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Cost-Benefit Analysis of a 43-Month Fluoride Mouthrinse Program in Ansonia-Derby, Connecticut

Theodoros Licourias

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COST-BENEFIT ANALYSIS OF A 43-MONTH FLUORIDE MOUTHRINSE PROGRAM IN ANSONIA-DERBY, CONNECTICUT

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Athens (Greece) University, 1951

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COST-BENEFIT ANALYSIS OF A 43-MONTH FLUORIDE MOUTHRINSE PROGRAM IN ANSONIA-DERBY, CONNECTICUT

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I. Introduction

This research analyzes the cost-effectiveness of the Ansonia-Derby mouthrinse program. The Ansonia-Derby research project was designed to determine the effectiveness and cost of a school-based fluoride mouthrinse program. The preventive measure used was a 0.2 percent solution of neutral sodium fluoride; public school children in grades 1 through 8 participated in the project during a 42 month period, beginning in 1975, and running through 1978. The program was sponsored by the National Institute of Dental Research (NIDR).

By definition, a "cost-benefit analysis attempts to measure the benefits of a program strictly in monetary terms and to relate the benefits to the costs of achieving them" (Klarman, H.E., 1972). In a sense, a cost-benefit analysis of a preventive dental program can never be totally accurate, since intangible benefits that may accrue are difficult to quantify in precise dollar amounts. For example, freedom from pain and increased well-being are valued differently by various cultures and strata in society. However, one tangible benefit that is easily quantifiable is the reduction in decayed, missing and filled surfaces or teeth (DMFS/DMFT) that may occur over a specific time period.

The method applied in this study is cost-benefit analysis, a method for determining the net worth of experimental results in terms of cost-benefit ratios and total net present value, based on a given discount rate. To determine the effectiveness of this program, tangible benefits are weighed against the cost of supplies, as is usually done in the literature. The present analysis also takes into consideration other factors mentioned in the literature, but usually
not included in cost-benefit analyses. Among these are: (a) cost of personnel, such as salaries of volunteers and teacher-supervisors; (b) overhead, including the cost of space needed to run the program, (for example, storage and treatment rooms, administrative offices, etc.), and equipment, (such as dental chairs, and instruments); and (c) the discount rate, including a sensitivity analysis to measure the cost effectiveness in terms of variation in the discount rate.

Data were obtained from NIH-NIDR, in the form of summary statistics (means and standard deviations) in tables of DMFS(T) for each year examination, in all four years (total), and data on the costs each year, and in all four years (see Tables 1 through 8). A more detailed description of the study is given on page 19.

II. Review of Literature

Literature on the efficacy of sodium fluoride mouthrinses in reducing caries in school age children is reviewed here in three parts. First, the literature dealing with dimensions associated with efficacy is discussed. Second, literature concerned with effectiveness is presented. Finally, cost-benefit analysis is considered.

A. Efficacy of Sodium Fluoride Mouthrinses

A drug or a procedure given to humans is said to be efficacious if it produces an accepted and/or desired physiological reaction. Efficacy is measured in well defined laboratory experiments or in controlled clinical trials. Results of these trials are referred to as "outcomes."

The efficacy of sodium fluoride mouthrinse programs in reducing caries is directly related to several factors, including 1) the amount of retention or presence of factors influencing retention of fluoride
in the outer enamel surfaces, 2) the number of teeth at risk, 3) the rinse frequency, and 4) the duration of the program. Research conducted in the United States and in Sweden suggests that trials using neutral sodium-fluoride mouthrinses provide caries reduction varying between 20-50 percent (Englander, et al., 1967; Averill, et. al., 1967; Torrell and Ericsson, 1967; and Horowicz, et al., 1971).

These factors will be discussed individually.

1. **Retention**

Observations that enamel is made more acid resistant by fluoride from water supplies guided experiments where fluoride mouthrinses were applied successfully (Volker, 1939). Ericsson (1958) reviewed the literature, and reported that fluoride added to the saliva is ionized, and that the resulting uptake by enamel surfaces was three quarters that from inorganic solutions.

Since the enamel substance is the most fluoride-sensitive organ in the body, the retention of fluoride rinses must be considered important, particularly during the period of enamel formation. Retention varies considerably for different types of local applications and different experimental conditions (Reviewed by Ericsson, 1961). These factors include concentration, frequency, volume and time of rinsing.

a. **Concentration**

The concentration of sodium fluoride mouthrinse is an important factor in determining the efficacy of such programs. The higher the concentration, the higher the expected retention and subsequent reduction in DMFS(T), (Heifetz, Driscoll, and Creighton, 1973; Koch and Lindhe, 1967). However, the upper limit for a recommended sodium fluoride concentration seems to be a 0.2 percent.
b. Frequency

Another important factor determining retention is the frequency of application. Other things being equal, the greater the frequency, the greater the retention. In a relevant experiment, Koch (1969) reported a 23 percent reduction in caries for bi-monthly rinses with 18 percent reduction for a frequency of 3 to 4 times per year (See The International Workshop on Fluorides, Maryland, 1974).

c. Volume

In an experiment with children age seven to 15 years, Hellstrom (1960) observed a retention of 19 percent for mouthrinses of 10 ml. retained in the mouth for one minute. In another experiment, Birkeland (1973) examined ten- and eleven-year-old, with rinsing volumes of 10 ml. opposed to a 7 ml. volume, and found a greater reduction of caries with the 10 ml. volume. Both rinses were the same concentration of 0.05 percent natural sodium fluoride.

d. Length of Rinsing Period

Adults rinsing with 7 ml. of 0.05 percent sodium fluoride were found to swallow greater quantities during a rinsing time of two minutes than during a 30 second rinsing time, where negligible quantities were absorbed in the oral cavity. An optimal rinsing time period is considered to be one minute (Birkeland and Lokken, 1972).

2. Number of Teeth at Risk

A determining factor in efficacy of a mouthrinse program in decreasing DMFS(T) is the number and type of teeth at risk. The greater the number of teeth at risk, the greater the efficacy.

Susceptibility to caries in teeth at risk was reviewed by Aimano (1970). He ranks the lower first molars as highest in risk, followed
by the upper first molars, lower second molars, upper second molars, second premolars, first premolars, third molars, upper incisors, lower incisors, and finally, the canines.

There are no clinical trials on record where the number of teeth at risk was controlled directly. Generally, most of the studies in this area have controlled teeth at risk indirectly, by using specific school grades. Horowitz et. al., (1971) ran an experiment with two grades, using the same solution, volume, frequency, and time of rinsing for twenty months. They reported results of a decrease in DMFS of 16 percent for the younger group of five- and six-year-olds, and a greater reduction of 44 percent for the ten- and eleven-year-olds. However, protection appeared to be greater for teeth erupting after the initiation of the preventive program.

Examination of the table of eruption (Logan and Kronfeld, 1933), shows that during a three-and-a-half year program for ages five through 12, all teeth at risk will be erupted, with the exception of the third molars. Age also is related to caries level and oral pathology (Newman and Anderson, 1972).

In a study involving different ages in New Britain, Connecticut between the years 1951 and 1961, the Connecticut Health Bulletin (Erlenbach, Tracy 1957) described significant changes of 40 to 63.8 percent before and after water fluoridation in the average DMF index. However, despite the overall effect of fluoride in reducing caries noted in the New Britain study, the effect of fluoride is most pronounced on smooth and proximal tooth surfaces (Birkeland and Torrell, 1978).
3. Duration

An important factor in increasing efficacy for reduction of DMFS(T) during a preventive program is program duration. The longer the duration, the greater the reduction in DMFS(T) indices. There is no obvious theoretical limit on program length. The program is efficacious as long as a person is caries active.

Conclusion

A review of the literature on the efficacy of fluoride mouthrinse suggests that 10 ml of a 0.2 percent neutral sodium fluoride solution used weekly will yield a reduction of 25 to 50 percent in caries incidence in DMFS. It can also be concluded that the greater the prevalence of caries, the larger the number of teeth at risk, and the longer the duration of the program, the greater the increase in efficacy. However, the amount of increase for each age or teeth at risk group is not known.

B. Effectiveness of Sodium Fluoride

The effectiveness of a program is its inherent efficacy in non-clinical or non-experimental settings. The effectiveness of fluoride mouthrinse programs is measured by decreasing DMFS(T) in the "real world," meaning, generally, school children under non-professional supervision. In fact, Burt (1978) draws a distinction between efficacy and effectiveness in that efficacy benefits an individual and effectiveness a population.

In a community program, an effective preventive method depends not only on the ability to prevent caries, but also is influenced by its efficacy, by caries susceptibility of the target population, by frequencies of application, and whether professionals, school personnel, or volunteers administer the preventive agent.
A real-world setting for a fluoride mouthrinse program may influence efficacy. Conditions associated with a clinical trial may vary, such as degree, consistency, and skill of supervision, as well as attendance, duration, and attrition. These may affect the volume, frequency, concentration and duration of mouthrinse. In general, given public acceptability and cooperation from school authorities, weekly mouthrinse programs of sodium fluoride 0.2 percent, are safe, feasible, need little time, and are relatively inexpensive. These practical issues influencing program effectiveness will not be considered individually.

1. **Supervision**

In the United States and Sweden, many programs have been introduced under professional supervision with a generally marked decrease in caries incidences (Torell and Ericsson, 1967; Heifetz, 1978; Torell, 1965; Torell, 1965; Government of Ireland, 1972). It is clear that effectiveness will vary with the quality of the supervision. For example, as noted earlier, whether or not the supervision is done by professionals, school teachers, or parent volunteers can influence the preparation of the concentration, volume, frequency, and length of time rinsing.

2. **Attendance**

Many school authorities are willing, given public acceptance, to cooperate in mouthrinse programs characterized by simple and easy procedures. The fact that such programs have been successful in Goteborg, Sweden and several communities in the United States, indicates high acceptability and high attendance (Torell, 1965; Torell and Ericsson,

3. **Duration**

In general, the longer the duration of a program, the higher the effectiveness (Koch and Lindhe, 1969); this was discussed in the previous section.

4. **Attrition**

Attrition, or the frequency with which subjects participating in the program are lost to follow-up or subsequent application of mouthrinse, is influenced by duration. In the United States, attrition has averaged approximately 15 percent per year (Heifetz, Horowitz and Driscoll, 1974). The degree of attrition is an important factor, whose influence has not been adequately assessed to date.

**Conclusions**

As review of the literature indicates, the degree of supervision, attrition, duration and attendance influences effectiveness, although, in many cases, estimates of the magnitude of these effects are not available.

C. **Cost-Benefit Analysis**

We now consider the topic of cost-benefit analysis, emphasizing its relation to dental programs.

Cost-benefit analysis is an analytical technique to help decision makers determine whether or not the services offered by a program are worth providing. If benefits exceed costs, then cost-benefit analysis criteria suggest the program should be provided (Klarman, 1972). In cost-benefit analysis, benefits and costs are expressed in pure monetary terms, and the criteria on which to base undertaking a specific
program can be expressed in two ways: as a net benefit (net cost), or as a cost-benefit ratio.

Under the net benefit (net cost) criteria, the differences between the monetary terms of benefits and costs are established. If the differences are positive (net benefits), the project under consideration is acceptable. If negative (net costs), then the project is to be rejected. Under the cost-benefit ratio method the ratio of monetary values of all benefits to the monetary values of all costs is established. If this ratio is greater than one, the project is acceptable. If the ratio is less than one, it is not acceptable. If the ratio is equal to one, the criterion is neutral.

In computing net benefit or benefit cost ratio, one utilizes the present values of benefits and present values of costs. If the duration of a program is more than one year, a discount rate must be incorporated, to make the values comparable over successive years. These concepts will be illustrated in the methodology section.

As an economic technique for evaluating specific projects in the dental public sector, application of cost-benefit analysis is relatively new. Until the early 1970s, little attention had been paid to the cost of caries prevention. In contrast to the extensive literature in efficacy and effectiveness, few cost-benefit analyses have been reported for fluoride mouthrinse programs.

Review of the literature indicates that fluoride mouthrinse programs vary in efficacy and effectiveness in reducing DMFS(T). It has been shown that the effectiveness of these programs depends on duration, attendance, supervision, attrition, public acceptability, and other factors. In order to increase the effectiveness of a program,
appropriate resources representing personnel, supplies, and space need to be utilized in an optimal way.

It is reasonable to expect that there will be a positive correlation between judicious utilization of such resources and program effectiveness. For example, having a strictly supervised program could yield more participation, appropriate use of concentration, volume and time of rinsing, as well as other experimental parameters, and thereby increase effectiveness. More importantly, the longer the duration, and, correspondingly, the more costly the program, the greater the influence on effectiveness.

In essence, there is a trade-off between the amount spent for resources and the effectiveness of a fluoride mouthrinse program in reducing caries. The higher the amount of resources expended (e.g., longer duration, better supervision), the higher the benefits arising from the procedures in reducing DMFS(T). The major question that arises, therefore, concerns whether or not increased costs are justified by greater benefits or increased effectiveness.

Cost-benefit analysis is a formal and systematic way to choose among different investments in public projects, by measuring the achieved benefits in strictly monetary values, and relating benefits to the corresponding costs (Klarman, 1974; Thompson, 1980; Luce and Warner, 1981). To apply cost-benefit analysis in a mouthrinse program, it is necessary to measure benefits (decrease in caries incidence) in monetary terms and to relate them to the corresponding costs. An important point to be made concerns the time span over which the actual cost and benefits are estimated. In order to be comparable, costs and benefits must be calculated for the same point in time; that is, future
costs and benefits must be discounted to their present values (Boggs, 1972).

In the following section, studies dealing with the cost-benefit analysis of fluoride mouthrinsing programs are reviewed in two parts: a) distinction between cost-benefit and cost effectiveness analysis, and b) measurement of cost and benefits in the literature.

1. Distinction Between Cost-Benefit and Cost-Effectiveness Analyses

A cost-effectiveness analysis is a procedure for estimating the least expensive method to achieve a specific objective (Klarman, 1972). Cost-benefit and cost-effectiveness analyses are the two basic techniques used to measure and determine if a program is worth pursuing (Thompson, 1970; Luce and Warner, 1981).

The differences between the two analyses lie in the measurement of output. Cost-effectiveness output is not measured in monetary terms as is a cost-benefit analysis, but as an outcome or end benefit; for example, DMFS(T) saved. The removal of monetary terms in cost effectiveness eliminates many of the difficulties associated with cost-benefit analysis (Prest and Turvey, 1965; Grainger, 1973; Klarman, 1974).

Horowitz and Heifetz (1969) stated that cost-benefit analysis often ignores unmeasurable benefits (intangibles), such as freedom from pain or dentition completely free from dental caries. However, at the same time, Davies (1979) concluded that indirect or intangible benefits should not be overestimated. He stated a preference for cost-benefit analysis over cost-effectiveness analysis. However, both analyses have their advocates.
Examples of direct benefits from a mouthrinse program include increased productivity, less travel time to and from the dentist, and less school-time lost. Examples of intangible benefits would be freedom of pain, dentition free of caries, positive psychological values, and greater social acceptability.

Several methodologies for cost-benefit analysis have been presented in the literature, although all basically propose that the cost-per child of the preventive treatment be subtracted from the cost per child of restorative care of those in the control group. These measures will yield the approximate net economic benefit for each treatment (Torell, 1965; Torell and Ericsson, 1965; Davies, 1979; Horowitz, Creighton, and McClendon, 1971).

2. Measurements of Costs and Benefits in the Literature

In the extensive preventive program of Goteborg, Sweden by Torell (1965), supervised mouthrinse with sodium fluoride was introduced as an integral part of the school dental service. The program started in 1960 with only two of the youngest age groups rinsing once a month. Later it was extended to new age groups in each new school year. In 1962, the frequency of application increased to twice a month. By 1966, 40,000 children were involved in the mouthrinses. A similar program was also applied in Erie, Sweden.

Program procedures in Goteborg were as follows. Dental nurses supervised the mouthrinses with each nurse responsible for 5,000 children. Each child rinsed in the presence of a nurse using a 10 ml. of 0.2 percent of sodium fluoride for two minutes.

The costs of the Goteborg program have been detailed by Torell (1965, 1965). The method used for the cost-benefit analysis subtracted
gross costs from gross gains. The gross gains were DMFS multiplied by
the dental treatment costs and the number of children. The net gains
were total gains divided by the number of children, showing the net
gain in monetary terms per child (Torell, 1965; Torell and Ericsson,
1967). Thus, in net benefits Torrell noted 4,600,000 - 433,000 =
4,177,000 which, when divided by 40,000, yielded a net gain per child
per year of 101 Sw. Cr.

In another study, the cost of supplies consisting of paper cups,
paper napkins and fluoride solution was about $0.31 per-child-per-year
or $0.62 in two years. Since the program was administered in schools
by school teachers, no additional charges were included for salaries
(Horowitz, Creighton and McClendon, 1971). The investigators obtained
a benefit-cost ratio of 1:16.4. The calculations are illustrated as
follows:

Savings in cost in DMFS per child in two years = $1.27
Savings in cost of fillings @ $8.00 per saved surface = $10.16

\[
\text{Benefit-cost} = \frac{\text{Cost of Implementation}}{\text{Savings in Cost of Treatment}} = \frac{0.62}{10.16} = 1:16.4
\]

In these calculations, only direct costs were included, such as
paper cups, paper napkins and the fluoride solution. No evidence of
additional charges were mentioned, such as salaries for teachers and
volunteers, space to run the program, cost of equipment, and discount
rate expenses, that in the future must be paid. By way of contrast, in
Goteborg Sweden, salaries of highly-paid professionals were included,
affecting the benefit-cost ratio.

The studies conducting benefit-cost analyses in fluoride mouth-
rinses were reviewed by Davies (1973). He concluded that there is no
general method to estimate benefits in dentistry, since the appropriate variables depend on the target population involved. For example, the analysis must be extended to account for specific ages, socioeconomic and sociodemographic backgrounds, health habits of the family, etc.

Of the demographic variables, men and women in families whose annual income was high tended to have more DMF units than those families with low incomes. For example, men of all races whose family income exceeds $19,000 had 19.0 DMFT per person, but those with incomes less than $12,000 averaged 15.3. Mean number of fillings was 10.1 for high income families and 2.3 for low income ones. These numbers are based on calculations of Kelly, Vankirk and Garnst (1967).

Among socioeconomic variables, income or ability to pay for dental services has been found to be highly correlated with use of dental services in many countries (Newman and Anderson, 1972). In general, there is no evidence of extensive and comprehensive measurements of benefits as a function of socioeconomic factors, sociodemographic factors, and a full spectrum of ages. There are comparisons for some specific ages, some in high-risk areas, and mostly in schools with varied races of socioeconomic and demographic levels with few grades.

Davies developed the same cost-benefit ratio as Horowitz, et al., where the costs are the implementation costs and the benefits are the savings of DMFS multiplied by the cost of restoration. He compared the different ratios for the United States and the United Kingdom, obtaining a more favorable ratio for the United States because of its higher fees for dental restoration.

There are few bonafide cost-benefit analyses in the literature. However, data from cost-benefit analysis in the literature are of
limited value, since the caries reduction varied with attributes of the trials, such as the selection of subjects, the prevalence of caries, the age of participants, frequencies of rinsing, duration of the program, etc. For example, in Goteborg (Torell, 1965) the children attended 31 different schools, and the caries prevalence varied considerably.

Studies reported in the literature were conducted in schools under the supervision of either dentists, dental hygienists, dental auxiliaries, teachers or volunteers. The differences in the costs of implementation varied, affecting benefits proportionately. Thus, important differences in operational costs can result from utilization of different personnel resources in providing the preventive agent.

It is apparent that costs will be affected by the frequency of rinsing, number of children, and duration of the program. To the extent that a program has a duration of more than a year for evaluation, the costs and benefits have to be discounted so that the units in dollars are homogenous with respect to time, as was suggested earlier.

Another problem arises from the need to separate the benefits occurring during the mouthrinse program from the effect of other dental health measures which may also be in progress at the same time, since these may bias estimates of the benefits.

The benefit measurements in the literature were priced and compared to the costs, but none of these analyses considered the time valuation of benefits, since costs and benefits of a program will occur in different magnitudes over a varying time period. For example, mouthrinses are acknowledged to prevent more caries lesions in the
tenth year than in the first, thereby ignoring the fact that costs and benefits are worth less if they occur in the future.

More research is needed including the salaries of teachers and volunteers as overhead costs when conducting preventive treatments, in addition to costs of space for storage and examinations. Cost-benefit analysis will indicate if a program is still beneficial when these overhead expenses are included, together with a discount rate. In addition, there is need for sensitivity analysis. It is vital to know what benefits, if any, accrue to the specific ages of five-year-olds through the twelve-year-olds, by year, if one begins the program during the eruption of the first molars, and continues through teeth erupting later.

Conclusions

To this point, it has been shown that fluoride mouthrinse programs can be efficacious and effective. It has also been established that there are factors influencing efficacy, which in turn will influence considerations of costs versus benefits.

An appropriate methodology is needed to make such assessments accurate and reliable. This type of analysis can help determine whether or not expensive clinical trials should be undertaken. The remainder of this paper presents such an analysis.

III. Objectives

The general objective of this study was to determine the costs and benefits (including overhead expenses) of a school based sodium fluoride (0.2 percent solution) mouthrinse program administered weekly to children ages five- to twelve-years over a 43 month period.
The general research hypothesis was that the program was cost beneficial in total, although there may have been differences in the cost benefit ratios for different age groups and different years of the program. Therefore, the secondary objective of this research was to determine at which age the highest cost-benefit can be achieved.

The specific objectives of this study can be outlined as follows:

1. To determine the anticaries effects of a weekly fluoride mouthrinse program.
2. To determine the effect of duration of the mouthrinse program on caries reduction.
3. To calculate the annual cost of a fluoride mouthrinse program.
4. To estimate the cost-benefit ratios in DMFS(T) of a fluoride mouthrinse program by age of participants, and for each year of the program.
5. To calculate the total Net Present Values (NPV) of the program, given a discount rate, and to perform a sensitivity analysis, by age and length of time in the program.

IV. Methodology

The description of the research methodology is presented in seven parts. The first part consists of a description of the program and the data base. Each of the next five parts is related to the specific objectives and the methods to be applied to achieve them. The seventh part deals with the statistical analysis.

A. Description of Data Base

1. Overview

The Ansonia-Derby program involved a study over three and a half years of supervised weekly mouthrinses with 0.2 percent sodium fluoride...
solution given to school-based children aged five through twelve years, living in a non-fluoridated central water supply area. The program started in December 1975 and ended in June, 1979 (43 months). A random sample of 125 children per grade was selected. This sample was to serve as a baseline control group, and compared with the annual examinations for subsequent years. Tables 1 and 2 show the number of participating students in each age group for each year.

It is important to note that the study did not have a separate control group. An internal control was used instead, with the subjects in each group compared with an appropriate baseline group in the program. For example, five-year-olds after one year were compared with six-year-olds at the baseline examination. One year later, when these children were seven-years-old, they were compared to the seven-year-olds at baseline. In one year there were 11 five-year-olds; the next year there were 14 five-year-olds. They had to be compared in the baseline with 83 children. However, this did not present a major problem since ages are easily compared. (Discussion of potential difficulties arising from these varying numbers is presented in the statistical analysis section.)

2. Site

The Ansonia-Derby area is an industrial community supporting industries such as heavy machinery, rubber, textiles and magazine printing. The area is located in the southwestern portion of the State of Connecticut and occupies 5.3 squares miles. The total population at the time of the study was 12,599, including 3,880 children.

The population consisted of 12,414 whites, 132 blacks, and 53 others. The per capita income was $3,314; per family income was
$11,274 (1970 U.S. Census). Ethnic groups consist of 7,135 natives and 5,464 of foreign parentage. The city has a basically stable population, with little movement outside the community, and with a one percent population loss per year (Connecticut Market Data Book, 1973).

The Derby area received its water supply from five sources, two reservoirs and three wells. There is no fluoride in the drinking water except for one well with 0.1 ppm of fluoride ion, far below the requirement of 1 ppm.

The Derby area has four public schools and two parochial schools. The adjacent town of Ansonia is similar to Derby in having a homogeneous population and similar socio-economic demographic characteristics. All schools in both towns agreed to participate in the mouth-rinse program.

Fifty percent of the children in the Ansonia-Derby area needed additional dental care. Many had untreated problems or neglected dentition with no previous dental care.

3. Data

There are two kinds of data used in this project. One measures costs and the other measures DMFS(T) findings. The raw data were not available. That is, the observations (DMFS or DMFT) for individual students were not made available. Instead, summary statistics (means and standard deviations) were provided for each age group for each year of the program, in addition to the total number comprising each group. These measures are shown in Tables 1 and 2. Data were supplied by the National Institutes of Dental Research (NIDR) as secondary sources for each year of the program.
Records of costs and staff time for implementation and conducting the program were reported to NIDR. The final tabulation of expenses were prepared by NIDR, and were categorized in four parts as: estimation of personnel time, estimation of cost for supplies, estimation of cost for equipment, and estimation of school overhead (Tables 6 through 8).

The DMFS and DMFT secondary data are provided for each year and presented in nine columns in Tables 1 and 2. Examination 0, the first year examination of the children, is called the baseline and subsequent annual examinations are labeled, respectively, examinations 1, 2 and 3.

The first column of each examination is the age of the children, five through 16 years; the second column gives the number of children; the third the adjusted number of children; and subsequently, the mean DMF, standard deviation, percentage of DMF, percentage of D, F, and M of DMF (See Tables 1 through 4).

In Tables 1 and 2, data for children in the experimental group (columns 6, 7, and 8) can be compared with data for children in the control group, after one, two and three years in the program; column 9 lists the differences. For example, the six-year-olds, after one year in the program had a mean DMFS of 1.353; after two years, a mean DMFS of 0.602, and after three years a mean DMFS of 0.962. These DMFS numbers can be compared with the baseline DMFS of 2.955 for the seven-year-olds, and subsequently, 4.289 and 5.152 for the eight and nine-year-old baseline groups, respectively.

4. Program Administration

The mouthrinse was administered, and data recorded by dental hygienists. The project personnel were appropriately calibrated and
trained. Diagnostic criteria to be used for the examinations were furnished by the (NIDR). Recorders were to enter all DMFS(T) findings according to scoring criteria provided by the National Caries Program (NCP) on data sheets furnished by NCP. Examinations were to be made by means of plane front surface glass mirrors, explorers, air syringes, portable dental chairs and lights. One day of in-service training was required to provide the classroom teachers and aides with the necessary instructions on weekly mouthrinsing procedures. The instruction consisted of procedures for preparing, dispensing and administering the mouthrinse solution, keeping attendance, and filling out supply forms. Periodic monitoring of classroom and dispensing procedures was conducted by the principal investigator, and weekly monitoring by the project staff.

The mouthrinse solution was mixed in a central area by an aide or volunteer, dispensed into paper cups and placed on pre-labeled trays. The trays were either taken by a student volunteer to the classroom, or placed on three-tiered carts to be distributed by the aid, depending on the method of rinsing.

Two rinsing methods were used: the classroom method and the central location method. In the traditional classroom method, the teacher supervised and timed weekly rinsing. This method was employed in schools where students did not change classes or where space was limited. When there were frequent room changes, the central location method was used. In this manner, the mouthrinser aide wheeled the cart filled with cups and solution to the door of each classroom and participating students came into the corridor to rinse.
The supervisors dispensed paper cups containing 10 ml. of the solution, and under their supervision the children carried out the following procedures. Simultaneously they "swished" the solution around their mouth for 60 seconds with their lips tightly closed and their teeth in contact. When "swishing," the solution is slowly strained back and forth through the interdental spaces. The children were reminded that at no time during the procedure was the solution to be swallowed.

In order to reduce absenteeism in the different schools, mouthrinses were scheduled every day except Monday and Friday. These two days were known to have a high degree of absenteeism. Attendance was kept by the supervisor.

B. Determining the Effects of a Weekly Fluoride Mouthrinse Program on the Reduction of DMFS(T)

One way to evaluate the effects of the prevention on school-based children is to measure the DMFS(T) at baseline, before treatment, and again at the end of the program. However, this method may not be appropriate if the program is lengthy. This is because, first, the impact of the program on the children of different ages may vary, and, second, the impact may vary over time.

Another more specific way to assess the impact is to measure DMFS(T) at baseline and at subsequent intervals of one, two and three years. Differences that occur may be attributed to the prevention treatment, as well as to the impact on different age groups of the eruption of new teeth at risk. Between ages five through 12, during three and a half years of preventive treatment, all teeth at risk will be involved at different stages, except the third molars. As a result,
the best way to measure the impact of the program is through the use of a control (non-experimental) group, with comparable similar age and other demographic characteristics. In this way, differences between the control and the experimental group for each specific age will reflect the differences in response to the mouthrinse alone.

As noted earlier, this study utilized an internal control group. Thus, effects of the mouthrinse program on reduction in DMFS and DMFT were estimated by comparing each experimental group with the appropriate baseline group. In this case, the latter group functioned as a de facto internal control. This method was illustrated in the previous section describing the database. Cost-benefit comparisons were derived in a similar fashion.

C. Determining the Effect of Duration on Caries Reduction

Tables 1 and 2, described in the previous section, illustrate the impact of program duration. For example, one can examine the progress of five-year-olds in the program, and the impact of the duration, directly to the last year. This can be done by examining the last column, showing the results in examination year three, or after one year for examination year one. The last column (9) of Tables 1 and 2 provide the differences between the two groups by year. For example, when comparing the findings of DMFS (Table 1) in the six-year-olds after one year, one first looks to the age group of six-year-olds where DMFS was 1.590 (Table 1, column 5). Then, after one year in the program the experimental group shows a DMFS of 1.353 (column 8) as compared with the seven-year-old children's baseline of 2.955. The seven-year-olds at baseline comprise the (internal) control group for the six-year-olds at examination 1. The difference between 2.955 and
1.353 is 1.602, so it can be concluded that, after one year of prevention, the six-year-olds had a mean decrease in DMFS of 1.602, and, subsequently, a difference of 3.687 and 4.200 for the second and third years when they were compared, respectively, with the eight- and nine-year-olds at baseline.

Table 1 suggests that the five-year-olds, in comparison with the control at baseline, had a mean decrease of 0.772 in DMFS after one year in the program, when they were six-years-olds and, subsequently, as seven- and eight-year-olds, the differences in mean DMFS were 2.955 and 1.706 respectively. In the same way, the mean differences for the seven-year-olds, after one year, was 1.805. At the second year, when they were nine years of age, the difference was 3.603; and when they were ten-years-old, the difference was 4.605. In fact, the largest decreases are in the age group consisting of the nine- through twelve-year-olds. In particular, the eleven- and twelve-year-olds, after three years in the program, were respectively fourteen- and fifteen-years-old, and manifested differences of more than 10.0 in mean DMFS.

D. Evaluating the Cost of Fluoride Rinse Program by Year

In this thesis aspects other than the usual found in the literature on cost-benefit analyses are included. One is the use of a discount rate; another is the use of a sensitivity analysis. In addition, overhead costs, such as the cost of space to run the program, costs of equipment, and the salaries of teachers and volunteers who supervise the program, will be included.

It is unimportant that there actually were no payments for some of the school work spaces used for the program. Zero payments of the costs for teachers and parent volunteers may actually be a misrepresen-
tation in a cost-benefit analysis, since the costs of supervisors will be negligible, yielding a more favorable ratio. This is not realistic since in most "real world" cases, the same services would have to be paid for.

Because the trial results are measured as savings in DMFS(T), it is possible to get a reasonable estimate on the savings in restorative treatments.

Costs and expenditures are necessary to achieve benefits and they are measured in monetary values. The costs of a mouthrinse program depend on several factors, including:

1. Supplies (sodium fluoride, cups, napkins, duration, and office supplies).
2. Personnel (dentists, hygienists, dental nurses, teachers, parent volunteers, and in general, salaries due to supervisory functions).
3. Equipment (dental chairs, instruments).
4. Space to run the program (storage, treatment rooms, administrative offices, etc.).

All costs were expressed as a mean-per-student, or a weighted mean of the cost of the application of a single dental service. These were estimated by year as follows: 1975-1976, 1976-1977, 1977-1978, and 1978-1979 (see Tables 5, 6, 7, and 8 for cost data). First, estimation of personnel time was based on hourly rates for teachers, nurse supervisors, rinse supervisors, typist volunteer staff and others. Second, estimation of costs of supplies, such as neutral sodium fluoride powder, forms, cups, napkins and plastic bags were obtained. Third, estimation of costs of equipment including locked cabinets, carts,
trays, and scissors were calculated. Finally, costs of total annual overhead were calculated in each of three categories: rinsing, mixing and storage.

Overhead costs for each category were based upon the fraction of total area of the school building involved, and the fraction of time (based upon a 365-day year, 24-hour day) the space was used. For example, in the first year, 117,369 square feet were used for rinsing; the total school area was 360,901 square feet. Thus, 117,369/360,901 = 0.3344 of the total school area used for rinsing. This space was used for a total of 33.28 hours, or 33.28/(365 x 24) = 0.0038 of the total year. Since the total annual overhead operating expenses for the school for the first year were $145,207.23, the fraction of this cost attributed to the project were computed as $145,207.23 x 0.334 x 0.0038 = $184.52. In a similar way, annual costs for mixing and storage were calculated for all years of the project. Thus, for each year or examination point, it was possible to calculate the cost of the total project. These figures were divided by the number of students at each examination to give an average cost for each student for each year in the project.

The first year, 1975-1976, the average cost per child was $3.17; for the second year $5.27; for the third $3.24; and for the last year, $3.46. A transcription of calculations for each year of the project is given in the analysis of the costs in Tables 3, 4, 5, and 6. Each table also is analyzed for separate expenses.

E. Evaluation of Cost Benefit Ratios by Age Each Year

These benefits include:

1. The intrinsic value of good health.
2. The value of good oral health in consuming or enjoying the consumption of all goods and services.

3. The value of good health as an investment.

4. The cost of restorative treatments.

The first three items are subjective in nature, and the corresponding values or benefits are likely to vary among individuals, depending, for example, on income, education, etc. The last benefit depends on the particular restorative treatment undergone; e.g., a filling, an extraction, or possibly a prosthetic appliance.

Benefits are measured in monetary terms. Although the first three benefits are intangible, and therefore difficult to measure, they should not be ignored. These benefits may be of greater value than the benefits arising from the restorative treatments. Klarman (1972) and Fein (1967) suggest that neglect of valuable intangible benefits may understate program benefits, and may thereby cause a program to be eliminated from consideration among competing programs. However, Davies concluded that indirect and intangible benefits should not be overestimated. The last benefit is also difficult to measure although it can be reasonably approximated.

In analyzing the Ansonia-Derby program, it was necessary to estimate the cost of dental services saved as a result of improvement in DMFS(T) assumed to accrue from the fluoride treatment. For each unit reduction in D or F, the cost of a restoration is saved. Similarly, for each unit by a reduction in M, the cost of an extraction is saved. Hence, it is necessary to estimate the cost of these dental services for the years covered by the project.
A survey conducted by the *Journal of the American Dental Association* (Reports of Councils and Bureau), February 1977, provided data on the costs of services for two of the years covered by the project. Linear increments in service costs were projected for other years. The cost of extractions, simple tooth, was based on American Dental Association service code 7116. The cost of an amalgam restoration was estimated from the cost of one, two, three and four surface permanent amalgams, American Dental Association service codes 2110, 2120, 2130, and 2140 respectively.

In determining the costs of these services, it was necessary to consider the relative frequency of each service seen in a population of dental patients. For example, a four surface amalgam, although much more expensive than a one surface amalgam, is nonetheless much less frequent.

In consultation with Dr. Jonathan Clive, it was possible to estimate frequencies of service utilization, based upon research conducted by Bailit and Clive (1981). In this way, a weighted average cost per restoration, equal to the cost of each type of amalgam multiplied by the relative frequency of the type of amalgam, was obtained. This was summed over amalgam types to give a simple estimated cost of restoring a tooth. The procedure was repeated for each year of the project, using the estimated individual costs for each type of amalgam for each year. To estimate the cost of restoring an individual tooth surface, the estimated cost of each type of amalgam was divided by the number of surfaces involved, one, two, three or four. This gave the average cost per surface per type of amalgam. These costs per
the mean of the baseline DMFT of the twelve-year-old group (6.992), since the eleven-year-olds were, on average, twelve-years-old after one year in the program. (The internal control group for the eleven-year-olds, after one year in the program, is the twelve-year-old baseline group.)

From the examination of Table 9, we see that the costs-per-patient to this point are $3.51 + 5.27 = $8.78. The difference in mean DMFT is 6.992 - 5.083 = 1.909. Hence there is an estimated reduction in DMFT resulting from the fluoride program. From examination of the data for the twelve-year-olds at examination year 1, we see that 98.30 percent of the difference is due to decayed or filled teeth and 1.7 percent due to missing teeth. Hence, to compute the dollar value of the benefit of the program, we need to multiply these percentages by the cost of the corresponding services, which it is assumed were not required due to reduced DMFT.

From Table 9, we have seen that the cost of a restoration for 1976-1977 was $16.46 and the cost of an extraction was $14.27. We use the costs for 1976-1977 since that is the applicable period of the project services. Actually, there is little differences among costs and these would not substantially affect the conclusions of this research.

Therefore, the total service costs saved (i.e., the benefit of the program for the eleven-year-olds after one year) can be calculated as follows. Using the equation given earlier, we have:

\[ B = 1.90 \times 0.983 \times 16.46 + (1.90 \times 0.017) \times 14.27 = 30.89 + 0.46 = 31.35. \]
This represents the mean benefit per patient. Since the costs to this point were $8.78, the cost benefit ratio is given by

\[
R = \frac{31.35}{8.78} = \frac{3.571}{1}
\]

\[R = \frac{31.35}{8.78} = 3.571/1\]

or, as it is written in the literature, 3.571 (Table 10 and 11).

F. Calculating the Net Present Value (NPV) by Age and Duration, Incorporating a Discount Rate, and Evaluation of Sensitivity Analysis

If program duration exceeds one year (in this case it is three and a half years), it is necessary to incorporate a discount rate when calculating the Net Present Value.

A problem associated with the cost-benefit analysis is choosing the appropriate discount rate to determine the future benefits and costs. In investment decisions applied to mouthrinse programs, all benefit and cost considerations are spread out over future years. When the benefits for each future year are known or can be estimated, some way of aggregating them is necessary. Economists generally agree that people place a higher value on one dollar today than one dollar in any future period even in the absence of inflation (Feldstein, 1964b, 1974; Harberger, 1968; Fein, 1971; Harberger, 1972; Marglin, 1963; Klarman, 1965a; Weinsbrod, 1961; Prest and Turvey, 1965).

The choice of a high or low discount rate affects choices among projects with different patterns of benefits and costs over time. This is particularly important for dental projects, because they often entail large costs initially, and have benefits spread out over many
years. After considering the factors affecting economic circumstances, (for example, with inflation a two digit number at the time of this writing), it is felt that a discount rate between 15 to 25 percent is adequate although it is likely that different rates could be proposed and adequately defended. To insure the validity of the cost-benefit analysis in the calculation of benefit-cost ratios and Net Present Value (NPV) a sensitivity analysis is performed for alternative discount rates, varying between .5 and 61 percent.

A discount rate is used to establish the relationship between the value of the program at different points in time. If the discount rate per year is $r$, then $\$1$ today is worth $\$(1+r)$ next year; or $\$1$ next year is worth $\$1/(1+r)$ today. That is, one dollar spent today is really equivalent to $(1+r)$ dollars next year, since the same dollar in the bank could have earned interest worth $r \times \$1$. This formula can be extended to deal with benefits which accrue over many years. One dollar two years from now is worth $\$1/(1+r)^2$ dollars; three years from now it is worth $\$1/(1+r)^3$ dollars. Letting $B =$ Benefits per year, $C =$ costs per year, and $(1+r) =$ discount rate, we say that the present value of a benefit stream $B_0, B_1, B_2, B_3, \ldots B_t$, where the subscript represents future years, is equal to

$$B_0 + \frac{B_1}{1+r} + \frac{B_2}{(1+r)^2} + \ldots + \frac{B_t}{(1+r)^t} = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t}$$

Given a corresponding stream of costs $C_0, C_1, C_2, \ldots C_T$, net present value is defined as

$$\sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t}$$
The basic decision-making rule is: Undertake the project if the net present value is greater than zero:

\[
\sum_{t} \frac{(B_t - C_t)}{(1+r)^t} > 0.
\]

or pursue the project if the discounted benefits exceed the discounted costs (Feldstein, 1964c; Weinstein, 1972; Marglin, 1963).

For example, to evaluate the net present value of the program for the eleven-year-olds after one year, we must convert the costs and benefits to baseline dollars; that is, they must be discounted. We will use a discount rate of 15 percent. The discussion that follows illustrates a basic technique and a cost-benefit ratio example which can be applied generally. Using the formula given earlier, we set \( t = o \), \( B_o = 0 \) (since there are 0 benefits when the program is just started), and \( C_o \) = the "start up" cost. Since we are considering the first year of the program for the eleven-year-olds, \( T = 1 \). Again we are dealing with costs and benefits per student. We have already determined that for \( t = 1 \), \( B = $31.25 \), and \( C1 = $5.27 + $3.51 = $8.78 \).

We know that \( C_o = $5.27 \), thus

\[
NPV = \frac{\sum_{t} B_t - C_t}{t_o(1-r)^t} = \frac{0 - $3.51}{(1.15)^0} + \frac{$31.35 - 5.27}{(1.15)^1} =
\]

\(-$3.51 + 26.08/1.15 = -$3.51 + 22.68, thus, NPV = +$19.17 (See Tables 12-13).\)
We can conclude that the program is cost beneficial if the NPV is greater than zero. Where there is equality, the criterion is neutral, and where the NPV is less than zero, the program is not worth the effort. In this example, then, we conclude that, after one year, the program was cost beneficial for the eleven-year-old group. That is, society has benefited from the program.

G. Statistical Methods

In this study, the benefit cost ratios are meaningful only if there is a statistically significant reduction in the amount of DMFT and DMFS when comparing the test and control groups. That is, if an observed difference is due to chance alone, then the notion of benefits and costs is irrelevant, since there may be no actual benefit. Hence, it is necessary to examine the statistical significance of the differences in mean levels of DMFT and DMFS between test and control groups.

To do this, a one-way analysis of variance (ANOVA) with repeated measures is appropriate, as described by Snedecor and Cochran (1980). Prior to implementing this procedure it is necessary to apply Bartlett's test for homogeneity of variances, in order to determine if the underlying assumptions of ANOVA are met. The results of this test showed that the variances were not always homogeneous (i.e., statistically equivalent). In such instances, the results of an ANOVA may be compromised.

There are certain statistical techniques for circumventing difficulties of this type, but their utilization depends on transformation of the original data values. Since these were unavailable, it was not possible to adjust for heterogeneous variances. Therefore, the results
must be accepted as is, with provision for indicating where the analysis may be suspect. In Tables 1, 2, 10, 11, 12, and 13, the group or groups inducing the heterogeneity are indicated with a cross (+) and groups marked with an asterisk (*) exhibit significant differences in mean values.

An alternative procedure is to eliminate the groups with disparate variances, and proceed to do the ANOVA on the homogeneous groups. In this case, we would be testing the null hypothesis of no difference among means against the alternative of nonequality of means. If the null hypothesis is not rejected, the groups can be combined, and the modified two sample t-test can be used, testing the mean of the composite group against the mean of the outlying group (Snedecor and Cochran, 1980).

Since the number of outlying groups was relatively small, and since ANOVA is a robust procedure, this last option was rejected. Instead, we proceeded with the ANOVA, and indicated in the appropriate tables where the results are subject to potential bias.

Table 14, shows that the Net Present Value of the program is always positive for values of the discount rate varying from 5 percent to 61 percent. Only for a discount rate of 61 percent is a negative Net Present Value observed. However, the Net Present Value is generally highly positive, even when the discount rate exceeds the unrealistic value of 61 percent.

For DMFT, the Net Present Value of the program was positive for the entire group in a wide range of values of the discount rate. In examining the results for individual age groups, it was noted that in most cases the Net Present Value was positive even in the presence of
wide variation in the discount rate. The only exceptions were in the
eight- and nine-year-old groups. However, the data in these cases are
suspect as will be discussed shortly. Thus, we can conclude that the
basic results of this study are insensitive to wide fluctuation in the
value of the discount rate, and the program is, in general, cost
beneficial.

V. Results

The primary results of this research are summarized in Tables 1, 2, 10, 11, 12, 13, and 14. In this section, we describe these results,
relating them to the specific objectives outlined earlier.

Table 1 presents the means and standard deviations for DMFS, for
all age groups, for all years of the program. The number of subjects
in each age group is also given, as the difference in mean DMFS between
the control and experimental groups for each age and year in the pro-
gram. This last measure was the control group mean DMFS minus the
experimental group mean DMFS, so that positive values in the mean
difference column (the last column in Table 1) reflect a positive
experimental effect; i.e., the mouthrinse reduced the mean level DMFS.

Examination of Table 1 shows that there was a reduction in mean
DMFS over all age groups, for all years of the project. The statistical-
ical significance of these mean differences is also indicated in Table 1.
In a number of cases, as noted in part seven of section IV, the
statistical significance of the differences is questionable. This was
due to differences in the standard deviations over years in the
project, within age groups. However, in many cases, these suspect
standard deviations were not far outliers (with the possible exception
of the twelve-year-old experimental group), so that, given the robust-
ness of the analysis of variance procedure (Snedecor and Cochran, 1980), there are strong indications that the program was effective in reducing mean DMFS.

It should be noted that there were two "suspicious" readings; namely, the mean difference in DMFS for the eight- and nine-year-olds after one year. These values are too low, and out of sequence with the after measurements. An analogue of this phenomenon was noted for the mean DMFT differences. The implications are discussed in Section VI.

Table 2 shows the mean DMFT scores for each age group, for each year in the program, as well as the difference in means. The format for Table 2 is identical to that of Table 1. For each age group and year in the project, there was a decrease in mean DMFT scores. As with DMFS, most of the mean differences for DMFT are positive (or so indicated), so that the rinse program may be judged clinically effective. We now consider the cost/benefit ratios.

Table 9 shows the estimated mean cost per student for restoration (DMFS and DMFT) and extractions, for each of the four program years. The derivation of these figures is given in Table 9A. Table 9 also gives the mean expenses per student for each year of the program. The figures in Table 9 were used to estimate the cost/benefit ratios.

Tables 10 and 11 show the cost/benefit ratios for each age group and program year, based on DMFS and DMFT respectively. The statistical significance of these ratios is also indicated (a repeated measures analysis of variance test of the null hypothesis that, within age groups, all ratios equal one). Examination of these tables indicates that, with few exceptions, the benefits exceed the cost for both DMFS and DMFT, for all program years and age groups. The same holds when
cost/benefit ratios are evaluated over the entire group. The only exceptions are the eight- and nine-year-old groups for the first year, in both DMFS and DMFT, and the five-year-old group, first year, DMFS. This stems from the small difference in mean DMFS and DMFT score between the experimental and control groups for these ages and year in program, which was alluded to earlier in this section.

Tables 12 and 13 show the Net Present Value for each age group, the entire group, by year in program, for DMFS and DMFT respectively. Again, these measures are positive (i.e., favorable) with the exception of the five- and eight-year-old groups (DMFS) for the first program year, and the eight- and nine-year-old groups (DMFT) for the first program year. The statistical significance of the Net Present Values is also indicated in Tables 12 and 13. These were determined using a repeated measures analysis of variance to test the null hypothesis that, for each age group, the mean Net Present Values were zero over all program years.

The Net Present Values in Tables 12 and 13 were based on an assumed discount rate of 0.15. Table 14 presents the results of a sensitivity analysis, where the Net Present Value was estimated for a variety of discount values, ranging from 0.05 to 0.61. This was done for DMFS, for each program year, over all students. The results are striking; only for a discount rate of 0.61 is a negative Net Present Value observed, and even then, only for the first program year.

In sum, then, the results strongly suggest that the program was effective and cost-beneficial, although several idiosyncracies in the data (i.e., the results for eight- and nine-year-olds) need to be considered.
VI. Discussion

There are aspects of the study design and implementation that might compromise the study results. We will discuss these in this section.

Perhaps the foremost deficiency in the design of the experiment involves the lack of an external control. All analyses of changes in DMFS and DMFT involved comparisons of baseline age groups and one of the other age groups after a certain number of years in the program.

In comparison with analysis of similar programs in Sweden and the United States, the Ansonia-Derby program is of equal or greater benefit. For example, Horowitz, et al. (1971) report a cost-benefit ratio of 1:16.4 in evaluating a mouthrinse program conducted in the United States. While this appears at first glance to be more cost-beneficial than the Ansonia-Derby program of 1:4.93 for the third year, closer inspection shows that only the cost of supplies (paper cups, napkins, solution) were included in the Horowitz analysis. The more extensive costs of personnel, equipment and space, as well as the fifteen percent discount rate, were not taken into account by Horowitz. Similarly, for a cost-benefit analysis of the Swedish program, Torell (1965) obtained a ratio of 1:10.6, also failing to include both the cost of equipment and space and the discount rate of fifteen percent.

Thus it has been shown that while the earlier American and Swedish programs report a greater cost-benefit ratio, the inclusion of actual program costs will tend to bring their cost benefit ratio closer to the 1:5 ratio found in the Ansonia-Derby program.

In general, the upper age levels did better than the younger age levels in the Ansonia-Derby program. In the five-year-olds after one
year in the program, the reduction is minimal, increasing the second year and decreasing again after three years. There are unequal numbers of students in each year. In case when the numbers are very different, the statistical comparison of groups with respect to DMFS(T) may be influenced. In particular, this may lead to unequal variances among groups being compared.

In the six-year-olds, there is a decrease of DMFS(T) each year in the program with the highly susceptible first molars erupting, and covered by the preventive program. The seven-year-olds show the same tendency, with more teeth at risk being protected.

In the eight-year-old group there is a decrease the first year, while for the second and third year in the program there is improvement. The reason for the smaller than average differences is not clear. The first year decrease might be attributed to the increasing incidence of caries, improving the second and third year because of the prevention. The situation for the nine-year-olds is similar to that of the eight-year-olds.

It was felt also that the ten-year-olds might benefit more than other ages, because of the pending eruption of permanent teeth. In general, this was reflected in the data and is another factor that should weigh in favor of a caries reduction preventive program that can be applied for the upper age levels of the ten-, eleven-, and twelve-year-olds.

In general, in each age group, decreasing indexes (i.e., decreases in mean DMFS and DMFT difference over time) are proportional to the length of the duration. In the upper levels of ten-, eleven-, and twelve-year-olds, the effect of the duration increases dramatically,
reaching a 10.943 DMFS decrease for the eleven-year-olds after three years in the program. This may be due to the protective covering of all teeth at risk.

A. Cost-Benefit Ratios

In general, for the entire group on DMFS, the second year cost-benefit ratio is the best in comparison with the first and third years. It is likely that the lower third year cost-benefit ratio is due to the accumulation of the cost by each year of the program. The cost-benefit ratio for the first years are the lowest, since the impact of the duration is only one year and fewer teeth at risk are present than in the later years.

The five-year-old group has the best cost-benefit ratio for the second year of the program, when they are six-years-old and the first molars are erupted. The six-year-olds reach a better ratio the third year of the program, when molars and new teeth at risk are protected.

The seven- through twelve-year-olds reach the better cost-benefit ratio in the third year when all the teeth at risk are erupted and covered by the prevention for the length of the program.

B. Net Present Value (NPV)

In the five-year-olds there is a negative NPV since, although expenses are incurred, there are no permanent teeth to benefit. In general, the third year is the most beneficial, reaching the optimum with the twelve-year-olds after three years in the program. For the eight- and nine-year-olds there is a negative NPV total, which may be due to questionable data, as noted earlier.

For DMFT, the Net Present Value of the program was positive for the entire group, for a wide range of values of the discount rate. In
examining the results for individual age groups, it was noted that in most cases, the Net Present Value was positive even in the presence of wide variation in the discount rate. The only exceptions were in the eight- and nine-year-old groups.

**Conclusion**

The basic conclusion of this research is that the fluoride mouthrinse program was cost-beneficial. This is true for each year of the project, for all grades, and for the study group as a whole. With few exceptions, as age increases, the cost-benefit ratios increase. Even with a discount rate as high as 61 percent, the benefit cost ratios still indicated the desirability of the project.

In summary, cost-benefit increased by age and duration, upper levels did better than younger age levels, eleven-year-olds benefited the most and five-year-olds the least; the project was cost beneficial for the entire group, and, in certain cases noted earlier, the data were suspicious.

The efficiency of a preventive measure must be measured in the context of whether or not it lessens the need for dental treatment and reduces the cost of dental treatment. Unfortunately, current def and DMF data cannot supply the answers with any acceptable degree of reliability. In most cases, the investigators responsible for the clinical trial and those responsible for the treatment of the subjects concerned (community practitioners) are different people. Each group approaches the detection of clinical caries via different criteria and different methods.

In the case of mouthrinse, this divergence is important, even though the extent of caries reduction can readily be detected by very coarse methods of diagnosis. Lack of a unified approach is doubly
critical when only the most careful and standardized diagnostic and statistical techniques can assess benefits accurately.

While a truly scientific approach to obtaining hard data is not presently available, findings to date do, at least, suggest the importance of cost-effectiveness and cost-benefit analyses. An appropriate methodology permitting such assessments to be made logically, accurately, and reliably is needed. A great deal of time and effort are wasted on the replication of clinical trials and procedures when an initial dependable cost-benefit analysis would have shown then to be worthless.

There is reason to be confident that, as more cost-benefit analysis of caries prevention are made, experience will suggest a vitally needed standardized methodology. The "state of the art" seems headed in that direction.
<table>
<thead>
<tr>
<th>Year</th>
<th>Group Examined</th>
<th>Number of Students</th>
<th>Findings at Final Exam</th>
<th>Mean Differences</th>
<th>Standard Deviations</th>
<th>Control Children (Std.)</th>
<th>Experimental Children (Std.)</th>
<th>Control Children (Std.)</th>
<th>Experimental Children (Std.)</th>
</tr>
</thead>
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<td>0.068</td>
<td>17</td>
<td>121</td>
<td>41</td>
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<td>0.068</td>
<td>17</td>
<td>125</td>
<td>45</td>
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<td>0.068</td>
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<td>2.266</td>
<td>0.068</td>
<td>17</td>
<td>125</td>
<td>45</td>
<td>140</td>
<td>125</td>
<td>45</td>
<td>140</td>
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<tr>
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<td>2.266</td>
<td>0.068</td>
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<td>125</td>
<td>45</td>
<td>140</td>
<td>125</td>
<td>45</td>
<td>140</td>
</tr>
<tr>
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<td>2.266</td>
<td>0.068</td>
<td>17</td>
<td>125</td>
<td>45</td>
<td>140</td>
<td>125</td>
<td>45</td>
<td>140</td>
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<tr>
<td>2.925</td>
<td>2.266</td>
<td>0.068</td>
<td>17</td>
<td>125</td>
<td>45</td>
<td>140</td>
<td>125</td>
<td>45</td>
<td>140</td>
</tr>
<tr>
<td>2.925</td>
<td>2.266</td>
<td>0.068</td>
<td>17</td>
<td>125</td>
<td>45</td>
<td>140</td>
<td>125</td>
<td>45</td>
<td>140</td>
</tr>
<tr>
<td>2.925</td>
<td>2.266</td>
<td>0.068</td>
<td>17</td>
<td>125</td>
<td>45</td>
<td>140</td>
<td>125</td>
<td>45</td>
<td>140</td>
</tr>
<tr>
<td>2.925</td>
<td>2.266</td>
<td>0.068</td>
<td>17</td>
<td>125</td>
<td>45</td>
<td>140</td>
<td>125</td>
<td>45</td>
<td>140</td>
</tr>
</tbody>
</table>

**TABLE 2**

Means, standard deviations (Std.) and mean differences in DPT for Experimental and Control Children for Each Program Year.
**TABLE 3**

Total Cost of Mouthrinse Program by Type of Cost* and Calculations of Average Cost per Student 1975-1976

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>532.72 hr.</td>
<td>$8.96/hr.</td>
<td>$4773.17</td>
</tr>
<tr>
<td>Other</td>
<td>85.52 hr.</td>
<td>$3.13/hr.</td>
<td>$267.68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>$5040.85</td>
</tr>
<tr>
<td>Rinse supervisors</td>
<td>404.74 hr.</td>
<td>$4.48/hr.</td>
<td>$1813.24</td>
</tr>
<tr>
<td>Student help</td>
<td>150 hr.</td>
<td>$2.25/hr.</td>
<td>$337.50</td>
</tr>
<tr>
<td>Typist</td>
<td>132.27 hr.</td>
<td>$3.85/hr.</td>
<td>$505.22</td>
</tr>
<tr>
<td>Volunteer</td>
<td>132.27 hr.</td>
<td>$2.25/hr.</td>
<td>$297.61</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>$2506.87</td>
</tr>
<tr>
<td>NaF 734 units</td>
<td>734 units</td>
<td>$0.11</td>
<td>$80.74</td>
</tr>
<tr>
<td>Forms</td>
<td>81.00</td>
<td></td>
<td>$81.00</td>
</tr>
<tr>
<td>Cups</td>
<td>16.2 cs</td>
<td>$25.90/cs</td>
<td>$419.58</td>
</tr>
<tr>
<td>Napkins</td>
<td>14.5 cs</td>
<td>$11.00/cs</td>
<td>$159.50</td>
</tr>
<tr>
<td>Plastic Bags</td>
<td>3.65 cs</td>
<td>$17.32/cs</td>
<td>$63.22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>$801.04</td>
</tr>
<tr>
<td>Cabinets</td>
<td>1500</td>
<td>$1.00</td>
<td>$1500.00</td>
</tr>
<tr>
<td>Carts</td>
<td></td>
<td></td>
<td>$120.00</td>
</tr>
<tr>
<td>Trays</td>
<td>257.60</td>
<td></td>
<td>$257.60</td>
</tr>
<tr>
<td>Scissors</td>
<td>12.75</td>
<td></td>
<td>$12.75</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>$1920.35</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td></td>
<td>$10269.11</td>
</tr>
</tbody>
</table>

Overhead rinsing: $33.38 hr x 117,369 sq.ft x 145,207.23 = 185.07

Mixing*: $606 x 128.03 x 145,207.23 = 3.67

Storage: $340 x 272 x 145,207.23 = 4.37

Average cost per student = $10,462.22 / 3009 = 3.48

*Mixing bottles not included.
TABLE 4

Total Cost of Mouthrinse Program by Type of Cost* and Calculations of Average Cost per Student 1976-1977

<table>
<thead>
<tr>
<th>Type of Cost</th>
<th>Cost Calculation</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>330.37 hr @ $9.71 avg per hr.</td>
<td>$3207.89</td>
</tr>
<tr>
<td>Aides</td>
<td>120.67 hr @ $3.51</td>
<td>$423.55</td>
</tr>
<tr>
<td>Supervisor</td>
<td>157 hr @ $5.28/hr</td>
<td>$828.96</td>
</tr>
<tr>
<td>Parents</td>
<td>205 hr @ $2.31</td>
<td>$473.55</td>
</tr>
<tr>
<td>NaF</td>
<td>619 units @ $0.11</td>
<td>$68.09</td>
</tr>
<tr>
<td>Consent Forms</td>
<td></td>
<td>$23.00</td>
</tr>
<tr>
<td>Cups</td>
<td>18.26 cs @ $24.29/cs</td>
<td>$443.54</td>
</tr>
<tr>
<td>Napkins</td>
<td>13.83 cs @ $11.40/cs</td>
<td>$157.66</td>
</tr>
<tr>
<td>Plastic Bags</td>
<td>8.5 bx @ $14.19/bx</td>
<td>$120.62</td>
</tr>
<tr>
<td>Cabinets</td>
<td></td>
<td>$1530.00</td>
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<tr>
<td>Carts</td>
<td></td>
<td>$60.00</td>
</tr>
<tr>
<td>Trays</td>
<td></td>
<td>$246.40</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>$24.20</td>
</tr>
<tr>
<td><strong>Overhead rinsing</strong></td>
<td>112266 x 330.37 x 545442.00 = 350901 x 365 x 24hr</td>
<td>$6581.26</td>
</tr>
<tr>
<td><strong>Mixing</strong></td>
<td>606 x 325.37 x 545442.00 = 350901 x 365 x 24</td>
<td>$34.99</td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>340 x 545442.00 = 350901</td>
<td>$528.50</td>
</tr>
</tbody>
</table>

Average cost per student = $14,752.86/2802 = 5.26

*Mixing bottles not included.
**Big increase from previous year
TABLE 5
Total Cost of Mouthrinse Program by Type of Cost* and Calculations of Average Cost per Student 1977-1978

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers avg.: 46.71 hrs @ $6.01</td>
<td>$280.73</td>
</tr>
<tr>
<td>Others: 3.61 hrs @ $3.15</td>
<td>11.37</td>
</tr>
<tr>
<td>Supervision: 178 hrs @ $6.47</td>
<td>1151.66</td>
</tr>
<tr>
<td>University helpers @ $3.06</td>
<td>403.16</td>
</tr>
<tr>
<td>Secretary: 11.73 hrs @ $3.06</td>
<td>31.20</td>
</tr>
<tr>
<td>Other: 13.5 hrs. @ $2.66</td>
<td>35.91</td>
</tr>
</tbody>
</table>

| Total                       | $2018.07   |

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaF 251 units @ $.15</td>
<td>$37.65</td>
</tr>
<tr>
<td>Forms A $</td>
<td>202.00</td>
</tr>
<tr>
<td>Cups 5.2 cs @ $3.00 cs</td>
<td>171.60</td>
</tr>
<tr>
<td>Napkins 4.61 cs @ $16.50 cs</td>
<td>76.07</td>
</tr>
<tr>
<td>Bags 972 @ $.01/cs</td>
<td>9.72</td>
</tr>
</tbody>
</table>

| Total                       | 497.04     |

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabinets</td>
<td>990.00</td>
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<tr>
<td>Carts</td>
<td>135.78</td>
</tr>
<tr>
<td>Trays</td>
<td>71.40</td>
</tr>
</tbody>
</table>

| Total                       | 1197.18    |

Total 3979.09; average cost per student: $3979.09/1228=$3.21

*Mixing bottles not included.
### TABLE 6

**Total Cost of Mouthrinse Program by Type of Cost and Calculations of Average Cost per Student 1978-1979**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost per Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers avg.</td>
<td>85 hr</td>
<td>$6.96</td>
<td>$591.60</td>
</tr>
<tr>
<td>Aides</td>
<td>34.49 hrs</td>
<td>$3.50</td>
<td>120.72</td>
</tr>
<tr>
<td>Supervision</td>
<td>146 hrs</td>
<td>$6.24</td>
<td>911.04</td>
</tr>
<tr>
<td>Sec/Helper</td>
<td>231.38 hrs</td>
<td>$3.46</td>
<td>800.59</td>
</tr>
<tr>
<td>Parents</td>
<td>17.66 hrs</td>
<td>$2.91</td>
<td>51.39</td>
</tr>
<tr>
<td>Other</td>
<td>21.75 hrs</td>
<td>$2.35</td>
<td>51.11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$2526.45</strong></td>
</tr>
<tr>
<td>NaF 473 units</td>
<td>@ $ .25</td>
<td></td>
<td>$118.25</td>
</tr>
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<td>Forms</td>
<td></td>
<td></td>
<td>53.00</td>
</tr>
<tr>
<td>Cups 13.87 cs</td>
<td>@ $27.10</td>
<td></td>
<td>375.88</td>
</tr>
<tr>
<td>Napkins 13.69 cs</td>
<td>@ $11.99cs</td>
<td></td>
<td>164.14</td>
</tr>
<tr>
<td>Bags 4.4 cs</td>
<td>@ $17.03</td>
<td></td>
<td>74.93</td>
</tr>
<tr>
<td>Bookcovers 3500 @ .10</td>
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<td></td>
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<td><strong>Total</strong></td>
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<td></td>
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</tr>
<tr>
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<td></td>
<td>990.00</td>
</tr>
<tr>
<td>Carts</td>
<td></td>
<td></td>
<td>135.78</td>
</tr>
<tr>
<td>Trays</td>
<td></td>
<td></td>
<td>71.40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>1197.18</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$4859.83</strong></td>
</tr>
<tr>
<td>Overhead rinsing:</td>
<td>34340 x 20.5 x 556069</td>
<td>=</td>
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</tr>
<tr>
<td></td>
<td>492436 x 365 x 24</td>
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</tr>
<tr>
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<td>1586 x 179.16 x 556069</td>
<td>=</td>
<td>36.63</td>
</tr>
<tr>
<td></td>
<td>492436 x 365 x 24</td>
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<td></td>
</tr>
<tr>
<td>Storage:</td>
<td>90 x 556069 =</td>
<td>=</td>
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</tr>
<tr>
<td></td>
<td>492436</td>
<td></td>
<td><strong>$5088.84</strong></td>
</tr>
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</table>

Total 5048.87; average cost per student: $5048/1398 = $3.64

*Mixing bottles not included.
### TABLE 7
Cost of DMFS 1975-1976, 1976-77 Average Cost of Each Type of Restoration

<table>
<thead>
<tr>
<th>Cost of Surface Times</th>
<th>Relative Frequency</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.99 x .429:1</td>
<td></td>
<td>= 4.71</td>
</tr>
<tr>
<td>16.90 x .399:2</td>
<td></td>
<td>= 3.37</td>
</tr>
<tr>
<td>22.84 x .155:3</td>
<td></td>
<td>= 1.18</td>
</tr>
<tr>
<td>27.00 x .017:4</td>
<td></td>
<td>= .12</td>
</tr>
</tbody>
</table>

Estimated for 1976-1977 = $10.11

### TABLE 8
Cost of DMFS 1977-1978, 1978-1979 Average Cost of Each Type of Restoration

<table>
<thead>
<tr>
<th>Cost of Surface Times</th>
<th>Relative Frequency</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.75 x .436:1</td>
<td></td>
<td>= 5.56</td>
</tr>
<tr>
<td>19.29 x .406:2</td>
<td></td>
<td>= 3.92</td>
</tr>
<tr>
<td>25.83 x .158:3</td>
<td></td>
<td>= 1.36</td>
</tr>
</tbody>
</table>

Estimated for 1978-1979 = $11.52
<table>
<thead>
<tr>
<th>Year</th>
<th>Restorations (DMFS)</th>
<th>Restorations (DMFT)</th>
<th>Extractions</th>
<th>Program Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-1977</td>
<td>10.11</td>
<td>16.46</td>
<td>14.27</td>
<td>5.26</td>
</tr>
<tr>
<td>1977-1978</td>
<td>10.84</td>
<td>17.47</td>
<td>15.39</td>
<td>3.21</td>
</tr>
<tr>
<td>1978-1979</td>
<td>11.52</td>
<td>18.48</td>
<td>16.51</td>
<td>3.64</td>
</tr>
</tbody>
</table>
**TABLE 9A**

Cost of DMFT - Average Cost of Each Type of Restoration and Extraction

Decayed: Diagnostic services not included
Restorations per surface

Restorations: Same as above per surface

Missing: Diagnostic - Same as restorations
Extraction - simple extraction
Replacement - not included

Restorations 1975-76 - Assume permanent, 1-4 surfaces. Weight according to frequencies of application. Use mean prices.

<table>
<thead>
<tr>
<th>Cost Calculation</th>
<th>Cost (1975-76)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.99 x .429</td>
<td>$4.71</td>
</tr>
<tr>
<td>16.40 x .399</td>
<td>6.54</td>
</tr>
<tr>
<td>22.84 x .155</td>
<td>3.54</td>
</tr>
<tr>
<td>27.00 x .017</td>
<td>.46</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$15.25</strong></td>
</tr>
<tr>
<td>(19.43 unweighted)</td>
<td></td>
</tr>
</tbody>
</table>

Estimated 76-77 - $16.46

Restorations 1977-78

<table>
<thead>
<tr>
<th>Cost Calculation</th>
<th>Cost (1977-78)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.75 x .436</td>
<td>$5.56</td>
</tr>
<tr>
<td>19.29 x .406</td>
<td>7.83</td>
</tr>
<tr>
<td>25.83 x .158</td>
<td>4.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$17.47</strong></td>
</tr>
<tr>
<td>(19.29 unweighted)</td>
<td></td>
</tr>
</tbody>
</table>

Estimated 78-79 - $18.48

Extractions 1975-76 13.15
1976-77 14.27
1977-78 15.39
1978-79 16.51

Ref: ADA Code: for Extraction 7110
Restoration 2140-2161
<table>
<thead>
<tr>
<th>Age Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1:0.903x</td>
<td>1:2.696+</td>
<td>1:1.268+</td>
</tr>
<tr>
<td>6</td>
<td>1:1.866x</td>
<td>1:1.338</td>
<td>1:3.199x</td>
</tr>
<tr>
<td>7</td>
<td>1:2.087</td>
<td>1:3.260x</td>
<td>1:3.440x</td>
</tr>
<tr>
<td>8</td>
<td>1:0.607x</td>
<td>1:3.304x</td>
<td>1:4.703+</td>
</tr>
<tr>
<td>9</td>
<td>1:0.999x</td>
<td>1:5.300x</td>
<td>1:5.434+</td>
</tr>
<tr>
<td>10</td>
<td>1:2.968x</td>
<td>1:5.585x</td>
<td>1:6.485x</td>
</tr>
<tr>
<td>11</td>
<td>1:2.678x</td>
<td>1:6.337x</td>
<td>1:7.889</td>
</tr>
<tr>
<td>12</td>
<td>1:3.646x</td>
<td>1:6.365x</td>
<td>1:8.259x</td>
</tr>
<tr>
<td>Entire Group</td>
<td>1:1.243</td>
<td>1:4.926x</td>
<td>1:4.394x</td>
</tr>
</tbody>
</table>

x - Indicates statistical significance at the 0.05 level.

+ - Statistical significance of the mean differences are questionable (See Text).
TABLE 11

Cost/Benefit Ratio by Age Group Program Year in DMFT

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Program Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1:1.213x</td>
<td>1:3.075</td>
<td>1:2.620x</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1:2.110x</td>
<td>1:4.160</td>
<td>1:3.171x</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1:1.981x</td>
<td>1:2.289x</td>
<td>1:3.363x</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1:0.353x</td>
<td>1:2.961x</td>
<td>1:4.786</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1:0.972x</td>
<td>1:5.019</td>
<td>1:5.783+</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1:3.313</td>
<td>1:5.755x</td>
<td>1:5.927x</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1:3.571x</td>
<td>1:5.854</td>
<td>1:7.757x</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1:3.174x</td>
<td>1:6.726x</td>
<td>1:6.687x</td>
<td></td>
</tr>
<tr>
<td>Entire Group</td>
<td></td>
<td>1:1.689</td>
<td>1:5.082x</td>
<td>1:4.462x</td>
</tr>
</tbody>
</table>

x - Indicates statistical significance at the 0.05 level.

+ - Statistical significance of the mean differences are questionable (See Text).
TABLE 12

Net Present Value in Dollars Per Student, by Year and Age Group for DMFS
(Discount Rate = 0.15)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Program Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>-1.20x</td>
<td>20.85+</td>
<td>31.51+</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>6.15x</td>
<td>27.89</td>
<td>29.68x</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>7.84</td>
<td>27.18x</td>
<td>32.97x</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>3.46x</td>
<td>24.12x</td>
<td>70.08+</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>-0.47x</td>
<td>45.25x</td>
<td>98.75+</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>14.57x</td>
<td>62.88x</td>
<td>127.15x</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>12.35x</td>
<td>67.50x</td>
<td>146.33x</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>19.74x</td>
<td>75.14x</td>
<td>157.64x</td>
</tr>
<tr>
<td>Entire Group</td>
<td></td>
<td>1.39</td>
<td>43.71x</td>
<td>73.37x</td>
</tr>
</tbody>
</table>

x - Indicates statistical significance at the 0.05 level.

+ - Statistical significance of the mean differences are questionable (See Text).
TABLE 13

Net Present Value in Dollars Per Student, by Year and Age Group for DMFT
(Discount Rate = 0.15)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Program Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>1.16x</td>
<td>26.66</td>
<td>51.33x</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>8.02x</td>
<td>43.38</td>
<td>73.34x</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>7.03x</td>
<td>30.83x</td>
<td>63.17x</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>-5.40x</td>
<td>19.06x</td>
<td>66.09</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>-0.68x</td>
<td>42.49</td>
<td>99.81+</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>17.20</td>
<td>67.06x</td>
<td>125.87x</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>19.17x</td>
<td>69.92</td>
<td>147.62x</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>16.14x</td>
<td>74.82x</td>
<td>141.47x</td>
</tr>
<tr>
<td>Entire Group</td>
<td></td>
<td>4.80</td>
<td>48.54x</td>
<td>92.23x</td>
</tr>
</tbody>
</table>

x - Indicates statistical significance at the 0.05 level.

+ - Statistical significance of the mean differences are questionable (See Text).
<table>
<thead>
<tr>
<th>Discount Rates</th>
<th>Program Year</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>.050</td>
<td>1.86</td>
<td>52.63</td>
<td>108.84</td>
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<tr>
<td>.075</td>
<td>1.74</td>
<td>50.17</td>
<td>102.55</td>
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<td>1.62</td>
<td>47.88</td>
<td>96.77</td>
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</tr>
<tr>
<td>.125</td>
<td>1.50</td>
<td>45.74</td>
<td>91.42</td>
<td></td>
</tr>
<tr>
<td>.150</td>
<td>1.39</td>
<td>43.71</td>
<td>86.49</td>
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</tr>
<tr>
<td>.175</td>
<td>1.29</td>
<td>41.83</td>
<td>81.94</td>
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<tr>
<td>.200</td>
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<td>44.76</td>
<td>82.42</td>
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<td>.225</td>
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<td>38.39</td>
<td>73.79</td>
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<tr>
<td>.250</td>
<td>1.00</td>
<td>36.82</td>
<td>70.14</td>
<td></td>
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<tr>
<td>.275</td>
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<td>35.34</td>
<td>66.73</td>
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</tr>
<tr>
<td>.300</td>
<td>0.83</td>
<td>33.96</td>
<td>63.57</td>
<td></td>
</tr>
<tr>
<td>.610</td>
<td>-0.01</td>
<td>21.58</td>
<td>37.17</td>
<td></td>
</tr>
</tbody>
</table>
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Feldstein, M.S. 1964c. Cost-benefit analysis and investment with Public Administration.


