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# Evaluation of silver diamine fluoride application in children and factors associated with arrested caries survival

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**Abstract.** Dental caries is one of the most prevalent infectious diseases in children in Indonesia. Therefore, a solution to overcome caries is needed. Evaluate Silver diamine fluoride (SDF) application for overcoming caries in children and determine factors related to the percentage of arrested caries after SDF application. Cohort study for evaluation and a cross-sectional study; 115 children aged 3-5 years who had active dentin caries were the subjects. Caries risk factors were measured by questionnaires filled out by subjects' parents. Active caries treated with SDF had odds ratios of 9.9 and 6.8 of being arrested after 3 and 10 months, respectively, when compared with those not treated. Conclusion: SDF is effective in arresting caries and decreasing toothaches suffered by children, thus potentially increasing children's quality of life.

## 1. Introduction

Caries is an infectious disease common among Indonesian people. According to the Health Survey conducted by the Ministry of Health in 2013, the Decayed, Missing, Filled Tooth (DMF-T) index in Indonesia was 4.6 [1]. A study conducted in Serpong, South Tangerang, indicated that 70% of children under 5 years of age had caries, with DMF-T 3.7, and 100% showed evidence of decay [2]. Thus, it could be concluded that children, especially those under 5 years old, are susceptible to dental caries.

Caries treatment in children is not easy, as it is difficult for less cooperative children to receive the proper dental treatment [3]. In light of the high level of need for dental care in society, there are several effective, efficient ways to overcome active caries in children's primary teeth. One of these, widely used in Australia, Japan, and Brazil, is Silver diamine fluoride (SDF) [4]. SDF is a material that can reduce the tooth demineralization that occurs during the formation of caries and inhibit the growth of cariogenic multispecies biofilm [5]. SDF is effective in inhibiting enamel and dentin caries, and it can be used to address deciduous dental caries among children, especially in children who are less cooperative when receiving dental treatment.

## 2. Materials and Methods

This study consisted of two research types. The first was a cohort study to evaluate the effectiveness of SDF application after 3 and 10 months. The baseline and 3-month evaluation were taken from a study of SDF secondary data on procedures that were conducted one year ago in the same place and with the



same subjects. The second was a cross-sectional study to obtain data on arrested dentin caries' status after 10 months, which was followed up with questionnaires filled out by the subjects' parents. The subject inclusion criteria were healthy children aged 3-5 years who had participated in previous research and who agreed to participate in all research activities. Each subject's mother agreed to fill out a caries risk factors questionnaire and signed a written informed consent. The exclusion criteria were subjects from the previous study who did not want to participate in the current research, those who did not want to continue as a subject, those whose mother refused to give informed consent and did not complete the caries risk factors questionnaire, and subjects who did not follow the research procedures. The independent variable in this study was an active dentin caries, the intervention variable was SDF application, and the dependent variable was arrested caries. Measurements were performed by clinical examination using disposable standard tools (mouth mirror, explorer, excavators). Arrested caries are black in color and have a hard surface. Active dentin caries were identified by clinical examination, with the explorer showing a bland surface. From this, the number of children's tooth surfaces with active dentin caries was calculated.

The first data collection was done by interviewing each subject's mother, based on a questionnaire that had been prepared. Then a clinical examination was performed with standard screening tools to obtain DMF-T scores as well as the number of active dentin caries. The results were then recorded into an odontogram. Collective toothbrushing was done by the subjects who fulfilled the inclusion criteria before the application of SDF. The follow-up evaluation was done by checking the condition of the surface of the teeth treated with SDF after 10 months. The collected data were entered into a computer and analyzed using the statistical software IBM SPSS Statistics 20 for Windows. Chi-square tests were carried out to discover any statistically significant differences between the mean percentage of arrested caries in the third- and tenth-month evaluations, and to obtain the odds ratio scores for the subjects treated with SDF compared to those not treated with SDF. Wilcoxon tests were conducted to uncover any significant differences between the baseline, third- and tenth-month evaluations in the subjects treated with SDF and those who were not. Finally, bivariate correlation tests were conducted to identify any correlation between the caries risk factors obtained from the questionnaires and the percentage of arrested caries 10 months after SDF application.

### 3. Results and Discussion

#### 3.1 Results

The research subjects consisted of 115 children divided into two groups: 81 children who were treated with SDF and 34 children who were not treated with SDF. Questionnaires were given to all 115 subject's parents, but only 88 subjects' parents returned the questionnaires (response rate = 77%). The subjects consist of 39 male subjects (44.3%) and 49 female subjects (55.7%). Table 1 shows the distribution of research subjects according to several variables, including gender, the mother's level of education, subject's ethnicity, and the father's occupation. Subjects with a college-educated mother make up the smallest percentage, consisting of 9 children (10.2%), whereas subjects whose mother had a junior high school education make up the largest percentage, consisting of 39 children (44.3%). Javanese subjects occupy the highest percentage, with 33 children (37.5%), and subjects of other ethnicities, such as Minang and Bugis, make up the smallest group, with only 4 children (4.4%). Subjects with entrepreneur fathers occupy the highest percentage, with 52 children (59.1%), followed by formal workers, such as civil servant or laborers, with 29 children (33%), and then by those whose father has another kind of job, with 7 children (8%).

The youngest mother's age was 21 years, and the oldest was 43 years, with a mean value of 30.52. Monthly household expenses were adjusted according to the number of family members aged over and below 15 years old (Mahanani, 2009). Monthly household consumption was divided by the adult equivalency scale  $eh = (Ah + \alpha Kh)\theta$ , where  $Ah$  is the number of family members over 15 years old,  $\alpha = 0.5$ ,  $Kh$  is the number of family members under 15, and  $\theta$  is the household economic scale, 0.75 (Maharani, 2009). The lowest monthly household expenses were 30.18 USD, and the highest were 150.60 USD, with a mean value of 64.15 USD  $\pm$  29.62 USD. These figures are seen in Table 2.

**Table 1.** Distribution of subjects

| Variable                    | N  | %     |
|-----------------------------|----|-------|
| Gender                      |    |       |
| Male                        | 39 | 44.3% |
| Female                      | 49 | 55.7% |
| Mother's level of education |    |       |
| Elementary school           | 12 | 13.6% |
| Junior High School          | 39 | 44.3% |
| Senior High School          | 28 | 31.8% |
| College                     | 9  | 10.2% |
| Ethnicity                   |    |       |
| Betawi                      | 30 | 34.1% |
| Javanese                    | 33 | 37.5% |
| Sunda                       | 21 | 23.9% |
| Other                       | 4  | 4.4%  |
| Father's Occupation         |    |       |
| Entrepreneur                | 52 | 59.1% |
| Formal workers              | 29 | 33.0% |
| Another job                 | 7  | 8%    |

**Table 2.** Mother's age and monthly household expenses

| Variable                   | Mean              | Min – Max        |
|----------------------------|-------------------|------------------|
| Mother's age               | 30.52 ± 4.82      | 21–43            |
| Monthly Household Expenses | 64.15 ± 29.62 USD | 30.18–150.60 USD |

As seen in Table 3, the highest mean value of subject's tooth surfaces affected by active caries at the baseline (July, 2013) occurred in female subjects, at 14.4; this meant that or 17.1% of their tooth surfaces were affected by active caries. In the male subjects, only 15.6% of surfaces were affected. Statistical analysis showed no significant difference between the mean values for active caries for female and male subjects ( $p = 0.527$ ).

**Table 3.** Mean value, by gender, of teeth, tooth surfaces, and tooth surfaces affected by active caries before application of SDF

|  | Male        | Female      |
|--|-------------|-------------|
| Mean value of teeth                                    | 18.87 (94%) | 19.10 (95%) |
| Mean value of tooth surfaces                           | 83.21 (95%) | 84.37 (96%) |
| Mean value of tooth surfaces affected by active caries | 13.0        | 14.4        |
| Percentage of tooth surfaces affected by active caries | 15.6%       | 17.1%       |

In this study, about 6,763 tooth surfaces were treated with SDF, and 2,723 tooth surfaces were not. The mean value of tooth surfaces affected by an active caries in the subjects treated with SDF is higher, at around 14.15, but this was not significantly different from the mean value of tooth surfaces affected by an active caries in the subjects not treated with SDF (Table 4). Arrested caries found at the beginning of data collection were not included in the percentage of arrested caries calculated 10 months after SDF application.

**Table 4.** Mean value of active caries surface in subjects treated and not treated with SDF

|                                      | SDF Application | No SDF Application |
|--------------------------------------|-----------------|--------------------|
| N                                    | 6,763           | 2,723              |
| Mean Value of Active Caries Surfaces | 14.15           | 12.88              |
| p-value                              | 0.581           |                    |

As shown in Table 5, statistical analyses showed a significant difference between the percentage of arrested caries surface in subjects who were treated with SDF and those who were not after 3-month and 10-month evaluations ( $p = 0.001$ ). The results of Wilcoxon tests between the tooth surfaces at baseline, 3-month, and 10-month evaluations showed that all subjects, both those treated with SDF and those not treated with SDF, had significant differences in arrested caries when compared to the baseline ( $p < 0.001$ ) at both the 3-month and the 10-month evaluation. There was no significant difference in the percentage of arrested caries between the 3-month and the 10-month evaluations in the subjects who were not treated with SDF ( $p = 0.322$ ); however, there was a significant difference in arrested caries percentage between the 3-month and the 10-month evaluations among subjects treated with SDF.

**Table 5.** Percentage of arrested caries after 3-month and 10-month evaluations

| Variable                        | 3<br>Months | 10<br>Months | p-value (Wilcoxon Test) |            |            |
|---------------------------------|-------------|--------------|-------------------------|------------|------------|
|                                 |             |              | (B vs. 3)               | (B vs. 10) | (3 vs. 10) |
| SDF Application<br>(N = 1144)   | 74.7%       | 69.7%        | 0.001                   | 0.001      | 0.002      |
| No SDF Application<br>(N = 437) | 23.0%       | 25.2%        | 0.001                   | 0.001      | 0.322      |
| p-value                         | 0.001       | 0.001        |                         |            |            |
| Odds Ratio                      | 9.9         | 6.8          |                         |            |            |

B = Baseline; 3 = 3 months evaluation; 10 = 10 months evaluation

About 50% of subjects who were not treated with SDF experienced a decreased amount of active caries surfaces after the 3-month evaluation. The highest decrease in active caries surfaces at the 3-month and 10-month evaluations were seen in the subjects treated with SDF, at about 96.2% and 97.5% decrease, respectively. For both the SDF-treated group and the control group, a Wilcoxon test showed no significant difference between the 3- and 10-month evaluations in terms of the number of subjects with active caries changes (Table 6).

**Table 6.** Active caries surface changes after 3- and 10-month evaluation per unit subject

|                        | 3 Months           |                 | 10 Months          |                 |
|------------------------|--------------------|-----------------|--------------------|-----------------|
|                        | No SDF Application | SDF Application | No SDF Application | SDF Application |
| Active Caries Decrease | 50%                | 96.2%           | 55.8%              | 97.5%           |
| Active Caries Increase | 0                  | 0               | 0                  | 0               |
| No change              | 50%                | 3.7%            | 44.5%              | 2.5%            |

B = Baseline; A = Application of SDF; T = No application of SDF

*Wilcoxon test:* B vs T1 = 0001; B vs A1 = 0.001; B vs. T2 = 0.001; B vs A2 = 0.001; A1 vs. A2 = 0.260; T1 vs T2 = 0.289

Table 7 shows the correlation coefficient of each questionnaire item. Of the 8 questionnaire items, number 8 showed a significant correlation ( $p < 0.050$ ), with p-value of 0.028, and  $r = 0.264$ , suggesting that the arrested caries percentage is related to how often children feel pain in their teeth.

**Table 7.** Correlation coefficient of arrested caries 10 months after SDF application

| No. | Question  | Value ( $r$ ) | Value ( $p$ ) |
|-----|---|---------------|---------------|
| 1   | How often does your child brush his/her teeth each day?   | 0.225         | 0.063         |
| 2   | How often do you help your child to brush his/her own teeth?  | 0.035         | 0.777         |
| 3   | How often does your child eat sweet treats (chocolate, cotton candy, snacks, candy, <i>pempek</i> , etc.)?                        | 0.111         | 0.364         |
| 4   | How often does your child drink sugar-sweetened beverages (soft drinks, juices, bottled teas, syrups, or other acidic beverages)? | -0.185        | 0.128         |
| 5   | How often do you see his/her teeth look dirty because of meal leftovers?  | -0.021        | 0.867         |
| 6   | How often does your child brush his/her own teeth two times a day?  | 0.108         | 0.375         |
| 7   | How often do you brush your child's teeth?  | -0.116        | 0.342         |
| 8   | How often does your child feel pain in his/her teeth?   | 0.264         | 0.028*        |

\* $p < 0.05$

### 3.2 Discussion

Statistical analysis showed significant differences in active dentin caries in subjects 3 and 10 months after SDF application ( $p < 0.001$ ) when compared with subjects who were not treated with SDF. At the baseline, there was no significant difference ( $p > 0.05$ ) between the mean value of active dentin caries in the subjects who were treated with SDF and those who were not; the mean value of active dentin caries in the subjects treated with SDF is 14.15 surfaces, while the mean value of active dentin caries in subjects not treated with SDF is 12.88. However, about 74.7% of active caries became arrested after 3 months, and about 69.7% after 10 months, among those treated with SDF. This is striking when compared with subjects not treated with SDF, among whom only 23% of active caries became arrested after 3 months, and about 25.2% after 10 months. There were significant differences between the subjects who were treated with SDF and those who were not, both in the 3-month and the 10-month

evaluations. These results are in line with previous studies, which showed that SDF 38% (44,800 ppm F) is effective for suspending the development of an active caries for up to 12 months [6]. Thus, it can be concluded that SDF application is effective on an active caries for up to 10 months.

Some active caries in the subjects who were not treated SDF have become arrested. This finding was also in line with a previous study in which the control group had an arrested caries mean value of about 1.6 after a 6-month examination [6]. Caries activity can be halted, and dentin demineralization can occur if the cariogenic environment changes [7]. Therefore, when the subject changes brushing pattern or eating habits regarding sweet foods, active caries can be halted. Statistical tests showed significant differences between the active caries' surface at the baseline, 3-month, and 10-month evaluations even among the subjects not treated with SDF. This may have occurred because of the examiner's low reliability values ( $Kappa = 0.4$ ), which may have caused differences in perception between the three examiners regarding the arrested dental caries on the subjects' tooth surfaces. Moreover, it may also have occurred because information and education on oral health (DHE) was given to all subjects at the baseline, which may have affected the mean values of arrested caries at the 3- and 10-month evaluations.

Wilcoxon test results showed differences in the surface change percentages in subjects' active caries surfaces between those treated with SDF and those not treated on both the 3-month and the 10-month evaluations. The percentage of active caries in the subjects not treated with SDF was only reduced by about 50% at the 3-month evaluation and by 55.8% at the 10-month evaluation, and the rest of the surfaces did not change. However, among the subjects treated with SDF, there was a 96.2% caries surface reduction at the 3-month evaluation and 97.5% reduction at the 10-month evaluation. These results indicate that the application of SDF can optimally halt the progression of an active caries.

Chi-square test results showed significant differences between the subjects who were treated with SDF and those who were not after 3 and 10 months. At the 3-month evaluation, 74.7% of subjects' tooth surfaces treated with SDF became arrested caries, while only 23% of subjects' tooth surfaces not treated with SDF became arrested caries. At the 10-month evaluation, 69.7% of subjects' tooth surface caries to which SDF was applied had become arrested caries, while only 25.2% of subjects' tooth surface caries not treated with SDF become arrested caries. Statistical tests also showed a significant decrease in the percentage of arrested caries after 3 months and 10 months ( $OR = 6.8$  to  $9.9$ ). Although SDF application is effective in halting active caries for 3 and 10 months after application, the effectiveness of SDF application decreases between 3 months and 10 months after application. This finding is in line with previous research that claimed that over time, the effectiveness of a 38% solution of SDF in stopping an active caries would be reduced [6].

The caries risk factors questionnaire reliability test showed Cronbach's alpha values below 0.7. This may have been caused by various factors. For instance, the items may have been difficult for subject's parents to understand, the subjects' parents' understanding may have been uneven regarding the questions' aims, or the subjects' parents' answer may not actually describe the environmental conditions and habits of the subjects in maintaining oral hygiene. After a few questions with the lowest Cronbach's  $\alpha$  were eliminated, there were 5 remaining questions with higher Cronbach's  $\alpha$  (0.6). These five questions ask parents to describe how often the children brush their teeth each day, how often the children consume sweet foods and beverages, how often the subject's mother helps her child to brush his/her teeth, and how often the child feels pain in his teeth.

Bivariate correlation tests between the caries risk factors questionnaire and the percentage of arrested caries showed no correlation between the percentage of arrested caries 10 months after the application of SDF and the child's tooth brushing habits, the subject's mother's habits in helping her child to brush his/her teeth, the child's consumption of sugary foods and beverages, or how often the child's teeth look dirty. Nonetheless, bivariate correlation tests did show a significant correlation between the percentage of arrested caries with how often the child felt pain in his/her teeth, at 0.028 ( $p < 0.05$ ), with the strength of correlation at 0.264. The more often a child felt pain in his/her teeth, the lower the percentage of arrested caries found on the child. This research is consistent with a

previous study that showed that SDF application was effective in overcoming toothaches caused by dentin hypersensitivity due to caries [8]. Caries are closely related to a child's ability to speak, mastication, social development, and quality of life [9]. Caries can cause pain in children that reduces their children's quality of life [10]. Chronic diseases included caries are increasing in developing countries, with the implication that quality of life related to oral health as well as general quality of life might be deteriorated. Oral health-related quality of life is measured in relation not only to know how the mouth and teeth affect physical, emotional and social well-being but also to functional activities such as eating, chewing, swallowing and speaking [11]. SDF application is effective in stopping active caries in children, thereby relieving the pain suffered by children due to caries. Therefore, SDF application can potentially improve children's quality of life. In further research, the sample size should be increased to achieve a power estimation of more than 80%, which could help prevent any false negative results. In addition, the reliability of the questionnaire greatly affects the ability to test hypotheses. Thus, any questionnaire used needs to achieve a higher Cronbach's  $\alpha$  value before it is implemented.

#### 4. Conclusion

SDF application is effective in stopping active caries, forming an arrested caries for up to 10 months after application. SDF application has high potential as a solution for children's complaints of tooth pain. This could improve children's quality of life, especially in areas where dental health care for children is still relatively unaccessible.

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