

Early identification of hearing loss: screening and surveillance methods

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Abstract

Service monitoring data on the outcomes of health visitors' screening for hearing loss at 8 months in West Berkshire indicate low sensitivity and low positive predictive value, despite efforts to improve the conduct of the screen. Nevertheless, data on a recent series of severely hearing impaired children indicate significantly earlier diagnosis than previously, due in part in the introduction of other service changes including neonatal 'at risk' screening and surveillance using parental observation. For a trial period the traditional screening method for the detection of hearing loss in babies will be discontinued and effort concentrated on these alternative procedures.

It is widely accepted that congenital sensorineural hearing impairment can have appreciable effects on the speech, language, social, psychological, and educational development of the impaired child. It is also widely accepted that the disability associated with severe congenital hearing impairment can be reduced significantly by early identification of the condition leading to appropriate intervention and rehabilitation. That there is little direct evidence of this is not necessarily reason to doubt it.¹ How early the identification should occur is not certain, but from a purely theoretical point of view it should probably occur as soon after birth as possible, at least for the more severely impaired cases.

In the United Kingdom there is an established nationwide hearing screening test, based on the distraction test first described by the Ewings,² and performed by health visitors with children aged 7-9 months. This and other aspects of the service aimed at early identification achieved a peak of notoriety in the late 1970s partly as a result of surveys, the results of which questioned the coverage and sensitivity of the test.³ Efforts before and since then in a number of districts, most notably Nottingham,^{4,5} seem to show that given the appropriate resources for training, equipment, and referral, the health visitors' screening test can be implemented relatively effectively and certainly more effectively than previously.

Experience in West Berkshire

In the early to mid 1980s, in response to the unacceptably low sensitivity of the health visitors' screen, improvements in training, techniques, and equipment for the health visitors in West Berkshire health district were introduced

after the lead given by the Nottingham services. Previously, screening by the distraction method had used sounds produced by the Nuffield high frequency rattle and voice, to provide a low frequency 'oo' and a high frequency 's' at approximately 35 dB. During the training days twice a year for newly appointed health visitors in West Berkshire, conducted by the senior clinical medical officer responsible for audiology, there was strong emphasis on the need for the sounds to be produced at this intensity, in the correct manner, and without visual clues and for the need for stringent self criticism in the conduct of each test. It was difficult to maintain these standards when sound level meters were not always available during testing sessions. The hearing test was passed if the baby responded to all the sounds presented by a full turning of the head to localise the source of the sound. Failure to do so indicated a need for a retest three to four weeks later and, if there was further failure at this stage, referral to the community audiology clinic for audiometric assessment and otological examination by clinical medical officers experienced in audiology or to the audiology unit at the Royal Berkshire Hospital.

To bring the screening of hearing by health visitors to its 'realistic best' modifications were made in the method of testing, the criteria for referral, and the training programme.

Calibrated electroacoustic warblers were introduced throughout the district. These provided warble tones at 0.5 KHz, 2 KHz, and 4 KHz and they were offered at 35 dB sound pressure level to both ears. Two opportunities were provided at each frequency to both ears for 2-3 seconds on each occasion. Localisation of the sound source by a full turning of the head on one occasion out of two was rated a pass. Failure to respond to any frequency for either ear indicated the need for a retest three to four weeks later. If failure of the retest occurred, referral to the community audiology clinic or hospital audiology unit was mandatory. The number of training days was increased to four per year, each involving both authors so that the scope of the training increased to include lectures on the nature and significance of hearing loss in babies as well as demonstration of the testing method and practice of the technique to ensure a high level of competence in testing by the health visitors. Not only newly appointed health visitors attended these training days but also those long established in the district attended for refresher courses on a rotational basis.

There remained a real problem, however, with the timing of the screen as a first line of attack for identification of severe or very severe

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hearing loss. For developmental reasons, the test cannot be implemented before about 6–7 months of age and even with an assessment service that could offer immediate appointments for suspected severe cases, the age at which hearing aids could be fitted would not be before about 9 months at very best and more likely 12 months (allowing time for retest, referral and differential diagnosis, counselling, and manufacture of earmoulds). While this might have seemed a service triumph a decade or two ago, we are now aware of the importance of the early stages of language development and the consensus has moved towards rehabilitative intervention within the first few months of birth, at least for severe cases. In view of these considerations, other efforts were made within West Berkshire to secure earlier diagnosis than could be offered by the health visitors' screening route even at its realistic best. In particular:

(1) Screening of 'at risk' neonates was introduced using initially the auditory response cradle,⁶ and later either or both auditory brainstem response screening and otoacoustic emission screening. The case for 'at risk' screening (mainly 'graduates' of special care baby units) has been documented and reviewed elsewhere.⁷

(2) Parental observation, at any age, no matter how early, was used as a guide to rapid referral. In particular the 'hints for parents' from a paper by McCormick was introduced and issued to all parents by the health visitor at the earliest opportunity, usually at the 10th day visit.⁸

(3) A concerted effort was made to encourage health visitors and general practitioners to refer children as early as possible whenever hearing was in doubt. A programme of awareness of hearing impairment and its consequences was implemented for all professionals, including health visitors, general practitioners, clinical medical officers, and paediatricians.

Thus from 1984, the services in West Berkshire offered neonatal screening for 'at risk' babies, heightened awareness, explicit guidelines for parental observation, and the health visitors' screening test performed near its 'realistic best' (given the inevitable constraints of staff turnover, limited resources, etc). The effects of these service changes within West Berkshire are illustrated by data on two series of severely or very severely hearing impaired children, one from 1974 to 1977 the other from 1984 to 1988. Table 1 shows the age of issue of hearing aids to children in these two series. Clearly there is a noticeable improvement in the 1984–8 series in that age of identification and diagnosis (and therefore age of hearing aid

Table 2 Children from 1984–8 series: referral routes (n=22)

Routine	No of children
Neonatal screening to full assessment	4
Parental concern to general practitioner or health visitor to full assessment	7
Paediatricians to full assessment	5
Health visitors' screen followed by accelerated referral because of concern	5
Health visitors' screen to full assessment via second tier community clinic	1

fitting) is reduced. The total numbers of severely impaired children (19 and 22) are in line with an overall (that is, including mild and moderate degrees of hearing loss) prevalence rate of between 1–2/1000, given the birth rate of 6000/year in West Berkshire.

The routes by which the 22 children in the later period were identified as severely hearing impaired are shown in table 2. The full audiological assessments were carried out in a tertiary level audiology unit based in a district general hospital with ear, nose, and throat opinion available and hearing aid provision adjacent.

These organisational details are incidental to the particular topic of this paper. A prerequisite of any good programme of audiological screening or surveillance, however, is a competent, adequately resourced audiology department, capable of accurate confirmation with minimal delay and of contributing to the multifaceted support required for aural rehabilitation in childhood.

As a result of the service changes implemented in West Berkshire in 1984, the traditional screening by health visitors had become more of a safety net than a first line of attack for congenital severe sensorineural hearing loss. Identification of the hearing loss was being made earlier than could be expected from the health visitors' screen, and therefore amplification was also being provided earlier. Table 2 indicates that babies with suspected sensorineural hearing loss reached the full audiological assessment stage by a number of routes, the traditional screening test being but one of them.

Data are also available on the effectiveness of the health visitors' screen itself during the same period of 1984–8. Unfortunately, given the efforts put into improved protocols, improved training, and the use of calibrated electroacoustic warblers as sound sources, the detection rate for moderate, severe, and very severe sensorineural hearing impairment still seems to be rather low. Of 12 such children confirmed as hearing impaired between 1984 and 1988 (those already identified or referred were not screened by health visitors), six had passed the screen. It is probable, though not certain, that the hearing losses had been present since or soon after birth. A sensitivity as low as 50% does not necessarily mean that a screen should not be undertaken; it depends upon cost, alternatives and the consequences of the condition going undetected. In the case of infant hearing screening, where a false negative will introduce undue delay and confusion into the processes leading to eventual confirmation, it is generally accepted that a

Table 1 Age of issue of hearing aid

Age (months)	1974–7	1984–8
0–6	—	4
7–12	—	3
13–18	3	8
19–24	3	4
25–30	10	1
31–36	—	—
>3 Years	3	2
Total	19	22

screening system needs to have a higher sensitivity to be acceptable. The issue reduces to whether the contribution of the health visitors' screen to the total sensitivity of the combined set of surveillance arrangements is sufficient to justify its cost.

Quite why the detection rate for severe cases remains poor is not clear. Other centres suggest better results from the improved screening by health visitors,⁵ although direct measures of detection rate are rather rare in the literature.

In West Berkshire, to implement the screening programme requires the successful training of 130 health visitors to carry out at least 6000 hearing tests each year. In view of the relatively high staff turnover the training, including background lectures, demonstrations, practice of training techniques, and discussion probably requires more than the eight days a year (four from each of the authors) which have been available.

It has been suggested that decision theory and vigilance theory might help to explain the low sensitivity: the search for one or two cases/thousand is a search for a relatively rare condition. Hence health visitors' criteria could not be expected (given an imperfectly specified test procedure) to be optimal.

This could only be a partial explanation, however. Although the eight month screen is orientated towards detection of severe congenital losses,⁷ it also refers many times more children with milder hearing losses associated with otitis media with effusion.⁵ Valid referral of screening is, therefore, not nearly as rare as would be the case if only sensorineural hearing loss existed. A further possibility for the poor detection rate of the improved screen may concern the nature of the task, which by necessity for a screen is an explicit, rigid, and quantitative test procedure, not open to post hoc discretionary interpretation.

Health visiting and the community child health services have always emphasised surveillance and good clinical judgment, taking into account the whole child, family background, and parental observation. In many ways a rigid non-interpretative screening test concerned with just one discrete sensory function does not sit easily within the broader role of health visitors, especially as the task of assessing a 7 months old's responses to sound involves (as health visitors are fully aware) a complex set of largely unquantified and unquantifiable variables. Haggard used the data on children with otitis media with effusion to examine the efficacy of the health visitors' screen.⁵ He argues that what applies to the less severe but more common hearing losses associated with otitis media with effusion provides the only practicable statistical reflection of what will apply to detection of sensorineural hearing losses. As otitis media with effusion is a fluctuating condition, the usual counting of false negatives (passed screen but with hearing loss at time of screen) is not possible. Haggard therefore suggests the use of two variables by which changes in the screen may be monitored, namely failure rate (FR) and positive predictive value (PPV). Failure rate is given by:

$$FR = \frac{\text{True positives} + \text{false positives}}{\text{Total}}$$

and positive predictive value by:

$$PPV = \frac{\text{True positives}}{\text{True positives} + \text{false positives}}$$

As otitis media with effusion and any associated hearing loss can fluctuate so rapidly, there must still be some doubt about the true and false positive rates unless a full assessment (presumed accurate) takes place on the same day as the screen. Provided the average time between screen and full assessment is static and reasonably short, however, this source of error can probably be ignored.

Table 3 shows the failure rate and positive predictive value for the health visitors' screen in West Berkshire for 1984-8. Data for 1984 and 1985 cover the whole district (birth rate 6000/year), while the data for 1986, 1987, and 1988 are for clinics covering two thirds of the district population (assumed birth rate 4000/year). All routine screening failures are referred first to intermediate community health service clinics staffed by experienced clinical medical officers.

Cases thought to be urgent or possible sensorineural losses may bypass this tier. The community clinics may refer to the audiology unit at the Royal Berkshire Hospital for ear, nose, and throat and audiological assessment (usually adjacent) or to the general practitioner for treatment, they may advise and review, or they may discharge. A few cases that have failed the health visitors' screen may also be referred directly to the audiology unit by the general practitioner or health visitor. Therefore, the figures in table 3 are contaminated by some sources of error, but these are likely to be small.

A number of points emerge from table 3. First, compared with 1984 and 1985, the failure rate has increased for recent years. This may reflect the gradual effects of the changes introduced in 1984 to the screening protocol, in particular the stricter criteria for a pass and the use of frequency specific electroacoustic warblers. It has been reported that babies are *more* responsive to warble tones than to the traditional wider band noise makers,⁹ but there are theoretical and empirical grounds for expecting narrower band stimuli to elicit *fewer* responses.¹⁰ Furthermore, a questionnaire to health visitors within the district also supported this view that the babies were less responsive to

Table 3 Number of cases referred by health visitors' screen in West Berkshire to the second tier clinics showing those discharged after only one appointment, those referred on to the third tier at Royal Berkshire Hospital, and hence failure rate and positive predictive value. Those neither discharged nor referred on were kept on review, and have been included in the calculation of positive predictive value (as true positives)

Year	No referred	No (%) discharged	No (%) referred	Failure rate (%)	Positive predictive value (%)
1984	183	110 (60)	11 (6)	3.05	*
1985	156	81 (52)	22 (14)	2.60	*
1986	152	88 (58)	29 (19)	3.80	42.1
1987	177	115 (65)	23 (13)	4.43	35.6
1988	264	169 (64)	42 (16)	6.60	35.9

*No data available.

warblers: 75% of respondents claimed that babies were 'slightly' or 'much less' responsive to warblers compared with their responsiveness to high frequency rattles for example.

The failure rate in West Berkshire in the more recent years is double that reported by Haggard and Gannon who examined a similar screening system that utilises strict protocols, warblers, and appropriate training.¹¹ This *may* reflect the stricter criteria for screening failure in our protocol but it is difficult to be sure without a closer examination of the fine details of both protocols for testing and training.

Second, the positive predictive value associated with the screen is low and much less than that of 78.6% quoted by Haggard for the Nottingham services.⁵ This difference is likely to be due largely to the (unacceptably) long waiting time of about six months that has existed in West Berkshire for some years for the second tier community clinics. As otitis media with effusion fluctuates it seems that many of the cases had improved spontaneously by the time they were seen in the second tier clinic, giving very high discharge rates. The time between screening and referral (at least for non-urgent cases) in the Nottingham services was considerably shorter and is commonly only six to eight weeks (B McCormick, personal communication). The data from table 3, and examination of the outcomes of those cases referred to the Royal Berkshire Hospital do incidentally emphasise the fact that the health visitors' screen was not designed for and is not an efficient way of detecting those children with otitis media with effusion of such severity and/or persistence to justify surgical intervention. Although the screening does detect over 30 times more children with otitis media with effusion than it detects cases of severe sensorineural loss,⁷ the number of surgical referrals of otitis

media with effusion requiring surgical treatment is really rather small. Table 4 shows the surgical and therapeutic outcomes for the cases referred (in table 3) to the Royal Berkshire Hospital. Of course, the ear, nose, and throat and the audiology services at the hospital were dealing with a much larger group of children with otitis media with effusion during these years and with a surgical intervention rate approaching 1000 operations/year on children below the age of 8 years (and mostly below 5 years). The referral route for these cases tends to be parental concern about illness, hearing loss, or speech/language development, to general practitioner, and to the ear, nose, and throat and audiology departments at the hospital.

A different approach

From 1 January 1989, initially for a trial period of two years, it has been decided to discontinue traditional hearing screening tests by health visitors at 7-8 months of age. In its place, a system of surveillance has been introduced that will involve parents and professionals in accordance with the principles being recommended for developmental surveillance by the Joint Working Party on Child Health Surveillance.¹² For the period of the trial: (1) parental observation and clinical concern will determine immediate referral at any age (however young the baby). (2) Neonatal screening of 'at risk' babies will continue. (3) Parental awareness about the importance of hearing and guidance for parental observations will be supported by the *Hints For Parents* leaflet introduced at the initial visit by the health visitor.⁸ (4) The hearing of every baby will be considered in depth at a convenient time between 6 and 8 months of age, usually in association with the developmental surveillance programme being carried out at that age. To ensure that the appropriate information is elicited, a questionnaire (see table 5) will be completed by each health visitor and forwarded to the senior clinical medical officer, accompanied by a referral for a hearing test in the community clinic if appropriate.

Professional awareness of the importance and relevance of hearing will be maintained among all health visitors by study days during which

Table 4 Outcomes for the cases in table 3 (excluding sensorineural losses) referred to Royal Berkshire Hospital in 1986-8

Year	No referred	No who had surgical intervention	Advice, review, and/or discharge	Not traced
1986	27	14	8	5
1987	20	10	6	4
1988	42	18	21	3

Table 5 West Berkshire health authority—community health services questionnaire about hearing for 7-8 month old babies

Name of baby:	Date of birth:
Address:	General practitioner:
.....	Health visitor:
Home telephone No:	Case load No:
Date of completion of questionnaire:	
1 Is there any history of deafness in young people in the family?	Yes/no
2 Was there any possibility of maternal rubella during the pregnancy?	Yes/no
3 Were there any problems associated with the birth?	Yes/no
4 Did the baby have to go into the special care baby unit?	Yes/no
5 Has the baby had frequent colds or ear infections?	Yes/no
6 Do loud noises make the baby jump?	Yes/no
7 Does the baby respond to some quiet sounds?	Yes/no
8 Does the baby anticipate a person approaching without visual clues?	Yes/no
9 Is double babble present?	Yes/no
10 Are there any concerns about the baby's general development?	Yes/no
11 Is there ANY parental concern about the baby's hearing?	Yes/no
12 Has a referral been completed?	Yes/no

Table 6 Advisory leaflet for parents. Children with mild hearing losses: how to help

1	Speak clearly. Look at your child when you are talking.
2	Try to keep background noises down: turn the TV off, tell others to be quiet while you are talking with your child.
3	Make the 'little bits' of a conversation clear—they are just as important as the rest.
4	Sometimes your child will nod, or smile, or say 'yes' even when he/she has not heard you.
5	Try to be patient and understanding, it's no fun not hearing well.

Remember—your child's hearing may be good one day, bad the next.

their knowledge of hearing loss and its implications will be extended. Opportunities will also be provided for discussion and exchange of ideas about the conduct of the programme. General practitioners and paediatricians will also be kept informed about the progress of the trial and reinforcements given about the importance of early referral in cases of suspected hearing loss. The aim of this programme is to provide a responsive service with waiting times for appointments reduced to a minimum. It is hoped to see all cases of possible sensorineural hearing loss within a few days and cases of possible conductive hearing loss associated with middle ear effusion within a month or two of referral.

If there is any parental concern about hearing loss, it is recognised that there may be continuing anxiety while waiting for an appointment. In order to help advise parents of sensible management, a simple advisory leaflet has been prepared that can be given to parents of children who have been referred through the non-urgent route (see table 6).

When the trial system is fully implemented, it is expected that:

(1) With 90% or more coverage for 'at risk' neonatal screening, about half of all the cases with sensorineural hearing loss will be identified by this screen.⁷

(2) The programme of surveillance by health visitors, general practitioners, and paediatricians and responses to parental observation will have a detection rate at least as good as the past health visitors' screen for the remaining severe or profound congenital cases. A trial period of longer than two years, however, will be required to verify this with any certainty.

(3) With appropriate support and training, health visitors will refer via general practitioner or community audiology clinics a set of severe and/or persistent cases of otitis media with effusion with referral rates and a positive predictive value more appropriate than those estimated for the traditional hearing screen. The effect of this should be to reduce the long waiting lists that currently exist in the community clinics, which are unnecessary (in that most cases are discharged) and which delay the referral of more appropriate or more urgent cases.

The training programme will no longer be constrained by the need to teach the technique of distraction testing. The emphasis will be on the development of communication and the relevance of normal and abnormal hearing to the acquisition of these skills. Video recordings of patterns of communication between parents of normal and hearing impaired children have proved to be very useful teaching aids, and considerable use will be made of such recordings.

It may be argued that the absence of a frequency specific hearing test will fail to identify

mild, U shaped, and high frequency hearing loss or moderate losses with recruitment until a child's delay in language acquisition raises suspicion of a significant loss. The question of whether a surveillance based system will be sharp enough to identify babies who have moderate or even severe hearing loss combined with very considerable recruitment will be answered empirically. The authors think that with suitable training and support for health visitors these cases will be identified early enough; however, doubt must remain until the results of the trial period are available. The case for very early intervention with mild, U shaped, and high frequency hearing loss have yet to be made convincingly and we argue, therefore, that any programme for early diagnosis should be primarily directed towards the more severely impaired at this stage. The possible case for early intervention with children with mild sensorineural hearing losses should not, in our view, be confused with the more obvious cases of intervention with mild fluctuating middle ear hearing losses associated with chronic otitis media with effusion. With the latter can go discomfort, illness, poor auditory attention, and difficult behaviour and it may be that together these give rise to a greater disability than does the static mild sensorineural hearing loss.¹³

Financial considerations

It is thought that the changes that are being introduced will not effectively cut the cost of the service. Although it will not be necessary to provide a tester and a distractor for each hearing test, the time taken for discussion of hearing and communication is time consuming. In addition, production costs of leaflets, questionnaires, videos, and information sheets for general practitioners and health visitors all add to the financial commitment.

Furthermore, a surveillance based scheme, coupled with neonatal screening, should only be contemplated: (a) on a trial basis with effective monitoring and data collection and (b) in districts offering a good paediatric audiology service.

Conclusion

Efforts have been made in West Berkshire health district to secure identification and diagnosis of severe congenital sensorineural hearing loss as early as possible. Neonatal screening, use of parental observation, questionnaires, better training for health visitors, general practitioners, and paediatricians, more responsive services and the 7 months screening test by health visitors improved to its 'realistic best' have been introduced. Data indicate that the screening by health visitors remains a pro-

blem, with low detection rate for sensorineural cases and over referral of cases with transient otitis media with effusion. For an initial trial period of two years, the screen is to be discontinued and a programme of surveillance introduced to secure a more efficient system. The data will be monitored and published in due course.

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Commentary

The appearance of this paper is very timely. Reports of studies demonstrating successful outcome from the use of the distraction test in a screening context are unfortunately very rare,^{1 2} and it is more common to see adverse reports.³ This situation reflects the extreme variability in the standard of application of the test technique and in the quality of services. There is absolutely no doubt that a properly performed distraction test can provide an effective method for screening hearing and Scanlon and Bamford acknowledge this.

The question at issue is whether it is worthwhile allocating the necessary resources to achieve this good level of performance or whether it might be more appropriate to redirect these resources in an attempt to identify impairment at an earlier age than is presently achieved. It is their hope that their alternative approach may detect deafness earlier and reduce the requirement to follow up cases with intermittent or less significant degrees of hearing loss in the first year of life.

Scanlon and Bamford are taking a bold step with their revised system, but the reader must be under no misapprehension about the resources required to achieve their alternative service. It is first necessary to establish a full neonatal hearing screening test programme with a back up diagnostic audiology service for

babies of a few weeks of age: this should be available in all districts already but unfortunately it is not and it is confined to only a few. The next requirement is to train health visitors in hearing surveillance and to develop an ongoing support service to ensure that such a vigilant service can continue to operate. Scanlon and Bamford stress that this requires new forms of training and a reallocation of resources. They are not talking about a cost cutting exercise but rather additional resources to establish these two basic introductions to their service before abandoning the distraction test for a trial period.

While respecting the need for the approach taken by Scanlon and Bamford there must be a concern as to whether they will acquire sufficient data within the time scale allocated. There will only be 10-12 000 births over that period in their district giving a yield of only six to eight severely or profoundly deaf children and it will be necessary to allow a period of three or four years to elapse after their two year trial period to see the appearance of any late detected cases missed by their method. Serious consideration will have to be given as to what they should do during that period given the evidence already available to show how effective the distraction test can be (given appropriate training and correct technique). The questions that really should be addressed before their study is undertaken are why do they not achieve better success already, why are their standards not at the level expected and achieved by others, and why do they not allocate resources to further improve the distraction test?

From the data they present there is clear evidence that their current level of performance of the distraction test is poor in terms of its sensitivity, positive predictive value, and referral rate and all of these values are unacceptable and fall far short of those reported by Haggard and Gannon for the Nottingham service.⁴ It may be instructive here to quote the results from the Nottingham service where every effort has been made over the years to refine and improve the distraction test in addition to incorporating neonatal hearing screening for at risk babies and introducing a surveillance method utilising the hints for parents form 'Can your baby hear you'.^{1 6}

Included in the table are the details of the initial factor leading to referral for babies/children with later confirmed congenital or neonatally acquired severe and profound hearing loss. The babies were born over the three year period 1984-6 from a total birth population of approximately 36 000. Babies born in more recent years have not been included because any late detected cases might not have emerged and a true picture would not be portrayed. Cases with mild, moderate, and acquired hearing losses have not been included.

Despite the availability of neonatal screening (for at risk cases) and a parent check list surveillance system the distraction test result was the singly most important factor leading to referral of severely and profoundly deaf children requiring hearing aids.

This method of analysis is useful because it