

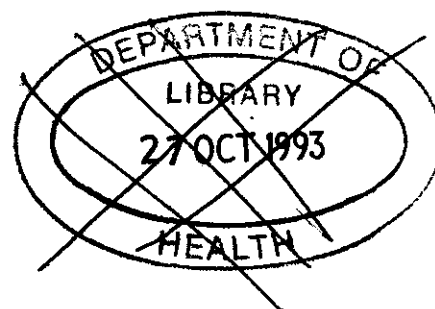
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Eastern Health Board
Directors of Community Care
and
Medical Officers of Health
COMMITTEE ON THE PROVISION OF AUDIOLOGY SERVICES

REPORT



COMMITTEE MEMBERS

Dr A Quinlan, *Chairperson*
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December 1989

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Recommendations

A summary of the major recommendations of the Eastern Health Board's DCC/MOH Committee on Audiology Services is given below:-

1. A 'Developmental Hearing Card' should be evaluated by a pilot study within the Eastern Health Board.
2. An 'At Risk Register' of infants liable to develop hearing loss should be used by PHNs to ensure that this high risk group is closely monitored.
3. All children within the Eastern Health Board should undergo full medical/developmental examination at 7-9 months of age.
4. All children should have their hearing tested by PHNs at 18-20 months with the co-operative/performance tests.
5. All children should have screening audiometry performed by the PHN within 2 years of school entry (5-7 years of age).
6. The committee recommend that the screening programme be evaluated at regular intervals and that the evaluation reflects outcome measurements.
7. Children who fail the initial screening tests should be referred to a designated AMO within each CCA for further assessment. This AMO will have overall responsibility for the provision of audiology services in the area.
8. The designated AMO should undertake further training in audiology.
9. The current one week training course in Audiology for PHNs should be maintained.
10. Staff conducting audiology screening should have their own hearing tested at regular intervals.
11. The committee recommend that a sound proof/attenuated room be made available in each CCA for audiology screening.

CHAPTER 1

INTRODUCTION

The early identification, assessment and management of hearing impairment in infants and young children is of the utmost importance. In the infant the aim is to facilitate the development of normal speech and language. In the older child deafness must be diagnosed and treated in order to avoid learning difficulties. It is thought that many of the social, psychological and economic sequelae of deafness in adulthood can be prevented if the hearing disability is detected and treated in childhood.

Hearing problems in children are relatively common, affecting 2-4% of schoolgoing children. Most have a mild or moderate hearing deficit, but 1:1000 have an average loss of 50dB or greater in their better hearing ear. Screening for hearing loss has been performed in Ireland, as in many other countries, for many years. Such screening is generally carried out as part of the routine developmental examination in the preschool child, and as part of the routine medical examination in the schoolchild.

In the Eastern Health Board area these screening examinations are performed by both Area Medical Officers and Public Health Nurses. Recently, the audiology training course for Public Health Nursing staff was shortened, and concern was voiced as to whether the content of the new truncated course was sufficient to enable them to perform hearing tests adequately.

The Directors of Community Care and Medical Officers of Health of the Eastern Health Board formed a committee to examine the current situation in the Eastern Health Board region with regard to audiology services, and the training needs of staff.

The membership of the committee was as follows:

Dr J Devlin, Trainee/Registrar in Community Medicine, Area 9
Dr M Hynes, Senior Area Medical Officer, Community Care Area 8
Dr M Peyton, Director of Community Care and MOH, Area 3
Dr A Quinlan, Director of Community Care and MOH, Area 5.

The brief of the committee was:

1. To review the current situation with regard to screening for hearing impairment in the Eastern Health Board area.
2. To review the training needs of staff in relation to screening for hearing impairment.
3. To recommend a future policy for the Eastern Health Board as to how a programme for hearing screening should be organised.
4. To make recommendations concerning the training and education requirements of staff in relation to audiology screening.

During the course of this review various other problems in relation to services for the hearing impaired came to light. In particular, the sanctioning of hearing aids for adult deaf patients posed difficulties. The committee considered it appropriate to broaden its terms of reference to include this issue and make recommendations as to how these difficulties should be addressed.

In order to document the current screening activities, a short questionnaire was devised and sent to each of the Superintendent Public Health Nurses. An extensive literature review was also carried out to establish what the screening policies are in other countries, with particular reference to the tests in use, the age at which children are screened, the frequency of screening, and the

management of those found to have a hearing deficit at screening.

The committee would like to express its thanks to Mary Warde (Drop-In Centre, Haddington Road) for the fast and accurate typing of this report, the Superintendent Public Health Nurses who completed and returned the questionnaires, and to Dr Cecily O'Donovan (Senior Medical Officer, National Rehabilitation Board), and Mr Denis (Consultant ENT Surgeon, Our Lady's Hospital, Crumlin) who gave their views.

Special thanks are due to the secretary of the committee, Dr John Devlin.

Ailis Quinlan
Chairman

August 1989

CHAPTER 2

LITERATURE REVIEW

2.1 SCREENING

Hearing impairment between 10 and 50 years of age is rare overall, while at the age extremes it is so common as to be almost normal. Therefore, the elderly and particularly the young are the focus of hearing as a community health problem. This review examines the applied science of identifying and meeting the needs of hearing impairment in childhood.

Hearing problems in children are important because of their potential effect on developing language and communication skills. These can in turn affect the psychosocial and educational progress of the child, so early identification and treatment of hearing loss is essential. Impaired hearing is a relatively common problem in childhood, affecting 2-4% of school age children. Most have mild/moderate hearing loss but approximately 1:1000 have an average loss of 50db or greater in their better-hearing ear. Many children also have intermittent hearing problems of varying severity due to secretory otitis media. This condition is of particular concern in children with other disabilities, for example a pre-existing sensorineural hearing loss, visual impairment, language disorder or mental retardation. Secretory otitis media is the most important cause of conductive hearing loss in children with a point prevalence between 20-30% at the end of the first year, decreasing with age (*Commission of the EC, 1988*.)

In contrast, hearing impairment in adults is usually caused by the progressive sensorineural loss associated with degeneration of the cochlea (*Haggard, 1987*). Approximately 90% of the hearing impaired are over 50 years of age and 35% of the over 50 group have at least a moderate hearing loss in their better ear (*Davis, 1987*).

In hearing impairment, the scope for primary prevention and curative treatment is currently restricted. Instead, early detection and rehabilitation are key elements in the management of hearing impairment and this will require a proactive approach from community health services.

Despite the fact that hearing impairment has long been recognised as an important handicap in children, early identification has not proved easy. Screening programmes can be classified in many ways and this review will group screening according to the age of the child. For practical purposes there are 3 main groups i.e. early infancy (0-6 months), late infancy to early childhood (6 months - 4 years) and early childhood (older than 4 years).

In spite of the many screening programmes in widespread use, results have been disappointing overall. In the EC study of children born in 1969 (*Martin and Moore, 1979*), only 55% of those children with losses of 50db or greater were found to be identified by 3 years of age. In the UK, the mean age of identification of hearing loss was 23.3 months (*Newton, 1985*). Sensitivity of hearing screening can be a problem and in the UK up to 45% of children subsequently found to be hearing impaired have passed an initial screening test and this leads to delay in identification and intervention (*Tell et al, 1977*).

Throughout the EC, most countries have programmes for early detection of hearing disorders (*Commission of the EC, 1988*). There is a concentration on testing in the first year of life and early school years. The tests used are similar but the arrangements vary greatly in respect of standardization and target age. The tests are executed by a variety of personnel: doctors, nurses, health visitors and speech therapists, in different locations including the home. Rarely is the screening evaluated and the Commission consider that the situation is a source of confusion. Further problems identified were inadequate coverage of the population groups, lack of trained personnel and quality control on performance, lack of research on methodology, outcome and project management and poor cooperation between preventive and curative services.

However, in recent years, new methods of screening are being introduced and various methods of amplification have been developed (Bellman, 1987). Following the Saskatoon conference (Gerber and Mencher, 1978) on the early diagnosis of hearing loss, it is now accepted that rehabilitation for hearing impaired infants should start as early as possible, and ideally within the first 6 months of life. This may improve the prognosis for the intelligibility of the child's speech and the recommendations of the conference have led to a search for new and more accurate methods of identifying affected infants. Now that it is possible to identify hearing loss in early infancy, the approach to screening programmes, curative therapy and parent counselling needs to be thought out anew. This report acknowledges recent developments and aims towards a practical, cost effective screening programme utilizing existing resources within the community.

2.2 EARLY INFANCY (0-6 MONTHS)

Neonatal screening could be effective in populations where hospital delivery is the norm and all babies are theoretically available for screening. Attempts have been made to use behavioural tests where the neonate's response to sound is observed. This can include changes in respiratory rate, head turn and body movements. However, responding patterns are variable and arousal-dependent, leading to high false positive rates and some children with mild to moderate hearing impairment pass the screen.

In an attempt to automate (and hence possibly to de-skill) the screening process, various instruments have been designed which eliminate observer error. The first of these was the Crib-O-Gram in the USA followed by the Auditory Response Cradle (ARC) in the UK. The Crib-O-Gram monitors sound response over a long period and can be used in the child's home whereas the ARC requires the baby to be monitored for approximately 20 minutes in a controlled state of arousal. The price of such equipment (£5,000 - £10,000) is not high if facilities are centralised.

The epidemiological characteristics of neonatal screening tests are not favourable when applied to all infants. The specificity of such tests is low if they are applied to all neonates and there is a corresponding high false positive rate. While screening for hearing loss in all neonates may not be justified in view of the low yield, many authors (Editorial, 1986; Bellman, 1987) advocate screening of at risk babies because this provides adequate justification in terms of yield. The proportion of all severely/profoundly deaf neonates who also have disorders of central origin is unknown, but multiple perinatal impairments, cerebral palsy and developmental delay are common in babies of 23-28 weeks gestation. The prevalence of severe/profound deafness is high (approximately 1 in 70) in special care baby units (SCBUs) and to assist identification of at risk neonates, high-risk registers have been used to detect congenital or early-onset hearing loss. Depending on the criteria used between 50-70% of sensorineural hearing loss can be detected in this high risk group. The high-risk register from Great Ormond Street Childrens Hospital (Appendix A) registered 7-9% of live births as high-risk and 1-2% of these were found to have a significant hearing loss - the proportion being highest in those at risk because of perinatal problems. Such a system only works effectively if the information is accurately recorded and if all high risk infants are identified and referred for assessment. Screening with ARC appears to identify the majority of severely impaired neonates and has a low false positive rate (1-2%) in this group.

Further screening tests such as the post-auricular myogenic response and the cochlear echo are under evaluation, and while preliminary results seem promising (Johnsen *et al*, 1983; Bellman, 1987), more detailed research is required. Objective electrophysiological tests (electrocochleography and auditorily evoked brain stem responses) are also available. Specially trained personnel are necessary to operate these sophisticated instruments and as such they are diagnostic rather than screening techniques (Commission of the EC, 1988).

In conclusion, the technology for screening in early infancy has improved greatly over the past 5 years. While early rehabilitation regimes are uncertain in the very young, these techniques will avoid difficulties arising from the mobility of parents because the tests are applied to a captive population when the infant is still in hospital. Such testing will improve the overall sensitivity of screening in the first year of life and undoubtedly reduce the age at which hearing loss is detected.

2.3 Late Infancy - Early Childhood (6 months - 4 years)

Most European countries use hearing screening tests based on behavioural tests that reflect

the child's developmental status. Between 6-18 months, children respond clearly to sound stimuli by turning the head towards the sound source. This localization response is most distinct at 9 months and fades away during the second year of life. The test method based on this response was described by Ewing (Manchester test) and further developed by Sheridan (Stycar test). In Scandinavia, a simplified Boel screening procedure is used but is less sensitive than the Ewing test. After 18 months the child is unlikely to respond to such 'distraction tests' and instead 'co-operative' or 'performance' tests are used. Here the child responds to commands or named out tasks when confronted with frequency - specific sounds (Chadderton, 1987). These co-operative tests require experienced personnel with assessment skills if acceptable sensitivity is to be achieved and consequently, in Europe most screening is performed in late infancy (8-9 months).

Evaluation of Late Infancy Screening

The validity and reliability of the screening test is important and depend on the way basic criteria are met for testing at a young age. In the Netherlands, Baart de la Faille (1986) has noted that the sensitivity of the 3 phase Ewing test is 100% with all children with hearing impairment identified by 2 years of age. However, elsewhere in Europe, the situation is far from satisfactory. In the UK, 75% of children with hearing problems are not detected by the Ewing screening (Haggard and Gannon, 1985). Johnson (1986) observed wide variations in the technique used in screening and at the age at which screening tests are administered. McCormick (1983) has identified that only 36% of districts in England provided training for screening while standardisation of the test was poor and these factors may have contributed to the late average age at which hearing problems were identified (2½ - 3 years). In particular, the health visitors' test technique was poor. Screening results, however, improved with staff training and use of a 'developmental hearing card' that was administered to parents (Appendix B).

Haggard and Gannon (1985) also noted that approximately one third of families failed to attend for their second audiology screening tests. They noted that adverse socioeconomic factors were responsible in part for the poor uptake of services. In comparison with Johnson (1986) and McCormick (1983) there was wide variation in screening techniques and they recommended improved training, provision of feedback to those who undertake screening and targeting of 'at risk' children to improve screening sensitivity. A national study carried out in the UK by Stewart-Brown and Haslum (1987) also found wide variations in screening practice and that few areas collected information that would allow them to make judgements about the efficiency of effectiveness of their screening programmes.

This problem is not confined to the UK and the Commission of the EC (1988) has found that virtually no research has been done throughout Europe on evaluation of the benefits of pre-school screening, determination of what could reasonably be achieved and the best methods of detecting hearing impairment in this age range.

The efficiency of the screening procedure improves when the test is repeated. Approximately one in three children failed the first Ewing (Manchester) test but when the procedure was repeated on two more occasions the fail rate was less than one in ten (Commission of the EC, 1988). Some of the most comprehensive data has emerged from the Netherlands, where a 19.4% false negative rate was found for the three phase Ewing (Manchester) test in sensorineural deafness. A more recent evaluation by Baart de la Faille noted a sensitivity of 95.5% (Commission of the EC, 1988). Screening for conductive deafness has a lower sensitivity of 87.5% and a false negative rate less than 10%. In contrast, the Boel test had a false negative rate of 37% (Hovind and Parving, 1987). In this study, it was found that in 57% of children, family members were the first to suspect the hearing impairment and they recommended the use of an easily understandable hearing developmental pamphlet to strengthen the non-professional screening resources present in the general population. The Boel test has a 63% true positive rate (Barr et al, 1978) which is lower than the Ewing test carried out under good supervision (Commission of the EC, 1988).

When evaluating screening programmes, it is important to consider test validity, but also to assess whether the basic goals of the programme are reached. Baart de la Faille (1986) has shown that most hearing impaired children who have undergone the Ewing test have been referred for specialist assessment before aged 3 years whereas most children who were not screened were referred one and a half years later. In England, very unfavourable early detection results improved with better training and the introduction of an open access hearing assessment centre (McCormick, 1983).

In this age group, there are also electronic screening devices available (eg Body Spek 2000). These are designed to measure and record responses electronically through electrodes fixed to the baby's skin (the post auricular myogenic response). This screening is performed at approximately 6 months. An evaluative survey has indicated that such a unit is not appropriate for use in routine screening tests, but can be very effective in selective testing (Bigglestone, 1986).

In conclusion, screening in late infancy can be sensitive and reliable when preconditions are met concerning: age of testing, test arrangement, strict standardisation, training and guidance. In Europe the tests used are similar but arrangements vary greatly in respect to standardisation and target age (Commission of the EC, 1988). There is relatively little evaluation regarding efficiency and cost effectiveness of screening procedures. However, most authors agree that early detection of hearing loss should be carried out in the first year of life. The success of such early detection programmes will depend to a large extent on the degree of standardisation of the test used and the training and guidance that is available for personnel. The view of the Commission of the EC on the early detection of hearing disorders in childhood (1988) is that special training and refresher courses for personnel performing the screening and regular evaluation of the procedures is necessary if targets are to be met. Co-operation between the preventive and curative sections and full coverage of the population is also essential if hearing loss is to be detected and treated in early childhood. While the Ewing (Manchester) test is the most sensitive, it is important that it is carried out according to strict guidelines. A less favourable screening test in conjunction with open referral to assessment centres may be more effective than a perfect test where resources are not available to adequately perform the test and barriers exist to referral. The ultimate goal is to have both an optimal screening test and a quick assessment for all children who fail.

2.4 School Children

Audiologic screening in school children is routine in many countries and such testing has two target groups. The first is a small group of children with undiagnosed sensorineural hearing impairment and the second is the larger group with middle ear negative pressure or effusion. In general, pure-tone audiometry has been standard procedure, but for many years studies have been conducted to introduce impedance audiometry as part of the screening process.

(i) **Pure tone audiometry** - this involves a sound stimulus presented monaurally through earphones (air conduction) or a bone vibrator (bone conduction), preferably in a sound treated room. Frequencies tested range from 250-8000 Hz in octave steps and hearing levels are measured in decibels (dB) (Fria, 1981). Screening usually commences with an initial 'Sweep Check Test' - an expedient method of identifying possible hearing defects. The child who fails the 'Sweep Check Test' is then given a more precise audiometric test - the Threshold Acuity Test. Both sweep check and threshold acuity tests can be used in primary care settings and in some schools (di Chiara, 1984). Criteria for failure of the sweep test range from a sound level worse than 15dB (Downs, 1978), 20dB (Renvall and Liden 1980; Gimsing and Bergholz 1983; Costa et al, 1988) to 25dB (di Chiara, 1984) and an air-bone gap of 10dB or more at any two frequencies. The frequency is also important, for example Downs (1978) recommends further assessment for children who fail 250-2000 Hz at 15dB and 4000-8000 Hz at 35dB.

Unfortunately just as in preschool screening there is a wide variation in the ages at which children are screened. In the UK, most districts screen at school entry while some screened again a few years later (Stewart-Brown and Haslum, 1987). In Sweden, children are screened at 7, 10 and 13 years (Gimsing and Bergholz, 1983; Costa et al, 1988). Again there is little evaluation of audiometry in schools. Stewart-Brown and Haslum (1987) note that in the UK most areas do not collect the sort of data that would allow them to make even the most rudimentary assessment of their screening programmes, far less any evaluation of cost consequences or benefits. In areas that did attempt evaluation, referral rates ranged from 0.5% to 25%. Costa et al (1988) found that 24% of children failed at least one of their screening tests but most of those who had unilateral hearing loss at age 7 affecting one test frequency passed screening at age 13. Bilateral multifrequency loss had a worse prognosis. Gimsing and Bergholz (1983), screening by audiometry and tympanometry found new cases of sensorineural hearing loss in 0.3% of children and a prevalence of protracted undiagnosed middle ear pathology in 2.5% of younger children and 0.5% in older children. Seven per cent of children failed audiometry, however the sensitivity of the test was low regarding middle ear effusion. The authors attribute this to screening at 20dB because it was practically impossible to screen at intensities lower than this due to background noise at school. This problem has also been noted by Stewart-Brown and Haslum (1987) who found that the vast majority of UK schools had neither a sound proof nor a sound attenuated room available.

In future years, however, reliability of testing may improve as more advanced audiometers (including computer controlled) become widely available for screening purposes (*Jervall et al, 1983*).

(ii) **Assessment of Middle Ear Function** - the resistance a sound encounters at the tympanic membrane is called impedance. High impedance may mean ossicular discontinuity. Tympanometry monitors the change in impedance associated with the variation of an air pressure load on the tympanic membrane. The change in impedance can be plotted and this is the tympanogram. The graph peaks when the air pressure is equal on both sides of the membrane, thus the position of the peak represents the air pressure in the middle ear. The height of the peak denotes the relative impedance of the tympanic membrane and the shape or gradient reflects the responsiveness of the membrane. The test is noninvasive, rapid and can be administered by minimally trained personnel (*Fria, 1981; Wheeler, 1986*).

The stapedius and tensor tympani muscles contract in response to loud noise. Called the acoustic reflex, it increases the impedance at the tympanic membrane. Middle ear disease may prevent detection of the reflex and moderate or severe sensorineural hearing loss may also result in failure to detect the reflex. Tympanometry and the acoustic middle ear reflex can be used in children younger than 5 years of age but are considered in this section as these tests have been advocated for mass screening of school-going children. The criteria for failure in tympanometry vary, but a flat or rounded curve with a definite peak, or a negative pressure at or greater than -150mm H₂O or -200mm H₂O should be accepted as abnormal. For acoustic reflex, a 105dB signal is used in contralateral testing and a 105dB sound pressure level signal or lower in ipsilateral tests. A pure tone between 1000 Hz and 3000 Hz is acceptable as the stimulus (*Downs, 1978*).

Gimsing and Bergholz (1983) have evaluated tympanometry as a screening tool and the results have been disappointing. In younger children only 2.5% were found to have previously undiagnosed pathology while in older children this fell to 0.5%. Their fail criteria included a middle ear pressure more negative than -150mm H₂O which resulted in up to 16% of school entrants failing the test. Many of these resolved and accordingly the authors recommend screening during summer months and using a negative pressure of -250mm H₂O to reduce over-referral. In the UK only 6% of districts screen for middle ear disease with tympanometry (*Stewart-Brown and Haslum, 1987*) although many areas would justify increased testing to identify conductive deafness due to secretory otitis media. *Wheeler's* study (1986), however, suggest that 'glue ear' is not a consequence of acute otitis media and that persistence of middle ear effusion is unlikely to predispose to recurrent otitis media and that in unilateral otitis media abnormalities are often present in both ears. Secretory otitis tends to remit spontaneously and it is questionable whether surgical intervention has any long term benefits on hearing (*Anonymous, 1986*). A recent study by *Zielhuis et al (1989)* has shown that screening and treatment of glue ear in preschool children did not improve language performance, mainly because of the large degree of spontaneous recovery. Thus secretory otitis media fulfils few of the criteria that should be met before a mass tympanometry screening programme can be considered likely to be either effective or ethical.

CHAPTER 3

AUDIOLOGY SERVICES

3.1 SERVICES WITHIN THE EASTERN HEALTH BOARD

The following child health examination services are available for preschool and primary national school children.

- (i) Developmental paediatric examinations for children at 7-9 months of age. In addition, Community Care Areas provide further examinations for 'review cases' as appropriate. At present the developmental examination is mainly confined to towns with populations of 5,000 or more. The services of the local public health nurse are available in rural areas to advise mothers and to assist in making arrangements for medical examinations if such an examination is considered necessary.
- (ii) A medical examination of all new entrants to national schools. Ideally this examination is given towards the end of the child's first year at school.
- (iii) A selective medical examination of children aged 9 years and examination of children at any age who may have given parents, teachers or the public health nurse (PHN) cause for concern on health grounds.
- (iv) Frequent audiometric screening of the school population is carried out by the PHN. A full analysis of this service is detailed in Appendix C.
- (v) The PHN also assesses the child's language and hearing as part of her routine developmental checks. Such checks are performed at 3, 7, 9, 12, 18, 24 and 36 months but many children do not undergo all of these checks and resources tend to be targeted where children have problems.
- (vi) Further audiological assessment may be carried out either in the National Rehabilitation Board (NRB) or by Sister Lydia at Our Lady's School for the Deaf (Cabra). Treatment services for aural defects and ENT out-patient specialist services for all defects discovered at these examinations are provided free of charge.

3.2 AUDIOLOGY SCREENING SURVEY

A questionnaire was administered to each Community Care Area to determine audiology screening practices within each region. The participants often found it difficult to give an overall picture of the situation which may be due to the prevailing infrastructures, the lack of standardisation and/or a central registration system which hindered the collection of data. The details from each Community Care Area (CCA) are summarised in Appendix C.

Preschool Testing

Such testing refers to 'distraction testing' (Manchester/Ewing test) carried out at 6-9 months and this represented a large proportion (22%-62%) of audiometric tests within the areas. However, in only two areas was the test regularly performed by two PHNs working together, a necessary requirement for the test. Also, in only one area was there a sound proofed room available for use in either infant or school screening.

School Screening

All areas undertake routine audiometric screening in schools but there was variation in the frequency of testing. All areas screened at school entry while some repeated screening for national primary school-leavers and whenever concern was expressed by parents, teachers or by medical personnel. There was also variation in the method of audiometric testing with 3 areas screening

at 20dB only while others undertook full diagnostic audiometry.

The percentage of failures at initial testing varied widely throughout the Eastern Health Board. In some centres less than 5% failed the initial test. This figure is probably too low and there may be a high corresponding false negative rate. On the other hand a failure rate in excess of 40% means that the specificity of the test is low and there will be many inappropriate referrals to the curative sector. It is accepted that the failure rate after initial screening should be in the order of 15% (*Commission of the EC, 1988*). Most areas repeated screening of initial failures - a procedure that is accepted practice. Those who failed the second screening tests were referred to a variety of sources, i.e. Area Medical Officers (AMOs), ENT, NRB and Sr Lydia, Cabra. There was variation in the ENT wait-lists in each area and finally PHN training differed throughout the Eastern Health Board with some areas having nurses who performed screening audiometry only. The questionnaire has highlighted the lack of standardization regarding audiological screening within the Eastern Health Board. Many areas were unable to provide the necessary data to complete the questionnaire and this compounded the problems in the evaluation of services within the Eastern Health Board. These problems are addressed in Chapter 5 where recommendations are made regarding the options facing the Eastern Health Board.

CHAPTER 4

ECONOMIC APPRAISAL

4.1 FINANCIAL CONSIDERATIONS

An economic appraisal of the audiology screening programme options is necessary in the planning process. Planning the programme in the formal sense will identify audiology screening as it relates to the organisation of services within the Eastern Health Board and to political and economic realities. In the long run, it is important that the screening programme provide benefits to the health care system. These benefits relate primarily to early identification of hearing loss and a reduction in inappropriate referral to expensive institutional care technology. However, it is unlikely that all of the benefits to the individual from the preventative care aspects of the programme can be quantified.

This appraisal deals with the two main options facing the Eastern health Board and compares these to the current screening service. Both of these options could include use of an 'At Risk Register' (Appendix A) and a 'Developmental Hearing Card' (Appendix B) administered to parents of young infants. The register could be used in hospitals to perform neonatal screening and in Community Care by Public Health Nurses (PHNs) to ensure that this high risk group is closely monitored. The developmental hearing card has been used successfully in other countries and should be evaluated by a pilot study within the Eastern Health Board. To reproduce it on a mass scale and hand it to parents is a relatively inexpensive piece of health care planning and general education. Approximately 20,000 of these cards could be printed per annum within the Eastern Health Board printing section at minimal expense. Although it does not come within the remit of the Community Care programme, the Auditory Response Cradle could be evaluated by a pilot study within the hospital setting and this equipment would cost between £5,000 and £10,000.

The two main options facing the Eastern Health Board are detailed below:

4.2 OPTION 1

Each Community Care Area (CCA) either employing or sharing an audiologist (salary £16,000 p.a.). An audiologist is either a qualified doctor, teacher of the deaf or speech therapist who have five years experience and who have taken a recognised Diploma Course in a University. He/she is qualified to assess infants, children of all ages and adults to fit hearing aids, perform audiometry and advise on language and educational development. In practice this would translate to approximately 6 audiologists with larger areas such as CCA 8 employing one audiologist and smaller areas such as CCA 2 and 3 having shared access. Audiometricians are technicians who have received training in audiometry and related audiologic tests. They are not qualified to test infants, young or handicapped children or advise on hearing aids and language development. Audiometricians could be used to undertake primary audiology screening in schools although this need not necessarily be part of the first option. If it were, each area would require at least 1 audiometrician (salary £12,000 p.a.) but larger areas with an extensive school population might require 2 audiometricians. Employing audiologists at peripheral centres throughout the Eastern Health Board has implications for diagnostic equipment and sound proof or sound attenuated rooms. Premises may have to be modified but it is likely that each CCA has a suitable room available which could be modified at little additional cost. The equipment would constitute a major expense (£14,800) and this is itemised in Table 1.

There is also the problem of a single PHN carrying out Ewing/Manchester screening of infants. This is unacceptable and at least 2 trained observers are required for the test. If 2 PHNs are to carry out the test (either in a health centre or the home), it is estimated that this time expense would translate to an additional whole time equivalent PHN in each CCA. It is recognised that urban areas with a greater population density and larger health centres will be less affected than rural areas. It is estimated that the costs of this option comes to £384,200 p.a. to the Eastern Health Board (Table 2).

TABLE 1

AUDIOLOGY EQUIPMENT (AUDIOLOGIST)

<i>Instrument</i>	<i>Unit Price (£)</i>
1. Clinical Audiometer (Pure tone air and bone conduction, speech and masking capabilities)	2,000
2. Stycar Set	100
3. Impedance Bridge	2,000
4. Hearing Aid Analyzer	4,050
5. Amplifier	200
6. Sound Level meter	1,350
7. Oscilloscope	770
8. Spectrograph	1,980
9. Miscellaneous (e.g. Stock hearing aids, impression materials grinders, etc.)	2,350
GRAND TOTAL	£14,800

TABLE 2
COSTINGS OF OPTION 1

<i>Items</i>	<i>Costs (£)</i>
Audiologist X 6	96,000
Audiologic Equipment X 6	88,200
PHN X 10	200,000
Audiometricians (optional) X 10	(120,000)
GRAND TOTAL	£384,800 (£504,800)*
<i>* includes Audiometricians</i>	

This option will confer benefits in terms of savings to the health care system. This will result from a reduction in inappropriate referrals to the ENT service. At present approximately 5% of children (infants and school children) are referred to the ENT service but there is wide variation throughout the CCAs in the EHB regarding the percentage of children who fail the screening tests. Referral rates after screening ranged from 3% to 18% and this has implications for screening quality. Referrals to ENT should reduce to less than 5% after screening by an audiologist (McCormick, 1983) and there will be a reduction in inappropriate referrals to ENT. It is difficult to quantify these savings but each child is seen twice on average in the ENT out-patients' department at a cost of £7 / OPD visit.

4.3 OPTION 2

The second option involves intermediate assessment by an Area Medical Officer (AMO) after initial audiological screening (Appendix D). A designated AMO within each CCA could undertake further training in audiology and be responsible for supervision and co-ordination of audiology services within the CCA. This would entail a 'day release' course over several months and include theoretical and practical components relating to audiology and ENT. It is estimated that this course will cost £600 per AMO or £6,000 to the entire Eastern Health Board. Such intermediate screening will have an opportunity cost because it is likely that this will take up 20% of the AMO's time (or 1 day a week) and the AMO may have to forego some of his/her other duties. If services are to be maintained at their present level sessional AMOs may be shared/required by some CCAs. This option will also necessitate upgrading the audiologic equipment in each CCA but to a lesser degree than the first option because specialised audiologic diagnostic items will not be needed. The necessary equipment is listed in Table 3 and the cost of this to the Eastern Health Board is £40,000.

The problem of having only one trained observer performing the Manchester test in late infancy would be overcome by extending the AMO 6-9 month child developmental examination to all children. At present the developmental paediatric clinics are mainly confined to towns with populations of 5,000 or more. The Dublin area already provides such a service but this would have implications for rural Counties such as Kildare where at present approximately half the children are ineligible because they come from rural areas. In Kildare, it is estimated however, that the developmental paediatric clinics could be extended to all children if school medical examinations are rationalised. Should school medical examinations be kept at their present level, then it is likely that an extra AMO may have to be employed on a sessional basis. The total cost of this option comes to £87,000 p.a. to the Eastern Health Board and is itemised in Table 4.

This option will also confer benefits in terms of an improvement in screening quality and a savings potential due to a reduction in inappropriate referrals to the ENT service.

TABLE 3

AUDIOLOGY EQUIPMENT (AMO)

<i>Instrument</i>	<i>Unit Price (£)</i>
1. Clinical Audiometer	2,000
2. Stycar Set	100
3. Impedance Bridge	2,000
GRAND TOTAL	£4,100

TABLE 4

COSTINGS OF OPTION 2

<i>Items</i>	<i>Costs (£)</i>
AMO Training	6,000
Audiologic Equipment X 10	41,000
Part Time/Sessional AMO for developmental clinics X 4	40,000
GRAND TOTAL	£87,000

CHAPTER 5

DISCUSSION

The central aims of this report have been to review the current situation regarding screening for hearing impairment in childhood and to make recommendations regarding audiology service within the Eastern Health Board. A strategy must be developed which accounts for the characteristics of the different screening techniques in order to achieve the goals of the programme for early detection of hearing loss. The structure of the health care system within the Eastern Health Board and the realisation that resources are not endless, limit these goals to some extent and a balance should be achieved so that the best screening programme is provided using the available resources.

From the questionnaire, it is clear that there are problems with the existing screening programme: (a) lack of standardization within the Eastern Health Board. This applies to all facets of audiology screening i.e. the examination, interpretation, registration and evaluation (b) there is concern with regard to the level of expertise of those performing the tests (c) lack of evaluation of effectiveness of the existing programmes and (d) the apparent lack of co-ordination between the various services especially between the preventive and curative health care workers.

This report has addressed these problems and has assessed the options facing the Eastern Health Board. It is unclear whether the option of employing audiologists would confer additional benefits to the screening programme and an economic analysis militates against this. Instead, the option of improved AMO training with this designated AMO supervising audiology services within each CCA would appear to be the most cost effective method of audiological screening within the Eastern Health Board. A detailed list of the recommendations is given below.

5.1 SCREENING PROGRAMMES

The ultimate goal is to detect early in the first year of life all sensorineural hearing deficiencies ranging from moderate to severe deafness, as well as longstanding conductive hearing loss in childhood.

(i) **Developmental Hearing Card** - such a card can be administered to parents by the PHN at the initial visit. This card is simple to use and contains a 'hearing checklist' (appendix B) at various childhood ages up to 12 months. The card has been used successfully in other countries and has reduced the age at which hearing loss is first detected. **This card should be evaluated by a pilot study within the Eastern Health Board.**

(ii) **At Risk Register** - this is a register of children with medical conditions where the baby is at particular risk of developing hearing loss. (Appendix A). **This register could be used in hospitals to perform neonatal screening and in Community Care by PHNs to ensure that this high risk group is closely monitored.** While it is not the brief of the committee to discuss neonatal screening, it is obvious that neonatal screening techniques have improved greatly in the past 5 years and it would be desirable that the Auditory Response Cradle (ARC) be evaluated by a pilot study within the hospital setting.

(iii) **Screening Ages** - behavioural testing of the total population in the second half of the first year of life is the most appropriate form of screening in childhood. Sensorineural hearing deficiencies should be detected early in the first year of life and subsequent testing should be possible in order to select the children with longstanding conductive hearing losses. **The committee recommend that all children within the Eastern Health Board have a developmental examination at 7-9 months.** At this age, behavioural screening is currently the most sensitive and specific means of reaching the objective of early detection of hearing loss. This is performed by an AMO and a PHN and would ensure that two trained observers are conducting the 'distraction test' (Manchester/Stycar) according to the 'norms' of the test (Appendix E). A full paediatric

developmental examination would confer additional benefits in terms of increased yield of other medical problems. This examination would also obviate the need for the 7 month PHN developmental check.

All children should have their hearing tested at 18-20 months by PHNs with the co-operative or performance tests (Appendix F). An assessment of language could also be carried out at this stage.

All children should have screening audiometry carried out by the PHN within 2 years of school entry (age 5-7 years). This should be performed at 20dB and across the frequency range 250-4000 Hz. Screening audiometry may also be carried out as part of the selective school medical examination at 9 years of age.

(iv) **Further Testing** - infants who fail the 7-9 month 'distraction test', the 18-20 month performance test, and school children who fail screening audiometry should be retested within one month and if the test remains abnormal be referred to a designated AMO within the Community Care Area who has had further training in audiology. This AMO would act as a resource person and have overall responsibility for the provision of audiology services within the area. It is recognised that at present audiology screening has low specificity (the ability to identify normals) and that this leads to inappropriate referrals to the curative sector where the consultant ENT OPD wait-lists are approaching 1 year. The designated AMO would conduct a further assessment (e.g. diagnostic audiometry, tympanometry) which would improve specificity and reduce the number of inappropriate referrals to ENT (Appendix D). The AMO will have a close liaison with the national centres of audiologic expertise (St Mary's School, Cabra and the NRB) and ensure that a rapid referral of hearing impaired children is made to these centres or the ENT service where appropriate. The AMO will ensure that audiology screening and training is adequately supervised and should conduct an annual evaluation of audiology services within the area.

5.2 EVALUATION AND STANDARDISATION

The questionnaire has highlighted the wide variation in screening practices throughout the Eastern Health Board and the difficulty evaluating the effectiveness of the programme. A systematic and thorough evaluation of the programme is necessary if screening quality is to be assured. This can only be guaranteed if adequate infrastructures and research components are present. The committee recommend a standardized screening protocol with directives for action for those children who fail screening tests. It will also be necessary to conduct a regular evaluation of the programme and data should be collected in such a way as to reflect outcome measures rather than an activity analysis. This proactive approach will facilitate the development of an effective screening programme for the early detection of hearing loss in childhood.

5.3 TRAINING

The designated AMO in each Community Care Area should undertake further training in audiology. This will entail a 'day release' course over several months and include theoretical and practical components relating to audiology and ENT. It is envisaged that training could include

- (a) **Medical Module** - Anatomy and physiology of auditory mechanism and disorders, medical and audiologic diagnostic techniques (otoscopy, distraction and co-operative testing, audiometry and tympanometry) and medical management (e.g. removal of cerumen, pharmacotherapy);
- (b) **Education Module** - speech and language development, consequences of hearing impairment, classroom acoustics and amplification;
- (c) **Aural Rehabilitation Module** - hearing aid evaluation and audiologic counselling.

The course should be arranged with the National Centres of audiologic expertise (NRB and Our Lady's, Cabra) and some practical sessions will be necessary in an ENT out-patients department. In this regard informal contact with some of the above agencies has revealed support for such improved AMO audiology training. When the designated AMO is suitably trained, he/she will act as a resource person within the area and ensure that the quality of audiologic screening is maintained by holding periodic refresher courses for staff and a regular evaluation of audiology screening in the area.

The committee recommend that the current one week training course in audiology for PHNs at Our Lady's School for the Deaf be maintained. Finally those staff involved in audiology screening, should have their hearing tested at regular intervals to maintain the quality of the screening programme.

5.4 *FACILITIES*

It is important that audiologic screening is performed in quiet surroundings. While this may be difficult in the school setting, every effort should be made to ensure that a sound attenuated room is available. The committee also recommends sound proof or sound attenuated rooms for infant testing. The designated AMO who will undertake further testing will require a sound proof room.

5.5 *HEARING AID SANCTION*

The present method of sanctioning hearing aids is cumbersome and leads to delays in children and adults obtaining their aids. There is no need for the DCC/MOH in each CCA to individually sanction each case and this should be dealt with centrally within the Eastern Health Board. The DCC/MOH should be notified however, when a child or adult receives a hearing aid.

In conclusion, the committee recommends a community based audiology service provided by improved training of a designated AMO within each Community Care Area. The AMO would assume responsibility for the provision of audiologic services in the area and provide a link to national centres and ENT where appropriate. The establishment of the audiology service on this geographic basis would also rationalise referral patterns for curative treatment. The extension of the paediatric developmental examination to all children will ensure that two trained observers perform the 'distraction test' and confer additional benefits in terms of increased yield of other medical conditions. The provision of improved audiologic services in each CCA will facilitate consumer access and improve uptake of screening because families will not have to travel far for testing. Out-patient ENT waiting lists will be shortened because of a reduction in inappropriate referrals. It is proposed that such a community based audiology service is the most feasible and cost-effective method of early detection of hearing impairment in early childhood.

APPENDIX A

AT RISK REGISTER FOR HEARING IMPAIRMENT

1. Family history of hearing loss.
2. Congenital infections (e.g. Rubella, cytomegalovirus, syphilis).
3. Anatomical malformations involving the head and neck (e.g. cleft palate, aural atresia, dysmorphic syndromes).
4. Birth weight less than 1500g.
5. Severe neonatal asphyxia.
6. Neonatal hyperbilirubinaemia exceeding 20mg/100ml (less in the preterm).
7. Bacterial meningitis.
8. Ototoxic drug administration (particularly if prolonged).



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APPENDIX B - 'DEVELOPMENTAL HEARING CHECKLIST' ISSUED TO PARENTS BY THE

PUBLIC HEALTH NURSE AT THE PRIMARY VISIT.

HINTS FOR PARENTS

CAN YOUR BABY HEAR YOU?

Here is a checklist of some of the general signs you can look for in your baby's first year:

Tick if
Response
Present

Shortly after birth

Your baby should be startled by a sudden loud noise such as a hand clap or a door slamming and should blink or open his eyes widely to such sounds.

☐

By 1 Month

Your baby should be beginning to notice sudden prolonged sounds like the noise of the vacuum cleaner and he should pause and listen to them when they begin.

☐

By 4 Months

He should quieten or smile to the sound of your voice even when he cannot see you. He may also turn his head or eyes towards you if you come up from behind and speak to him from the side.

☐

By 7 Months

He should turn immediately to your voice across the room or to very quiet noises made on each side if he is not too occupied with other things.

☐

By 9 Months

He should listen attentively to familiar everyday sounds and search for very quiet sounds made out of sight. He should also show pleasure in babbling loudly and tunefully.

☐

By 12 Months

He should show some response to his own name and to other familiar words. He may also respond when you say 'no' and 'bye bye' even when he cannot see any accompanying gesture.

☐

Your Public Health Nurse will perform routine hearing screening tests on your baby during infancy and your child will have a medical examination by the Public Health Doctor between 7 and 9 months. If you suspect that your baby is not hearing normally either because you cannot place a definite tick against the items above or for some other reason, then seek advice from your Public Health Nurse.

APPENDIX C - EASTERN HEALTH BOARD AUDIOLOGIC SCREENING SURVEY

Community Care Area	Audiometric Tests (1988)	Pre School (%)	Pre School Tests by 2 PHN's	Sound Proof Room?	Routine Screening (School)	Selective Screening (School)	Audiometry * Method	Initial Tests Abnormal (%)
1	7223	2516 (35%)	Yes	No	5-7 Yrs	Yes	Diagnostic	282 (6%)
2	1428 (sch)	---	---	No	5-7,12-13	Yes	Both	59 (4%)
3	2265	820 (36%)	No	Yes	6&11 Yrs	Yes	Screening	94 (6.5%)
4	9455	2090 (22%)	No	No	6&11 Yrs	Yes	Both	390 (5.3)
5	579 (sch)	---	---	---	6,9&12 Yr	Yes	Diagnostic	---
6	5599	3458 (62%)	Usually	No	5-6 Yrs	No	Screening	280 (5%)
7	3500	1700 (49%)	No	No	7 Yrs	Yes	Diagnostic	420 (12%)
8	12075 (sch)	---	---	No	6,9&12 Yr	Yes	Both	980 (8%)
9	4275	2200 (51%)	Rarely	No	5-7 Yrs	Yes	Both	934 (45%)
10	4549 (sch)	---	---	No	5-12 Yrs	No	Screening	136 (3%)
Total EHB	41493	12784 (40%)						3575 (12%)

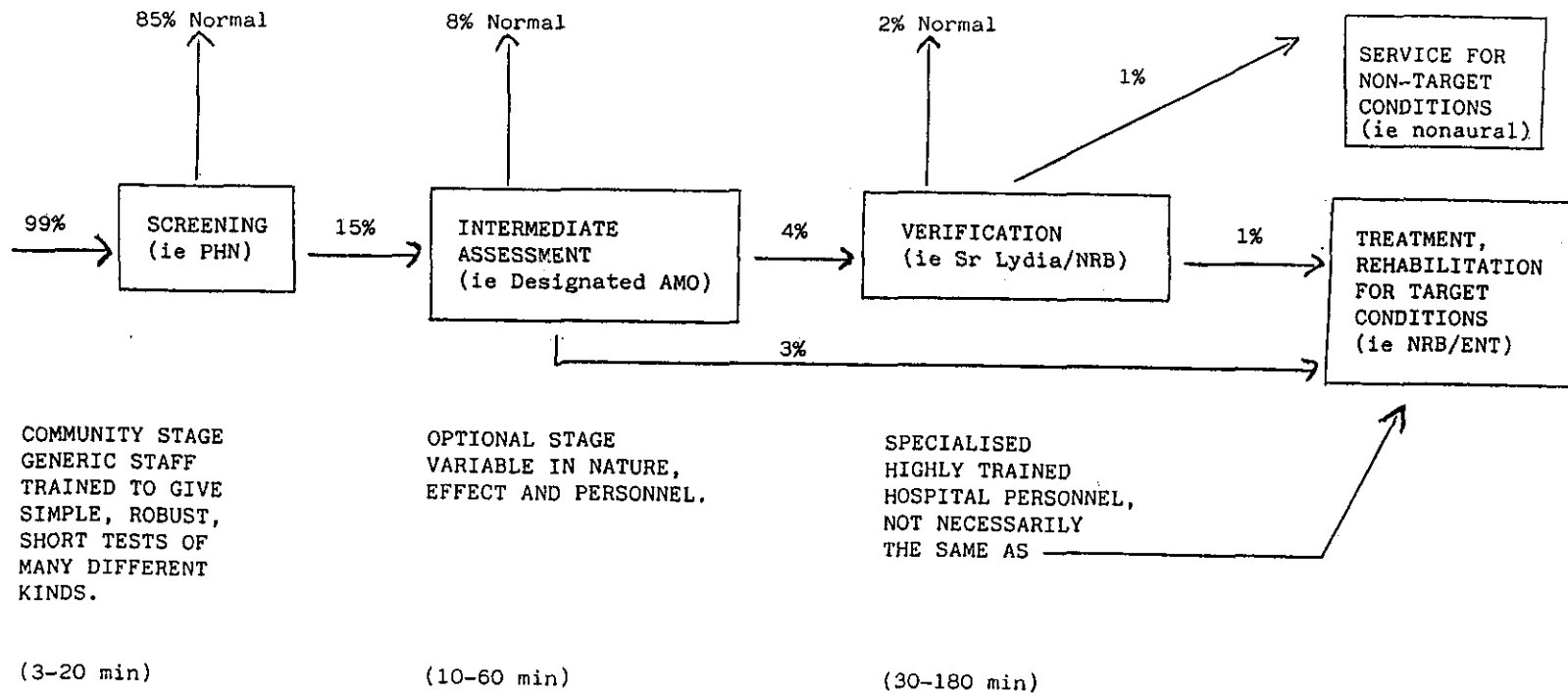
* Screening audiometry (Sweep Check Test) refers to testing at 20dB only while diagnostic audiometry (threshold acuity) involves full plotting of hearing loss in dB's.

APPENDIX C - (CONTINUED)

Community Care Area	Abnormal Tests Repeated	Repeat Tests Abnormal (%)	Referrals After Abnormal Test	ENT Referrals	Sr Lydia NRB Referrals	ENT Wait (months)	Public Health Nurses		
							Screening	Diagnostic	Both
1	Yes	250 (87%)	Sr Lydia ENT	250	8	2	--	12	--
2	Yes	17 (29%)	AMO	17	0	4	--	--	3
3	No	---	ENT	262	-	0	16	--	--
4	Yes	233 (60%)	ENT NRB	200*	-	5	--	--	13
5	---	---	---	200*	-	-	--	7	--
6	Yes	---	ENT Sr Lydia	224	60	6-8	6	--	--
7	Yes	150 (36%)	ENT Sr Lydia	140	-	9	3	--	14
8	Yes	218 (22%)	AMO	169	-	6	--	--	7
9	Yes	374 (40%)	NRB Sr Lydia ENT	193	276	12	3	--	6
10	Yes	136 (100%)	AMO	128	8	5	3	--	--
TOTAL EHB		1378 (43%)		1783 *estimate	352		31	19	43

APPENDIX D - IDENTIFICATION BY SCREENING SYSTEMS

Adapted from Haggard MP, UK - Bassum Workshop



APPENDIX E - THE STYCAR TEST (7 - 9 months)

APPLICATION OF TESTS

General Rules

First, the room should be quiet and homely and the mother or other familiar adult should remain with the child throughout.

Second, the tests are based on fundamental psychological and acoustic principles so that, although it is permissible to vary the spoken 'carrier phrases' and in some instances the order of application, the materials used may not be varied. The tests themselves must be applied with strict attention to detail or they will cease to give valid results.

Third, the record should state clearly the test used, the distance, and the results obtained, with a note regarding the child's own vocalizations or speech which have been *personally* observed by the examiner during the interview. The mother's *report* of the child's speech and hearing behaviour at home must always be sought, but meticulously recorded as hearsay evidence.

Fourth, the test appropriate to the child's chronological age should be attempted first, his ability to name toys or pictures being checked at 3 ft. If the child shows the slightest confusion in recognizing the objects or pictures, the examiner, without permitting the child to realize his inadequacy, should discard that particular test in favour of the easier one preceding it in the same series. In order to obtain consistent results, it is important that the child should regard the test as an enjoyable game throughout.

Procedures

A considerable amount of research has been carried out in Britain, America and elsewhere during the past decade regarding the auditory development and behaviour of young babies including neonates. The instrumental and behavioural testing procedures employed usually demand specialized equipment and highly trained personnel. Consequently they are best left to experts. As Gesell pointed out many years ago (1947), a normal baby cannot be expected to give *consistent*, unmistakable localizing response to sound-making instruments before the age of 16-20 weeks. After the age of 20 weeks, however, localizing responses can be readily elicited. All the present tests are designed for experienced *clinical* use with children of mental ages between 6 months and approximately 7 years. They are set out in broad overlapping sections, according to age groups approximating 6 to 12 months; 13 to 24 months; 2 to 3 years; 3 to 5 years; 5 to 7 years.

Babies 6 to 12 months (inclusive)

Babies over 6 months are comparatively easy to test, those between

9 and 12 months particularly so. At this stage of development a child is eagerly seeking through vision, hearing and manipulation, to explore and find meaning in the world around him. He has already learned to associate certain sounds with human beings and the interesting events they initiate, but his worldly experience is still so incomplete and his ability to discriminate between foreground and background noises so elementary that he cannot yet take the significance of any sound within his area of attention for granted, but is impelled to support his uncertain powers of auditory recognition and localization with visual reinforcement. Hence his immediate response to any alerting sound in his environment is to turn with a look of inquiry towards the person or object originating it. This localizing reaction probably plays a necessary part in normal stereoscopic and stereophonic learning and thus in the acquisition of concepts not only of space, but also of time. The response is so constant at this age that it is almost automatic and therefore provides a very convenient testing procedure. (Figures 1 and 2).

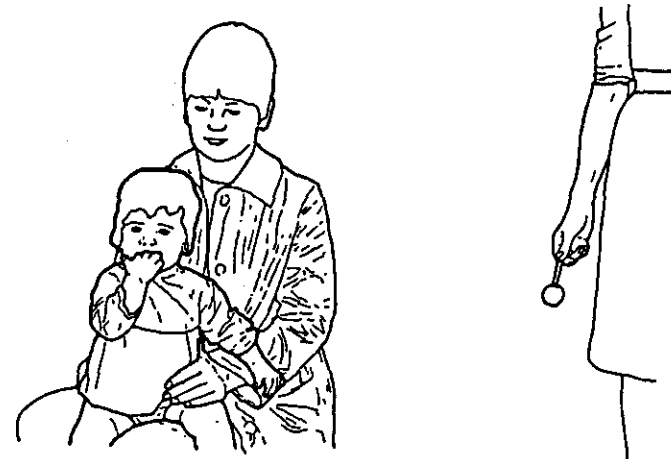


Figure 1 6 months. Child's attention lightly attracted forwards.

APPENDIX E - Continued

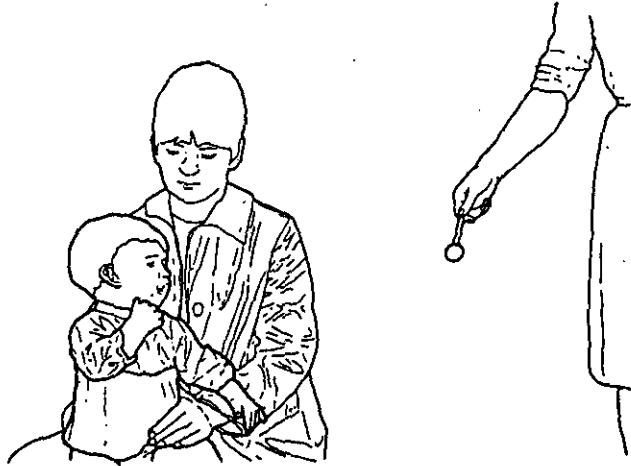


Figure 2 6 months. Normal localizing response to rattle.

It is necessary to bear constantly in mind however, that an infant's integrated sensory world is restricted and only gradually expands. Although he probably perceives vague impressions of external space, his span of selective visual and auditory attention and recognition is at first fragmentary in time, and limited in space to an area determined by his mother's care-giving activities. After 6 months his sphere of continual awareness rapidly increases until by 18 to 20 months, it usually encompasses full room-size. Hence soft, varied, meaningful sounds close to the infant are much more likely to evoke consistent response than loud, featureless noises further away.

The examiner (E) should stand 1-3 feet to the side of the child (C) but well outside the range of his peripheral vision (see diagram on page 23). To ensure the most consistent results the first sound stimulus should be given on a level with the ear. Sounds below this horizontal plane are less easy to localize and above it less easy still. Sounds immediately behind or over the head, particularly when they occur in the middle line, appear to be very difficult to distinguish and to locate. Murphy (1964) has defined the normal developmental sequence of auditory localization.

Babies of 6 to 7 months are usually very forthcoming and friendly, but after this age the near approach of strangers is apt to be unwelcome and acceptance must be won. E should not immediately make boisterous frontal overtures to C, but should allow himself to be seen moving about at a respectful distance and heard in friendly conversation with the mother (M). The gestural, visual, auditory and vocal reactions of C to E's voice and to M's will be instructive, particularly when M is addressing herself directly to him.



Figure 3 6 months. Normal child's inquiring response to voice test.

E should first ask by what name C is known at home. C may sit on M's knee facing outwards, or in his cot or pram within touching distance of her. C's position must not be closer than 4 feet to any wall. In all tests it is essential that E does not stand where his movements or his shadow are likely to be within C's peripheral visual fields. Similarly, reflections in a shiny surface, light touches, vibrations, currents of air and even perfumed cosmetics may provide unsuspected clues to an observant child who has learned, of necessity, to make use of them.

If an assistant (A) is available E should sit in front of C observing his reactions while A applies the selected stimulus. If E is alone he must wait until C's attention is visually attracted straight ahead, but not too deeply engaged, before he begins the test. The rattle requires special application (see below). The remaining sound-makers are applied at distances from 1½ feet (at 6 months) to 3 feet (8 months upwards), preferably in the following order, voice, rattle, spoon against cup, tissue paper, handbell, voice again.

The speech sounds are delivered at very quiet conversation level. They consist of the low-tone vowel 'oo', repeated in sing-song cadence, 2 - 4 times, (e.g. 'Oo-oo, John, oo-oo'), the high-pitched consonant sounds 's-s-s', 'tit-tit-tit', 'ps-ps-ps', 'pth-prh-pt', repeated rapidly 4 - 6 times. The remaining sounds are given for 2 - 3 seconds. The rattle must be moved correctly (see below), the tissue paper rustled very softly, the handbell tinkled very gently and the spoon merely stroked round the inside brim of the cup, unless for any reason a sharp tapping sound is needed, when the spoon can be struck briskly against the side. Between each repetition of any sound, there should be an interval of at least 2 seconds. The use of a portable sound level meter for monitoring is recommended whenever possible.

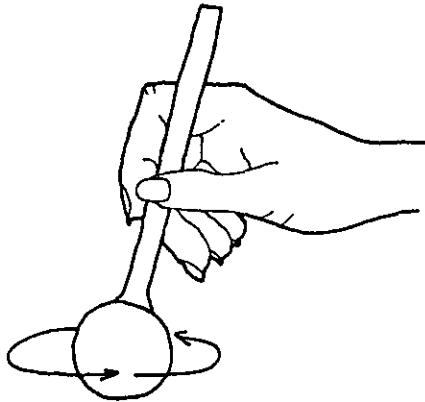


Figure 4 The Nuffield Rattle in use.

The Nuffield Rattle was specially designed (Kemp, 1976) to produce the delicate high-frequency sounds which occur in speech - for example during /s/f/ and /sh/. It is therefore a very practical test for high tone hearing. When held 6 to 12 inches from the ear, the rattle produces sounds equal in loudness to the /ss/ and /sh/ sounds in normal conversational speech, and thus is readily heard by the normally hearing child. (Figures 4, 5, 6 and 7).

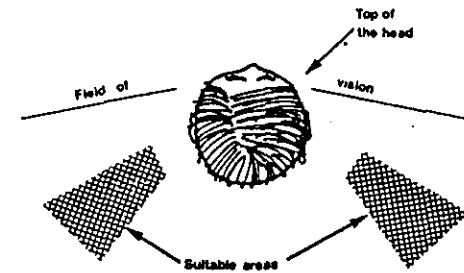


Figure 5

Operation The rattle is held like a pen, ball downwards, and is moved as if drawing an 'O' shape rapidly, so that the contents slide around inside the ball (Figure 1).

Distance 6 - 12 inches from ear.

Position Always hide the rattle from the child's view - not behind

APPENDIX E - Continued



Figure 6 Normal 6 months. Prompt localization of rattle at ear level.

objects, but in the lateral (shaded) areas indicated in the diagrams (Figure 2).

Precautions

- (a) Do not allow your clothing to make additional sounds whilst using the rattle.
- (b) Do not grasp the ball whilst shaking — this spoils the sounds.
- (c) Never allow the rattle to become damp and take care not to strain the join between ball and handle.

With normal children of 8 months upwards the first application of the stimulus usually provokes instant turning, often with a delighted smile (E should respond to the smile), and when the same sound is repeated immediately afterwards on the other side of his head C will promptly localize it in the new position. Younger babies may be slower to react. If the first stimulus evokes no response E should wait for 2 seconds and then repeat it. E should then wait a further 2 seconds as C may still turn slowly and deliberately although the sound has ceased.



Figure 7 Normal 6 months. Hears but is unable to localize rattle above ear level.

This delayed response is also apt to occur in retarded older children. It is as if there is a definite time-lag following reception of a sound in the primary cortical auditory area, subsequent processing in higher cortical areas and the initiation of responsive motor impulse. Incidentally, a baby who has not responded to a single application of a sound on one side of his head will often localize it promptly and correctly when it is repeated immediately afterwards on the opposite side. This may represent the result of a summation of subliminal stimuli. Nevertheless, I prefer to apply a double (or occasionally treble) stimulus to one ear, since absence or delay in response provides additional information not only regarding hearing but also regarding ability to localize sound. If no response is elicited to the second (or third) repetition of the sound the stimulus should then be changed or the child will become bored and withdraw from the situation. After response to the handbell has been evoked it should be presented to the child, since his use of it as a plaything provides further useful information regarding his ability to comprehend its function and his willingness to make and enjoy sound (Gesell, 1947). (Figures 8 and 9).

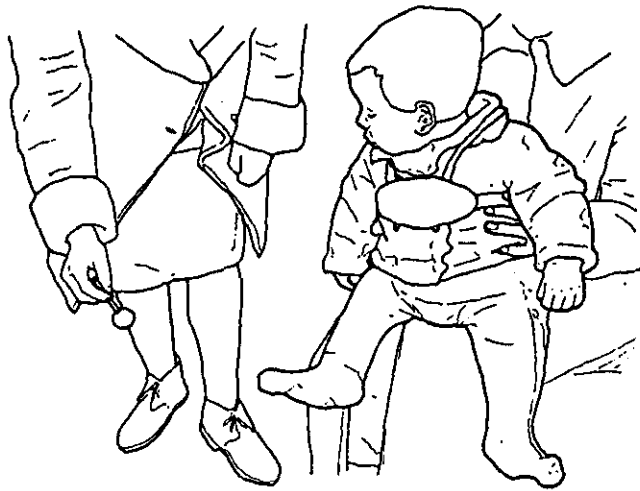


Figure 8 Normal 8 months. Immediate localization of rattle below ear level.

Results

If a child shows a clear-cut response to any four of these 5 sounds, which ensures that either the rattle or the high-pitched consonants are always included, there is good reason for the assumption that he



Figure 9 Normal 8 months. Immediate localization of rattle above ear level.

APPENDIX E - Continued

possesses enough hearing to learn to speak, but it must be remembered that *these tests are not fine enough to determine partial deafness, with ABSOLUTE certainly, particularly high-tone loss.* If the child does not respond in the expected fashion to these sounds on each side separately, if he persistently turns in one direction only, or if he shows by moving his head and eyes searchingly from side to side that he is uncertain of the location from which the sound has come, the tests should be re-applied as soon as possible within the following month. If the result of this second test is still uncertain, expert opinion should be sought without further delay.

APPENDIX F - CO-OPERATIVE/PERFORMANCE TESTS

Toy Tests

The child between 14 and 20 months should first be addressed by name at conversational distance and invited to hand to E in play the *cup*, *ball*, *motor-car* and *dolly*. The larger (hand-grasp) sized car and doll should be used at this age. If he does not respond, the baby tests at 3 - 6 ft may be tried, E remembering that it will be necessary to vary them frequently, as the immediate repetition of a sound which has just evoked response on one side will seldom, at this age, arouse equal interest on the other. The rustling of the paper wrapping of a packet of sweets followed by the spoken invitation 'Come and get one', and the presentation of the bell accompanied by the definite instruction, 'Ring it. Good. Ring it with the other hand', are useful extensions of these baby tests. Commands are more likely to produce results than friendly suggestions.

With children over 20 months, it is desirable to attempt application of the next toy test, i.e. the *5-toy test*. The objects used are the former-sized *cup* and *ball*, but *miniature motor car*, *small baby doll* and *toy brick*, i.e. a coloured inch cube which, to prevent any delay in visual recognition, should be a different colour from the motor car. C is placed sitting or standing by a small table with E facing him at 2 - 3 ft i.e. conversational distance. E presents the objects slowly in the following order, saying 'here is a *cup*' (the responsive child will delightedly echo 'tup'). 'Here is a *ball* - and a motor *car*', then presenting the doll E says 'What's this?' and waits for C to say 'dolly' or 'baby' and thereafter uses C's own word. If C does not speak E says, 'A dolly - and here is a *brick*'. (The word 'brick' being acoustically essential must not be altered). Then holding out his hand flat (not suggestively cupped) E says in this order, 'Give me the *ball*, please. Thank you - give me the *brick*, please ... the *car* ... the *dolly*. Good'. If C does this correctly E hands the cup to M saying 'Now I am going over there and you're going to give the things to Mummy when I tell you'. E places the toys on the table and retreating to 6 ft says 'Give Mummy the *ball*, then slowly retreating to 10 ft. 'Give Mummy the *brick* ... the *car* ... the *dolly*', then finally, 'Put the toys in the cup (M may help). Bring it to me'. If E feels that he has dropped out of C's attentional world at 10 ft he should return to 6 ft noting this in the case record.

If C does not give the correct toy when requested E should wait a moment without speaking, as another delayed response may be operating. C may even lift the incorrect toy then put it down and hand the correct one. If C gives an incorrect toy E should put it down gently and repeat 'The *ball*, please'. If C still hands the incorrect toy E puts it down again, saying 'No, I want the *ball*, please'. If C persists in giving the incorrect toy or goes on handling the other toys without waiting for the command, E accepts them, then giving the cup to M holds out the toys to C, saying 'Give them to Mummy'. While C is doing this E retreats to 6 ft saying 'Good, put the toys in the cup'. M may help. While C's attention is momentarily engaged in filling the cup the vocalized sounds 'ps-ps' or 'tit-tit', the high-pitched rattle, or the rustle of paper usually provoke the turning response.

The 4 *animal pictures* test should also be tried. The procedure is given below in section for 2 years.

Speech

By 18 months most children have acquired 6 - 12 recognizable words. The child continues to jabber to himself while he is playing or in his cot, but as his vocabulary grows this jabbering begins to include an increasing number of distinguishable words.

Normally by 2 years, a hearing child is able to use words to demand what he wants at table, communicate his toilet needs, and ask to be taken for a walk. He is usually putting two or three words together to form simple sentences. He tends to echo the last word addressed to him. His understanding of spoken language related to the familiar

APPENDIX F - Continued

objects, activities and emotional states of daily life, continue to improve rapidly and is far in advance of his ability to use speech. At this stage he is physically restless and vocally demanding, incessantly provoking his mother to give a verbal reply to his loudly-expressed claims on her attention.

After 20 months persistent tendency to tug silently at his mother's garments to demand her attention or merely to point dumbly with his finger at something he wants to be given is very significant of auditory or linguistic incompetence and should be immediately followed up.

REFERENCES

- American Academy of Pediatrics (1982). *Joint committee on Infant Hearing: Position Statement*. Pediatrics, 70, 496-7.
- Anonymous (1986). *Screening for hearing impairment in the newborn*. Lancet, Dec, 1429-30.
- Anonymous (1987). *Audiological Services for children*. Lancet, Aug 1, 256.
- Baart de la Faille (1985). *Infant Hearing Screening in the Netherlands*. EEC Workshop, 1-8.
- Baart de la Faille (1986). *Infant Hearing Screening in the Netherlands*. Audiology in Practice, 3, 6-8.
- Barr B, Stensland Junker K, Svard M (1978). *Early discovery of Hearing Impairment; A Critical Evaluation of the Boel Test*. Audiology, 17, 62-7.
- Barr B (1980). *Early Detection of Hearing Impairment*. In: Taylor I G & Markides A (Eds), *Disorders of Auditory Function, Vol 3*. London, Academic Press.
- Bellman S (1986). *Hearing Screening in Infancy*. Arch Dis Child, 61, 637-8.
- Bellman S (1987). *Hearing Disorders in Children*. Br Med Bull, 43, 966-82.
- Bigglestone S (1986). *Screening Babies' Hearing: Evaluating the Body Spek 2000*. Health Visitor, 59, 377-8.
- Chadderton J H (1987). *Hearing Testing in Young children*. Practitioner, 231, 1129-32.
- Commission of the European Communities: *Health Services Research (1988)*. In: *Early Detection of Vision, Hearing and Language Disorders in Childhood*. Van der Lem et al (eds), Commission of the E.C., Brussels.
- Corrado O J (1988). *Hearing Aids*. Brit Med J. 296, 33-5.
- Costa O A, Axelsson A, Aniansson G (1988). *Hearing loss at age 7, 10 and 13 - An Audiometric Follow-up Study*. Scand. Audiol. Suppl., 30, 25-32.
- Davidson J, Hyde M L, Alberti P W (1988). *Epidemiology of Hearing Impairment in Childhood*. Scand. Audiol. Suppl., 30, 13-20. 37.
- Davis A C (1987). *Epidemiology of Hearing Disorders*. In: Kerr A, (Ed). *Scott-Brown's Audiology (5th edn.)*, Vol 2. Guildford: Butterworth.
- di Chiara E (1984). *A Sound Method for Testing Childrens Hearing*. AM J Nursing, Sept., 1104-6.
- Downs M P (1978). *Auditory Screening*. Otol Clin N AM, 11, 611-29.
- Fria T J (1981). *Assessment of Hearing*. Ped Clin N AM, 28, 757-75.

- Gerber S E, Mencher G T eds, (1978). *Proceedings of the Saskatoon Conference on Early Diagnosis of Hearing Loss*. New York, Grune & Stratton.
- Gimsing S, Bergholz L M (1983). *Audiologic Screening of Seven and Ten Year Old Children*. Scand. Audiol. 12: 171-77.
- Haggard M P and Gannon M M (1985). *Analyses from Service Records of Screening Systems for Hearing Impairment in Pre-School Children*. MRC Institute of Hearing Research, Series A, No 3.
- Haggard M P (1987). *Hearing as a Community Health Problem*. Br Med Bull, 43, 1027-37.
- Hovind H, Parving A (1987). *Detection of Hearing Impairment in Early Childhood*. Scand. Audiol., 16, 187-93.
- Jerlvhall H, Aryselius H, Arlinger S (1983). *Comparison of Manual and Computer Controlled Audiometry using Identical Procedures*. Scand. Audiol., 12, 209-13.
- Johnsen N J, Bagi P, Elberling C (1983). *Evoked Acoustic Emissions from the Human Ear. Findings in Neonates*. Scand. Audiol., 12, 17-24.
- Johnson A (1986). *Screening Tests for Hearing and Visual Impairment: How and When are they done?* Health Visitor, 59, 140-1.
- Knight JJ (1987). *Hearing Aids*. Practitioner 231, 1121-6.
- Latham A D, Haggard M P (1980). *A Pilot Study to Detect Hearing Impairment in the Young*. Midwife, Health Visitor and Community Nurse, 16, 370-4.
- Ludman H (1981). *Deafness in Childhood*. Br Med J., 282, 381-3.
- Mc Cormick B (1983). *Hearing Screening by Health Visitors: A Critical Appraisal of the Distraction Test*. Health Visitor 56, 449-51.
- Mc Cormick B, Curnock D A, Spavins F (1984). *Auditory Screening of Special Care Neonates using the Auditory Response Cradle*. Arch Dis Child, 59, 1168-72.
- Mac Farlane (1986). *Child Health Services in the Community: making them work*. Br Med J., 293, 222-3.
- Maran A G, Wilson J A (1986). *Glue Ear and Speech Development*. Br Med J., 293, 713.
- Martin J, Moore W (1979). *Childhood Deafness in the European Community*. Luxembourg: Commission of the E.C.
- Martin J, Bentzen O, Colley J et al (1981). *Childhood Deafness in the European Community*. Scand. Audiol., 10, 165-74.
- Maw A R, Herod F (1986). *Otoscopic, Impedance and Audiometric Findings in Glue Ear treated by Adenoidectomy and Tonsillectomy*. Lancet, June, 1399-1402.

- Newton V (1985). *Aetiology of Bilateral Sensineural Hearing Loss in Young Children*. J Laryngol Otol Suppl., 10.
- Oyiborhoro J M (1988). *Audiology Training in Nigeria - I: a Training Model*. Soc Sci Med, 26, 1035-42.
- Oyiborhoro J M (1988). *Audiology Training in Nigeria - II: a Cost Effective Approach to Training Programmes*. Soc. Sci. Med., 26, 1043-7.
- Palfrey J S, Hanson M A, Pleszczyńska C et al (1980). *Selective Hearing Screening for Young Children*. Clin Pediatr, 19, 473-7.
- Parving A (1988). *Hearing Disabled Children - Epidemiology and Identification*. Scand. Audiol. Suppl., 30, 21-23.
- Renvall V, Liden G (1980). *Screening Procedure for Detection of Middle Ear and Cochlear Disease*. Ann Otol Rhinol Laryngol Suppl, 89, 214-6.
- Stewart-Brown S, Haslum M N (1987). *Screening for Hearing Loss in Childhood: A Study of National Practice*. Brit Med J, 294, 1386-8.
- Tell L, Levi C, Feinmesser M (1977). *Screening Infants in Well-Baby Clinics*. In: Bess F H, (Ed). *Childhood Deafness: Causation, Assessment and Management*. New York; Grune and Stratton: 117-26.
- Thompson G, Folsom R (1981). *Hearing Assessment of At-Risk Infants*. Clin Pediatr, 20, 257-61.
- Wheeler M T K (1986). *Tympanometry in Children with Treated Acute Otitis Media*. Lancet, Mar., 529-31.
- Zielhuis G, Rach G H, Van den Broek (1989). *Screening for Otitis Media With Effusion in Preschool Children*. Lancet, Feb., 311-3.