# Caries-preventive effect of fluoride toothpaste: a systematic review

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With a questionnaire addressed to general dental practitioners in Sweden, the Swedish Council on Technology Assessment in Health Care launched a project group in 1999 to systematically review and evaluate the existing literature on various caries preventive methods. The aim of this article was to report findings concerning the caries preventive effect of fluoride toothpastes in various age groups, with special emphasis on fluoride concentration and supervised versus non-supervised brushing. A systematic search in electronic databases for articles published between 1966 and April 2003 was conducted with the inclusion criteria of a randomized or controlled clinical trial, at least 2 years follow-up and caries increment in the permanent (ΔDMFS/T) or primary (Δdmfs/t) dentition as endpoint. Out of 905 articles originally identified, 54 met the inclusion criteria. These studies were assessed independently by at least two reviewers and scored A–C according to predetermined criteria for methodology and performance. The measure of effect was the prevented fraction (PF), expressed as percent. The results revealed strong evidence (level 1) (i) for the caries preventive effect of daily use of fluoride toothpaste compared to placebo in the young permanent dentition (PF 24.9%), (ii) that toothpastes with 1,500 ppm of fluoride had a superior preventive effect compared with standard dentifrices with 1,000 ppm F in the young permanent dentition (PF 9.7%), and (iii) that higher caries reductions were recorded in studies with supervised toothbrushing compared with non-supervised (PF 23.3%). However, incomplete evidence (level 4) was found regarding the effect of fluoride toothpaste in the primary dentition. In conclusion, this review reinforced the importance of daily toothbrushing with fluoridated toothpastes for preventing dental caries, although long-term studies in age groups other than children and adolescents are still lacking. □ *Dental caries; fluoride; systematic review; toothpaste*

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There is widespread understanding that fluoride is the most important anti-caries component in toothpaste. Toothpaste with fluoride was introduced in the industrialized countries during the late 1960s and is today the most common vehicle delivering fluoride to the oral cavity. The content of fluoride varies between 500 and 1,500 ppm, predominantly in the form of sodium fluoride (NaF), sodium monofluorophosphate (MFP) or combinations thereof (1). There are also toothpastes available with amino fluoride (AmF) or stannous fluoride ($SnF_2$). In addition, almost all toothpastes contain sweeteners and abrasives such as silicone dioxide or calcium carbonate as well as detergents (sodium laurylsulphate). Modern products may also contain herbal extracts, enzymes and antibacterial agents such as triclosan, and anti-calculus or bleaching additives (1). The Swedish National Board of Health and Welfare recommends the introduction of a pea-sized amount of fluoridated toothpaste from the eruption of the 1st primary molar, around 1.5–2 years of age (2). Owing to swallowing and the risk of fluorosis, the low-fluoride toothpastes (<1,000 ppm) are primarily intended for preschool children.

The caries preventive effect of fluoride-containing toothpaste has gained continuous interest over the years. In the recent evidence-based era in dentistry, a number of reviews and systematic reviews have been published (3–6) and the benefits of fluoride toothpaste in children and adolescents are well established. On the basis of a questionnaire addressed to Swedish general dentists, the Swedish Council on Technology Assessment in Health Care (SBU) launched a project group in 1999 to systematically review and evaluate the existing literature on various caries preventive methods (7). The aim of this article was to report the findings concerning the caries preventive effect of fluoride toothpastes in non-selected populations of various ages with special emphasis on fluoride concentration and supervised versus non-supervised brushing.

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Table 1. Criteria for grading of assessed studies

| Grade A<br>All criteria should be met | Grade B<br>All criteria should be met | Grade C<br>One or more of conditions below |
|---|---|---|
| Randomization by subject | Randomization by subject, school or class | No or unclear randomization |
| Diagnostic reliability described | Diagnostic reliability described | Diagnostic reliability not described |
| Baseline values described | Baseline values described | Baseline values not described |
| Attrition explained, <10% per year | Attrition explained, >10% per year | Attrition not explained or reported >10% per year |
| Blinded outcome assessment | Blinded outcome assessment | Non-blinded outcome assessment |
| Representative sample of population under study, results can be generalized | Population under study defined, results cannot fully be generalized | Population under study not defined, results cannot be generalized |
| Bias and confounders considered | Bias and confounders considered | Bias and confounders not considered |

## Methods

### *Search strategies*

Relevant literature was identified by searching the MEDLINE and Cochrane library databases (1966 to November 2001 with a later update in April 2003) using the following search terms: 'dental caries', 'fluoride toothpaste', 'fluoride dentifrice', and 'fluoride dental cream'. The search was made in cooperation with an information specialist at SBU. A total of 905 records were originally identified and filters were then used to allow only for clinical trials, resulting in 258 articles. These papers were printed out as abstracts or full-text articles when an abstract was missing. In a second step, relevant papers were selected independently by two of the authors. An article was ordered in full text if at least one of the reviewers considered the study potentially relevant according to the basic criteria for inclusion that was set up in advance: randomized controlled trials (RCT) or controlled clinical trials (CCT) of at least 2 years' duration with coronal caries increment in the permanent (ΔDMFS/T) or in the primary (Δdmfs/t) dentition as primary endpoint. Only original papers were considered and double publications, abstracts, letters, short communications and textbooks were discarded. Articles in Swedish, Danish, Norwegian, English, German, French, Italian, and Spanish were accepted. If multiple reports of the same material had been published, only the last publication based on the longest follow-up period was included. Reference lists of selected papers were hand-searched for additional studies not found in the database search. At this stage, it was decided not to include papers published prior to 1975 and the main reasons being: (i) the significant caries decline, making any generalization to the caries situation of today questionable, and (ii) to sort out old toothpaste formulas and products no longer available or in use. Thus, a total of 77 papers were selected and ordered in full text.

### *Evaluation of papers and level of evidence*

The selected papers were subjected to critical appraisal done independently by at least two members of the project group. Data were extracted using a pilot-tested form and each article was assessed with a score A–C according to predetermined criteria for methodology and performance as given in Table 1. In the event of disagreement among the examiners, the article was re-evaluated and discussed by the entire group until consensus was reached. If a selected article for some reason was found irrelevant for the research questions, the article was excluded. The assessed papers were compiled in tables and the results were calculated. The primary measure of effect was the prevented fraction (PF), calculated as the difference in mean caries increment between the treatment and control groups expressed as a percentage of the increment in the control group. Correlations were calculated with the Pearson correlation coefficient and statistically non-significant treatment effects were calculated as 'zero'. A $P$ value $<0.05$ was considered statistically significant. Based on the evaluated literature, the level of evidence was judged within the entire project group according to the protocol of the Swedish Council on Technology Assessment in Health Care (8), as described in Table 2.

## Results

Out of the 77 papers that were critically assessed, 54 were included for evaluation of evidence as presented in Tables 3 and 4 (9–62). The 23 reports that were discarded are listed in Table 5 along with the main reason for exclusion (63–85).

Table 2. Definitions for level of evidence (8)

| Evidence level | Definition |
|---|---|
| 1 Strong evidence | At least two studies assessed with level 'A' |
| 2 Moderate evidence | One study with level 'A' and at least two with level 'B' |
| 3 Limited evidence | At least two studies with level 'B' |
| 4 Inconclusive evidence | Less than two studies with level 'B' |

Regarding levels 1–3: there should be no major study disclosing contradictory results.

Table 3. Studies of unsupervised toothbrushing with fluoridated toothpaste

| First author (year) | Design | Intervention test | Intervention control | No. of subjects* | Age (years) | Drop-outs | Follow-up (years) | Effect Δ DMFS (dmfs); PF | Evidence-level¶ |
|---|---|---|---|---|---|---|---|---|---|
| Primary dentition | | | | | | | | | |
| Davies, 2002 (9) | RCT, SB | NaF440/1,450 | Placebo | 7,422 | 1 | 50% | 4–5 | 2.5/2.2/2.6; −16% | C |
| Winter, 1989 (10) | RCT, DB | MFP-NaF550 | MFP1,055 | 3,040 | 2 | 21% | 3 | 2.2/2.5; NS | B§ |
| Cahen, 1982 (11) | RCT, DB | MFP1,500/ AmF1,500 | Placebo | 2,500 | 6–8 | 20% | 3 | 13.6/9.4/18.3; −25 | C |
| Young permanent dentition—*comparison with non-fluoridated toothpaste* | | | | | | | | | |
| Heidmann, 1997 (12) | RCT, DB | MFP1,000 | Fluoride-free | 2,087 | 12 | 20% | 3 | 3.1/4.1; −24% | B |
| Buhe, 1984 (13) | RCT, DB | MFP1,500/1,000 | Placebo | 1,562 | 11–13 | 18% | 3 | 12.6/14.1/17.1; −26% | A |
| Hanachowicz, 1984 (14) | RCT, DB | MFP1,500 | Placebo | 1,318 | 10–12 | 28% | 3 | 5.3/7.2; −27% | B |
| Andlaw, 1983 (15) | RCT, DB | MFP1,000 | Fluoride-free | 1,486 | 11–13 | 11% | 3 | 5.1/6.0; −15% | A |
| Mainwaring, 1983 (16) | RCT, DB | MFP1,000 | Fluoride-free | 1,113 | 11–12 | 19% | 4 | 9.3/11.0; −15% | A |
| Cahen, 1982 (11) | RCT, DB | MFP1,500/ AmF1,500 | Placebo | 2,500 | 6–8 | 20% | 3 | 3.9/3.3/4.1; −5% | C |
| Zacherl, 1981 (17) | RCT, DB | NaF1,100 & $SnF_2$1,000 | Placebo | 3,093 | 6–14 | 43% | 3 | 3.6/4.6/6.0; −40% | C |
| Abrams, 1980 (18) | RCT, DB | $SnF_2$1,000 | Placebo | 2,210 | 5–12 | 36% | 3 | 7.2/7.9; NS | C |
| Murray, 1980 (19) | CCT, DB | MFP1,000 | Placebo | 1,431 | 11–13 | 17% | 3 | 4.2/6.4; −34% | C |
| Ennever, 1980 (20) | CCT, DB | NaF1,000 | Placebo | 1,708 | 6–13 | 37% | 2.25 | 2.4/3,6; −33% | C |
| Fogels, 1979 (21) | RCT, DB | $SnF_2$1,000 | Placebo | 2,218 | 5–13 | 39% | 3 | 6.6/8.3; −21% | C |
| Naylor, 1979 (22) | RCT, DB | MFP1,000 | Placebo | 1,183 | 11–12 | 20% | 3 | 7.7/10.0; −23% | C |
| Ringelberg, 1979 (23) | RCT, DB | $SnF_2$1,000/ AmF1,250 | Placebo | 2,056 | 11 | 39% | 2.5 | 5.1/5.1/6.3; −19% | C |
| Glass, 1978 (24) | RCT, DB | MFP1,000 | Placebo | 553 | 6–11 | 37% | 3 | 4.8/6.9; −30% | C |
| Mainwaring, 1978 (25) | RCT, DB | MFP1,000 | Placebo | 2,104 | 11–12 | 18% | 3 | 6.9/8.3; −17% | A |
| James, 1977 (26) | RCT, DB | MPF2,400 | Placebo | 964 | 11–12 | 19% | 3 | 8.2/11.8; −31% | A |
| Kinkel, 1977 (27) | RCT, DB | MPF | Control | 927 | 9–11 | 82% | 7 | 6.0/9.3; −35% | C |
| Lind, 1976 (28) | RCT, DB | MFP2,400 | Placebo | 1,407 | 7–12 | 17% | 3 | 3.7/5.4; −32% | A |
| Reed, 1975 (29) | RCT, DB | NaF1,000 | Placebo | 567 | 8–13 | 29% | 2 | 3.0/4.3; −30% | C |
| Andlaw, 1975 (30) | RCT, DB | MFP1,000 | Placebo | 846 | 11–12 | 13% | 3 | 7.1/8.8; −19% | B |
| Stookey, 1975 (31) | CCT, DB | NaF, 1000 | Placebo | 656 | 8–15 | 33% | 2.25 | 6.0/8.1; −26% | C |
| Young permanent dentition—*comparison with fluoridated toothpaste* | | | | | | | | | |
| Saporito, 2000 (32) | RCT, DB | NaF1,100 | MFP1,000 | (2,479) | 6–14 | ? | 2 | 3.6/3.6; NS | B |
| Glass, 1997 (33) | RCT, DB | NaF-MFP1,000 | MFP1,000 | 1,913 | 10–12 | 7% | 3 | 4.9/5.4; NS | A |
| O'Mullane, 1997 (34) | RCT, DB | NaF1,500 | NaF1,000 | 4,196 | 11–12 | 28% | 3 | 3.9/4.2; −6% | A |
| Stephen, 1994 (35) | RCT, DB | NaF1,000/1,500 | MFP1,000/1,500 | 4,294 | 11–12 | 18% | 3 | 6.6/7.0; −6% | A |
| DePaola, 1993 (36) | RCT, DB | MFP1,000 | NaF1,100 | 3,063 | 10 | 28% | 3 | 1.5/1.5; NS | A |
| Marks, 1992 (37) | RCT, DB | MFP2,500/2,000/ 1,500 | MFP1,000 | 6,425 | 7–11 | 31% | 3 | 3.8/4.1/4.2/4.2; NS | B |
| Petersson, 1991 (38) | CCT, DB | NaF250 | MFP1100 | 322 | 12–13 | 12% | 3 | 6.5/6.0; NS | C |
| Koch, 1990 (39) | RCT, DB | NaF250/1,000 | MFP1,100 | 1,161 | 11–12 | 11% | 3 | 12.7/10.1/10.9; 14% | A |
| Ripa, 1990 (40) | RCT, DB | NaF1,100 ± AC | MFP1,000 ± AC | 2,021 | 7–12 | 29% | 3 | 1.8/2.1/2.0/1.9; NS | B |
| Beiswanger, 1989 (41) | RCT, DB | NaF1,100 | MFP1,100 | 3,290 | 6–16 | 31% | 3 | 2.8/3.0; NS | B |
| Blinkhorn, 1988 (42) | RCT, DB | NaF/MFP1,450 | MFP-NaF1,450 | 2,680 | 11–12 | 17% | 3 | 4.7/4.8/4.5; NS | B |
| Ripa, 1988 (43) | RCT, DB | NaF-MFP1,000, 2,500 | MFP1,000 | 3,785 | 10–14 | 34% | 3 | 3.6/3.7/3.7; NS | C |
| Stephen, 1988 (44) | RCT, DB | MFP2,500/1,500 | MFP1,000 | 3,003 | 11–14 | 13% | 3 | 5.6/6.4/6.8; −6% | A |
| Lu, 1987 (45) | RCT, DB | NaF2,800 | NaF1,100 | 4,494 | 7–15 | 46% | 3 | 3.9/4.4; −11% | C |
| Mitropoulis, 1984 (46) | RCT, DB | MFP250 | MFP1,000 | 818 | 12–13 | 11% | 2.5 | 4.3/3.6; 16% | B |
| Koch, 1982 (47) | RCT, DB | NaF250 | NaF1,000 | 288 | 12 | 6% | 3 | 7.5/7.2; NS | B |
| Beiswanger, 1981 (48) | RCT, DB | NaF1,100 | $SnF_2$1,000 | 1,824 | 6–14 | 34% | 3 | 3.7/4.5; −18% | C |

PF = prevented fraction; RCT = randomized controlled trial; CCT = controlled clinical trial; DB = double blind; SB = single blind; NaF = sodium fluoride (ppm F); MFP = sodium monofluorophosphate (ppm F); $SnF_2$ = stannous fluoride (ppm F); AmF = amino fluoride (ppm F); TMP = sodium trimetaphosphate; AC = anticalculus agent; NS = No statistically significant difference.

¶ Evidence level A–C: see grading in Table 1 for details.

* Total number of randomized participants.

§ Rated as grade B in spite of missing baseline examination due to the low age of the participants.

Table 4. Studies of supervised toothbrushing with fluoridated toothpaste

| First author (year) | Design | Intervention test | Intervention control | No. of subjects* | Age (years) | Drop-outs | Follow-up (years) | Effect Δ DMFS (dmfs); PF | Evidence-level¶ |
|---|---|---|---|---|---|---|---|---|---|
| Primary dentition | | | | | | | | | |
| You, 2002 (49) | RCT, SB | NaF1,100 | Placebo | 1,334 | 3 | 31% | 2 | −21% | C |
| Schwarz, 1998 (50) | CCT | MFP1,000 | No intervention | 289 | 3 | 13% | 3 | 3.6/6.3; −43% | C |
| Young permanent dentition | | | | | | | | | |
| *Comparison with non-fluoridated toothpaste or no intervention* | | | | | | | | | |
| Curnow, 2002 (51) | RCT, SB | MFP1,000 | No intervention | 534, at risk | 5 | 14% | 2 | 0.2/0.5; −60% | B |
| Rule, 1984 (52) | RCT, DB | MFP1,000 | Placebo | 1,154 | 9–12 | 24% | 2 | 4.6/6.5; −29% | B |
| Glass, 1983 (53) | RCT, DB | MFP1,000 | Placebo | 1,017 | 7–11 | 16% | 2.5 | 2.5/3.1; −19% | B |
| Peterson, 1979 (54) | RCT, DB | MFP1,000 | Placebo | 950 | 8–12 | 25% | 2.5 | 2.5/3.2; −22% | B |
| Howat, 1978 (55) | RCT, DB | MFP1,000 | Placebo | 560 | 11–12 | 12% | 3 | 5.7/7.7; −26% | A |
| *Comparison with other fluoridated toothpaste* | | | | | | | | | |
| Chesters, 2002 (56) | RCT, DB | MFP2,500 | MFP1,000 | 2,387 | 11–14 | 16% | 2 | 5.0/5.5; −9% | A |
| Marks, 1994 (57) | RCT, DB | MFP2,500, 2,000, 1,500 | MFP1,000 | 8,027 | 6–14 | 32% | 3 | 3.5/4.0/4.3/4.3; NS | B |
| Moorhead, 1991 (58) | RCT, DB | MFP1,500 | MFP1,000 | 2,415 | 7–13 | 6% | 3 | 1.6/2.0; −20% | A |
| Fogels, 1988 (59) | RCT, DB | MFP1,500 | MFP1,000 | 2,469 | 9 | 21% | 3 | 2.0/2.4; −17% | A |
| Conti, 1988 (60) | RCT, DB | MFP1,500 | MFP1,000 | 3,957 | 7–14 | 39% | 3 | 1.9/2.4; −21% | C |
| Triol, 1987 (61) | RCT, DB | MFP-NaF1,000 | MFP1,000 | 1,288 | 9 | 20% | 2.5 | 11.2/11.3; NS | B |
| Hodge, 1980 (62) | RCT, DB | MFP-NaF1,100 | MFP1,000 | 979 | 11–12 | 19% | 3 | 6.1/7.3; −16% | B |

PF = prevented fraction; RCT = randomized controlled trial; CCT = controlled clinical trial; DB = double blind; SB = single blind; NaF = sodium fluoride (ppm F); MFP = sodium monofluorophosphate (ppm F); NS = No statistically significant difference.
*Total number of randomized participants.
¶ Evidence level A–C: see grading in Table 1 for details.

### *Effect compared with placebo*

For calculations of the overall effect, only studies with fluoridated toothpaste and a placebo or other fluoride-free toothpastes in parallel arms were accounted for. The anti-caries effect of fluoride toothpaste in young permanent teeth was compared with placebo in 26 papers (11–31, 51–55; Tables 3 and 4) with an average prevented fraction of 24.9% ($s$ (standard deviation) $\pm$ 11.5%). The mean number of saved DMFS/year was 0.58 ($s \pm 0.34$). The number of saved tooth surfaces per year exhibited a statistically significant positive correlation with the baseline caries levels ($r = 0.542$, $P < 0.01$). Seven of the included papers were assessed with score 'A'. There was thus strong evidence of a caries preventive effect of daily use of fluoride toothpaste compared to placebo in the young permanent dentition (evidence level 1).

### *Effect in the primary dentition*

Five studies concerning the caries preventive effect of fluoridated toothpaste in primary teeth were included in the evaluation (Tables 3 and 4). Three studies were RCTs with unsupervised brushing (9–11) while two investigated supervised brushing in preschool children (49, 50). In the study by Cahen et al. (11), the effect of two high-fluoride compositions (MFP 1,500 ppm and AmF 1,500 ppm, respectively) was compared with a placebo in 2,500 young schoolchildren (6–8 years) during 3 years. The results disclosed a significant caries reduction from the fluoride toothpastes and the effect was better in the primary teeth than in the permanent dentition. The AmF-containing toothpaste displayed a relative risk reduction of 49% in the primary dentition, while the corresponding value for the MFP formulation was 25% (11). Winter and co-workers compared low-fluoride toothpaste (550 ppm MFP/NaF) with a control containing 1,050 ppm (NaF) in 3,040 2-year-olds during 3 years (10). The children who used the low-fluoride dentifrice developed slightly more cavities than those that used the control product, but the difference was not statistically significant. A follow-up study was performed when the children were 9 years of age (86). The difference between the groups was by then accentuated and reached significant levels in favor for the control toothpaste. Three recent contributions were single blind studies in which the use of fluoridated toothpastes was compared with placebo or no intervention in preschoolers (9, 49, 50). Rated with 'C', the results were clearly in favor of the fluoride dentifrice in two of the three investigations. The findings from the available papers were suggestive and pointed in the same direction but only one was ranked with a 'B'. Thus, the evidence for caries prevention by fluoride toothpaste in the primary dentition was rated as inconclusive (evidence level 4).

Table 5. Excluded studies

| Main reason for exclusion | Reference no. |
|---|---|
| Effect of fluoride in toothpaste cannot be separated | 70, 74, 77, 84 |
| Endpoint not applicable | 81–82 |
| Fluoride delivery system evaluated | 66, 68 |
| Later result available | 83 (data in 43) |
| Short duration | 63–64, 72–73, 75–76, 80 |
| Severe confounder after 1 year | 65 |
| Toothbrushing frequency or technique | 67 (data in 35), 85 |
| Triclosan intervention | 69, 71, 78–79 |

*Effect of supervised versus non-supervised toothbrushing*

Non-supervised study settings ($n = 40$, Table 3) were more common than supervised ($n = 14$, Table 4) settings among the included papers. In non-supervised studies, toothpaste was regularly delivered to the participant's home with instructions for its use. In studies with supervised toothbrushing, this was normally performed in schools and supervised by teachers, thus limited to schooldays and semesters. Additionally, however, the assigned toothpaste was provided for domestic use *ad libitum* in most investigations. Unfortunately, no direct 'head-to-head' comparison with equal toothpaste formulations was identified. The results from the papers with supervised and non-supervised brushing with fluoridated toothpaste versus other dentifrices were therefore compiled in Table 6. Interventions dealing with supervised brushing displayed a higher preventive fraction than those with unsupervised interventions, both when compared to placebo (31.0 vs 23.3%) and other fluoride-containing controls (12.0% vs 3.9%). Four of the evaluated papers were assessed with grade 'A' and therefore we found strong evidence (evidence level 1) for the fact that supervised toothbrushing with fluoride-containing toothpaste had a superior caries preventive effect over non-supervised.

*Influence of fluoride concentration*

Two questions were in focus regarding the possible dose–response relationship of fluoride in toothpaste. The first was whether or not toothpastes with a low fluoride content (<1,000 ppm) were as effective as standard dentifrices with 1,000–1,100 ppm and, secondly, whether those with higher fluoride were more effective. Four studies were considered for evaluation of the low-fluoride issue in the young permanent dentition (38, 39, 46, 47). Two C-rated papers displayed no significant differences between low-fluoride and standard products, while two studies, scored 'A' and 'B', were in favor of the standard fluoride toothpastes. There was therefore limited evidence (level 3) for an anti-caries difference between low-fluoride and standard fluoride toothpastes in the young permanent dentition.

The evaluation of toothpastes with higher fluoride content was limited to comparisons between standard products and those containing 1,500 ppm, since this is at present the highest concentration allowed in the European Union. Nine papers were included in the evaluation; five of them reported non-supervised trials (13, 34, 35, 37, 44) and four supervised study designs (57–60). In seven of the papers, the results displayed a significantly higher caries reduction after the daily use of toothpaste with 1,500 ppm fluoride compared to standard formulations with a mean difference in prevented fraction of 9.7% (range 0–22%). Six of the studies were rated grade 'A', and consequently we found strong evidence that toothpastes with 1,500 ppm of fluoride had a superior preventive effect compared with standard dentifrices with 1,000 ppm F in the young permanent dentition when used daily (evidence level 1).

*Efficacy on adults and the elderly*

All adult studies identified in the electronic search were carried out in selected materials or dealt with additional active ingredients other than fluoride. Furthermore, they were of shorter duration than 2 years. Thus, no papers concerning the effect of fluoridated toothpaste on adults and the elderly met the inclusion criteria and therefore no further evaluation could be made.

Table 6. Prevented fraction (mean and range) in permanent dentition and number of saved tooth surfaces expressed as DMFS/year

| Brushing | Fluoride toothpaste vs. non-fluoride toothpaste | Fluoride toothpaste vs. another fluoride toothpaste |
|---|---|---|
| Supervised brushing | | |
| No. of studies | 5 | 7 |
| Prevented fraction | 31.0% (19–60%) | 12.0% (0–21%) |
| Saved surfaces/year | 0.46 (0.15–0.95) | 0.15 (0–0.40) |
| Unsupervised brushing | | |
| No. of studies | 21 | 17 |
| Prevented fraction | 23.3% (0–40%) | 3.9% (0–18%) |
| Saved surfaces/year | 0.61 (0–1.5) | 0.10 (0–0.6) |

## Discussion

The systematic search for literature, data extraction and quality assessment of included papers are now well-established measures in evidence-based medicine. However, the methods for the process differ slightly between various Health Technology Assessment organizations. The methodology used in the present paper was adopted from the guidelines of the Swedish Council on Technology Assessment in Health Care. The primary object of this systematic review was to examine the caries preventive effect of fluoride toothpastes in non-selected populations of various age groups. Therefore studies in selected groups of compromised or disabled patients were not included, nor investigations in which fluoride toothpaste was part of a comprehensive preventive program. Furthermore, no attempts were made to evaluate possible differences between different fluoride formulations. With these limitations, the literature focused almost exclusively on schoolchildren with young permanent teeth. The small number of investigations concerning daily use of fluoride toothpaste in preschool children was a concern and the lack of studies regarding coronal caries in adults and elderly was striking. Although it was noted that almost all reviewed papers were carried out with a proper design and evaluation according to the ADA recommendations for clinical trials (87), many studies suffered from a significant

drop in the number of participants, which impaired the score and flawed the level of evidence.

The results of the present evaluation were in good agreement with previous meta-analysis and systematic reviews (5, 6, 88). For example, the mean prevented fraction presented here concerning fluoride versus non-fluoride toothpaste studies (25%) corresponded well with the 24% given by the recent Cochrane review (5), in spite of the fact that we discarded all articles published before 1975. Our findings were also congruent with the general beliefs of the scientific community (89). We found strong evidence that daily use of fluoride toothpaste had a significant caries-reducing effect in young permanent teeth compared with placebo. Moreover, strong evidence suggested the existence of a dose–response relationship, with enhanced caries protection with increasing fluoride content in the toothpaste. Also this was in agreement with previous reports (5, 6, 90). It should be noted, however, that although the meta-analysis of Bartizek and co-workers (90) disclosed some directional advances of 1,700 ppm dentifrices over toothpastes with 1,000 ppm fluoride, no statistically significant difference was reached. A greater caries reduction was seen in studies with supervised brushing in school or preschool settings compared to unsupervised 'ad lib' brushing at home (evidence level 1). The reason for this was probably the increased brushing frequency and compliance with the protocol, which emphasizes the importance of regular administration of fluoride ions to the oral cavity. Another clear finding was the positive relationship between initial caries levels and saved tooth surfaces, indicating that most dental health is gained in high-caries populations. However, this should not be mixed up with the preventive strategy of selecting high-risk individuals within populations. Caries-active individuals or subjects at risk are likely to display disparate caries etiologic factors and should thus be candidates for a targeted and comprehensive caries-preventive approach.

In the light of the present evidence, it appears appropriate to reflect over whether or not fluoride toothpaste is optimally utilized. Self-reported data from Sweden and Europe suggest that fluoride toothpaste is used almost by the entire population (91–93) but that does not necessarily mean that it is used two times a day or even once daily. Moreover, toothbrushing behavior may vary by socio-economic status and education level as well as life-style factors and self-esteem (94, 95). As an example, a recent study from Finland has indicated that up to 20–30% of the adolescents brush their teeth more seldom than daily (96). Taken together with clinical experience, it could therefore be anticipated that brushing with fluoride toothpaste is under-utilized as a preventive measure, both at community and individual level. Therefore toothbrushing with fluoride toothpaste needs continuous promotion and reinforcement in all age groups.

In conclusion, we found strong evidence that daily use of fluoride toothpaste had a significant caries-reducing effect in young permanent teeth compared with placebo (evidence-level 1). Supervised toothbrushing was more effective than non-supervised brushing (evidence level 1). Moreover, strong evidence suggested a dose–response relationship with enhanced caries protection from toothpastes with 1,500 ppm of fluoride compared with formulations with 1,000 ppm in young permanent teeth following daily use (evidence level 1). Further studies have to be carried out concerning preschool children, the elderly and selected groups of patients with special needs.

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