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Screening infants for hearing loss

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SUMMARY A computerised child health register was used to study the coverage, referral rate, and false positive rate of the eight month hearing distraction test in a cohort of 1990 births to residents of one district during an eight month period. Coverage by the age of 9 months was under 60% and varied with ethnic group and immunisation record. The true problem rate among those referred was 48%. None of the three children in the cohort who had a sensorineural hearing loss was picked up by screening, although it did identify children with conductive loss. The findings question the value of the distraction test as currently used, and underline the usefulness of computerisation, even if limited to child registration, in the evaluation of screening tests.

Without prompt preventive action, deafness in the early years of life can hinder the development of communication. In order to identify affected children as early as possible the Department of Health and Social Security (DHSS) recommended that all infants be screened at about the age of 8 months, using the 'distraction' test, and that this should be done by health visitors because of their role in the assessment of children and in the counselling of parents.[1] Most district health authorities have now implemented early screening for hearing loss for all children, followed by testing of those who are 'screened out' by specially trained clinical medical officers and—where appropriate—audiologists. This programme is complex, and its effectiveness is reduced by the poor sensitivity and specificity of the screening test, and problems of coverage and follow up in areas where the population is mobile.[2–8] Because of this complexity few districts have been able to evaluate their own programmes.[9]

This paper evaluates the process and effectiveness of the programme in one district health authority in an inner city. The investigation was planned as part of a larger study supported by the DHSS of the efficiency, effectiveness, and cost of child health services.

Subjects and methods

RECOMMENDED PROGRAMME OF HEARING SCREENING IN THE STUDY DISTRICT

The health visitors arrange to see all the children when they have reached the age of 8 months, preferably in a clinic, and at a time when a trained colleague is available to assist. The distraction hearing test is carried out according to the recommended method, and if the response is not satisfactory the child is given an appointment for a repeat test, unless the health visitor is so concerned that she refers the child immediately for an audiological assessment. In some cases children are not referred unless a third or even fourth test is also unsatisfactory. Failure of a test may be the result of a respiratory infection, or failure to cooperate, or because of a genuine hearing defect.

A child referred because of an unsatisfactory screen is normally given an appointment for a secondary audiology clinic held by a senior clinical medical officer and a speech therapist. The purpose of these is to separate false positives from those screened out and to refer for tertiary audiology those children with confirmed serious hearing problems. Children with a mild and apparently temporary loss are counselled or referred to the general practitioner or the hospital as appropriate.

The purpose of the tertiary audiology clinic is primarily to assess those children who are difficult to test and those with sensorineural hearing loss, and where appropriate to prescribe hearing aids.

In addition to the screening services offered by the community child health services, general practitioners may also refer children directly for an audiological assessment. They are requested to make all referrals to the secondary and tertiary audiology clinics through the community child health services to ensure that children are not given two appointments. Consultant paediatricians may also refer children directly to the secondary or

tertiary audiology clinics. Neither clinic has 'open access' to parents who are concerned about their child's hearing.

The DHSS guidelines recommend that infants should be screened when they are as near the age of 8 months as possible, and for this reason the present study focused on the tests carried out before 10 months.

METHOD

Sample studied and data collection

No data were readily available, but the health visitors had been using a standard form completed by hand to record the date of the test and the child's response to each stimulus during his or her first and, if necessary, second test. This form was redesigned to make it computer compatible, and to include additional information such as the action taken as a result of the screen. It was then used as the basis of a prospective study of a cohort of 1990 children born between 7 August 1985 and 31 March 1986.

The computerised child health register was used to produce preprinted labels for every eligible child in the birth cohort resident in the district in April 1986. The information printed on each label included the child's 'soundex' code, which is a unique identifier generated by the computer and made up from a code derived from the child's last name, date of birth, sex, and a suffix code and check digit. Also printed on each label was the child's name and address and codes identifying the child's health visitor, the child health clinic or health centre, and the name of the general practitioner. Each label was attached to one of the redesigned forms and delivered to the child's health visitor for completion. Forms without labels were provided for children born between 7 August 1985 and 31 March 1986 who attended a clinic for a hearing test but for whom no prelabelled form was available (perhaps because he or she had recently moved into the district). For these a section was added to be completed with the child's name, address, date of birth, and sex. Each form had a carbonned second sheet that was identified with either the soundex code or the name and address if no label was supplied. Health visitors were asked to keep the top copy for their records and return the carbon copy to the researchers.

The completed forms were collected for those children in the cohort tested up to the end of November 1986. Health visitors were also asked to return the forms of children who were not screened because they had not attended, moved, or died.

Matching of data to child register

The completed forms were then matched by their soundex code to their records on the child health register. For those children for whom no preprinted label had been supplied, the section completed by the health visitor giving the child's name, address, date of birth, and sex made it possible to match data with that kept on microfiche by the district's community child health services and to select a soundex code from this. The number of children in the cohort for whom no screening results were received could then be ascertained.

Referral data

The district's community child health service keeps a card index of each child for whom a referral appointment has been made giving the name, address, and audiology clinic concerned. This allowed us to abstract from clinic notes information on the diagnosis or action taken as a result of the audiological assessment. Children who were to have their test repeated again after their second test were also followed up by asking the health visitors what action was subsequently taken.

Children tested elsewhere

The soundex codes of 10 children who had been tested or assessed elsewhere were also noted and their names and addresses obtained in the same way. The health visitor of three of these children indicated that they had passed their test, but the remainder were followed up to see if an appointment had been made by the community child health services for a secondary or tertiary audiology clinic. Three children of low birth weight and two others were referred directly for an auditory evoked brain stem test.

Validation exercise on those reported not screened

In some cases failure to screen may have been accounted for by the fact that the children would only just have reached the age of 9 months by the last month of data collection, or that forms for other eligible children may not have been returned. To investigate those non-responders a random approximate 10% sample was taken, after excluding 10 children who were known to have moved away, 27 who had failed to attend, and those who had weighed less than 1500 g at birth (who are usually referred directly for tests). The relevant health visitors were then asked whether the remaining children in this sample had actually been screened and if so the date of the test, or, the reason why it had not been carried out.

Results

COVERAGE

Of the 1990 children in the cohort, 1109 forms were

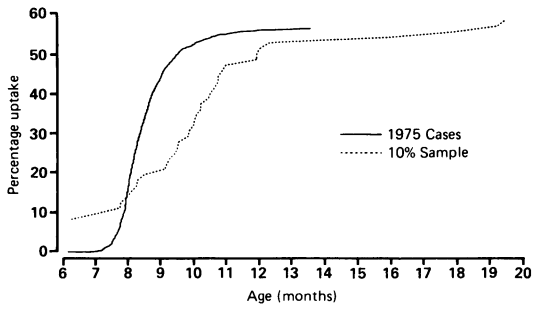

Fig 1 *Cumulative percentage uptake rate for total 1975 cases eligible, and for the 10% sample.*

returned indicating that the child had been screened. As stated earlier a further 15 children had been screened elsewhere or it was found they had already had an audiological assessment. No screening results were received for the remaining 866 children. This implied an overall uptake rate in the study cohort of 56%, excluding the 15 children screened or assessed elsewhere. The mean age at screening for these 1109 children was 8·6 months and the cumulative percentage coverage rate, ascending steeply between 8–9 months, is shown in fig 1. Data on the age at screening was missing for only one child.

The approximate 10% sample of those for whom no screening results were received comprised 77 cases. Thirty one (40%) had failed to attend for their screening test. The most common reason given (accounting for 15 of the 31) was that the health visitor was unable to persuade the parent to attend the clinic or to carry out the test in the child's home. Another 14 had either moved or were part of the district's substantial Bangladeshi community (who often return to their home country for several months at a time). Two children had been incorrectly entered on the regional child health register and were not in the cohort.

Forty three children (56%) had actually been screened but no form returned. A further child was untraceable, and two were tested elsewhere. The mean age at screening was available for 37, and was 10·7 months, significantly higher than for the 1109 children for whom results were received ($p \leq 0{\cdot}0001$). This is reflected in the difference in the cumulative percentage uptake rate shown in fig 1.

The results from the original completed forms correctly reflected the coverage rate up to 9 months of age, though using data from the 10% sample an estimated 72% were screened up to the age of 10 months, and 80% up to the time of analysis (fig 1). Many were tested after the age for which the test is designed, and after a time at which they would have been screened again by clinical medical officers. The results that follow apply only to the 1109 cases said to have been screened in the original cohort.

Table 1 *Percentage coverage and mean age at screening, by sex, ethnic group, mothers' age, and birth weight*

Characteristics	*No of eligible children*	*Total No tested*	*Percentage uptake*		*Mean age at screening (months)*
Sex:					
Male	1014	553	54·5		8·60
Female	961	446	46·4		8·56*
Ethnic group:					
Asian	743	413	55·6	†	8·62
White	746	457	61·3		8·54
Other	175	109	62·3		8·55*
Not known	311	130	41·8		8·62
Mothers' age:					
<20	220	133	60·5		8·53
20–24	587	329	56·0		8·62
25–29	512	311	60·7		8·60
30–34	281	148	52·7		8·50
≥35	182	114	62·6		8·41*
Not known	193	74	38·3		8·79
Birth weight (g):					
<1500	9	5	55·6		9·86
1500–2499	139	80	57·6		8·60
≥2500	1655	960	58·0		8·55*
Not known	172	64	37·2		8·84

*Data on age at screening missing for one case; †$p<0{\cdot}05$, χ^2 (2 DF) 5·91.

FACTORS AFFECTING COVERAGE

The linkage with the child health register meant that the percentage uptake rate and mean age at screening could be analysed by the children's sex and ethnic group, maternal age at birth, and birth weight (table 1), excluding the 15 children tested elsewhere.

For boys the coverage was lower and mean age at screening higher than for girls but not significantly. The coverage for Asian children was significantly lower than that for other children and the mean age at screening higher but not significantly. There was no obvious pattern for coverage and mean age at screening by maternal age. Coverage for infants who had weighed less than 1500 g at birth was lower and the mean age at screening higher (but not significantly) than for the remaining babies, but it is known that these are referred directly.

Use of the child health register data also enabled a comparison to be made between rates of uptake of the first 'triple' immunisation for children who had and who had not been screened. The results (table 2) show that the immunisation uptake rate of those screened for hearing loss is significantly greater than of those who had not been screened.

The coverage of the 317 children with health visitors attached to their general practice is higher, but not significantly so (60%), than that of those whose health visitors were not attached to a practice (56%) (table 3), and very much lower for those for whom data were not available.

Table 2 *Comparison of number of children immunised and number of children screened*

	Total No	*No (%) who had received first dose of triple vaccine*		*p Value*
Screened	1109	1049	(94·6)	<0·001*
Not screened	866	682	(78·8)	
Total	1975	1731	(87·6)	

*z=10·63

Table 3 *Comparison of screening uptake rate between children whose health visitors were attached to a general practice and those who were not*

	Total No	*No (%) screened*
Health visitor attached to a general practice	317	189 (59·6)
Health visitor not attached to a general practice	1644	917 (55·8)
Not known	14	3 (21·4)
Total	1975	1109 (56·2)

ACTION TAKEN AS THE RESULT OF SCREENING

Fig 2 illustrates the complexity of the action taken as a result of screening. Of the 1109 children screened 888 (80%) 'passed' their screen and 207 (19%) were asked to return for a repeat test. Six of the 207 were also referred to their general practitioners, and 20 to a clinical medical officer. Three other children were referred to a clinical medical officer, and eight children (1%) were directly referred for a full audiological assessment. One other child, a preterm infant, was referred directly to the district's child development ('disability') team.

Table 4 gives the outcome of the first test by sex, ethnic group, maternal age at birth, and birth weight. The proportion of infants thought to have a 'problem' as a result of their screen (those who were to have their tests repeated or who were referred for further investigation) is significantly greater for boys and for Asians, but maternal age at birth was not associated with outcome. The analysis by birth weight suggests that a higher proportion of infants of low birth weight thought to have a 'problem' as a result of their first screening test is not statistically robust, but those at highest risk tend to be directly referred.

Of the 207 children recalled for a second test 120 (58%) 'passed', 14 (7%) did not attend, 18 (9%) were to have their tests repeated, 16 (8%) were referred to their clinical medical officer, and 39 (19%) were referred for a full audiological assessment. Of the three referred to their clinical medical officer, one did not attend a second time and the other two were referred for a full audiological assessment.

Of the 18 children recalled for a third test, 12 (67%) passed, four (22%) did not attend, one (6%) was recalled for a fourth test (which was satisfactory), and one (6%) was referred for a full audiological assessment. Of the 16 referred to their clinical medical officer after their second test, 10 (63%) passed, one (6%) did not attend, and five (13%) were referred for a full audiological assessment.

Thus of the 1109 children screened 55 (5%) were eventually referred for audiological assessment as a result of the screening process, one child was referred by his general practioner because of wax in his ears, and another was referred back to the district's child development team. The last child was subsequently referred for full audiological assessment.

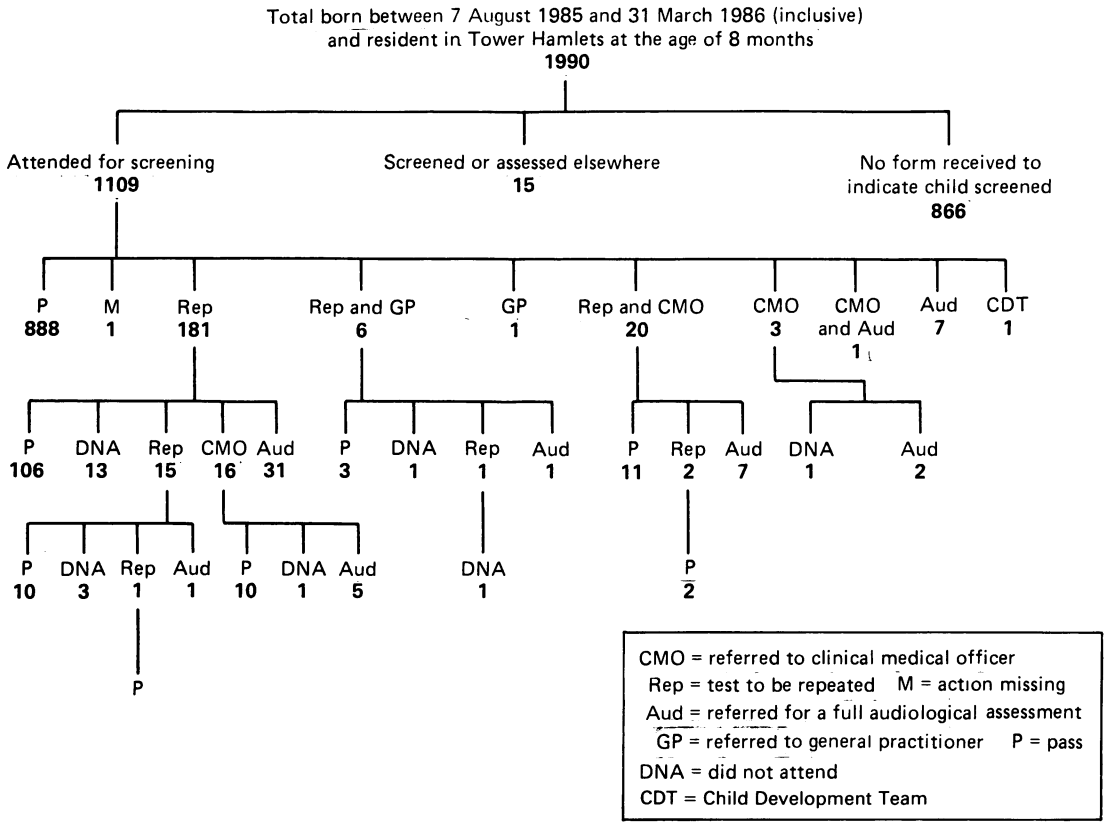

Fig 2 *Flow diagram showing action taken as a result of screening.*

CHILDREN REFERRED FOR AUDIOLOGY AS A RESULT OF SCREENING

Fig 3 shows that no appointment was made for two of the 55 children in the main study referred for a full audiological assessment. Six children (11%) did not attend and were discharged back to their health visitor. Of the remainder, 18 children (38%) were diagnosed as having mild conductive hearing loss, of whom six were subsequently referred to a hospital ear, nose, and throat (ENT) department. A further four children also had problems related to hearing, namely wax in the ears or flat tympanic membranes. No further action was taken for two of these: one was referred back to the child development team and one referred to the general practitioner.

The baby already under the care of the district's child development team who had failed its first test was also referred to the secondary audiology clinic, and subsequently referred to a hospital ENT department for a mild conductive hearing loss.

PREVALENCE OF HEARING PROBLEMS IN CHILDREN WHO WERE FOUND TO HAVE A PROBLEM ON SCREENING

In summary 48 of the children were seen at an audiology clinic, of whom 25 (52%) were discharged without a problem being found. The remaining 23 (48%) had confirmed problems, none of which were sensorineural. Twenty children (1·8% of the 1109 screened) were confirmed to have some degree of conductive deafness picked up by the screening, including two who had been screened elsewhere.

It is of some interest that of the 43 children in the 10% sample who were screened but whose forms were not received four (9·3%) were found to have a conductive hearing loss, a considerably higher proportion than in the main study.

PREVALENCE OF SENSORINEURAL DEAFNESS IN THE COHORT

There were three children in the birth cohort who, by the end of the study, were known to have

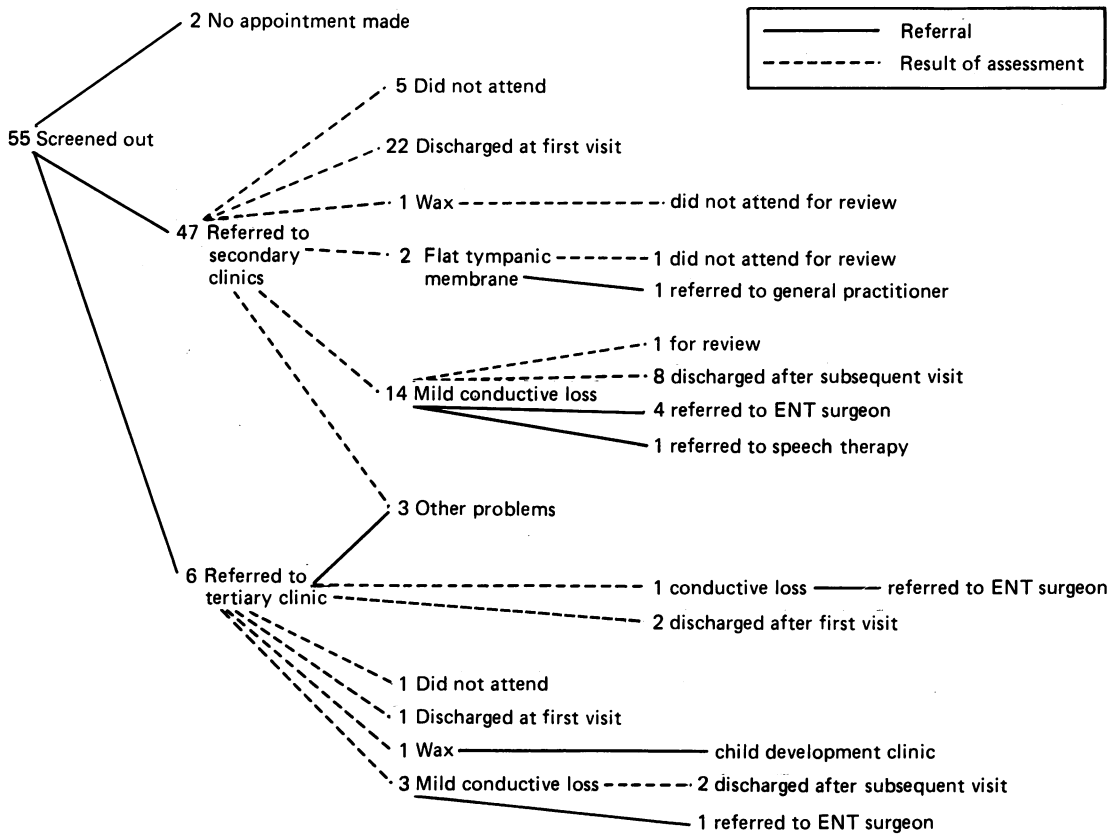

Fig 3 *Intermediate outcome of children referred for full audiological assessment.*

sensorineural hearing loss. One child, diagnosed at 18 months as having mild sensorineural hearing loss, had been screened at the age of 8 months and no defect was reported. The deafness was detected at the tertiary audiology clinic when he attended with his brother who had failed his school screen, accompanied by their deaf father; it seems likely that the hearing loss had been present at 8 months.

Of the five children referred directly (see methods) two were found to have mild sensorineural hearing loss diagnosed by an auditory evoked brain stem test. One of the children was also blind and the other had cerebral palsy.

TIME BETWEEN REFERRAL AND THE FIRST APPOINTMENT

Urgent cases were given priority, but the mean overall time between a child's test and a subsequent audiology appointment was 4·7 months. For the 22 children found to have a problem the mean waiting time was 4·0 months (median 5·3 months), lower (but not significantly so) than the mean of 5·1 months for the 31 remaining children who were seen at a secondary audiology clinic.

The maximum waiting time after screening was 15·2 months, but this occurred when the health visitor concerned was on sick leave for eight months. If the latter child is excluded there was a maximum waiting time of 9·8 months (mean 4·5, and median 5·3).

Discussion

Although the distraction screening for hearing loss was originally introduced to identify (so permitting special care for) infants with sensorineural hearing loss, the current thinking is that it is also important to detect children with conductive hearing loss. It is thought that these children benefit from the counselling given to their parents, as well as the treatment

Table 4 *Results of the first test by sex, ethnic group, mothers' age, and birth weight*

Characteristics	*No tested*	*Percentage with 'problem'*	*p Value*
Sex:			
Male	553*	22·4	<0·05†
Female	556	17·3	
Ethnic group:			
Asian	413	25·9	<0·05‡
White	457	16·6	
Other	109	16·5	
Not known	130*	14·6	
Mothers' age:			
<20	133	15·8	
20–24	329	21·9	
25–29	311	19·0	
30–34	148	20·9	
35+	114	22·8	
Not known	74	14·9	
Birth weight (g):			
<1500	5	60·0	
1500–2499	80	26·3	
≥2500	960	19·4	
Not known	64	15·6	

*Data on action taken missing for one case; †z 2·17; ‡χ^2 (2 DF) 12·66.

they receive, including speech therapy. Our results have shown that infants with conductive hearing loss were being picked up by the screening programme, but that children with sensorineural hearing loss were being detected by other means. If the primary aim of the screen is becoming the detecting of conductive hearing loss it should perhaps be carried out later, as Haggard and Gannon have pointed out, as the optimum age for detecting conductive hearing losses is over 8 months.[10]

It would have been of interest to have collected data on the number of children with conductive hearing loss apparently missed by the screen, but this would have required a second and more skilled screening of the whole group. Moreover, in view of the constantly changing nature of such a loss one would not expect a high degree of repeatability.

In the present study the screening coverage was 56% by the age of 9 months, increasing to about 80% by relaxing the screening age cut off point. There was a significant deficit in coverage of Asians, and a small but not significant deficit of coverage of boys. Reports from other districts have described overall coverage rates for the routine infant screen of between 50% to 90% but we could find no more detailed data comparable with ours.[3–5 8]

The analysis of the Nottingham system included an investigation into the variation of the failure and referral rates between groups of health visitors based at different health centres.[10 11] The variation found raised the question of whether the test as carried out is an objective and repeatable procedure. The fact that a decision to refer a child for a full audiological assessment may be made after taking account of factors other than the result of the test is also reflected in the eight different pathways that we have described by which children reached an audiology clinic, many children seeing the clinical medical officer or their general practitioner, and some having their test repeated more than twice before a final decision was made to refer. As Haggard and Gannon stated, the subjective factors within the screening procedure may well be efficient but they are unspecified.[10] The testing procedure needs further examination.

The referral rate for the present study was 5% and the percentage found to have a problem at an audiology clinic was 48. Comparable studies of the Nottingham system showed an original referral rate of 2·8% and a true problem rate of 59·3% in 1981, which had increased to 4·1% and 78·6%, respectively, by 1984, reflecting the improvements introduced as a result of the working party set up to look into the programme.[10 11] These included the offer of open access for full audiological assessment, a revised training system and refresher courses, plus the introduction of a 'clue list', to alert parents to the possibility of deafness in their babies, used to supplement the community screening.[4 5 7 10–13]

In comparison with the latter figures, the study district had a slightly lower threshold for referral and a lower proportion of true positives, and there is therefore scope for improvement. Trials of the effect of introducing the 'clue list' are under discussion.

The computerisation of preschool health programmes will make it easier to introduce trials of the long term effectiveness of different types of screening, including the consequences of early treatment of conductive deafness and ways of reducing non-attendance. There is an urgent need for such studies to justify the continuation of the 8 month distraction screen, which is a time consuming programme, the resources for which may be put to better use.

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