Cost-effectiveness of two methods of screening for asymptomatic bacteriuria

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Rich, G., Glass, N. J., and Selkon, J. B. (1976). *British Journal of Preventive and Social Medicine*, 30, 54-59. **Cost effectiveness of two methods of screening for asymptomatic bacteriuria.** A comparison of two methods of screening schoolgirls for asymptomatic bacteriuria has shown that a supervised method of collection successfully obtained specimens of urine from 96·3%, but that the home self-administered use of dipslides was successful in only 70·2%. The failure to obtain the return of satisfactory dipslides was most frequent in children under seven and over 11 years of age, and in children from the lower social classes; satisfactory dipslides were returned by 84% of children from social classes I, II, and III non-manual workers, but by only 58% of children from social class V and the unemployed. The cost per child screened was £0·77 with the supervised method and £0·26 with the dipslide method. An alternative supervised method which would have successfully screened 85% would have cost £0·55 per child screened. Using the home dipslide method, the cost per case of asymptomatic bacteriuria detected would vary from £10·40 to £20·00, depending on the age group screened.

Surveys of urinary tract infection (UTI) have shown that children, like adults, may have UTI without any symptoms, or with symptoms which do not lead their parents to seek medical advice (Kunin, Zacha, and Paquin, 1962; Meadow, White, and Johnston, 1969; Asscher *et al.*, 1973; Mair, 1973; Savage *et al.*, 1973; Newcastle Asymptomatic Bacteriuria Investigation, 1975). This condition is usually referred to as asymptomatic bacteriuria (ASB). The prevalence of ASB is considerably higher in girls than in boys (Kunin *et al.*, 1962; Newcastle ASB Investigation, 1975).

Approximately 15% of girls with ASB have renal scarring when first detected, although only in a small proportion is it extensive. The possibility that the early detection and treatment of ASB may prevent progression of renal damage leading to impaired renal function in later life has stimulated an increasing interest in screening for ASB. Several prospective studies have therefore been undertaken to investigate the natural history of ASB and the effectiveness of treatment (Savage *et al.*, 1975; Newcastle ASB Investigation, 1975). In the meantime, it is necessary to

delineate the methods which could be used for screening programme of children. The use of the supervised collection of midstream specimens of urine (MSU) has been compared with the self-administered use of slides coated with bacteriological culture medium (dipslides) by Asscher *et al.* (1973) and Edwards *et al.* (1975). The 'success' rate and costs of these two methods have been analysed and both studies showed that the self-administered dipslide was as effective as, and much less costly than, the supervised method. As a continuation of the Newcastle epidemiological studies on ASB, an investigation has been undertaken of the comparative sensitivity and reliability of these two methods of screening with particular emphasis on the relative costs and effectiveness in different social classes.

PATIENTS AND METHODS

The study took place in seven schools in the Newcastle area, six primary and one secondary during the period September 1973 to March 1974. The schools had on their registers 1322

girls, aged between four and 16 years. A costing analysis was carried out in three of the schools containing just over 500 girls.

Each child was given an explanatory letter to the parents the week before screening began. A class list of children was prepared and each child was given a survey number. Each dipslide* was labelled with the child's name and survey number and then it was packed into an envelope containing a letter of instruction to parents identical with that used by Edwards *et al.* (1975) (Addendum). The study nurse distributed the dipslides to each class and, in the presence of the teacher, explained the procedure to be followed. The next day the teachers collected the dipslides and reminded defaulters to bring their specimens. On the day after that, all the slides which had been returned were collected by the nurse and taken to the laboratory. The slides were incubated overnight at a temperature of 37°C and then read, using the manufacturer's 'model charts', and the genus of the isolates was identified. The names of girls who had positive dipslides, with growth equivalent to 10⁵ organisms or more per ml, were given to the nurse who then visited the parents and arranged for another dipslide to be inoculated and mailed to the laboratory.

After the dipslides had been collected, each girl attended the mobile laboratory (Asscher *et al.*, 1973), which was parked in the school grounds. A supervised MSU was collected and quantitative bacteriology carried out by the resident technician, using the methods and criteria described in the Newcastle ASB Investigation (1975). Any child having $\geq 10^5$ organisms per ml in the MSU specimen or two positive dipslides was recalled on successive days and two further MSUs were obtained after the perineum had been cleaned with sterile water. All girls who had three MSUs containing $\geq 10^5$

organisms per ml were considered to have significant bacteriuria, and were then referred to hospital for further investigation.

In three schools, the various participants were asked to keep a detailed record of the various tasks which they performed, and in particular, to time the sessions devoted to each task in the case of both the dipslide and the supervised MSU procedures.

RESULTS

Of the 1329 girls on the school registers of the seven schools visited, 1280 (96.3%) yielded a supervised MSU specimen, and 1146 (86.2%) returned a dipslide (Table I). Of the 49 girls who did not have an MSU collected, 32 were absent for the whole period the caravan was at the school (two because they were in hospital and 30 without explanation); the parents of 16 of the girls refused to give permission and one girl refused to co-operate. Of the 1146 dipslides returned, 213 (19%) were unsatisfactory for examination for bacteriuria. Many slides had been damaged by fingering or all or part of the culture medium had been removed, some were returned immersed in urine, and others yielded the growth of two or more species of organisms. In addition, it appeared that a small number of slides had not been inoculated, and this may also have applied to a few which were classified as showing no growth. Dipslides which were suitable for examination were thus obtained from 933 (70.2%) of the 1329 girls on the school registers.

Of the 1280 girls who had an MSU specimen collected, 41 (3.2%) yielded growth of $\geq 10^5$ organisms per ml. On two repeat specimens, 10 failed to yield growth from either specimen and 31 (2.4%) yielded growth of $\geq 10^5$ organisms per ml in both specimens and were classified as having significant bacteriuria. Of the 933 girls examined by the dipslide method, 46 (4.9%) yielded significant growth on the first

TABLE I
RETURN OF SPECIMENS RELATED TO AGE

Age Group (years)	Total	MSU Obtained	Dipslide Returned	Valid Dipslide	Dipslide Unsatisfactory
4 to 6	406	396 (98)	343 (85)	262 (65)	81 (24)
7 to 11	605	588 (97)	566 (94)	469 (78)	97 (17)
12 to 16	318	296 (93)	237 (75)	202 (64)	35 (15)
Total	1329	1280 (96)	1146 (86)	933 (70)	213 (19)

Percentages are given in parentheses

*Uricult—Bristol Laboratories, Middlesex

test, but in only 29 (3.1%) was this confirmed in a second test. Furthermore, six of the 29 girls gave negative results in each of the two MSU specimens collected within that week, and were therefore also regarded as being false positives.

The efficiency of the dipslide as a screening test is examined in Table II for the 933 children

TABLE II
THE EFFICIENCY OF THE DIPSLIDE METHOD AS A SCREENING TEST IN GIRLS WHO RETURNED A DIPSLIDE

Result of Dipslide Screening Test	Final Assessment After Three MSU Examinations		Total
	Positive	Negative	
Positive	23	23	46
Negative or not satisfactory	3	884	887
Total	26	907	933

who returned dipslides, and the return of an unsatisfactory dipslide is regarded as equivalent to a negative result. From this analysis, and using the formulae of Wilson and Jungner (1968), the sensitivity of the dipslide method was 88% and its specificity 97.5%. However, if, for this analysis, the failure to return a dipslide was also regarded as equivalent to a negative result (Table III), then the sensitivity of the dipslide method was 74% and its specificity 98.2%.

TABLE III
THE EFFICIENCY OF THE DIPSLIDE METHOD AS A SCREENING TEST IN GIRLS

Result of Dipslide Screening Test	Final Assessment After Three MSU Examinations		Total
	Positive	Negative	
Positive	23	23	46
Negative or not satisfactory or not returned	8	1226	1234
Total	31	1249	1280

FACTORS ASSOCIATED WITH THE FAILURE TO RETURN SATISFACTORY DIPSLIDES

AGE As shown in Table I, dipslides were returned by 85% of girls aged between four and six years, 94% of girls aged between seven and 11 years, and 75% of girls aged between 12 and 16 years. Satisfactory dipslides were returned

by 65%, 78%, and 64%, respectively. The poorer returns in the youngest and oldest groups compared with the seven to 11-year group are statistically significant ($P < 0.001$).

SOCIAL CLASS One of the purposes of the study was to examine whether the 'success' of the home dipslide method varied between social classes. The occupation of the child's father was found from school medical records but this was available for only 1170 (88%), since the parents are not obliged to provide this information. These 1170 girls were classified into the Registrar General's six social classes, plus those 'unemployed'. The percentage not returning a dipslide or returning a spoilt slide—the 'failure' rate—was then calculated. As shown in Table IV, the failure rate was 16% for social class I, II, and III non-manual workers, 25% for social class III manual workers and IV, and 42% for social class V and the unemployed. These differences are statistically significant.

TABLE IV
FAILURE TO OBTAIN A SATISFACTORY DIPSLIDE RELATED TO SOCIAL CLASS

Social Class	No. of Children	'Failure' Rate	
		(No.)	(%)
I, II, and III non-manual	129	21	16
III Manual	543	138	25
IV	176	44	25
V	232	98	42
Unemployed	90	38	42
Unclassified	159	57	36
Total	1329	396	30

COST OF THE DIPSLIDE METHOD

An analysis of the time devoted to the various tasks showed that, out of a total of 5.3 minutes expended per dipslide circulated, 2.6 minutes were for administration (including packing and distribution), 1.7 minutes were for examining and recording the results in the laboratory, and 1.0 minute was for visiting the parents of the girls with a positive dipslide result.

From data kindly provided by Dr Asscher, the comparative times for his study, which used a slightly different method, were 2.1 minutes for administration and 2 minutes for examining and recording. Although the method used by Asscher

et al. (1973) included home visits to 'positives' by a health visitor, this was not specifically allowed for in his calculations. The lower figure for administration in their results may partly reflect the fact that they made no time allowance for distribution and collection of the dipslides, or for typists' time in the preparation of labels. The results from the study of Edwards *et al.* (1975) are difficult to compare with the present study since a precise time analysis of the home dipslide method was not carried out.

In calculating the costs, the assumption has been made that the administration of the scheme would be carried out by a clerk and the home visits by a health visitor. Thus the administrative costs include the time spent by the clerk in delivering the dipslides to the schools and collecting them as well as for general administrative tasks in connexion with the scheme, such as record-keeping, filing, and contact with schools and doctors. It has also been assumed that all the participants have no slack time, that is, when not employed on the scheme they can be given other tasks.

The cost of the dipslide scheme per 1000 dipslides was calculated using the same 1972 prices and salary scales used by Asscher *et al.* (1973). These are set out in Table V and show that the cost of each dipslide distributed was £0.18, and for each child screened £0.26. The cost incurred by Asscher *et al.* (1973) per dipslide distributed (not per child screened, as stated), was about £0.15, but this figure excluded, the cost of the items mentioned above—namely

labelling, stationery, and home-visiting—and probably also the cost of the plastic jars which were used in their home dipslide method. On the basis of our assessments, these omissions could increase the cost of their method by as much as £0.09 per dipslide distributed. On their 91% success rate, this would give a cost per child screened of £0.26. The cost figure determined by Edwards *et al.* (1975) is once again not strictly comparable, but an estimated figure would be £0.12 per dipslide distributed.

To the total cost of £181 per 1000 dipslides must be added the 'opportunity' cost of approximately 30 hours of laboratory space and 60 hours of office space. This opportunity cost will vary according to circumstances. Some allowance should also be made for the time of a higher level administrator, medical or lay. These last two factors are likely to add at least £0.02 to the cost per dipslide distributed.

COST OF THE SUPERVISED MSU METHOD

Timings were made for the supervised MSU procedure and found to differ little from the home dipslide method. However, since it cannot be assumed that the nurse and technician could be fully employed carrying out other tasks when not working on the screening programme, the use of these timings would underestimate the cost of the supervised method. Consequently, the total time for the days during which specimens were collected was used as the time for which the staff would be employed plus an allowance for the time taken to move the caravan between

TABLE V
COST OF THREE SCREENING METHODS (IN £ PER 1000 ELIGIBLE CHILDREN)

Method	Dipslide (Distributed to total but 70% successfully returned)	MSU 96% Screened (960 children)	MSU 85% Screened (850 children)
Labour*	86	441	240
Dipslides, laboratory media ..	77	82	73
Mileage, stationery, postage, sundries	18	70	75
Vehicle capital cost	—	142	77
Total cost	181	735	465
Cost per 'eligible' child	£0.18	£0.74	£0.47
child screened	£0.26	£0.77	£0.55

*Cost of labour used for administration, examining and recording specimens, and visiting parents of children with positive results, see text

schools. It was necessary to distinguish between the pace which a research project, with its attempt to achieve coverage of 100%, might demand, and the pace which would be more appropriate for a public health screening programme, where a somewhat lower percentage yield might be acceptable. At the research pace, where two further specimens were demanded from positives, the absentees or recalcitrants were given ample time to turn up, so that 1280 (96.3%) girls on the register were tested. This took 41 days of testing and seven days for moving the caravan.

A programme which would have confined itself to going through each class, obtaining only a second specimen from the 'positives' and leaving those 'positives' who were discovered on the final day to be approached at home by a health visitor, would have obtained an 85% success rate in 19 testing days, plus seven moving days.

The costs of these two programmes have been assessed on the assumption that the staff are paid only for those days on which the scheme is in operation, that is during school term time, and that it would be possible to move from school to school in one day. It has also been assumed that most of the administrative tasks would be carried out by the staff on the moving day, or during slack periods. The capital cost of the caravan, £5000, has been converted to a 10% interest charge.

As shown in Table V, to get a 96% yield costs about £0.77 per child screened, while an 85% yield costs about £0.55 per child screened. Thus, whereas the first 850 children could be screened for £0.55 per child, the next 110 would cost £2.68 per child because disproportionately more time would be needed.

According to our calculations, Asscher *et al.* (1973) using a supervised dipslide method with a 90% success rate incurred a cost per child screened of £0.69.

Once again, an additional allowance must be made to both methods for some form of supervision by a senior person.

DISCUSSION

The principal purpose of this study was to compare the cost-effectiveness of two methods of screening schoolchildren for bacteriuria by a controlled trial and to analyse the consequences of different options for such a screening programme.

The supervised MSU option in this study

achieved a 96% success rate—that is, 96% of eligible children had a valid specimen collected and, based on 1972 prices, this cost £0.77 per child screened. An alternative supervised method was estimated to give a yield of 85% and to cost £0.55 per child screened. The unsupervised method, using a dipslide inoculated at home, had an estimated cost of £0.26 per child screened, but an overall success rate of only 70% (84% success rate in social classes I, II, and III non-manual, and 58% success rate in social class V). Adjusting the findings of Asscher *et al.* (1973) to be comparable with those in the present study, their costs per child screened were similar, being £0.69 for the supervised method and £0.26 for the home dipslide method. However, both their methods were successful in testing about 90% of the girls eligible for screening. The home dipslide method was used by Asscher *et al.* (1973) in Oxford on five to 11-year-old girls and differed from the present study in that children provided a borate-preserved urine specimen in addition to a self-inoculated dipslide. It is not clear whether it was this additional specimen which allowed the study to have such a comparatively low rate of invalid specimens, or whether part of the answer might lie in differences in the social class composition of the population in Newcastle and Oxford. It is also not clear whether the 'skilled observers', referred to by Asscher *et al.* (1973) and required by this part of their method, corresponds to the junior laboratory technician allowed for in their costing.

The success of the home dipslide method differed not simply between social classes, but also between children of different ages. Thus, the unsupervised method was least successful with the youngest children (65%) who were more likely to return the dipslides although very often in a damaged state, and the oldest children (64%) who were less likely to return a dipslide, but if they did so it was more likely to be valid. The most successful group was the junior school children, aged seven to 11 years (78% success rate), a finding which is particularly relevant since this age group has the highest prevalence of ASB (Newcastle ASB Investigation, 1975). If the costing from the present study and the information on the prevalence of ASB from this Newcastle study are combined, the costs can be determined per child screened and per case detected. Thus, for junior children (seven to 11 years) using the home dipslide method, if the cost per child screened were £0.26, the cost per case detected would be £10.40. The respective

costs for infants (four to six years) would be £0.28 and £20.00, and for senior girls (12 to 16 years) £0.28 and £17.50. For the 85% successful supervised MSU method, with a cost per child screened of £0.55, the cost per case of ASB detected would be £22.00 for junior girls, £39.29 for infants, and £34.37 for senior girls. The cost per case of renal scarring detected would be sixfold higher, and this would apply equally to both methods.

These estimates do not include an allowance for the false positives (21%) in the dipslide method who would be referred to hospital. The cost of these false positives would depend on what action was taken at the hospital when a suspect child was referred. If the child were to be regarded as another outpatient, then this would increase the cost of screening each schoolchild by a further £0.02.

The home dipslide method used in this trial had a higher failure rate than the method used by Asscher *et al.* (1973), in which a borate-preserved specimen of urine, as well as a dipslide, was collected. If this latter method could be shown to reduce the failure rate in the lower social classes, then it would be the method of choice. However, considering the cost of the large number of unsatisfactory dipslides which were returned in the present study, it would perhaps be worth evaluating whether it would be even more economical to dispense with inoculating a dipslide at home and to obtain only a home collected specimen of urine. This specimen would be stabilized with boric acid to prevent the growth of bacteria until cultured in the laboratory. Dipslides could then be used to culture the specimen but, if facilities are available, it would be preferable and more economical to use standard bacteriological methods.

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ADDENDUM

ASYMPTOMATIC BACTERIURIA SURVEY

INSTRUCTIONS FOR TESTING URINE WITH DIPSLIDE KIT

Tomorrow morning, as soon as your daughter wakes up and wishes to pass urine, take the Dipslide Kit and unscrew the red cap. Do not pull out the plastic slide which is attached to the cap until she starts to pass urine.

Then, holding it by the red cap, pull out the slide, which is covered with coloured jelly, and hold it in the stream of urine, turning it to wet it on both sides. Take care not to wet your fingers.

Please do not allow any urine to get into the bottle, and be careful not to touch the slide with your fingers or dip it into the toilet.

Return the wet slide to the bottle, screw the cap tightly, and keep it upright for a few minutes.

Please give the Dipslide Kit to your daughter to hand to the nurse at school.