

**Economic Evaluation of Dental Sealant and  
Fluoride Mouthrinsing Program in Two Non-  
Fluoridated Regions of Victoria**

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## ABSTRACT

**Purpose:** This study assessed the cost-effectiveness of a 3 year school-based dental sealant and fluoride mouthrinsing (DS and FMR) program in 2 non-fluoridated regions in Victoria, Australia.

**Methods:** The primary analysis was based on a community intervention in 5 schools comparing an intervention group receiving the DS and a weekly FMR, and a non-intervention group. The study measured mean differences in DMFS increments between study groups.

**Results:** The mean discounted DMFS gain between study groups was 1.22 DMFS over 3 years. The incremental cost-effectiveness ratio between intervention to control groups varied between a net saving of \$7.00 to a cost of \$35.60 per DMFS gained. The results were sensitive to assumptions on program effectiveness, dental examination rates, and baseline DMFS of students. The program became more cost-effective with each successive year.

Extrapolation of results of the 3-year intervention to the wider non-fluoridated community over a 10 year time frame resulted in a benefit- to-cost ratio above unity, regardless of assumptions used for either program cost or effectiveness.

**Conclusions:** The introduction of such a preventive program in non-fluoridated regions of Victoria will represent an efficient use of community resources. Policy issues that need consideration are whether to target adolescents with a history of high dental disease experience, and whether dentists or auxiliaries are to be used. There is a need for a systematic evaluation (including an economic evaluation component) of dental prevention and treatment programs in Victoria.

# Economic Evaluation of a Dental Sealant and Fluoride Mouthrinsing Program in Two Non-Fluoridated Regions of Victoria

## 1 Introduction

There has been a significant improvement in the dental health of children and adolescents in Australia and other industrialised countries since the mid-1970's. Mean DMFT (Decayed, Missing and Filled Teeth) scores in 12-year-old children in Australia have declined from 3.0 in 1982 to 1.2 in 1992 - a reduction of 60 % (1). In addition, the decay free rates (DMFT score of zero) of 12-year-olds has increased from 22.2 % to 53.8 % over the same time frame (1).

Not all groups in the Australian community have benefited to the same extent from this improvement in oral health. Characteristics of children still having a higher burden of dental disease include: low income families; low educational status of parents; Aborigines and Torres Strait Islanders; recent immigrants; and residing in areas with non-fluoridated water supplies (2, 3).

In particular, the dental health experience of children in non-fluoridated areas is significantly compromised compared to children residing in fluoridated regions. Brown et al found a 31.4% difference in DMFT (3.5 compared to 2.4) in 8 year old children in the metropolitan fluoridated area of Melbourne compared to the non-fluoridated Geelong region (4). Similarly Slade et al. reported that a greater exposure to fluoridated water was associated with significantly lowered DMFS (Decayed, Missing and Filled Surfaces) in South Australia and Queensland (5). Given that 33% of Australians do not have access to a fluoridated water supply, children in these areas provide an important target group for the implementation of dental prevention programs (6).

The aims of this paper are two-fold. The first aim is to undertake an economic evaluation of a 3 year school-based dental sealant and fluoride mouth-rinsing program (DS and FMR) in a single cohort of Year 7 adolescents (first year of secondary school) from low income families in Geelong and Ballarat, 2 non-fluoridated areas in rural Victoria, Australia - hereafter referred to as the "small-scale" prevention program. Since the 1970's, municipalities of both Geelong and Ballarat have been resistant to the introduction of fluoride into reticulated drinking water supplies.

Second, the paper extrapolates the results of the small-scale program to a wider context by estimating the economic benefits, from a societal perspective, over a 10-year time frame of a

publicly funded program available to all adolescents in Geelong and Ballarat - hereafter referred to as the “large-scale” prevention program.

The rationale for the current study is that both preventive and treatment services are extremely limited for low income adolescents in non-fluoridated regions of Victoria. Further, the school-based dental public health program currently terminates at the completion of primary school education (12 years of age). Previous research in Victoria has highlighted the need for primary prevention strategies including DS and FMR programs to be introduced into Victorian secondary schools (7-10).

The current study represents the first Australian economic evaluation of a DS and FMR program aimed at reducing dental caries in the population. As such, it will inform decision makers on the value of introducing a similar program into the public dental health services in rural Victoria. This has particular policy relevance in Victoria given that the state government has recently announced plans to expand the School Dental Service to include secondary school-aged children.

## 2. Methods and Materials

Economic evaluation is a form of analysis that compares alternative forms of action (either prevention or treatment) in terms of both their costs and benefits (often termed outcomes, effectiveness or consequences). Such an analysis can assist policy makers determine which dental health intervention (or mix of interventions) - either prevention or treatment - maximises improvements in oral health within available community resources.

A detailed discussion of economic evaluation methodology is found in texts by Drummond (1988), and Drummond, Stoddart and Torrance (1988) (11,12). Their application to dental health programs have been discussed in the dental journal literature (13 -17). The forms of economic evaluation methodology used in the small scale and large scale programs were cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) respectively. These methodologies are described in more detail in the methodology section below.

### (a) Small Scale Program

The economic evaluation was based on a secondary analysis of outcome data collected as part of a recently completed 3 year community intervention described below (18). The intervention was not designed to collect economic data alongside the trial. The cost data used in the economic evaluation was a combination of a retrospective analysis of resource use associated with implementing and operating the community intervention, and an estimate of the difference in dental treatment costs associated with oral health outcomes between the two study groups.

#### *Intervention design*

The DS and FMR intervention study design involved a school-based 3 year (1989-1991) prospective non-randomised trial consisting of an intervention group (n=256) and a control or non-intervention group (n=266). The intervention group received in addition to their routine dental care from a private dental practitioner, the DS and FMR program. The control group received routine dental care only.

The sample of Year 7 children was drawn from 5 schools with known high levels of dental caries experience from the non-fluoridated regional cities of Geelong and Ballarat, in rural Victoria. Each school was classified by the Ministry of Education as being in the lowest 20 % of the Australian Bureau of Statistics' Index of Socio-economic Advantage and Disadvantage (19). The age-group was chosen primarily because the second permanent molar teeth would on average have just erupted, or would be erupting during the trial period, and therefore, be at the most appropriate stage for dental sealing. In addition, subjects had entered secondary school and consequently no longer had access to free School Dental Service care. Finally, it was considered that subjects of this age would be able to carry out the mouth-rinsing effectively.

Each subject's oral health status was recorded using the DMFS index at an annual dental examination (20). Subjects were given a standardised dental examination by calibrated examiners on a portable dental chair or school table. The dental examination was undertaken using a sickle probe and mouth mirror attached to a fibre optic light source. No radiographs were taken.

The dental sealant application was undertaken by a dentist independent of the research team. Sealants were placed on all second molar teeth and first permanent molars where appropriate based upon the morphology and sealant retentiveness predictors of Bader et al (21). The dental sealants were placed, repaired, or replaced at each 12 month interval on the basis of individualised treatment plans established by the dentist.

The FMR component comprised a supervised weekly mouthrinse with 0.2% neutral sodium fluoride. A Community Health Centre, also independent from the research team, was employed to provide staff to supervise the weekly FMR activities.

### ***Program Efficacy and Effectiveness***

The primary outcome used in the economic appraisal was intervention effectiveness based on the difference in total DMFS (and components) increment between the intervention and control group from baseline to the completion of the trial. DMFS increments were also calculated annually. Individuals who withdrew from the trial were not followed up to measure their subsequent dental experience due to demands of confidentiality by participating schools and the logistical reasons of students moving to other localities.

Outcomes were available for individuals who completed the trial. These “efficacy” results were re-calculated (based on assumptions about the outcomes of student withdrawals) to provide estimates of program “effectiveness”, based on “intention-to-treat” (outcomes for individuals to whom the program was offered). The analysis assumed that students who withdrew from either arm of the trial received (in the year they withdrew) the average outcome of their respective group for students for whom a measure was available at the annual examination. In years subsequent to withdrawal, students in both the intervention and control group were assumed to incur the same DMFS increment as the control group for whom a measure was available. This is considered a “worst case scenario”. In practice it would be expected that students in the intervention group would receive better outcomes than the control group as they should receive some clinical benefit from that “partial” treatment. As such, the measurement of program effectiveness is considered a conservative estimate of the true program effect. The concept of intention-to-treat, and the effect on study outcomes of making different assumptions about study withdrawals is discussed in a number of recent papers (22-24).

### ***Cost Analysis***

The cost analysis was restricted to resource expenditure associated with organising the DS and FMR program, and the costs of dental treatment. Thus total costs in the intervention group was specified as program costs plus dental treatment costs. For the control group, total costs were those associated with dental treatment. The difference between the total costs of the intervention group and the control is termed the incremental (or additional) costs (or savings) associated with the DS and FMR intervention. Resource use associated with the 1989-91 intervention was inflated by use of dental services price index to reflect AUD\$ 1994 (an Australian dollar having the same purchasing power parity as 0.76 US dollars).

In determining resource use associated with the DS and FMR program, estimates were based on those costs that would be expected to occur under “usual” practice conditions. Clinical trials and community interventions are often protocol driven resulting in resources being consumed solely for the purpose of evaluating and analysing trial data. The current study excluded resource

use associated with such activities. Judgements on which cost categories to include were made in consultation with senior management from the Victorian School Dental Service. The study focused on measuring direct costs, with the cost of “unpaid” teacher time assisting in organising the children to participate in the intervention also being included. Cost categories included in the analysis and assumptions used in their estimation are summarised in Table 4.

As mentioned previously, the study was not designed to collect economic data. Thus information from children or parents on dental treatment costs incurred by either study group was not directly collected. The cost of treatment performed necessary for both study groups was estimated by multiplying the annual incremental change in the individual components of the DMFS index by the average charge for each procedure based on 1994 average Victoria state-wide dentist fees (25). It was assumed that all students received dental care from private practice dentists. It was assumed that the treatment costs associated with increases in the decayed component of the DMFS score occurred in the year of the increment.

It was also assumed that each student in the intervention group received (and was charged for) a dental examination once every three years, and those in the control group every two years. This is considered a conservative assumption given that students in the control group incurred twice the increment in dental caries experience as the intervention group, and thus were more likely to receive and be charged for a dental examination associated with dental care. The observation that individuals with higher levels of dental disease attend the dentist at a greater frequency (and thus receive higher dental examination rates) has been shown in a recent dental sealant study (26).

### ***Form of Economic Evaluation***

The form of economic evaluation used in the small-scale study was CEA. The incremental cost effectiveness ratio - that is the additional costs and level of effectiveness in the intervention group compared to the control group - was defined as:

$$(C1 - C2) / (E1 - E2) = \Delta C / \Delta E$$

where

**C1** = Total cost associated with the DS and FMR intervention, plus cost of dental treatment in the intervention group

**C2** = Total cost associated with dental treatment in control group

**E1** = DMFS increment in intervention group

**E2** = DMFS increment in control group

For the purpose of estimating the incremental cost-effectiveness ratio, it was assumed that a cohort of 250 students entered both study groups. Year 2 and 3 costs and outcomes were discounted to their present value using an annual discount rate of 5%. It is usual practice in economic evaluations to discount future costs and benefits to reflect the social preference for the present over the future, whereby money spent or benefits gained immediately is given a higher value than those that occur some time in the future.

### ***Sensitivity Analysis***

The sensitivity of the cost-effectiveness ratio to a number of assumptions was explored.

Additional analyses included: using lower and upper boundaries of the 95 % confidence interval

for program effectiveness; using a zero and 10 % discount rate; varying the assumptions on dental check-up rates; and substituting a dental auxiliary to place the dental sealants instead of the dentist.

## **(b) Large Scale Program**

A major limitation of the small scale program was that it estimated costs and effectiveness for the duration of the 3 year intervention only. While there will be no ongoing program costs, additional benefits will accrue to individuals in years subsequent to their receiving the program due to the DS being retained for periods up to 15 years and the residual benefit of the FMR (27-29). Thus the economic benefit of the preventive program will be under-valued. In addition, the small scale program targeted schools within a non-fluoridated region with students having a known history of high levels of dental caries - levels of dental experience likely to be worse than the average adolescent of the same age in non-fluoridated areas.

The large scale program is a hypothetical extrapolation of expanding the small-scale program to all year 7 students in Geelong and Ballarat. The study estimated indicative costs and benefits over a 10 year period of a full implementation of a publicly funded DS and FMR program rather than a single cohort of students over 3 years as in the small scale program.

The combined population of Ballarat and Geelong based on the most recent 1991 Australian Bureau of Statistics' Census was almost 250,000 (30). The estimated combined growth rate for the regions is 1.3 % per annum (31, 32). Based on age population figures and estimated growth rates the study assumed that on average 3500 adolescents enter year 7 annually.

Assumptions used in the analysis were: each participant received the DS and FMR intervention for 3 years as in the small-scale program; 75 % of adolescents agree to participate in the program - as Victoria currently does not have a secondary school dental program, this figure was based on current School Dental Service participation rates in South Australian secondary schools (33); one cohort of Year 7 students participated in the first operating year of the program, these students plus a new cohort of Year 7 students participated in the second year, and in each subsequent year there was one cohort at each stage of the 3 year program (thus resulting in 3 cohorts receiving the program in any one year); costs and outcomes of the program accrue over a ten year period, under assumptions that are discussed in the effectiveness and cost analysis sections below.

### ***Program Effectiveness***

There is only limited evidence regarding the dental health status of children 12 years and older in non-fluoridated regions in Australia (34). In addition there has been no evaluation of the effectiveness of a community-wide sealant program in non-fluoridated regions of Australia. Given this lack of epidemiological data the current study provides a range of estimates of effectiveness based on the following assumptions:

(a) *Disease increment in year 1 to 3 of program.* First, the study assumed that the mean baseline DMFS and subsequent disease increment for the community-wide program in years 1 to 3 was the same as that found in the small scale program. This is considered the "upper" scale of potential program benefits. Second, given that the small scale program targeted high risk individuals and may therefore have produced a greater improvement in oral health than might be

expected in the wider Geelong and Ballarat adolescent community, the analysis also considered a more conservative estimate of program effect. This estimate, considered the “lower” scale of potential program benefits, was based on adolescents entering the program having the same baseline DMFS and DMFS increment for years 1 to 3 as the lowest quartile of baseline DMFS in the small scale program (refer Table 7 and Results section for more details).

(b) *Residual effectiveness years 4 to 10.* For both the lower and upper estimates of program effectiveness in years 1 to 3 as outlined above, it was assumed that the overall mean effectiveness rate in year 3 declined at a constant rate from years 4 to 10. A number of estimates have been provided assuming year 10 effectiveness rate (compared to Year 3) varying between zero and 60 %.

There is some justification in the literature for assumption (b) above. Weintraub in a review of available evidence on the effectiveness of pit and fissure sealants concluded that while effectiveness rate declined over time, cumulative effectiveness rates were of the order of 55 to 66 % after 7 years of sealant placement (35). Simonsen in a small scale longitudinal study found that after 10 years after a single sealant application on permanent first molars that there was a 57 % complete sealant retention and 21 % partial retention rate (27). This study also reported a savings of 4.7 surfaces per child from caries or restoration during the 10 year study period. Kobayashi et al. in a study measuring the post treatment effects of a FMR program found that at age 20 years, a 64 % difference in DMFS scores existed between the treatment and a control group despite the treatment group not having rinsed for 5 years (29).

### **Cost Analysis**

The costs associated with the large scale DS and FMR intervention were extrapolated from the small scale program taking into account an estimate of the operating and capital expenses associated with delivering the program to the 32 schools within Ballarat and Geelong. Workforce requirements and operating costs of the larger program were estimated after consultation with Dental Health Services Victoria and the South Australian School Dental Service.

The same assumptions on labourforce requirements as in the small scale program were used in the large scale program. It would be expected that there would be limited scope for achieving economies of scale in expanding the small scale program to the wider community setting. For ease of estimation, the analysis assumed that dental examination rates would be the same with or without the dental intervention, thus representing a more conservative estimate of intervention benefits than the primary analysis of the small scale program.

The study assumed that a purpose-built mobile dental van for use by the dental staff would be purchased for an expanded program. The “equivalent annual cost” of the capital costs associated with the mobile van was estimated to incorporate both the depreciation and opportunity costs of capital by annuitizing the initial capital outlay of \$80,000 over the mobile van’s useful life. The assumption was made that the useful life was 10 years and the van would have a scrap value of 20 percent after 10 years usage.

## Form of Economic Evaluation

The policy question of interest in the expanded program analysis is whether the dental prevention program would pay for itself in terms of reduced dental treatment costs. CBA was used to answer this question. Program costs were defined as the costs of operating the DS and FMR intervention, with benefits specified as the value (in terms of market prices) of reduced dental care utilisation resulting from the intervention. The study presents CBA results in two forms. First, a net economic benefit or cost (net present value) is derived by subtracting the present value of costs from intervention benefits over the ten year time frame. An investment decision is considered economically viable if the discounted benefits exceed the discounted costs, i.e. if the discounted net benefits are positive. Second, a benefit-cost ratio is derived by dividing the present value of benefits by the present value of costs over the same time period. The decision criterion here is that a program is worth funding if the discounted benefit-to-cost ratio is above unity.

### 3. Results

#### (a) Small Scale Program

A total of 931 children (431 for intervention group and 500 for control group) were invited to take part in the DS and MFR program. Of these, 256 experimental subjects and 266 control subjects agreed to participate giving a response rate of 59.4 percent and 53.2 percent for the intervention and control groups respectively. Table 1 summarises retention rates and loss to follow-up for each year of the program. The final number of students available for examination (ie. had completed three years of the study) were 207 intervention and 237 control subjects. This represented 80.9 percent and 89.1 percent of the those who commenced the trial in the intervention group and control group respectively. This did not represent a statistically significant difference in retention rates between study groups. The mean baseline DMFS did not differ significantly between the intervention (3.66 +/- 4.30) and control groups ( 3.70+/- 4.30).

**Table 1: Summary of Trial Participants and Loss to Follow-Up by Year of Trial**

Year	Intervention Group		Control Group	
	Number Available for Examination	Loss to Follow-up	Number Available for Examinations	Loss to Follow-Up
Commencement	256	-	266	-
1	228	28	248	18
2	209	19	240	8
3	207	2	237	3
<b>% Completing Trial</b>	<b>80.9</b>	<b>19.1</b>	<b>89.1</b>	<b>10.9</b>

Table 2 presents annual mean DMFS increments (gain) per student and overall 3 year increments for both study groups. Outcome data is presented first as efficacy (based on those completing the program) and second as effectiveness (based on assumptions of "intention to treat). In addition, both non-discounted and discounted forms are presented, the latter being used in the cost-effectiveness analyses. At the end of the 3 year program the mean DMFS increment in the intervention group was 0.93 (+/- 2.50) compared to 2.35 (+/- 4.05) in the control

group for those individuals who completed the 3 year program. The gain of 1.42 DMFS (or 1.33 DMFS discounted value) between the two study groups was statistically significant ( $p < 0.001$ ). Pit and fissure surfaces, and smooth surfaces accounted for increments of 1.0 and 0.42 surfaces respectively.

**Table 2: Summary of Program Efficacy and Effectiveness as Measured by DMFS Index by Year**

	Year 1	Year 2	Year 3	DMFS Increment
<b>Efficacy</b>				
Intervention	0.26 (sd 1.55)	0.31 (sd 1.63)	0.36 (sd 1.37)	0.93 (sd 2.50)
Control	0.43 (sd 1.62)	0.81 (sd 2.07)	1.11 (sd 2.64)	2.35 (sd 4.05)
DMFS gain				
Non-discounted	0.17 (NS)	0.50 (95% CI =0.14, 0.83)	0.75 (95% CI = 0.38, 1.15)	1.42 (95 % CI =0.79, 2.03)
Discounted (d=5%)	0.17	0.48	0.68	1.33
<b>Effectiveness</b>				
Intervention	0.26	0.36	0.50	1.12
Control	0.43	0.81	1.11	2.35
DMFS gain				
Non-discounted	0.17	0.45	0.61	1.23
Discounted (d=5%)	0.17	0.43	0.55	1.15

Adjusting the efficacy estimates to account for student withdrawals resulted in overall program effectiveness to be reduced to 1.22 DMFS (or 1.15 discounted value). Almost 77 % of this gain was attributable to filled surfaces (FS), with missing surfaces (MS) and decayed surfaces (DS) contributing equally to the remaining dental caries experience (refer Table 3).

**Table 3:  
Program Effectiveness by DMFS Component for 3 Years**

(A) DMFS Component	(B) Intervention	(C) Control	(D) DMFS Component Gain (Non-discounted)
DS (Decayed)	0.11	0.25	0.14
MS (Missing)	0.21	0.35	0.13
FS (Filled)	0.80	1.74	0.96
<b>Total DMFS</b>	<b>1.12</b>	<b>2.35</b>	<b>1.23</b>

Table 4 summarises the estimated cost of operating the DS and FMR program for 250 students from the 5 schools. A present value of \$24,750 was estimated for the 3 year program - equivalent to approximately \$33 per annum per child. Salaries contributed to almost 72% of total program costs with consumables and other overheads accounting for most of the remaining costs. Whilst not shown in Table 4, the weekly FMR accounted for approximately 35 % of the total costs of the intervention. This value of \$12 per child per annum for the weekly FMR program is significantly higher than US estimates due to the current study using community health workers to supervise the FMR and inclusion of the opportunity cost of teachers time in the

analysis. In contrast most US state programs use non-costed volunteer labour to supervise the mouthrinsing and most do not include teacher's time in the analysis (36,37).

**Table 4:  
Summary of Total Program Costs Over 3 Years Associated With Mouthrinsing and Fissure Sealant Program**

<b>Cost Category</b>	<b>Amount \$(1994)</b>	<b>% of Total</b>
<b>Capital equipment</b> (Dental light)	550	2.2
<b>Salaries</b>		
Dentist <sup>2</sup>	7,150	28.9
Dental nurse <sup>2</sup>	3,550	14.3
Community health Worker <sup>2</sup>	6,200	25.1
Teachers' time <sup>3</sup>	850	3.4
<b>Consumables</b>		
Rent mobile dental unit	1600	6.5
Building rent <sup>4</sup>	1200	4.8
Travel	1000	4.0
Program consumables <sup>5</sup>	1150	4.6
Office expense <sup>6</sup>	1500	6.1
<b>TOTAL</b>	<b>24,750</b>	<b>100.0</b>

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**Notes:**

1. The cost of running the annual oral hygiene instruction session was not included in the analysis, as it was common to both study groups.
  2. The dentist salary component was based on an hourly wage rate of \$30 per hour (includes 25% on-costs) with an estimate of 20 minutes dentist time per student per annum (includes travel and any administration duties). The dental nurse salary \$15 per hour. Community Health Worker wage rate including on-costs \$18 per hour, 3 hours per week for 40 weeks of school year.
  3. Teachers time valued at average wage rate with on-costs (\$20 per hour). Total cost is based on 3 hours teacher time per school per annum to organise children to participate in program.
  4. This value is imputed and an estimate of what rent would have cost to organise program. No rent was paid for use of school building for purposes of mouthrinsing program.
  5. Program consumables includes mouth rinse, sterilising solution, fissure sealants, and other disposable equipment.
  6. Office expense includes heat, light, power, stationery, telephone/fax, postage, cleaning services, and other expenses associated with program.
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**Table 5:  
Summary of Costs of Dental Treatment in Intervention and Control Groups Over 3 Years  
of Program**

Treatment Items	Intervention \$(1994)				Non-intervention \$(1994)			
	Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Total
Restorations	2900	3010	4480	<b>10,390</b>	4540	7730	1023	<b>22,500</b>
Extractions	450	860	1630	<b>2,940</b>	750	1290	2860	<b>4,900</b>
Decayed	140	1180	130	<b>1,450</b>	690	1570	1000	<b>3,260</b>
Examinations	3710	3540	3370	<b>10,620</b>	5630	5400	5060	<b>16,090</b>
<b>Total Costs</b>	<b>7200</b>	<b>8590</b>	<b>9610</b>	<b>25,400</b>	<b>11610</b>	<b>15990</b>	<b>19150</b>	<b>46,750</b>

**Notes:**

1. The cost for treatment items are \$55, \$60, \$55 and \$45 for restorations, extractions, decay (restorations required), and examinations respectively.
2. The above estimates assume that the potential cost associated with unmet needs (decayed teeth requiring restorations) accrued in the year of examination.
3. Cost estimates calculated by multiplying the DMFS component increment in each year by the average 1994 dental charge.
4. Costs are discounted at 5 % per annum
5. The above analysis assumes that 50 % of children in control group and 33 % of children in intervention group are charged for an examination each year.

The estimated cost of dental treatment in the intervention and control groups is shown in Table 5. Dental treatment costs were 84 % higher in the control group (\$46,750) compared to the intervention group (\$25,400). Tooth restorations and dental examinations accounted for the majority of costs in both study groups. The cost of restorations in the control group was over twice that of the intervention group.

Combining estimates of the operating costs of the prevention program with dental treatment costs resulted in an overall net cost of \$3,400 (or \$13.60 per child) attributable to the program over the 3 year study (refer column D, Table 6). Thus a public investment of \$33 per annum per child resulted in an approximate \$28.50 reduction per child per annum in dental treatment costs.

**Table 6:  
Total Costs, Total Benefits and Incremental Cost-effectiveness  
Ratio For Each Additional Year of Program Intervention**

(A) Year of Program	(B) Total Cost Intervention \$(1994)	(C) Total Cost Control \$(1994)	(D) Net Cost (or Savings) 1994(\$)	(E) Incremental Benefits (DMFS Avoided)	(F) Incremental Cost (or Savings) \$ (1994) per DMFS Avoided
1	15,900	11,610	4,290	43	99.80
2	16,840	15,990	940	107	8.80
3	17,410	19150	(1,740)	138	(12.60)
<b>Overall</b>	<b>50,150</b>	<b>46,750</b>	<b>3,400</b>	<b>288</b>	<b>11.80</b>

**Notes:**

1. Total cost in the intervention group per annum is the sum of the costs of the program (\$8,700 in year 1, \$8,250 in year 2 and \$7,800 in year 3) plus the annual treatment costs from table 6. The annual costs in the treatment group is the costs of treatment from Table 6.
2. Net costs is the difference between the treatment and control costs (Column B minus Column C). A bracketed number indicates a net savings
3. The incremental benefits are estimated by multiplying the annual DMFS gain between the intervention and control group (from table 3) by the 250 participants in the intervention group
4. Incremental cost-effectiveness ratio (Column F) is calculated by dividing Column D by Column E

Table 6 (Column F) summarises the incremental cost-effectiveness ratio for the intervention group both for the overall program and year of program. The overall ratio was estimated to be \$11.80 per DMFS averted over the 3 year period. The incremental cost-effectiveness ratio (additional net cost divided by additional benefits from one year to the next) becomes more favourable with time. This was due to the increasing cumulative DMFS gain between the intervention and control group over the course of the program. For example, in Year 1 of the program a relatively high cost of \$99.80 per DMFS averted was estimated. In year 2 the additional cost was \$8.80 per DMFS gain. Year 3 of the program produced a net savings of \$12.60 per DMFS prevented - that is, not only was there a significant difference between the intervention and control groups in terms of dental caries increment, but in addition the program demonstrated a net cost saving to the community. It would be expected that this net incremental savings per DMFS would occur in years subsequent to program completion due to there being no additional program costs but significant residual benefit associated with the DS and FMR intervention. Weintraub et al. in the DS study cited earlier likewise found that cost-effectiveness ratios improved over time (26).

There was a significant positive relationship between the baseline DMFS of students and subsequent dental caries increment. In addition, program effectiveness was significantly higher in students in the top quartile of baseline DMFS compared to students in both the bottom quartile of DMFS and the intervention group overall. DMFS gain (in intervention group compared to control group) was 1.88 and 0.81 for the top and bottom quartiles of baseline DMFS respectively. The cost-effectiveness ratio for the top quartile was an overall savings of \$26.60 per DMFS avoided compared to a cost of \$32.00 per DMFS avoided in the bottom quartile (refer Table 7).

**Table 7:**  
**Analysis of DMFS Gain, Total Costs and Benefits and Cost-Effectiveness Ratio by Quartile of Baseline DMFS**

Baseline DMFS Score <sup>1</sup>	Total Costs \$(1994)		Net Cost (or Savings) \$(1994)	Total Benefits DMFS Avoided)	Net Cost (or Savings) \$(1994) DMFS Avoided	Net Cost (or Savings) \$(1994) per child
	Intervention	Control				
<b>Primary Analysis</b>	50,150	46,750	3,400	288	11.80	13.60
<b>Bottom Quartile</b>	43,100	35,100	8,000	203	39.40	32.00
<b>Top Quartile</b>	85,300	91,950	6,650	460	(14.50)	(26.60)

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**Notes:**

1. ( ) refers to an overall savings.

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The sensitivity analysis (Table 8) found that the cost-effectiveness ratio was particularly sensitive to assumptions of mean effectiveness rates and frequency of dental examinations. The results showed less sensitivity to the use of zero and 10% discount rates. For example, the most favourable results were obtained when the control group received, and were charged for, twice the annual examination rate as the intervention group ( a net saving of \$7.00 per DMFS avoided over the three years) - a not unrealistic assumption given that they showed twice the dental caries increment of children who received the DS and FMR preventive program. Substituting the labour costs of a dental auxiliary rather than a dentist (and assuming the same effectiveness rates) could improve the ratio to a net cost of \$4.20 per DMFS averted over three years. This issue is discussed further in the discussion section of this paper. The least favourable result was found when it was assumed that the intervention and control group received the same rate of examination (a net cost of \$35.60 per DMFS avoided over the three years of the program).

**Table 8:** Sensitivity Analysis: Summary of Costs, Outcomes and Cost-effectiveness of Mouthrinsing and Fissure Sealant Program Under Various Assumptions<sup>1</sup>

Variation of Assumption	(A) Program Cost Intervention \$ (1994)	(B) Cost of Treatment Intervention \$ (1994)	(C) Cost of Treatment Control \$ (1994)	(D) Incremental Cost (or Saving) \$ (1994) <sup>2,3</sup>	(E) Incremental Benefits (DMFS Avoided) ( <i>d</i> = 5%)	(F) Incremental Cost (or Saving) \$ (1994) per DMFS Avoided <sup>4</sup>	(G) Incremental Cost (or Saving) \$ (1994) per Child <sup>5</sup>
Primary Analysis	24,750	25,400	46,750	3,400	288	11.80	13.60
Intention-to-treat-analysis <sup>6</sup>	24,750	22,900	46,900	750	330	2.30	3.00
Effectiveness (95% Confidence interval)							
• Lower boundary	24,750	17,050	36,100	5,770	244	23.40	22.80
• Upper boundary	24,750	35,100	57,200	2,650	300	8.80	10.60
Discount rate							
• 0 %	25,250	26,800	49,500	2,550	308	8.30	10.20
• 10 %	23,450	24,150	44,350	3,250	271	12.00	13.00
Dental Examination <sup>7</sup>							
• Same (33%/annum)	24,750	25,400	41,250	8,900	288	30.90	35.60
• Control 66%/annum, intervention 33 %	24,750	25,400	51,900	(1,750)	288	(6.10)	(7.00)

**Notes:**

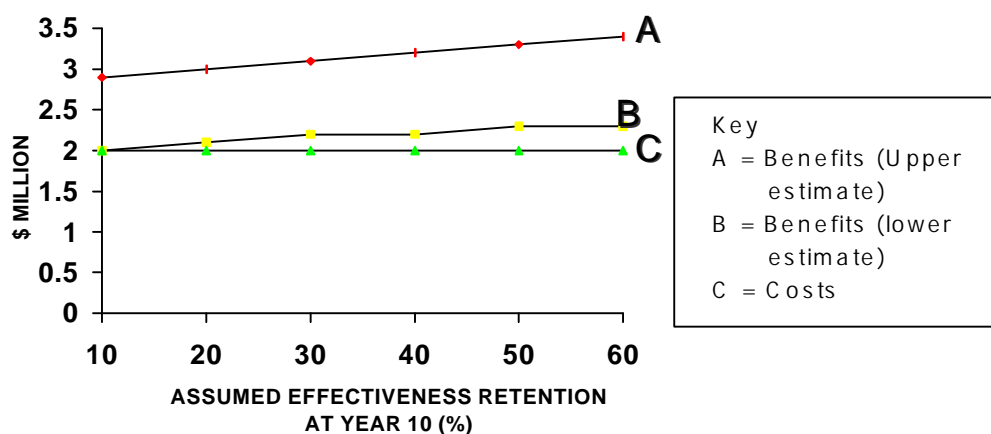
1. The sensitivity analysis performed above is a one-way analysis - one assumption is varied with all other assumptions remaining constant, as in the primary analysis.
2. Figures in brackets represent a net savings.
3. Incremental cost (or saving) in Column D is estimated by the difference between the program and treatment costs of intervention, and the treatment costs in the control group i.e. Columns (A + B) - Column C
4. Incremental cost (or saving) per DMFS avoided (Column F) is calculated by dividing Column D by Column E.
5. Incremental cost per child (Column G) is calculated by multiplying Column E by Column F and dividing by 250 (the cohort of children in the intervention group).
6. The intention-to-treat analysis provides an upper scale estimate of outcomes in students in intervention group lost to follow-up, described under sensitivity analysis in the text.
7. The primary analysis assumes that 50 % of children in the control group will be charged for a check-up each year compared to 33 % in the intervention group. The sensitivity analysis firstly assumes that the 2 groups receive the same (33%) check-up rate, then subsequently assumes that the control receive twice the check-up rate (66 %) as the intervention group.

**(b) Large Scale Program**

The estimated annual cost for operating a full scale DS and FMR program (ie. year 3 and beyond) in Geelong and Ballarat was \$272,500 (non-discounted). This figure equates to approximately \$33 per child, the same value as the small scale program. The present value of operating costs for the 10 years was estimated to be \$1.96 million.

Figure 1 summarises the program costs (line C) and monetary value of the “upper” and “lower” scale of benefit estimates at different levels of effectiveness (lines A and B respectively). The net difference between either of lines A and B, and line C depicts the net economic benefits or net present value of the DS and FMR program.

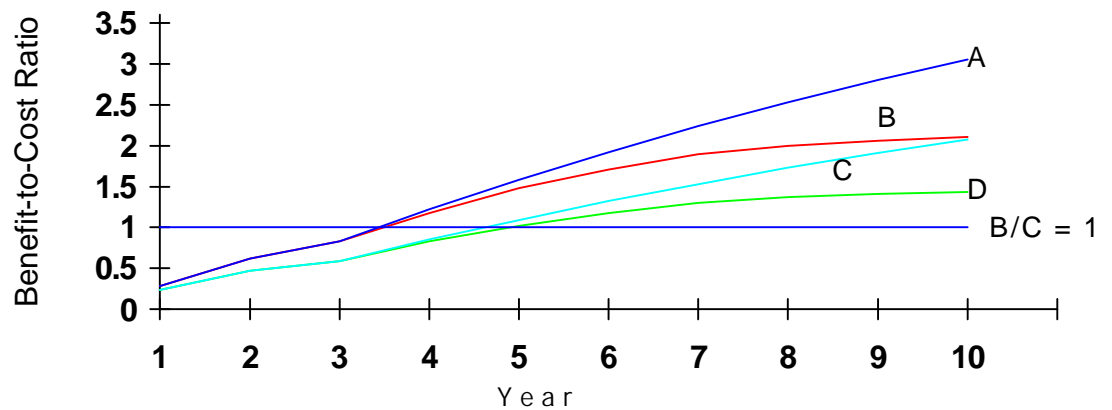
**Figure 1.**  
**Program Costs, Benefits, Net Economic Benefits, and Benefits - to Cost ratios for Large Scale Program (AUD \$1995) Under Varying Assumptions of Program Effectiveness**



The range of estimates for the economic gain (net present value) for the 10 year time frame varied from the most conservative value of \$7,000 (“lower” estimate, zero % effectiveness) to the most optimistic estimate of \$1.73 million (“upper” estimate, 60% effectiveness). These economic gains translate into benefit-to-cost ratios of approximately 1.0 and 1.7 respectively.

The incremental benefits-to-cost ratios under all assumptions improved with each successive year of the program. This is illustrated in Figure 2 for the upper and lower estimates of benefits at zero and 60% effectiveness in year 10. For example in the most conservative estimate (lower estimate, 0 % effectiveness) the benefit-to-cost ratio for year 1 is a very low 0.2. This figure increased to achieve a level of 1.4 in year 10 of the program, resulting in an overall 10 year benefit-to-cost ratio of just above 1.0.

**Figure 2.**  
**Benefit to Cost Ratio for Large Scale Intervention by Year of Program**



Key: A = Upper estimate (Year 10 effectiveness 60 %)  
 B = Upper estimate (Year 10 effectiveness 0 %)  
 C = Lower estimate (Year 10 effectiveness 60 %)  
 D = Lower estimate (year 10 effectiveness 0 %)

#### 4. Discussion

The current study estimated that the incremental cost-effectiveness ratio for the small scale 3 year intervention compared to non-intervention varied between an overall saving of \$7.00 to a net cost of \$35.60 per DMFS averted, depending upon the assumptions used in the analysis. The primary analysis estimated a cost-effectiveness ratio of \$11.80 per DMFS avoided. It is difficult to make a judgement as to whether the small scale program constitutes a rational use of scarce community resources due to the lack of Australian studies on the relative cost-effectiveness of alternative dental prevention and treatment programs. In addition, limiting the time frame of the analysis to 3 years significantly undervalues the potential economic benefits of the intervention.

Extrapolation of the small scale intervention results to the wider non-fluoridated community of Geelong and Ballarat over a 10 year time frame indicate that a benefit-to-cost ratio above unity and a positive net present value (net economic benefits) will be achieved irrespective of the assumptions used in the analysis. While these results strongly suggest that the expanded program will represent an efficient use of resources, the assumptions used in the analyses are based on imperfect data. A number of these assumptions warrant further discussion.

The effectiveness rates in the first 3 years of the large scale program was based on the results of a single prospective community intervention. There are two aspects to this point. First, the care given in a trial may not reflect the pattern of care found in the “usual” practice setting. For example, extra care may be taken with the placement and repair of DS due to the high standards of research evaluation, thus resulting in higher effectiveness rates. The design of the current study tried to minimise this problem by employing a dentist independent of the research team to place, repair and replace the DS. Second, the external validity of results would be improved by

using efficacy data based on a meta-analysis or overview of a number of similar trials, rather than relying on a single study. Such studies have not been undertaken in Australia, and few studies of similar design have been reported in the international literature. For example, overseas studies have focused on either FMR or DS (with less emphasis on combined approaches); targeted children of different ages; been performed within communities with varying levels of water fluoridation; and have been undertaken in different time periods - thus limiting the generalisability of the results. Those studies that most resemble the current study design have estimated (non-discounted) DMFS gains of between 1.22 surfaces over 2 years to 1.90 surfaces over 4 years - results of similar magnitude to the current study (38-40).

The benefit-to-cost ratio of the large scale program was also dependant upon the assumptions about the mean caries experience of the adolescents in the 2 communities under study and their subsequent oral disease increment. In the wider setting, adolescents may have lower mean baseline DMFS scores than the higher risk students targeted in the small scale program, which may in turn produce less beneficial outcomes. The current authors believe that the lower estimate of program effect for years 1 to 3 (based on the effectiveness rates of students with lowest quartile of baseline DMFS in the small scale program) would represent the most pessimistic estimate of the average benefit of the expanded program. This point is reinforced by the fact that even though there was an overall statistically significant relationship between baseline DMFS and subsequent DMFS increment in the overall study sample in small scale program, the same correlation was not statistically significant in the intervention group. The influencing factor in the overall relationship was the very significant relationship between baseline and subsequent DMFS increment in the control group compared to the intervention group.

Another area of uncertainty in extrapolating the results of the small scale program to the wider non-fluoridated community was the assumption on DS retention rate and corresponding effectiveness rates over time. The current study relied on evidence regarding retention rates and effectiveness rates found in overseas studies, discussed in the methodology section. Benefit-to-cost ratios above unity were found even with the most conservative estimate of zero percent effectiveness retention at year 10 after sealant application. The issue is complicated by the fact that oral health of children and adolescents has improved (and may continue to improve) in both fluoridated and non-fluoridated areas in most developed countries independently of any large scale interventions. If for example, levels of dental caries continue to fall in non-fluoridated areas, the potential benefit as estimated in this study may be overstated. To what extent this will continue to occur is a debatable issue, and ongoing monitoring and surveillance of changing dental patterns will become increasingly vital to policy makers in the dental health care services.

A number of assumptions relating to dental treatment costs as used in the analysis are also subject to debate. First, the result in the small scale program is highly sensitive to the assumption of dental examination rates between the control and the intervention group. The cost-effectiveness ratio changed from a net cost of \$11.80 per DMFS gained under the assumption of 50 % higher examination rates in the control group to a ratio of \$30.90 per DMFS if examination rates are the same. This issue has not been extensively examined in the literature except in the Weintraub et al study cited earlier. We believe intuitively that in practice, as a group, adolescents who received more dental treatment would have been charged for more dental examinations. This assumption was relaxed in the expanded program with the analysis based on the same check-up rates with or without the intervention. Second, the study assumed that the decay component of the DMFS index was restored in the year of the increment. There is no guarantee that the necessary dental treatment will be undertaken. The potential cost of

treating decayed teeth was estimated to be approximately 6 % of total dental treatment costs, and is thus likely to have little impact on the overall cost-effectiveness results. An alternative analysis could have been employed whereby a series of probabilities (ranging from, for example, 0.8 to 0.5) could have been attached to costs, indicating the probability of treatment being undertaken in the year of increment.

While the above discussion has focused on areas of uncertainty that may lead to the overstatement of the potential economic benefits of the prevention program, other assumptions were of a more conservative nature. For example, for the purposes of estimating program effectiveness from efficacy results from the 5 school intervention a “worst case scenario” was assumed for those students in the intervention group lost to follow-up. These same assumptions were used for years 1 to 3 of the large scale program. In addition, the longer term potential savings due to reductions in secondary caries and/or maintaining restored tooth surfaces has not been considered in the analysis. Whilst it is difficult to predict the potential savings here, secondary caries and treatment costs have been shown to contribute significantly to the total dental services expenditure in Australia (41).

On balance, weighing up the assumptions outlined above, the authors believe that implementation of the preventive program into the Geelong and Ballarat secondary school system would represent an efficient use of community resources. However, before introducing such a program, the governmental sponsoring agency will need to address a number of key issues.

First, whether to substitute a dental auxiliary in place of a dentist to provide the preventive program. This action has the potential to reduce overall costs, and there is evidence to suggest that it will do so without compromising patient quality of care (REFS). Dental auxiliaries currently provide total dental care to children attending primary schools in Victoria. Second, given that the small scale program clearly demonstrated that the higher the caries risk of students, the more favourable the cost-effectiveness ratio, consideration will need to be given as to whether the program should be introduced to all students in these non-fluoridated regions or whether they should be targeted to either individuals or schools with known high risks. A third issue that will warrant evaluation is the worth of the combined DS and FMR compared to a DS program alone. International studies have questioned the additional benefit of a FMR intervention (REFS). The results of the small scale program also raises doubts as to the worth of the combined approach. Whilst the FMR accounted for approximately 35 % of total program costs, smooth surfaces (most likely to be attributable to FMR) accounted for only 30 % of the DMFS averted.

Finally, there is a need in Australia to systematically evaluate the costs and consequences of alternative means to achieve improvements in the community's oral health in non-fluoridated areas. Programmes that need to be evaluated include water fluoridation, and existing publicly funded school-based programmes and community dental health programmes. Such evaluations must include the incremental costs and benefits of expanding the programme to different age groups and subjects at risk.

There is also a need to incorporate economic evaluation alongside future preventive dental programmes. Whilst the historical aim of dental prevention programmes has been to ascertain program efficacy, care and attention must be given to estimate the costs and benefits to all those who are offered the program (effectiveness). This requires the often resource intensive task of following up programme drop-outs. In addition it would be appropriate to prospectively collect information

regarding actual treatment costs alongside the intervention. In the current study, it would have assisted in determining, for example, whether those with poorer oral health receive, and are charged for, more frequent oral examinations. It is also important that the results of future programmes are generalisable to the wider community setting. Thus the target groups, the setting and treatment provided (eg. examinations etc.) must reflect usual practice patterns. This would ensure that protocol driven programme costs are easily separated from those that would occur in real life.

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