Cost and Effectiveness of a Program to Prevent Rheumatic Fever

DEREK ROBINSON, M.B., Ch.B., D.P.H., M.D.

THE PRIMARY aim of Massachusetts' throat culture program is to prevent rheumatic fever by identifying and eradicating infection by group A beta-hemolytic streptococcus. In the year ending December 31, 1969, the program had processed 176,094 cultures, of which 40,446 (23 percent) contained group A beta-hemolytic streptococci. The demand for this service by physicians in private practice in Massachusetts continues to accelerate.

The throat culture program must compete with other health programs for finances, personnel, and technical resources. In order to answer questions raised by management, that is, clinicians, fiscal managers, and legislators, studies were conducted by the Massachusetts Department of Public Health with the cooperation of the practicing physicians and the participating laboratories.

Study Procedures

The following procedures were used in the study.

1. Physicians licensed in Massachusetts were divided into 26 randomly selected groups (to avoid seasonal bias) and, during a 12-month period, each physician was asked by questionnaire for his experience in the previous 2 weeks with newly diagnosed cases of rheumatic fever, chorea, rheumatic heart disease, and acute glomerulonephritis.

2. The records of 84,000 cultures submitted during a 6-month period were analyzed (*a*) by residence and age of the patient, (*b*) by residence, training, and type of practice of the physician, and (*c*) by time factors needed to complete laboratory identification.

3. Followup reports were obtained from physicians on the treatment and outcome of illnesses of 500 patients with negative and 500 with positive throat cultures for group A beta-hemolytic streptococcus.

4. Retrospective studies were made of 423 patients with a history of recent rheumatic fever whose symptoms satisfied the Jones criteria (*1*) and whose physicians had commenced free prophylactic penicillin under the department's program during the 12-month study.

5. Cost analyses were completed for the laboratory streptococcal identification programs.

Results

Of the 8,400 physicians in active practice and licensed in Massachusetts, 6,481 (76.4 percent) replied to the questionnaire; of the 1,000 patients whose cultures had been tested and the results known, followup reports were obtained on 838 (83.8 percent); of the 423 patients with rheumatic fever studied in retrospect, a medical history was available for 232 (54.8 percent).

From these data came the answers to questions about the primary aim of the proposed service; the extent of the problem in the community and its effects upon individual persons; the reliability of means of prevention, control, or cure; the cost effectiveness of procedures employed; and the thorough matching of need with service.

Extent of the Problem

Among the 6,481 physicians' reports of their 2-weeks experience with newly diagnosed cases were 30 patients with chorea, 161 with acute glomerulonephritis, and 655 with previously undiagnosed rheumatic heart disease. The 141 patients with newly diagnosed rheumatic fever reported by these physicians were equivalent to 3,666 new cases in the full 12-month period.

Taking the 2,621,000 persons under 25 from 1965 population estimates suggests that, subject to variation in streptococcal epidemicity, 1.4 per 1,000 young people in Massachusetts each year may have newly diagnosed acute rheumatic fever. Many more would likely be affected by the other poststreptococcal sequelae.

Dr. Robinson is director of community operations, Massachusetts Department of Public Health. Tearsheet requests to Derek Robinson, M.D. Division of Community Operations, Massachusetts Department of Public Health, 600 Washington St., Boston, Mass. 02111.

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The supplementary inquiry of the 838 physicians cooperating on throat culture followup indicated an annual equivalent of 2,112 new cases of rheumatic fever after correction had been made for the sample's bias toward pediatricians and family physicians.

The lower figure results from seasonal factors because the supplementary inquiry was made only during the summer. From the year long study of all streptococcal sequelae, prevalence was calculated by community of case origin. The chart displays the direct relationship between population density and frequency of known streptococcal sequelae. Frequency was highest in the central part of Boston, next highest in the affluent western suburbs, and lowest in scattered rural areas regardless of economic variations.

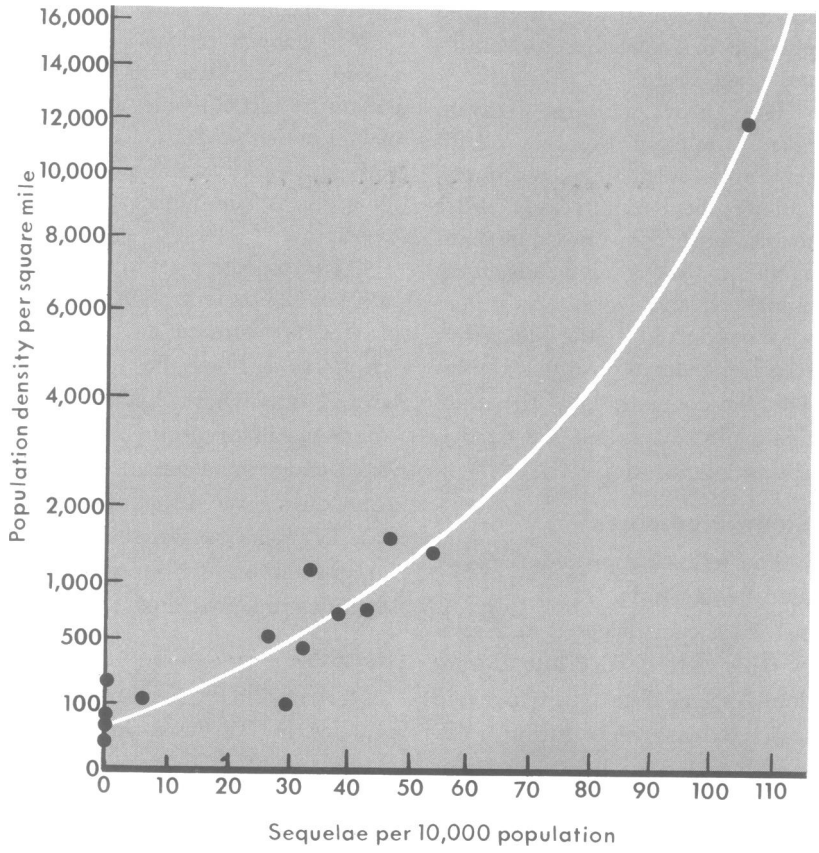
Reliability of prevention control or cure. Of 500 children followed up after notification of a positive throat culture, rheumatic fever subsequently developed in one child and acute glomerulonephritis in another. For the first patient, adequate penicillin dosage was started within 3 days of onset of illness, and clinical features suggested that a streptococcal reinfection was responsible for the subsequent rheumatic fever. For the child who developed acute glomerulonephritis, the throat culture was not made until after several days of illness, and penicillin had been withheld pending the laboratory report. One child of the 500 for whom no streptococci were found on culture also had rheumatic fever. The child's throat swab had been delayed in the mail for 3 days at the height of the hot summer.

Analysis of 84,000 records showed that results from 21.3 percent of the cultures were reported to the physician by the fourth day of the patient's illness. Laboratory processing was completed by the second day after receiving the specimen in 97.1 percent of the cases. Generally, the physician was notified of positive findings by telephone within 30 hours of the swab's arrival at the laboratory.

Delays occurred because only 52.6 percent of the patients were seen by the physician before the third day of the streptococcal infection and 51 percent of the specimens mailed to the laboratory were in transit 2 or more days. Followup studies revealed that penicillin or erythromycin was not given to 31.1 percent of the patients whose cultures were subsequently positive or to 46.8 percent of those whose cultures were subsequently negative for group A beta-hemolytic streptococci, pending the outcome of the frequently delayed process of identification.

Study of 232 recent cases of rheumatic fever, for which a clear medical history was obtained and which met the Jones diagnostic criteria, revealed that 164 (70.7 percent) experienced a clear streptococcal-like illness. Of these persons, 114 had sought medical care before the onset of the rheumatic fever, including 36 with cultures that were positive for group A beta-hemolytic streptococci. Of those receiving medical care, 45 received at least 1.2 million units of benzathine penicillin, equivalent oral penicillin, or erythromycin with dosages intended for 10 days. The median interval between the onset of illness and this unsuccessful antibiotic treatment was 5 days.

Frequency of streptococcal sequelae and population density in Massachusetts counties



Although the median latent period between the original illness and rheumatic fever was 15 days, 10 percent of the active sequelae had already begun by the sixth day.

Costs of dealing with the problem. Unit costs for the throat culture program were related to providing throat culture kits to physicians, laboratory processing, telephoning positive reports, and mailing the final results of the procedures. By 1967 the Massachusetts program, which employs fluorescent antibody identification, had reached a maximum volume for the staff with a unit cost of $1.02. On the assumption that the program is designed only to prevent rheumatic fever in the 1 percent of the streptococcal infections at risk, the cost per 404 presumably aborted cases in 1969 was approximately $497 with 6 percent annual cost inflation.

Effectiveness of matching service to need. Prevalence studies, based on communities of 10,000 or more whose socioeconomic grouping was well known, show that acute streptococcal sequelae are especially frequent in the older sections of cities. Community demand for throat cultures was directly related to mean family income. The 15.3 percent of the State's population with the lowest income obtained 3.7 percent of the service, while the 14.8 percent most affluent obtained 36.7 percent of the service (table 1). There was considerable disparity of distribution of service within the Massachusetts Bay area. Physicians from the wealthy western Boston suburban communities made heavy demands on the program, but physicians in the central city and its older industrial suburbs made few demands.

Table 2 shows the variable service demands of the Boston metropolitan towns served by rapid public transit. A suburban enclave obtained 15.5 times as much service per capita as a community 5 miles away whose inhabitants were less affluent. Table 3 shows that not only were there twice as many physicians per capita in high user communities, when compared with those communities where the service was little used, but also that individual physicians in the well-served areas were three times as likely to use the free throat culture program. Breakdown of physicians by speciality confirmed that virtually all pediatricians in Massachusetts used the program although only one-third of the internists and general practitioners did so.

Discussion

Study of the Massachusetts throat culture program produced no evidence that rheumatic fever and the other streptococcal sequelae had diminished to the point of insignificance, even though the syndrome of acute polyarthritis associated with myocardial and valvular signs of classic rheumatic heart disease may be noted infrequently. Not easy to diagnose, low grade, but heart damaging rheumatic manifestations may be unexpected and underestimated.

The dangers of subclinical streptococcal infection have already been documented (*2*), and the prevention of initial sensitization has been shown to be of prime importance (*3*). Even with the Jones criteria, reliance on reporting of rheumatic fever by physicians provides only approximate data on prevalence, but an attack rate per year of 1.4 per 1,000 persons under 25 years old supports the evidence of previous studies showing a history of rheumatic fever of 9.6 per 1,000 Massachusetts college freshmen (*4*).

The limiting of case recall by physicians to a 2-week period was shown to increase recording accuracy (*5*). In this study, further support was given to the continuing high prevalence of residual rheumatic heart disease in young adults noted in the Framingham (*6*) and National Health Surveys (*7*).

Youths of military age have been reported to have a rheumatic valvular disease prevalence of 12 to 18 per 1,000 (*8*). A statewide survey showed similar rates for rheumatic fever and chorea in Massachusetts in 1963 (unpublished data, B. F. Massell, M.D., research director, House of the Good Samaritan, Children's Medical Center, Boston). The finding that streptococcal sequelae occurred far more frequently than expected in crowded communities, despite a likely deficiency in reporting, is also consistent with other studies (*9*).

Evidently it is dangerous to rely

Table 1. Service level and community income

Cultures per 10,000 population	Number of communities [1]	Mean family income [2]	Percent of State population	Percent of service demand
Under 60	30	$6,115	15.3	3.7
60–119	34	6,355	22.9	12.1
120–239	29	6,597	27.4	27.6
240–479	17	7,022	12.1	26.7
480 or more	7	8,397	2.7	10.0
	All rural		19.6	19.8

[1] Excludes 3 towns with independent throat culture programs.
[2] Mean community income per family $6,572.

too much on the laboratory diagnosis of streptococcal infection, because many patients are ill for several days before seeking medical care. The reliance upon mail delivery to the laboratory was subject to many delays, and a mailbox is not always a suitable environment for survival of bacteria. In these circumstances, the results of throat cultures were most useful in determining the patient who needed continued treatment and observation. The clinical possibility of streptococcal infection was reason enough to commence penicillin which could be discontinued if the throat culture was subsequently found to be negative.

Study of cases of confirmed rheumatic fever revealed the frequently short latent period between onset of illness and subsequent sequelae, also reported by other observers (*10*). Our results confirmed previous discoveries (*11*) that about one-third of rheumatic fever patients have no clear history of streptococcal infection, and these cases cannot be avoided by physicians' use of a throat culture program.

Persons with rheumatic fever run the multiple hazards of not reporting to physicians until late in the infection, of not having a throat culture taken even though the history and clinical signs are suggestive, and of not receiving effective treatment with penicillin until it is too late. In such instances, the finding of group A beta-hemolytic streptococci on culture is academic.

In terms of cost, $497 to prevent each case of acute rheumatic fever is reasonable, especially given the ubiquitous nature of streptococci, their resistance to control by primary prevention, and the frequently disastrous outcome for patients who have rheumatic fever both in immediate sequelae and in subsequent likely recurrence. The extent to which a throat culture program would also prevent acute glomerulonephritis is not clear; however, a connection between some types of streptococcal infection and the damaging if less apparent renal sequelae has been documented (*12*).

The throat culture program was probably least successful in matching the service to the need in the community. If the program prevented 400 or more cases of rheumatic fever while more than 3,000 others were still known to physicians, a proportionate increase in service would be required to control the sequelae of all clinically apparent streptococcal infections. More than 1 million additional throat cultures would be required to meet the need. Selectivity in the use of the freely available program might reduce the negative load primarily through the education of physicians.

The present skewing of the service toward communities of more affluent persons at low risk simply indicates that most pediatricians are well aware of the dangers of streptococcal infection and take appropriate measures to combat it. Moreover, affluent persons when crowded together still appeared to be at considerable risk of streptococcal sequelae.

The throat culture program has been deficient in failing to stimulate demand for streptococcal identification as part of the health care delivery system in the crowded communities. Responding passively to physician participation while working at maximum capacity, a tax-supported program may inadvertently fail to expend scarce resources at the point of maximum priority. It is for such reasons that investment in freely available med-

Table 2. Program demand by income of communities, Boston metropolitan area

Type of community	Mean income	Use of throat cultures per 10,000 population
Central city	[1] $5,608	34
Central city	5,275	39
Low average	[1] 5,608	63
Low average	5,636	75
Low average	5,692	65
Mixed	[1] 5,608	105
Mixed [2]	[2] 5,498	[2] 172
Average	[1] 5,608	118
Upper average	6,437	284
Suburban enclave	8,164	527
Suburban	9,615	421

[1] Part of Boston city.
[2] Academic community.

Table 3. Physician concentration and service demand

Use of throat cultures per 10,000 population	Number of communities	Population per physician	Percent of physicians using service
Under 60	30	1,013	5.5
60–119	33	901	9.1
120–239	29	523	8.0
240 or more	24	496	15.8

ical programs cannot depend upon consumer demand for effective utilization.

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The prevention of rheumatic fever through a statewide throat culture program was examined to determine the extent of the problem, the reliability of combative measures, the cost per case achievement, and the matching of service to community needs. Data were obtained through a statewide questionnaire to all physicians licensed in Massachusetts through the followup of 500 positive and 500 negative throat cultures for group A beta-hemolytic streptococci, a program cost analysis, and the retrospective study of 84,000 throat cultures and 423 newly confirmed cases of rheumatic fever.

Rheumatic fever and other streptococcal sequelae continue to be diagnosed and confirmed with significant frequency in Massachusetts. Prevalence was markedly higher in crowded communities. In 1969, the year of study, it was estimated that 1.4 per 1,000 persons under 25 had rheumatic fever. On the hypothetical basis of 404 cases expected from the 40,446 streptococcal infections diagnosed by throat culture, the cost per case prevented was $497.

The primary diagnostic tool, rapid and efficient laboratory procedures, was undermined by delays in seeking medical care, by the slowness of mail delivery of swabs to laboratories, and by failure of the physician to initiate appropriate antibiotics on the possibility of streptococcal infection. The throat culture program was most useful in indicating which patients needed further observation and continued treatment with penicillin.

Because the free diagnostic service relied on physician demand, the service was inadvertently biased toward less crowded communities with a lower prevalence of sequelae. Not only did core sections of cities have fewer primary care facilities, but individual patients were less likely to benefit from the free program even when they obtained medical care. In high-risk communities only deliberate management of service availability, intensive education of internists and general practitioners, and stimulation of consumer demand can reduce the prevalence of poststreptococcal infections.

Rheumatic fever and other sequelae of infection by group A beta-hemolytic streptococcus are still prevalent and damaging to young persons. Streptococcal identification should be used as a confirmatory rather than a primary diagnostic tool. More active methods than reliance on patient and physician demand for service may be needed to reduce long-term damage from streptococcal sequelae in high-risk communities.