2 - 49.1)	7.8 (2.2 - 13.5)
61-70 years	58.7 (40.5 - 77.0)	63.8 (37.5 - 90.2)	53.1 (28.4 - 77.9)	48.3 (29.1 - 67.4)	55.4 (28.6 - 82.1)	40.3 (13.1 - 67.5)
71+ years	73.5 (45.7 - 100.0)	87.7 (41.6 - 100.0)	63.8 (31.4 - 96.2)	62.8 (35.0 - 90.5)	86.5 (40.0 - 100.0)	46.5 15.2 - 77.8)
Overall	22.2 (16.8 - 27.5)	26.0 (17.0 - 34.9)	18.4 (12.5 - 24.3)	16.6 (11.7 - 21.5)	20.3 (12.2 - 28.3)	12.9 (7.3 - 18.5)

Table 5.2: Prevalence (%) of hearing impairment (dB hearing threshold level averaged over 0.5, 1, 2, 4kHz at ≥21dBHTL) in the WORSE and BETTER ear for the South Australian population, by age group and sex (n=926)

	WORSE EAR ≥21dBHTL			BETTER EAR ≥21dBHTL		
Age Group	**Persons**	**Males**	**Females**	**Persons**	**Males**	**Females**
15-50 years	7.4 (2.2 - 12.6)	10.5 (1.5 - 19.5)	4.0 (0.0 - 9.1)	3.6 (0.1 - 7.1)	5.2 (0.0 - 11.6)	1.9 (0.0 - 4.6)
51-60 years	31.3 (16.2 - 46.4)	43.9 (20.1 - 67.8)	20.5 (4.3 - 36.8)	23.0 (8.6 - 37.4)	32.1 (9.1 - 55.0)	15.1 (0.0 - 30.7)
61-70 years	64.7 (46.2 - 83.3)	78.6 (51.6 - 100.0)	54.9 (30.0 - 79.8)	54.2 (35.8 - 72.5)	58.5 (31.7 - 85.2)	49.6 (25.0 - 74.3)
71+ years	87.5 (61.7 - 100.0)	88.9 (42.6 - 100.0)	86.5 (59.5-100.0)	77.2 (50.3 - 100.0)	87.9 (41.7 - 100.0)	69.9 (40.2 - 99.5)
Overall	26.6 (21.1 - 32.1)	30.1 (20.9 - 39.3)	23.0 (17.0 - 29.1)	20.3 (15.3 - 25.2)	22.4 (14.3 - 30.5)	18.2 (12.6 - 23.8)

The level of impairment (at or above the specified threshold levels) measured in the worse ear for the population is taken as the population prevalence. The level of measured hearing disability (at or above the specified threshold levels as distinct from reported disability) is, however, determined by the level of impairment in the better ear. At an individual level, a person who is impaired at ≥25dBHTL, averaged across the air frequencies 0.5, 1, 2 and 4kHz in the worse ear, may have vastly improved hearing thresholds in the better ear and suffer little in terms of day to day communication (ie actual disability).

From Table 5.1 and Table 5.2 it can be seen that the prevalence of hearing impairment increases steeply from 51 years onwards. This increase is more pronounced for males than females and the latter group never reach the prevalence levels of males at any age. Using the threshold level of ≥25dBHTL in the worse ear, the overall prevalence of hearing impairment for the South Australian population is 22%, with the overall prevalence for males approaching eight percentage points higher than females (Table 5.2). Using the threshold level of ≥25dBHTL in the better ear, then approximately 17% of the population have a level of impairment that is likely to be causing some speech discrimination difficulty.

Table 5.3 summarises the severity of impairment and disability for males and females in the worse and better ear for three levels of severity as described by Davis (1989). Males have higher prevalence rates of moderate and severe impairment, as determined by the worse ear, however, these differences are not statistically significant. The higher prevalence rate in males is also translated into higher levels of disability as determined by the better ear, although differences between males and females are consistent they are not statistically significant.

Table 5.3: Prevalence (%) of hearing impairment (dB hearing threshold level averaged over 0.5, 1, 2, 4kHz) in the WORSE and BETTER ear for the South Australian population, by sex (n=926)

	WORSE EAR (dBHTL)			BETTER EAR (dBHTL)		
Gender	**≥25**	**≥45**	**≥65**	**≥25**	**≥45**	**≥65**
Male	26.0 (17.0 - 34.9)	10.5 (4.0 - 16.9)	3.3 (0.0 - 7.5)	20.3 (12.2 - 28.3)	3.9 (0.0 - 9.6)	0.5 (0.3 - 0.8)
Female	18.4 (12.5 - 24.3)	4.7 (2.3 - 7.1)	1.7 (1.0 - 2.4)	12.9 (7.3 - 18.5)	1.8 (1.1 - 2.4)	0.5 (0.2 - 0.9)
Overall	22.2 (16.8 - 27.5)	7.6 (4.1 - 11.0)	2.5 (0.4 - 4.6)	16.6 (11.7 - 21.5)	2.8 (0.0 - 5.7)	0.5 (0.3 - 0.7)

Table 5.4 and Table 5.5 show the prevalence of hearing impairment for the three levels of severity (≥25dBHTL, ≥45dBHTL, ≥65dBHTL), in both the worse and better ears, for the South Australian and the British populations. Davis (1989) points out that these levels correspond in some usages to the lower boundaries of mild, moderate and severe impairment.

Table 5.4: Prevalence (%) of hearing impairment (dB hearing threshold level averaged over 0.5, 1, 2, 4kHz) in the WORSE ear for South Australia (n=926) and the United Kingdom (n=2662), by age group

	SOUTH AUSTRALIA			UNITED KINGDOM		
	Worse Ear			Worse Ear		
Age Group	≥25dBHTL	≥45dBHTL	≥65dBHT	≥25dBHTL	≥45dBHTL	≥65dBHTL
15-50 years	5.2 (0.7 - 9.7)	0.8 (0.4 - 1.1)	0.4 (0.2 - 0.7)	10.6 (8.9 - 12.2)	2.8 (2.1 - 3.5)	0.8 (0.2 - 1.3)
51-60 years	28.3 (12.8 - 43.9)	12.2 (0.0 - 24.7)	5.2 (0.0 - 12.5)	33.8 (30.2 - 37.4	10.7 (8.7 - 12.8)	4.4 (3.1 - 5.8)
61-70 years	58.7 (37.9 - 79.6)	10.4 (3.5 - 17.2)	2.7 (1.6 - 3.9)	51.2 (46.3 - 56.2	19.0 (15.9 - 22.1)	7.5 (5.3 - 9.7)
71+ years	73.5 (42.5 - 100.0)	41.2 (15.3 - 67.1)	12.1 (0.0 - 28.9)	71.6 (64.0 - 79.3	33.2 (27.4 - 39.0)	12.6 (9.4 - 15.8)
Overall	**22.2 (16.8 - 27.7)**	**7.6 (4.1 - 11.0)**	**2.5 (0.4 - 4.6)**	**26.1 (24.5 - 27.6**	**9.3 (8.4 - 10.1)**	**3.5 (3.0 - 4.0)**

Table 5.5: Prevalence (%) of hearing impairment (dB hearing threshold level averaged over 0.5, 1, 2, 4kHz) in the BETTER ear for South Australia (n=926) and the United Kingdom (n=2662), by age group

	SOUTH AUSTRALIA			UNITED KINGDOM		
	Better Ear			Better Ear		
Age Group	≥25dBHTL	≥45dBHTL	≥65dBHTL	≥25dBHTL	≥45dBHTL	≥65dBHTL
15-50 years	2.8 (0.0 - 6.2)	0.1 (0.0 - 0.3)	0.1 (0.0 - 0.2)	3.6 (2.8 - 4.5)	0.8 (0.4 - 1.2)	0.3 (0.0 - 0.6)
51-60 years	16.3 (3.3 - 29.2)	2.0 (1.2 - 2.8)	0.4 (0.1 - 0.7)	18.9 (16.1 - 21.7)	4.0 (2.8 - 5.2)	0.9 (0.5 - 1.4)
61-70 years	48.3 (27.1 - 69.4)	2.5 (1.2 - 3.7)	0.7 (0.1 - 1.3)	36.8 (32.4 - 41.2)	7.4 (6.0 - 8.8)	2.3 (0.4 - 3.2)
71+ years	62.8 (33.2 - 92.4)	21.4 (0.0 - 45.7)	3.3 (0.0 - 6.6)	60.3 (53.0 - 67.6)	17.6 (14.0 - 21.2)	4.0 (2.6 - 5.4)
Overall	**16.6 (11.6 - 21.6)**	**2.8 (0.0 - 5.7)**	**0.5 (0.3 - 0.7)**	**16.1 (15.0 - 17.3)**	**3.9 (3.4 - 4.3)**	**1.1 (0.8 - 1.3)**

The data in Table 5.4 show that, in addition to an overall prevalence rate of 22% in the South Australian adult population, almost 8% have a moderate impairment at ≥45dBHTL and 2.5% have a severe impairment at ≥65dBHTL in at least one ear. The overall estimates for the South Australian population are largely in agreement with those of the MRC National Study of Hearing and at each level of severity the confidence intervals overlap. At a threshold level of ≥25dBHTL the age specific prevalence rates for South Australian adults are lower than those for the United Kingdom in the two youngest age groups, but catch up in the ≥61 age group. Table 5.5 shows that the overall level of disability for South Australia and the United Kingdom, as determined by the better ear, are also largely in agreement with each other, with the exception of the group whose hearing impairment is ≥65 dBHTL. The age specific confidence intervals for this severely impaired group overlap and it is only the summary measure that is significantly different.

Table 5.6 shows the severity of hearing impairment at three different levels (≥21dBHTL, ≥41dBHTL, ≥61dBHTL). As indicated earlier, these levels conform to more common Australian usage and reset the lower boundaries of mild, moderate and severe impairment.

Table 5.6: Prevalence of hearing impairment (dB hearing threshold level averaged over 0.5, 1, 2, 4 kHz) in the WORSE and BETTER ear for the South Australian population, by age group

	WORSE EAR			BETTER EAR		
Age Group	**≥21dBHTL**	**≥41dBHTL**	**≥61dBHTL**	**≥21dBHTL**	**≥41dBHTL**	**≥61dBHTL**
15-50 years	7.4 (2.2 - 12.6)	1.1 (0.1 - 2.2)	0.5 (0.2 - 0.8)	3.6 (0.1 - 7.1)	0.1 (0.0 - 0.3)	0.1 (0.0 - 0.2)
51-60 years	31.3 (16.2 - 46.4)	14.0 (1.6 - 26.4)	5.9 (0.0 - 13.2)	23.0 (8.6 - 37.4)	2.4 (1.0 - 3.8)	0.6 (0.1 - 1.0)
61-70 years	64.7 (46.2 - 83.2)	11.7 (4.2 - 19.2)	3.0 (1.3 - 4.6)	54.2 (35.8 - 72.5)	4.1 (1.9 - 6.3)	0.7 (0.0 - 1.4)
71+ years	87.5 (61.7 - 100.0	44.8 (19.4 - 70.2)	14.3 (0.0 - 31.6)	77.2 (50.3 - 100.0	26.3 (1.1 - 51.6)	4.5 (0.5 - 8.5)
Overall	**26.6 (21.1 - 32.1)**	**8.5 (5.0 - 12.0)**	**2.9 (0.7 - 5.0)**	**20.3 (15.3 - 25.2)**	**3.6 (0.6 - 6.6)**	**0.7 (0.4 - 0.9)**

It can be seen from Table 5.6 that reducing the threshold levels at which hearing impairment is determined increases the overall prevalence of impairment among South Australian's by 4.4%, however, the proportion of people with a moderate (≥41dBHTL) or severe impairment (≥61dBHTL) only increases marginally when compared with the

higher threshold cut off points used earlier. Reducing the level to ≥21dBHTL increases the overall prevalence of impairment by almost 4 percentage points as determined by the better ear.

The South Australian data were also analysed to determine the prevalence of each type of hearing impairment experienced in the population. Type of hearing impairment, for both the better and worse ear, was determined not only on the basis of average air frequencies (≥21dBHTL at 0.5, 1, 2, 4kHz), but also on the configuration and size of the air-bone gap. Decisions in classifying type of impairment were based on criteria provided by Davis (1995). The air-bone gap was averaged over the frequencies 0.5, 1, 2 kHz as recommended by Davis (1995). A conductive component was deemed to be present if the averaged air-bone gap was ≥15dBHTL and all bone conduction frequencies were less than the averaged air frequency of 21dBHTL. A sensorineural impairment was deemed to be present if air-bone gap was ≤15dBHTL. A mixed hearing impairment was determined if the air bone gap was ≥15dBHTL and at least one of the bone frequencies was greater than 21dBHTL.

Table 5.7 shows the prevalence by type of impairment, in the worse ear, by the criteria outlined above. By far the largest contribution to overall prevalence is provided by sensorineural hearing impairment. This is largely due to the process of ageing. There are no large differences apparent in overall prevalence of hearing impairment by type if different average thresholds (≥21dBHTL or ≥25dBHTL) are used. Some age specific differences are apparent in the older age groups, but again these differences are not statistically significant.

In addition to using strict threshold and frequency criteria to determine level and type of hearing impairment it is also important to consider classification by audiologists opinion. This is a professional judgement given to many patients in audiological clinics throughout Australia everyday. Table 5.8 shows the classification by audiological opinion. In this classification the audiologist was asked to classify hearing impairment across the four air frequencies 0.5, 1, 2, 4 kHz at threshold levels ≥21dBHTL and ≥25dBHTL and to use the bone information for the frequencies 0.5, 1, 2 kHz at the same threshold levels to determine type of impairment. This was previously described in Chapter 4. With few exceptions the level of agreement between audiologist and criteria (Davis, 1995) used for the computations in Table 5.7 is very high.

Table 5.7: Prevalence of hearing impairment (dB hearing threshold level averaged over 0.5, 1, 2, 4kHz : air-bone gap averaged over 0.5, 1, 2 kHz) in the worse ear for the South Australian population, by type of impairment and age group

	≥25dBHTL			≥21dBHTL		
Age Group	**SENSORI**	**CONDUCT**	**MIXED**	**SENSORI**	**CONDUCT**	**MIXED**
15-50 years	4.0 (0.0 - 8.3)	0.5 (0.2 - 0.7)	0.8 (0.0 - 2.0)	5.5 (0.9 - 10.2)	1.0 (0.0 -3.2)	0.8 (0.1 - 1.5)
51-60 years	25.5 (10.8 - 40.3)	0.4 (0.0 - 1.1)	2.4 (0.6 - 4.1)	28.5 (13.6 - 43.4)	0.4 (0.0 - 1.1)	1.6 (0.2 - 3.0)
61-70 years	55.5 (37.4 - 73.6)	0.5 (0.0 - 1.2)	2.7 (1.2 - 4.3)	64.2 (45.7 - 82.7)	0.5 (0.0 - 1.2)	3.6 (1.9 - 5.3)
71+ years	68.5 (41.3 - 95.7)	0.0	5.0 (0.0 - 11.8)	77.7 (51.4 - 100.0)	4.8 (0.0 - 11.5)	4.1 (0.0 - 10.6)
Overall	**20.2 (14.9 - 25.4)**	**0.4 (0.1 - 0.7)**	**1.6 (0.7 - 2.5)**	**23.6 (18.3 - 29.0)**	**1.3 (0.0- 2.9)**	**1.5 (0.9 - 2.1)**

Audiologists opinion was also used to go beyond the normal classification of hearing impairment as determined by averaging air frequencies (0.5, 1, 2, 4 kHz) and bone frequencies (0.5, 1, 2 kHz). Audiograms were classified according to the audiologists opinion that a hearing impairment existed at **any of the frequencies** recorded on the audiogram. These data are shown in Table 5.9 and in this case the hearing impairment is classified as unilateral or bilateral, summarised for both males and females. The audiologists opinion is compared with the determination of unilateral and bilateral impairment at ≥21dBHTL averaged over the frequencies 0.5, 1, 2, 4kHz.

Table 5.8: Prevalence of hearing impairment in the worse ear and better ears (audiologists opinion used to determine type of impairment) in the worse ear for the South Australian population, by type of impairment and age group

	≥25dBHTL			≥21dBHTL		
Age Group	**SENSORI**	**CONDUCT**	**MIXED**	**SENSORI**	**CONDUCT**	**MIXED**
15-50 years	4.2 (0.0 - 8.7)	0.3 (0.1 - 0.5)	0.7 (0.0 - 1.4)	5.8 (1.0 - 10.5)	0.8 (0.0 - 3.0)	0.8 (0.1 - 1.5)
51-60 years	26.3 (11.5 - 41.1)	0.4 (0.0 - 1.1)	1.6 (0.2 - 3.0)	29.2 (14.3 - 44.2)	0.4 (0.0 - 1.1)	1.6 (0.2 - 3.0)
61-70 years	55.2 (37.0 - 73.3)	0.0	3.6 (1.9 - 5.3)	63.9 (45.4 - 82.3)	0.0	3.6 (1.9 - 5.3)
71+ years	69.4 (42.2 - 96.6)	0.0	4.1 (0.0 - 10.6)	83.4 (58.3 - 100.0))	0.0	4.1 (0.0 - 10.6)
Overall	**20.5 (15.1 - 25.9)**	**0.2 (0.0 - 0.5)**	**1.5 (0.9 - 2.1)**	**24.4 (19.1 - 29.7))**	**0.6 (0.0 - 2.0)**	**1.5 (0.9 - 2.1)**

Table 5.9: Comparison of Audiologists opinion of prevalence of unilateral and bilateral hearing impairment compared with threshold levels (dB hearing threshold level averaged over 0.5, 1, 2, 4kHz)

	Frequency Criteria (worse ear)		Audiologists Opinion * (worse ear)		
Gender	**Unilateral ≥21dBHTL**	**Bilateral ≥21dBHTL**	**Unilateral ≥21dBHTL**	**Bilateral ≥21dBHTL**	**Noise Component***
Male	7.7 (0.0 - 15.5)	22.4 (14.2 - 30.6)	7.0 (3.1 - 10.9)	53.2 (43.6 - 62.8)	49.3 (39.3 - 59.2)
Female	4.8 (0.4 - 9.2)	18.2 (12.5 - 23.8)	12.0 (5.6 - 18.4)	40.4 (33.5 - 47.3)	24.6 (17.9 - 31.4)
Overall	**6.3 (1.8 - 10.8)**	**20.3 (15.3 - 25.3)**	**9.5 (5.7 - 13.2)**	**46.8 (40.9 - 52.8)**	**37.0 (31.0 - 43.0)**

* noise component is the audiologist opinion of the audiogram

It is apparent from Table 5.9 that the audiologists opinion regarding the prevalence of hearing impairment for the worse ear goes far beyond the prevalence determined by the averaging criteria used earlier. When asked to adhere to strict criteria the audiologists opinion is very close to the averaging criteria. When asked, however, to give an opinion on whether there is a hearing impairment at any of the frequencies on the audiogram at a threshold level ≥21dBHTL there is a considerable increase in the prevalence of hearing impairment. Unilateral and bilateral impairment can be summed to give total impairment. Table 5.9 again shows the prevalence of hearing impairment averaged at ≥21dBHTL is 26.6%. This comprises of 6.3% with unilateral and 20.3% with bilateral impairment. Total hearing impairment according to audiologists opinion in Table 5.9 amounts to 56.3% of the South Australian population (unilateral + bilateral). This is largely explained by higher frequency impairment which is not described by prevalence rates based on averaging across the speech frequencies. Table 5.9 also shows that, in the audiologists opinion a noise component is apparent for 37% of the population.

5.3 Comparison of descriptive characteristics of the Hearing Impaired and Non-impaired

Comparisons were drawn between descriptive features of subjects found to be hearing impaired and non-impaired in this study. This was a secondary activity directed at generating hypotheses of differences that could be tested in further studies designed specifically for this purpose.

It was recognised that the individuals verified as being hearing impaired and non-impaired through the audiological testing may not have been fully representative of their underlying populations due to selection effects from the initial self-reporting. Nonetheless, they did provide a ready opportunity for initial comparisons and hypothesis development.

Bivariate comparisons were drawn, together with multivariate comparisons using logistic regression. Account was not taken of the clustering of the sample design in these analyses, which could have affected the confidence ranges. Accordingly, these ranges have not been interpreted literally, but only as a guide to non-random differences for hypothesis development.

The variables included in the bivariate comparison and their classifications were:

- age (18-50 years, 51-60 years, 61-70 years, 71+ years);
- sex (male v's female);
- annual household income level (≤$12,000, $12,001-$20,000, $20,001-$30,000, $30,001+);
- socio-economic status (high, medium, and low);
- education (post school education v's no post school education);
- body mass index (acceptable weight v's overweight);
- place where they live (metropolitan area v's country);
- alcohol risk (no risk v's alcohol risk);
- smoking status (current smoker v's ex and non-smoker);
- current relationship (married or de facto relationship v's divorced, widowed or no current relationship);
- country of birth (Australia born v's overseas born);
- length of time exposed to noise (none, 0-10 years, > 10 years);
- hospital admissions in the last twelve months (none v's one or more);

- visits to casualty last twelve months (none v's one or more);
- absence from work last two months (none v's one or more);
- experienced a hearing related difficulty in activities of daily living (none v's one or more);
- needed help for this difficulty (yes v's no);
- history of tinnitus (yes v's no);
- been in the armed services (yes v's no);
- fired guns (yes v's no);
- exposed to other sources of noise for long period (yes v's no);
- regularly taking medications (yes v's no);
- require domestic help (yes v's no);
- suffer diagnosed asthma (yes v's no);
- suffer diagnosed diabetes (yes v's no);
- visits to the general practitioner in the last twelve months (none v's one or more);
- prolonged spontaneous tinnitus (yes v's no);
- frequency of attendance at concerts (never or less than once a month v's more than once a month);
- frequency of attendance at a live concert or disco (never or less than once a month v's more than once a month).

Decisions to dichotomise variables in these analyses were made where differences between categories were observed and no further information would be yielded in retaining ordinal categories.

The data were examined for evidence of multi-collinearity and interactions. None were found[5] .

5.4 Results

The bivariate analyses describing the hearing impaired and the non-impaired identified a number of descriptive variables that are associated with the various levels of hearing impairment (mild, moderate, severe). As shown in Table 5.10 these are: age; sex; country of birth; household income; diagnosed diabetes; hospital admissions in the last

[5] Evidence from other studies suggests that interactions are usually present. A more thorough analysis of this aspect may be warranted to determine whether this study's result was due to sampling issues.

twelve months; visits to the general practitioner in the last twelve months; experiencing a hearing related difficulty affecting at least one aspect of life (study, work, social, family, recreational, pain, suffering, depression); needing help for this difficulty; suffering prolonged spontaneous tinnitus; a history of work related noise exposure; some other source of noise exposure; less likely to attend discos; regularly taking medicines; and, needing domestic help.

A number of the variables associated with hearing impairment are also associated with ageing. Variables in the bivariate analyses that were statistically significantly associated with hearing impairment at the $p \leq 0.25$ level (Hosmer & Lemeshow 1989) were, therefore, entered into a logistic regression analysis, at a single step, to identify from the variables in Table 5.10 which best jointly explained hearing impairment. An alternative logistic regression analysis using forward stepwise regression was also used. This produced similar results to those displayed in Table 5.11.

Table 5.11 shows that the variables that best jointly explain the probability of South Australians being hearing impaired. They are: age, sex, experiencing a hearing related difficulty, requiring help for that difficulty and more than ten years of occupational noise exposure. A history of occupational noise exposure of less than ten years also approached statistical significance.

5.5 Discussion

This study has provided the first precise audiological estimates of hearing impairment for an Australian population. As shown in Chapter 1, previous Australian population surveys, based on self-reported disability, have provided wide ranging estimates. The data in this study show that the prevalence of hearing impairment is higher than previously reported (Wilson et al, 1992(c)) and using the criteria of average impairment across the frequencies 0.5, 1, 2, 4 kHz ≥21dBHTL, the best estimate of hearing impairment for the South Australian population is 16.6% in the better ear. However, this estimate is not significantly different from the estimate of 14.1% (chi square=2.15, df=2, p=0.14) who reported a hearing disability in the 1991 Australian survey (Wilson et al, 1992(c)). Even if the higher estimate is used from the 1991 study, the difference is only marginally significant (χ^2=3.47, df=2, p=0.06). We cannot therefore reject the null hypothesis of no overall difference between self-reported hearing disability and measured hearing impairment in the South Australian population. Although the pattern

of impairment with increasing age is similar for males and females, the prevalence and severity of impairment is higher in males. In comparing the estimates of hearing impairment obtained in this study by sex with self-reported disability, there were no statistically significant differences for hearing impairment at ≥25dBHTL, but if comparisons by sex are made at ≥21dBHTL, the estimate for males is statistically significantly higher than the estimate for females. The lack of statistical significance of some comparisons is largely a function of sample size.

When the South Australian data are compared with the data from the British Study of Hearing it would appear that the extent of hearing impairment, as a public health problem, is similar in both countries. To date, these two studies provide the most comprehensive population data on hearing impairment worldwide.

Three of the variables that were predictive of hearing impairment in the logistic regression were also predictive of hearing impairment in the MRC National Study (Davis, 1989). These were older age, male sex and occupational noise exposure. The striking and progressive contribution of age suggests that early intervention and prevention strategies are required. Davis (1997) recommends early (mid-life) intervention. He also suggest that we can prioritise people with an identifiable impairment in terms of the better ear averaged over the mid frequency range (0.5, 1, 2, 4 kHz). If we apply the data in this study to this suggestion then we would identify 23% of people in the mid-age (ie early intervention) group, 51-60 years, from Table 5.6. Given, however, that presbycusis, or progressive sensorineural impairment, is a condition in which the higher frequencies are affected first and the lower frequencies gradually follow then it may also be a viable strategy to include higher frequencies in the prioritising process, because of their potentially predictive nature (Ballantyne et al, 1993). In this study the audiologist, when asked to give an opinion regarding impairment, identified higher prevalence rates than those determined by the averaging criteria (Table 5.9). A supplementary analysis of the these data showed that in the age range 51-60 years, identified by Davis as the early intervention group, 43% would be classified as impaired by audiologists opinion, because this would include higher frequency impairment not identified by averaging across the four speech frequencies. This would add 20% to the priority group identified above.

The importance of early intervention is also dependent on the readiness of services to deal with the health problem. Davis (1997) again identifies important goals for planners and purchasers of health services in responding to the public health problem of hearing

impairment. In summary, these recommendations are:

- development of local epidemiology regarding hearing impairment and vestibular dysfunction on the basis of which service needs can be developed.

- increased education and prevention strategies regarding avoidable hazards (noise, antibiotics, toxins).

- improved access to auditory care for the 50-65 year old pre-retirement group.

- evaluation of technological intervention.

- provision of a clear statement of need for purchasers and providers of health services.

A number of comments can be made about the application of these strategies in Australia. With regard to the development of local epidemiology, the data in this study begin to fill some of the information gaps in establishing need, however, local epidemiology, which includes reliable threshold measures, has only just begun and seriously questions earlier assessments of hearing disability based on self-report. It would seem, therefore, that future epidemiological information for purchasers and providers must also be underpinned by audiology. This issue will be debated further in the next chapter when the level of agreement between self-reported disability and measured impairment is discussed. As yet there is no plan for education and preventive strategies for South Australians. This too will need to be linked to epidemiology with an emphasis on the identification and characterisation of target groups and the development of pilot interventions. More epidemiological work is also required on the distribution of preventable hazards such as noise exposure and the groups exposed. Again, according to audiologists opinion, 37% of people in this study had a noise component involved in their hearing impairment. In South Australia improved access to auditory care for Davis's mid-age group priority group is a significant challenge. Access to auditory care is available for the 65 plus age group via medical services provided by Australian Hearing Services, but there is no payment for audiological services for the younger elderly in the 51-60 priority age group, unless they are receiving a pension. This situation could be corrected by covering this age group by Medicare for bona-fide assessment by private practice audiologists. If necessary, this could also be means tested. This strategy should be subject to precise cost benefit

analysis including: the economic and work benefits, the social benefits of earlier detection, the benefits to family life, and the benefits recreationally. A comprehensive cost benefit analysis would also include future direct and indirect savings for the older age group given the potential benefit of earlier detection.

Overall, 11.4% of the South Australian population had a measured impairment in the worse ear ≥41dBHTL (Table 5.6). This is the level at which people would usually benefit from wearing a hearing aid, but further analysis of the study data showed only 38% of this group did so on a daily basis. It has already been identified that hearing aids do not meet expectations for a large proportion of those for whom they are prescribed and this would suggest the need for more Australian work on the underlying phenomena. The disease specific quality-of-life work currently being done by Gatehouse (1994) on the components and determinants of hearing aid benefit suggests that considerable advances can also be made in Australia in improving hearing aid satisfaction and use.

It is apparent from this study that although there was an overall increase in prevalence rates when the level of impairment was lowered from ≥25dBHTL to ≥21dBHTL, there was little increase in prevalence for the moderate severe impairment groups. The increase in prevalence was small irrespective of whether we compare the better ear (2.8% v's 3.6%) or the worse ear (7.6% v's 8.5%). This would tend to suggest that the lower threshold level should be used in assessing impairment in epidemiological and preventive studies because of the opportunity to identify groups at earlier stages of progression without contaminating the target group of moderate and severe impairment who are more likely to need help now.

Table 5.10: Bi-variate analysis of variables associated with hearing impairment (data were collected in SAHOS, from self completed questionnaires and at audiological examination)

VARIABLE	ODDS RATIO	*P* VALUE
AGE GROUP		
Mild		
15-50 years	1.0	
51-60 years	4.76 (2.75 - 8.25)	
61-70 years	10.64 (6.41 - 17.70)	
71+ years	41.47 (20.16 - 86.73)	<0.0001
Moderate		
15-50 years	1.0	
51-60 years	12.28 (5.21 - 29.46)	
61-70 years	17.95 (7.56 - 41.76)	
71+ years	219.3 (86.36 - 577.93)	<0.0001
Severe		
15-50 years	1.0	
51-60 years	4.95 (1.97 - 12.39)	
61-70 years	8.12 (3.43 - 19.32)	
71+ years	85.44 (34.43 - 218.12)	<0.0001
SEX		
Mild		
female	1.0	
male	1.62 (1.15 - 2.29)	.008
Moderate		
female	1.0	
male	1.88 (1.24 - 2.86)	0.002
Severe		
female	1.0	
male	1.19 (0.72 - 1.95)	0.48
COUNTRY OF BIRTH		
Mild		
Australia	1.0	
Overseas	1.65 (1.12 - 2.43)	0.008
Moderate		
Australia	1.0	
Overseas	1.52 (0.96 - 2.42)	0.06
Severe		
Australia	1.0	
Overseas	1.19 (0.72 - 1.95)	0.48
HOUSEHOLD INCOME		
Mild		
$12,000 or less	1.0	
$12,000-20,000	0.88 (0.49 - 1.56)	
$20,001-30,000	0.38 (0.20 - 0.71)	
$30,001+	0.25 (0.16 - 0.41)	<0.0001
Moderate		
$12,000 or less	1.0	
$12,000-20,000	0.89 (0.48 - 1.64)	
$20,001-30,000	0.33 (0.17 - 0.67)	
$30,001+	0.13 (0.07 - 0.23)	<0.0001
Severe		
$12,000 or less	1.0	
$12,000-20,000	0.51 (0.24 - 1.08)	
$20,001-30,000	0.28 (0.12 - 0.63)	
$30,001+	0.09 (0.04 - 0.18)	<0.0001

Table 5.10: Bi-variate analysis of variables associated with hearing impairment (cont.)

VARIABLE	ODDS RATIO	*P* VALUE
AREA		
Mild		
metro	1.0	
country	0.86 (0.60 - 1.24)	0.40
Moderate		
metro	1.0	
country	1.13 (0.75 - 1.72)	0.53
Severe		
metro	1.0	
country	1.12 (0.67 - 1.89)	0.64
SOCIO-ECONOMIC STATUS		
Mild		
high	1.0	
medium	1.19 (0.80 - 1.77)	
low	0.84 (0.55 - 1.29)	0.28
Moderate		
high	1.0	
medium	1.23 (0.78 - 1.94)	
low	0.56 (0.32 - 0.97)	0.015
Severe		
high	1.0	
medium	1.02 (0.55 - 1.90)	
low	1.06 (0.57 - 1.94)	0.97
EDUCATION		
Mild		
post school	1.0	
no post school	1.14 (0.81 - 1.60)	0.43
Moderate		
post school	1.0	
no post school	1.60 (1.06 - 2.40)	0.02
Severe		
post school	1.0	
no post school	0.50 (0.29 - 0.84)	0.005
DIABETES		
Mild		
no	1.0	
yes	3.21 (1.51 - 6.87)	0.0006
Moderate		
no	1.0	
yes	3.97 (1.76 - 8.98)	<0.0001
Severe		
no	1.0	
yes	3.79 (1.41 - 9.96)	0.0018

Table 5.10: Bi-variate analysis of variables associated with hearing impairment (cont.)

VARIABLE	ODDS RATIO	*P* VALUE
BODY MASS INDEX		
Mild		
normal weight	1.0	
overweight	1.44 (1.01 - 2.04)	0.03
Moderate		
normal weight	1.0	
overweight	1.36 (0.90 - 2.06)	0.12
Severe		
normal weight	1.0	
overweight	1.01 (0.06 - 1.70)	0.98
DRINK AT RISK LEVELS		
Mild		
non risk	1.0	
risk	0.80 (0.49 - 1.29)	0.34
Moderate		
no risk	1.0	
risk	0.44 (0.22 - 0.89)	0.01
Severe		
no risk	1.0	
risk	1.69 (0.93 - 3.06)	0.06
SMOKING STATUS		
Mild		
non-smoker	1.0	
smoker	0.6 (0.34 - 1.04)	0.06
Moderate		
non-smoker	1.0	
smoker	0.76 (0.40 - 1.41)	0.35
Severe		
non-smoker	1.0	
smoker	0.86 (0.40 - 1.82)	0.67
HOSPITAL ADMISSIONS		
(last twelve months)		
Mild		
none	1.0	
one or more	1.20 (0.81 - 1.79)	0.34
Moderate		
none	1.0	
one or more	1.84 (0.81 - 1.79)	0.004
Severe		
none	1.0	
one or more	1.16 (0.64 - 2.09)	0.06
CASUALTY VISITS		
(last twelve months)		
Mild		
none	1.0	
one or more	0.86 (0.57 - 1.29)	0.45
Moderate		
none	1.0	
one or more	1.07 (0.66 - 1.71)	0.77
Severe		
none	1.0	
one or more	1.7 (0.99 - 2.92)	0.40

Table 5.10: Bi-variate analysis of variables associated with hearing impairment (cont.)

VARIABLE	ODDS RATIO	*P* VALUE
GP VISITS		
(last twelve months)		
Mild		
none	1.0	
one or more	1.33 (0.87 - 2.03)	0.17
Moderate		
none	1.0	
one or more	1.24 (0.75 - 2.03)	0.38
Severe		
none	1.0	
one or more	3.23 (1.38 - 7.89)	0.003
ABSENT FROM WORK		
(last two months)		
Mild		
none	1.0	
one or more	0.22 (0.12 - 0.40)	<0.0001
Moderate		
none	1.0	
one or more	0.14 (0.05 - 0.33)	<0.0001
Severe		
none	1.0	
one or more	0.32 (0.14 - 0.71)	<0.0001
HEARING RELATED DIFFICULTY		
Mild		
no difficulty	1.0	
some difficulty	3.45 (2.40 - 4.94)	<0.0001
Moderate		
no difficulty	1.0	
some difficulty	9.15 (5.70 - 14.75)	<0.0001
Severe		
no difficulty	1.0	
some difficulty	14.54 (7.49 - 28.73)	<0.0001
REQUIRED HELP FOR DIFFICULTY		
Mild		
no	1.0	
yes	4.75 (2.82 - 8.02)	<0.0001
Moderate		
no	1.0	
yes	14.91 (8.69 - 25.67)	<0.0001
Severe		
no	1.0	
yes	15.90 (8.46 - 30.02)	<0.0001
HISTORY OF TINNITUS		
Mild		
no	1.0	
yes	0.83 (0.59 - 1.17)	0.27
Moderate		
no	1.0	
yes	1.18 (0.77 - 1.79)	0.43
Severe		
no	1.0	
yes	1.29 (0.75 - 2.22)	0.33

Table 5.10: Bi-variate analysis of variables associated with hearing impairment (cont.)

VARIABLE	ODDS RATIO	*P* VALUE
PROLONGED SPONTANEOUS TINNITUS		
Mild		
no	1.0	
yes	2.18 (1.16 - 4.07)	0.008
Moderate		
no	1.0	
yes	2.89 (1.47 - 5.67)	0.0006
Severe		
no	1.0	
yes	2.09 (0.84 - 5.05)	0.08
SERVED IN ARMED SERVICES		
Mild		
no	1.0	
yes	1.19 (0.83 - 1.71)	0.32
Moderate		
no	1.0	
yes	1.17 (0.76 - 1.82)	0.45
Severe		
no	1.0	
yes	0.93 (0.53 - 1.62)	0.78
FIRED GUNS		
Mild		
no	1.0	
yes	1.19 (0.83 - 1.71)	0.32
Moderate		
no	1.0	
yes	1.17 (0.76 - 1.82)	0.45
Severe		
no	1.0	
yes	0.93 (0,53 - 1.62)	0.78
ATTENDANCE AT CONCERTS		
Mild		
<once a month	1.0	
>once a month	0.41 (0.14 - 1.12)	0.06
Moderate		
<once a month	1.0	
>once a month	0.92 (0.36 - 2.27)	0.85
Severe		
<once a month	no responses	
>once a month		
EXPOSED TO NOISE AT WORK[6]		
no exposure	1.0	
1-10 years exposure		
mild impairment (25-44dBHTL)	0.74 (0.47 - 1.17)	
moderate impairment (45-64dBHTL)	0.71 (0.39 - 1.27)	
severe impairment (≥65dBHTL	1.15 (0.52 - 2.12)	0.32
11+ years exposure		
mild impairment (25-44dBHTL)	1.86 (1.21 - 2.85)	
moderate impairment (45-64dBHTL)	2.52 (1.69 - 3.78)	
severe impairment (≥65dBHTL	1.85 (0.99 _ 2.12)	<0.0001

[6] Exposure was based on self-reported length of time in occupations clasified as noisy from the Australian Standard Classification of Occupations.

Table 5.10: Bi-variate analysis of variables associated with hearing impairment (cont.)

VARIABLE	ODDS RATIO	*P* VALUE
ATTENDANCE AT DISCOS		
Mild		
<once a month	1.0	
>once a month	0.13 (0.04 - 0.37)	<0.0001
Moderate		
<once a month	1.0	
>once a month	0.41 (0.18 - 0.91)	0.02
Severe		
<once a month	1.0	
>once a month	0.26 (0.06 - 0.90)	0.02
EXPOSED TO OTHER NOISE		
Mild		
no	1.0	
yes	0.76 (0.54 - 1.08)	0.11
Moderate		
no	1.0	
yes	0.53 (0.35 - 0.80)	0.001
Severe		
no	1.0	
yes	0.98 (0.58 - 1.65)	0.93
REGULARLY TAKING MEDICINES		
Mild		
no	1.0	
yes	2.30(1.63 - 3.25)	<0.0001
Moderate		
no	1.0	
yes	3.19 (2.08 - 4.91)	<0.0001
Severe		
no	1.0	
yes	3.88 (2.23 - 6.79)	<0.0001
DOMESTIC HELP REQUIRED		
Mild		
no	1.0	
yes	2.6 (1.11 - 6.10)	0.01
Moderate		
no	1.0	
yes	2.86 (1.1 - 7.35)	0.01
Severe		
no	1.0	
yes	7.81 (3.24 - 18.88)	<0.0001

Table 5.11: Logistic regression analysis of variables associated with hearing impairment (data were collected in SAHOS, from self completed questionnaires and at audiological examination)

VARIABLE	ODDS RATIO	*P* VALUE
AGE GROUP		
15-50 years	1.0	
51-60 years	4.20 (2.35 - 7.50)	
61-70 years	10.58 (5.76 - 19.40)	
71+ years	54.48 (25.20 - 117.90)	<0.0001
SEX		
female	1.0	
male	2.16 (1.30 - 3.57)	<0.003
HEARING RELATED DIFFICULTY		
no difficulty	1.0	
some difficulty	2.15 (1.35 - 3.42)	0.0013
REQUIRED HELP FOR DIFFICULTY		
no	1.0	
yes	3.29 (1.85 - 5.87)	<0.0001
YEARS OF NOISE EXPOSURE		
no noise exposure	1.0	
≤10 years noise exposure	1.56 (0.91 - 2.68)	
>10 years noise exposure	1.88 (1.11 - 3.17)	0.05

6. LEVEL OF AGREEMENT BETWEEN REPORTED HEARING DISABILITY AND MEASURED HEARING IMPAIRMENT

OVERVIEW

This chapter examines the level of agreement between self-reported disability and measured hearing impairment. The groups whose self-reported hearing disability disagreed with audiological threshold measures were compared with those who agreed on both estimates. Three groups were involved in the analysis: those whose self-reported disability agreed with measured impairment; those who under-estimated their hearing impairment and those who over-estimated their hearing impairment. Differences in characteristics between groups are identified by comparing those who underestimated or overestimated their hearing impairment with those whose self-reported disability agreed with measured impairment.

6.1 Introduction

This chapter deals with the analysis of the level of agreement between self-reported hearing disability and hearing impairment determined by measured hearing thresholds, and how agreement between the estimates is distributed across the categories of mild, moderate and severe impairment. This is an important issue, because a number of studies have relied on self-reported hearing disability as their only estimate of prevalence (Australian Bureau of Statistics, 1978; Australian Bureau of Statistics, 1984; Australian Bureau of Statistics, 1990(b); National Center for Health Statistics, 1994; Wilson et al, 1992(c)) and if there is substantial disagreement between self-reported disability and measured impairment these prevalence estimates are in question. On the other hand if there is good agreement between the two estimates then this could mean considerable time and financial savings in future surveys of hearing status. The level of agreement issue raises two major questions: (*1*) how much do self-reported estimates of disability vary from actual measures of hearing impairment and what are the implications of any variation; and (*2*) if there is poor agreement between self-report disability and measured impairment, does the tendency to misreport also affect people's perception of quality-of-life? The first of these questions will be dealt with in this chapter and the second in chapter 7.

6.2 Method

To recap, the self-reported question of hearing disability asked in each SAHOS was as follows:

> Do you usually have difficulty hearing what people say to you in a quiet room?
>
> *When they speak loudly to you?*
>
> *If they speak normally to you?*
>
> *If they whisper to you?*
>
> *None of these?*,
>
> (respondents were asked to choose one response)

Variations of this question have been asked in previous hearing studies reporting prevalence estimates. Some examples are: in the MRC National Study of Hearing (Davis, 1989), in major United States population studies (US Department of Health and Human Services, 1994) and in an earlier Australian population study providing estimates of hearing disability (Wilson et al, 1992(c)). Only the MRC Study used hearing threshold levels to confirm the presence or absence of hearing impairment. The other studies, therefore, run the risk of providing inaccurate estimates of prevalence and inappropriate descriptive profiles of the hearing impaired population if people misclassify themselves on the basis of the self-report question.

Each of the response categories of the self-report question is taken to indicate discrete hearing categories: no hearing disability; mild hearing disability (whisper); moderate hearing disability (speak normally); and severe hearing disability (speak loudly). The British Society of Audiology recommends the use of categories which approximate with these levels (British Society of Audiology, 1988). Support for these classifications was also given by Davis (1989) in the MRC Study of Hearing which classified the hearing impairment of the study group (in the better ear) according to these categories as: mild: 25-44dBHTL; moderate: 45-64dBHTL; severe: ≥65dBHTL. In the present study these threshold levels were used, because of their documented international acceptance.

Table 6.1: Analysis of the level of agreement between self-reported hearing disability and audiologically measured hearing impairment

	Self-reported disability				
Measured Hearing Impairment	**No disability n(%)**	**Mild n(%)**	**Moderate n(%)**	**Severe n(%)**	**Total n(%)**
No impairment	**197 (21.3)**	260 (28.0)	53 (5.7)	6 (0.6)	515 (55.6)
Mild	30 (3.3)	**124 (13.4)**	43 (4.6)	5 (0.5)	202 (21.8)
Moderate	7 (0.7)	68 (7.4)	**39 (4.2)**	15 (1.7)	130 (14.0)
Severe	2 (0.3)	32 (3.5)	28 (3.1)	**16 (1.7)**	79 (8.6)
Total	237 (25.6)	484 (52.2)	163 (17.6)	42 (4.5)	**926 (100.0)**

Table 6.1 shows the analysis of the level of agreement between measured impairment and reported hearing disability. These data can be related back to the sample data which was based on differential sampling of the groups reporting hearing disability and reporting no hearing disability. The samples for these groups were used to produce the overall weighted population estimate for the South Australian population. This

computation is shown in Table 6.2. From this it can be seen that a total of n=926 valid tests were obtained from the audiologists. Of the n=689 who reported a hearing disability n=373 (53.7%) were assessed as audiologically impaired at the hearing threshold level of 25dBHTL. For the group who reported no disability there were n=237 valid tests of whom n=39 (16.5%) were hearing impaired. If these data are related back to the overall sample then it can be seen from Table 6.2 that 22.2% (2003/9027) of the total SAHOS were impaired at the threshold level of ≥25dBHTL. This is the weighted population estimate of hearing impairment in the worse ear for the South Australian population at 25dBHTL already shown in Table 5.1.

Table 6.2: Estimates of hearing impairment obtained from the differential samples of reported disability and reported no disability

	(1) SAHOS Sample	(2) Valid Audiology Tests	(3)% Measured Impairment (3/2)	(4) Population Prevalence (4/1)
Reported disability	1378	689	372 (53.9%)	743 (53.9%)
Reported no disability	7635	237	39 (16.5%)	1260 (16.5%)
Total	9027	926	413 (44.6%)	2003 (22.2%)

The overall prevalence of self-reported hearing disability from the November 1994 SAHOS was 16.5%. This was a little higher than the overall self-reported estimate of 15.3% for all three recruitment surveys shown earlier in Table 4.2. Both estimates of self- reported hearing disability would therefore underestimate the true prevalence of hearing impairment, the latter estimate by 5.8%. This means that approximately a quarter of the hearing impaired population would not be identified from the self-report questions. However, the problem does not stop here because self-reported disability also produces a significant false positive (46.1%) and false negative rate (16.5%). This would also lead to misclassification of the severity of impairment.

The statistical test selected to assess level of agreement between self-reported disability and measured hearing impairment is Kappa (Donner & Eliasziw, 1992). This measures the agreement between two rating systems when both are rating the same phenomena. As indicated in Chapter 3, the Kappa statistic is computed from the difference between the observed proportion expected by chance, divided by the maximum difference possible between the observed and expected proportions, given the marginal totals. A

value of 1 indicates perfect agreement. A value of 0 indicates that agreement is no better than chance.

Returning to the data in Table 6.1, the number and proportion of cases where the two measures agree is to be found in the diagonal running through the centre of the Table from left to right (highlighted). The cells to the left and right of this diagonal line do not agree. People in the cells to the left of the diagonal believe their hearing is better than actually measured and for the purposes of this discussion will be called the optimistic group. People to the right of the diagonal believe their hearing is worse than measured and will be called the pessimistic group. People who agree with their measured hearing status (bold diagonal) will be called the concordant group. No value judgement is implied in the use of the terms pessimistic and optimistic. They are simply convenient descriptions for the purposes of analysis. They could equally be called under-estimators and over-estimators, but use of these terms would be more confusing in discussion.

In Table 6.1 the cumulative percentage on the diagonal, where there is agreement between reported disability and measured impairment is 40.6%. In addition, 41.1 % of the sample lie to the right of the diagonal and are classified as the pessimistic group. The remaining 18.3% of the sample lie to the left of the diagonal and comprise the optimistic group. The Kappa statistic measuring agreement computed from the data in Table 6.1 is =0.17, (p =0.02). According to Landis and Koch (1977) the observed agreement between the two measures of hearing ability is classified as slight agreement. We must therefore reject the hypothesis that there is no difference in the estimates produced by self-reported disability and hearing impairment determined from hearing threshold levels.

It should be mentioned that the p value associated with the Kappa statistic was not adjusted for the design effect because it was considered that the main interest was in the point estimate and that a small adjustment to the p value for design effect would not change the conclusion regarding the level of agreement between self-reported disability and measured impairment.

Self-reported hearing disability underestimates the prevalence of hearing impairment, but the problem does not stop here because self-reported disability also affects classification of sub-groups of the hearing impaired and, in turn, our overall

understanding of hearing morbidity. So far we have been extrapolating the sample data to yield population estimates, however, in further exploration of the problems of misclassification we shall return solely to the sample data. From Table 6.1 it can be computed that 34.3% of the sample group, who reported a hearing disability, had no measurable impairment at all. This is part of the pessimistic group described above. In addition to this proportion, a further 6.8% misclassify themselves believing their hearing disability is worse than it is, and 18.3% believe it is better than it is according to audiological measurement. 4.3% of the sample believed they had no measurable impairment but actually had a mild, moderate or severe hearing impairment. A descriptive analysis from a self-report sample would not only provide an incorrect estimate of prevalence, but also inaccurate estimates of the severity groups. This would also seriously affect our ability to describe the characteristics of the hearing impaired population for each of the categories of hearing severity. A comparative description of the hearing impaired and non-impaired, based on self-report, would lead to incorrect conclusions regarding the characteristics of each group and make targeting of the hearing impaired difficult from a policy or intervention point of view. Optimists are less of a problem in this study than pessimists because the group is smaller (18.3%) and most of the optimists actually had hearing impairment. The main problem with the optimistic group, however, is still in relation to classification of severity.

The lack of agreement between reported disability and measured hearing impairment makes it important to describe the groups further and to investigate any public health implications of misclassification. If optimists are underestimating their hearing problem this may operate to their disadvantage in the longer term, because they could forego the advantages of early diagnosis and rehabilitation. Pessimists, on the other hand, may be the "worried well" and use health resources for diagnoses that are inappropriate. For these reasons descriptive analyses were conducted to compare each of these groups with the concordant group and determine how they differed from those who had a correct perception of their hearing impairment.

6.3 Descriptive Study Method

As mentioned, the study group shown in Table 6.1 were divided into three groups according to their level of agreement with measured hearing impairment: optimistic, pessimistic and concordant. The optimistic and pessimistic groups were compared with

the concordant group using univariate chi-square tests. The variables of interest and their classifications were:

- age (18-50 years, 51-60 years, 61-70 years, 71+ years);
- sex (male v's female);
- annual household income level (≤$12,000, $12,001-$20,000, $20,001-$30,000, $30,001+);
- socio-economic status (high, medium, and low);
- education (post school education v's no post school education);
- body mass index (acceptable weight v's overweight);
- place where they live (metropolitan area v's country);
- alcohol risk (no risk v's alcohol risk);
- smoking status (current smoker v's ex and non-smoker);
- current relationship (married or de facto relationship v's divorced, widowed or no current relationship);
- country of birth (Australia born v's overseas born);
- length of time exposed to noise (none, 0-10 years, >10 years);
- hospital admissions in the last twelve months (none v's one or more);
- visits to casualty last twelve months (none v's one or more);
- absence from work last two months (none v's one or more);
- experienced a hearing related difficulty in activities of daily living (none v's one or more);
- needed help for this difficulty (yes v's no);
- history of tinnitus (yes v's no);
- been in the armed services (yes v's no);
- fired guns (yes v's no);
- exposed to other sources of noise for long period (yes v's no);
- regularly taking medications (yes v's no);
- require domestic help (yes v's no);
- suffer diagnosed asthma (yes v's no);
- suffer diagnosed diabetes (yes v's no);
  visits to the general practitioner in the last six months (none v's one or more);
- prolonged spontaneous tinnitus (yes v's no);
- frequency of attendance at concerts (never or less than once a month v's more than once a month);
- frequency of attendance at a live concert or disco (never or less than once a month v's more than once a month).

Decisions to dichotomise variables in this analysis were made where differences were observed between categories and no further information would be yielded in retaining ordinal categories. Cell sizes were also an important consideration in dichotomising variables. All variables that were significant at $p \leq 0.25$ level (Hosmer & Lemeshow, 1989), were entered into two logistic regression analyses, at a single step, to assess which of the attributes best jointly described the pessimistic and optimistic hearing impaired groups.

The data were assessed for multi-collinearity and interactions. Neither of these conditions applied in these data that would have necessitated a different approach to the analysis. In the logistic regression analyses the data were entered at a single step, to identify those variables which best jointly explained the optimistic and pessimistic groups. Alternative models using forward stepwise regression did not change the regression results presented.

6.4 Results

Table 6.3 shows a comparison of the three hearing categories according to the variables of interest. It can be seen from this analysis that the pessimistic group vary from the concordant group in their age, social class status, country of birth, annual household income, work in a noisy job, length of time exposed to noise, absences from work in the last two months, experience of hearing related difficulties with activities of daily living, history of tinnitus, likelihood of suffering diagnosed asthma, consumption of alcohol at some level of risk, and smoking status. The optimistic group vary from the concordant group in their age, household income, work in a noisy job, length of time exposed to noise, absences from work in the last two months, experience of hearing related difficulties with activities of daily living, their need for professional help with these difficulties, prolonged spontaneous tinnitus, exposure to other sources of noise, the need for domestic help and the likelihood of suffering diagnosed diabetes.

Table 6.3: Comparison of the pessimistic & optimistic groups with those whose self-reported hearing disability agreed with measured impairment

Variable	Pessimist Odds Ratio	Optimist Odds Ratio
Age Group		
15-50 Years	1.0	1.0
51-60 Years	0.92 (0.59 - 1.44)	3.09 (1.54 - 6.22)
61-70 Years	0.62 (0.41 - 0.96)	4.41 (2.41 - 8.11)
71+ Years	0.22 (0.13 - 0.36)#	6.80 (3.95 - 11.76)#
Social Class		
High	1.0	1.0
Medium	2.37 (1.60 - 3.53)	1.05 (0.67 - 1.65)
Low	1.06 (0.73 - 1.54)	0.86 (0.33 - 1.39)
Sex		
Female	1.0	1.0
Male	1.08 (0.80 - 1.45)	1.40 (0.89 - 2.20)
Area of State		
Metro	1.0	1.0
Country	1.17 (0.86 - 1.6)	0.84 (0.55 - 1.26)
Country of Birth		
Australia	1.0	1.0
Migrant	0.69 (0.48 - 0.98)^	1.43 (0.95 - 2.16)
Educational Level		
Post School Education	1.0	1.0
No Post School Education	1.20 (0.90 - 1.62)	0.8 (0.54 - 1.17)
Income		
Less than $12,000	1.0	1.0
$12,001 - $20,000	1.19 (0.69 - 2.07)	0.67 (0.38 - 1.15)
$20,001 - $30,000	1.65 (0.94 - 2.89)	0.40 (0.20 - 0.76)
$30,001 and above	1.72 (1.10 - 2.69)#	0.25 (0.15 - 0.41)#
Body Mass Index		
Normal Weight	1.0	1.0
Overweight	1.07 (0.71 - 1.55)	1.05 (0.71 - 1.55)
Worked in Noisy Job		
No	1.0	1.0
Yes	1.52 (1.13 - 2.06)*	1.58 (1.07 - 2.33)^
Length of Time Exposed to Noise		
None	1.0	1.0
1-10 Years	1.80 (1.25 - 2.59)*	1.59 (0.99 - 2.55)^
More than 10 Years	1.09 (0.88 - 2.19)	1.39 (0.88 - 2.19)
Hospital Admission Last 12 months		
None	1.00	1.0
One or More	0.87 (0.61 - 1.24)	1.04 (0.67 - 1.60)
Casualty Visits Last 12 Months		
None	1.0	1.0
One or More	1.32 (0.93 - 1.87)	1.38 (0.88 - 2.14)
Absent From Work Last 2 Months		
None	1.0	1.0
One or more	1.47 (1.01 - 2.14)^	0.37 (0.18 - 0.72)*
Hearing Related Difficulties		
None	1.0	1.0
One or More	1.73 (1.26 - 2.37)*	5.63 (3.7 - 8.59)#

Table 6.3: (cont.)

Needed Professional Help		
No	1.0	1.0
Yes	1.01 (0.66 - 1.56)	3.78 (2.41 - 5.92)#
History of Tinnitus		
No	1.0	1.0
Yes	1.52 (1.13 - 2.07)*	1.43 (0.97 - 2.12)
Prolonged Spontaneous Tinnitus		
No	1.0	1.0
Yes	0.98 (0.54 - 1.76)	1.91 (1.01 - 3.60)^
Served in Armed Services		
No	1.0	1.0
Yes	1.18 (0.86 - 1.63)	1.14 (0.74 - 1.73)
Fired Guns		
No	1.0	1.0
Yes	1.18 (0.86 - 1.63)	1.14 (0.75 - 1.72)
Exposed to Other Noise		
No	1.0	1.0
Yes	0.61 (0.31 - 1.21)	0.27 (0.09 - 0.78)*
Regularly Taking Medicines		
No	1.0	1.0
Yes	0.99 (0.74 - 1.33)	1.94 (1.31 - 2.87)^
Need Domestic Help		
No	1.0	1.0
Yes	0.86 (0.40 - 1.84)	2.04 (0.95 - 4.36)^
Suffer Diabetes		
No	1.0	1.0
Yes	1.09 (0.52 - 2.31)	0.32 (0.16 - 0.65)^
Suffer Asthma		
No	1.0	1.0
Yes	0.61 (0.38 - 0.97)^	0.78 (0.43 - 1.44)
Attendance at Concerts		
Once a month or less	1.0	1.0
More Than Once a Month	1.10 (0.54 - 2.26)	0.65 (0.21 - 1.92)
Attendance at live band or disco		
Once a month or less	1.0	1.0
More Than Once a Month	1.21 (0.73 - 1.99)	0.48 (0.20 - 1.11)
Alcohol Risk Level		
No Risk	1.0	1.0
At Least Mild Risk	2.52 (1.46 - 4.38)*	1.63 (0.81 - 3.31)
Smoking Status		
Non Smoker	1.0	1.0
Smoker	4.17 (2.50 - 7.00)#	1.36 (0.65 - 2.85)

^ statistically significant p=0.05
* statistically significant p=0.01
# statistically significant p=0.0001

Variables in Table 6.3 that were statistically significant at the 0.25 level were entered into two separate logistic regressions comparing the concordant group with firstly, the pessimistic group and secondly, the optimistic group. The logistic regression model (Table 6.4) comparing the pessimistic and concordant groups provided a model that was

a good fit to the data (χ^2=176.7, df=23, p< 0.0001) and correctly classified 72% of the sample. Table 6.4 shows that four variables best jointly explained the pessimistic group when compared with the concordant group. Pessimism declined significantly with age. Pessimists were also more likely to have experienced one or more hearing related difficulties associated with working life, study life, social life, family life, recreational life, experienced depression, physical pain or some other hearing related difficulty. They were also more likely to be smokers and consume alcohol at risk levels.

Table 6.4: Logistic regression analysis comparing the pessimistic group with those whose self-reported hearing disability agreed with measured impairment

Variable	Odds Ratio	*p* value
Age Group		
15-50 Years	1.0	
51-60 Years	0.81 (0.48 - 1.34)	
61-70 Years	0.41 (0.23 - 0.71)	
71+ Years	0.16 (0.08 - 0.31)	<0.0001
Hearing Related Difficulty		
No	1.0	
Yes	2.60 (1.74 - 3.93)	<0.0001
Alcohol Risk		
No Risk	1.0	
Risk level	2.30 (1.21 - 4.20)	0.01
Smoker		
Yes	1.0	
No	2.02 (1.05 - 3.86)	0.03

The logistic regression model comparing optimists with those whose self-reported hearing disability agreed with audiological measure, also proved to be a good fit of the data (χ^2=138.5, df=26, p<0.0001) and correctly classified 75% of the sample. The two variables that best described optimists showed there was a trend for optimism to increase with age and that optimists were also more likely to have a hearing related difficulty. Diabetes approached statistical significance (p=0.08) indicating that optimists were less likely to be diagnosed with diabetes. Length of time exposed to noise also approached statistical significance in this model indicating that optimists were also likely to have experienced increased noise exposure.

Table 6.5: Logistic regression analysis comparing the optimistic group with those whose self-reported hearing disability agreed with measured impairment

Variable	Odds Ratio	*p* value
Age Group		
15-50 Years	1.0	
51-60 Years	2.31 (1.47 - 3.50)	
61-70 Years	2.21 (1.47 - 3.30)	
71+ Years	3.78 (2.49 - 5.72)	0.02
Hearing Related Difficulty		
No	1.0	
Yes	4.20 (2.34 - 7.55)	<0.0001
Diabetes		
No	1.0	
Yes	0.48 (0.21 - 1.10)	0.08
Length of time exposed to noise		
None	1.0	
1-10 Years	1.73 (1.26 - 2.38)	
More than 10 Years	0.85 (0.61 - 1.19)	0.08

6.5 Discussion

These analyses have shown quite different prevalence rates for self-report disability and measured impairment. They have identified a self-report group who over estimate their hearing disability (pessimists); a group who under estimate their hearing disability (optimists); and a group whose reported hearing disability agreed with measured impairment. As has already been shown the population prevalence of hearing impairment in this study is 22.2%, using ≥25dBHTL as the threshold level at which hearing impairment is determined. The self-reported estimate of population prevalence is 15.4%. Thus self-reported hearing disability would underestimate hearing prevalence by about 25%. The relative importance of hearing impairment as a public health priority is, therefore, likely to be devalued by self-report studies. This in turn will affect the priority of hearing impairment and its sequelae in resource allocation. In addition to incorrectly stating the prevalence, self-reported estimates misclassify categories of the hearing impaired. If policy decisions were based on self-reported categories of disability, the problems of mild and moderate impairment would be overestimated and the problem of severe impairment underestimated.

Misclassification, through self-report, also affects the descriptive profiles of the various levels of impairment. If self-report data were to be used to describe and target the

hearing impaired it would include a large proportion who had no impairment and also classify proportions of the hearing impaired in the wrong categories. This affects the ability to target groups based on salient characteristics, or to develop effective communication strategies regarding diagnosis, treatment or rehabilitation. Misclassification may also affect our understanding of the problem. In the case of the pessimistic group, who actually have hearing impairment (6.9%), their may be other co-morbid factors creating the pessimism that needs to be dealt with in an adequate diagnostic assessment and development of treatment or rehabilitation programs. Misclassification would also exclude people from therapy who report no disability, but actually have a mild moderate or severe impairment (4.3%). This group may be lost to, or underestimate, their need for treatment based on self-assessment. It may then be a matter of serendipity that they ever find appropriate treatment and care. Misclassification may also affect our ability to monitor hearing impairment. If self-report studies capture people who are not truly representative of those with a measurable impairment then the data cannot be used to develop accurate indicators, or provide a basis for monitoring outcomes. In summary, self-report studies do not allow us to accurately target sub-groups of the hearing impaired population or assess progress towards goals and targets.

The logistic regression analysis has helped to identify the characteristics of those who misclassify their hearing impairment based on self-report. Pessimists are more likely to be from younger age groups, experience a hearing related difficulty, drink alcohol at risk levels and smoke. Some of them will truly have a hearing impairment (6.8%) and some will not (34.3%), but think they have. The first of these groups are likely to require assessment and rehabilitation programs for their hearing impairment. From their descriptive profile it would appear that, despite their age advantage, they are less healthy than optimists. It may therefore be necessary in rehabilitation programs to assess pessimists for co-morbidity and consider the possible effect of this on the proposed program. This hypothesis is strengthened by the fact that, in this analysis, pessimists reported a hearing related difficulty which affected their educational, working, social, family or recreational life. The second of these groups may also require help. Pessimists who think they have a hearing difficulty, but do not have any impairment at ≥25dBHTL may genuinely have noticed a decline in their hearing ability. If so they could be a group who will move into a hearing impaired category in the future. It is also possible that this group who think they have an impairment, but do not, request and may even receive services they do not need. Further research needs to identify whether this is in fact the case and propose ways of dealing with it.

Pessimists and optimists can be identified when their hearing thresholds are measured simply by asking the self-reported disability question and comparing the response category with measured impairment. How the hearing impaired individual sees their own hearing status in relation to the threshold measure will identify their level of pessimism or optimism.

There is not enough information in this analysis to determine whether or not the pessimistic group comprises of the "worried well"; however, given the fact they are more likely to be smokers and consume alcohol at a risk level, their health is likely to be suffering. Their pessimism and social drug consumption patterns may, additionally, imply other anxieties.

This chapter is incomplete without further discussion of self-reported assessments of prevalence. Schow & Gatehouse (1990) review the literature on self-assessment of hearing but this is mainly in relation to more comprehensive instruments assessing disability and handicap. The authors point out that several studies have found only modest correlation between self-assessment and pure-tone data. This is again reinforced by this study. The findings do not, however, lead to the conclusion that accurate estimates of self-reported prevalence are unobtainable. They do point to the fact that much more work needs to be done to develop the question(s) that provide accurate prevalence estimates. Self-assessment methods have worked with asthma (Abramson et al, 1992), but the validated questions that were used to establish prevalence are quite extensive. For hearing, much more work needs to be done to find a set of self-report questions that are valid and reliable predictors of hearing impairment. Future population work in South Australia can include different questions asked simultaneously of population groups and supported by audiological measure. Collaborative studies between research groups that have developed a population research dimension in hearing studies, including audiological measures, would speed up the process in testing the efficacy of proposed questions. Development of reliable self-report questions would facilitate more population research and ongoing monitoring of hearing and related issues, especially in places where this does not already occur.

7. QUALITY-OF-LIFE ANALYSES

OVERVIEW

This chapter examines the quality-of-life of the hearing impaired as measured by the SF-36. The mean scores for the eight health dimensions of the SF-36 for the hearing impaired are compared to people with asthma and diabetes and with a control group reporting no chronic condition. In addition, standard scores are used to compare the hearing impaired population with the SF-36 norms for the South Australian population as a whole. The same comparisons are also made using the summary mental and physical health scales of the SF-36.

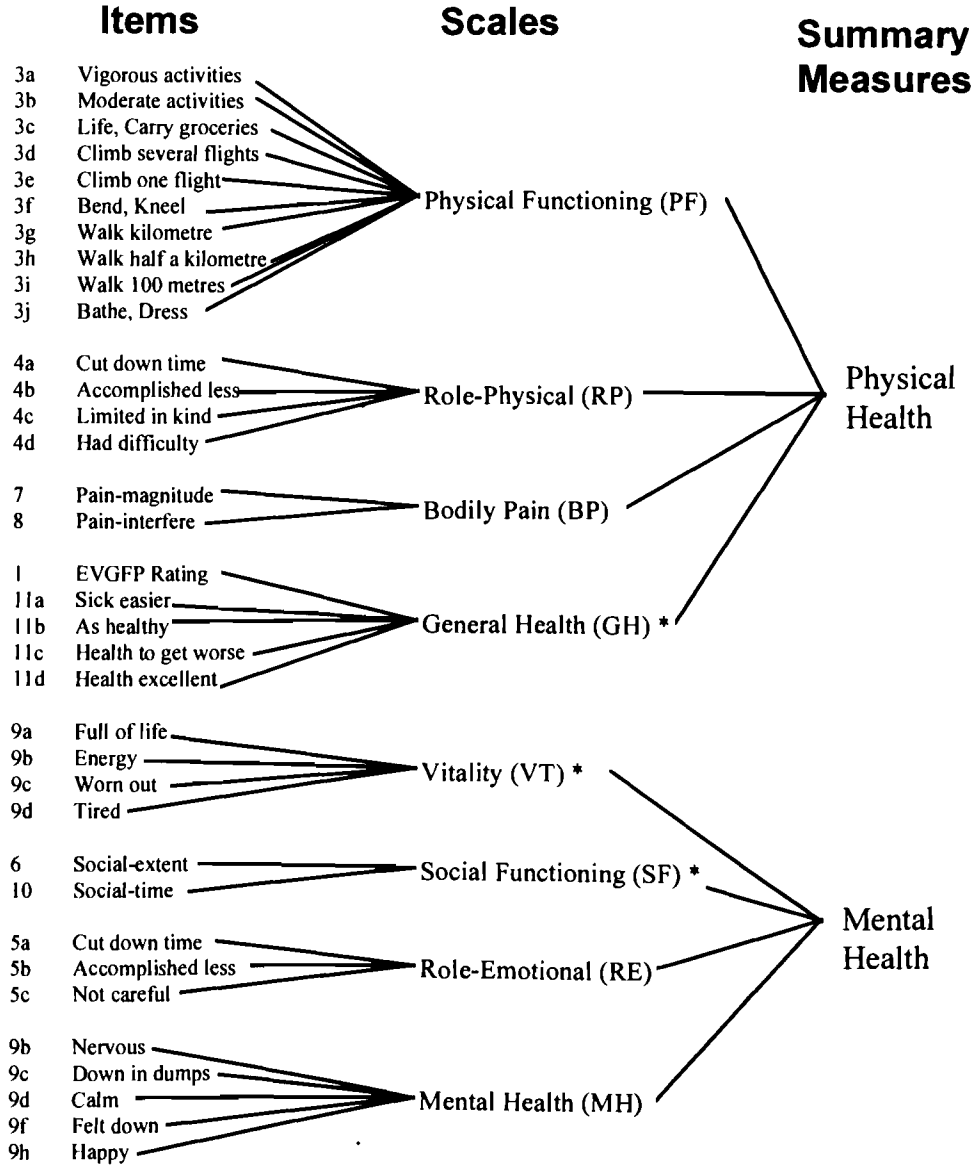
7.1 Introduction

This chapter investigates the impact of hearing impairment on functional ability as measured by the SF-36 health related quality-of-life instrument. This is done first, by examining the association of hearing impairment with the eight health dimensions and, second, with the two summary dimensions, of the SF-36. Hearing impairment is compared with two other chronic disease conditions: diabetes and asthma, for which SF-36 data were also obtained in the South Australian Health Omnibus Surveys (SAHOS). Comparison of hearing impairment with other chronic health conditions provides an important reference point for assessing the impact of hearing impairment as a public health problem in its own right. In addition, comparisons of the hearing impaired, made with a control group reporting none of the conditions, and with population norms, show where the hearing impaired person lies in relation to the average person in the population on each health dimension and on the summary mental and physical health scales.

7.2 The SF-36 Health Survey Questionnaire

The SF-36 is a generic, multi-item, self-report questionnaire and, as discussed earlier, satisfies adequate psychometric design standards (Ware et al, 1993b). It is relatively easy to use, can be completed in a short period of time and is ideal for health interview surveys like the SAHOS. The SF-36 is described as a generic instrument because it can be used to assess universal aspects of health that are not age, treatment or disease specific. Generic instruments assess aspects of health that contribute to quality-of-life for both sick or well populations and provide a range of scales along which populations, or sub-populations, can be measured and compared. As indicated by its title, the SF-36 comprises thirty six health questions that sum to eight health dimensions. The dimensions in turn sum to produce two summary measures of physical health and mental health. Figure 7.1 is adapted from the SF-36 Users Manual (Ware et al, 1993(b)) and illustrates the construction of the eight health dimensions and the summary mental and physical health dimensions. The full questionnaire is contained in Appendix 7.

Figure 7.1: Construction of the SF-36 Health Dimensions and the Summary Mental and Physical Health Measures



* Significant correlation with other summary measure

As shown earlier the SF-36 has been modified appropriately and validated for use on an Australian population (McCallum, 1994). The SF-36 questionnaire reflects several decades of advancement in the design of methods that assess patient and population perspectives of health status. Among the more important of these advances has been, firstly, an improved understanding of what comprises a health dimension and secondly, the design of specific scales for assessing each dimension. An early focus of health

status measures was on the presence or absence of negative health status, functional limitations, symptoms of disease and acute and chronic health problems (Kaplan & Bush, 1982). Prior to the 1970's, few measures of health status were based on the notion of dimensions of health, which reflect an underlying conceptual understanding, and explanation, of how individuals perceive various health states. The application of psychometric techniques to an understanding and clarification of health dimensions, and the development of scales, has been a significant advance in the measurement of health status (McDowell and Newell, 1987). The 1970's and 1980's saw a period of extensive development and refinement of measures particularly through the Health Insurance Experiment (HIE). The general aim of the HIE was improved understanding of the major dimensions of health and to construct scales that would measure, as well as possible, a broad range of functional status and well-being dimensions (Brook et al, 1983; Ware, 1986). This period saw one of the most extensive applications of psychometric theory, development, testing and refinement and led to the production of a range of health status measures culminating in the SF-36. Figure 7.1 encapsulates this development taking single items of health status that are then aggregated to form dimensions[7] that, in turn, are aggregated to form summary measures. Jenkinson et al (1993) argue that until the development of the SF-36 the search for an acceptable generic health questionnaire that was easy to administer was a venture with few successes.

The original SF-36 questionnaire was modified for Australian use through pre-testing discussion and interviews (McCallum, 1994). "Walking more than a mile" was changed to "walking more than one kilometre." "Walking several blocks" was changed to "walking half a kilometre." "Walking one block" was changed to "walking 100 metres." "Did you feel full of pep" was changed to "feel full of life." "Have you felt downhearted and blue" was changed to "have you felt down." It was with these modifications that the instrument was validated for use with an Australian population (McCallum, 1994).

United States studies have shown that the SF-36 discriminates well between groups with major and minor physical and psychiatric conditions (McHorney et al, 1993). In 1993, the SF-36 was being used in more than 200 clinical trials in the United States where investigators were interested in documenting changes in quality-of-life following

[7] The term "dimension" has sometimes been used synonymously with the term "scale", however, in this text the "dimension" will be used to refer to the broad area of health functioning (vitality, social functioning, etc.) and the term "scale" to the calibrated response items measuring these dimensions.

treatments (Ware et al, 1993). In one British study, Brazier et al (1994) found that the SF-36 discriminated between patients with chronic disease and patients who had recently consulted a general practitioner. Brazier also reported that the instrument performed well in comparison with the Nottingham Health Profile (NHP) by being able to detect levels of ill health in patients who remained undetected on the NHP.

The SF-36 is not without critics. Donovan et al, (1993), has questioned its value in making purchasing decisions and Ziebland (1995) has identified that it may have some problems in detecting changes in population health status that occur from community wide interventions. The SF-36 has also been criticised for failing to detect low levels of morbidity (Bellman, 1992). Its use in this study was not, however, for any of these purposes, but to compare the perceived health status of different chronic conditions. This latter function was one of the primary intentions of the SF-36 designers and this aspect will be discussed further in a later section.

In this study the SF-36 was used to compare the quality-of-life of people with various degrees of hearing impairment (mild, moderate, severe) with other chronic disease groups (asthma, diabetes) and, in addition, with people who reported none of these problems. The earlier information on the validity of the instrument and the information given here on the generic nature of the SF-36, suggest that it is a reasonable choice of instrument for comparing groups of different health status. In addition, in this study, a further comparison of the disease groups (hearing impairment, asthma and diabetes) was also made with normative SF-36 population data for the South Australian population (Behavioural Epidemiology Unit, 1995) using standard scores. Jenkinson et al (1993) and the designers of the SF-36 both have pointed out that normative data can be used for comparisons with other population samples. In this study the normative data provides another reference point for assessing the quality-of-life of the hearing impaired population. Ideally, a prospective study should be used to assess the impact of hearing impairment on quality-of-life. This cross-sectional study was, however, able to examine the association of hearing impairment with quality-of-life scores in relation to the scores for other groups of people. The results provide support for a causal relationship between hearing impairment and quality-of-life that can only ultimately be measured in prospective studies.

7.3 Method

The survey sampling method was discussed in Chapter 4, however, it is necessary here to explain more detailed aspects of the method that applied to the quality-of-life analyses.

The SF-36 quality-of-life questionnaire was administered only in the first two of the three SAHOS used to recruit the hearing impaired sample. These two SAHOS provided a sample size of n=6011 on which to compute population norms for the SF-36 quality-of-life scales (Table 7.1). Normative data make it possible

Table 7.1: Population norms developed from the 1994 and 1995 SAHOS

	PF	RP	BP	GH	VT	SF	RE	MH
1994 NORMS (n=3010)								
Mean	85.4	80.2	77.2	73.2	64.0	88.2	87.5	78.7
S.D.	21.6	34.9	25.5	21.7	21.4	21.3	28.9	17.7
1994/5 NORMS (n=6011)								
Mean	85.9	80.3	77.2	73.6	64.0	88.4	88.2	79.4
S.D.	21.3	35.4	25.8	21.4	21.1	21.3	28.9	17.0

to interpret the scale scores for any individual, or the mean score for a group of people by comparison with the scores for the average person in the population[8] . This comparison is based on where they lie in the distribution of scores in the normative sample. The norms reported here upgrade an earlier publication that reported South Australian population norms based on the 1994 SAHOS only (n=3010) (Behavioural Epidemiology Unit, 1995). Table 7.1 shows both sets of normative mean scores for the quality-of-life scales for the South Australian population, together with their standard

[8] The maximum possible score for each quality-of-life dimension is 100 and the minimum score is 0. Five of the scales (physical functioning, role-limitations-physical, bodily pain, social functioning, role-limitations-emotional) define health status as the absence of limitation or disability. For each of these scales the highest score is obtained when no limitation or disabilities are reported. The remaining three scales (general health, vitality and mental health) are bipolar in nature and measure a wider range of negative and positive health states. For the bipolar scales a score of 100 is recorded when people identify the positive extremes, indicating favourable health.

deviations. It can be seen that the level of agreement for the two sets of norms is very high.

The sample of n=6011, included in the first two SAHOS, completed the SF-36 questionnaire and these data were reweighted and used to produce the South Australian population norms for the SF-36. Of this sample, n=715 who reported normal and impaired hearing status had their hearing thresholds measured by an audiologist and also provided detailed information on the other chronic diseases of interest (asthma and diabetes). Threshold measures provided four categories of hearing: normal, mild impairment, moderate impairment and severe impairment. This sample of n=715 was used to make the comparisons between hearing impairment, the other chronic conditions reported in this chapter and with the population norms

In identifying those in the sample who had diabetes people were asked: "have you been told by a doctor you have diabetes?" Although classification of diabetes is based on self-report, this question has been asked in a number of SAHOS over several years and has produced consistent prevalence estimates, indicating that the question is reliable. In determining who had asthma people were asked: "have you ever had asthma?"; "was your asthma confirmed by a doctor?"; "do you still have asthma?". The asthma questions have been validated and reliability tested previously in a study by Abramson et al (1992).

Table 7.2 shows the independent comparison groups used in the quality-of-life analyses and the sample size for each group. As will be explained, different groups were selected for each quality-of-life analysis from the list of groups shown in Table 7.2. It was considered that the primary assessment of the impact of hearing impairment should be made by comparing discrete groups who suffered one chronic condition only (hearing impairment only, asthma only, diabetes only) and the control group who suffered none of these. Groups **a** to **f** of Table 7.2 were used for the first two analyses. The first analysis compared the mean scores for each group on the eight health dimensions. The second analysis compared the scores for each group on the summary mental and physical dimensions.

It should be pointed out that the "no chronic conditions" group means they reported no asthma or diabetes, and did not have measured impairment. It is possible that some people in this group had other chronic conditions that were not investigated in this study.

Table 7.2: Sample size of comparison groups used in the quality-of-life analyses

	STUDY GROUPS	n
a	No chronic conditions (hearing impairment, asthma or diabetes)	334
b	Mild hearing impairment	135
c	Moderate hearing impairment	83
d	Severe hearing impairment	42
e	Asthma	56
f	Diabetes	9
g	Chronic disease (asthma or diabetes)	65
h	Concordant no hearing impairment	169
i	Concordant mild/moderate hearing impairment	102
j	Concordant severe hearing impairment	40
k	Pessimistic no hearing impairment	165
l	Pessimistic hearing impairment	34
m	Optimistic hearing impairment	84
n	Multi-Chronic (severe hearing impairment and at least one other reported health condition)	56

Following the findings of the first two analyses using groups **a** to **f** (Table 7.3 & Table 7.4), the data were recoded to permit further exploration of the differences in reported disability and measured impairment. Given the discovery of the pessimistic and optimistic groups reported in Chapter 5, this was considered an important perspective of the study. Recoding of the data facilitated investigation of the hypothesis that people who reported their hearing disability was worse than measured impairment (pessimists) had a lower quality-of-life score than those who reported their hearing was better than measured (optimists). As indicated in Chapter 5 the disagreement between measured impairment and reported hearing disability raised the question as to whether or not self-perception of a hearing disability, better or worse than that actually measured, also affected perception of quality-of-life.

Groups **a** to **f** were therefore, recoded producing groups **g** to **m** for two further analyses. In recoding the data three concordant hearing groups were formed (Table 7.2). Those people who correctly reported no disability were recoded into a concordant no impairment group. Because the first of the quality-of-life analyses showed there were only small differences between the mild and moderately impaired groups in quality-of

life scores (Table 7.3), they were collapsed and recoded into a concordant mild/moderate group. Those who correctly reported severe impairment were recoded into a concordant severe group. In addition to the concordant groups, those who reported disability, but were assessed as having no impairment were recoded into a pessimistic no impairment group. Those who reported a hearing impairment that was worse than actually measured were recoded into a pessimistic impaired group. Those who reported a hearing disability better than was actually measured were recoded into an optimistic impaired group. The asthma and diabetes groups were also recoded. Given the small number of people with diabetes in the first set of analyses, asthma and diabetes were collapsed to form a chronic disease group in the second set of analyses (Table 7.2). In addition a new multi-chronic group was formed comprising those with measured hearing impairment and who had also reported at least one other chronic condition (asthma, diabetes). It can be seen from Table 7.2 that the same number of people used in the first set of analyses: n=659 (groups **a** to **f**), were recoded into the groups used in the second set of analyses (groups **g** to **m**). The multi-chronic group (group **n**) is an additional group included in the third and fourth analyses. These analyses compared group mean quality-of-life scores for each of the eight health dimensions and the summary physical and mental health dimensions.

In addition to comparing the mean quality-of-life scores for each of the health conditions standard scores were also used to compare the chronic disease groups with population norms. Garrat et al, (1993) has previously compared quality-of-life scores for specific chronic disease conditions with quality-of-life population norms using standard scores. Garrat's methods were used in these analyses. Standard scores were calculated for each dimension by dividing the differences between the quality-of-life scores for each chronic disease group and the norm of the general population, by the standard deviation of the general population. The mean of the general population is set at zero for each quality-of-life dimension allowing comparisons to be made in terms of standard deviations for each of the comparison groups. Kazis et al, (1989) and Cohen (1977) discuss the use of effect sizes for interpreting the differences between groups in standard scores. An effect size 0.2, or one fifth of a standard deviation, is described as small or mild, one of 0.5 as moderate and one of 0.8 or greater as large. Another advantage of using standard scores is that they can be equated with centiles of the population. For example, people with diabetes with a standard score of 1.29 for general health correspond to the lowest scoring 10% of the population for this item. The standard scores are shown in Figures 7.2 to 7.5.

The first stage of the analyses assessed possible interaction effects between the chronic disease conditions. Although co-morbidity was not a major focus of this study the assessment of interactions was considered important in interpreting disease effects on quality-of-life and of potential value to other investigators of chronic disease. The multi-variate analysis of variance model (MANOVA) was used to investigate possible interactions between the chronic disease groups: moderate and severe hearing impairment, diabetes and asthma. Age, sex and socio economic status were included as co-variates in the model. Quality-of-life scores were entered together as the dependent variables. The model used backward elimination of non-significant terms. No higher order interactions were found. One two-way interaction of sex with asthma was statistically significant at the five per cent level, but this has no bearing on the main line of inquiry. The main effects of age, sex, socio-economic status, asthma, diabetes and moderate and severe hearing impairment on quality-of-life scores were statistically significant at less than the five percent level, and mild hearing impairment approached statistical significance ($p=0.1$). This preliminary analysis, showed there were no statistically significant multiplicative interactions between the chronic diseases, age, sex and socio-economic status and quality-of-life score, but it should be pointed out that the number of people suffering more than one chronic condition in these analyses was small.

Following assessment of interactions, a series of MANOVA (univariate) analyses of variance were conducted to examine the relationship between the chronic disease categories and each quality-of-life dimension. The MUPLUS procedure (Norusis, 1993) was used to produce weighted means for each health condition. The data from these analyses are contained in Table 7.3 to Table 7.6. In each analysis one quality-of-life dimension, or one summary quality-of-life dimension, was included as the dependent variable. The groups shown in Table 7.2 were entered as factors in the model controlling for the effects of age, sex and socio-economic status. In all quality-of-life analyses hearing impairment was defined as ≥21dBHTL over the air frequencies 500, 1000, 2000 and 4000Hz (Ballantyne, 1993). This lower threshold level was used in this analysis in preference to 25dBHTL in order to maximise sample size.

The analyses of quality of life data was conducted using regression techniques based on the normal distribution, as has been the practice in previous studies using the SF-36. The approach is, however, not without criticism because the distribution of the data for the quality-of-life scales in this study are skewed. This finding led to a supplementary analysis using ordinal regression techniques which is reported at the end of the Chapter.

7.4 Results

The first conclusion to be drawn from the data in Table 7.3 is that, despite the mean differences, the confidence intervals show there are few differences that achieve statistical significance. There are, however, aspects of consistency and plausibility about the data that may be just as important as statistical significance in sustaining justifiable inferences. It can be seen from Table 7.3 that for all of the quality-of-life scales, those who suffer no impairment or other chronic conditions, mild impairment, or moderate impairment, obtain higher scores than severe impairment, asthma or diabetes, indicating better functioning for the first three groups. It would appear, from these data, that there are few substantial differences between mild and moderate hearing impairment and those reporting no chronic health conditions for each health dimension. For two dimensions (role emotional and mental health) mild and moderate impairment record higher mean scores than no chronic conditions, indicating improved functioning. For all scales except role physical, severe impairment lies in the same relative position scoring higher than asthma and diabetes, but lower than mild or moderate hearing impairment.

The overall consistency of the information will become clearer as the other analyses are reported. However, from Table 7.3, it can be seen that severe hearing impairment, asthma and diabetes groups lie in the same position relative to each other for most scale scores and also in relation to the scores for the control group: people who reported suffering no chronic conditions. From this it may be concluded that, of these three chronic conditions, diabetes would have greatest overall impact on those who experience it, followed by asthma then severe hearing impairment.

A second aspect of consistency is to be found in the particular dimensions that are affected by each condition. General health, bodily pain and vitality are affected more by asthma and diabetes than by severe hearing impairment. Severe hearing impairment has its greatest impact on social functioning and role physical. These issues will be taken up further in the discussion.

Of interest in this analysis, and contrary to the findings of other studies, is the fact that hearing impairment, and especially severe impairment, has little or no effect on mental health score when compared to the control group. This will be discussed later.

Table 7.3: Mean quality-of-life score and confidence intervals for different health conditions adjusted for age, sex and socio-economic status

CONDITION	MEAN score for Physical Functioning Scale	CONFIDENCE INTERVAL
No chronic conditions	85.6	83.3 - 87.6
Mild hearing impairment	84.0	80.7 - 87.4
Moderate hearing impairment	86.0	81.6 - 90.5
Severe hearing impairment	80.6	74.7 - 86.5
Asthma	78.8	73.6 - 84.1
Diabetes	78.0	65.8 - 90.2

CONDITION	MEAN score for Role Physical Scale	CONFIDENCE INTERVAL
No chronic conditions	78.6	74.1 - 83.1
Mild hearing impairment	79.4	72.8 - 86.1
Moderate hearing impairment	76.1	67.3 - 84.9
Severe hearing impairment	64.5	52.7 - 76.3
Asthma	68.8	58.4 - 79.1
Diabetes	64.5	40.2 - 88.8

CONDITION	MEAN score for Bodily Pain	CONFIDENCE INTERVAL
No chronic conditions	73.9	70.7 - 77.1
Mild hearing impairment	71.5	66.7 - 76.3
Moderate hearing impairment	74.9	68.6 - 81.2
Severe hearing impairment	71.0	62.5 - 79.4
Asthma	68.6	61.1 - 76.0
Diabetes	64.6	47.2 - 82.0

CONDITION	MEAN score for General Health Scale	CONFIDENCE INTERVAL
No chronic conditions	73.6	71.2 - 75.9
Mild hearing impairment	73.0	69.5 - 76.5
Moderate hearing impairment	76.0	71.4 - 80.7
Severe hearing impairment	70.8	64.6 - 77.0
Asthma	63.3	57.8 - 68.8
Diabetes	46.0	33.1 - 58.8

Table 7.3: Mean quality-of-life score and confidence intervals for different health conditions adjusted for age, sex and socio-economic status (cont.)

CONDITION	MEAN score for the Vitality Scale	CONFIDENCE INTERVAL
No chronic conditions	61.6	59.0 - 64.2
Mild hearing impairment	64.5	60.7 - 68.3
Moderate hearing impairment	64.8	59.8 - 69.8
Severe hearing impairment	62.4	55.7 - 69.2
Asthma	57.3	51.4 - 63.3
Diabetes	50.5	36.6 - 64.3

CONDITION	MEAN score for Social Functioning Scale	CONFIDENCE INTERVAL
No chronic conditions	88.1	85.4 - 90.8
Mild hearing impairment	87.2	83.2 - 91.2
Moderate hearing impairment	91.2	85.9 - 96.4
Severe hearing impairment	81.2	74.2 - 88.2
Asthma	81.1	74.9 - 87.3
Diabetes	68.0	53.5 - 82.6

CONDITION	MEAN score for Role Emotional Scale	CONFIDENCE INTERVAL
No chronic conditions	85.9	82.1 - 89.6
Mild hearing impairment	90.3	84.7 - 95.8
Moderate hearing impairment	87.9	80.6 - 95.1
Severe hearing impairment	84.3	74.6 - 94.0
Asthma	73.7	65.1 - 82.4
Diabetes	52.9	32.7 - 73.0

CONDITION	MEAN score for Mental Health Scale	CONFIDENCE INTERVAL
No chronic conditions	78.0	75.9 - 80.1
Mild hearing impairment	80.4	77.3 - 83.5
Moderate hearing impairment	83.4	79.4 - 87.5
Severe hearing impairment	77.4	72.0 - 82.9
Asthma	72.5	67.7 - 77.3
Diabetes	71.2	60.1 - 82.4

The standard scores for the eight health dimensions are shown graphically in Figure 7.2. For some dimensions mild and moderate impairment scores are slightly above the mean for the population. According to Cohen's criteria for interpreting effect size, severe hearing impairment has slightly more than a mild negative impact on physical functioning and body pain. It has a mild to moderate negative impact on role physical and social functioning. For all other dimensions severe hearing impairment has less than a mild negative impact. Overall the greatest impact on quality-of-life is among the people with diabetes. Asthma lies between severe hearing impairment and diabetes, but is closer to severe hearing impairment in its negative impact than it is to diabetes.

Figure 7.2: Mean SF-36 health profiles for six health categories and the general population expressed as standard scores

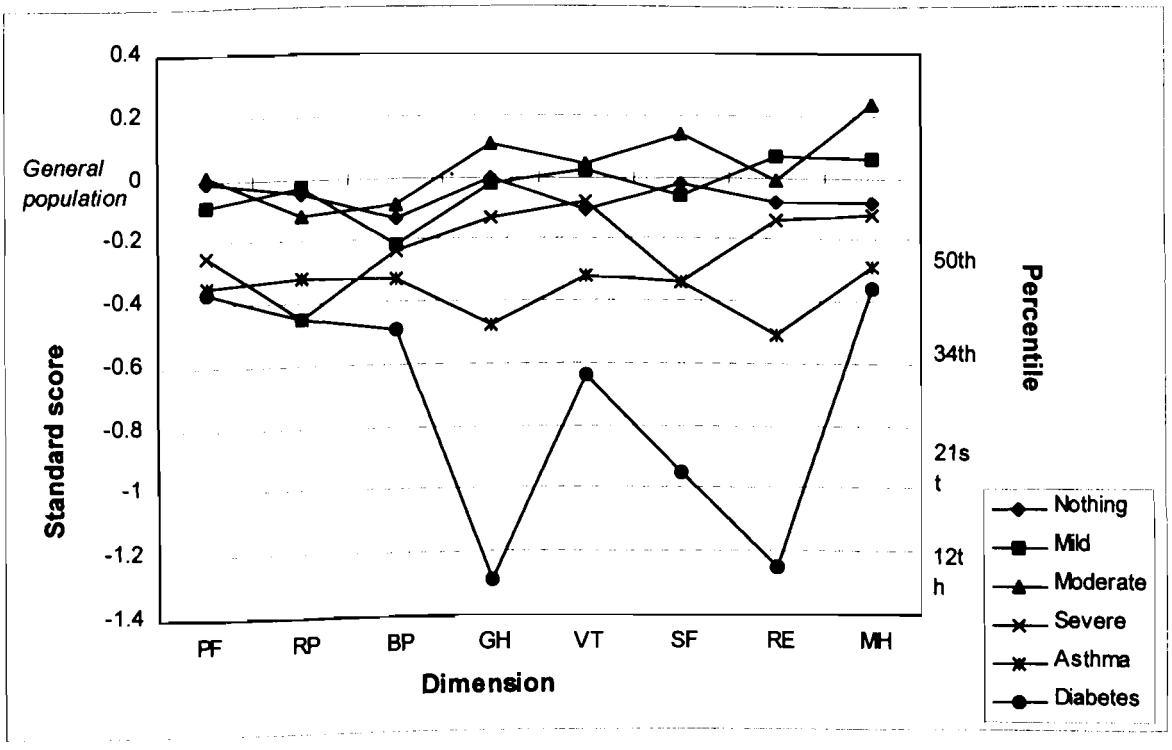
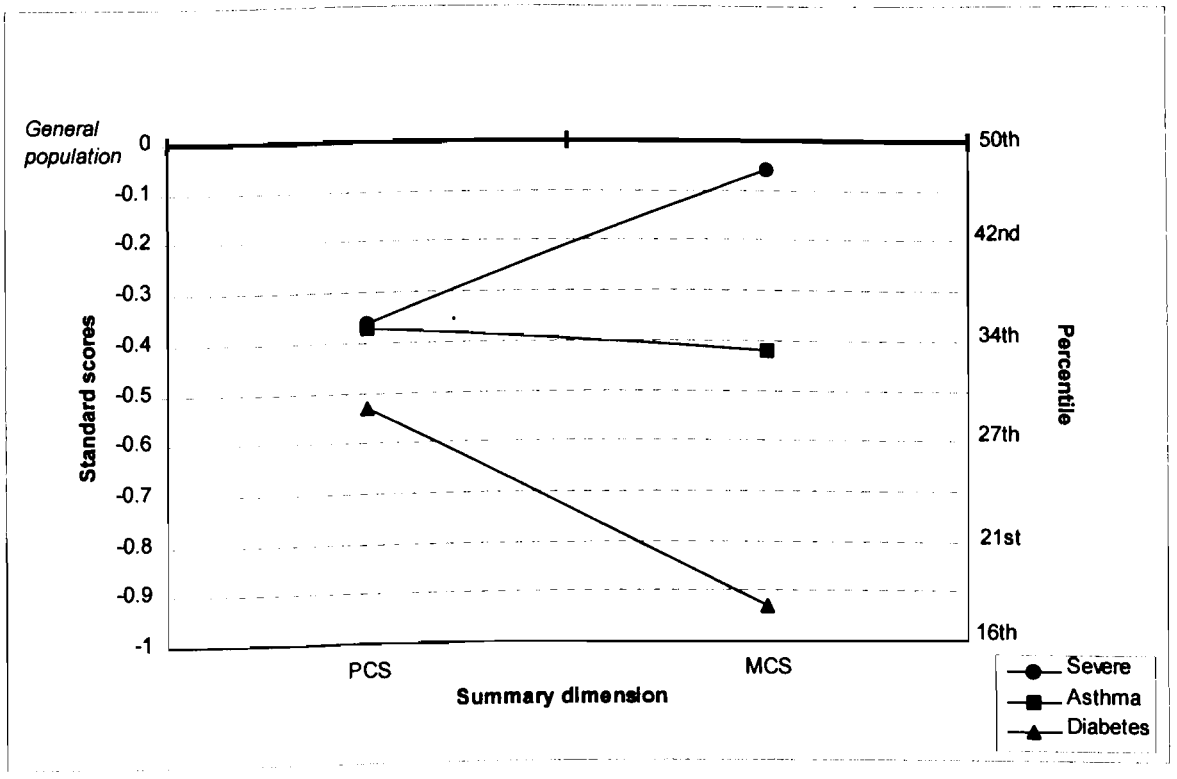


Figure 7.3 shows the standard scores for severe hearing impairment, asthma and diabetes for the summary mental and physical health scales. The data used in this Figure are contained in Table 7.4. Mild and moderate hearing impairment have been excluded from Figure 7.3, because of their minimal difference with the population norm.

Table 7.4: Mean summary quality-of-life score and confidence intervals for different health conditions

CONDITION	MEAN (95% CI) score for summary **Physical Health** Scale	MEAN (95% CI) score for summary **Mental Health** Scale
No chronic conditions	49.7 (48.5 - 50.8)	49.4 (48.2 - 50.7)
Mild hearing impairment	48.6 (46.9 - 50.3)	51.0 (49.2 - 52.9)
Moderate hearing impairment	48.7 (46.5 - 51.0)	52.3 (49.9 - 54.7)
Severe hearing impairment	46.5 (43.4 - 49.5)	49.6 (46.4 - 52.8)
Asthma	46.9 (44.2 - 49.5)	46.1(43.3 - 49.0)
Diabetes	44.9 (38.7 - 51.1)	41.1(34.5 - 47.8)

Figure 7.3: Mean SF-36 summary health profiles for three health categories and the general population, expressed as standard scores



PCS: Physical component summary measure

MCS: Mental component summary measure

Table 7.4 shows the effect of each health condition on the summary physical and mental health dimensions. Much the same order of effect is observed for each of the groups on the summary health dimensions. Figure 7.3 shows the standard scores for each of the

summary dimensions and again mild and moderate hearing impairment have been excluded because of their minimal difference with the population norms. From Figure 7.3 it can be seen that the overall summary impact of severe hearing impairment can be described as mild to moderate in its effect on the quality-of-life physical health dimension. The impact of severe hearing impairment is comparable to asthma in its effect on physical health. Severe hearing impairment has little or no impact on the mental health summary dimension.

In the second analysis, using groups **g** to **n** from Table 7.2, a similar pattern emerges in the relationship between the chronic disease groups and quality-of-life scores. The means for the recoded groups are shown in Table 7.5. For every dimension in the second analysis, with one marginal exception, the pessimistic impaired group obtain a lower quality-of-life score than the optimistic impaired group and record a mild to moderate impact in terms of standard scores for each dimension. Because the differences between the pessimistic and optimistic groups are not statistically significant we cannot reject the null hypothesis of no difference between these two groups. The mean differences are however quite large for a number of dimensions and, it should be remembered, that statistical significance is a function of sample size and larger samples in future studies may show that the mean differences are significant. Although mean differences are not statistically significant, the consistency of the information across the dimensions does provide support for the hypothesis that those people who perceive their hearing disability to be worse than it actually is, obtain a lower quality-of-life score. In this analysis it can also be seen that there is even an impact on quality-of-life score for the pessimistic no impairment group (ie those who thought they had a hearing disability, but were assessed as normal) for some dimensions, indicating that a pessimistic health viewpoint on its own affects quality-of-life score. It should also be pointed out that pessimistic impaired group comprises only mild or moderate hearing impairment. This is so because if a person classified themself as severe they could only be measured as moderate at worst to be classified as a pessimist.

The multi-chronic group, including people who have a hearing impairment and at least one other chronic condition, recorded a lower score for four of the health dimensions than the chronic disease group without hearing impairment (role physical, physical functioning, general health and vitality). This indicates an additional effect of hearing impairment for these dimensions. For two of the dimensions (role physical and role emotional) severe hearing impairment was shown in the earlier analysis to have had a mild to moderate impact. In one case (role emotional) the multi-chronic group seems to

Table 7.5: Mean quality-of-life score and confidence intervals for recoded health conditions adjusted for age, sex and socio-economic status

CONDITION	MEAN score for Physical Functioning Scale	CONFIDENCE INTERVAL
Concordant no impairment	85.6	82.4 - 88.8
Concordant mild/moderate impairment	83.3	79.3 - 87.2
Concordant severe impairment	81.2	75.0 - 87.4
Pessimistic no impairment	84.1	80.8 - 87.2
Pessimistic impairment	78.3	71.7 - 84.9
Optimistic impairment	87.4	83.0 - 91.8
Chronic disease group	78.1	73.1 - 83.1
Multi-chronic group	70.0	64.6 - 75.4

CONDITION	MEAN score for Role Physical Scale	CONFIDENCE INTERVAL
Concordant no impairment	76.8	70.6 - 83.0
Concordant mild/moderate impairment	80.3	72.7 - 87.9
Concordant severe impairment	65.2	53.2 - 77.2
Pessimistic no impairment	78.7	72.6 - 84.8
Pessimistic impairment	67.0	54.3 - 79.8
Optimistic impairment	78.7	70.2 - 87.2
Chronic disease group	67.3	57.7 - 77.0
Multi-chronic group	62.5	52.1 - 72.9

CONDITION	MEAN score for Body Pain Scale	CONFIDENCE INTERVAL
Concordant no impairment	76.0	71.5 - 80.4
Concordant mild/moderate impairment	74.0	68.5 - 79.5
Concordant severe impairment	72.8	64.2 - 81.5
Pessimistic no impairment	71.8	67.4 - 76.2
Pessimistic impairment	64.0	54.8 - 73.2
Optimistic impairment	72.2	64.2 - 81.5
Chronic disease group	68.1	61.1 - 75.0
Multi-chronic group	70.5	63.0 - 78.0

CONDITION	MEAN score for General Health Scale	CONFIDENCE INTERVAL
Concordant no impairment	75.0	71.7 - 78.4
Concordant mild/moderate impairment	74.5	70.3 - 78.6
Concordant severe impairment	71.4	65.0 - 77.9
Pessimistic no impairment	71.2	67.9 - 74.5
Pessimistic impairment	63.6	56.8 - 70.5
Optimistic impairment	77.2	72.6 - 81.8
Chronic disease group	60.4	55.1 - 65.6
Multi-chronic group	60.1	54.4 - 65.7

Table 7.5: Mean quality-of-life score and confidence intervals for recoded health conditions adjusted for age, sex and socio-economic status (cont.)

CONDITION	MEAN score for Vitality Scale	CONFIDENCE INTERVAL
Concordant no impairment	63.5	60.0 - 67.0
Concordant mild/moderate impairment .	63.7	59.4 - 68.0
Concordant severe impairment	63.2	56.4 - 70.0
Pessimistic no impairment	59.0	55.5 - 62.4
Pessimistic impairment	57.0	49.8 - 64.2
Optimistic impairment	68.9	64.1 - 73.7
Chronic disease group	56.0	50.5 - 61.4
Multi-chronic group	53.0	47.1 - 58.9

CONDITION	MEAN score for Social Functioning Scale	CONFIDENCE INTERVAL
Concordant no impairment	89.9	86.1 - 93.6
Concordant mild/moderate impairment	88.4	83.8 - 93.0
Concordant severe impairment	82.8	75.5 - 90.0
Pessimistic no impairment	86.5	82.8 - 90.2
Pessimistic impairment	81.4	73.7 - 89.1
Optimistic impairment	90.9	85.8 - 96.0
Chronic disease group	79.3	73.5 - 85.2
Multi-chronic group	81.6	75.3 - 87.9

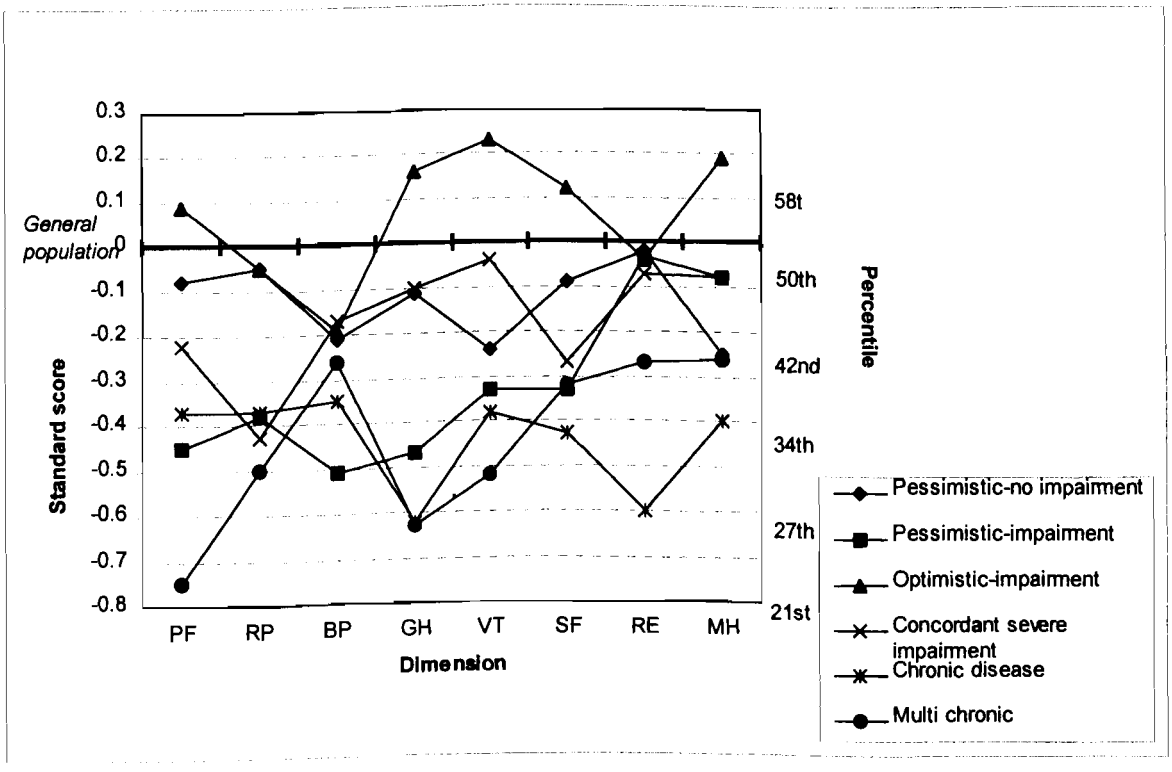
CONDITION	MEAN score for Role Emotional Scale	CONFIDENCE INTERVAL
Concordant no impairment	90.0	84.9 - 95.1
Concordant mild/moderate impairment	90.4	84.1 - 96.7
Concordant severe impairment	86.3	76.4 - 96.3
Pessimistic no impairment	82.5	77.4 - 87.6
Pessimistic impairment	87.3	76.8 - 97.9
Optimistic impairment	87.0	80.0 - 94.0
Chronic disease group	71.2	63.2 - 79.2
Multi-chronic group	80.5	71.8 - 89.1

CONDITION	MEAN score for Mental Health Scale	CONFIDENCE INTERVAL
Concordant no impairment	81.5	78.7 - 84.4
Concordant mild/moderate impairment	80.9	77.4 - 88.5
Concordant severe impairment	78.1	72.5 - 83.6
Pessimistic no impairment	75.1	72.3 - 77.9
Pessimistic impairment	82.8	78.9 - 86.7
Optimistic impairment	82.8	78.9 - 86.7
Chronic disease group	72.6	68.2 - 77.1
Multi-chronic group	75.0	70.3 - 79.8

produce a large improvement in quality-of-life score compared with chronic disease alone, however, again it must be pointed out that the difference is not statistically significant and the true value could be lower than the score for the chronic disease group.

The standard scores for the data shown in Table 7.5 are shown graphically in Figure 7.4. Concordant no impairment has been dropped from this Figure because the disease groups are being compared to the population norms and including this group adds nothing to our understanding of the impact of chronic disease group on quality-of-life. The standard scores of Figure 7.4 show that the greatest overall impact for a hearing impaired group is to be seen with the pessimistic impaired group.

Figure 7.4: Mean SF-36 health profiles for six health categories and the general population, expressed as standard scores



The groups used in the analysis shown in Table 7.5 were used in a final analysis to investigate their relationship with the quality-of-life summary dimensions: mental and physical health. These results are shown in Table 7.6. For both dimensions concordant severe impairment and pessimistic impairment score lower than the

concordant no impairment and the concordant mild/moderate groups, again indicating that severe impairment and pessimistic impairment are the affected hearing groups.

Figure 7.5 shows the standard scores for the dimensions in Table 7.6. It can be seen that while concordant severe impairment has little or no impact on the mental health dimension it does have a mild to moderate negative impact on the physical health dimension. The pessimistic impaired group has a larger impact than the severely impaired group on the physical dimension indicating again that hearing impairment and poor perception of the problem may combine to produce a larger effect on quality-of-life than does severe hearing impairment on its own. Hearing impairment combines with other chronic conditions (multi-chronic) to produce a moderate impact in terms of standard score on the physical health dimension. On the mental health dimension the concordant mild/moderate impaired and the optimistic impaired group have a positive effect on the standard score. Hearing impairment combines with other chronic conditions to produce a mild to moderate negative effect on the mental health standard score.

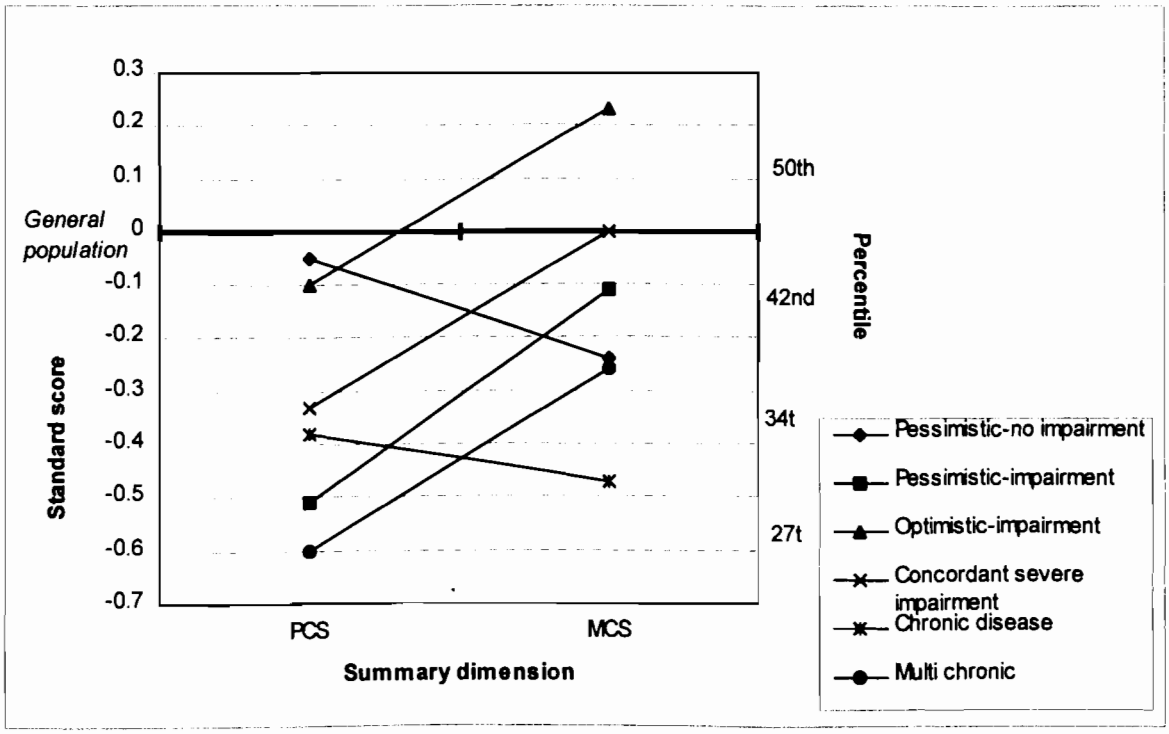
Table 7.6: Mean summary quality-of-life score and confidence intervals for recoded health conditions

CONDITION	MEAN (95% CI) summary scores for Physical Health Scale	MEAN (95% CI) summary scores for the Mental Health Scale
Concordant no impairment	49.1 (47.5 - 50.8)	51.4 (49.8 - 53.1)
Concordant mild/moderate impairment	48.9 (46.9 - 50.9)	51.2 (49.2 - 53.3)
Concordant severe impairment	46.8 (43.7 - 49.9)	50.1 (46.9 - 53.4)
Pessimistic no impairment	49.5 (48.0 - 51.1)	47.8 (46.1 - 49.4)
Pessimistic impairment	45.0 (41.7 - 48.4)	49.1 (45.7 - 52.6)
Optimistic impairment	49.0 (46.8 - 51.2)	52.5 (50.2 - 54.8)
Chronic disease group	46.3 (43.8 - 48.8)	45.6 (42.9 - 48.2)
Multi-chronic group	44.1 (41.4 - 46.8)	47.7 (44.9 - 50.5)

In the summary mental health dimension a difference is again observed between the pessimistic and optimistic impairment groups. The mental health score for the pessimistic group is lower than that for the optimistic group. Although this difference

is not large it is consistent with other findings that the hearing impaired individuals own perception of their hearing problem has an affect on their quality-of-life score independent of hearing impairment.

Figure 7.5: Mean SF-36 summary health profiles for six health categories and the general population, expressed as standard scores



PCS: Physical component summary measure

MCS: Mental component summary measure

7.5 Discussion

Quality-of-life, in this study, referred to the impact of hearing impairment on functional domains of daily living as defined by the SF-36. Impact on the quality-of-life of the individual may also be interpreted as handicap associated with hearing impairment. The generic nature of the SF-36 allows us to assess the relative importance of hearing impairment as a public health issue by comparing the quality-of-life impact with other chronic disease groups and with the general population. The diseases used as a reference point for hearing impairment were diabetes and asthma.

Despite reasonable sample sizes for some groups in the quality-of-life analyses reported, the differences observed in the scores between groups do not achieve

statistical significance. Caution must therefore be exercised in the conclusions drawn and in the application of the information in developing policy and designing programs for the hearing impaired. The consistency of the information, however, supports the hypothesis that hearing has an effect on quality-of-life.

In the summarised quality-of-life data at least one hearing impaired group scored below the population mean. People with a severe hearing impairment score below the population mean on all quality-of-life scales. As a health problem severe hearing impairment approaches asthma in its impact on the quality-of-life of the individual, and this is most apparent for the summary physical health dimension. The pessimistic impaired group recorded a mild to moderate standardised impact on six of the eight quality-of-life scales, using the criteria of Kazis et al (1989) and Cohen (1977), and had the second greatest impact of all the comparison groups on the summary physical health dimension. This is a remarkable finding when it is realised that the mild/moderate groups of the first two analyses had little impact on any dimension and that the pessimistic group in the second analyses comprised entirely of the mild and moderately impaired. The finding suggests that the perception of the problem by the individual is a determinant of impact. It would seem important, therefore, that future studies should be designed to describe the positive and negative groups more carefully. This may lead to further insights of the impact of hearing impairment on different personality types and help to target rehabilitation programs more precisely. This information would also add to the content and clarity of disease specific assessment questionnaires assessing hearing morbidity and the content of rehabilitation programs. The effects of pessimism on the physical quality-of-life scale and associated functional ability, also points to the fact that individual's perception of their hearing impairment should be investigated during audiological assessments and related to actual threshold measures. This may indicate the likely impact of any hearing deficit and give early warning of rehabilitation needs. The self-report hearing disability question may have good value in assessing the perception of the individual during audiological examinations and testing, even though it has slight correlation with severity of hearing impairment.

The fact that hearing impairment, and the individual's perception of their hearing impairment is associated with a lower quality-of-life score for some people can be interpreted in number of ways, each of which have implications for the rehabilitation of the hearing impaired. An impaired quality-of-life score may be the effect of the hearing impairment itself and, with appropriate intervention and rehabilitation, the

deficit can be made up. Alternatively, as the multi-chronic group showed on some scales, the deficit may be due (at least in part) to other health problems that are not hearing related, but again are remedial. Alternatively, either of these two situations can exist, but the deficit cannot be made up. These scenarios are summarised in Table 7.7. For each position in the Table different interventions will be required. If the lower quality-of-life status is due to the hearing impairment, and some or all of the deficit can be made up, then appropriate skills training will be required. The starting point for this skill training may lie in the administration of a generic questionnaire as used in this study. Given that SF-36 population norms are available for an Australian population, immediate comparisons for a hearing impaired individual can be made with the general population. Following the use of a generic questionnaire a disease specific questionnaire should be used to detail limitations more precisely. For example, in the case of role physical deficits, it will be necessary to develop a disease specific questionnaire that leads the rehabilitation counsellor through the daily physical activities that the hearing impaired have difficulty performing, or the work they are unable to do and the way in which hearing impairment limits them in these situations. Where the deficit in quality-of-life is not due to the hearing impairment or, in addition to the impairment, is also due to other health problems, then a more comprehensive medical examination and work up may be required to assist in the identification and use of other disease specific instruments. Other morbidity of the hearing impaired individual should be carefully assessed as part of the differential diagnosis. At least part of the solution for this group will include appropriate referral to other specialists. For the groups who are unable to improve their quality-of-life score, intervention will still be required. This may be in the form of adaptive training to their reduced quality-of-life status and/or counselling to help with the adjustment.

The schema in Table 7.7 provides a means of classifying and attributing the difficulties of the hearing impaired individual and, in conjunction with the use of appropriate disease specific instruments, the tailoring of skill development and counselling as appropriate. It should be pointed out that the difficulties of the hearing impaired person are unlikely to fit neatly into any one of the four categories in Table 7.7 and there may be considerable overlap in the source of problems or the extent to which some are remedial. It should also be identified that although this study has identified certain dimensions where the hearing impaired population are affected, this situation may be radically different on an individual basis. Given, however, the extensive psychometric development of the SF-36 and its validity as a comprehensive

Table 7.7: Rehabilitation strategies to be considered for different groups of the hearing impaired

	DUE TO HEARING IMPAIRMENT	NOT DUE TO HEARING IMPAIRMENT ENTIRELY
REMEDIAL	Disease specific quest. Skill training Environmental adaptations	Referrals Medical examination Other disease specific quest. Skill training
NOT REMEDIAL	Disease specific quest. Counselling Adaptive training Environmental adaptations	Referrals Counselling Adaptive training Environmental adaptations

health measure, then it would seem suitable for use on an individual basis for a "first pass" assessment of the areas most affected by hearing impairment and to assess how badly individuals are affected in relation to population norms. This can then be followed by disease specific questionnaires that detail the areas of handicap more precisely.

Disease specific questionnaires have an important potential function in rehabilitation of the hearing impaired. Following on from the use of a generic instrument to identify the dimensions of impairment for people with a hearing difficulty, it will be appropriate and necessary to use disease specific instruments to detail the particular tasks and activities that are impaired so that rehabilitation resources can be efficiently targeted. Given the dimensions that were shown to be affected by hearing impairment in this SF-36 study, and the limited development of disease specific hearing questionnaires, it would seem that more developmental work is needed. Davis (1997), has identified the multi-dimensionality of need of the hearing impaired and the notion is supported by the pessimistic group data in this study. For example, the pessimistic impairment group were affected across the dimensions: physical functioning, role physical, general health, body pain, vitality and social functioning. No single disease specific hearing questionnaire covers all of these dimensions and before they can be developed more qualitative work is required with the hearing impaired population. The notion of multi-dimensionality of need is also currently a feature in the development of a disease specific questionnaire by Gatehouse (1994) for the

investigation of hearing aid benefit. Although the content of Gatehouse's questionnaire may not be relevant for the problem under discussion his approach to questionnaire design and administration is. This first covers a range of situations in which areas or domains of functional difficulty are identified then, given the importance of each area to the individual, more information is extracted on the extent and level of difficulty. This approach to questionnaire design is an efficient way of exploring the type and extent of functional difficulty caused by a hearing impairment and provides a model for the development of more comprehensive disease specific questionnaires that can be used to inform rehabilitation programs.

Although a number of disease specific hearing instruments exist already, they have been developed mainly to assess the disease specific aspects of listening in different situations. Some of these quality-of -life difficulties may be modified by rehabilitating the listening ability of the individual. The Hearing Performance Inventory (Giolas et al, 1979) was developed to assess hearing performance difficulties and examines listening ability associated with personal, social and occupational situations. It can amplify some disease specific limitations identified in this study, but does not cover the situations identified using the SF-36. The disease specific disability/handicap questionnaire, reported by Lutman et al (1987), covers other listening situations, but again misses areas identified by the SF-36. Other questionnaires, such as the Hearing Handicap Inventory for the Elderly (Ventry & Weinstein, 1982) and the Hearing Handicap Inventory for Adults (Newman et al, 1990) are limited for use with particular groups of hearing impaired people and still do not investigate dimensions revealed by the SF-36 that are related to physical daily activity tasks, for which the hearing impaired will require rehabilitative assistance. If we are to document the needs of the hearing impaired more precisely for rehabilitation purposes, then further development of disease specific instruments are a priority concern. Qualitative research will assist in amplifying and extending the dimensions covered by the SF-36 and also in explaining the ways in which limitation or disability is related to handicap. In addition to the qualitative research epidemiology can play a large part in future developments of disease specific instruments. Its contribution will be in providing more detailed population data on the extent and distribution of specific functional limitations of the hearing impaired and how these vary across hearing impaired groups as the SF-36 data has begun to identify.

As already discussed, the fact that there are few statistically significant differences between the groups in this study but good internal consistency of data does indicate

that hearing impairment has an impact on quality-of-life. The large standard errors in the data were unexpected and point to the need for even larger samples to be used for quality-of-life analyses in future. It is argued, however, that the consistency of the data argues an impact of hearing impairment on quality-of-life. Consistency is also reinforced by the plausibility of the scales affected. General health, bodily pain and vitality are more likely to be affected by asthma and diabetes than by hearing impairment. Given the suffering associated with asthma and diabetes this is expected. Severe hearing impairment has its greatest impact on social functioning and role physical. Given the effect of hearing impairment on communication the impact on social functioning is also to be expected. What is more difficult to explain is the effect of the severe hearing impaired group on the summary role physical dimension and the pessimistic hearing impairment groups on both role physical and physical functioning dimensions.

As the SF-36 questionnaire shows, the questions that comprise these two scales relate to limitations in work, effects on other regular daily activities, and exercise and other strenuous activities (see Figure 6.1 and Appendix 7). Although difficulties with employment have been documented for the hearing impaired (Hetu et al, 1988) there is less information on the affect on other regular daily activities, exercise and strenuous activity. There is, however, a possible explanation for the survey results in the association between hearing impairment and balance. The hearing literature shows this connection is prevalent from infancy through to old age (Bellman, 1992; Tsue et al, 1994; Keim & William, 1995; Manabe et al, 1995; Merchant et al, 1993; Vargas, 1995). Bellman (1992) and Tsue et al (1994) both identify it as a "common" and often untreated problem. The combination of hearing and balance is most dramatically observed in a condition such as Meniere's disease and Meniere type conditions, but has also been documented via a microvascular pathway in hypoperfusion of the central nervous system (Keim & William, 1995). The connection between noise induced hearing impairment and balance has also been made (Manabe et al, 1995), where co-existing hearing and balance disorders have been shown to result from the impairment of hair cells in the inner ear or vestibular system. The connection between balance and hearing impairment is now so well established that it has led to the formation of the National Temporal Bone, Hearing and Balance Pathology Resource Registry at the National Institutes of Health in Washington (Merchant et al, 1993). Perhaps the most famous case of co-existing hearing and balance disorders is that of Goya who suffered balance, vision and hearing disturbance

caused by a condition known as bilateral uveitis (Vargas, 1995). This may have contributed to period in Goya's life when he produced the "Black Paintings".

Given the connection of hearing impairment and balance it is not a large cognitive leap to conclude that daily functioning, normal work activity, exercise and other strenuous activity may also be affected. It would seem that attention to the specific effects on these daily activities for the hearing impaired should also be considered of importance in disease specific questionnaires and rehabilitation programs. Best practice guidelines for the general practitioner would also include an emphasis on the functional assessment of patients with hearing problems in these areas. Audiologists could also consider upgrading the importance of balance as part of the patient assessment together with the identification of limitations in normal daily activities.

Another conclusion that may be extracted from this study is that the physical and mental health scales are quite independent of each other as far as hearing impairment is concerned, but both scales are affected by both diabetes and asthma as shown in the first analysis of dimension and summary scores. The largest mental health effect for a hearing impaired group is observed in the mental health summary score for the multi-chronic group, but given the preceding analyses, this effect is more likely due to the other two chronic diseases and less likely due to hearing impairment.

The findings, of hearing impairment having little or no effect on the mental health scale, are at some variance with other studies that have investigated aspects of mental health. Mulrow et al (1990), used the emotional health sub-scale of the Hearing Handicap Inventory for the Elderly (HHIE) to investigate the connection between hearing and emotional health. In this study hearing impaired people scored significantly higher than those with normal hearing indicating greater emotional dysfunction. Ireys et al (1994), used the psychiatric Symptom Index to measure the mental health status of young adults and found that the prevalence of hearing and speech problems had significant effects on mental health status. Lichtenstein (1992) showed an improvement in depression scores using the HHIE a short time after receiving a hearing aid and so identifying the association between hearing impairment and depression. Kreeger et al, (1995), looked at the impact of hearing deficits on psychopathology of hearing impaired geriatric subjects and showed that they displayed less psychopathology when tested using a functioning hearing aid. This study indicates that hearing impairment may have been a confounder in the psychiatric assessment process rather than a cause of fundamental psychopathology. For all of

these studies clinical or convenience samples were used and questions are raised as to how representative they are of the population of hearing impaired people. This was discussed in detail in chapter 2. Two studies were identified that used representative population samples to assess mental health. Using Becks Depression Index, Carabellese et al (1993) found that hearing impairment was not the most important variable in measured mood states and that female gender and few social relationships were more strongly associated with low mood states. Lindgren (1994), investigated self-reported worry and loneliness in people aged 75 years and older and found that, although hearing problems were common in the sample, they did not affect perceived health with regard to these variables. Most recently in an Australian study of Cochlear implantees and other deafened adults Hogan (1997), using the revised version of the Auto-Thoughts Questionnaire, showed that even at the extreme end of hearing impairment there was no significant mental health morbidity. Other authors have reported on or discussed various aspects of psychosocial functioning of hearing impaired groups using qualitative research methods (Hetu et al, 1988; Hetu & Getty, 1993) but these studies are not concerned with prevalence of mental ill-health. The conclusions that must be drawn from the current study is that hearing impairment has little effect on mental health, except via other mechanisms (pessimism) or in association with co-morbidity. The findings of this study agree with previous population studies of Carabellese (1993) and Lindgren (1994) and not with the studies that used the unrepresentative samples identified above.

7.6 Postscript to Chapter 7

Multiple regression methods were used to analyse the quality-of-life data reported in this chapter. This allowed the exploration of a number of factors of interest with the quality-of-life outcome variable. In all of the quality-of-life studies using the SF-36 that were reviewed prior to this study, multiple regression and linear regression were the statistical methods of choice in the analyses. In the analysis of the present study distribution of the data was found to be negatively skewed. This raised questions as to the propriety of using statistical methods based on the normal distribution. No explanation is given in the SF-36 quality-of-life literature for using multiple and linear regression. No statistical model should be routinely used without checking that it does indeed provide a reasonable description of the available data. A number of attempts were made to transform the data of this study without success, and the histograms produced in these transformation attempts were no closer to the characteristic shape of the normal distribution than those of the original data. Instead, it was considered that non-parametric ordinal regression could be used to analyse the data as a check on the results obtained from the multiple regressions. This was considered a responsible checking procedure even though the creation of ordinal categories from the distribution of each quality-of-life dimension was a fairly arbitrary process and would mean a loss of information and a reduction in the level of measurement.

Ordinal regression is a method for fitting a statistical model to data in which the response variable is ordinal, that is, the response is categorical but the categories are ordered, for instance, "poor", "good", "excellent"; which may, for example, be the reply to a question about health status.

The categories of chronic disease used in the first set of analyses of this chapter were used for the ordinal regression. The Stata Statistical Package (Stata Corp., 1977) was used to compute the probabilities of people within a particular disease category falling above or below the cut points for each health scale.

For seven of the eight quality-of-life scales it was possible to create five ordinal categories (cut points). For these scales the cut points were set at the 20th, 40th, 60th and 80th percentile. The exception to this was the role emotional scale where the observations were clustered at four points along the scale from 0 to 100. This contrasted with the general health scale where the observations were distributed over

39 points on the scale. For the role emotional scale the cut points were set at the 25th, 50th and 75th percentile.

The results of the ordinal regression analysis are shown in Table 7.8 and produce results similar to the multiple regression analyses reported earlier. It can be seen from Table 7.8 that the proportion of people who fall above or below the cut off points varies by disease condition and scale. By way of example, using the proportion of each disease category falling above the cut point 5 for the physical functioning dimension scale in Table 7.8, it can be seen that the relative order of disease categories starting with highest quality-of-life is: moderate hearing impairment, no chronic conditions, mild hearing impairment, severe impairment, asthma and diabetes. This is exactly the same relative ordering that was produced for the physical functioning dimension by the multiple regression methods and is shown in Table 7.3. The relative ordering of the disease categories for each of the other scales in the ordinal regressions of Table 7.8 is almost the same as that shown by the relative ordering created by the mean scores for the other dimensions shown in Table 7.3. There are slight changes of order for body pain, social functioning and vitality, but the overall relative ordering of the disease categories for all of the dimensions leads to the conclusion that similar results are achieved by both the multiple and ordinal regression analyses, leading to the further conclusion that multiple regression methods are fairly robust when used to compare the quality-of-life dimensions where the distributions deviate from normal.

Table 7.8: Ordinal regression analysis of the health conditions for each health scale showing the proportions of each condition falling above each cut point

Cut point	No chronic conditions	Mild. hearing impairment	Moderate hearing impairment	Severe hearing impairment	Asthma	Diabetes
Physical Functioning Scale						
1	0.004	0.004	0.003	0.004	0.008	0.011
2	0.008	0.010	0.007	0.011	0.019	0.027
3	0.041	0.047	0.037	0.054	0.087	0.115
4	0.174	0.191	0.159	0.210	0.287	0.330
5	0.772	0.746	0.792	0.719	0.597	0.516
Role Physical Scale						
1	0.067	0.064	0.085	0.125	0.105	0.132
2	0.044	0.043	0.055	0.074	0.065	0.078
3	0.023	0.022	0.027	0.036	0.032	0.037
4	0.034	0.032	0.039	0.050	0.046	0.052
5	0.831	0.838	0.793	0.714	0.751	0.701
Bodily Pain Scale						
1	0.114	0.118	0.103	0.115	0.142	0.210
2	0.111	0.114	0.103	0.112	0.129	0.165
3	0.132	0.135	0.126	0.133	0.145	0.160
4	0.185	0.186	0.183	0.185	0.187	0.176
5	0.457	0.446	0.486	0.454	0.397	0.290
General Health Scale						
1	0.066	0.067	0.055	0.069	0.154	0.428
2	0.085	0.086	0.073	0.088	0.161	0.225
3	0.255	0.258	0.234	0.261	0.324	0.225
4	0.251	0.251	0.252	0.250	0.193	0.073
5	0.343	0.338	0.386	0.333	0.167	0.046
Vitality Scale						
1	0.267	0.210	0.198	0.273	0.307	0.591
2	0.225	0.205	0.199	0.227	0.234	0.203
3	0.179	0.184	0.184	0.178	0.172	0.097
4	0.205	0.240	0.247	0.202	0.183	0.075
5	0.123	0.161	0.172	0.120	0.103	0.034
Social Function Scale						
1	0.166	0.229	0.102	0.249	0.252	0.481
2	0.084	0.103	0.058	0.108	0.108	0.127
3	0.105	0.119	0.079	0.122	0.122	0.111
4	0.107	0.110	0.089	0.110	0.110	0.080
5	0.538	0.439	0.670	0.411	0.407	0.200
Role Emotional Scale						
1	0.143	0.088	0.141	0.178	0.248	0.490
2	0.089	0.061	0.087	0.103	0.125	0.145
3	0.079	0.058	0.078	0.088	0.097	0.087
4	0.689	0.792	0.693	0.631	0.529	0.277
Mental Health Scale						
1	0.363	0.296	0.199	0.349	0.450	0.429
2	0.218	0.209	0.177	0.217	0.216	0.217
3	0.167	0.180	0.187	0.169	0.144	0.150
4	0.172	0.207	0.270	0.179	0.133	0.142
5	0.080	0.106	0.167	0.085	0.057	0.062

8. CONCLUSIONS & RECOMMENDATIONS

OVERVIEW

This chapter discusses the implications of the thesis findings in dealing with hearing impairment, disability and handicap as a public health issue in Australia. The discussion is concerned with organisational and administrative needs. Specific issues and recommendations regarding various aspects of hearing morbidity have already been discussed in the respective chapters.

This thesis has provided an epidemiological perspective of the prevalence of hearing impairment and the quality-of life (handicap) of people who are hearing impaired in an adult Australian population. In addition, it has examined the accuracy of previous self-reported disability surveys providing prevalence estimates of impairment. Many conclusions have already been drawn from the data in the preceding chapters and will not be reiterated at length here. Where previous material is used again it will be to draw other conclusions that relate to macro-issues of dealing with hearing impairment, disability and handicap in the Australian context.

It has already been discussed that self-report studies provide inaccurate overall prevalence estimates and inaccurate estimates for different sub-group categories of severity. This study is the first Australian population study to provide estimates of hearing impairment that are based on valid audiological threshold measures and is, therefore, the first representative study that can be used with confidence for public health planning. On this basis (as stated at the outset) the primary objectives of the study were to deal with the prevalence and impact of the problem in a relative sense that would allow us to identify whether or not hearing impairment is a health problem that deserves a higher public health profile.

We have already seen that severe hearing impairment has an impact on the physical health scale that is similar to that of asthma, a health problem that is well established as causing periodic physical trauma (Bauman et al, 1991). In addition, the pessimistic loss group, which comprised entirely of the mild and moderately hearing impaired, also had an impact on the summary physical health scale comparable to the chronic disease group in the second set of quality-of-life analyses. Although the type of physical impact is different for hearing impairment this study has shown that the scale of quality-of-life impact is similar to asthma. From a number of viewpoints asthma enjoys a relatively higher public health priority than hearing impairment and this may, in part, have a lot to do with the age group who are most affected by asthma, the visibility of the condition and the fact that it sometimes results in death. However, it is also due to the fact that in terms of its public health profile asthma is in a much better developmental position than hearing impairment. It has a well established foundation, action plans for sufferers (National Asthma Campaign, 1993), evaluated guidelines for general practice (Farmer et al, 1995), health promotion programs (Foundation South Australia, 1994) and has featured as one of the original health goals and targets for Australia (Nutbeam, 1993). Diabetes seems to enjoy a similar high public health profile. It affects mainly the same

age group as does hearing impairment and is clearly identified as a national and South Australian state health goal (Australian Institute of Health and Welfare, 1996; South Australian Health Commission, 1996(a)). In making these comparisons with the public health profile of asthma and diabetes, the aim is not to insist on parity with these issues from a public health viewpoint, but to learn lessons from these chronic diseases that may be applied to hearing impairment. The comparison is also made to point out that hearing impairment requires a blueprint for the future incorporating strategic directions that are based on a clear epidemiological statement of the problem.

Development of an Australian blueprint is, however, frustrated by current funding priorities. By way of example, in South Australia in 1995/96 hearing was allocated a grant of $60,000 for public education and rehabilitation services (South Australian Health Commission, 1996(b)). This equates to 60 cents for each of the estimated 100,000 hearing impaired people in the state who have at least a moderate hearing difficulty at ≥45dBHTL averaged across the frequencies 0.5, 1, 2, 4kHz. No other funding is provided on an annual basis in this state for population research, guideline development, medical training, health promotion, prevention, or other research. Although, as we shall see, other funds are allocated for clinical hearing services and engineering research via the Federal Government, the low funding for the services mentioned above is some measure of the current level of the public health importance of hearing impairment. In Australia lack of funding for the public health dimensions of hearing impairment means that, until this study, there has been no clear epidemiological perspective of hearing impairment and associated handicap; or even substantial qualitative information about educational and rehabilitation needs. It is also difficult to see how the resources allocated to existing clinical and engineering services can be justified, or priorities, targets, or forward plans developed, without population data or some other monitoring process. The questions to be asked, and answered to some extent, are: does hearing deserve a higher importance than it currently enjoys, and if so, what needs to be done to increase its profile?

The paucity of resources for public health planning and related activities mentioned above are only part of the financial hearing story. From another perspective there are already considerable resources available for hearing . There are extensive clinical services in both the private and public sector which deal with the assessment of hearing and prescribing of required aids. Private practice audiologists and hearing aid companies dominate the private sector. The main aim and function of these is to diagnose and prescribe on a fee for service basis. Fee for service determines who will

be dealt with in the private sector and this could mean that many who cannot find the money will forego a service perhaps at a critical time. This may apply to some of the 50-60 year old priority group where early detection, education and rehabilitation was identified as an important target. A subsidised service is not provided in the public sector unless the individual is in receipt of a pension and for many this will not occur until they are 65 years of age and have gone beyond the priority age group identified by Davis for early action (Davis, 1997). Subsidised services in Australia are provided by Australian Hearing Services (AHS) who also conduct scientific and engineering research and development, but do not conduct population, epidemiological or prevention studies. In 1995/96 the Australian budget for services and research provided for AHS throughout Australia was $106 million (Australian Hearing Services, 1996). This is also an indication that hearing is considered a health priority from the Australian Federal Governments viewpoint, but only for clinical services in the form of diagnosis and aid fitting, rehabilitation related to aid fitting, noise consultancy services to government and industry, and engineering research.

One of AHS's recent reports stated that "effective habilitation or rehabilitation of hearing-impaired people must be based on knowledge of auditory function, including how normally hearing and hearing impaired people can make use of different types of auditory information." (Australian Hearing Services, 1996). While this statement is true it encapsulates the scientific/engineering focus of AHS and the statement, and goals of the organisation, tends to ignore the many other factors involved in habilitation or rehabilitation. It was identified in Chapter 5 that only a third of people who would potentially benefit from a hearing aid were in possession of one. This problem requires further epidemiological explanation, however epidemiological explanation and targeting of impaired groups goes beyond the scientific explanations of auditory function conducted so expertly by AHS. · In addition, we know little about the detail of the handicaps identified in relation to quality-of-life in this study; the explanations for impaired physical health scores, or the nature and effects of pessimism on quality-of-life outcomes. These other aspects of the problem either require independent funding or, at least, should be considered as opportunity cost investments for existing expenditure. A blueprint for the future should also consider the need for a comprehensive approach to hearing in which the epidemiological, rehabilitation, educational and preventive aspects of the problem are considered together with the clinical and scientific issues. As questions increase regarding the value and allocation of health resources there is more pressure on professionals to set health goals and targets that are based on best practice and/or are evidence based. Further, there is the continuing need to evaluate the outcome

of health investment so that best practice is continually upgraded. From the findings of this study it would appear that there is an need to debate the current allocation of resources for hearing impairment and its sequelae and to consider appropriate health goals and targets for the hearing impaired.

Many of the previous Australian studies pointed to a low prevalence rate (Australian Bureau of Statistics, 1978, 1984, 1990(b)) and this can be offered as some explanation why the public health aspects of hearing impairment are not regarded with more importance in this country. It is also evident from the review of the literature in Chapter 2 that, in the Australian context, there have been few questions about the validity of the estimates provided for hearing impairment, disability and handicap. As reported in Chapter 2 they were based entirely on self-reported disability and grossly underestimated prevalence. These estimates must have helped maintain the complacency about the effects of hearing impairment on the Australian population. This study has shown the value of self-report as a prevalence measure and it is recommended that such studies are not funded in future. Future research should be based on audiological validation and there should be a planned epidemiological approach to population research based on the model developing at the Medical Research Council's Institute of Hearing Research in Nottingham. The advanced status of MRC's research also provides the opportunity for cooperative studies where Australia can benefit from the planning and methodological experience of that organisation. The support provided by MRC to this study has already demonstrated the value of such a relationship. When public resources are used to purchase health services it is essential that the process is monitored to assess the value of the purchase for the good of the community. Epidemiology, as a primary science of public health, can provide validated data which guide decisions on health investment. To continue to make investments without such input, even in relation to existing resource allocation is, similar to building a ship without a navigation system.

Davis (1997) points out that for Britain, given the current demographic trends of the population, the number of hearing impaired will increase by 20%, without any increase in the current prevalence rate; this carries the implication of an increasing health burden. It is likely that demographic trends in Australia will be similar to the United Kingdom over the next two decades (The Ageing Project, 1986) and we need to consider now the infrastructure available for dealing with the problem. To achieve this the following summary recommendations are made. These are considered additional to the conclusions drawn and targets discussed in the discussion section of each chapter.

- An administrative framework be established to consider and develop a system wide (holistic) approach to setting health goals and targets for hearing impairment, disability and handicap for Australia.

- That a major part of the goals and targets process deal with previously under-developed issues, priority groups, prevention, education, guidelines for health professionals, and research.

- That resources be allocated to underpin the health goals and targets process.

- That future hearing services be evidence based and demonstrate best practice.

- That guidelines on hearing impairment, disability and handicap be developed for health professionals.

- That the Australian relationship with international organisations at the forefront of hearing research be strengthened.

In justification of these recommendations it should be stated that current, best practice, approaches to public health problems adopts a goals and targets framework. Goals and Targets provides a useful framework by emphasising an outcome orientation. However, in themselves goals and targets are not adequate for priority setting without a focus on interventions and assessment of comparative costs and benefits. For the analyses centred in this thesis it would seem apparent that here is considerable scope for health gain as indicated by quality-of-life measures. It would also seem apparent from the data analyses and subsequent discussions that new strategies can be pilot tested to assess potential gain in health outcomes for the hearing impaired.

The value of epidemiological methods in assessing health status and health interventions should also be apparent from this thesis. Epidemiological studies are, however, expensive and often have a long lead time. Some institutions overseas are already well advanced with epidemiological approaches to hearing impairment and this presents considerable opportunity for collaboration. Much more is likely to be gained

from collaborative and comparative studies than from stand alone Australian research. The similarity of the British and Australian hearing problem found in this thesis also strengthens the argument for collaboration and quicker progress.

Acknowledgment

This thesis is incomplete without some reference to the people who took part in the study. There are many stories to be told that paint a qualitative picture of hearing impairment as a fundamentally important issue to those involved, such as the case of the 93 year old lady with severe impairment, who was almost lost to the study because she had great difficulty hearing with the phone equipment she owned. The study team came across a number of cases of other profoundly deaf people who were not benefiting from available technology and relied on hearing aids to hear an incoming call then to understand what was being said to them. There were many people who responded extremely positively to the opportunity to be part of a population study of hearing, often at great inconvenience to themselves. This was true of the elderly man with advanced diabetic complications who had great difficulty walking because of his circulatory problems, but insisted that the study was too important for him to miss out on his audiology appointment. The same is true of the man on his death bed who, having already returned his questionnaire, insisted his daughter phone the study team to say that he would not be able to keep his audiological appointment. There were also the stories of people with hearing difficulties who had withdrawn from many activities and refused to take part initially, but who the study team were able to persuade to accept a home visit. The study team also came across people who clearly would have benefited from a hearing aid, but had never considered the possibility. From many there was the request for further information that dealt with other aspects of the problem or other sources of appropriate help. In a number of cases the audiologist was able to make appropriate referrals and provide critical information to an impaired person's general practitioner. Some people were identified in the study with significant pathology that may not have been discovered had the study not taken place. From this qualitative point of view, in a sample of just under 1000 people, hearing impairment is also an important issue and deserves more appropriate consideration as a public health problem. The data provided in this report provides a basis for planning the way forward and in establishing appropriate diagnostic, treatment and rehabilitation services, and research programs, on the basis of which we can target resources effectively and assess health outcomes.

Appendix 1

Wilson, D., Xibin, S., Read, P., Walsh, P. and Esterman, A. (1992) Hearing loss: an underestimated public health problem.
Australian Journal of Public Health, 1992, vol 16 (3), pp. 282-286

Appendix 2

Checklists for statisticians

The statisticians who review BMJ papers complete one of two checklists: one is for general papers and the other, which is more detailed, is for papers on clinical trials. These checklists may be sent to the authors.

CHECKLIST FOR STATISTICAL REVIEW OF GENERAL PAPERS

Design features

1 Was the objective of the study sufficiently described?
2 Was an appropriate study design used to achieve the objective?
3 Was there a satisfactory statement given of source of subjects?
4 Was a pre-study calculation of required sample size reported?

Conduct of study

5 Was a satisfactory response rate achieved?

Analysis and presentation

6 Was there a statement adequately describing or referencing all statistical procedures used?
7 Were the statistical analyses used appropriate?
8 Was the presentation of statistical material satisfactory?
9 Were the confidence intervals given for the main results?
10 Was the conclusion drawn from the statistical analysis justified?

Recommendation on paper

11 Is the paper of acceptable statistical standard for publication?
12 If "No" to question 10, could it become acceptable with suitable revision?

CHECKLIST FOR STATISTICAL REVIEW OF PAPERS ON CLINICAL TRIALS

Design features

1 Was the objective of the trial sufficiently described?
2 Was a satisfactory statement given of diagnostic criteria for entry to the trial?
3 Was there a satisfactory statement given of source of subjects?
4 Were concurrent controls used (as opposed to historical controls)?
5 Were the treatments well defined?
6 Was random allocation to treatment used?
7 Was the method of randomisation described?
8 Was there an acceptably short delay from allocation to start of treatment?
9 Was the potential degree of blindness used?
10 Was there a satisfactory statement of criteria for outcome measures?
11 Were the outcome measures appropriate?
12 Was a pre-study calculation of required sample size reported?
13 Was the duration of post-treatment follow up stated?

Conduct of trial

14 Were the treatment and control groups comparable in relevant measures?
15 Were a high proportion of the subjects followed up?
16 Did a high proportion of subjects comple treatment?
17 Were the subjects who dropped out from the trea ment and control groups described adequately?
18 Were side effects of treatment reported?

Analysis and presentation

19 Was there a statement adequately describing referencing all statistical procedures used?
20 Were the statistical analyses used appropriate?
21 Were prognostic factors adequately considered?
22 Was the presentation of statistical materi satisfactory?
23 Were confidence intervals given for the mai results?
24 Was the conclusion drawn from the statistic analysis justified?

Recommendation on paper

25 Is the paper of acceptable statistical standard fc publication?
26 If "No" to question 25, could it become acceptabl with suitable revision?

Appendix 3

THE SOUTH AUSTRALIAN HEARING STUDY

A Study Designed to Improve the Hearing Health of all Australians

PLEASE COMPLETE AND RETURN THIS QUESTIONNAIRE IN THE FREEPOST ENVELOPE ENCLOSED .

Instructions

This questionnaire has been designed for you to complete on your own and in your own time. Below are a few helpful suggestions which will help you complete it successfully.

1. Read each question carefully because the instructions may be different from the previous question. For example, it could ask you to tick only one box. On the other hand it may ask you to tick any boxes, which means you can choose as many as you like.

2. Depending on the choice of answer you give you may be asked to jump a few questions. For example, it may say " Go to Q23."

3. At the end of the questionnaire you will find questions with five point scales and you are asked to circle the point where you think you belong on that question. For example

Strongly disagree	(1)	2	3	4	5	Strongly agree

If you circle 1 it means you strongly disagree with the statement.
If you circle 5 it means you strongly agreee.
If you circle 3 it means you neither agree nor disagree.

If you cannot answer any question please leave it blank.

THANK YOU FOR BEING PART OF THIS IMPORTANT STUDY.

HEALTH CARE UTILISATION QUESTIONS AND SICK DAY QUESTIONS

The following questions are about your use of health services

1 *Have you been admitted to a hospital in the last twelve months ?*

	tick one
Yes	[ ]
No	[ ] go to Q4

2 *Not counting any times you just went to outpatients, clinic or casualty, how many times have you been admitted to hospital in the last twelve months ?*

Number of times.....

None	[ ]

3 *Concerning your most recent stay in hospital, how many nights did you stay in hospital ?*

	tick
None	[ ]

Number of nights.....

4 *How many times have you visited casualty or the outpatients clinic at a hospital about your own health in the last two weeks?*

	tick
None	[ ]

Number of times.....

5 *How many times in the last twelve months?*

	tick
None	[ ]

Number of times.....

6 *How many times have you visited a general practitioner for a health problem in the last six months?*

	tick
None	[ ]

Number of times.....

7 *How many times in the last twelve months?*

	tick
None	[ ]

Number of times.....

8 *In the last two months have you stayed away from your job/school/place of study for more than half a day because of any illness or injury?*

	tick one	
Yes	[ ]	
No	[ ]	go to Q10
Don't work/retired	[ ]	go to Q11

9 *How many days in the last two months have you stayed away from your work/school/place of study, because of any illness or injury?*

	tick
None	[ ]

Number of days.....

10 *How many days in the last two weeks have you stayed away from your work/school/place of study, because of illness or injury?*

	tick
None	[ ]

Number of days.....

HEALTH SERVICE QUESTIONS

11 *How frequently have the following health professionals visited you in your own home over the last twelve months?*

	DOM CARE	DISTRICT NURSE	OTHER SERVICE
1) once a week	[ ]	[ ]	[ ]
2) twice a week	[ ]	[ ]	[ ]
3) more than twice a week	[ ]	[ ]	[ ]
4) once a fortnight	[ ]	[ ]	[ ]
5) once a month	[ ]	[ ]	[ ]
6) other	[ ]	[ ]	[ ]
7) NONE	[ ]	[ ]	[ ]

12 *If other, please state how frequently*.....

13 *In your opinion, do you suffer from any hearing loss?*

	tick one	
Yes	[ ]	
No	[ ]	go to Q28

14 *In the last twelve months have you seen any of the following about your hearing problem? Place a tick in the appropriate boxes.*

	tick any boxes
a) AUDIOLOGIST (AHS, NAL, HOSPITAL, PRIVATE)	[ ]
b) GENERAL PRACTITIONER	[ ]
c) EAR NOSE and THROAT (ENT) SPECIALIST	[ ]
d) HEARING AID COMPANY	[ ]
e) BETTER HEARING AUSTRALIA	[ ]
f) PHARMACIST	[ ]
g) OTHER	[ ]
h) CAN'T REMEMBER	[ ]
i) NONE	[ ]

15 *What do you consider to be the **MOST SERIOUS DIFFICULTY** you have had that you thought was related to your hearing problem? Please place a tick in the appropriate box (**one box only**).*

	tick one
1) AFFECTED MY STUDY LIFE	[ ]
2) AFFECTED MY WORKING LIFE	[ ]
3) AFFECTED MY SOCIAL LIFE	[ ]
4) AFFECTED MY FAMILY LIFE	[ ]
5) AFFECTED MY RECREATIONAL LIFE	[ ]
6) MADE ME DEPRESSED	[ ]
7) CREATED PHYSICAL PAIN & SUFFERING	[ ]
8) Other (specify).....	[ ]
9) NONE (go to Q17)	[ ]

16 *Which, if any, of the following health care professionals did you contact in regard to the most serious problem mentioned in the previous question.* ***Tick one box only?***

	tick one
1) AUDIOLOGIST (AHS, NAL, HOSPITAL, PRIVATE)	[ ]
2) GENERAL PRACTITIONER	[ ]
3) EAR NOSE and THROAT SPECIALIST	[ ]
4) HEARING AID COMPANY	[ ]
5) BETTER HEARING AUSTRALIA	[ ]
6) PHARMACIST	[ ]
7) CAN'T REMEMBER	[ ]
8) OTHER (specify).....	
9) NONE	[ ]

HEARING AID USE

17 *Have you ever been prescribed a hearing aid?*

YES [ ]

NO [ ]

18 *Have you ever had a hearing aid?*

YES [ ]

NO (go to Q28) [ ]

19 *How long have you had a hearing aid (If you have more than one aid give longest time)?*

YEARS [ ]

MONTHS [ ]

20 *Nowadays, how often do you use your hearing aid?*

	tick one
1) EVERY DAY	[ ]
2) MOST DAYS	[ ]
3) SOME DAYS	[ ]
4) ONLY OCCASIONALLY	[ ]
5) NEVER (go to Q28)	[ ]

21 *On <u>average</u>, how many hours a day do you use your hearing aid ?*

	tick one
1) LESS THAN 2 HOURS A DAY	[ ]
2) 2 BUT LESS THAN 4 HOURS A DAY	[ ]
3) 4 BUT LESS THAN 8 HOURS A DAY	[ ]
4) 8 HOURS A DAY OR LONGER	[ ]
5) DO NOT USE EVERY DAY	[ ]
6) VARIES	[ ]

22 *If you have ever had a hearing aid, how much help do (did) you feel you got from it ?*

	tick one
1) HEARING AID MADE THINGS WORSE	[ ]
2) HEARING AID IS NO USE AT ALL	[ ]
3) HEARING AID IS SOME HELP	[ ]
4) HEARING AID IS A GREAT HELP	[ ]
5) CAN'T SAY	[ ]

23 *In general, how satisfied have you been with your hearing aid ?*

	tick one
1) NOT AT ALL SATISFIED	[ ]
2) NOT VERY SATISFIED	[ ]
3) FAIRLY SATISFIED	[ ]
4) VERY SATISFIED	[ ]
5) DELIGHTED WITH HEARING AID	[ ]

24 *How helpful has your current hearing aid been compared to what you expected <u>before</u> you got it ?*

	tick one
1) MUCH LESS HELPFUL THAN EXPECTED	[ ]
2) A BIT LESS HELPFUL THAN EXPECTED	[ ]
3) ABOUT WHAT I EXPECTED	[ ]
4) A BIT MORE HELPFUL THAN EXPECTED	[ ]
5) MUCH MORE HELPFUL THAN EXPECTED	[ ]

25 *In the following situations how would you rate your hearing aid? PLEASE CIRCLE THE APPROPRIATE WORD*

(a) In person to person conversation with other people around

VERY GOOD / GOOD / AVERAGE / POOR / USELESS

(b) In person to person conversation without other people around

VERY GOOD / GOOD / AVERAGE / POOR / USELESS

(c) In a group of family or friends at home

VERY GOOD / GOOD / AVERAGE / POOR / USELESS

(d) Listening to music

VERY GOOD / GOOD / AVERAGE / POOR / USELESS

(e) Listening to TV or (radio) news

VERY GOOD / GOOD / AVERAGE / POOR / USELESS

(f) With a group of people in noisy conditions

VERY GOOD / GOOD / AVERAGE / POOR / USELESS

26 *Please indicate, by putting a circle around words or expressions, those that describe your feelings NOW about your hearing aid and its use*

(circle as many as you wish):

a	*Difficult to insert*	*k*	*Noisy*
b	*Conspicuous*	*l*	*Difficult to handle*
c	*Helpful*	*m*	*Beneficial in company*
d	*Tiresome*	*n*	*Uncomfortable*
e	*Makes me less tense*	*o*	*Invaluable*
f	*Boosts my confidence*	*p*	*Unnecessary*
g	*Makes me feel stupid*	*q*	*Indispensible*
h	*Easy to use*	*r*	*Regret not obtaining one sooner*
i	*Not very helpful*	*s*	*Other*_____
j	*Visible*		_____

27 *Please try to assess your satisfaction with your hearing aid on the five point scale below. Circling number 1 means you are completely satisfied. Try to assess how satisfied you are overall.*

COMPLETELY SATISFIED	(circle one number only)					TOTALLY DISSATISFIED
	1	2	3	4	5	

TINNITUS

28 *Many people get tinnitus, noise in their head or ears such as ringing, buzzing or whistling. Have you ever had these sorts of noises in your head or ears ?*

	tick one	
Yes	[ ]	
No	[ ]	**Go to Q35**

29 *Do you still get noises in your head or ears ?*

	tick one	
No	[ ]	**Go to Q35**
Some of the time	[ ]	
Most of the time	[ ]	
All of the time	[ ]	

30 *Do these noises usually last for longer than five minutes?*

	tick one
Yes	[ ]
No	[ ]

31 *When do you hear these noises ?*

	tick one
Only after loud sounds (e.g. loud music,shooting, noise at work)	[ ]
Both after loud sounds and at other times	[ ]
Only at other times	[ ]

32 In which ear or side of the head are you affected by these noises ?

	tick one
Equally in both ears or in the middle of the head	[ ]
More on the right	[ ]
More on the left	[ ]

33 *How annoying are these noises when they are at their worst?*

	tick one
Severely annoying	[ ]
Moderately annoying	[ ]
Slightly annoying	[ ]
Not annoying at all	[ ]

34 *When you are awake and it is quiet, how much of the time are the noises in your head or ears present ?*

	tick one
A small part of the time	[ ]
About half of the time	[ ]
Most of the time	[ ]
All of the time	[ ]

NOISE EXPOSURE

35 *Have you ever had a job where you had, at any time, to raise your voice to be heard above the noise of the job ?*

Yes [ ]

No [ ] **Go to Q37**

36 *In the table below please indicate the type of noisy job you worked in and how long you worked there.*

TYPE OF JOB	NO. OF YEARS	NO. OF MONTHS

37 *Were you ever in the armed services (including the reserves)?*

Yes [ ]

No [ ] **Go to Q39**

38 *In the services were you exposed to noise from guns, rifles etc?*

Yes [ ]

No [ ]

39 *Have you ever fired guns or rifles as a sport or hobby ?*

Yes [ ]

No [ ] **Go to Q41**

40 *Nowadays,do you shoot guns or rifles without hearing protection ?*

Yes [ ]

No [ ]

41 *Have you ever been <u>frequently</u> exposed to any other high levels of noise, e.g. hammering of metal, motor sports, powered models, motor mowers, power tools, aircraft noise etc. ?*

Yes [ ]

No [ ]

42 *Nowadays, how often do you attend a live concert with amplified music ?*

	tick one
Never or less than once a month	[ ]
Once or twice a month	[ ]
Once a week	[ ]

43 *Nowadays, how often do you attend a disco or club with amplified music ?*

	tick one
Never or less than once a month	[ ]
Once or twice a month	[ ]
Once a week	[ ]
Twice a week or more	[ ]

<u>MEDICATIONS</u>

44 *Are you regularly taking any tablets or medicines at present ?*

Yes [ ]

No [ ]

45 *What are the medicines for ?*

tick any boxes

a) Sleeping [ ]

b) To keep you calm [ ]

c) Water [ ]

d) Blood pressure [ ]

e) Heart [ ]

f) Depression [ ]

g) Pain Relief [ ]

h) Something else [ ]

(please specify.....)

These questions apply whether you have a hearing problem or not.

For each of the statements below please circle the number which indicates how strongly you agree or disagree *For example, if you normally wear a hearing aid then the questions should be answered as if you are wearing the aid.*

(EXAMPLE)

Strongly disagree 1 2 3 4 5 Strongly agree

46 *I usually have difficulty hearing a conversation in a quiet place with one other person.*

Strongly disagree 1 2 3 4 5 Strongly agree

47 *When someone visits I can usually hear when they ring the doorbell or knock.*

Strongly disagree 1 2 3 4 5 Strongly agree

48 *At social gatherings I sometimes find it hard to follow conversations.*

Strongly disagree 1 2 3 4 5 Strongly agree

49 *I have difficulty hearing radio announcers.*

Strongly disagree 1 2 3 4 5 Strongly agree

50 *I mix less with friends, relatives and neighbours than I would like because of hearing problems.*

Strongly disagree 1 2 3 4 5 Strongly agree

51 *I have difficulty hearing during conversation in a car.*

Strongly disagree 1 2 3 4 5 Strongly agree

52 *I generally have difficulty hearing what people say on TV programs.*

Strongly disagree 1 2 3 4 5 Strongly agree

53 *Sometimes it is difficult for me to follow a conversation when others are talking near me.*

Strongly disagree 1 2 3 4 5 Strongly agree

54 *I can hear someone come into the room when my back is to the door.*

Strongly disagree 1 2 3 4 5 Strongly agree

55 *I often cannot unravel the words being said even though I can hear someone speaking.*

Strongly disagree 1 2 3 4 5 Strongly agree

56 *I often feel left out in a group because of difficulty hearing.*

Strongly disagree 1 2 3 4 5 Strongly agree

57 *If someone talks to me while I'm watching TV, I sometimes have trouble hearing them.*

Strongly disagree 1 2 3 4 5 Strongly agree

58 *I often have difficulty hearing in group conversations.*

Strongly disagree 1 2 3 4 5 Strongly agree

59 *It is easy for me to tell how far away a person is by the sound of their footsteps.*

Strongly disagree 1 2 3 4 5 Strongly agree

60 *I sometimes get annoyed when I have trouble hearing?*

Strongly disagree 1 2 3 4 5 Strongly agree

61 *I avoid groups of people because of difficulty hearing in these situations.*

Strongly disagree 1 2 3 4 5 Strongly agree

62 *It is difficult for me to hear a conversation in the kitchen when the tap is running.*

Strongly disagree 1 2 3 4 5 Strongly agree

63 *I find it difficult to hear the news on TV.*

Strongly disagree 1 2 3 4 5 Strongly agree

64 *Sometimes I feel left out when I can't follow the conversation of those I'm with.*

Strongly disagree	1	2	3	4	5	Strongly agree

65 *I often have trouble hearing the phone ring.*

Strongly disagree	1	2	3	4	5	Strongly agree

66 *I often think that people mumble.*

Strongly disagree	1	2	3	4	5	Strongly agree

67 *I know where people are when they speak behind me.*

Strongly disagree	1	2	3	4	5	Strongly agree

68 *Please give your age in years.*

.....years

69 *Please record your gender.*

male [ ]

female [ ]

70 *Please provide your postcode.*

.....

FOR WOMEN ONLY

71 *Have you ever taken the contraceptive pill for longer than three months ?*

Yes [ ]

No [ ]

72 *Are you on, or have you ever, taken hormone replacement therapies?*

Currently taking them [ ]

No longer taking them [ ]

Never taken them [ ]

73 *For how long have you taken or did you take hormone replacement therapy?*

YEARS..... MONTHS.....

DON'T KNOW [ ]

The South Australian Hearing Study Team would like to express their appreciation for the time and trouble you have taken in completing this questionnaire.

Appendix 4

Dear

I am writing to thank you for agreeing to take part in the South Australian Hearing Study. You may remember giving your support for this when you were interviewed during the recent health survey.

The South Australian Hearing Study is the first of its kind in Australia and aims to measure hearing levels and hearing problems among Australians. In turn this will help to improve the way in which hearing levels are preserved and difficulties are managed.

Your contribution to the research program is very important even if you have no hearing problems, because you are part of a random sample of South Australians. The study will involve a short hearing measure by a study team audiologist at a centre near to where you live or work and at a time convenient to you. You will be paid $20 to cover out of pocket expenses.

A free appointment will be made for you by the audiologist, sometime during the next two months, and at a time and place which is convenient to you. The information we collect will be an expert assessment of your hearing capacity and the results will be given to you and explained by the audiologist.

The first step in the study is to ask you to complete the enclosed questionnaire and return it in the reply paid envelope. Should you have any queries you can contact Ingerid Meagher, the Study Research Officer on either (08) 2266054 or (08) 2673979 or mobile phone 015-976713.

On behalf of the study team, I thank you again for your interest.

Yours sincerely

Ingerid Meagher
Research Officer
South Australian Hearing Study

Appendix 5

AUDIOLOGY HISTORY

CLIENT'S NAME:_____ D.O.B.:[ ][ ][ ]

DATE:_____ ID NO:[ ][ ][ ][ ]

1. Do any of your close family members have a hearing problem? Yes [ ] 1
(Apart from hearing loss associated with old age?) No [ ] 2

2. How long have you had a hearing problem? Years [ ]
Months [ ]
No hearing problems [ ] 99

3. Do you have any previous history of ear problems?

Yes	a)	Ear infection as child	[ ] 1
	b)	Ear infections as an adult	[ ] 2
	c)	Impacted wax	[ ] 3
	d)	A perforated ear drum	[ ] 4
	e)	Ear canal infections	[ ] 5
	f)	Other_____	[ ] 6
No			[ ] 7

4. Do you find loud sounds..... (tick all that apply)

a)	unpleasant	[ ] 1
b)	distressing	[ ] 2
c)	intolerable	[ ] 3
d)	painful	[ ] 4
e)	None of these	[ ] 5

5. Have you ever had any tinnitus? yes [ ] 1
no [ ] 2

6. Do you have tinnitus NOW? yes [ ] 1
no [ ] 2

		yes(1)	no(2)
7. Otoscopic Exam:	a) R TM health appearance	[ ]	[ ]
	b) L TM health appearance	[ ]	[ ]
	c) R Canal occluded	[ ]	[ ]
	d) L Canal occluded	[ ]	[ ]

8. NOTES	yes(1)	no(2)
a) Ear Wax letter given	[ ]	[ ]
b) Consider audio reliable	[ ]	[ ]
c) Likely to have difficulty obtaining follow-up services	[ ]	[ ]

Appendix 6

SOUTH AUSTRALIAN HEARING STUDY

Location:_____ File No: _____

Name:_____ Date of Birth:_____

Address:_____

Main Lifetime Occupation:_____ Sex: M/F

This audiogram shows:

Left Right

[ ] [ ] Normal hearing across all frequencies
[ ] [ ] Sensorineural hearing loss
[ ] [ ] Conductive hearing loss
[ ] [ ] Mixed hearing loss

Overall degree

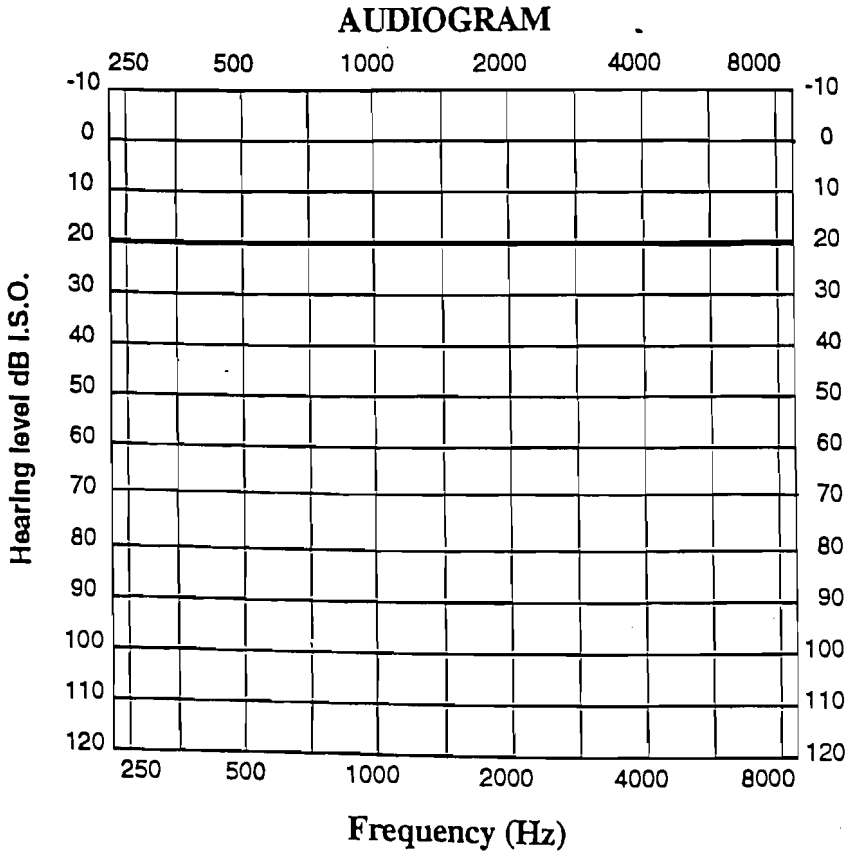
[L] Mild/Moderate/Severe/Profound
[R] Mild/Moderate/Severe/Profound
Unilateral/Bilateral

Left Right

[ ] [ ] Better ear
[ ] [ ] Worse ear
[ ] Symmetrical

Date:___/___/___

Tester:_____



O = R
X = L

<> = Unmasked BC
[ ] = Masked BC
X = Masked Air (L)
● = Masked Air (R)

Recommendations

- ☐ Monitor hearing levels regularly
- ☐ Wear hearing protection
- ☐ Seek further audiological services
- ☐ Consider hearing aid fitting
- ☐ Contact G.P. for ENT investigation
- ☐ Consider hearing support services eg Better Hearing Aust
- ☐ Other_____

Hearing Threshhold Levels

Ear	250	500	1000	2000	3000	4000	6000	8000
Left air								
bone	—				—		—	—
Right air								
bone	—				—		—	—

dB

The South Australian Hearing Study (a National Health & Medical Research Council research project) acknowledges the support of the AUDIOLOGICAL SOCIETY OF AUSTRALIA INC.

Audiologists are University Graduates who have extensive specialist training at Post-graduate level.

Audiologists specialise in the assessment, prevention and non-medical management of hearing impairment and associated disorders of communication.

Appendix 7

APPENDIX

SF-36 QUESTIONNAIRE, AUTHORISED AUSTRALIAN VERSION

Q1 These first questions are about your health now and your current daily activities. Please try to answer every question as accurately as you can.

In general, would you say your health is:

1.....Excellent
2.....Very Good
3.....Good
4.....Fair
5.....Poor

Q2 Compared to one year ago, how would you rate your health in general now? Would you say it is:

1.....Much better then one year ago
2.....Somewhat better than one year ago
3.....About the same as one year ago
4.....Somewhat worse now than one year ago
5.....Much worse now than one year ago

Q3a The following questions are about activities that you might do during a typical day. As I read each item, please tell me if your health now limits you a lot, limits you a little, or does not limit you at all, in these activities.

First, vigorous activities, such as running, lifting heavy objects, participating in strenuous sports. Does your health limit now limit you a lot, limit you a little, or not limit you at all?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3b What about moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf. Does your health limit now limit you a lot, limit you a little, or not limit you at all?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3c And what about lifting or carrying groceries? *(Interviewer: If necessary, ask does your health now limit you a lot a little, or not at all?)*

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3d Climbing several flights of stairs?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3e Climbing one flight of stairs?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3f Bending, kneeling or stooping?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3g Walking more than one kilometre?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3h Walking half a kilometre?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3i Walking 100 metres?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q3j Bathing or dressing yourself?

1.....Yes, limited a lot
2.....Yes, limited a little
3.....No, not limited at all

Q4a The next four questions ask about your physical health and your daily activities. During the past four weeks, have you had to cut down on the amount of time you spent on work or other regular daily activities as a result of your physical health?

1.....Yes
2.....No

Q4b During the past four weeks, have you accomplished less than you would like as a result of your physical health?

1.....Yes
2.....No

Q4c During the past four weeks, were you limited in the kind of work or other activities you do, as a result of your physical health?

1.....Yes
2.....No

Q4d During the past four weeks, have you had any difficulty performing the work or other activities you do, for example, it took extra effort?

1.....Yes
2.....No

Q5a The following three questions ask about your emotions and your daily activities. During the past four weeks, have you cut down the amount of time you spent on work or other regular daily activities as a result of any emotional problems, such as feeling depressed or anxious?

1.....Yes
2.....No

Q5b During the past four weeks, have you accomplished less than you would like as a result of any emotional problems, such as feeling depressed or anxious?

1.....Yes
2.....No

Q5c During the past four weeks, did you not do work or other regular daily activities as carefully as usual as a result of any emotional problems, such as feeling depressed or anxious?

1.....Yes
2.....No

Q6 Again during the past four weeks, to what extent has your physical health or emotional problems interfered with your social activities like visiting friends or relatives?

Would you say: *(Interviewer: read out responses)*

1.....Not at all
2.....Slightly
3.....Moderately
4.....Quite a bit
5.....Extremely

Q7 During the past four weeks, how much did pain interfere with your normal work, including both work outside the home and housework?

Did it interfere: *(Interviewer: read out responses)*

1.....Not at all
2.....Slightly
3.....Moderately
4.....Quite a bit
5.....Extremely

Q8 How much bodily pain have you had during the past four weeks?

Have you had: *(Interviewer: read out responses)*

1.....None
2.....Very mild
3.....Mild
4.....Moderate
5.....Severe
6.....Very severe

Q9a The following questions are about how you feel and how things have been with you in the past four weeks. As I read each statement, please give me the one answer that comes closest to the way you have been feeling.
How much of the time during the past four weeks did you feel full of life? Would you say all of the time, most of the time, a good bit of the time, some of the time, a little of the time or none of the time?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9b And how much of the time during the past four weeks have you been a very nervous person? Would you say all of the time, most of the time, a good bit of the time, some of the time, a little of the time or none of the time?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9c And how much of the time during the past four weeks have you felt so down in the dumps that nothing could cheer you up?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9d How much of the time during the past four weeks have you felt calm and peaceful?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9e And how much of the time during the past four weeks did you have a lot of energy?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9f And how much of the time during the past four weeks have you felt down?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9g How much of the time during the past four weeks did you feel worn out?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9h How much of the time during the past four weeks have you been a happy person?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q9i How much of the time during the past four weeks did you feel tired?

1.....All of the time
2.....Most of the time
3.....A good bit of the time
4.....Some of the time
5.....A little of the time
6.....None of the time

Q10 During the past four weeks, how much of the time has your physical health and emotional problems interfered with your social activities like visiting friends and relatives?

Would you say: *(Interviewer read out)*

1.....All of the time
2.....Most of the time
3.....Some of the time
4.....A little of the time
5.....None of the time

Q11a Now I'm going to read you a list of statements. After each one, please tell me if its definitely true, mostly true, mostly false, or definitely false. If you don't know just tell me. Firstly, "I seem to get sick a little easier than other people". Would you say that's definitely true, mostly true, mostly false, or definitely false, or you don't know?

1.....Definitely true
2.....Mostly true
3.....Don't know
4.....Mostly false
5.....Definitely false

Q11b What about the statement, "I am as healthy as anybody I know". Would you say that's definitely true, mostly true, mostly false, or definitely false, or you don't know?

1.....Definitely true
2.....Mostly true
3.....Don't know
4.....Mostly false
5.....Definitely false

Q11c What about the statement "I expect my health to get worse". Would you say that's definitely true, mostly true, mostly false, or definitely false, or you don't know?

1.....Definitely true
2.....Mostly true
3.....Don't know
4.....Mostly false
5.....Definitely false

Q11d And finally, what about the statement "My health is excellent". Would you say that's definitely true, mostly true, mostly false, or definitely false, or you don't know?

1.....Definitely true
2.....Mostly true
3.....Don't know
4.....Mostly false
5.....Definitely false

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