EVALUATION OF SCOLIOSIS SCREENING
AT SIMON FRASER HEALTH DISTRICT
by
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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
(HEALTH SERVICES PLANNING)
in
THE FACULTY OF GRADUATE STUDIES
Department of Health Care and Epidemiology

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
October 1981

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ABSTRACT

This study evaluates scoliosis screening carried out by the Simon Fraser Health District among grade seven students from September 1976 to June 1980. The results of screening were reviewed to determine if the evidence of four years of screening substantiates the continuation of the program. The program was initiated with the belief that detection of scoliosis at an early stage would allow bracing treatment as an alternative to major spinal surgery for correction of scoliosis curvatures.

The criteria for evaluation of screening programs in general and specifically for scoliosis screening were selected after a search of the literature. Four principal criteria were utilized to evaluate this screening program: the acceptability of the test to the parents, children and physicians affected by screening, the acceptability of the treatment, the validity of the test and the availability of resources to carry out the program.

Class lists, record cards and previous reports of the program were sources of data on the results of the screening program. Additional data was gathered during telephone interviews of parents and through questionnaires to physicians.

Outcomes of the 169 screening positives identified from the screening population of 8010 boys and girls, primarily grade seven students, were examined and it was found that results were available for 167 of the 169 students screened positive. Of these, 40 (24 percent)
were orthopedically positive (curve over 10° by Cobb method), 4 boys 
and 36 girls for a male to female ratio of 1:9.

Active treatment by brace and/or surgery was recommended for 
12 children, all female. There were three refusals in the nine cases 
in which bracing was recommended (33.3 percent) and three of the nine 
children for whom surgery was recommended also refused (33.3 percent). 
Six children were braced, but three of these eventually required surgi-
cal correction. A total of six children had spinal surgery. Of the 
38 curves for which X-ray information is known, 25 were less than 20° 
initially and 13 were greater than 20°. None of the curves initially 
under 20° required treatment.

A fourfold table was presented using an estimate of scoliosis 
prevalence to derive total diseased in the screening population. Sen-
sitivity of the screening test was estimated at 26.2 percent, specifi-
city at 98.4 percent, overreferral at 75.1 percent, underreferral at 
1.5 percent and the positive predictive value at 24.9 percent. Overall 
predictive validity was 97 percent. Prevalence of scoliosis in SFHD 
was estimated at 0.6 percent compared to prevalence reported in the 
literature of 2 percent to 4 percent in similar populations using the 
same orthopedic standard for a positive curve.

Costs for the screening program to the health district were 
approximately $17,800 for four years. The costs of referral services 
excluding surgery for diagnostic (true) positives were estimated at 
$12,250 and costs for the false positives (orthopedically negative) 
were $6,325.

The conclusion reached was that although scoliosis screening
has had community acceptance, the acceptability of treatment was ques-
tionable, the validity of the test was not supported and that consid-
erable resources were consumed. The absence of a central referral 
clinic was identified as a resource deficiency.

It was recommended that the program be discontinued at this 
health district. Furthermore it was recommended that scoliosis screen-
ing not be introduced to other areas of the province because of the 
difficulties forseen in orthopedic evaluation and orthotic service, as 
well as because of doubts about validity of the test and acceptability 
of treatment.

Some suggestions were made for modifications should the program 
be continued at SFHD and for future studies.
DEDICATION

To Tom, Mary and Andrew.
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ACKNOWLEDGEMENT

This study has been facilitated by the encouragement and cooperation of the staff of Simon Fraser Health District. A special thank you is extended to Dr. John Blatherwick, Director, who endorsed this program evaluation, to physiotherapists June Moore and Ann Ryder, who shared their records and expertise and to the clerical staff for their able assistance in the preparation and distribution of letters of introduction and questionnaires.

I wish to express appreciation to my thesis committee - Dr. James Robinson, chairman, and Dr. Annette Stark and Kirsten Weber. Each has provided special advice and guidance to enable the thesis to be produced.

Others in the field, who have shared their studies of scoliosis screening programs, particularly Dr. J. I. Williams, were of considerable assistance. Dr. Eric Holowaty provided advice in the preliminary stages of the study proposal.

Finally I would be remiss in this acknowledgement if I did not say a particular thank you to the families who so willingly shared information and feelings about the scoliosis program with me. The physicians of the health district, particularly Dr. Michael Piper, were also a great assistance in providing necessary outcome data.
CHAPTER I

INTRODUCTION

Improved health status of individuals in the community is a primary goal for all workers in the field of public health. As basic standards of environmental health are achieved and communicable diseases controlled it is logical that attention is focusing on prevention of chronic disabling diseases. Those that affect children and afflict lifelong disability are of special concern to the community health professional. Scoliosis is one such disease.

Administrators and policy-makers seek a factual basis for program decisions with the realization it is no longer acceptable to "eyeball" the effects of programs in public health and medicine and thereby judge their utility (Freeman 1978). What is being sought are systematic, replicable and precise assessments of both established and innovative programs within the health care field. Unfortunately most preventive screening has been carried out without evidence of its health effectiveness and in some cases in direct contradiction to the available evidence (Sackett 1975b).

This study proposes to evaluate the efforts of a public health district to find cases of scoliosis early, that is, before they were clinically evident, so that conservative treatment would lead to better health for adolescents in its community. There is recognition that this program has become an accepted part of the public health delivery system
The Hypothesis

The hypothesis proposed is that evaluation of the results of four years of screening for scoliosis at SFHD will substantiate that the screening program should be continued. The principal criteria for evaluation that will be applied to the results of screening are the acceptability of the screening test, acceptability of treatment for the disease detected by screening, the validity of the test and the availability of resources.

Consideration will also be given to whether the goal of the program has been met, that is, whether early detection of scoliosis and treatment with the Milwaukee brace has eliminated the need for surgery for scoliosis in the screened population. To test the hypothesis it is necessary to consider the use of screening in general and as related to the management of scoliosis in the community.

Description of Scoliosis

Scoliosis is a condition in which a lateral curvature of the spine develops leading to rotational deformity of the vertebrae and ribs. The curve may progress and result in serious disability with impairment of the heart and lungs and a shortened lifespan. Scoliosis is classified as non-structural (reversible) and structural (irreversible). Idiopathic scoliosis is a type of structural scoliosis and accounts for about 70 percent of all cases of scoliosis (Keim 1978). While it may occur in infancy or the juvenile years it is most common in adolescence. The cause is unknown but a genetic factor appears to be present.
Scoliosis has affected mankind since the days of the Stone Age. Early drawings on cave walls and evidence in skeletal remains have revealed that the disease was present in our earliest ancestors (Keim 1978). Hippocrates used the Greek word "skoliosis" meaning crooked in his writings and describes the use of forceful mechanical means to treat the curves. Indeed treatment of scoliosis has intrigued and challenged medical practitioners throughout history. Pare in 1550 applied an iron brace after traction. Exercises and gymnastics were utilized in the 1800's as was surgery followed by the use of a hinged frame. The first spinal fusion for scoliosis was performed in 1914. Modern management includes observation of the curve with bracing or surgical treatment of those curves which progress to a serious stage.

The Implications of Screening

To discover disease at the earliest stage in its natural history when measures may be applied to arrest its progress or effect a cure has enormous appeal to the health care practitioner concerned about the prevalence of chronic disease. Screening has held promise as the route to this discovery for the professional seeking to use preventive measures. The goal of screening is to apply a simple maneuver to a population for the purpose of separating these apparently well individuals into two distinct groups. The division is based on the probability of the presence of disease or of a precursor of the disease. The premise is that early intervention in the "at risk" or diseased group will result in improved outcome.

Screening has been a controversial issue in recent years. Debate has clouded the merits of accepted maneuvers such as screening for
cervical cancer. The lack of randomized clinical studies at the incep-
tion of certain now widespread screening procedures has been viewed as
a critical omission by several scientists (Cochrane and Holland 1971;
McKeown and Knox 1968; Sackett 1975a). Evaluative criteria have been
established by researchers as the issue of accountability for screening
programs has evolved as a major concern.

Those who question the institution of widespread screening with­
out validation of its effectiveness in terms of improved health, point
out the different responsibility given the professional who screens.
As distinct from therapeutic medicine, in screening the health care
practitioner seeks out an apparently well individual and subjects that
person to a maneuver to detect unknown disease or disability. In ther­
apeutic medicine the individual seeks medical attention because of
symptoms or signs of illness and expects assistance in terms of reason­
able current practice. The practitioner of screening

... should have conclusive evidence that screening can alter
the natural history of disease in a significant portion of
those screened. (Cochrane and Holland 1971)

Of course it is not screening itself which can "alter the natural
history" but the application of effective interventions. It is essen­
tial that screening of a prescriptive nature be proven to do more good
than harm. This means that there must be knowledge that the clinical
procedures which may result from screening will be of greater benefit
than detriment to the client (Sackett 1975a).

As well as the ethical concern of the practitioner about effec­
tiveness, he is required to be financially accountable to the government
or individuals funding his practice or agency. Preventive measures such
as screening are sometimes considered to be cost effective; the premise is that early treatment will reduce total health care costs. In British Columbia the proportion of the provincial budget allocated to health has risen annually to its present level of 1.975 billion or 30 percent of all governmental expenditures. There are plans to contain rising costs by allocating resources to those programs which have shown themselves to be most effective. Those making decisions within the Ministry of Health are therefore considering program evaluation as a means to choose the most effective use of resources.

In this context of governmental and professional concern about the effectiveness of screening this investigator wishes to evaluate the scoliosis screening program which began at SFHD in 1976. This is timely for the reasons given and especially because several other provincial health districts are considering introducing programs and would benefit from evaluation of the experience at SFHD.

Scoliosis Screening at Simon Fraser Health District

Simon Fraser Health District (SFHD) encompasses the Cities of New Westminster, Port Coquitlam, Port Moody, the Municipality of Coquitlam, the Village of Belcarra and Electoral Area B, for a total population of about 140,000. It is primarily a middle class suburban area with a large number of its workforce commuting to jobs in the nearby city of Vancouver. The school population of the health district was 26,643 as of September 30th, 1980. It is a health district within the Ministry of Health of the Province of British Columbia. The Chief Administrative Officer, the Health District Director is responsible to
the Assistant Deputy Minister of Preventive Services within the Ministry of Health.

The impetus for instituting screening for scoliosis at SFHD in January 1976 was concern about the number of major surgical procedures performed in recent years to correct severe scoliotic curves in young people within the district. Surgery was known to have been required in at least ten cases in the community. An orthopedic surgeon and the health unit director together with health district personnel planned a pilot project to examine school children to assess if a school screening program could detect the disease at an early stage. From the initial project district-wide screening began in September 1976. The belief was

... that a screening program in the community would discover children with signs of scoliosis while still growing, thus permitting conservative treatment with the Milwaukee brace. (SFHU Report 1977)

Reports of earlier programs such as the statewide program in Delaware suggested that screening eliminated the need for surgery (Lonstein et al. 1976). The American Academy of Orthopedic Surgeons had published its position on scoliosis screening in 1974 as follows

The American Academy of Orthopaedic Surgeons hereby gives its official recommendation to any program of routine examination of school children for the detection of scoliosis and other crippling spine deformities. The Academy recognizes that by early detection more appropriate treatment can be given and a better total treatment of this disabling health problem can be carried out. (Lonstein et al. 1976, p. 52)

In spite of the endorsement of this respected body there were other views about the worth of scoliosis screening. In a 1980 Report of the Canadian Task Force considering Periodic Health Examinations,
the recommendation concerning scoliosis was

There is no scientific justification for the view that screen-
and/or casefinding for Scoliosis is distinctly beneficial. 
Until better evidence is established, screening in a periodic 
health examination should be conducted only within the context 
of an evaluative study. (Report of a Task Force Considering 
Periodic Health Examination 1980, p. 73)

In light of the divergent views on the value of scoliosis screen-
ing it appears timely to review the results of the program at SFHD. Some 
evaluation has already been done. Since inception of scoliosis screening 
at SFHD there have been yearly reports of the available outcomes, how-
ever many physicians who received the referrals of screening positives 
reported that they would continue to follow the child but the final out-
come was not reported to the health district. An estimate of the time 
spent by staff was made in all years except 1978-79. Some costs were 
also estimated.

Small studies were done in 1977 and 1978 by the health unit to 
establish how the program was received by the community. A public health 
nurse visited a random sample of 31 families who had a child screened as 
positive and the assistant medical health officer visited 10 general 
practitioners to determine their reaction to the program. The general 
conclusion reached was that the program was well received.

In the absence of a prospective study it is by ascertaining what 
the outcomes have been from the screening program that the necessary 
planning decisions can be made now about the future of this program and 
about expansion of screening to other health districts.

Organization of the Thesis

The following chapter will review the literature to outline the 
criteria used to evaluate screening programs. Next, the literature on
scoliosis and scoliosis screening will be reviewed to determine how the principal criteria have been met.

Chapter three will present the methodology of this study and will include a description of the program under review and of the data available. The procedure utilized to gather additional outcome information and to analyse the relevant information will be discussed.

In Chapter four the results will be presented in narrative and tabular form by percentages, rates and use of the fourfold table.

Chapter five will contain discussion of the results in terms of the criteria selected: acceptability of the screening test, acceptability of treatment, validity of the test and availability or resources. There will be a brief review using the other criteria.

The concluding chapter will summarize the position of scoliosis screening in terms of the chosen criteria and make recommendations about the continuation of the program at SFHD. Suggestions for further study will also be made.

**Definition of Terms Used in This Study**

Acceptability - the extent to which the volunteer was willing to undergo the screening, which can be expressed in terms of utilization, or negatively, as attrition during the program.

Bracing - an application of an orthopedic appliance (orthosis) to correct or maintain a scoliotic curve. An example would be the Milwaukee brace.

Cobb method of curve measurement - the method of measuring the structural curve of scoliosis in which the upper and lower end vertebrae are
first selected, perpendicularels to their transverse axes are next erected, then the angle of the curve is measured at their point intersection. It is the method of measurement advocated by the Scoliosis Research Society.

Effectiveness - the characteristic of a maneuver or treatment doing more good than harm to individuals to whom it is offered (efficacy plus acceptance), the same as usefulness.

Efficacy - the characteristic of a maneuver or treatment doing more good than harm to those who fully comply with the treatment or recommendations.

Efficiency - the attribute of worthwhileness - the best use of resources for the expenditure made.

Observation - as it pertained to an outcome of scoliosis screening was the process by which the physician who received a referral for possible scoliosis saw a child regularly for physical examination, with or without radiography.

Orthopedic positive - any scoliotic curve greater than 10° initially or which reached 11° or more while under observation. Those curves which were labelled "significant" or "at risk" by an orthopedist will be called positive until X-ray results determine the degree of curvature.

Predictive value - the ability of a test to give an accurate measure. When given as positive, it is the percentage of those identified as positive who have the disease, or if negative, those who are correctly identified as disease free. Total predictive value gives the percentage correctly labelled by the test.
Referral - those children found with a positive sign of scoliosis on screening for whom a letter to the parent was sent advising medical consultation.

Reliability - the ability to yield consistent results in repeated trials or when administered by different screeners.

Scoliosis - for the purpose of this study, adolescent idiopathic scoliosis, described as a lateral curvature of the spine with rotation of the spinal column and ribs, that is, with demonstrated structural features.

Screening - the presumptive identification of unrecognized disease or defect by the application of tests, examinations or other procedures.

Screening positive - a child found to have a sign or signs of scoliosis.

Sensitivity - the ability of a test to classify as positive those persons with the disease.

Specificity - the ability of a test to classify as negative those persons free of the disease.

Surgery - in this study any operation performed for correction of a scoliotic curve, usually spinal fusion with Harrington Rod instrumentation.

Validity - the measure of the frequency with which the result of a test is confirmed by an acceptable diagnostic procedure. The ability of the test to separate those who have the condition from those who do not.
CHAPTER TWO

REVIEW OF THE LITERATURE

This chapter will first review the literature on evaluation of screening programs and second will review what has been written about scoliosis and screening programs in respect to these evaluative criteria.

Evaluation of Screening Programs

Since the 1950's it has become increasingly popular for medical and public health agencies to institute screening programs to detect disease at an early, symptomless stage. This discovery of disease in apparently healthy individuals has the purpose of bringing to medical care individuals at an earlier and hopefully more optimal stage of disease for successful treatment. "Successful" implies that there will be less disability or premature mortality from the disease when it is discovered and treated early in its natural course.

Researchers agree that for ethical and economic as well as scientific reasons certain criteria or principles should be met before screening is instituted. The following is a review of the criteria, which have been set out as guidelines both before screening is instituted and to use in the continuing evaluation of screening programs in practice, by the major papers on this subject in English literature.
Reinke (1969) cites the five criteria proposed by Acheson in 1963 to use in determining which diseases are suitable for screening. These criteria were

1) Each disease should occur fairly frequently in the population under consideration.

2) A disease should be dangerous to life and cause excessive absence from work and/or disability.

3) A single sign should carry with it the high probability that the disease is present.

4) Eliciting the sign should be simple and economical and at the same time unobjectionable to the patient.

5) There should be reasonable prospect that steps can be taken to cure the disease or to prevent its progressing once the diagnosis has been made.

These criteria while useful lack precision when they are applied, for example as to what constitutes "fairly frequently" or "excessive absence". More precise criteria which incorporated the criteria of Acheson were proposed by Wilson and Jungner in 1968.

In a World Health Organization publication ten basic principles were enunciated and it was recommended that these should be met before mass screening was instituted.

1) The condition should be an important health problem.

2) There should be an accepted treatment for patients with recognized disease.

3) Facilities for diagnosis and treatment should be available.

4) There should be a recognizable latent or early symptomatic stage.
5) There should be a suitable test or examination.

6) The test should be acceptable to the population.

7) The natural history of this condition, including the development from latent to declared disease, should be adequately understood.

8) There should be an agreed upon policy on whom to treat as patients.

9) The cost of case-finding (including diagnosis and treatment of patients diagnosed) should be economically balanced in relation to possible expenditure on medical care as a whole.

10) Case-finding should be a continuing process and not a "once and for all" project. (Wilson and Jungner 1968, pp. 26-27)

Wilson and Jungner suggest these principles are guides to planning case-finding so that the main goal of early disease detection, that of finding and treating those with previously unknown disease, while not harming people who are well, is achieved. When evaluating screening Wilson and Jungner say that two separate but interrelated aspects are considered. First is the evaluation of the screening test and second, the evaluation of the results. In both aspects there is the need for a standard of criteria.

McKeown

Thomas McKeown (1968) gave two major requirements for screening: the procedure is effective and it makes more optimum use of limited resources than the alternatives available. The ethical differences between screening and normal medical practice were discussed by this writer. He concluded that screening should not be undertaken unless there is proven medical benefit. The criteria to be applied to screening fall into two categories accordingly: biological and economic.
Before a screening measure can be declared sound on biological grounds the natural history of the disease must be known, identification must be possible at an early stage of the condition and beneficial methods of treatment must be available. For economic justification the assurance must be given that limited resources are better employed with this measure than any competing one.

McKeown outlines a scheme for evaluation of screening procedures. He begins with definition of the problem and review of the position before screening. Next is review of evidence concerning the screening procedure itself within two major divisions; that is review of the evidence about the effectiveness first of the diagnostic methods and second, of the proposed treatment. Evidence is assessed in terms of applicability, error rates, comparison to traditional methods, availability of resources, acceptability and cost. After the preceding review is accomplished McKeown suggests that a conclusion could be reached concerning the state of evidence on the problem as a whole. This conclusion would utilize the evidence on the natural history of the disease and the effects of the screening in terms of both diagnosis and treatment. Lastly, there would be comparison of alternative approaches to the problem in terms of medical gains and losses and financial costs and gains. In conclusion proposals for acquiring further evidence and for applications of the validated screening procedure complete the evaluation scheme.

Cochrane and Holland

These writers (1971) reiterated points made by McKeown and emphasized the ethical consideration in the introduction of screening programs. The call for conclusive evidence that screening could alter
the natural history of the condition in a significant proportion of those screened raised the issue of economic benefit. What yield from screening makes it worthwhile? These authors concluded that scientific and possibly financial justification is required before introducing screening tests.

The decision about which diseases justify screening rests on evaluation of the test used to detect them. The criteria given by Cochrane and Holland for validating the test are:

1) Simplicity
2) Acceptability
3) Accuracy
4) Cost
5) Precision or repeatability
6) Sensitivity
7) Specificity

The choice of test will be based on compromise because fulfillment of one condition may be offset by another. In summary Cochrane and Holland argue that screening procedures are validated by posing two questions:

Is the test justified, scientifically and financially by the resulting benefit to the community?

How efficient is the proposed test as a method of measurement? (Cochrane and Holland 1971)

Sackett

David Sackett (1975b) adds predictive power to the seven properties of Cochrane and Holland used in evaluation of a screening measure and emphasizes that the importance given to a particular property will
vary according to the purpose of a test. He states that simplicity, acceptability and cost are important in screening but he gives sensitivity the most important ranking among properties of a test used for screening because the consequences of missing a case may be "tragic and costly" (Sackett 1975b). As well as technological requirements as he terms these eight properties, Sackett feels clinical and health care requirements must be considered. He poses six questions:

1) Are screening maneuvers able to detect disease which is likely to have an important impact upon health?

2) Will the treatment of risk factors have a major impact upon the subsequent development of disease?

3) What are the prospects that patients will comply with therapeutic regimens initiated as a result of screening programs?

4) Do existing screening programs really alter the outcomes of the target disease?

5) Are we misled by the traditional methods used in evaluating the clinical effectiveness of early detection programs?

6) Have we considered the entire range of possible effects of screening, labelling of individuals as diseased and the long-term therapy. (Sackett 1975a, p. 42)

These questions were discussed at a meeting of the World Health Organization in 1971 and translated into seven criteria for evaluating screening programs:

1) Screening must lead to an improvement in end-results (defined in terms of mortality; physical, social, and emotional function; pain; and satisfaction) among those in whom early diagnosis is achieved or in the other members of the community.
   a) The therapy for the condition must favorably alter its natural history, not simply by advancing the point in time at which diagnosis occurs, but by improving survival, function, or both. The modification of "risk factors" is not sufficient evidence of effectiveness, nor is the fact that the proposed therapy is commonly accepted. Claims for therapeutic effectiveness must
withstand rigorous methodologic scrutiny, and experimental evidence, such as controlled clinical trials, is a prerequisite. The measurement of survival and other end-results must withstand epidemiologic and biostatistical scrutiny.

b) Available health services must be sufficient both to ensure diagnostic confirmation among those whose screening is positive and to provide long-term care.

c) Compliance among asymptomatic patients in whom an early diagnosis has been achieved must be at a level to be effective in altering the natural history of the disease in question.

d) The long-term beneficial effects, in terms of end-results, must outweigh the long-term detrimental effects of the therapeutic regimen utilized and the labeling of an individual as diseased or at high risk.

2) The effectiveness of potential components of multiphasic screening should be demonstrated individually prior to their combination.

3) If the benefits of screening accrue to the community at large rather than, or in addition to, the individual identified (e.g. disease carriers, specific occupations), the community benefit claimed must withstand scientific scrutiny.

4) The cost-benefit and cost-effectiveness characteristics of mass screening and long-term therapy must be known. This knowledge is considered essential in developing an appropriate mix of diagnostic and therapeutic services in the face of finite manpower and financial resources. Therefore, a mechanism for the formal periodic weighing of costs against benefits or effectiveness should constitute a basic component of the initial screening activities.

5) The burden of disability for the condition in question (in terms of disease frequency, distribution, severity, and alternative approaches to its detection and control) must warrant action.

6) The cost, sensitivity, specificity, and acceptability of the screening test must be known, and it should lend itself to the utilization patterns of the target population.

7) Ideally, an estimate of the social benefit of preventing, arresting, or curing the condition in question should be known. (Sackett 1975a, pp. 49-50)

Sackett (1975b) suggests that when these criteria are applied to most preventive screening tests they are performed without evidence
as to their health effectiveness. He comments that by implementation of untested or invalid programs long-term ill effects may be encountered. There is damage to the credibility of the health professionals, research into alternative approaches to detection are discouraged and there is wastage of resources.

Chamberlain

Chamberlain (1979) in his approach to evaluation of screening depicts six factors which must be considered. These are shown in Figure 1.

![Diagram showing factors influencing the effectiveness of a screening programme]

Fig. 1.--Factors influencing the effectiveness of a screening programme.

Chamberlain believes that the importance of natural history is foremost. Unless it is known what the course of the disease would be without intervention, there cannot be evaluation of the maneuver under investigation. The best way to evaluate the effectiveness of screening and early treatment in altering the natural course of the condition is by the randomized clinical trial. He suggests that these trials are of necessity long-term because they involve large numbers of people in the case of the chronic, low prevalence diseases for which screening is suggested. The acceptability of treatment must be considered in the evaluation of a preventive measure. Unless there is compliance with the recommended therapy then there is little point in detecting the condition — indeed there may be a disadvantage in terms of anxiety and increased absenteeism. The validity of the screening test is measured by sensitivity and specificity. It is obvious that a screening test is not satisfactory if it allows a large number of diseased people to slip through or if it incorrectly labels as diseased those individuals who are really well. The screening test must be acceptable to the people at risk of the disease or resources will be wasted. The last factor, availability of resources, must be considered in evaluating screening because it is pointless to begin a screening program without the capacity both to carry out the program and to do further diagnostic tests and treatment as required.

Chamberlain emphasizes the importance of the administrator having as complete information as possible so that the best possible decisions can be made about the allocation of scarce resources in an attempt to control an important disease by means of screening programs. Because
the effects of screening are dependent on what can be done to improve prognosis by treatment, Chamberlain stresses that a research priority should be the study and development of effective therapies.

**Periodic Health Examination Report**

In 1980 a federally appointed Task Force on the Periodic Health Examination reported its findings after reviewing 100 potentially preventable conditions. The decision was made as to whether the condition was truly preventable after judging it according to a standard which applied three sets of criteria.

The first set of criteria judged the effectiveness of the available treatment or preventive measure. To measure effectiveness the question was asked: Does the available treatment, preventive or therapeutic, instituted as a result of carrying out the periodic health examination, do more good than harm to those patients to whom it is offered? The Task Force identified three grades of validity. In level I, effectiveness was demonstrated in a randomized clinical trial. In level II, either a well-designed cohort or case-control study or comparison between times and places with and without treatment, would show that treatment or prevention does more good than harm. The third level of validity was based on the opinion of respected authorities who used descriptive studies, clinical experience or reports for their information.

The second set of criteria judged the current burden of potentially ameliorable suffering. Two aspects were considered: the impact on the individual and the impact on society. For the individual,
measures such as life years lost, morbidity in terms of hospital days, pain, and treatment costs were indicators of impact. The impact on society was determined by indicators such as mortality, morbidity and costs of treatment.

The third and last set of criteria for judging whether the condition was potentially preventable applied to the maneuver undertaken to find or prevent the condition. Aspects considered in applying these criteria were the benefits and risks; the sensitivity, specificity and predictive value; and the safety, simplicity, acceptability to patients and cost.

Following assessment of evidence using these three sets of criteria, prevention of the condition would receive one of five classes of recommendation. These recommendations were labelled A to E according to the strength of the evidence to include screening for the condition in a periodic health examination (A) or to excluding it (E). Category C, in which scoliosis was placed, stated that there is poor evidence for inclusion or exclusion of the condition in the periodic health examination and posed the most difficulty for the committee. The committee suggested in cases of inadequate evidence it was better to err on the side of prudence and not include the condition in a periodic health examination.

Summary of Criteria

Reviewing the criteria presented it is obvious that there is general agreement on a core of criteria. It is basic that screening must make a difference, and a positive difference, that is, it must do
more good than harm. To know that is happening, the course of the
disease must be understood. The test itself must be valid and accep-
table to the client. Effective treatment which is acceptable must be
possible and the resources for diagnosis and treatment available. After
these criteria are met, economical review should show that screening for
the particular disease represents a worthwhile use of finite resources
compared to other alternative uses. Underlying all criteria is the
premise that the evidence presented to meet the criteria has been derived
scientifically, preferably using experimental or at least quasi-experi-
mental methodology.

This completes the review of criteria proposed for evaluation
of screening. In the next section the literature on scoliosis and its
screening programs are examined to determine how these criteria have
been filled.

Evaluation Criteria Applied to Scoliosis
and Scoliosis Screening

While there has been a great deal written about scoliosis and
active encouragement by the Scoliosis Research Society for screening
programs to be included in school health programs, evaluative studies on
the efficacy and effectiveness of this screening are rare. Wingate
after a literature search concluded that "to date, no critical evalua-
tions have been performed on any published scoliosis programs" (1977,
p. 73). The rationale for introduction of screening programs is the
reportedly high prevalence rates of scoliosis and the benefit of early
treatment. No validation of the test procedure, nor any estimates of
the costs, benefits or effectiveness had been reported at the time of
Wingate's publication.
Howell (1978) in Edmonton and Williams and Tice (1980) in Ontario have presented research findings in recent years which attempt to evaluate screening programs in place in those provinces. They call attention to several concerns about the effectiveness of scoliosis screening of school children in their jurisdictions with particular concern about the reliability and validity of the screening test.

To utilize criteria for evaluation of scoliosis screening programs as described in the literature it appears useful to begin with the ten criteria defined by Wilson and Jungner in 1968. Verrier et al. (1979) and Wingate (1977) have also utilized this framework. Two additional criteria have been selected from the 1971 WHO statement on screening (Sackett 1975a) so that twelve criteria in all will be utilized.

1. The condition should be an important health problem

Although scoliosis has been known for centuries the question for consideration now is - how significant is scoliosis? Of particular concern is the importance of adolescent idiopathic scoliosis which has been the target of SFHD's screening program. To evaluate importance the prevalence and effects of the disease will be discussed.

Prevalence

Moe et al. (1978) suggest that prevalence is determined by mass screening techniques applied to large unselected population groups. Scoliosis prevalence information is available from two major sources. The first is based on chest X-rays taken for tuberculosis screening and the second from school screening programs.
**TB X-rays** provided early information on the prevalence of scoliosis. In a study of 50,000 minifilms taken in TB surveys, in those over 14 years of age scoliosis curves of 10° or more were noted in 1.9 percent and curves of 20° or more in 0.5 percent (Shands and Eisberg 1955). Other studies report prevalence of 1.1 percent and 0.47 percent (Moe et al. 1978) respectively. The disadvantages of data from chest minifilms are the small size of the film, underpenetration of the spine and the fact that visualization of the lumbar spine is not included.

**School screening programs** have provided data since programs began in the state of Delaware in 1962. While prevalence studies vary there is general agreement that curves 11° or greater are present in 2 percent to 4 percent of young adolescents (Brooks 1980; Hornung 1977; Howell et al. 1980; Kane 1977a; Moe et al. 1978; Rogali et al. 1978). Lonstein (1977) reviewed 23 prevalence studies from 1957 to 1976 which included over a million subjects from around the world. He reported that while there was some variability in ages screened and criteria for recording a positive, the prevalence rate generally fell between 2.5 percent and 4 percent.

Kane (1977b) comments on the danger of the overstated case in regards to published prevalence figures from scoliosis screening studies. He notes the consistency of figures improves as the severity of curve increases. He suggests that a curve can be drawn based on a log normal distribution (the natural log of the number of degrees of a curvature is normally distributed). From this curve prevalence figures of 0.5 percent for 20° or greater curves, 0.2 percent for 30° or greater and 0.1 percent for 40° curves can be estimated. Kane suggests that by
using two criteria, first, that scoliosis of 20° in an immature person should be treated and second, that any immature individual with a curve over 10° should be followed, that the adolescent scoliosis population is 2.5 percent. Of the population screened for scoliosis there appears to be consensus on the prevalence of treatable curves. Rogala et al. (1978) suggests 0.275 percent and Lonstein (1977) 0.3 percent.

The Health Surveillance Registry can provide prevalence figures for scoliosis by age-group and sex for British Columbia but it is acknowledged that there has not been comprehensive reporting so that the figures do not reflect the true prevalence of scoliosis (Colls 1981).

Prevalence by sex has been studied extensively. Originally scoliosis was felt to be far more prevalent in females but the occurrence of minor curves is distributed in a female to male ratio of 1.5:1 (Lonstein 1977) or 1.24:1 (Rogala et al. 1978). Rogala found the ratio varied with the severity of the curve; 1:1 for curves 6° to 10° and up to 5.4:1 for curves over 20°. The ratio was 7:1 for curves under treatment. Keim (1978) reports a 7:1 incidence of persistent curves.

In the only study reporting prevalence by racial group Segil in Johannesburg, South Africa found 2.5 percent of the Caucasians had curves of 10° or more (N = 929) and Africans (N = 1016) had a prevalence of 0.03 percent (Lonstein 1977).

There appears to be a familial tendency for scoliosis to occur. Rogala found a positive family history in 19 percent of the subjects in a study carried out by himself and others in 1978.

In summary it could be stated that scoliosis is a disease of low prevalence and that females with a family history of scoliosis are the most at risk for significant curves.
Effects of scoliosis

The curvature of the spine in scoliosis may be non-progressive but those few curves which progress can have serious effects (Kane 1978). The developing curvature is accompanied by spinal column rotation causing fanning of the ribs on one side and inward compression on the other. This distortion results in cramping of the heart and lungs. Less mobility of the spine and a disfiguring rib hump are other untoward effects.

While there are many studies of the prevalence of scoliosis in the adolescent population there is a lack of studies indicating the population prevalence of severe symptomatic scoliosis. Studies which document the death, disability, disruption, discontent and dissatisfaction due to scoliosis are rare. While it may be useful to note that about 2 percent of an early adolescent group have curves greater than 10°, to consider the importance of scoliosis further information is vital.

Statistics citing scoliosis as a cause of death are available from Statistics Canada and are presented in Table I.

Kyphoscoliotic heart disease which was mentioned by Nachemson (1968) as a leading cause of death in scoliotics, claimed no lives in B.C. in 1979 and caused only three deaths in Canada.

Limited information is available from case studies which report the long-term effects of progressive scoliotic curves. It has been on the basis of these retrospective studies that the importance of prevention of scoliosis has been based.
TABLE I
DEATHS DUE TO SCOLIOSIS* AND DUE TO ALL CAUSES,
B.C. AND CANADA, 1972-1978

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*ICD code 735.0

SOURCE: Suzanne Draper, Inquiries Officer, Statistics Canada (Personal Communication, Aug. 12, 1981)
Vancouver, B.C.
In a brief report of a study by Drummond et al. (1976) long-term effects of untreated scoliosis were cited. Back pain was reported by 40 percent of the patients and this was constant in 24 percent of the sample. In this study group: 24 percent were unemployed, 15 percent had never worked, 69 percent were embarrassed by their appearance and 20 percent avoided social contact. Thirty percent of the men and 42 percent of the women were unmarried. The sample was of 55 adults from an unselected series of 107 patients seen as children in three Quebec hospitals. The degree of curvature however is not reported.

Further descriptions of persons with untreated scoliosis from retrospective studies are reported under criteria seven, concerning the natural history. The reported physical and social effects of untreated progressive scoliosis would appear to indicate a serious health problem in those persons affected with severe disease but information is lacking relating degree of curvature to effects and to prevalence in the population. Statements that scoliosis is an important health problem must be considered as presumptive.

2. There should be accepted treatment for patients with recognized disease

Wilson and Jungner call this the most important criterion because it is of paramount importance to treat the condition adequately when it is discovered. In the sense that "accepted" is used in this criterion other writers, such as Chamberlain and Sackett, use the term "effective". Effective implies efficacy, that is, that the treatment does more good than harm in those receiving it. Sackett suggests as well as efficacy, effectiveness includes acceptance of the treatment by
those to whom it is offered while Chamberlain lists acceptability as a separate criteria. Both efficacy and acceptability of the recognized treatments for scoliosis will be discussed under this criteria.

The Scoliosis Research Society has published a Physician's Handbook of Spinal Screening and Treatment which contains the recom-mended treatment for scoliosis in three major categories: controlled observation, bracing and surgery. Controlled observation includes periodic clinical examinations with standing X-rays of the spine as necessary throughout the years of growth to determine progression of a curve. Keim (1978) states that only two treatments, spinal bracing and surgery effectively correct scoliosis. These treatments will be considered in terms of efficacy and acceptability as the components of effectiveness using what is described in the literature.

There are difficulties in locating conclusive evidence of the efficacy of treatment of scoliosis. One problem lies in the deter-mination of differences in outcome due to early diagnosis and treatment of scoliosis when there is lack of knowledge about the natural history of the disease, that is, which curves will progress. As mentioned pre-viously some curves can even spontaneously improve (Brooks 1977; Rogala et al. 1978). Other difficulties occur because there may be discrep-ancies in measuring curves. Rogala et al. (1978) found that any curve can be shown to vary up to 5° with different examinations.

The proposed treatment for scoliosis will be considered by examining evidence as to the effectiveness of non-operative and oper-ative approaches.
Non-operative approaches

**Exercises** are mentioned as treatment by Keim (1978) so that he could strongly condemn them as a sole cure for scoliosis. He rejects the practice of detecting a patient early and prescribing an exercise program and thus losing the patient to follow-up until the curve is severe. In a study reported by Stone et al. (1979) it was concluded that exercise had no effect on change in curvature of 42 patients with minimal idiopathic scoliosis (defined as less than 20°).

James (1976) reports on a 1941 study of several thousand cases treated by exercise. The conclusion was that exercises were demonstrably ineffective in controlling a curve's deterioration or in improving curves already present. Brooks (1980) reports on a study of 42 adolescents with minimal idiopathic curves given an exercise regime. No significant improvement was found in comparing the study group with a control group during the 9 to 15 month study period.

**Bracing** to treat scoliotic curves is usually accomplished with the Milwaukee brace. It is recommended in general for progressive flexible curvature of 20° to 40° in growing children. The main purpose of the brace is to prevent progress of the curve with the secondary aim of improving the curve (Moe et al. 1978). The length of treatment with the brace averages three years. X-rays may be taken three or more times yearly. Response to the brace is variable and unpredictable, therefore monitoring the curve is essential. It must not be worn by patients whose curves progress while they are wearing it.

Several studies have been done which give end-result evaluations a year or so after completion of the brace program. One such study by
Edmonson and Morris (1977) considered a group of 52 patients followed for more than six months and an average of 22 months after cessation of brace wearing. The conclusion reached was that the improvement accomplished in bracing was not as great as for surgery however progression of curves under 60° was usually halted. Although improvement in some curves did occur this gradually was lost after treatment ceased.

A study of long term results was carried out by Mellencamp et al. (1977) of 47 patients completing treatment of at least five years with the Milwaukee brace. There was no statistically significant variation when the results were analysed according to age, size of initial curve or location of curve. One-third of patients lost 5° of their correction. The other two-thirds had curves which progressed. The range was from a gain of 40° to a loss of 26°. The most important findings of this study were that there was extreme variability in the age at which curves stabilized or at which correction occurred and variation in the end-results. The main deficit was that neither of these studies were randomized clinical trials of bracing.

Blount (1981) emphasizes the importance of using the Milwaukee brace only in curves occurring in immature girls so that vertebrae may be reshaped with growth. The brace may correct curves in those near skeletal maturity but the spine will not maintain the correction and will return to the original curve. The crux is whether this is an acceptable curve. If it is not, then surgery should be the original choice. In evaluation of efficacy of bracing it would be important to know if bracing were applied only to those curves meeting the criteria of immaturity or if the sample was unselected as to bone age.
A randomized clinical trial of the Milwaukee brace has not been done. It might be considered unethical at this point in time because of the general belief by orthopedic surgeons using the technique that it is beneficial but the only evidence available as to its efficacy is from end-results of children in bracing programs and these results are equivocal.

In searching the literature for evidence of the acceptability of bracing there were limited reports available. Wickers (1977) states that the Milwaukee brace may be rejected by some adolescents despite its suitability for treatment of their condition. Concern about looking different, being less mobile and having to wear camouflaging clothing have been cited as reasons for refusal to wear the brace. Moe and Kettleson (1970) report 20 percent of their patients refused to wear their braces. One-third of brace patients required intervention to overcome psychological difficulties in adjusting to brace treatment (Heckman-Schatzinger et al. 1977). Gurr (1977) reports refusals over a two year period of 4 of 75 children who had braces prescribed.

Operative approaches

Surgery is needed for those cases not manageable by bracing or for large inflexible curves. There appears to be general agreement that curves over 50° require surgery, curves from 40° to 50° may require operative treatment and those under 30° can be dealt with more conservatively. These recommendations appear quite uniformly in the literature (James 1976; Moe et al. 1978) and in direct communication with orthopedic surgeons (Tredwell 1981).
The surgical approach to treatment for scoliosis is usually by Harrington Instrumentation with fusion. Moe et al. (1978) state that surgical treatment is safe in good hands, while James (1976) suggests that correction (i.e. traction) followed by fusion of the spine is the basic treatment method for scoliosis except for slight curves manageable by bracing.

Evidence of the effectiveness of surgery has been reported by Goldstein (1969) but a pseudarthrosis rate of 5 percent occurred (4 of 80). In the 76 patients with solid fusion post-operative loss of correction averaged 7° or less. Ponder (1975) with an earlier mobilization approach averaged a loss of 5.3° in curve correction and a pseudarthrosis rate of 5 percent. Other complications occurring are infection and neurological damage. A study by the American Scoliosis Research Society quotes an incidence of 0.7 percent for the latter. The mortality rate has been reported variously as 6 percent, 0.07 percent and 1.4 percent (Ponder 1975). Edgar (1980) reported a 15° average curve deterioration post-operatively in adolescents between fusion and maturity. Deterioration in adult life averaged 2°.

Acceptance of the recommendation for surgery was not documented in the literature but one can surmise some reluctance to have a child undergo major surgery with post-operative incapacity for several months when the child may have been symptomless and appear normal to the parents.

Acceptance of initial referral

Before leaving the aspect of acceptability of the treatment, there is another level of acceptability prior to either bracing or
surgery and that is the acceptance of the initial referral for medical assessment after screening has determined a possible scoliosis curve.

Brooks et al. (1975) found among a group of 374 patients being observed after a screening program that 25.9 percent refused further evaluation or were lost to follow-up. In an Ontario study in 1977, 827 children were referred for medical follow-up after screening and there was no evidence of a completed referral in 20 percent of the cases (Williams and Tice 1980). In a North Vancouver study only 2 of 307 referrals failed to comply with referral (North Shore Health Department 1981).

To complete consideration of this criterion mention should be made of the conclusion of the Task Force on the Periodic Health Examination (1980) that efficacy of treatment was difficult to determine because of the incompleteness of follow-up data and the fact that improvement could occur without treatment. Evidence presented on methods of treatment such as the Milwaukee brace are not acceptable because none are based on case-control or even quasi-experimental study design. While surgery prevents the deformity from progressing it has an accompanying mortality and morbidity. In this Task Force report the effectiveness of prevention/treatment is given as "unknown".

3. Facilities for diagnosis and treatment should be available

Wingate (1977) and Frost (1978) discuss diagnostic and treatment facilities which are necessary before introduction of scoliosis screening programs.

In planning for the implementation of statewide screening in
Hawaii, Frost (1978) considered the availability of personnel, equipment and supplies and community resources before screening would commence. The number of orthopedic specialists, particularly those specializing in scoliosis, and of clinic facilities (including visiting clinics to other areas) were all reviewed. No mention was made of radiological services or orthotic (bracing) resources.

Wingate (1977) stressed the importance of consideration of available diagnostic and treatment facilities when introducing scoliosis screening in an urban setting. She mentions that spinal X-rays must be possible and referral centres alerted to the possible influx. Here also no mention is made of brace service or orthopedists but this may be considered part of the clinic resources.

Taylor et al. (1978b) suggest that a school screening program for scoliosis should not commence without consideration of available diagnostic and treatment services. They found that in Australia there were deficits in the number of orthopedic surgeons available and in the state of development of orthotics. They also suggest institution of screening without considering available treatment could create a dilemma caused by anxious parents and children, long waits for appointments necessitating involved travel and inadequate brace maintenance. The conclusion: that while screening programs could under the right conditions be an admirable addition to public health services they should only be introduced under the prime medical guidelines "the right thing, for the right reasons, at the right time" (Taylor et al. 1978b, p. 3).

In the large school screening programs begun in Montreal in 1974 the resources which were coordinated as integral parts of the
program included the community health department, school nurses and hospital medical centre services such as the medical consultant, radiology, physiotherapy and orthotist. Administrative services for records and data collection and the bus company were other services included in the "team" which was managed by a program coordinator (Gurr 1977).

It is generally agreed that before screening begins personnel should be available to carry out screening and that diagnostic and treatment facilities should be capable of absorbing referrals from the screening program.

4. There should be a recognizable latent or early symptomatic stage

In the early or preclinical stages of scoliosis there is no pain or other symptoms, but certain signs do occur which may be indicative of pathology. These early signs include visible fixed rotation on forward bending (the classic rib hump), scapular prominence, unequal shoulder level, unequal waist angles, pelvic obliquity as evidenced by iliac crest level and plumb bob misalignment (Keim 1978; Moë et al. 1978).

It is agreed that there is a stage of scoliosis when an early curve may be detected but it is difficult to determine which of these early curves are significant, that is, which are minor non-progressive curves not requiring continuing management and those which will become progressive severe structural deformities. This aspect of scoliosis will be discussed in more detail under criterion seven - the natural history.
5. **There should be a suitable test or examination**

Description of the tests

The commonly recognized screening test for scoliosis is described in the Screening Handbook of the Scoliosis Research Society, as a forward bending test, with the feet together, clothing removed to the hips, in which the examiner observes the spine in upright and forward bending positions. There is another less common method of screening using photogrammetry called the Moire test. The subject is positioned in front of a screen of fine wires. A light is projected through the screen and shadows from the wires outline the contours of the subject's back. A photograph is taken and studied for asymmetrical patterns (Howell et al. 1978). The suitability of the Moire test will be reviewed after the standard test.

The criteria for a screening test have been discussed previously (Cochrane and Holland 1971, Sackett 1975b) and selected ones are applied to the scoliosis screening test as follows:

**Simplicity**

The test is easy to understand and rib humps of marked degree are obvious. No expensive equipment is required in testing. Lonstein (1977) suggests the test can be done by school nurses or physical education teachers and a large group processed rapidly and easily "a 30 second investment for a lifetime of dividends".

**Validity**

Wingate (1977) as well as Howell and Craig (1980) give validity as the key criterion for a test. Validity can be measured in terms of
the sensitivity, specificity, (or false positive and false negative rates) as well as by the predictive value. Howell and Craig (1980) suggest that the predictive value of a positive test (PVPT) is the best indicator of validity of a screening test. In a study assessing physician screeners Howell et al. (1980b) found a PVPT range of 7 percent to 30 percent for curves equal or greater than 15° and 31 percent to 54 percent for curves equal or greater than 10°. Comparing nurses and physicians in validity of screening decisions, the following is reported: for curves equal to or greater than 10° - nurses' sensitivity 71 percent, specificity 36 percent, physicians' sensitivity 81 percent, specificity 22 percent, while for curves equal to or greater than 15° - nurses' sensitivity 76 percent, specificity 35 percent, physicians' sensitivity 81 percent, specificity 21 percent.

Verrier et al. (1979) assessed the validity of the screening test in a trial in Etobicoke, Ontario and found that in a sample of 60 children seeded with 16 confirmed scoliotics who were screened by public health nurses, physiotherapists, a physician and by photographers, only one child was found free of scoliosis by all screeners and only two were found positive by all examiners. Overall there was 60 percent inter-rater agreement. In this study to eliminate the possibility of poor training of the raters in use of the screening test, additional training was given to all raters with no significant improvement in a second screening experience.

In completion of a fourfold table Verrier found sensitivity 77 percent, specificity 40 percent, and PVPT 35 percent. Overall validity as determined by the number of children accurately classified was 51
percent. These researchers concluded on the basis of these results that the reliability and validity of the test for scoliosis was questionable.

Repeatability

This can be assessed by measuring interrater, intermethod and intrarater agreements. Verrier et al. (1979) report on all three in their study in Ontario. It was reported that raters agreed with themselves an average of 61 percent of the time. Overall average of interrater agreement was 69 percent (standard deviation of 11 percent). Intermethod agreement (using Moire photograph) was 59 percent overall. All raters (physiotherapists, nurses, physicians) were found equally likely to make errors.

Cost

Direct cost of screening itself is generally agreed to be acceptable because of the use of volunteers and available personnel; however the indirect costs are not always included, i.e. X-rays, physicians and specialists. In view of the high false positive rate these costs are significant. Moe reports on cost accounting and gives cost of screening as $1684 per 400 students screened. He suggests without early detection, assuming one child in 400 required surgery the cost would be $5500 (Moe et al. 1978). Williams and Tice (1980) remind readers that besides cost of screening and medical follow-up indirect costs - for time lost, anxiety and fear - must be accounted for.

In summary the standard screening test appears to meet the criteria of a suitable test on the grounds of simplicity and direct costs;
but evidence on validity and repeatability raises concerns as do the indirect costs generated by screening.

Moire test

The criteria of simplicity, validity, repeatability and cost will be considered briefly in relation to the Moire test as reported in the literature.

There have been several studies utilizing photogrammetry along with clinical screening (Howell et al. 1978; Howell and Craig 1980; Howell et al. 1980). This technique involves use of heavy equipment which requires transportation. Difficulties positioning subjects have been noted (Howell et al. 1980). Seventy-one percent of curves of 10° or more went undetected (Howell et al. 1978). Verrier et al. (1979) in a study to compare Moire topography and physical examination found an unacceptably low rate of reliability and validity with an unacceptably high level of false positives and negatives. Because of those unacceptable findings use of the Moire test is still in the experimental state. The reduction of expensive time required to screen large numbers of children was anticipated to be an advantage of this method (Howell et al. 1980). This possibility keeps interest in its development high.

It appears the Moire test fails to meet the criteria of a simple, valid, reliable test and the question on cost is still unanswered.

6. The test should be acceptable to the population

Stangler et al. (1980) proposes that all who will be affected by a screening test should find it acceptable. This includes families, children, the professionals who receive the referrals and the whole community.
In some areas where a signed parental consent was required before screening 85 percent to 90 percent were returned (Williams and Tice 1980). These same investigators suggest that questions could be added to the consent form to determine if previous history of back problems was a reason for refusal to consent to screening. In other areas a consent form along with an explanatory letter was used (Howell et al. 1978). The form was to be returned only if there was objection to screening. They report this a highly acceptable method. The North Vancouver Health Department also uses the dissent method of consent (1981). During a scoliosis screening pilot project in Hawaii involving 875 children there were 24 parent refusals (3 percent) and 18 student refusals (2 percent) (Frost 1978).

Howell and Craig (1980) recommend from their Edmonton experience where all grade seven girls are screened, that because adolescent girls are easily perturbed by the program it should be de-emphasized. They accomplish this by having the regular school nurse do screening as part of grade seven periodic examinations. Wingate (1977) found that undressing and semi-nudity caused some embarrassment but in general the test was acceptable.

Acceptability of the Moire test was only 70 percent to 80 percent in one Ottawa study, because parents misunderstood the test and assumed radiation was involved (Columbian April 7, 1979). Another concern expressed was the lack of privacy because the buttocks were exposed and the embarrassment caused by the presence of a young male technician.
Physician acceptance

Another recommendation from the study of Williams and Tice (1980) was that physicians in Scarborough be surveyed to determine their views on the screening program and criteria for diagnosis and management. The survey could identify physician acceptance of the program.

There appears to be a range of acceptability of scoliosis screening reported in the literature of from 70 percent to 95 percent.

7. The natural history of this condition including the development from latent to declared disease should be adequately understood

The natural history of a disease is learned by studying those with the condition who have not had treatment. The course of adolescent idiopathic scoliosis is unclear in some respects. Moe (1980, p. 90) comments that

We are still far from the ultimate goal of knowing its (scoliosis) etiology and determining which of the small curves are going to progress to severe curves . . .

Taylor (1978a) suggests that data is urgently needed on the natural history of minor curvatures. Blount (1981) feels the lack of accurate information about patients under observation before 1960 makes the study of the natural history of scoliosis over a long period difficult. He sees that this situation will be improved in the future with the availability of present records which document skeletal age as well as other relevant information needed to describe the natural history of scoliosis.
Studies of untreated curves during growth

There are three possible outcomes for a curve: spontaneous resolution, no change and progression. As has been discussed previously more curves progress in girls than boys, and those most at risk for progression are immature females with curves over 10° (Rogala et al. 1978).

Ponseti and Friedman (1950) in a review of 394 patients, 335 of whom were followed to maturity, found that the most severe progressions were related to early onset of the curve. Thoracic curves progressed most, with the average thoracic curve at maturity 81° (in 71 patients). The average curve in the remaining cases was between 35° and 52°.

Studies of untreated curves after maturity

In a further study of 215 of these same patients (Collis and Ponseti 1969) most were found to have led normally productive lives. While back pain was reported frequently it was minimal and non-limiting. Vital capacities were diminished in 45 percent but only 2 percent had more than slight dyspnea on exertion. The death rate was similar to the general population.

Nilsonne and Lundgren (1968) studied the long-term prognosis of 113 patients with idiopathic scoliosis up to 50 years after original diagnosis at the average age of 15.9 years. Only 11 of the 113 were lost to contact, of the remainder 56 were alive and 46 had died. Mean age of death was 46.6 years. The mortality rate was calculated to be twice as high as for the general population and cardiac or pulmonary disease accounted for 60 percent of deaths. Forty-seven percent of the
living patients were disabled, 76 percent of the females were unmarried, 90 percent reported back symptoms.

Nachemson (1968) did a follow-up study of 117 patients 48 to 53 years after initial diagnosis at a mean age of 14. Mortality rate was twice that expected. In 16 of 20 patients who had died, kyphoscoliotic cardiopathy was listed as cause of death. Thirty percent of the patients received a disability pension. Recurring back pain occurred in 37 of 97 individuals.

It is agreed that curves over 60° often progress in adulthood. Ponseti et al. (1976) found that in 26 percent of patients curves increased 15° or more and in 8 percent of patients 25° or more. Some curves show lifelong increase.

Reporting of spontaneous improvement of curves shows wide variation. Brooks et al. (1975) found 22 percent of curves in his study population of 3492 improved while Rogala reported 3 percent (19/603) improved. Improvement is defined as virtual disappearance of the curve on the roentgenogram (Rogala et al. 1978) or a decrease of 5° or more from initial to final visit (Brooks et al. 1975). In Rogala's study (Rogala et al. 1978) it was found that 20 percent of the curves in immature girls of a magnitude of 20° to 30° did not progress. In lesser curves there was progression in 2.1 percent of children with 6° to 10° curves and 10.3 percent of children with curves greater than 10°. Progression for the purpose of that study meant increasing 5° or more to a final curve of 20° or more.

The conclusion one can reach is that there remains a lack of information from prospective studies on the natural history of scoliosis
and retrospective studies have a bias to give information on those curves in the treatable range.

8. There should be an agreed upon policy on whom to treat as patients

For purpose of examining this criterion, treatment will be considered as active medical follow-up which includes observation. There is some variation in the standards for management of children identified with spinal curvature particularly in the range of smaller curves.

Howell et al. (1980b) reports the criteria agreed upon in Edmonton screening programs. They focus on curves of at least 15° to avoid unnecessary referrals. The school nurse rechecks suspicious curves every six months. There is active follow-up of girls with curves greater than 15° to be sure they are being seen. The guidelines established by an advisory panel to their programs were as follows:

**Interpretation of radiographic findings in scoliosis**

While the prognosis varies according to age and state of maturity it may generally be said that

1) curves of less than 5° are within normal variation
2) curves of 5°-9° are insignificant
3) curves of 10°-19° require observation with clinical re-examination every 3 months and re X-ray after 6 months. If no change is seen, observation interval can be extended to clinical examination yearly for 2 years, with re X-ray if change is suspected.
4) curves of 20° or over should be referred and may require treatment. (Howell et al. 1980, p. 2)

If treatment includes observation as some orthopedists suggest, "observation is active treatment" (Tibbits 1980), and the Scoliosis Research Society categorizes it as the first level of treatment, then usually persons with curves over 10° are those considered by most experts in the literature to require treatment. Otherwise Rogala et al. (1978) would suggest progression of a curve by 5° or more to over 20° places
the person in the treatment category. The immature female with a curve 11° or more is most at risk and should be observed closely. Taylor (1978a) suggests there is no sound basis for management of curves under 25°, found by screening programs. He warns of the potential hazards of over exposure to radiation which could occur if X-rays were taken at frequent intervals over an extended period of time to observe small curves. Earlier Brooks et al. (1975) recommended follow-up of 5° curves but in a more recent discussion (1980) suggested that 11° and greater curves should be followed.

Kane (1977a) says any immature individual with a curve of 20° deserves treatment and any immature individual with a curve over 10° is "at risk" and should be followed. These two groups constitute the scoliosis population, in his opinion.

Blount (1981) suggests that there has been failure to recognize the skeletal age in considering whether to brace patients with moderate scoliosis. The magnitude of the curve is too often the sole criterion. A progressive curve should be treated at an early age. Bracing will not be effective for an unacceptable curve in an almost mature individual. Although the curve may improve it will return to its prebrace level later because there has been no vertebral reshaping with growth.

In Sweden where school children are regularly examined for scoliosis few patients in whom brace treatment is begun early require surgery later (11 of 477 patients where curve was less than 40°) (Torell et al. 1981).

There is some lack of agreement on who to treat as a scoliosis patient. All would agree that immature individuals are the ones "at
risk" but whether the level for concern is at 11°, 15° or 25° varies with the publication.

9. There should be economic balance of the cost of case-finding in relation to total expenditure on medical care

There are limits to the resources which any society can devote to health care. Funds spent in one area mean benefits foregone in another. Wilson and Jungner (1968) suggest it would be helpful to compare the economics of medical care through screening with the results of the same expenditure on conventional care. To do this they suggest a prospective study is needed to determine if morbidity has been reduced and working life improved in a screened population compared to an unscreened sample.

Cochrane and Holland (1971) have suggested that the decision of whether the cost of screening is reasonable can be made by costing screening programs carefully and then asking a group of lay and medical people whether such cost is acceptable.

There is a dearth of information about the cost of scoliosis screening in relation to total costs and no experimental evidence available. Moe et al. (1978) cites a study of Drummond in Montreal in which "cost accounting" was done. Cost of screening was calculated at $1684 per 400 students. The assumption was made that of 400 children one would require surgical treatment (if screening had not occurred) so that without screening the cost would be $5500. Details are not available, but one would question what was included in the calculated costs of screening and whether all referral and follow-up services including X-ray, physiotherapy, orthoptics and physician visits for both
true and false positive are calculated. Further discussion of costs is found under criterion 11.

10. Case-finding should be a continuous process and not a "one-time" project

Wilson and Jungner (1968) suggest the single-occasion examination is usually of limited value, particularly in terms of "weeks" or "fairs" because only a small proportion of the population is reached and only those who have the condition at that particular time. They suggest that continuing examinations of the population at risk have great advantages.

In the case of adolescent idiopathic scoliosis the disease is likely to show early signs between the ages of 10 and 15 years and so the reported options for screening have been one or more examinations during that early adolescent period and in some cases a one-time screening test has been considered adequate. The Scoliosis Research Society suggests that although all screening is useful a "once-and-done effort" is not adequate and they recommend annual screening in the fifth through tenth grades.

Rogala et al. (1978) in a prospective study in Montreal described screening of both grade six students and those in grades seven and eight. It was concluded that screening between ages 12 to 14 years was most successful. In Scarborough district, Ontario (Williams and Tice 1980) screening was done in grade six and grade eight. In Edmonton grade seven girls were screened in the evaluative program taking place there. Lonstein et al. (1976) suggests yearly screening during the "at risk" years which he defines as ages 10 to 13 or grades five through eight.
In Sweden screening is performed by school doctors and nurses as part of routine medical screening usually at ages 7, 11 and 14 (Torell et al. 1981). Wingate (1977) in her plan for an urban program had the objective of screening children annually between ages 8 and 16. Frost's (1978) plan for a statewide program in Hawaii describes the ideal target group for screening as including children age 10 to 15 but due to realities of limited personnel and time, one age group - grade seven - was considered an adequate target group.

Most scoliosis screening programs described in the literature have been on-going programs however they usually aim at screening once only - in early adolescence.

11. Cost-benefit and cost-effectiveness characteristics of mass screening and long-term therapy must be known. A mechanism for weighing costs against benefits should be a component of initial screening activities. The long-term benefits must outweigh the costs including therapeutic costs and detriments due to labelling.

The criteria relating to estimation of benefits are considered together.

The lack of studies measuring costs and benefits of screening for scoliosis is noted by Verrier et al. (1979), although she comments that there is a general belief that benefits outweigh the costs. It is her contention that the benefits which accrue from scoliosis screening are those due to secondary prevention, that is, the prevention of early death, disability and extensive care. Cost includes all costs of screening, follow-up, diagnosis, observation and treatment of those referred for care. The problem of identifying and measuring the intangibles such as social and emotional costs and benefits both for the correctly and incorrectly labelled is also recognized.
The issue of individual versus public benefit is discussed by Williams and Tice (1980). Some might argue one child saved from spinal fusion justifies a program, while from a societal viewpoint the direct costs from screening and medical care and the indirect costs for worry and time, may be excessive in terms of the actual benefits gained. The difficulty for the administrator in public health occurs because while the health unit may be aware of individuals who are helped, the overall costs are not appreciated because of lack of available information about program results (Williams and Tice 1980).

No mechanism for assessing costs and benefits had been designed as a feature of the screening program reviewed by Wingate (1977), nor were estimates of costs, benefits or effectiveness of screening programs available at the time of her paper. She suggests that in the organization of a model screening program for an urban population that the costs be measured. It is her proposal that they include salary or a portion thereof, of the health care coordinator, cost of the time of physical education teachers, school nurses, therapists and physicians; costs of training of personnel and costs of referral to physicians, pediatricians, orthopedists, physiotherapists and orthotists. The greatest costs will be for hospitalization and surgery for severe cases. Other costs she includes are for letters, postage and data collection.

On the other hand, according to Wingate, benefit will be exceedingly hard to measure in dollars. Quality of life considerations are mentioned as well as the avoidance of physical incapacity with related consequences to employment. Wingate's contention is that estimated
costs of surgery should be deducted from program costs on the assumption that most patients would not have needed this extreme form of treatment with early detection. The rationale is that early detection with bracing as necessary prevents curves requiring surgery. Her conclusion is that regardless of whether benefit exceed costs, society must determine the worth of improving the quality of life for a small number of citizens and decide on a humanitarian basis. The aspect of finite resources and choice of the best alternatives for those limited dollars is not discussed. No mention is made of the "opportunity cost" when resources are deployed in screening.

The opinion that society cannot afford perfect treatment for all patients and all conditions is presented in a discussion of the economics of the treatment of scoliosis (Dahlberg, Nachemson 1977). It is important to note this study is based on 1971 prices and Swedish medical practice, but it is interesting in terms of being the only available paper on the topic. These authors concluded that the present day treatment of young patients with thoracic curves showed an extremely high benefit/cost and effectiveness ratio. They also concluded that a definite economic benefit can be derived from early brace treatment in younger patients compared to surgery at a later date. This led them to conclude that early recognition is highly advisable. Their study is based on data from the Swedish disability pension fund correlated with the degree of curvature for individuals receiving a pension. One of their premises is that after treatment with a brace curves do not progress - an inaccurate assumption in light of the studies of Edmonson and Morris (1977) and Mellencamp et al. (1977) who documented progress of curves after treatment ceased.
As mentioned in discussion of criterion nine concerning costs, Drummond and Rogala (Dwyer et al. 1978) estimate a saving of $600,000 in surgical costs after deduction of screening costs in their study. Taylor et al. (1978b) criticizes this conclusion. They quote Shapiro's conclusion that cost/benefit analysis is only useful in very special circumstances. Because of the long-term follow-up required in spinal deformity, their conclusion is that there is not a sound basis for a critical study such as that of Rogala et al. (1978). McKeown and Knox (1968) have suggested that without a balance sheet relating cost to benefit, it may not be possible to decide about a screening program in terms of alternative methods of diagnosis and treatment.

On the basis of a review of the published evidence the Task Force for the Conference of Deputy Ministers of Health on Periodic Health Examination reported (1980) that scoliosis screening is of doubtful value in terms of cost benefit. The lack of information about the outcome of children who were treated after detection during screening is considered a serious deficit. Because of lack of evidence as to the benefits of a particular form of therapy the committee recommended that screening be done only within the context of an evaluative study. The extremely low yield from screening programs was another factor in their recommendation. Because the Task Force Report represents a review of published reports on scoliosis and is of recent date their conclusion must be seriously weighed.

12. Ideally an estimate of the social benefit of preventing, arresting or curing the condition should be known and if community benefits are claimed to result from screening this benefit must withstand scientific scrutiny.

Generally the social benefit claimed is that documented in studies
such as those of Nachemson (1968), Nilsonne and Lundgren (1968), and Drummond et al. (1976). These studies indicate the restricted working ability of patients with untreated scoliosis. In Nachemson's study 97 patients were questioned. This group consisted of the patients available from a group of 130 seen between 1927 and 1936 at a major referral centre in Sweden. No X-rays were available. Of the 97 patients questioned: 30 percent were claiming a disability pension and the average age at which it was claimed was 36. Another study (Nilsonne and Lundgren 1968) found almost one-half of the patients contacted were unable to work. The high proportion of unmarried (76 percent) in Nilsonne and Lundgren's study is another statistic which could be used to illustrate social benefit of early treatment and prevention of cosmetic deformity. Drummond et al. (1976) in a Quebec study found 24 percent unemployed while 42 percent of females and 30 percent of males were unmarried.

It is important to know that the sample in these studies is of adolescent idiopathic scoliotics. Nilsonne and Lundgren (1968) mention that scoliosis due to paralysis and rickets were excluded from their sample but that some congenital scoliosis may be inadvertently included. As the incidence is 5 percent for congenital scoliosis in their estimation this should not be significant to the results.

Nachemson includes untreated scoliotics of all types in his study and of the 130 patients, 59 were idiopathic scoliosis. It was possible to trace 52 of these 59 patients and 10 of the 52 were 75 percent disabled. These statistics for disability were the lowest for any of the five types of scoliosis in the sample. This study is widely quoted to illustrate the benefit of prevention in scoliosis and so it is
important to know whether social effects described are due to scoliosis in general or to a specific type. In the time of these studies there were scoliotics who were polio casualties or rachitic. It would appear from Nachemson's paper that the sequelae of idiopathic scoliosis are the least severe. The information on Drummond's study does not indicate whether the sample is exclusively idiopathic scoliotic patients.

In summary if benefits are to be claimed on the basis of sequelae prevented by screening then scientific scrutiny would require experimental or quasi-experimental evidence. Evidence of this nature could not be found in this literature survey and it is questionable if the descriptive studies found are useful in terms of claimed benefits for screening for idiopathic scoliosis.

This completes the application of 12 selected criteria to the literature on scoliosis and scoliosis screening. Further discussion of whether the evidence justifies scoliosis screening in terms of these criteria will follow in Chapter five.
CHAPTER III

METHODOLOGY

Purpose of the Study

This study evaluates the scoliosis screening program carried out in SFHD to substantiate that the program should be continued. The evaluation was done by applying established criteria to the outcomes of screening to determine the acceptability of both the screening test and the treatment recommended, the validity of the screening test and the availability of resources. The data from the study was analysed mainly in relation to these four principal criteria but consideration was also given to the implications of the other important criteria of screening for continuation of the program.

Description of the Screening Program

Time Period

The time period for this study was from September 1976 to June 1980 and includes the screening for scoliosis carried on during four school years. A pilot project of scoliosis screening was conducted during January to June 1976 and involved 775 students from selected schools. The data from this pilot program and the data from children screened after June 1980 were not included in this study.

Sample

To qualify for screening it was required to be a student at a
school within SFHD (private or public). SFHD is comprised of two school districts: School District #43 (Coquitlam, Port Coquitlam, Port Moody) and School District #40 (New Westminster). In the school years 1976-77, 1977-78, and 1978-79 only School District #43 pupils were screened. In the school year 1979-80 pupils from New Westminster were included in the screening program. In school year 1976-77 all grade seven pupils (N = 1879) were screened and a sampling of 35 percent of the grade eights (N = 708). In the school year 1977-78 all grade sevens (N = 1748) and a group of 125 rechecks from the previous year were seen (grade eight and nine students). In the 1978-79 and 1979-80 screening years only grade seven students were screened, 1690 and 1860 respectively. The grand total of pupils screened was 8010. Both boys and girls were included in the program. No consent was required for screening. The school principal sent home an explanatory letter about the program and notification of the date of screening. Consent was implied if no dissenting communication was received by the time of screening. All children known to have scoliosis (the public health nurse would identify these children) were excluded from screening. Those children who refused screening or for whom a note or telephone message was received advising refusal of screening were so noted on the class list used by the screening team. Those already known as scoliotic were included in the figures used to determine prevalence in this study.

**Screening test**

Each child was examined by one of the screening team, which consisted of two public health nurses and a physiotherapist. There
were four to six public health nurses and three physiotherapists rotating on the teams. The physiotherapists had received training from an orthopedic surgeon at the time of the pilot project. The nurses, some of whom were new to screening each year were trained by the physiotherapists and by use of a training film produced by the Scoliosis Research Society.

The examination consisted of viewing the child with shoes and top clothing removed. Girls could wear halters or brassieres. Pants were lowered to the level of the iliac crests. The child was first examined standing erect, facing away from the examiner with weight equal on both feet and arms at sides. The examiner noted: shoulder level, level of inferior angles of scapula, waist angles, iliac crest level, dorsal superior iliac spine level, and plumb bob alignment from seventh cervical vertebrae. Next the child was examined standing, forward flexed, with hands clasped in front, head well flexed and knees straight. The examiner then noted the level of thoracic and lumbar region. The screener was looking for a raised area at the side of the spine which is the classic rib hump of thoracic scoliosis.

Criteria for referral

Any one of the following was considered a positive sign of scoliosis: presence of a thoracic and/or lumbar elevation, shift of spine, waist angle change, pelvic asymmetry, one prominent shoulder blade or cafe au lait spots (neurofibromatosis). These standards were used consistently in all years of screening under consideration in this study.

A screening positive was a student with one of the signs of scoliosis which had been confirmed during rescreening two days later
by another physiotherapist. Upon the decision to label the child as positive, a letter was mailed to the parent. The district public health nurse telephoned the parents to explain the recommendations and give reassurance. This call was made on the day of the rescreening, in the evening if necessary.

**Referral procedure**

Accompanying the letter to the parent was a letter from the physician to be presented to him by the parent at time of the medical examination. The family doctor was requested to:

a) re-examine the child, especially in forward flexion  
b) have a standing X-ray done if there was agreement with the findings  
c) refer to an orthopedic surgeon if signs were confirmed on X-ray.

The physician was requested to write his findings on the back of the letter of referral and mail his reply in the stamped addressed envelope provided by the health district.

When the pilot program was initiated an orthopedic surgeon was actively involved in the planning stages. A meeting was held of orthopedic surgeons working in the health district at which time it was agreed that one of them, an orthopedic surgeon, would take primary responsibility for referrals from the program. This decision was discussed at a meeting of the New Westminster Medical Society so that general practitioners who made referrals to orthopedists would be aware of this agreement. This informal policy was in effect during the period of screening under review.
Confirmed positives

The presence of a curve greater than 10° (Cobb method) on a thoracic-lumbar anterior-posterior X-ray was considered orthopedically positive for the purpose of this study. As well any orthopedist's confirmation of "scoliosis--to be followed" was considered positive until X-ray confirmation of the degree of curvature.

Program data

Class lists were used during screening so that every child examined was recorded. Any screening refusals were noted on these lists as were absentee. There was an attempt to screen absentee on the day of rescreening. From the physician reports and public health nurse contact of parents and physicians, a record card was completed by the physiotherapists for each child who initially failed screening. For the period of this study 169 screening positives have been identified. The records for these 169 children were examined for completeness of outcome information. For 47 children there was complete information noted and no further contact was necessary.

Study Method

The record cards for the remainder (122) were scrutinized and checked for an up-to-date address and phone number. Health District records, telephone book, student directories and school records were used to confirm the location. There were five cases where a current address was not available, however, in each case enough outcome information was available from initial health district contact to include them in the sample. The new addresses of three cases away from the
district were available and these parents were contacted by letter and asked to reply to the same questions posed in the telephone interview. All replied including a family traced to California.

For those 114 cases in which information was incomplete and an address was available the following procedure was followed:

1) First a letter of introduction from SFHD was sent to the parents of the 114 children (Appendix A) before any contact was made.

2) One week following the mailing of these letters telephone interviews began, during which parents were asked about the outcomes of the referral of their child following screening (Appendix B outlines the interview format). All parents cooperated by giving information. From these interviews records for 68 children were completed.

3) For the remaining 46 children a contact to the physician was necessary to complete the outcome information. The parents were asked at the time of the telephone interview if they consented to physician contact. A consent (Appendix C) was mailed with an enclosed stamped addressed envelope to the 46 families.

4) Prior to the investigator contacting the physician a letter of introduction was mailed from SFHD (Appendix D). The purpose of this letter was to explain the objective of the scoliosis program evaluation and encourage physician cooperation in completing the questionnaire.

5) As the parental consents were received they were mailed along with the questionnaire to each physician (Appendix E), including a stamped addressed envelope for the reply. The orthopedic specialist who received the majority of referrals from the family doctors was contacted directly and an arrangement made to work directly in his medical records system.
At this point in the study a mail strike was threatened and so a postscript was added to the questionnaire that pickup of the completed questionnaire would be arranged upon a telephone call to the investigator.

**Calculation of Resources Used**

Resources required for a screening program include the resources to carry out the screening procedure itself and those that provide diagnosis and treatment as necessary to those who are referred from the program. To describe resources utilized, the amount of staff time used in the screening program was tabulated for physiotherapists, public health nurses and clerks, according to each program year. Diagnostic and treatment resources were categorized as medical, X-ray, orthotic and physiotherapy. From the information given in the interviews and questionnaires any problems encountered in obtaining services in any of the necessary areas; medical, X-ray, orthotic or physiotherapy, were documented. The resulting tabulations are presented in Chapter four.

Because there are implications for province-wide application of screening the location of orthopedic surgeons and orthotists in B.C. was determined. To obtain this information the Medical Directory published by the College of Physicians and Surgeons of British Columbia and the list of Certified Orthotists of the B.C. Association of Orthotists was consulted. These data are also found in Chapter four.

**Economic evaluation**

It is accepted that evaluation of evidence that a screening measure is effective should precede economic evaluation of the program
(McKeown and Knox 1968; Sackett 1975a). The question of effectiveness of the screening measure (that is, its validity) is to be assessed in this study, as well as its acceptability and the acceptability of the treatment for the condition. There is no point in economic evaluation of a measure which is not valid nor acceptable, or which results in detection of a condition for which no acceptable treatment exists.

For this reason a complete economic evaluation is not attempted. Instead the time used by health district staff has been estimated and data is presented under the discussion of availability of program resources (see Chapter four). Such tabulation may prove useful to the health district in planning the deployment of staff. If program alternatives are considered information about the amount of time available from cancellation of scoliosis screening could be helpful. The cost of the screening program derived by multiplying the unit costs by the number of services has been estimated to provide some measures of the direct cost of the screening procedure and for the cost of diagnostic and treatment services resulting from screening, for both screening positives and negatives.

Methods of Analysing Program Data

To determine the outcomes of scoliosis screening for the period under review this investigator examined all available results of screening. The data was reviewed as follows.

Class lists

Each list was examined to determine the number of children screened and the number noted as screening refusals.
Record cards

The investigator reviewed each of the screening positives and tabulated the total number and the number of:

1) refusals for referral at any level
2) referrals to family doctor
3) referrals to orthopedic surgeon
4) children X-rayed by family doctor and by orthopedist
5) children who were screening positive and orthopedically negative (less than 11° curve)
6) children who were orthopedically positive (greater than 10°)
7) children who were already known to have scoliosis
8) children with other spinal disease
9) unknown outcomes

The orthopedic positives were analysed and are described by:

1) the initial curve and number remaining stable, progressing and decreasing

2) the follow-up received - observation, physiotherapy, bracing, surgery, and other such as chiropractice services, and non-acceptance at any level

3) distribution by sex

Quantitative analysis

Data collected from all sources including class lists, record cards, interviews, questionnaires, previous health district reports on scoliosis, Statistics Canada, Ministry of Health, Research Division, Medical Directories and other are categorized and presented in tables and narrative form in Chapter four.
The fourfold table

Using the generally accepted fourfold table illustrated in Figure 2, Grant (1974) has constructed a model from which useful evaluative indices can be calculated.

<table>
<thead>
<tr>
<th>Screening Results</th>
<th>Diseased</th>
<th>Nondiseased</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>a</td>
<td>b</td>
<td>a+b</td>
</tr>
<tr>
<td>Negative</td>
<td>c</td>
<td>d</td>
<td>c+d</td>
</tr>
<tr>
<td>Total</td>
<td>a+c</td>
<td>b+d</td>
<td>a+b+c+d</td>
</tr>
</tbody>
</table>

Fig. 2.—Fourfold table classifying participants in a screening program.

The subjects in the preceding table are classified as follows:

- a = true positives, diseased persons detected by screen
- b = false positives, nondiseased persons screened positive
- c = false negatives, diseased persons not detected by screen
- d = true negatives, nondiseased persons screened negative

Status of screening negatives

Grant suggests that to overcome the deficit in information about the status of the screening negatives (that is, whether they are diseased or nondiseased) a technique be borrowed from the methodology of systems analysis. A "research estimate" is the key to the quantities "c" and "d".

Of the four methods for estimating disease prevalence listed by Grant, a prevalence estimate from another study on a population demographically comparable was the one chosen for this analysis. The
prospective study of Rogala et al. (1978) was selected for this purpose. The proposed model is summarized in Figure 3. The key, the total number diseased in the population \((a + c)\) is obtained by multiplying the total screened by the prevalence estimate obtained from other studies.

Fig. 3.—Analytical derivation of the fourfold table.


Application of the model

Using the prevalence estimate of the disease to calculate total diseased as proposed by Grant allows completion of a fourfold table and calculation of the measures of validity.

1) The model was used to evaluate sensitivity \(\frac{a}{a+c}\), i.e. the proportion of the truly diseased who were correctly identified.

2) The model was used to evaluate specificity \(\frac{d}{b+d}\), i.e. the proportion of the truly non-diseased who were correctly identified.
3) The model was used to determine overreferral \( \frac{b}{a + b} \), or false positives, i.e. the ratio of non-diseased persons with positive screens to all those referred.

4) The model was used to determine underreferral \( \frac{c}{c + d} \), or false negatives, i.e. the ratio of diseased persons with negative screen to all those not referred.

5) The model was used to determine the positive predictive value \( \frac{a}{a + b} \), the probability that a patient with a positive screening test is diseased.

6) The model was used to determine the total predictive value \( \frac{a + d}{a + b + c + d} \), the probability that the test correctly identifies the recipient (both positives and negatives).

**Ethical Review**

A request for ethical review of activities involving human subjects in questionnaires, interviews, observations, testing, video and audio tapes, etc. was submitted to the University of British Columbia Screening Committee for Research and Other Studies Involving Human Subjects: Behavioural Sciences. Permission to proceed with the study was received (Appendix F).

The telephone interviews and questionnaires were administered by the investigator while on educational leave from her position as nursing supervisor of the Simon Fraser Health District. She is an experienced public health nurse who is familiar with the interviewing process and the need for respect of confidentiality in the gathering of data from individuals. She has the endorsement of the Deputy Minister of Health for this study (Appendix G).
CHAPTER IV

RESULTS OF THE SCREENING PROGRAM

The results of scoliosis screening will be presented relative to the four principal criteria which have been selected for this study as most useful in evaluation of the program at Simon Fraser Health District.

Acceptability of the Screening Test

To assess the acceptability of the screening test to the population consideration will be given to acceptability of the test to 1) parents, 2) child screened and 3) physicians.

1) Acceptability to parents

A measure of the acceptability of screening to parents is the proportion of refusals to consent to screening of their child.

As mentioned previously the school class lists were searched and the number of children who were exempted from screening noted along with the reason if one was given. Of 8031 children a total of 21 refusals (0.3 percent) were received in the four years of the screening program under review. In nine cases the reason given was a spinal problem under medical care. Two exemptions were also asked on the basis that the family chiropractor would check the child's spine. In ten cases no reason was given. The results are tabulated in Table II.
TABLE II
REFUSAL OF CONSENT FOR SCREENING

<table>
<thead>
<tr>
<th></th>
<th>number screened</th>
<th>total of refusals</th>
<th>known problem</th>
<th>chiropractor would screen</th>
<th>no reason given</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967-77</td>
<td>2587</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>1977-78</td>
<td>1873</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1978-79</td>
<td>1690</td>
<td>5</td>
<td>2</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>1979-80</td>
<td>1860</td>
<td>5</td>
<td>3</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>8010</td>
<td>21</td>
<td>9</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

During the 114 telephone interviews carried out by this investigator to complete data on screening outcomes, with few exceptions there was widespread endorsement by parents of the screening program. One parent criticized the notification process, as she had been shocked by the arrival of the letter advising referral. She had not received a phone call of explanation before the letter’s arrival as is the recommended health district practice.

When the program was evaluated for acceptability in 1977 and 1978 some parents felt more explanation about the disease of scoliosis would be helpful. Subsequently the health district provided school principals with a model letter explaining the program and a brief description of scoliosis which could be distributed at the time of notification of the screening date.
2) Acceptability to the child screened

Only one documentation of refusal to be screened by the pupil (N = 8022) is noted on survey of the class lists. The screening team has reported that self-conscious giggling and remarks were common during the screening procedure. Attitudes appeared to be improved with the introduction of a short explanatory talk by the school nurse a few days prior to the screening session. The children were told what to expect of screening and what wearing apparel was suitable. Absentee rate has been assessed and was normal at the time of screening. This can be considered as an unobtrusive measure of the acceptability of the screening procedure.

When parents (N = 114) were interviewed during this study three commented on the anxiety experienced by their children due to the rescreening examination at school. In one case the child had a friend who had just had surgery for scoliosis and he was very apprehensive.

During previous evaluation of the screening program when a public health nurse visited a random sample of families (N = 31) to ask their reaction to the program nine (29 percent) mentioned that their daughters were very self-conscious about being examined by health unit personnel (Ladner 1978).

3) Acceptability to the physicians

When a sample of ten physicians was interviewed by the Assistant Medical Health Officer in 1977 all indicated approval of the program. These ten were selected randomly from those physicians (N = 82) who had received a referral from the program during school year 1976-77. In
two instances (2 percent) during the study interviews (N = 114) to complete data for this study parents reported the comment of their physician that the referral had been a "waste of time".

Acceptability of Treatment

Treatment alternatives

There were five approaches to treatment documented after a child was diagnosed in this program as scoliotic: 1) observation at regular intervals, 2) placement on an exercise program under physiotherapist supervision, 3) bracing, 4) surgery, or 5) other care such as chiropractic. The same child could progress from one category to another as a result of change in the curve and treatment might be refused at any stage. The following table (Table III) illustrates the treatments utilized by those children who were diagnosed scoliotic.

**TABLE III**

**TREATMENT OF ORTHOPEDIC POSITIVE CHILDREN**

<table>
<thead>
<tr>
<th>year</th>
<th>total</th>
<th>observed only</th>
<th>physio</th>
<th>brace</th>
<th>surgery</th>
<th>other*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-77</td>
<td>17</td>
<td>9</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1977-78</td>
<td>14</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1978-79</td>
<td>5</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1979-80</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>24</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

*Chiropractic care in these cases (self-referral).*
1) **Observation** includes those children under the supervision of either the family physician or the orthopedic specialist. Children in this category are presumed "at risk" for a progressive curve because they had a curve greater than 10° and were skeletally immature. They were seen at intervals of from three months to one year, with X-ray examination on some or all visits. The number failing to comply with the recommendation for observation are noted in Table IV.

2) **Physiotherapy** in the ten cases treated by this means alone, usually involved a continuous program of exercises under the supervision of a physiotherapist in a clinical setting (hospital or office) concurrent with a home program. Royal Columbian Hospital offered a tri-weekly program of group physiotherapy for scoliosis patients and eight of the ten patients attended this program. Some of the children have been treated for over two years. Others have had shorter periods of treatment (two months to six months). The recommendation for treatment by physiotherapy was accepted in all cases.

3) **Brace treatment** was prescribed for nine children. Three refused bracing and of these, two have had surgery. The third girl has a 38° curve and is under chiropractic care. Of the six children who were braced one child was fitted and wore her Milwaukee brace only a few hours before rejecting it completely. She required surgical correction one year later and received chiropractic treatment during the intervening year. Two children each wore their braces for about 15 months but their curves progressed to the degree that surgery (Harrington Rod and spinal fusion) was required. Of the remaining three girls in braces one began brace treatment in September 1980 (10 months ago) and
has been maintained successfully. She is seen by the orthopedic surgeon every three months and is X-rayed on every second visit. Her curve of 27° is reported as "holding steady" and it is anticipated that she will be in her brace at least until September 1982. Another child has been maintained in a brace since January 1979 for a 28° curve. In the two and a half years of brace treatment the curve has reduced to 16° and the girl is now being weaned from the brace eight hours daily. The third girl moved to California a year after referral from screening. She was under observation of her family doctor prior to her move but no X-ray was taken. In California she was referred to an orthopedic surgeon who placed her in a modified brace fitted below the shoulder blades to hipline. Her mother writes that she is seen every four months with X-rays and that she does exercises daily.

Surgical correction was carried out on six girls who had placement of a Harrington Rod and subsequent spinal fusion. As mentioned previously two of this category were brace failures and three rejected bracing. The remaining case was not considered suitable for correction by the Milwaukee brace. All the corrections are reported to be successful. One girl is wearing a brace post-operatively (for six months) and another will have a portion of the rod removed because it has become troublesome. Surgery was refused by three girls.

The total resources utilized for these orthopedic positive cases and for those who were screening positive but orthopedically negative, will be discussed in detail under the availability of resources.

Refusals of referral recommendation

For a successful screening program besides acceptance of the screening test there must be acceptance of the recommendations which follow for
those who are determined to be a screening positive. There are several stages at which there may be non-compliance. First there may be refusal to obtain a medical assessment as recommended. This occurred in 2 of the 169 in this study. Of those who do see their family physician a certain number will fail to follow his recommendations for continued observation, 2 of the 37 are in this category. At a further stage, the orthopedist will recommend a certain course of action for those children who are referred to him, 20 of the 82 eligible, a rate of 25 percent (65 for observation, 9 for bracing, 9 for surgery with one girl refusing two treatment modes), disregarded the recommendation made. In the majority of those cases the curve had been minor and non-progressive. One mother gave "concern about unnecessary radiation" as the reason for not returning to the orthopedic specialist.

Table IV outlines the levels and numbers for non-compliance.

TABLE IV

<table>
<thead>
<tr>
<th>REFUSAL OF REFERRAL RECOMMENDATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>refused referral (N = 169)</td>
</tr>
<tr>
<td>refused observation (family Dr.) (N = 37)</td>
</tr>
<tr>
<td>failed to complete observation (N = 65)</td>
</tr>
<tr>
<td>refused brace (N = 9)</td>
</tr>
<tr>
<td>refused surgery (N = 9)</td>
</tr>
<tr>
<td>1976-77  84  1  -  7  2*  3*</td>
</tr>
<tr>
<td>1977-78  42  -  1  6  -  -</td>
</tr>
<tr>
<td>1978-79  17  -  -  1  2  -</td>
</tr>
<tr>
<td>1979-80  26  1  1  1  -  -</td>
</tr>
<tr>
<td>Total   169  2  2  15  4  3</td>
</tr>
</tbody>
</table>

*One of the bracing refusals had a progressive curve, surgery was then recommended and refused.

Physiotherapy was not tabulated as there were no known refusals in the 10 cases treated by this means alone.
Validity of the Test

The validity of the screening test is evaluated by its ability to correctly identify children who have the disease and those who do not. In order to assess validity one must know 1) the screening positives and negatives, 2) the diagnostic positives (called orthopedic positives in this study) and negatives, and 3) the true prevalence.

From this information a fourfold table is constructed which allows calculation of recognized measures of validity; sensitivity, specificity, overreferral and underreferral rates and the predictive value of the test, using the method of Grant (see Chapter three).

The last consideration of validity will be a derivation of the prevalence rate of scoliosis in the SFHD screening population.

Table V gives the results of the screening tests and the diagnostic tests with tabulation of the positives and negatives.

TABLE V
RESULTS OF SCOLIOSIS SCREENING 1976-1980 IN SFHD

<table>
<thead>
<tr>
<th>year</th>
<th>number screened</th>
<th>positive</th>
<th>negative</th>
<th>orthopedic positive</th>
<th>orthopedic negative</th>
<th>unknown</th>
<th>other**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-77</td>
<td>2587</td>
<td>84</td>
<td>2503</td>
<td>17</td>
<td>65</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1977-78</td>
<td>1873</td>
<td>42</td>
<td>1831</td>
<td>14 (+1)*</td>
<td>27</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1978-79</td>
<td>1690</td>
<td>17</td>
<td>1673</td>
<td>5 (+1)*</td>
<td>9</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>1979-80</td>
<td>1860</td>
<td>26</td>
<td>1834</td>
<td>4</td>
<td>20</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>8010</td>
<td>169</td>
<td>7841</td>
<td>40 (+2)</td>
<td>121</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

*Orthopedically positive but previously identified and under care.
**Other spinal disease.
1) Screening positives and negatives

There were a total of 8010 children screened during the four years of the program at SFHD. Of these, 169 met the criterion of "screening positive" and 7841 were "screening negative". The criteria for a screening positive were described in Chapter two. In children called "screening negative" no sign of scoliosis was present on screening. The signs of scoliosis were listed in Chapter three.

2) Orthopedic positive and negative

The recognized diagnostic measure for scoliosis is the standing anterior-posterior thoraco-lumbar X-ray. A curve of 11° or more on X-ray was considered an "orthopedic positive" or confirmed scoliosis in this study. In the case of some referrals the orthopedic surgeon deferred X-ray and observed the child periodically. Until these children had a diagnostic X-ray they were presumed positive. Any curve which reached 11° or greater was labelled a positive for the purpose of this study.

Those who were not confirmed by a diagnostic test or followed by an orthopedist as a significant curve were considered negative. Children who were labelled negative were not necessarily X-rayed but all were examined by a physician who pronounced them as negative.

In the study sample there were two cases where referral was not completed and four children with spinal disease other than idiopathic scoliosis. This is noted in Table V as "other". All these children were diagnosed previous to screening. The other spinal diseases represented were scoliosis secondary to: Marfan's syndrome, Scheuermann's
disease, neurological disease and post-operatively following correction of pectus excavatum. While none of these four cases are orthopedic positives as defined they do illustrate that screening for scoliosis may identify other spinal pathology.

Description of orthopedic positives

The orthopedic positives are a very significant group and will be described in terms of sex, degree of curvature and progression of curves.

**Sex** distribution of the orthopedic positives is presented in Table VI. Of the total of 40 (N = 169) who were categorized as positive, 4 were male (10 percent) and 36 were female (90 percent), for a ratio male to female of 1:9.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER</th>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-77</td>
<td>17</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>1977-78</td>
<td>14</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1978-79</td>
<td>5</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>1979-80</td>
<td>4</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>40</td>
<td>4</td>
<td>36</td>
</tr>
</tbody>
</table>

The *degree of curvature* on initial X-ray examination ranged from 10° to 38°. The two 10° curves were included in the orthopedic positive group because they subsequently progressed so that they met the
qualifications of orthopedic positive (see page nine). One child had not been X-rayed but is examined every six months by an orthopedic surgeon who has categorized her as clinically positive and skeletally immature. For these reasons she too qualifies as orthopedic positive. Of the 38 curves, 25 (65.8 percent) are between 10° and 19°, 10 (26.3 percent) lie between 20° and 29° and 3 (7.9 percent) are greater than 30°. One curve has not been X-rayed and the X-ray status of a girl in brace treatment in California is not known.

**Progression of curves** is revealed by periodic X-ray examinations. Of those curves (36 of 38) which have been followed radiographically, 13 (36.1 percent) showed progression ranging between 1° and 20°, 16 (44.4 percent) remained unchanged and 7 (19.4 percent) decreased from 1° to 6°. None of the 25 curves which were below 20° initially has required treatment. Of the 13 curves greater than 20°, 8 have received active treatment by bracing or surgery. Of the 25 curves below 20°, 5 or 20 percent progressed whereas in the 13 curves over 20°, 80 percent of those followed by X-ray increased (8 of 10), two were operated on immediately and one refused follow-up. Of the four curves occurring in males none progressed. Figure 4 illustrates the pattern of curvatures in the sample.

3) True prevalence

As discussed in chapter three the figure for true prevalence is necessary to complete the fourfold table and determine measures of validity such as sensitivity, specificity and predictive value.

The number of total diseased in the population ideally would be
Fig. 4.—Pattern of progress of scoliosis curves from initial curve to maximum curve.
determined by radiography however it is unethical to submit individuals
to this procedure for research purposes as well as costly and unaccept­
able to the population. Other strategies as suggested by Grant (1974)
are available. For the purpose of estimation of prevalence of adoles­
cent idiopathic scoliosis the studies of Rogala et al. (1978), Brooks
(1980) and Kane (1977b) were used to select a prevalence of 2 percent.
In a screening population of 8010 this would suggest 160 cases of scol­
iosis with an 11° curvature or greater.

The fourfold table

Table VII shows the figures for diseased positive, non-diseased
positive and total positive from the screening program results. An
adjustment to the diseased positive group was made to account for two
children who were screened and were orthopedically positive but were
already known and under physician observation. These two are screening
positive because their curves have been accurately identified by the
screening program.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Screening results</th>
<th>diseased</th>
<th>non-diseased</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td></td>
<td>42</td>
<td>127</td>
<td>169</td>
</tr>
<tr>
<td>Negative</td>
<td></td>
<td>118</td>
<td>7723</td>
<td>7841</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>160*</td>
<td>7850</td>
<td>8010</td>
</tr>
</tbody>
</table>

*The 2 percent prevalence statistic (Rogala et al. 1978) is applied to
the screening population, i.e. 8010 X .02 = 160.

Chi Square with 1° of freedom = 69.8019 p<.01.
By using the 2 percent prevalence calculation to estimate a total diseased population as 160, a diseased screening negative group of 118 can be derived. Estimates for non-diseased screening negative and total non-diseased then follow by addition or subtraction (see Chapter three, Fig. 3, page 65).

From the derived fourfold table certain estimations can now be made about the screening test (see formulae page 66).

Sensitivity

Overall sensitivity

\[
\frac{42}{160} \times 100 = 26.2% 
\]

For each of the years of the screening program sensitivity was calculated as:

1976-77

\[
\frac{17}{52} \times 100 = 32.7% 
\]

1977-78

\[
\frac{14}{37} \times 100 = 37.8% 
\]

1978-79

\[
\frac{5}{34} \times 100 = 14.7% 
\]

1979-80

\[
\frac{4}{37} \times 100 = 10.8% 
\]

Specificity

\[
\frac{7723}{7850} \times 100 = 98.4% 
\]
Overreferral (false positives)

\[ \frac{127}{169} \times 100 = 75.1\% \]

Underreferral (false negatives)

\[ \frac{118}{7841} \times 100 = 1.5\% \]

Positive predictive value

\[ \frac{42}{169} \times 100 = 24.9\% \]

Overall predictive value

\[ \frac{42 + 7723}{8010} \times 100 = 96.9\% \]

Prevalence of scoliosis at SFHD

Comparison of the prevalence rate of scoliosis curves identified at SFHD with others in the literature provides another measure of the validity of the screening test. Prevalence will be discussed as prevalence of curves 11° and greater and prevalence of treatable curves.

Prevalence of curves 11° and greater was used to estimate the prevalence of scoliosis in the population of SFHD screened between September 1976 and June 1980. The number of children identified as orthopedically positive, that is with a curve 11° or greater on radiographic examination (Cobb method of calculation) (N = 40) along with the total screening population of 8010 is the basis of the calculation but two adjustments were made to reflect a more accurate prevalence figure. The 9 children who were not screened because parents advised that they were under management for spinal disease will be considered as positive (although the true status of all cases in terms of being
orthopedic positive is not known) along with the 2 children who were screening positive and already known to their physicians as scoliotics, for a total of 51 cases.

The calculation for prevalence then is

\[ \frac{51}{8019} \times 100 = 0.636\% \text{ or rounded to } 0.6\% \]

The rate is expressed as a percentage or per hundred to concur with the literature. The prevalence rate for each screening year with adjustment for other scoliotics is given in Table VIII.

**TABLE VIII**

**NUMBER AND RATE OF ORTHOPEDIC POSITIVES PER SCREENING YEAR**

<table>
<thead>
<tr>
<th>year</th>
<th>number screened</th>
<th>orthopedic positive</th>
<th>other</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-77</td>
<td>2587</td>
<td>17</td>
<td>0</td>
<td>0.66</td>
</tr>
<tr>
<td>1977-78</td>
<td>1873</td>
<td>14</td>
<td>5</td>
<td>1.0</td>
</tr>
<tr>
<td>1978-79</td>
<td>1690</td>
<td>5</td>
<td>3</td>
<td>0.47</td>
</tr>
<tr>
<td>1979-80</td>
<td>1860</td>
<td>4</td>
<td>3</td>
<td>0.38</td>
</tr>
<tr>
<td>Total</td>
<td>8010</td>
<td>40</td>
<td>11</td>
<td>0.636</td>
</tr>
</tbody>
</table>

Incidentally the prevalence rate was reported as 0.65 percent for the SFHD pilot project January to June 1976 (SFHD Report 1977).

The prevalence of treatable curves in the screening population is suggested in the literature (Rogala et al. 1978) as 2.75 per thousand or 0.275 per hundred. At SFHD there have been 12 cases in which active treatment was recommended (bracing and/or surgery). This includes those who rejected active treatment. The rate at SFHD for treatable curves is
0.1498 per hundred or about one-half the rate found in the study of Rogala et al. (1978). This prevalence figure does not take into account the 11 presumptive cases in the community that were added for calculation of prevalence. If they were all actively treated the prevalence of treatable curves would be

\[
\frac{12 + 11}{8019} \times 100 = 0.287\%
\]

which is close to that of Rogala et al. (1978) and the 0.3 percent reported by Moe et al. (1978). It is known that 2 of the 11 had surgery for scoliosis and that 2 are under physician observation but the status of the other 7 is unknown.

**Availability of Resources**

The resources described are those which are utilized in the screening program and those which are required as a result of screening. The accessibility of services for follow-up of the screening referrals will be reported and particular mention made of the orthopedic services.

**Screening program resources**

The data in Table IX are from the annual reports written by the physiotherapists at SFHD. No figures were estimated in 1978-79 screening year. To complete the table therefore an estimate of resources used in that year is made. The cost per screenee in 1977-78 was $2.07, in 1979-80 it was $2.19. If each of these costs is multiplied by the number screened in 1978-79 (1690) and averaged, the figure of $3599.70 could be considered an estimate for 1978-79 screening costs. Given that all hours of service are estimated there is not a precise costing
<table>
<thead>
<tr>
<th></th>
<th>1976-77</th>
<th>1977-78</th>
<th>1979-80</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>number screened</td>
<td>2587</td>
<td>1873</td>
<td>1860</td>
<td>8010*</td>
</tr>
<tr>
<td>time in hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>physiotherapy</td>
<td>400 ($8.5/h)</td>
<td>137 ($10/h)</td>
<td>107 ($12.8/h)</td>
<td>644</td>
</tr>
<tr>
<td></td>
<td>$3,400.00</td>
<td>$1,370.00</td>
<td>$1,369.60</td>
<td>$6,139.60</td>
</tr>
<tr>
<td>public health nursing</td>
<td>127 ($10/h)</td>
<td>146 ($10/h)</td>
<td>221 ($11/h)</td>
<td>494</td>
</tr>
<tr>
<td></td>
<td>$1,270.00</td>
<td>$1,460.00</td>
<td>$2,431.00</td>
<td>$5,161.00</td>
</tr>
<tr>
<td>clerical</td>
<td>32 ($6.8/h)</td>
<td>34 ($6.8/h)</td>
<td>29 ($7.3/h)</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>$217.60</td>
<td>$231.20</td>
<td>$211.70</td>
<td>$660.50</td>
</tr>
<tr>
<td>preparation of report</td>
<td>100 ($8.5/h)</td>
<td>55 ($10/h)</td>
<td>5 ($12.8/h)</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>$850.00</td>
<td>$550.00</td>
<td>$64.00</td>
<td>$1,464.00</td>
</tr>
<tr>
<td>evaluation study</td>
<td>28 ($10.7/h)</td>
<td>25 ($11/h)</td>
<td>-</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>$299.60</td>
<td>$275.00</td>
<td>-</td>
<td>$5,746</td>
</tr>
<tr>
<td>medical health officer</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>$200.00</td>
<td>-</td>
<td>-</td>
<td>$200.00</td>
</tr>
<tr>
<td>total hours</td>
<td>697</td>
<td>397</td>
<td>362</td>
<td>1456</td>
</tr>
<tr>
<td>total cost</td>
<td>$6,237.20</td>
<td>$3,886.20</td>
<td>$4,076.30</td>
<td>$14,199.70</td>
</tr>
</tbody>
</table>

If estimate of $3,599.70 is used for 1978-79 total cost = $17,799.40.

*includes 1690 screened 1978-79.
for any year. In round figures for four years the cost of screening has been $17,800. Costs include salaries of health district personnel involved in the program but excludes travel expenses, health district office overhead, clerical service in the schools, stationery and postage and cost of supplies such as training manuals, texts and films.

Cost of other services utilized

The number of services in the categories of X-ray, family physician, orthopedic specialist, chiropractor, physiotherapy and bracing is presented for the orthopedic positive cases in Table X. Although six of these children required surgery, this item is not included as it is the writer's contention that surgery would have occurred eventually without screening, when the curve was noted by the family or physician and medical care commenced.

The number of referrals seen by the general practitioner and the orthopedist and the X-ray status is found in Table XI. Of those 169 children who were screening positive, 166 went to the family physician who ordered X-rays for 39 percent of them. Thirty-eight children (24 percent) were pronounced normal on clinical examination alone without X-ray. Some were not X-rayed by the general practitioner but referred directly to the orthopedic specialist who X-rayed 74 percent of the children seen by him.

The cost of health care services which have been utilized for the screening positives of the program for the four years of the study are tabulated in Table XII. The highest cost of any screening year occurred in 1976-77, bracing was the most expensive service followed by
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>17</td>
<td>-</td>
<td>5</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Number of X-rays</td>
<td>48</td>
<td>35</td>
<td>11</td>
<td>7</td>
<td>98</td>
</tr>
<tr>
<td>Visits to family physician</td>
<td>21</td>
<td>16</td>
<td>6</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Visits to orthopedic specialist</td>
<td>80</td>
<td>49</td>
<td>19</td>
<td>13</td>
<td>158</td>
</tr>
<tr>
<td>Number of chiropractic services</td>
<td>39</td>
<td>-</td>
<td>22</td>
<td>-</td>
<td>61</td>
</tr>
<tr>
<td>Number of physiotherapy services</td>
<td>169</td>
<td>34</td>
<td>14</td>
<td>4</td>
<td>221</td>
</tr>
<tr>
<td>Number of cases braced</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Surgical procedures</td>
<td>3</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>6</td>
</tr>
</tbody>
</table>
# TABLE XI

NUMBER OF REFERRALS SEEN BY GENERAL PRACTITIONER AND ORTHOPEDIST AND X-RAY STATUS

<table>
<thead>
<tr>
<th>Year</th>
<th>Number Referred</th>
<th>To General Practitioner</th>
<th>X-ray</th>
<th>Percentage</th>
<th>To Orthopedist</th>
<th>X-ray</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-77</td>
<td>84</td>
<td>83</td>
<td>36</td>
<td>43%</td>
<td>44</td>
<td>34</td>
<td>77%</td>
</tr>
<tr>
<td>1977-78</td>
<td>42</td>
<td>41</td>
<td>17</td>
<td>41%</td>
<td>24</td>
<td>19</td>
<td>79%</td>
</tr>
<tr>
<td>1978-79</td>
<td>17</td>
<td>17</td>
<td>5</td>
<td>29%</td>
<td>12</td>
<td>7</td>
<td>58%</td>
</tr>
<tr>
<td>1979-80</td>
<td>26</td>
<td>25</td>
<td>6</td>
<td>24%</td>
<td>9</td>
<td>6</td>
<td>67%</td>
</tr>
<tr>
<td>Total</td>
<td>169</td>
<td>166</td>
<td>64</td>
<td>39%</td>
<td>89</td>
<td>66</td>
<td>74%</td>
</tr>
</tbody>
</table>

Refused referral 2, Unknown 1.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>14**</td>
<td>5</td>
<td>4</td>
<td>39</td>
</tr>
<tr>
<td>X-rays</td>
<td>795.60</td>
<td>647.40</td>
<td>204.80</td>
<td>148.10</td>
<td>1,795.90</td>
</tr>
<tr>
<td>Family physician</td>
<td>206.30</td>
<td>165.75</td>
<td>68.35</td>
<td>60.50</td>
<td>500.90</td>
</tr>
<tr>
<td>Orthopedic specialist</td>
<td>1,351.75</td>
<td>1,006.68</td>
<td>412.30</td>
<td>317.30</td>
<td>3,088.03</td>
</tr>
<tr>
<td>Chiropractic</td>
<td>319.25</td>
<td>-</td>
<td>181.25</td>
<td>-</td>
<td>500.50</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>1,188.50</td>
<td>240.75</td>
<td>100.00</td>
<td>28.00</td>
<td>1,557.25</td>
</tr>
<tr>
<td>Bracing</td>
<td>1,600.00</td>
<td>900.00</td>
<td>1,300.00</td>
<td>1,000.00</td>
<td>4,800.00</td>
</tr>
<tr>
<td>Total</td>
<td>5,461.40</td>
<td>2,960.58</td>
<td>2,266.70</td>
<td>1,553.90</td>
<td>12,242.58</td>
</tr>
</tbody>
</table>

*Surgery not included as a cost of screening.

**Costs are unknown for one case (braced).
the cost of the orthopedic specialist. The total cost was estimated at $12,242.58, excluding costs of surgery and hospitalization.

The cost of screening must also include the costs to the health care system of those who were screening positive but ultimately diagnosed as negative. The number of services for this group is presented in Table XIII and the costs in Table XIV. The total cost is estimated at $6,324.63. The most costly service for the false positives, which this group constitutes, was for the orthopedic specialist.

Acceptability of follow-up services

None of the families expressed any difficulties in obtaining appointments with physicians, either family doctors or orthopedists. When an earlier review of the scoliosis program was done there were comments that the wait for orthopedic appointments was unduly long but this was not mentioned during any of the latest telephone interviews. X-ray services, physiotherapy and chiropractic services were not mentioned as causing any problem in availability.

The orthotic service has been an area of concern to those who required bracing during the period of this study. At an early stage of this screening program the service was provided at Shaughnessy Hospital. There was an interval of over a year when this orthotist from Shaughnessy who is recognized as the provincial expert on the Milwaukee brace was away. On his return orthotic service resumed through his private firm and his services are available at the weekly Children's Hospital scoliosis clinic where the orthotist is part of the team evaluating and prescribing brace treatment.
TABLE XIII
SERVICES PROVIDED FOR ORTHOPEDIC NEGATIVE* SCREENEES

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cases</td>
<td>65</td>
<td>27</td>
<td>9</td>
<td>20</td>
<td>121</td>
</tr>
<tr>
<td>X-rays</td>
<td>47</td>
<td>18</td>
<td>7</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>Visits to family physician</td>
<td>118</td>
<td>48</td>
<td>18</td>
<td>27</td>
<td>211</td>
</tr>
<tr>
<td>Visits to orthopedic specialist</td>
<td>47</td>
<td>24</td>
<td>6</td>
<td>5</td>
<td>82</td>
</tr>
<tr>
<td>Chiropractic services</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Physiotherapy visits</td>
<td>17</td>
<td>28</td>
<td>0</td>
<td>0</td>
<td>45</td>
</tr>
</tbody>
</table>

*does not include other spinal diseases.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>65</td>
<td>27</td>
<td>9</td>
<td>20</td>
<td>121</td>
</tr>
<tr>
<td>X-rays</td>
<td>749.90</td>
<td>328.90</td>
<td>90.90</td>
<td>156.20</td>
<td>1,325.90</td>
</tr>
<tr>
<td>Family physician</td>
<td>1,187.40</td>
<td>503.20</td>
<td>204.20</td>
<td>340.40</td>
<td>2,235.20</td>
</tr>
<tr>
<td>Orthopedic specialist</td>
<td>1,280.87</td>
<td>660.82</td>
<td>157.14</td>
<td>196.40</td>
<td>2,295.23</td>
</tr>
<tr>
<td>Chiropractic</td>
<td>150.55</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>150.55</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>121.75</td>
<td>196.00</td>
<td>-</td>
<td>-</td>
<td>317.75</td>
</tr>
<tr>
<td>Total</td>
<td>3,490.47</td>
<td>1,688.92</td>
<td>452.24</td>
<td>693.00</td>
<td>6,324.63</td>
</tr>
</tbody>
</table>
Those children from SFHD who were not referred to the scoliosis clinic at Children's Hospital had a less coordinated approach to orthotic treatment. The team of physiotherapist, orthopedic specialist, orthotist and child/parent was not involved in prescription and assessment. Of the six children who were braced three had problems with their adjustment to the brace or in obtaining a good correction of their curves. Of the three successfully braced one has been followed every three months at the Children's Hospital clinic while the second child is seen privately with review by the orthopedist every three to four months with refitting of the brace as indicated. The details of the orthotic service received by the case living out of British Columbia is not known.

Orthopedic services in British Columbia

In the latest Directory published by the College of Physicians and Surgeons of B.C. (1980) there are 108 orthopedic surgeons listed. Of the 108, 80 or 74 percent are located in the Lower Mainland and Greater Victoria region. The population covered by these 80 orthopedists is 1,372,002. The balance of the people in B.C., 1,264,898, are located in areas served by the 28 remaining orthopedic specialists. They are located as follows:

<table>
<thead>
<tr>
<th>Area</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancouver Island (except Victoria)</td>
<td>7</td>
</tr>
<tr>
<td>Okanagan (Vernon, Kelowna, Penticton)</td>
<td>7</td>
</tr>
<tr>
<td>Fraser Valley</td>
<td>5</td>
</tr>
<tr>
<td>Trail</td>
<td>1</td>
</tr>
<tr>
<td>Nelson</td>
<td>1</td>
</tr>
<tr>
<td>Kamloops</td>
<td>3</td>
</tr>
<tr>
<td>Prince George</td>
<td>2</td>
</tr>
<tr>
<td>Dawson Creek</td>
<td>1</td>
</tr>
<tr>
<td>Kitimat</td>
<td>1</td>
</tr>
</tbody>
</table>
Population information was provided by Hospital Programs, Ministry of Health, Victoria (Selwood 1981).

Surgery for scoliosis was performed on 84 people in B.C. during the period April 1, 1979 to March 31, 1980. The following Table XV indicates by hospital where surgeons performed surgery with the Harrington Rod and spinal fusion (ICD code 930.4). Of the 84 operations, 82 (98 percent) were performed in hospitals in the vicinity of Vancouver and Victoria.

**TABLE XV**

SURGERY WITH HARRINGTON ROD (ICD CODE 930.4) IN B.C. BY HOSPITAL APRIL 1, 1981 TO MARCH 31, 1980

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Total</th>
<th>0-14</th>
<th>15-44</th>
<th>45-69</th>
<th>70-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children's</td>
<td>32</td>
<td>22</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Vancouver)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Royal Columbian</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>-</td>
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<tr>
<td>(New Westminster)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Royal Inland</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>(Kamloops)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Royal Jubilee</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Victoria)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaughnessy</td>
<td>16</td>
<td>2</td>
<td>14</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Vancouver)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surrey Memorial</td>
<td>3</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Surrey)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vancouver General</td>
<td>19</td>
<td>9</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Vancouver)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victoria General</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Victoria)</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>38</td>
<td>43</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

SOURCE: W. E. Selwood, Research Division, Hospital Programs, Ministry of Health, Victoria, B.C. Interview, June 23, 1981.
CHAPTER V

DISCUSSION

In this study evaluation of scoliosis screening at SFHD is based on the application of established criteria to the program results and on the evidence in the literature about scoliosis. All twelve criteria identified in the literature review will be used but four principal criteria were chosen as of special significance on the basis of data available and the limits of time and resources for this study.

These four criteria are:

1) acceptability of the screening test
2) acceptability of treatment
3) validity of the test
4) availability of resources

Before relating the results of this study to these principal criteria there will be a brief discussion of the significance of the remaining criteria to the evaluation of this scoliosis screening program.

Application of General Criteria

Importance as a health problem

The criterion that scoliosis must be an important disease to justify screening has not been fulfilled. Data on morbidity and mortality due to scoliosis in the population is limited. The statistics for the seven years from 1972-78 revealed 2 deaths in B.C. and 24 in
Canada due to scoliosis, an insignificant number. Valid morbidity statistics are not available but there are some reports in the literature which discuss disability and death due to scoliosis. Reports of back pain, dyspnea and premature death range from normal (Collis and Ponseti 1968) to notably higher (Nilsonne and Lungren 1968) in untreated scoliosis patients. In the sphere of social effect mention is made of fewer marriages, embarrassment about appearance and social isolation among scoliotics. Information regarding the degree of curvature, type of scoliosis and prevalence of the disability are all necessary to evaluate the reported effects of scoliosis and are not always available to assist in reaching a conclusion about the significance of the disease.

Accepted (Effective) treatment

The literature survey found that the efficacy of treatment for scoliosis has not been assessed by either randomized clinical trial or a trial of quasi-experimental design. The descriptive evidence about treatment from this study is not conclusive. In the study sample six children were braced; treatment was unsuccessful in three cases and it would be premature to call the three remaining cases successful. Outcome of surgery in the six cases has appeared to be successful, although one girl requires a second operation to modify the Harrington Rod because of discomfort. This is reported to be a minor procedure.

This study has not attempted to evaluate the efficacy of physiotherapy treatment but in view of the reported lack of efficacy of exercise as a treatment for scoliosis the use of physiotherapy as sole treatment in ten cases was a questionable practice.
Acceptability of treatment which was considered along with efficacy as a component of the effectiveness of treatment will be considered as one of the four principal criteria.

Recognized latent stage and known natural history

From what is written about scoliosis there may be a recognizable latent or early symptomatic stage but it is not yet clear which curves will progress from this stage. There is promise that evaluative studies now possible because of widespread screening in early adolescence will shed light on the natural history of scoliosis including the latent period. The evidence to date from prospective studies suggests that some curves improve, many remain unchanged and about three per thousand progress to what is called a treatable curve. In this study sample none of the curves (N = 25) which were below 20° initially progressed to a treatable curve. In those initially 20° and above (N = 13), 77 percent (N = 10) progressed or required immediate treatment. Of those followed by X-ray (N = 10) in the 20° and over group 80 percent progressed compared to 20 percent in the under 20° category (5 of 24). These findings could have implications for modifying the screening test so that fewer insignificant curves (i.e. below 20°) are referred.

Whom to treat as a patient

The issue of who to treat as a scoliosis patient may be somewhat confusing until the upper range of curvatures is reached. There is general agreement that curves over 50° require surgery, those between 40° to 50° are debatable, and that for curves between 30° and 40° bracing is the most desirable treatment for the majority of cases. Curves
between 20° and 30° are usually cosmetically acceptable and Rogala et al. (1978) found that one in five in this range in an immature female did not progress so that bracing should not be applied routinely. Instead it was suggested waiting for signs that the curve was progressing before bracing.

Kane (1977b) has defined the population at risk for scoliosis as those with curves 11° and over. Taylor et al. (1978a) suggest there is no sound agreement for management of curves under 25° and Howell and Craig (1980) suggest 15° curves are the ones to aim at identifying. This screening program using 11° and over as the level of significance had a positive predictive power of about 25 percent, which means one out of four positives was truly positive. The question occurs that if a curve was considered significant only if it was 20° or over and the screening procedure was geared to detection of that range of curvature, would a better program result?

Bone age appears to be the critical factor. Unless the individual has growth potential bracing will not be effective. Bracing can not be relied on to correct a curve but it may arrest the progress of a curve during the balance of the growth period. If bone age is this important for proper curve management, lack of an X-ray would appear to be a major deficit in diagnosis and treatment of scoliosis. Of the screening positives in this study 38 (24 percent) did not receive X-rays. The presumption is that there was lack of clinical evidence of scoliosis upon examination by the physician to warrant exposure to radiation. It is also presumed that these potential positives were examined by physicians cognizant of the early clinical signs of scoliosis. No further
rechecks were done by the health district screening team following the
physician's report of negative findings unsupported by X-ray.

**Economic balance**

The criteria suggesting economic balance in the cost of case-
finding in relation to total medical expenditures is not answered in
the literature or in this study. While there has been some effort to
estimate direct costs, indirect costs for anxiety, time lost and for
health district overhead costs (for example, telephone, office, films
and books, postage) are not estimated. There is the opportunity to
examine the medical expenditures which have resulted from the screening
program in terms of the follow-up of both orthopedic positive and
negative screenees.

Total estimated costs of $18,567.21 (Table XII and XIV) should
be considered as a minimal figure which does not include the cost of
the six surgical procedures which resulted from the referrals of the
program. It is considered that these operations would have occurred
regardless of the screening program. They have occurred earlier and
with presumably better results, a benefit which has not been measured
at this time. Costs for one of the braced children treated in the U.S.A.
were not estimated.

An interesting aspect of cost is that many children pronounced
as negative continue to be followed. In a North Vancouver study (1981)
of 111 children physicians categorized as normal it was reported that
39 would continue to be followed by the private physician. The cost
of continued surveillance should be evaluated in terms of eventual
returns. An initial diagnostic X-ray as recommended at SFHD should mean that only those curves "at risk" for progression are followed.

**Continuous case-finding**

The criteria that case-finding should be continuous throughout an individual's period of "risk" is more applicable to other types of screening than to scoliosis. In the case of scoliosis it appears generally acceptable to screen at a stage of adolescence when growth is active and early scoliotic curves are visible.

Ages of 12 to 14 have been considered most suitable. Rogala's (1978) study involving a sample tested at an earlier age found no benefit. From the literature it would appear that screening every child once during the age represented in grade seven is adequate. In respect to continuity of a screening program SFHD has had a continuous program for five years.

**Cost-benefit and cost-effectiveness**

The criteria calling for knowledge of cost-benefit, cost-effectiveness have not been met in studies in the literature or by this study. The SFHD program like all others described in the literature searched does not contain a mechanism for weighing costs against benefits and because of the long-term nature of the condition economic analysis would be complex.

**Estimation of social benefits**

Estimation of social benefits in terms that withstand scientific scrutiny is not possible from the literature or this study. The
population in the studies which describe the social costs of scoliosis are not representative populations and control groups have not been used.

**Evaluation by Principal Criteria**

Application of the four criteria to the results of screening at SFHD will now be discussed.

**Acceptability of screening test**

At SFHD the scoliosis program has been very well accepted by parents, children screened and physicians. The refusal rate for initial screening (21/8031) of 0.3 percent is indicative of this acceptability. The use of a refusal only consent however may contribute to this high level of acceptance. It should be recognized that all notices of screening do not reach home. In one telephone interview by this investigator it was volunteered by the parent that no notice had been received. The child in this case had Marfan's syndrome with secondary scoliosis and the mother would have refused permission if she had known of the program. In an earlier study at SFHD (Ladner 1978) 3 of 29 (10 percent) stated that they had not received the introductory letter.

In the telephone interviews conducted by this investigator there were many voluntary expressions of appreciation for the screening program. In several cases these were by parents who had children with no confirmed scoliotic disease but who had been referred for orthopedic consultation including X-rays. There appeared to be no resentment created by this process. Specific opinions about acceptability of the program were not solicited from parents or physicians.
The self-consciousness of the screenees has been a minor difficulty but not a drawback to screening in terms of refusal to consent by the screenee. As the program has developed the staff have devised ways to interpret the program and deal with the screenee in an assured matter-of-fact manner which has minimized the insecure reactions of the adolescents.

Acceptability in the school districts among principals, teachers, trustees and parents has been reported favorably throughout the screening period. The possible cancellation of the program in the fall of 1980 because of shortage of physiotherapy staff was greeted with consternation by those in the community who were aware of the possibility, including members of the Union Board of Health. This points out the implication for a health district public relations effort if the program is modified or deleted in the future.

Physician acceptance has also been demonstrated by an earlier small survey and at present by the cooperation received by this investigator during their study.

Acceptability of treatment

To be effective a treatment must be efficacious or do more good than harm to those who fully comply with its recommendations. As well as efficacy, effectiveness has another component, that of acceptance of the treatment by those to whom it is offered.

This aspect of effectiveness of treatment can be considered in relation to the numbers of known refusals to comply with recommended treatments as well as refusals to accept referral to the physician
(either general practitioner or specialist). The refusal of 2 of 169 referrals for a rate of 1.2 percent indicates a high compliance rate compared to others reported in the literature. Compliance with the recommendations of the family physician for continued observation was 95 percent.

The level of compliance with the recommendation of the orthopedic specialist was 73 percent considering rejection of any of the recommendations of this physician as non-compliance. In 68 percent (15 of 22) of the instances the non-compliance was with the recommendation to return for a further examination. In the majority of these cases there had been no significant progress of the curve to that point. In four cases there was failure to accept the recommendation for brace treatment (three outright refusals, one after receiving her brace). For the orthopedic positives (N = 40) this is a rate of 10 percent and 44.4 percent of those for whom bracing was recommended (N = 9). This indicates a questionable level of acceptability of bracing and is significant because the primary goal of the screening program was to apply bracing as an alternative to surgery.

The recommendation for surgery has been rejected by three girls (N = 9). In one of the these cases the girl continues under chiropractic care and is occasionally seen by the general practitioner who reports a curve of 38° which is disfiguring but apparently acceptable to the girl (now 17) and her parents.

Validity of the test

Validity of the screening test in use at SFHD has been assessed
in terms of how well the results of screening have related to the diagnostic measure.

The sensitivity of the screening test was 26.2 percent over the four years of the program. When it was calculated on a yearly basis the range was from a high of 38 percent in 1977-78 to a low of 11 percent in 1979-80. This sensitivity is unacceptably low. At least a 75 percent minimal level of sensitivity should be reached (Howell et al. 1978). Of particular interest is the significance of the trend to lower sensitivity which may have indicated declining screen competency. Although over 70 percent of the children with 11° or greater scoliotic curves apparently were missed by this screening it must be remembered that scoliosis is also identified by the observations of others and also that many curves are not significant health problems so that missing them is not as critical as would be the case in screening for other diseases more life-threatening.

The specificity of the screening test is 98.4 percent which meets the criterion of Howell et al. (1978) of at least 95 percent.

The 127 false positives which give an overreferral rate of 75.1 percent is a concern because of the resources used in unnecessary diagnostic testing and possibly treatment as well as the anxiety generated and the time lost in the process of needless follow-up. There are probably two reasons why overreferral was not creating difficulties in the health district. First there were no direct client costs because of the Medical Services Plan and second, physicians were in ample supply and readily available. In considering this high false positive rate it may be useful to recall that when a disease is infrequent in the
population-like scoliosis - even a screening test with high specificity (and the rate is 98.4 percent) will yield a high percentage of false positives (Friedman 1974). It should also be noted that Wilson and Jungner advised that a fairly high false positive rate is acceptable but the false negative rate should be low. A false positive rate of 75.1 percent appears more than "fairly high" however. The costs of overreferral for four years of screening are estimated at $6,324.63, which is not a formidable sum in terms of other health care program costs.

Underreferrals are calculated at 1.5 percent. This represents the missed cases. It has been suggested that an underreferral rate of less than 5 percent is sometimes considered an acceptable percentage of false negatives (Stangler et al. 1980).

The positive predictive power is the figure of interest to physicians who see referrals as it represents the proportion of true cases they might expect to see in the children referred to them. It was 24.9 percent for the screening program at SFHD, which meant that three out of four times the referral was needless. However, the overall predictive validity of the screening test was 97 percent, an acceptable figure indicating 97 out of every 100 children were correctly identified by the screening process.

This screening test has identified a sample of orthopedically positive children in a sex distribution similar to that reported in the literature. The finding that the ratio is 1:9 (male to female) has implications for program modification. None of the treatable curves have occurred in males in four years of screening a population of 8010
children. In other areas such as Edmonton, girls only are screened. A similar approach could be considered in SFHD, effectively halving the population to be screened.

The SFHD screening program has not found the number of orthopedically positive screenees which would be expected from published prevalence figures in similar screening populations. The rate of 0.6 percent is much lower than that found in Vancouver's pilot program (Hornung 1977) which reported a rate of 4 percent (41 in 1006). Contrasted to the major study in Montreal (Rogala et al. 1978) where 2 percent of the screened population had curves greater than 10°, SFHD's prevalence is notably low. The prevalence of treatable curves in the study population at a rate of 0.1498 percent or about one-half the prevalence expected (0.275 or 0.3 percent) is another questionable finding but must be viewed with caution because of the unknown treatment status of other scoliosis curve cases in the community.

The concern is of course that curves that are most "at risk", with potential for preventive treatment are being missed.

Availability of resources

There is no question that the existence of this screening program at SFHD has taken a considerable portion of health district staff time (see Table IX) as well as using other community health services such as general physician, orthopedist, X-ray and physiotherapy (Tables X, XII, XIII and XIV). There has been no apparent problem in meeting the demand for these services.

The question of costs generated and alternatives foregone has not been evaluated. The health district at the present time has begun
the process of zero-based budgeting. In preparation for this each professional group in the health district is identifying program priorities and the minimal levels of service which must be provided. The figures on staff time spent in scoliosis screening will be useful in this process of choosing between alternative programs.

The one apparent deficiency identified has been lack of a central clinic to receive referrals for all screening positives. Such a clinic would enable outcomes to be readily available for the monitoring of screening validity. Staff training in screening would be facilitated by a clinic where orthopedic positives could be seen clinically. The follow-up of positives could be ensured with a call-back system. Proper diagnostic X-rays would be assured. If treatment were also handled in a clinic approach more successful bracing treatment could be possible. In this way some group support for those requiring bracing could be used to help the bracing candidate work through her acceptance of the treatment.

The area of orthosis is the one of most concern. At the present time this service for the fitting of the Milwaukee brace is available from a certified orthotist in Vancouver. During the period covered by this study there were gaps in orthotic service offered. As orthotics for scoliosis appears to be highly specialized and 90 percent of the children in B.C. come to this one orthotist in Vancouver, one might question the problem generated if more bracing treatment results from expanded screening efforts should the program become provincewide.

The same problem could be created through deficiency in orthopedic expertise in scoliotic treatment. Pediatric orthopedists are
rare (3 of 108 practicing orthopedists in B.C.) and these are located in the Lower Mainland and Victoria areas so that considerable difficulty could be generated for patients throughout the province seeking a consultation. The level of expertise in diagnosis of scoliosis for the average family physician is unknown. In the SFHD program many of the general practitioners referred the child directly to an orthopedist without X-ray examination in spite of the health district's recommendation contained in the letter of referral. In some cases no physical examination was done either, which would indicate some questionable physician confidence in this area.
CHAPTER VI

CONCLUSION

As Chamberlain has said so aptly in his paper on evaluation of screening:

The decision on whether or not to provide a screening service to control one or more diseases can seldom be an easy one for the health administrator. He not only has to devise an efficient method of organization within the existing health care system, but he also has to measure the total cost of this and decide whether the extent of benefit likely to be achieved is greater than that which could be derived from alternative ways of spending his scarce resources. To make this decision rationally requires a scientific evaluation of screening and early treatment, taking into account all the factors which can influence its success. (Chamberlain 1979, p. 757)

The same challenge confronts the health administrator in deciding whether a program should be continued. In an effort to provide a rational basis for program planning at SFHD criteria were applied to the scoliosis screening program and the results from that program for the 8010 children screened from September 1976 to June 1980. The following hypothesis was proposed for the study:

Evaluation of the results of four years of scoliosis screening at Simon Fraser Health District will substantiate continuation of the screening program.

The conclusion that the evidence does not support program continuation is reached on the following basis.

First, the original program objective of identification of scoliotic curves at a stage when the Milwaukee brace could be applied and
surgery avoided, has not been achieved. Six operations for scoliosis have occurred in the screening population. In five of these six cases bracing was either unsuccessful or unacceptable and thus did not prevent the surgery.

The criterion of acceptability of the screening test has been well met at SFHD. The screening test has been highly acceptable to parents and children with few exceptions. The refusal rate was estimated at 0.3 percent however it is recognized that all parents were not aware of the screening date to offer dissent because notices had not been received. This has not been a problem and this highly visible program is also well-supported by school district personnel, the Union Board of Health and personnel of the health district.

The evidence from this study suggests that the criterion that a screening program should be offered only if acceptable treatment is available to those who require it, has not been fulfilled. Active treatment for scoliosis is recognized as bracing or surgery. In this screening population bracing was recommended for nine children and was refused in three cases. Another child rejected the brace immediately after receiving it. Essentially then four of the nine (44.4 percent) candidates for bracing did not accept this treatment. Surgery was recommended for nine children and in three cases (33.3 percent) this recommendation was not accepted.

The criterion that the screening test is valid may be assessed by the level of sensitivity and specificity achieved by that test as well as overreferral and underreferral rates and the predictive value of the test. A sensitivity of 26.2 percent was derived using scoliosis
prevalence from the literature to give a "total diseased" estimate for the fourfold table. Using this standard only one child in four with scoliosis is recognized in this screening program. Specificity was estimated at 98.4 percent, underreferral at 1.5 percent and total predictive value at 96.9 percent. While specificity, underreferral and overall predictive value are acceptable, the 75.1 percent rate for over-referral is a concern because of the direct costs generated in unnecessary diagnostic and possibly treatment services. Indirect costs of over-referral are harder to estimate but do occur because of anxiety and time loss and possibly due to unnecessary exposure to radiation.

Published prevalence figures of 2 percent to 4 percent using the same age group, screening test and diagnostic standard have been widely reported. Prevalence of scoliosis at SFHD was estimated at 0.6 percent for the four years of the program under review. In spite of adjustments made to account for known scoliosis in this population apart from the screening sample, this low figure calls into question the validity of the screening test. Socio-economic, ethnic differences or other variables were not apparent between SFHD's population and those with the higher prevalence.

This study has not attempted to explore the reasons for the identification of fewer true positives in this screening population.

The last criterion applied to SFHD's program was that resources were available to carry out the program and to treat cases found by screening. While provision of staff for screening can be a major resource problem there has been no evidence that this was a difficulty during the period of this study apart from a brief period when the
district was without two physiotherapists. As the health district examines its priorities under a new system of fiscal management the priority given to scoliosis screening is being reassessed. The estimates of staff time and cost will have a place in this assessment.

The aspect of the criterion that available resources for treatment be available is questionable in two areas. First, the absence of a clinic for referral of all screening positives has been a disadvantage in the operation of this screening program and in its continuing evaluation. Such a resource would have enabled the screening program to be monitored, ensured standard X-rays necessary for accurate diagnosis of scoliosis, and been a resource for training screening personnel. Second, orthotic service has been an area of concern during the four years of the screening program. There were periods when experienced orthotic service was not available. In the long term this may have detracted from bracing as a treatment alternative.

In summary, continuation of the scoliosis screening program is not supported because although the screening test and program have been acceptable, the acceptability of treatment by bracing and surgery is questionable. The low sensitivity and high overreferral rate of the screening test call into question its validity. The criterion of available resources is not fulfilled because of lack of coordinated orthotic services and a clinic for referral of screening positives for diagnosis and treatment.

General Recommendations

Because the hypothesis of this study has not been supported it is recommended that the scoliosis screening program at SFHD be discontinued.
This decision is rationalized by review of the results of the program using the four principal evaluative criteria of screening and by the lack of evidence that other criteria to validate screening are fulfilled.

The introduction of the scoliosis screening program to other provincial health districts would not appear advisable because of the concerns evidenced in this study about acceptability of the treatment and validity of the screening test. Even more important if screening were extended into the provincial system, would be the fulfillment of the criterion of available resources. The provincial distribution of orthopedic specialists and orthotists is unequal, and considerable frustration and anxiety as well as cost could be created by offering a program with the potential for a high rate of overreferral.

In the event of discontinuation of the program the rationale should be interpreted carefully to the health district staff, school district personnel, physicians and general public. The high visibility and wide acceptance of the program warrant a carefully planned public relations effort.

As an alternative physical education teachers of the district should be taught about scoliosis and the signs of the condition so that obvious curves may be referred to the public health nurse. This group of teachers see adolescents in gym clothing and bathing suits regularly and so are most likely to detect obvious signs of a scoliotic curve such as unequal shoulder and hip levels, unequal waist angles, rib humps, a tilted pelvis and a curved spinal column in the normal course of their duties. It is not intended that they screen per se but that they refer apparent problems.
In the event that the decision is made to continue the screening program two recommendations are made. First that the screening of girls only would reduce the time and cost of the program with negligible effect on the number of treatable cases detected. Second, the establishment of a central clinic for referral of all screening positives should be a contingency of program continuation with the proviso that screening results will meet set evaluative criteria or the program will be discontinued.

**Recommendations for Further Study**

Evaluative studies of the screening test for scoliosis have been carried out in other parts of Canada. Consideration may be given to carrying out a study of the validity and reliability of the screening test using SFHD staff and selected school children. There is available known X-ray status of a sample of children in the district to facilitate such a study.

The status of children who were screening positive but who were classified as normal without radiographic evidence by the physician should be investigated to determine their present clinical status. Availability of the radiographic status of these 38 screening positives could effect the estimation of sensitivity of the screening test.

A study should be done on why bracing has not been acceptable to the children who rejected this form of treatment in this program. Such a study will be useful in the future approach to bracing as an acceptable treatment. Because of the small number available at SFHD the study could involve children from other areas.
And finally, a study of the status of the screening refusals would be helpful in arriving at a more accurate prevalence rate for scoliosis in SFHD. Some of this group indicated spinal disease as the reason for refusal and it would be pertinent to know how many were idiopathic scoliosis with an $11^\circ$ or greater curvature.
LIST OF REFERENCES


Draper, Suzanne. Inquiries Officer, Statistics Canada. Vancouver, B.C. Personal communication, August 12, 1981.


Selwood, W. E. Research Officer, Research Division, Hospital Programs, Ministry of Health, Victoria, B.C. Personal communication, June 23, 1981.


Stone, Barbara; Beekman, Claire; Hall, Vivian; Guess, Virginia; and Brooks, H. Leon. 1979. The effect of an exercise program on change in curve in adolescents with minimal idiopathic scoliosis. Phys. Ther. 59: 759-763.


APPENDIX A

Introductory Letter to Family
APPENDIX B

Interview Format
Hello, I am Betty Wynne, a Public Health Nurse at Simon Fraser Health District. I am calling you at this time to ask for further information about what happened after your child ____________ was identified at school in__________________________ as having possible scoliosis. At Simon Fraser Health Unit we have conducted scoliosis screening since 1976 and feel it is timely to assess the results of our program by determining what was the outcome of the referrals which were made. While no individual information will be published I would appreciate some details about the follow-up which occurred after the referral for scoliosis. I recognize that you may not wish to answer these questions and that your participation is entirely voluntary. You have the right to withdraw at any time.

After your received the referral letter:

1) Did you take your child to your family physician?

   ________ or ________
   Yes        No

2) Was an X-ray done? ________ or ________

   Yes        No

   What was the result? __________________________
   ___________________________________________
3) What was recommended for future follow-up?

Possibilities are:

a) Referral to an orthopedic surgeon? _______ or _______

   Name: ____________________________________________

b) Continued observation by family physician _______ or _______

c) No further follow-up required _______ or _______

d) Can't remember _______ or _______

4) If referral to an orthopedic surgeon was made, what was his recommendation?

a) Continued observation:

   at intervals of ____________________________.

b) X-rays _______ or _______

   at intervals of ____________________________.

c) Bracing (type) ___________, Exercises ____________.

d) Surgery ____________.

This has been most helpful. May I contact your physician _________
and the orthopedic surgeon ____________ for further information?

   _______ or _______

   Yes or No

(If yes) I will mail a consent form for you to complete and return.

Thank you very much.
APPENDIX C

Consent for Physician Contact
APPENDIX D

Introductory Letter to Physician
APPENDIX E

Questionnaire to Physician
I am continuing to observe Yes ____ or No ____ at intervals of __________________________.

This patient no longer requires observation Yes ____ or No ____ and can be categorized as:

(i) minimal scoliosis (less than 10°) __________________________
(ii) stabilized curve of __________________________ degrees
(iii) non-scoliotic Yes ______ or No ______
(iv) or __________________________

This child is being followed by an orthopedic surgeon

Name: ____________________________________________

* If treatment for scoliosis was instituted:

Bracing was applied ________ (date) for _______ (length of time)
(if still in brace please indicate continuing)

Surgery by Harrington Rod procedure was performed ________________.

Other Treatment: __________________________.

Is further information obtainable by contacting another physician?
Who is ____________________________________________.

We appreciate your assistance in our program review. If you would like a summary of our evaluation please indicate by a check here _____ and a copy of our scoliosis program evaluation will be mailed to you in the fall.

Betty Wynne
Nursing Supervisor.
APPENDIX F

Certificate of Approval
APPENDIX G

Letter of Permission