Screening infants for hearing loss—an economic evaluation

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Abstract

Study objective—The aim was to carry out an economic evaluation of the programme implemented in one district health authority for the screening of infants for hearing loss.

Design—The approach taken was a cost-effectiveness analysis using the methodology of decision analysis to model the options appraised: (1) the conventional screening policy was for a health visitor and colleague to screen at 8–9 months, and at 10 months for each child to be seen again by a clinical medical officer for a developmental assessment plus hearing screen if necessary; (2) the alternative policy was for screening to take place at 10 months only if concern is expressed (or if there is a clinical indication) at the developmental assessment; the introduction of a "clue list" was considered; (3) the third option was no screening.

Main results—The annual expected cost per unit output was £20·57 for the conventional screening policy, between £11·13 and £11·23 for the alternative policy, and £11·27 for the third option of no screening. Introducing the "clue list" under the alternative screening policy is likely to raise the cost per unit output, but the effects are uncertain.

Conclusions—The results suggest that the alternative screening policy is more cost-effective than the conventional policy, but has little advantage over not screening at all. The effects of introducing a clue list need further investigation.

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Concern has been expressed as to whether the recommended programme of screening infants around the age of eight months, using the distraction test, is satisfactory.[1][2] Moreover, despite being a well established part of the preschool assessment, rigorous appraisal has been lacking, particularly so far as its cost-effectiveness is concerned.[3]

An economic evaluation was thus carried out of the programme in one district health authority in an inner city. The policy current at the time of evaluation was for parents to be invited by their health visitor to bring their child at the age of 8–9 months to the respective clinic/health centre during a hearing test session when a colleague was available to assist. Tests may be performed in the home following repeated failure to attend. At 10 months each child was again seen by a clinical medical officer (CMO) for a developmental assessment plus hearing screening test, if necessary. Tests may be carried out either by the CMO, or health visitor, and a colleague. In some cases tests were carried out by the health visitor and colleague separately from the developmental assessment. For purposes of the study it was assumed that children were screened for hearing loss at 10 months under the conventional screening policy only if they missed screening at 8–9 months.

Under the conventional policy parents are therefore being asked to attend two clinic sessions within a short period of time. Given this and the current emphasis in published reports on the importance of parental opinion,[4][5] the alternative screening option appraised was for screening to take place only if concern is expressed at the developmental assessment or if there is a clinical indication. In addition, the effect was considered of implementing a "clue list", as used by the Nottingham Health Authority.[6][7] This is a check list of the general signs indicating that a baby is hearing normally during the first year of life and is issued to the family at the health visitor's initial visit. Since the environment is often too noisy for testing at the developmental assessment, performance of the test on a separate occasion was also considered. The effect of using different testing personnel was examined, and the third option of not screening at all was appraised.

Methods

Economic evaluation in a health care setting involves the comparison of resources consumed by a programme with the health improvements it creates. A cost-effectiveness analysis was carried out using the methodology of decision analysis to model the alternatives for appraisal.[8][9] The purpose of this paper is to discuss the methodological approach taken in the study and the results obtained.

THE MODEL

The decision tree in fig 1 illustrates the possible routes that an infant may follow under the conventional screening policy. It places a child in one of 11 groups. A child will be grouped as either true positive, false positive, false negative, or true negative as a result of being screened at 8–9 months, or similarly as a result of being screened at 10 months. If not screened at all, the child will be grouped as (a) having a hearing problem which could have been detected by screening, or (b) being well but developing symptoms of hearing loss which could have been resolved by screening, or (c) being well and developing no symptoms.

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Similarly, the decision tree in fig 2 suggests that under the alternative screening policy a child is placed in one of 10 groups.

Under the third option of no screening a child is placed into one of three groups, as for a child not screened under the conventional screening policy.

The probability of a child being grouped as a true positive, false positive, false negative, or true negative can be estimated by multiplying the probability of a child being screened by the probability of a screened child being classified as any one of the relevant groups. Following the methodology of Gravelle *et al*,[10] the latter can be expressed in terms of the prevalence (p) (ie, the probability that a screened child has a hearing problem) and the sensitivity (π_1) or specificity (π_2) of the screen. Thus the probability of a screened child being true positive is $p\pi_1$, false positive is $(1-p)(1-\pi_2)$, false negative is $p(1-\pi_1)$, and true negative is $(1-p)\pi_2$.

Figure 1   Decision tree for the conventional screening policy

Figure 2   Decision tree for the alternative screening policy

The probability of an unscreened child falling into any relevant group can be expressed in terms of the probability of an unscreened child developing symptoms of hearing loss (h), and the prevalence rate (q) among those children. Thus the probability of an unscreened child developing a hearing problem is hq, the probability of being well but developing symptoms of a hearing problem is h(1-q), and the probability of being well is (1-h). To obtain the relevant probabilities the latter need to be multiplied by the probability of a child not being screened.

In the case of the alternative screening policy, if the proportion of children who attend their developmental assessment is denoted by x and the proportion screened as w, then the overall proportion of children screened at 10 months is xw, the proportion unscreened who did attend the developmental assessment is x(1-w), and the proportion unscreened who did not attend the developmental assessment is (1-x).

DATA

A prospective cohort study of 1990 children who were born between 7 August 1985 and 31 March 1986 and resident in the district at least up to the age of 8 months has been described elsewhere.[2] This investigated the process and effectiveness of screening infants for hearing loss within the district. For purposes of economic evaluation the study also provided data on the place of test and testing personnel for all tests carried out between the five month period July to November, 1986, inclusive. The study focused mainly on children screened before the age of 10 months, but an approximate 10% sample was taken, two months after initial data collection, of those for whom no screening result was received. Information was collected from the health visitors on why the children were not screened or the date of testing and, where appropriate, on the consequence of referral. This provided additional information, in particular, for children screened over the age of nine months. For clarification purposes it was assumed that those first tested over the age of nine months are screened at 10 months and those before at 8–9 months.

ESTIMATING THE PROBABILITIES

The model was set up to look at the costs and effects for a population of 3500 as this approximately corresponds to the number eligible for screening each year within the district.

Under the conventional screening policy, on the basis of the prospective cohort study, it was assumed that 60% of the population are screened at 8–9 months and 21% at 10 months, thus implying 19% would be unscreened. Data collected from the prospective cohort study and a retrospective analysis of children registered with the district as either deaf or partially hearing (on 13 August 1986) suggested that the prevalence rate of hearing problems in the screened population at 8–9 months is 5% and at 10 months is 13%.

Under the alternative screening policy it was assumed that 81% of the eligible population attend the development assessment at 10 months and 10% of these are consequently screened. Fifty six percent of children screened were assumed to have a problem of some degree.[11] [12]
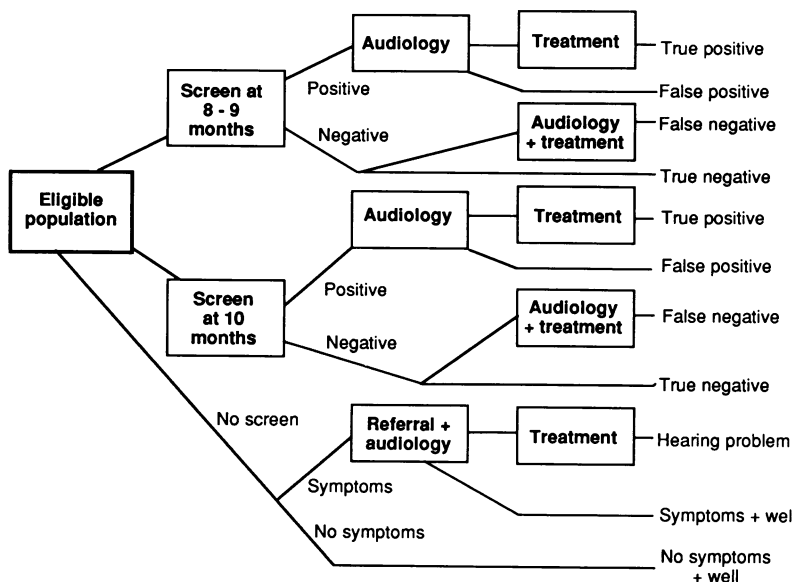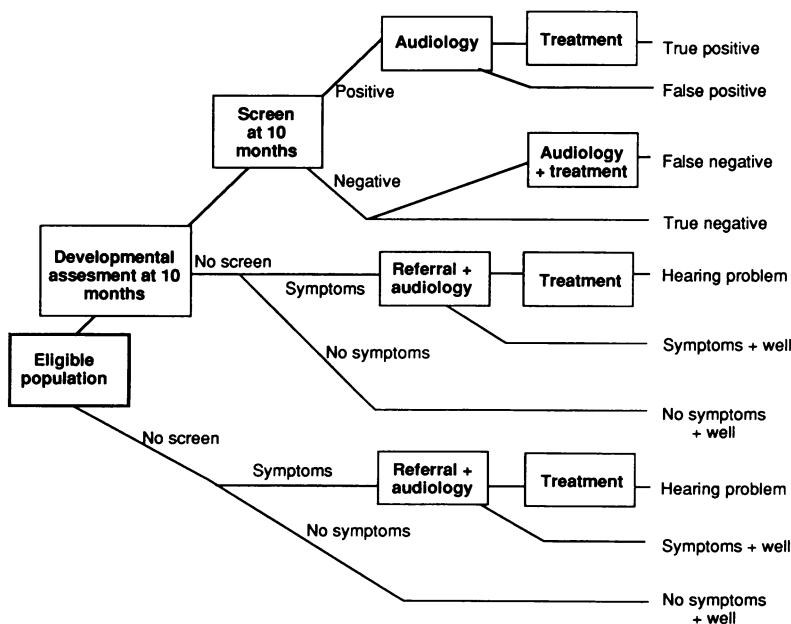
The sensitivity of the test at 8–9 months and at 10 months under both screening policies was assumed to be 60%. The latter was estimated from the data collected on children registered with the district as either deaf or partially hearing and is consistent with figures quoted in the literature.[13][14] The specificity of the test was estimated as 97% at 8–9 months for the conventional screening policy and 95% at 10 months and used for both the conventional and alternative screening policies.

For all policies, it was assumed that, of the children who are not screened but later developed symptoms of hearing loss resulting in a referral to audiology, 56% have a hearing problem of some degree which could have been detected earlier if they had been screened.[11][12] Under the alternative policy, 13% of those who did not attend the developmental assessment were assumed to develop symptoms of hearing loss. The proportion of those not screened who did attend the developmental assessment and who later develop symptoms of hearing loss was assumed to be 3·2%. The latter was estimated by assuming that the prevalence rate in the unscreened and those attending the developmental assessment is equal to 7%, ie, the overall prevalence rate among the screened population, either at 8–9 months or at 10 months, under the conventional policy.

VALUING THE COSTS

Resource use is associated with screening, the marginal cost of questioning parents at the developmental assessment, the cost of issuing a clue list, referral of unscreened children, audiological assessment, and treatment. The associated costs will differ for each group under the options for appraisal. The costs will be incurred both by the health service and by the clients and their families.

The following section describes the values assigned to the costs incurred. All values were estimated at or deflated, using the retail price index, to 1986 prices.

Screening costs

The costs of screening at 8–9 months or at 10 months were estimated for the conventional screening policy as shown in table I. The district finance office provided expenditure figures for the year April 1986/87. The clinic costs were apportioned to hearing test sessions and divided by the estimated number of hearing tests (including aborted attempts) for one year to give an average clinic cost of £1·94.

The gross mid-point salary for each type of personnel involved in testing was divided by the number of hours worked, net of sick leave, bank holiday, and annual leave, to give the time cost per hour and hence per minute. An average test time of 23 minutes for the median test gave a value of £5·78 and £5·89 for the personnel costs associated with screening in the clinic at 8–9 months and at 10 months, respectively.

The parent's travel costs associated with a test in a clinic were estimated using figures on the mode of transport by mothers to clinic presented by Watson[15] and the cost of a journey by each mode reported by the Management Services Division.[16]

A parent's travel time was assumed to be a total of 20 minutes.[15] This, plus 23 minutes of testing time, was valued by the methodology used by the Department of Transport.[17] Non-working time is valued at 3 p per minute (1986 prices) and working time as the gross wage rate plus 36·5% to cover non-wage costs of employment. Figures on the gross wage rate in Greater London were taken from the Department of Employment new earnings survey for 1986.[18][19] A value of 10 p per minute was estimated for women in full time employment and 8 p for women in part time employment. It was further assumed that 30% of women would be in full time and 13% in part time employment.[20] The average time cost per minute was thus estimated as 6 p and the total cost of a parent's time was valued at £2·58.

Hearing tests carried out in the home were assumed to have zero clinic costs. The tests were assumed to take 30 minutes of the tester's time, including travelling, and 23 minutes of the parent's time. The tester's travel cost was based on the report by the Management Services Division.[16] Parent's time was valued at the non-working rate.

Data on the proportion of tests carried out in the clinic and in the home and on the number of tests per screen were taken from the prospective cohort study. The average cost per screen at 8–9 months was thus estimated as £13·38 and at 10 months as £12·20.

Estimates of resource use associated with the event of screening under the alternative policy are shown in table II. The same methodology as for

Table I The resource use associated with the screen under the conventional policy

	Age at screening	
	8–9 months	10 months
Percentage of tests performed in		
clinic	93	88
home	7	12
Number of tests per screen	1·3	1·2
Clinic test costs (£)		
NHS costs: clinic	1·94	1·94
personnel	5·78	5·89
Private costs: travel	0·14	0·14
time	2·58	2·58
Cost per clinic test	10·44	10·55
Home test costs (£)		
NHS costs: personnel	7·42	6·44
travel	0·20	0·20
Private costs: time	0·69	0·69
Cost per home test	8·31	7·33
Average cost per screen (£)	13·38	12·20

Table II The resource use associated with the screen performed under the alternative policy

	Testing personnel*		
	a	b	c
Percentage of tests in:			
clinic	91	100	100
home	9	0	0
Clinic test costs (£)			
NHS costs: clinic	1·94	1·94	1·94
personnel	5·98	6·90	5·98
Private costs: travel	0·14		
time	2·58	1·38	1·38
Cost per clinic test	10·64	10·22	9·30
Home test costs (£)			
NHS costs: personnel	6·44		
travel	0·20		
Private costs: time	0·69		
Cost per home test	7·33		
Average cost per screen (£)	10·34	12·29	11·37

* a = health visitor and colleague screening at a separate visit to the developmental assessment.
  b = clinical medical officer and colleague screening at the same visit as the developmental assessment.
  c = health visitor and colleague screening at the same visit as the developmental assessment.

the conventional policy was used, the estimates differing depending on the testing personnel and whether testing takes place at the developmental assessment. It was assumed that 1·2 tests are carried out per screen.

Additional developmental assessment costs

The additional costs of attending the developmental assessment in order to determine whether a child requires screening are shown in table III. The average cost was estimated to be 65 p. It was assumed that two extra minutes of the CMO's and the parent's time would be required. In addition the prospective cohort study suggested that an interpreter would be present in 4% of the cases. Clinic costs were assumed to be 16 p on the basis that a clinic cost per minute of 8 p could be estimated from screening costs.

Costs associated with issuing a clue list

The cost of issuing the clue list to a child was estimated to be 52 p by assuming it took an extra 3 minutes of health visitor's and parent's time. Again it was assumed that an interpreter would be present in 4% of the cases. The parent's time was valued at the non-working rate and the cost of the form was assumed to be 3 p. The breakdown of costs is shown in table III. The prospective cohort study suggests that 108% of the population eligible for the developmental assessment would receive a clue list.

Referral costs

The approximate figure of £3 was assumed for a referral by assuming it could take 5 minutes of the time of a health visitor, CMO, or general practitioner and 45 minutes of a parent's time, including waiting and travel.[15] Moreover, some referrals may be incidental, as in the case of a child being seen routinely for another reason.

Audiology costs

It was assumed that all children referred for an audiological assessment attend the audiology clinic. It was not possible to obtain the relevant health service data from the health authority in order to cost an audiological assessment. Instead a proxy of £31 was based on the figures on outpatient attendance published by the Department of Health and Social Security Welsh Office on health service costing returns for the year ending 31 March 1987.

Private costs were assumed to be the equivalent of £9, taking account of travel and waiting costs. The total cost of one audiology visit was therefore valued at £40. On the basis of the prospective cohort study it was assumed that children found to have hearing losses require two visits. All others require only one visit.

Treatment costs

Not all children with hearing losses (defined as those requiring two audiology visits) will be referred for further investigation. Those with temporary losses, for example, may be discharged after counselling the parents. The proportions referred were estimated on the basis of the prospective cohort study.

It was assumed, using data from published studies,[11] [12] that of those referred for further investigation 45% incur treatment costs. It was assumed that the remainder incur the costs of review, which are equivalent to two visits to an audiology clinic, ie, £80.

Health service costs for treatment were adapted from figures quoted by a private London hospital and deflated by 35% to take account of the profit margin. A further £22·50 was added for parents' travel and waiting costs to give a treatment cost of £443·40.

Discounting

Allowance was made for the differential timing of audiology and treatment costs by discounting at 5%. It was assumed that audiology and treatment costs are incurred three years later for children referred after false negative results and two years later for those not screened at all. Table IV shows the resulting audiology and treatment costs.

Referral costs were also discounted at 5% and assumed to arise two years later than screening to give a value of £2·72.

Table III The additional costs associated with determining whether a child needs screening under the alternative policy

	Additional developmental assessment costs (£)	Costs associated with the clue list (£)
Personnel	0·37	0·40
Clinic	0·16	—
Private costs	0·12	0·09
Cost of form	—	0·03
Average cost	0·65	0·52

Table IV The resource use associated with audiology and treatment

Group	Audiology (£)	Treatment (£)
Screened at 8–9 months[a]		
True positive	76	46·03
False positive	40	—
False negative	65·65	39·76
True negative	—	—
Screened at 10 months[a]		
True positive	78·40	0
False positive	40	—
False negative	67·72	0
True negative	—	—
Screened at 10 months[b]		
True positive	77·20	31·71
False positive	40	—
False negative	66·68	27·39
True negative	—	—
Unscreened[c]		
Hearing problems	70·02	28·76
Symptoms + well	36·28	—
No symptoms + well	—	—

[a] Under the conventional screening policy
[b] Under the alternative screening policy
[c] Under all policies, including those who have had a developmental assessment under the alternative policy

Table V The values assigned to the weights used in the output measure

Hearing state	Weight*	Value
No problem:	H_{TN8}	1
	H_{TN10}	0·95
	H_{NSW10}	0·925
	H_{NSW}	0·9
	H_{SW10}	0·875
	H_{SW}	0·85
	H_{FP10}	0·825
	H_{FP8}	0·8
Problem:	H_{TP8}	0·6
	H_{TP10}	0·5
	H_{HL}	0·3
	H_{HL10}	0·2
	H_{FN8}	0·1
	H_{FN10}	0

* H denotes the weighting. For children screened the subscript TN denotes a true negative, FP a false positive, TP a true positive, and FN a false negative screening result. The additional subscripts 8 and 10 denote screening at 8–9 months and at 10 months. For children not screened the subscript NSW denotes those who develop no symptoms of hearing loss and are well, SW denotes those who develop symptoms but are well, and HL denotes those with hearing problems. The additional subscript 10 denotes those who have a developmental assessment under the alternative screening policy.

Table V shows the values chosen to weight the number of children falling into each group under the options appraised in order to calculate the output measure.

COSTS AND EFFECTS

The annual expected cost of an option is estimated by multiplying the size of the eligible population by the sum of the costs associated with each group multiplied by the respective probability of a child being in that group.

Similarly, the output measure is the size of the eligible population, multiplied by the sum of the weights associated with each group multiplied by the respective probability of a child being in that group.

The most efficient option is therefore that with the lowest annual expected cost per unit output. The annual expected cost per unit output was estimated for each option by setting the model up as macros in lotus 123 worksheets[21] and substituting the above estimates.

Results

A comparison of the annual expected cost per unit output is shown in table VI. The results suggest that the alternative policy of screening at 10 months, if concern is expressed regarding the child's hearing during developmental assessment, is more cost-effective than the conventional screening policy. Moreover, the model predicts that the alternative screening policy has little advantage over a policy of no screening.

Issuing the clue list at the health visitor's initial visit increases the cost per unit output for the alternative screening policy to £11·86, if screening is assumed to be carried out by the CMO and a colleague. It is likely, however, that certain variables within the model might change for the alternative policy under the influence of the clue list. Table VII shows that the model predicts that an increase in attendance rate for the developmental assessment, or an increase in the sensitivity of the test or the proportion screened,

may still cause a higher cost per unit output for the alternative policy than if the clue list had not been introduced. If, however, introducing the clue list causes parents to become better predictors of hearing problems, such that the proportion of children with hearing problems among those screened is increased, the cost per unit output may decrease.

The methodology of Gravelle *et al*[10] was used to test the sensitivity of the results to the values assigned to the costs and the variables used to estimate the probabilities. The values were reduced in turn by 25%, so were the discount rates and the years discounted.

The analysis suggests that the main components affecting the cost per unit output for the options appraised are audiology costs, and in the case of the alternative screening policy and the option of no screening, the treatment costs. Given this, it is not surprising to find the results are sensitive to the prevalence rate. In addition, the cost per unit output under the conventional screening policy is sensitive to the screening costs at 8–9 months and the percentage screened at 8–9 months. The results suggest, however, that the uptake needs to be close to zero both for screening at 8–9 months and at 10 months under the conventional policy, ie, no screening, for the cost per unit output to be comparable with the alternative screening policy.

A low cost estimate of the screening costs for the conventional policy was estimated by assuming the minimum allocation of running and rent costs per hearing test and a test time of 12 minutes for a clinic test and assuming a home test takes up 15 minutes of the tester's time and 10 minutes of the parent's time valued at 3 p per minute. Health service travel costs were assumed to be equal to private travel costs valued at 14 p. Thus the low estimate for the average cost per screen at 8–9 months was £6·93 and at 10 months was £6·31. The resulting cost per unit output was £15·03 which does not affect the overall results.

It was assumed that the prevalence rate for screen detectable hearing losses under the alternative policy is the same as the overall rate at 8–9 months and at 10 months under the conventional screening policy. One could, however, expect the prevalence rate at the age of 10 months to be greater than that at the age of 8–9 months, since an increase in the incidence of middle ear problems, such as glue ear, occurs around 8 months.[3] In the latter case, however, screening at 8–9 months misses cases only apparent at 10 months and hence some of those screened as true negative and false positive at 8–9 months may at 10 months have problems. The argument against the conventional screening policy may therefore be strengthened.

It was also argued that not all children with hearing losses, ie, those requiring two visits to an audiology clinic, require a referral for further investigation to see if they need treatment. The sensitivity of the results to the assumptions used regarding the proportions requiring further investigation and treatment was tested by examining two extreme situations. The first assumes that all children referred for an audiological assessment require two visits to an audiology clinic and all require treatment, and the second

Table VI The annual expected cost per unit output for the options appraised

Option	Cost per unit output (£)
Conventional screening policy	20·57
Alternative policy—test performed by:	
(a) Health visitor and colleague at a separate visit	11·23
(b) Clinical medical officer and colleague at the same visit	11·22
(c) Health visitor and colleague at the same visit	11·13
No Screening	11·27

*Table VII The effects of introducing a clue list under the alternative policy**

Extreme effects caused by introducing the clue list	Cost per unit output (£)
(a) No change in behaviour	11·86†
(b) 100% attendance for developmental assessment	11·86†
(c) 100% test sensitivity	12·05
(d) All those attending the developmental assessment are screened	11·62
(e) Zero prevalence among those not screened	10·90

* test is performed by the clinical medical officer and colleague at the same visit as the developmental assessment.
† differences are lost in the rounding up of figures

assumes that all hearing problems require only one visit to audiology and therefore none require any form of treatment. The overall results were stable.

The sensitivity of the results to the attendance rate of an audiological assessment was tested by assuming that the attendance rate for those screened at 8–9 months is 90% and at 10 months is 76%, as suggested by the prospective cohort study. In addition, as the prevalence rate among those who do not attend their audiology appointment is unknown, two hypothetical situations were considered. The first assumes that all those who do not attend audiology have no hearing problems with a weight equal to false positive screening result at 8–9 months or at 10 months, respectively. The second situation assumes that the distribution of hearing problems among those who do not attend audiology is the same as for those not screened. The overall results were unaffected.

The sensitivity of the results to the ordering of the weights shown in table V was tested by substituting $H_{FP8} > H_{FP10} > H_{SW} > H_{SW10}$ for $H_{SW10} > H_{SW} > H_{FP10} > H_{FP8}$ and $H_{FN10} > H_{FN8} > H_{HL10} > H_{HL}$ for $H_{HL} > H_{HL10} > H_{FN8} > H_{FN10}$ both separately and combined. In addition, the effect of the distribution of weights was also analysed for the original ordering and substitutions by giving an even distribution to the weights.

The effect was also investigated of evenly distributing the weights and imposing the following restrictions. True negative screening results, at 8–9 months and 10 months, are given the same weight as an unscreened child who does not develop symptoms of hearing loss, thus $H_{TN8} = H_{TN10} = H_{NSW10} = H_{NSW}$. Unscreened children who develop symptoms of hearing loss are given the same weight as false positive screening results, thus $H_{SW10} = H_{SW} = H_{FP10} = H_{FP8}$. True positive results are given the same weight, thus $H_{TP8} = H_{TP10}$, and the weights given to unscreened children with hearing problems are the same weight as for false negative screening results, thus $H_{HL} = H_{HL10} = H_{FN8} = H_{FN10}$.

The situation was also examined whereby preference is given in the weighting of true screening results. The overall results remain unaffected unless extreme weight is given to true negative results and they are considered to be at least twice the value of the outcome of unscreened children who do not develop any symptoms of hearing loss.

Discussion

Decision analysis involves stating, for each option appraised, all possible outcomes which are assigned a probability estimate and value of importance. It is a systematic approach to decision making under uncertainty and is particularly appropriate to the field of health care where clinical decisions are made on data, evidence, and information and its interpretation, which are not free from error. Where probabilities and values are judgmental, sensitivity analysis can be applied to assess whether these judgments affect the choice of option.[8] [9]

Several uncertainties surrounding the screening for hearing loss were highlighted in the study. Arbitrary weights from 0 to 1 were used to reflect the value of the health outcomes under the different options. Greatest value was given to those outcomes where children have no hearing problem and within this ordering, false results, because of the anxiety caused and the consequence of delayed diagnosis, were valued less than true results. The ordering also depended on whether the outcome was known sooner or later. Evaluation was made difficult by the absence of any quantitative measure of the effects of early diagnosis and treatment of hearing problems. Further research is needed in this area.

Uncertainties arose concerning the probability estimates; in addition the health service costs of audiology and treatment were based on crude data. Not unreasonable hypothetical situations also had to be considered in order to estimate the health service costs of referral, the clue list, and private costs associated with the respective events under the options appraised.

Given the uncertainties, an analysis was carried out to test the sensitivity of the results to the underlying assumptions. The results appear fairly robust. Nonetheless, they should be viewed with caution because of the arbitrary nature of the health outcomes.

The results suggest that the alternative policy of screening at 10 months, if concern is expressed regarding a child's hearing at its developmental assessment, is more cost-effective than the conventional screening policy. Moreover, the alternative has little advantage over not screening at all. It may, however, be argued that it is unethical not to screen at all at this age since it implies taking away a service currently available.

Under the alternative screening policy the cost per unit output was found to be similar regardless of the testing personnel or whether testing is arranged for a separate appointment.

At the time of analysis, some health visitors in the district did not attempt to carry out hearing tests in the home as they found the environment unsuitable, particularly if other children are present diverting the attention of the infant being tested. In addition, the environment is often too noisy for testing at the developmental assessment. Thus it is suggested that if screening were to be introduced under the alternative policy children should be given a separate appointment for testing and tests should be carried out in the home only when necessary.

The DHSS[1] recommended that health visitors were the most appropriate personnel to carry out the hearing screen because of their role in the overall assessment of the children and the counselling of parents. Data on testing personnel from the prospective cohort study revealed that the assisting colleague or "distractor" may be a health visitor, student health visitor, clinic assistant, or even a school nurse. It may be that the appropriateness of personnel other than health visitors needs to be considered, particularly if they have not had any formal training.

It was also found that introducing a clue list under the alternative screening policy can be justified if it leads to parents becoming better predictors of hearing problems. Further investi-

gation is needed, however, possibly in the form of a controlled trial.

CONCLUSION

The arbitrary nature of the weights given to reflect the value of health outcomes requires that the results of the study be viewed cautiously. More research is needed into the quantitative effects of early intervention and treatment of hearing problems.

The results suggest that the alternative screening policy is more cost-effective than the conventional policy, but has little advantage over not screening at all. If screening were to be introduced under the alternative policy it is suggested that it be carried out by a health visitor and colleague and that tests in the home should only take place where necessary. The study also suggests that the effects of introducing a clue list need further investigation.

1 DHSS Advisory Committee on Services for Hearing Impaired People. Final report of the subcommittee appointed to consider services for hearing impaired children. London: HMSO, 1981.
2 Brown J, Watson E, Alberman E. Screening infants for hearing loss. *Arch Dis Child* 1989; **64**: 1488–95.
3 Haggard MP, Gannon MM. Analysis from service records of screening systems for hearing impairment in pre-school children. Internal Report Series A, No 3. Nottingham: Medical Research Council Institute of Hearing Research, 1985.
4 Butler J. *Child health surveillance in primary care, a critical review.* London: HMSO, 1989.
5 Hall B, ed. Health for all children. A programme for child health surveillance. The Report of the Joint Working Party on Child Health Surveillance. Oxford: Oxford University Press, 1989.
6 Latham AD, Haggard MP. A pilot study to detect hearing impairment in the young. *Midwife, Health Visitor and Community Nurse* 1980; **16**: 370–4.
7 Hitchings V, Haggard MP. Incorporation of parental suspicions in screening infants' hearing. *Br J Audiol* 1983; **18**: 71–5.
8 Weinstein MC, Fineberg HV, Elstein AS, et al. *Clinical decision analysis.* Philadelphia: WB Saunders, 1980.
9 Aspinall PA, Hill AR. Is screening worthwhile? In: Macfarlane JA, ed. *Progress in child health*, Vol. 1. Edinburgh: Churchill Livingstone, 1984: 243–60.
10 Gravelle HSE, Simpson PR, Chamberlain J. Breast cancer screening and health service costs. *J Health Econ* 1982: 1: 185–207.
11 McCormick B, Woods SA, Cope Y, Spavins FM. Analysis of records from an open-access audiology service. *Br J Audiol* 1984; **18**: 127–32.
12 Allen TJ, Richardson T. Providing open hearing clinics in a rural area of Cambridgeshire. *Health Visitor* 1988; **61**: 52–5.
13 National Deaf Children's Society. *Discovering deafness. A report for National Deaf Children's Week 15–21 May 1983.* London: National Deaf Children's Society, 1983.
14 Newton V. Aetiology of bilateral sensorineural hearing loss in children. *J Laryngol Otol* 1985; **10** (suppl): 1–57.
15 Watson E. Health of infants and mothers and "appropriateness" of use of health services by different ethnic groups in the inner city [PhD thesis]. London: University of London, 1986.
16 Management Services Division for Tower Hamlets District Health Authority. Transport analysis—community health visitors. Report No 1585. London: Tower Hamlets Health Authority.
17 Department of Transport. *Values for journey time savings and accident prevention.* London: Department of Transport, 1987.
18 Department of Employment. *New earnings survey 1986. Part E: Analysis by region and age group.* London: HMSO, 1987.
19 Department of Employment. *New earnings survey 1986. Part F: Hours, earnings of part-time women employees, size of organisation.* London: HMSO, 1987.
20 Office of Population and Census Surveys. *Census 1981 England and Wales County reports, Greater London.* London: HMSO, 1981.
21 Cobb D, with Cobb SS, Cobb GB. *1-2-3 Handbook. The complete guide for power users.* Toronto: Bantum Books, 1986.