# The 'Significant Caries Index' (SiC): a Critical Approach

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**Purpose:** This study was designed to validate the SiC index in a 12-year-old population, and also considers the level of the disease, expressed as DMFS index, with the aim of comparing the capability of the two indices for preventive and prognostic goals.

**Materials and Methods:** Data from a previous study (Campus et al, 2001) based on 403 12-year-old subjects (205 females and 198 males) were reconsidered, and the SiC was calculated both on DMFT and DMFS. Several background factors were evaluated: classified as socio-economic levels (SOCFAM), Oral Hygiene Habits (OHH), Onset of Toothbrushing Habits (OTH), and gingival conditions expressed as the presence of plaque or calculus. Several regression models were built-up to estimate the dependence of each index – DMFT, DMFT (SiC), DMFS and DMFS (SiC) – on background variables. The four groups, picked out by the 66$^{th}$ percentiles on the ranking series of DMFT and DMFS following the SiC method were compared.

**Results:** Mean ± standard deviation, median and percentiles ($p_{25}$ – $p_{75}$) were 5.5 ± 2.1, 5 ($p_{25}$ = 4 – $p_{75}$ = 6) for DMFT (SiC) and 8.9 ± 5.8, 8 ($p_{25}$ = 5 – $p_{75}$ = 11) for DMFS (SiC). Intrinsic variability in SiC groups was lower, but the distributions remained skewed. In the multiple regression procedure, using DMFT and DMFS scores as dependent variables, OTH, bleeding and calculus were statistically significant. OHH ($p < 0.05$) and calculus ($p < 0.05$) gave a significant contribution to DMFS in the SIC group, while the model for DMFT (SiC) was not significant. In a stepwise logistic regression model, OTH, bleeding and calculus played a significant role ($p < 0.05$) on DMFT (SiC) and DMFS (SiC), as the likelihood for an individual to have a value ≥ 66$^{th}$ percentile. The concordance between the two selected series was rather good (kappa = 0.82; 95%CI: 0.73 – 0.91). No association with background factors was found on the two discordant groups. However, a linear trend in proportions between the two groups across SOCFAM categories was observed (p = 0.027).

**Conclusions:** The use of SiC may solve the problem related to skewed caries distribution. Nevertheless if only SiC is used, it can lead to a lack of relevant information especially in countries where high caries prevalence is still present.

**Key words:** dental caries, epidemiology, SiC index, Italy

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Although the majority of European children shows remarkably good oral health, a significant proportion of low-income, minority, medically and developmentally compromised, and socially vulnerable children continue to suffer significant and consequential dental and oral disease. The majority of these socio-economic problems are preventable through early and individualized preventive care. In Italy a decline of caries experience was described, but data available in journals are based

**Table 1 Background variables**

| | |
|---|---|
| SOCFAM (Family Socio economic status)*: | |
| | Medium-low level |
| | Medium level |
| | Medium-high level |
| OHH (Oral Hygiene Habits): | |
| | Never + Once a day |
| | Twice a day |
| | More than twice a day |
| OTH (Onset of Toothbrushing Habits): | |
| | Before 1 year-old |
| | 1-2 years old |
| | 3-4 years old |
| | 5 or more years old |
| CPITN (Community Periodontal Index of Treatment Needs): | |
| | 0 = healthy |
| | 1 = presence of bleeding |
| | 2 = presence of calculus |

* Both father and mother jobs were coded following ISTAT indications (ISTAT, 1991), graded by number on ascending scale from 0 (unemployment status) to 9 highest social class occupation. SOCFAM: 0-6 medium low, 7-10 medium, >10 medium high.

only on local surveys (Ferro et al, 1991; Angelillo et al, 1999). In Sardinia, caries experience is still high, both in the deciduous, 34.8% at 3–5 years old, 66.6% at 6 years old (Campus et al, 2000; Castiglia et al, 2002) and in the permanent dentition, 61.6% at 12 years old (Campus et al, 2001).

The caries decline and the growing problem of the social cost of dental care can suggest the hypothesis for identifying high-risk groups (Stamm et al, 1988; Batchelor and Sheiham, 2002). Nevertheless, the risk approach, through screening of susceptible individuals contributed to the affirmation that prevention could be directed at those who would benefit most (Sheiham and Joffe, 1992).

Based on these features, a new index called the 'Significant Caries Index' (SiC) was recently proposed by the World Health Organization (WHO) to draw attention to those individuals with the highest caries scores in each population (Bratthall, 2000). The SiC index leads to significant gains for society and for the persons concerned as more specific targeted preventive actions can be implemented. The SiC is the mean DMFT of one third of the study group with the highest caries score. If caries experience is indeed expressed as mean DMFT/S values, using the SiC index, it cannot correctly reflect the skewed distribution, leaving high caries groups undiscovered in the general population.

The purpose of this study was to validate the SiC index in a 12-year-old population. We also considered the level of the disease, expressed as DMFS index, to compare the ability of the two indices to classify subjects for preventive and prognostic goals. Moreover, the roles played on SiC by background factors (socio-economic levels, Oral Hygiene Habits, Onset of Toothbrushing Habits and gingival conditions) were evaluated.

## MATERIALS AND METHODS

### *Data Collection*

Data from a previous study (Campus et al, 2001) based on 403 12-year-old subjects (205 females and 198 males) were reconsidered. The background factors, investigated using an *ad hoc* questionnaire, were classified: socio-economic levels (SOCFAM), Oral Hygiene Habits (OHH), Onset of Tooth brushing Habits (OTH), gingival conditions (plaque or calculus) expressed as CPITN index (Table 1). In the previous paper caries experience was coded as DMFT > 0. In bivariate analysis OHH, OTH, CPITN, SOCFAM were significantly associated with caries experience ($p < 0.05$), while in multivariate logistic regression, using caries experience as dependent variable, only CPITN was significant ($p < 0.05$). Gender acted as an effect modifier on CPITN, so logical regressions by gender showed that CPTIN and OTH were associated with caries experience in males and in females, respectively.

### *Data Analysis*

Following WHO indications, the third with the highest caries value (DMFT) was selected and the SiC was calculated based on this group (Bratthall, 2000). The same calculation was made for the DMFS index.

Based on the data from the previous study, descriptive analysis was re-performed. *Student's t* test between genders in groups was calculated, at 0.05 significant level. To avoid the attenuating effect of unequal variability among groups on the value of *t*, a square root transformation was per-

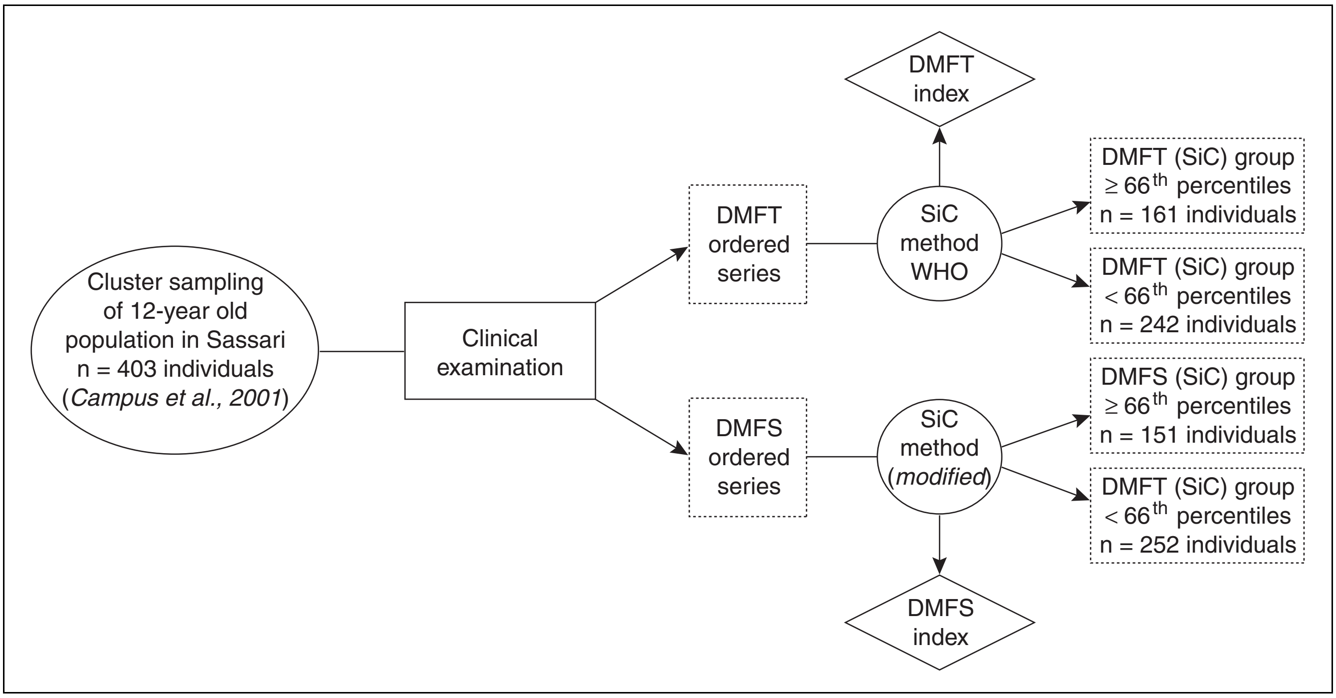


**Fig 1** Flow chart of subjects considered in this study.

formed when the response variable was a count (Fleiss, 1986). Four groups were picked out by the 66th percentiles on the ranking series of DMFT and DMFS following the SiC method, as described in the flow chart (Fig 1). With the aim to assess the possible associations between background factors, all the individuals scheduled by the threshold value, namely with DMFT or DMFS ≥ 66th percentile, were considered in statistical analysis. Several regression models were built up to estimate the dependence of each index – DMFT, DMFT (SiC), DMFS and DMFS (SiC) – on background variables. In particular, four multiple linear regression models were run using each index as dependent variable. Moreover, two *dummy* variables were generated: DMFT (SiC) positive = 1 and negative = 0, DMFS (SiC) positive = 1 and negative = 0, and stepwise logistic regression procedures were run using each *dummy* variable as dependent.

The concordance between the four groups picked out by the 66th percentiles on the ranking series of DMFT and DMFS was measured by Cohen's kappa (Armitage and Berry, 1995). The association with background factors on the two groups of discordant subjects was evaluated with $\chi^2$ test. Fisher's exact test was used when an expected cell value was lower than 5. Regarding SOCFAM, odds ratios (ORs) were calculated considering as a reference group the most favorable exposure level, namely medium-high socio-economic status. 95% Confidence Intervals (CI) on ORs were calculated according to the Woolf method (Woolf, 1955). Linear trends in proportion were tested using $\chi^2$ test for trend (Mantel, 1963). Statistical analysis was performed using SPSS 10.1 and Stata 7.0, for Windows.

## RESULTS

Following the SiC method the mean DMFT and DMFS were calculated on the third (134 subjects) with the highest caries score. The cut-off points were DMFT = 3 and DMFS = 4. Descriptive statistics are displayed in Table 2. Mean ± standard deviation, medians and percentiles ($p_{25} – p_{75}$) were 5.5 ± 2.1, 5 ($p_{25} = 4 – p_{75} = 6$) for DMFT (SiC) and 8.9 ± 5.8, 8 ($p_{25} = 5 – p_{75} = 11$) for DMFS (SiC). No differences about means were observed between genders. In the SiC groups the intrinsic variability, expressed as coefficient of variation, was lower, but the distribution remained skewed.

Considering the SiC cut-off points 161 subjects with DMFT ≥ 3 and 151 subjects with a DMFS ≥ 4

**Table 2 Descriptive statistics of DMF (T and S) and relative SiC indice**

| Indices | | Individuals | Mean ± SD | Coefficient of Variation. % | Skewness | Lowest | Largest | Percentiles 25 | 50 | 75 |
|---|---|---|---|---|---|---|---|---|---|---|
| DMFT Total | | 403 | 2.4 ± 2.7 | 112.5 | 1.3 | 0 | 15 | 0 | 2 | 4 |
| | Males | 198 | 2.4 ± 2.5 | 104.2 | 1.3 | 0 | 15 | 0 | 2 | 4 |
| | Females | 205 | 2.3 ± 2.8 | 121.7 | 1.3 | 0 | 15 | 0 | 2 | 4 |
| | p-value | | p > 0.05 | | | | | | | |
| DMFT (SiC) Total | | 134 | 5.5 ± 2.1 | 38.2 | 1.8 | 3 | 15 | 4 | 5 | 6 |
| | Males | 65 | 5.3 ± 2.1 | 39.6 | 2.0 | 3 | 15 | 4 | 5 | 6 |
| | Females | 69 | 5.6 ± 2.2 | 39.3 | 1.6 | 3 | 15 | 4 | 5 | 6 |
| | p-value | | p > 0.05 | | | | | | | |
| DMFS Total | | 403 | 3.6 ± 5.1 | 141.7 | 2.9 | 0 | 46 | 0 | 2 | 5 |
| | Males | 198 | 3.5 ± 5.4 | 154.3 | 3.7 | 0 | 46 | 0 | 2 | 5 |
| | Females | 205 | 3.7 ± 4.8 | 129.7 | 1.8 | 0 | 28 | 0 | 2 | 5 |
| | p-value | | p > 0.05 | | | | | | | |
| DMFS (SiC) Total | | 134 | 8.9 ± 5.8 | 65.2 | 2.9 | 4 | 46 | 5 | 8 | 11 |
| | Males | 65 | 8.7 ± 6.8 | 78.2 | 3.3 | 4 | 46 | 5 | 7 | 10 |
| | Females | 69 | 9.2 ± 4.6 | 50.0 | 1.5 | 4 | 28 | 5 | 8 | 11 |
| | p-value | | p > 0.05 | | | | | | | |

were selected. All subsequent statistical analyses concerning SiC were performed on these individuals. In multiple regression procedures using DMFT and DMFS scores as dependent variables OTH ($p = 0.018$ and $p = 0.027$, respectively), bleeding ($p < 0.001$ and $p = 0.006$, respectively) and calculus ($p = 0.003$ and $p < 0.001$, respectively) made a contribution. However, in SiC groups the regression model was significant only for DMFS (SiC). In particular, besides calculus ($p = 0.016$) OHH made an important contribution ($p = 0.039$) (Table 3). Considered as *dummy* dependent variables the positivity for DMFT(SiC) and DMFS(SiC), OTH (OR = 1.29, 95%CI: 1.01 – 1.65 and OR = 1.34, 95%CI: 1.04 – 1.72, respectively), bleeding (OR = 1.18, 95%CI: 1.07 – 1.29; OR = 1.21, 95%CI: 1.10 – 1.33, respectively) and calculus (OR = 1.21, 95%CI: 1.06 – 1.37; OR = 1.23, 95%CI: 1.08 – 1.40, respectively) showed a significant association in a stepwise logistic regression model (Table 4).

The uncorrected overall agreement reached 91.6% and the kappa statistic marked a rather good overall concordance between subjects picked out by DMFT ≥ 3 and DMFS ≥ 4 cut-off points (K = 0.82; 95%CI: 0.73 – 0.91) (Table 5). However, 34 subjects were discordant between the two picked out series. The relationship with background factors in these subjects is reported in Table 6. No significant association was found with background variables. Nevertheless, a linear trend in proportions between the two groups across SOCFAM categories was observed ($\chi^2$ for trend = 6.39, $p = 0.01$).

## DISCUSSION

The most common indices for scoring dental caries are the DMFT/S (WHO, 1997). These indices have been used extensively for more than 60 years and are widely accepted throughout the world. However,

**Table 3 Multiple regression analysis: contributions of background factors on DMFT/S and DMFT/S(SiC)**

a) DMFT

F = 8.99 P < 0.0001

| Variable | b (SE) | P-value | 95% Confidence Interval |
|---|---|---|---|
| OTH | 0.37 (0.16) | 0.018 | 0.06 – 0.67 |
| Bleeding | 0.22 (0.06) | < 0.001 | 0.10 – 0.34 |
| Calculus | 0.25 (0.08) | 0.003 | 0.09 – 0.42 |
| Intercept | 0.75 (0.42) | 0.073 | -0.07 – 1.56 |

b) DMFS

F = 8.78 P < 0.0001

| Variable | b (SE) | P-value | 95% Confidence Interval |
|---|---|---|---|
| OTH | 0.67 (0.30) | 0.027 | 0.08 – 1.26 |
| Bleeding | 0.32 (0.11) | 0.006 | 0.09 – 0.54 |
| Calculus | 0.64 (0.16) | < 0.001 | 0.32 – 0.96 |
| Intercept | 0.79 (0.80) | 0.322 | -0.78 – 2.38 |

c) DMFT (SiC)

Not significant model (p > 0.05)

d) DMFS (SiC)

F = 3.21 P = 0.026

| Variable | b (SE) | P-value | 95% Confidence Interval |
|---|---|---|---|
| OHH | 1.85 (0.88) | 0.039 | 0.10 – 3.60 |
| Calculus | 0.64 (0.26) | 0.016 | 0.12 – 1.17 |
| OTH | 0.49 (0.54) | 0.355 | -0.56 – 1.56 |
| Intercept | 1.71 (2.92) | 0.560 | -4.07 – 7.49 |

OTH = Onset of Toothbrushing Habits
OHH = Oral Hygiene Habits
Bleeding = score 1 of CPITN index
Calculus = score 2 of CPITN index

a varying number of shortcomings have been described (Kingman and Selwitz, 1997). Since half of the 1990 s new paradigm for assessing and scoring caries lesions involved debate – particularly to solve the problem related to the skewness of the DMFT index – it is necessary to underline that the mean score has a precise relationship to the variance. If the specific relationship can be evaluated, the proportion of the population that is caries free and those with high levels can be calculated (Knutson, 1958). Moreover, if caries indices are considered as discrete variables, no matter how accurate the diagnosis of caries, the answer is always dichotomous (0 = no caries; 1 = caries). The distribution became skewed at the two extremes of possible caries distribution (0 and 32 for DMFT scores and 0 and 148 for DMFS scores). In 2000 the SiC index was proposed (Bratthall, 2000) as a solution to the above mentioned problem.

We explored the SiC index in 12 year-old Sardinian children both on the DMFT and the DMFS indices. The aim of calculating the index on DMFS was

**Table 4 Stepwise logistic regression estimates for DMFT (SiC) and DMFS (SiC) positivity**

| | | | |
|---|---|---|---|
| a) DMFT (SiC) | | | |
| | Log Likelihood = -253.46 | $\chi^2_3$ = 21.67 | P = 0.0001 |
| Variable | P-value | Odds Ratio | 95% Confidence Interval |
| OTH | 0.045 | 1.29 | 1.01 – 1.65 |
| Bleeding | 0.001 | 1.18 | 1.07 – 1.29 |
| Calculus | 0.005 | 1.21 | 1.06 – 1.37 |
| b) DMFS (SiC) | | | |
| | Log Likelihood = -245.80 | $\chi^2_3$ = 27.06 | P < 0.001 |
| Variable | P-value | Odds Ratio | 95% Confidence Interval |
| OTH | 0.027 | 1.34 | 1.04 – 1.72 |
| Bleeding | < 0.001 | 1.21 | 1.10 – 1.33 |
| Calculus | 0.003 | 1.23 | 1.08 – 1.40 |

OTH = Onset of Toothbrushing Habits
Bleeding = score 1 of CPITN index
Calculus = score 2 of CPITN index

**Table 5 Estimation of Cohen's kappa concordance between the ranking series of DMFT and DMFS ordered by SiC**

| | | DMFS (SiC) negative | DMFS (SiC) positive | |
|---|---|---|---|---|
| DMFT (SiC) | negative | 230 | 12 | 242 |
| | positive | 22 | 139 | 161 |
| | | 252 | 151 | |

*K: 0.82; 95% CI: 0.73 – 0.91*

to implement SiC upon the severity of the disease based on the number of involved surfaces. Following the WHO indication we believed that the SiC index calculation could contribute a small but significant amount of information, especially in a population with a similar high caries experience to our town (Campus et al, 2001). A recent multicenter survey in Italy showed that caries experience is higher in Sardinia (in a 6-year-old cohort) than in other Italian regions (Castiglia et al, 2002). A confirmation of this hypothesis is that in the SiC calculation, based on the two indices (DMFT/S), the cut-points are different, resulting in a discordant classification of 34 subjects (8.4%). Moreover, the distribution remained skewed even if the SiC calculation yielded a lower intrinsic variability in our population.

When background factors were considered as explanatory variables for prediction purposes, Onset of Tooth Brushing Habits (OTH) and gingival condition (presence of bleeding or calculus) gave a significant contribution for both DMFT and DMFS when all subjects were reconsidered. Whereas in SiC groups no information has been obtained using DMFT (SiC), while the use of DMFS (SiC) emphasized the contribution of OHH and calculus. These features highlighted the fact that in our population the influence of both oral hygiene habits and gingival conditions are probably important not only for children's caries experience, as presently reported (Campus et al, 2001), but also for the severity of disease. In addition, the significant trend in propor-

**Table 6 Background factors on discordant subjects for DMFT (SiC) and DMFS (SiC)**

| Gender | DMFT+ | DMFT− | | |
|---|---|---|---|---|
| Males | 9 | 5 | | |
| Females | 13 | 7 | | |
| *Fisher's exact = 1.00* | | | | |
| OHH | DMFT+ | DMFT− | | |
| Once a day | 7 | 1 | | |
| Twice a day or more | 15 | 11 | | |
| *Fisher's exact = 0.21* | | | | |
| OTH | DMFT+ | DMFT− | | |
| 2-3 years-old | 17 | 6 | | |
| 4 or more years-old | 5 | 6 | | |
| *Fisher's exact = 0.14* | | | | |
| Gingival condition | DMFT+ | DMFT− | | |
| Healthy | 12 | 4 | | |
| Bleeding | 10 | 8 | | |
| *$\chi^2$ test (Yates corrected) = 0.68, p = 0.41* | | | | |
| SOCFAM | DMFT+ | DMFT− | Odds Ratio | 95% Confidence Interval |
| Medium-high | 1 | 3 | 1 | – |
| Medium | 6 | 6 | 3.0 | 0.24 – 37.67 |
| Medium-low | 15 | 3 | 15.0 | 1.14 – 198.05 |
| *$\chi^2$ test for trend = 6.39, p = 0.01* | | | | |

DMFT+ = Subjects positive for DMFT(SiC) and negative for DMFS(SiC)
DMFT− = Subjects negative for DMFT(SiC) and positive for DMFS(SiC)

tion observed among SiC discordant subjects through SOCFAM categories underlines that other traditional risk factors could influence the disease during early years of childhood.

The SiC Index calculated on our 12-year-old population was able to draw attention to the subgroup with the highest caries value, partially solving the problem of skewed distribution of caries index.

Nevertheless, if only SiC is used, it can lead to a lack of relevant information, i.e. severity of the disease (DMFS), especially in areas like Sardinia where a high incidence of caries is still present. By using all indices a more complete picture of oral status and a wider understanding of distribution patterns and mechanisms can emerge.

## REFERENCES


1. Angelillo IF, Torre I, Nobile CGA, Villari P. Caries and fluorosis prevalence in communities with different concentrations of fluoride in the water. Caries Res 1999;33:114-122.
2. Armitage P, Berry G. Statistical methods in medical research. Oxford: Blackwell 1995.

3. Batchelor P, Sheiham A. The limitations of a 'high-risk' approach for the prevention of dental caries. Community Dent Oral Epidemiol 2002;30:302-312.
4. Bratthall D. Introducing the Significant Caries Index together with a proposal for a new global oral health goal for 12-year-olds. Int Dent J 2000;50:378-384.
5. Campus G, Lumbau A, Bachisio SL. Caries experience and streptococci and lactobacilli salivary levels in 6-8-year-old Sardinians. Int J Paediatr Dent 2000;10:306-312.
6. Campus G, Lumbau A, Lai S, Solinas G, Castiglia P. Socio-economic and behavioral factors related to caries experience in twelve-year-old Sardinian children. Caries Res 2001;35: 427-434.
7. Castiglia P, Petti S, Fabiani L, Campus G, et al. Prevalence of dental caries at the age of 6 in three different Italian areas. Sanità e Sicurezza 2002;1:422-426.
8. Ferro R, Saran G, Berengo M. The operating and preventive dental ergonomic aspects in a public dentistry service. Minerva Stomatol 1991;40:739-744.
9. Fleiss JL. The design and analysis of clinical experiments. New York: John Wiley & Sons 1986;62-63.
10. Kingman A, Selwitz RH. Proposed methods for improving the efficiency of the DMFS index in assessing initiation and progression of dental caries. Community Dent Oral Epidemiol 1997;25:60-68.
11. Knutson JW. Epidemiological trend patterns of dental caries prevalence data. Am Dent Soc 1958;57:821-829.
12. ISTAT. Classificazione delle professioni. Roma: Istituto Poligrafico e Zecca dello Stato 1991;1-218.
13. Mantel N. Chi-square tests with one degree of freedom; extensions of the Mantel-Haenszel procedure. J Am Stat Ass 1963;58:690-700.
14. Sheiham A, Joffe M. Public dental health strategies for identifying and controlling dental caries in high and low risk populations. In: Johnson NW (ed). Risk markers for oral diseases, vol. 1. Dental caries: markers of high and low risk groups and individuals. Cambridge: Cambridge University Press 1992;445-481.
15. Stamm JW, Disney JA, Graves RC, Bohannan HM, Abernathy JR. The University of North Carolina Caries Risk Assessment Study. I: Rationale and content. J Public Health Dent. 1988; 48:225-232.
16. WHO Oral Health Surveys - Basic methods Geneva 1997: 39-44.
17. Woolf B. On estimating the relation between blood group and disease. Ann Hum Gen 1955;19:251-253.