

A Time-and-Motion Approach to Micro-Costing of a School-Based Fluoride Mouth Rinsing Programme

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ABSTRACT

Introduction: Fluoride mouthrinsing has been established as an effective method to prevent dental caries among school children. Time-and-motion studies help to identify the efficiency of different processes and give a comprehensive cost estimate. Economic cost of utilising teachers for fluoride mouthrinsing in schools has not been explored.

Aim: To determine the economic costs of fortnightly school-based Fluoride Mouthrinsing (FMR) program using the micro-costing technique for a period of three years.

Materials and Methods: The cost analysis study (community trial) was conducted in three government primary schools among 110 school children who were six to seven years old with high caries risk as assessed by the American Academy of Paediatric Dentistry guidelines. The school teachers were trained to carry out the FMR program by the investigator. Data on costs of resources was collected by micro-costing method

using time-and-motion technique. Costs were classified as capital and recurrent costs and the total cost of the program along with unit cost were estimated.

Results: In the three years, 58 sessions of mouthrinsing were conducted with dentist being the provider for the first three sessions and the rest were provided by the teachers. The total economic cost of all inputs amounted to Indian Rupees 2,00,592.6 (US \$ 3,283.0) with 95.4% from recurrent costs and only 4.6% from capital costs. The capital costs with teachers as program providers were higher than that with the dentist as program provider whereas the recurrent costs with teachers was lower than the dentist as a program provider.

Conclusion: Since the recurrent costs that make up 95% of the total costs was lower with teachers as providers than dentists, school-based FMR program using teachers can be used to provide dental services for underserved children with unmet preventive care needs.

Keywords: Cost analysis, Preventive care, School teachers

INTRODUCTION

Dental caries is one of the most common preventable childhood disease affecting 60 to 90% of school children [1]. It can cause a substantial burden on individuals and society due to considerable medical and financial impacts as well as functional, social and psychological consequences [2,3]. The mechanisms of fluoride to control caries are well known. Even in low concentrations, topical fluorides can reduce enamel demineralisation and enhance remineralisation [4,5]. Adequate fluoride exposure from various school-based FMR programs, in particular, is considered an important low-cost strategy to prevent caries among school children [6].

Preventive dental treatment in India may not be accessible or affordable to all the sections of society. Catering the oral health needs to the deprived members in society is an ongoing challenge. Thus, school setting can be recognised as a favourable environment for the implementation of caries-preventive programs [2]. School teachers, through attendance of a short workshop or training programs, can be trained to provide FMR program in the classrooms. It could reduce the financial burden of private households and may economically benefit the society [6].

Economic evaluations have shown that FMR is both cost-effective and cost-saving [7,8]. Despite cost-effectiveness studies existing in the literature, there is a gap in understanding the comprehensive cost estimate of using teachers as program providers. In time-and-motion study, for a defined set of activities, the resources used, their quantities and the time taken in conducting the activities will be objectively recorded. While the motion study method sought to make processes more efficient by reducing the motions involved, time study method aims at reducing the process' time [9]. These two

techniques, time studies and motion studies, became integrated into a widely accepted method in scientific management referred to as Time Motion Studies (TMS) [10,11]. Until now, no study has been conducted on micro-costing using TMS on FMR programs where costs of using dentists and school teachers have been compared.

Hence, the present study attempted to estimate the economic costs of a fortnightly FMR program in the school premises and also to determine the cost of mouthrinsing per child per session. It also aimed to assess the costs involved when dentist is the program provider as compared to teachers as providers.

MATERIALS AND METHODS

The cost-analysis study was part of a community trial conducted to measure the cost-effectiveness of various caries preventive methods for a period of June 2016 to June 2019 (under publication). It was prospectively registered in Clinical Trial Registry-India of National Institute of Medical Statistics, Indian Council of Medical Research with the registration CTRI/2015/06/005946 (Registered on: 26/06/2015). The study protocol was approved by the Institutional Review Board of The Oxford Dental College, Bengaluru, bearing number 277/2013-14. Necessary permissions were obtained from the Deputy Directors of Public Instructions of both Bengaluru North zone and Bengaluru South zone and the Heads of the selected public schools. Public school children of six to seven years of age belonging to low socio-economic status and high caries risk were included in the study based on American Academy of Paediatric Dentistry (AAPD) criteria [12,13]. The sample size of 110 children was selected based on the assumption of a minimum caries reduction of 20% as clinically relevant effect and an additional 15% to compensate for the loss to follow-up. Written informed consent were obtained from the

parents. At baseline, details related to socio-demographic data, child's oral hygiene practices, child's daily exposure to sugars and the past use of dental care were collected using a validated structured interview proforma.

A detailed Standard Operating Procedure (SOP) for FMR was prepared after referring the instructions on the packed material, published literature on the procedure, guidelines from existing and currently functional school dental programs and description in textbooks of Preventive Dentistry [14,15]. After the preparation, the SOP underwent a review process, pilot tested and found to be comprehensible by the teachers. The FMR used in the study was fortnightly rinsing using 0.2% (900 ppm) neutral sodium fluoride solution which was prepared in the proportion of 2 gm of sodium fluoride powder (Qualigens, Fisher Scientific Pvt. Ltd., Mumbai, India) in 1 litre of bottled water by the class teacher [14]; 10 mL of same was dispensed into plastic cups and the child was advised to rinse for one minute once fortnightly under the supervision of the teacher. Permission to train the teachers was sought from the head of the schools. Once granted, the class teachers of second and third grades were approached to take part in the program. A total of six teachers consented to participate in the program.

A capacity-building module was prepared for training of the school teachers to carry out the FMR program in the classrooms which included handouts with SOP, demonstrations, discussion opportunity to discuss questions and concerns and hands-on activity. Training sessions lasted for 30 to 45 minutes. The evaluation of the training process was conducted using a pre and post test questionnaire and skill demonstration by the teachers. Training and retraining took place throughout the year as required. Attendance records were kept throughout the three years. Sessions were discontinued during school holidays. To evaluate the rigors of the sessions, the investigator or the research assistant visited the schools randomly and witnessed the activity. Any deviations from the protocol were discussed and clarified. These teachers carried out the mouthrinsing for the rest of the period without any exclusion.

Along with the mouth rinsing exercise, oral health education using leaflets, flipcharts, coloring sheets, etc., was delivered to the children along with the class teacher. Topics covered were mechanism of caries, good oral hygiene practices, and dietary advices. Further, the children were provided with a set of toothpaste and toothbrush once in three months to carry out oral hygiene practices at home.

Cost Analysis

The costs were calculated and assessed from the provider perspective. In the present study, the data on the costs of the resources used were collected by micro-costing method of quantitative data collection [16]. The bottom-up micro-costing studies involving the 'direct enumeration and costing out every input consumed in the treatment of a particular patient' was used [9]. While there are numerous techniques of collecting cost data in micro-costing, the present study used the method of 'direct observation and time-and-motion-technique' [16]. Time-and-motion studies prospectively collect information through direct observation of time and other resources consumed during a medical intervention. The cost analysis involved a study of the actual time and materials used to carry out the intervention using personnel daily time logs and daily consumable use records. The trained research assistant was utilised to record the start and end time for each intervention and keep a log of materials used.

In the present study, classification of costs proposed by the World Health Organisation (WHO) was applied where the two categories of costs by inputs were capital costs and recurrent costs [17]. Capital costs were those that lasted longer than a year (e.g., equipment, instruments, etc.) and recurrent costs were those that were used

up in the course of a year and were usually purchased regularly e.g., personnel, supplies, etc., Collection of data on costs involved the following steps: identification of the resource and classifying it as capital or recurrent cost; quantifying the resource; and calculating the cost of the resource by discounting for capital costs and multiplying the unit cost with the quantity used for recurrent costs. The unit cost for each type of capital resource and equipment used in the sop reflects the purchase price of the item. The unit prices for supplies reflect the local purchase prices of the items. Each purchase price was divided by the number of units contained within the purchased item to establish a per-unit cost, which was then multiplied by the units used.

For each personnel type, the hourly costs of the work were calculated by dividing the monthly salary of the personnel by their working hours. A per-minute salary rate was calculated based on a typical 8-hours workday, taking into consideration statutory holidays and vacation days. The resulting per-minute rate was multiplied by the mean hands-on time to derive a per-minute labour cost estimate. The cost of time spent by children for mouthrinsing was not included in the study. Costs also included the resources used during training and supervising classroom teachers. Total costs were calculated based on the observed use of quantities of resources in the program.

Once costs were derived for each resource category, the mean cost per child for the entire three-year program and the total cost of the program were calculated by summing the capital and recurrent costs. All costs were priced using Indian Rupee (₹) and converted to US Dollars (US\$) for the base year 2014-15 (1US\$=₹61.1). The costs were adjusted to the base year using the Consumer Price Index (CPI) and discounted to their present value using an annual discount rate of 3% [18,19].

STATISTICAL ANALYSIS

The data was analysed using SPSS (version 24) software. Mean, median and Interquartile Range (IQR) costs were presented for each type of cost.

RESULTS

The program was carried out for a period of three years with the first six months by the dentist and research assistant (both dentists) and the later two and a half years by the six trained school teachers accounting for a total of 58 sessions. A total of 110 children with a mean age of 6.66±0.2 years belonging to low socio-economic status were included in the program. The trained teachers essentially taught primary school children and had a B. Ed degree qualification. The age range of the teachers was 25-46 years with a mean age of 34.8±1.7 years.

The entire program has been divided into four phases based on the academic years running in the schools. [Table/Fig-1] gives the mean number of sessions attended by each child and the mean number of children in different phase.

During phase one of the program, though the teachers were planned to be trained to undertake the mouthrinsing, due to their busy schedule of annual examinations, the investigator had to carry out the required sessions. Hence, the costing is presented as that for the dentist and that for the teachers.

Phase	Year	Mean number of sessions attended by each child	Mean number of children in each session
1.	2015-16	2.6±0.3 out of 3 sessions	96.3±12.7
2.	2016-17	17.3±2.5 out of 20 sessions	94.9±6.4
3.	2017-18	16.8±5 out of 20 sessions	92.1±4.4
4.	2018-19	13.2±1.7 out of 15 sessions	96.8±6.5

[Table/Fig-1]: Mean number of sessions attended by each child and mean number of children in different phase.

The total economic costs of all inputs which amounted to Rs. 2,00,592.1 (US \$ 3,283.0). Recurrent costs contributed to 95.4% of all costs and capital costs contributed to only 4.6% [Table/Fig-2].

Costs	In Indian Rupee (Rs.)	Percentage contribution	
Recurrent costs			
Dental materials and supplies	9472.2	4.7	
Toothpaste and toothbrush	105783.1	52.8	
Health education material	3612.2	1.8	
Transport of dentist	1212.6	0.6	
Personnel	Dentist	27294.9	13.6
	Teacher	43999.6	21.9
Total recurrent costs	191374.6	95.4	
Capital costs			
Equipment for mouthrinsing	1437.9	0.7	
Training of teachers	3121.2	1.5	
Equipment for health education	477	0.2	
Preparation of health education materials	4181.4	2.1	
Total capital costs	9217.5	4.6	
Total costs	200592.1	100	

[Table/Fig-2]: Total economic costs of inputs.

Phase	No. of mouthrinsing sessions	Capital costs/year (in Indian Rupee)	Recurrent cost (in Indian Rupee)				
			Mean	SD	95% CI	Median	IQR
Dentist as program provider (phase 1)	3	2032.1	558.2	51.8	429.5, 686.9	544.5	100.9
Teacher as program provider (phase 2-4)	55	3072.5	223.4	282.6	147, 299.8	60.1	456.5
Total	58	2725.7	240.7	285.2	165.8, 315.8	60.3	493.7

[Table/Fig-3]: Average per child costs with dentist and teacher as program providers.

[Table/Fig-2] shows the capital and recurrent costs per child over the three-year period in which the program was conducted. Since phase one was entirely conducted by the dentist, the average costs of the program with the dentist as a provider were also calculated. The capital cost per child was Rs. 2725.7 (\$ 44.6) and the average recurrent cost was Rs. 240.7 (\$3.9) during the entire period of the program. However, when the costs were analysed according to the provider of the program, it was found that during the dentist provider phase, the capital costs were lower than the teacher provider phase. This is attributable to the costs involved in training the teachers to implement the program. On the contrary, the recurrent cost of the teacher provider phase (Rs. 223.4) was substantially lower than that of the dentist provider phase (Rs. 558.2) [Table/Fig-3]. This reflects the cost saved by substituting dentist with a teacher who bears lower personnel cost and also the cost saved by the absence of the dentists' travel to the school. Thus, the results demonstrate that in spite of initial higher capital costs using teachers as providers of FMR in schools as compared to that of dentists, the cost of running the program is lower with teachers than the dentists.

DISCUSSION

Faced with availability of numerous caries preventive measures on one hand and scarce funds on the other hand, decision-makers rely on clinical and cost-effectiveness analyses from the evidence base to frame policies [20]. Under such circumstances, the significance of methodical and pragmatic accounting cannot be overstated. To the best of our knowledge, this is the first study to analyse the per-case

cost estimate of undertaking FMR in a school setting with teachers as program providers using micro-costing technique.

While the present study estimated the total economic costs of all inputs to be \$3,283.0 for three years, another study on weekly FMR projected the costs to (in 1982 US\$) \$15,200 and \$4,000 with costs of teachers' time and without costs of teachers' time, respectively [21]. Also, higher costs were calculated by a Chilean study where the total program cost of weekly FMR for six years was US \$38,983 (in 2009) [22]. The variability in the total costs is not surprising given the variability in the frequency of intervention and cost of resources especially the teachers' time. Using a dental nurse to supervise the FMR in the school, Skold UM et al., estimated the total cost per pupil per year to be SEK 63 (2006 price level) [23]. Manau C et al., estimated the average cost per child to be US\$ 0.56/ year and total cost to be US\$1,47,000 per year for 2,60,000 Catalonian children [24].

While there exists various classification of costs in healthcare, the present study has adopted the cost categories as recommended by WHO in the training manual for programme managers [17]. The capital costs have been annualised over a conservative estimate of 'useful lifetime' of the equipment. Contrary to the present study wherein the capital costs contributed to 4.6% of total costs, Neissen LC and Douglass C, reported nil capital outlay to initiate the programme [21]. The low capital costs indicate minimal initial expenditure in terms of equipment unlike other preventive methods such as pit and fissure sealants. When the costs of the fluoridated toothpaste and toothbrush were set aside, the costs of personnel (labour) formed a major portion of the total costs (35.5%) and similar finding was reported by Doherty NGJ et al., and Morgan MV et al., [25,26]. Garcia AI found that the labour cost varied from 5% to 73% based on the type of personnel used for executing the FMR [27]. Though capital costs remained constant throughout the program, the recurrent costs exhibited a reduction over the phases. This is plausible by what in economic theory is called the 'learning effect' that is, an improvement in efficiency and the resultant decrease in unit costs as the program progresses and personnel gain experience [26]. Other behaviours of the costs that were observed in another FMR study were a tendency for some average costs to increase with the size of the target population and also a relationship between the average costs and wages and labour productivity. These aspects were not assessed in the present study.

In any long-term study (more than one year), the costs and outcomes have to be discounted to the past from the present. Discounting refers to the time value of money and the difference between the present value to the past value. The choice of discount rate affects both costs and outcomes. In a study based on a hypothetical population, all the costs were discounted at 5% [21], another study discounted at 10% [25] and 7% per annum in a Spanish study [24]. In contrast, in the present study, all the costs were discounted at 3% as per WHO recommendation [19].

Strengths of the present study are firstly, the inclusion of opportunity costs constituting the teachers' time in training and implementing the program which could be easily overlooked during cost accounting. Secondly, time-and-motion direct observation approach is, as compared with self-reported estimates, more precise but time consuming [20]. The unwarranted consequence of using this approach could be the tendency to alter the activity to be more favourable to the observer. To a large extent, this effect has been mitigated through collection of data on multiple occasions. The educational aspect of FMR and toothbrushing with fluoridated toothpaste interventions that involve the active role of children should also be accounted for. This program can be expected to create effective oral hygiene habits which the child can adhere to for the rest of his/her life.

Children from low-income families have 50% more risk of dental caries in their permanent teeth compared to children from high-income families. Also, they are nearly 50% less likely to access dental care [28]. That being said, in India, the population living below poverty line varies from 42% and 26% in rural and urban areas, respectively [29]. Further worsening the situation is the economic constraints in implementing public programs. Under prevailing conditions, saving money by using appropriate, cost-efficient personnel who can deliver FMR in a school setting is paramount. In reality, there is a significant opportunity costs avoided, in terms of substituting a higher cost input for equally effective, less costly inputs by the teachers [30]. Moreover, the impact would not be limited to any geographic locations but can be extended to rural schools as well.

Limitation(s)

The limitations that justify attention in the future studies are that the costs involved in obtaining parental consent for the children to participate were not included in the analysis; the setting of the study were Indian public schools which have dissimilar local conditions when compared to private schools, specifically, the varying wage rates of teachers between public and private school. These conditions can influence the final cost estimate.

CONCLUSION(S)

The reduction in recurrent costs when teachers are used as FMR providers has several implications for the promotion of oral health of school children. Switching to lower cost labour can be a best practice regarding capital and labour usage given a program's economic constraints.

Contribution(s)

AKM: Idea, Formulation of hypothesis, performed the study, statistical analysis, wrote the manuscript.

NF: Idea, Formulation of hypothesis, performed the study, statistical analysis, proofread the manuscript, consulted on statistical analysis.

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