Individualized daily values affecting the dentist condition of Greek students

Miltiadis S. Chalikias 1* and Grigorios L. Kyriakopoulos 2
1 Technological Institute of Piraeus, Department of Business Administration, 250 Thivon & Petrou Ralli Av., 122 44 Egaleo, Greece. 2 National Technical University of Athens, School of Electrical and Computer Engineering, Electric Power Division, Photometry Laboratory, 9 Heroon Polytechniou str., 157 80 Zografou Campus, Greece. *e-mail: mchalikias@hotmail.com

Received 30 October 2010, accepted 2 January 2011.

Abstract
This study is based on a questionnaire organized on the basis of the World Health Organization’s (WHO) equivalent. The research has been completed by volunteering dentists, members of Fthiotida prefecture (Greece) dentists’ association, concerning students of oral health and hygiene as well as their social attributes. The proposed methodology adopts generalized linear models, as well as other statistical methods, oral health and hygiene differentiations while representative independent variables included the gender and the age of the participants. Consequently, the objective of the present study is focusing on the statistical processing by comparing the junior high schools’ results with the utilization of both parametric and non-parametric methods. The present study adopts a holistic approach of nutrition habits’ exploration, since the Fthiotida prefecture ideally combines rural and urban areas, thus revealing the possibility of its residents’ balanced vegetarian-meal daily value intake and the outcome results’ evaluation with the support of advanced statistical tools.

Key words: DMFT, CPITN, ordinal logistic regression, generalized linear model, Kruskall-Wallis, statistics.

Introduction
Within the last three decades, in the Greek context, universities, professors and individual dentists have initiated sporadic efforts in order to record epidemiologic problems of oral health origin in specific areas and specific age target groups from the general population. The first important epidemiologic study concerning the recording of mouth-related illnesses in Greece was carried out by the World Health Organization in co-operation with the Greek Health Ministry 16. Consequent notable attempt was implemented by the epidemiologic research of the Greek Dental Federation in collaboration with Colgate multinational company 20. At the same time, in Europe, in the USA, even in third-world countries – including Asia and Africa – innovative research in oral health has been constantly materialized under the aegis of World Health Organization and the financial support of private corporations. The above research, conducted in an international level of analysis, aims at the provision of even online access to governments’ information on food and human nutrition for consumers. Indeed, the nutrient values of foods consists an imperative administrative tool for valuable representation of thousands of foods nutrient profiles eaten worldwide. The present study focuses on a typical representative Greek province, ideally combining the nutrient habits of its citizens, residing closely to both urban and rural areas, and their dentist condition. Therefore, it was assumed that in this province could be ideally applied the benefits of the healthy typical Mediterranean nutrition. Therefore, the present study adopts a holistic approach of monitoring (statistical tool) and evaluating (nutrient tool) the above assumption of citizens balanced daily values’ intake, by recording the epidemiological illnesses; while the results of different studies promoting oral health are also reported and co-evaluated.

Epidemiologic research overview regarding daily values (DV) and dental condition of citizens in Greece: Epidemiologic studies which were carried out from 1940 up to 1981 showed that dental caries constitutes the most frequent microbial-based disease in human. It is noteworthy that among the roughly 1000 diseases, belonging to the field of dentistry, the cases of dental caries and periodontal diseases monopolize the interest, competence and time devotion of most dentists. Among them, the dominated case in childhood is the dental caries.

Plentiful relevant studies – regarding the Greek context – focus on the dental cases occurring to children aged at 6 years or older. Indicatively, an epidemiologic study of mouth diseases conducted in the district of Larissa 1, by using a sample of 2051 students aging from 6 to 18 years. The total population sampling was separated in three categories: agricultural mountain population, agricultural lowland population and urban population. The study concluded that the dental caries index (DMFT) was high, specifically reporting an 88.54% decay of primary dentition and an 86% decay of permanent dentition. Moreover, the study revealed a low dental care rate among the agricultural mountain population (20%) and a high dental care rate among the urban population (80%). Furthermore, any assiduity concerning the dental hygiene was almost non-existent.

According to Athanasoulis and Mitsis 3, who used a sample from all over Greece, the percentage of 12-year-old children who suffered from dental caries was 85%. The sampling proportion suffering permanent teeth was also considered high. The number of cases of dental caries in children aging from 12 to 14 years has been increased by 41.0-62.5% in both samplings from the cities of...
Athens and Thessalonica. However, during the last five years, the levels of accession of caries remain stable, due to restrictive measures that have been undertaken.

In 1988, an epidemiologic study in the basis of oral health and dental habits was carried out in Thessalonica 15. The study used a sampling of 2320 children aging from 7 to 12 years, who were tested by the Laboratory of Preventive Dentistry and Periodontology, the University of Thessalonica, indicated that only a small percentage of children brush their teeth daily. This outcome, in conjunction to the fact that the potable water of the city did not contain fluorine, led to elevated dental caries indices. It was also observed that since the percentage of children with regular visits to their dentist is low, the percentage of primary teeth which were extracted because of dental caries at the age of 7 was high and only a small percentage of permanent teeth were filled at the age of 12.

In the epidemiologic study of Agresti 2 the dental needs of 1166 children at the school age from 6 to 12 in the area of Athens, demonstrated that 71.6% of the sampling had experienced dental caries problems and that the need of dental treatment was increasing as age increased. Moreover, 85.9% of the children followed a mediocre or even poor oral hygiene and only 18.04% of them adopted an appropriate dental behaviour, with girls generally followed better oral hygiene except for the age at 8. Finally, 36.7% of the children presented some sort of orthodontic problem.

In 1998, an epidemiologic study of the dental health was undertaken in Kozani in 1996 13 in a sample of 3878 children aging from 2 to 11. The study indicated that the dental caries index decreased as the age advanced, specifically from 34% in 6-year-old children to 19% in 11-year old children. Moreover, as children growing up, the number of fractured teeth and the frequency of appearance of orthodontic problems also increased. Furthermore, the children presented little need regarding periodontal care. The periodontal index (CPTIN) was at zero level in younger children, but reached approximately one, in older children. Finally, the percentage of permanent teeth, without dental caries occurrence, was 95% in 6-year-old children, dropping to 33% in 11-year-old children.

In 2002, an epidemiologic study of the prevalence of dental caries and the need for treatment was carried out in the district of Argolidia 16 in a sample of 581 children aging at 12. The sampling was selected from 13 public junior high schools of the provinces beside Argos and Nauplium. The study concluded that the DMFT (1.59) in conjunction to the percentage of dental caries-free children resulted in a low prevalence in the population. Moreover, the indices of need for treatment were 59% regarding permanent dentition and the children with dental caries had suffered in an average 2.3 decayed teeth.

In 2005, the Greek Dental Federation in collaboration with Colgate multinational company 20, conducted a study as a part of a program for Recording and Promotion of Oral Health in the Greek Population. The study presented that the most dental caries cases have appeared in Ioannina (subjects 5, 12, and 35-44 years old), in Achaia (subjects15 years old) and in Thessalonica (subjects 65-74 years old), while the lowest values appeared in Athens (subjects 12, 15, and 35-44 years old) and in Thessalonica (subjects 5 years old). Moreover, the study stated that the dental caries indices were affected by the population group – agricultural or urban – and the educational level. Indicatively, the mean number of extracted teeth because of dental caries, in participants completing only illiterate/elementary school of a 65-74 years old group, was 17.69, whereas the respective number in participants of higher/ highest education level group was 13.26. The results of the research, comparing to those of 1985 participants in Athens and those of up to 2000 participants in European countries showed that the percentage of dental caries in children had been drastically reduced. The percentage of uncovered needs for children aged at 5, 12, and 15 was 87%, 56% and 44.8%, respectively. Among the children aged at 12 and 15, 83% experienced problems with their gingiva (CPTIN) and 53% reported that they visited their dentist because of pain or restoration needs, not as a regular check or a precaution measure. Furthermore, 90% of the children did not use basic means, by which oral health is protected. In spite of the fact that half the population of children aged at 12 and 15 needed orthodontic treatment, only 13.7% and 13.0%, respectively, actually received the recommended treatment. Finally, the percentage of people aging from 65-74, who brushed their teeth two or more times a day ranged from 5.9 in Naxos to 39.5% in Athens, while the corresponding percentage range for people aging from 35-44 was 29.7% in the Kastoria district to 53% in the Ioannina district.

**International epidemiologic research overview regarding daily values (DV) and dental condition:** International research concerns recording not only the dental caries index of the sampling population, as in the Greek content. Nowadays, research refers to more composite factors, for example the correlation between dental caries and blood groups, such as in Uganda (Africa), or the correlation between dental caries and periodontal diseases besides various groups of patients – like epileptic children, children or pregnant women who are carriers of AIDS or children with mental retardation. Numerous studies, relevant to the present work, have been carried out throughout the last four decades.

An old study which was conducted by the World Health Organization in Papua-New Guinea 18 recorded the reasons that caused dental caries in the population. This research was carried out in three stages within 1978 and investigated the correlation among the soil, water and food quality in the appearance of dental caries. Various statistical methods were used, while the main statistical tool was the simple and multiple linear regressions. In a sample of n = 301 people, it was found that the DMFT index ranged from 0 (which corresponds to perfect health) to 10, indicating the appearance of up to ten decayed teeth per person, whether extracting or not. Furthermore, there were no filled teeth, a direct consequence of the financial status of the country at the time of the study implementation. The average DMFT index of this sample was 3.3.

In another research, which was carried out by private dentists in Tanzania by Kerosuo et al. 12, the oral health of adolescent students in the city of Dar Es Salaam and the percentages of dental caries and periodontal diseases were studied. The sample consisted of 640 students, aging from 12 to 18, and the results showed that the dental caries index was higher in girls than in boys – 1.2 compared to 0.7 – respectively. Moreover, the two thirds of the children did not present any dental caries, however, most children, that is over 50%, needed periodontal treatment.

A research conducted in France from Cahen et al. 6 in the Louis Pasteur Institute of Strasburg explored the percentages of the dental caries index and the periodontal state in 1987, after the
implementation of a fluoridation program in the schools all over the country in 1986. Altogether, 19,366 children, aging from 6 to 15, were tested by a group of well-educated surgeon dentists from the 16 French university specialty departments. The computation of DMFT demonstrated that every year new teeth with dental caries appeared at level 0.5 of the index in children below the age of 11 and at level 1.0 of the index in children above the age of 11. The values of the index at the age of 6, 12 and 15 were 0.5, 4.2 and 6.9, respectively. The percentage of children without dental caries ranged from 32.2% in 6-years-old children, dropping to 7.9% in 15-years-old children.

A recent research, carried out in 2001 by the Dentistry Department of the University of Louvain in Belgium, showed a significant reduction of dental caries index DMFT in children aged at 12, from 7.5 to 1.6, over the period 1983-1998. The children percentage without dental caries increased from 4% up to 50%. The research also revealed that indicative factors which contributed to this notable decrease were fluoridation, use of toothpaste with fluoride, and more frequent visits to the dentist.

In March 2009, the Epidemiology Department of the University of Bangkok, in collaboration with the Public Health Ministry of Thailand, published a research on the correlation between the nutrition of 862 children, aging from 12 to 14, and dental caries in permanent teeth. The results depicted that lean children and children with regular height expressed 1 to 1.94 and 2.22 times greater DMFT index, respectively, than overweight or obese children. The main outcome of this research was that the promotion of hygiene in schools has to put emphasis on the improvement nutritional habits, in order to attain a decrease in dental caries in children.

### Materials and Methods

The present paper involves three junior high schools (gymnasiums) of Greek provinces, 2 in Lamia and 1 in Atalanti. The paper aimed at the recording of the oral health of 12 to 15 years old children in Greek provinces, 2 in Lamia and 1 in Atalanti. The research was conducted in the school facilities, during the lessons. The students filled in the part of the questionnaire, which positioned personal details, including personal and nutritional habits and habits concerning oral hygiene. The research was carried out by the Technological Educational Institute of Piraeus and the University of Central Greece under the guidance of dentists, who had examined the children.

For the analysis the non-parametric methods Kruskall-Wallis and \( x^2 \) were used, especially for the comparison of the results between the schools, and a generalized linear model: ordinal logistic with the dental caries index DMFT as depended variable.

The ordinal logistic regression was used when the dependent variable is categorical (ordinal) with more than 2 categories. When we used ordinal regression we assumed that the categories of the dependent variable \( Y \), were coded 0, 1 or 2 (analogous is the process for more categories). Recall that the logistic regression model for binary dependent variable was parameterized in terms of the logit of \( Y = 1 \) versus \( Y = 0 \). In the three category model there are two logit functions (in the four category model three etc): one for \( Y = 1 \) versus \( Y = 0 \) and the other for \( Y = 2 \) versus \( Y = 1 \). We could use any two of the pair-wise logit comparisons of outcomes. Let \( \mathbf{x} \) be the vector of the covariates of length \( p+1 \) with \( x_0=1 \) to account for the constant term. We will denote the two logit functions as

\[
g_1(x) = \ln\left[\frac{P(Y = 1 | x)}{P(Y = 0 | x)}\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p = (1, \mathbf{x}) \mathbf{\beta}_1
\]

and

\[
g_2(x) = \ln\left[\frac{P(Y = 2 | x)}{P(Y = 1 | x)}\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p = (1, \mathbf{x}) \mathbf{\beta}_2
\]

The three conditional probabilities of each outcome category, given the covariate vector, are as follows:

\[
P(Y = 0 | x) = \frac{1}{1 + e^{1 + \mathbf{x}' \mathbf{\beta}_1}}
\]

(3)

\[
P(Y = 1 | x) = \frac{e^{1 + \mathbf{x}' \mathbf{\beta}_1}}{1 + e^{1 + \mathbf{x}' \mathbf{\beta}_1}}
\]

(4)

\[
P(Y = 2 | x) = \frac{e^{2 + \mathbf{x}' \mathbf{\beta}_2}}{1 + e^{1 + \mathbf{x}' \mathbf{\beta}_1}}
\]

(5)

Following the convention for the binary model, we will let \( \pi(x) = P(Y = j | x) \) for \( j = 0, 1, 2 \) each of which is a function of the vector of \( 2(p+1) \) parameters \( \mathbf{\beta} = (\mathbf{\beta}_1, \mathbf{\beta}_2) \). A general expression for the conditional probability, in the three category model, is:

\[
P(Y = j | x) = \sum_{k=0}^{j} e^{e_{j-k}(x)}
\]

(6)

The variables which were used in the analysis of the results are consequently presented and analyzed.

**Explanation of the variables’ values:**

- **School:** values ranging from 1 to 3:
  1: 1st junior high school (Gymnasium) of Lamia,
  2: 2nd junior high school of Lamia,
  3: junior high school of Atalanti.

- **Sex:** values 0 and 1:
  0: female,
  1: male.

- **Age:** values ranging from 12 to 17 (in years).
- **Weight:** values ranging from 32 to 108 (in kg).
- **Height:** values ranging from 105 to 192 (in cm).
Body mass index (BMI): values ranging from 13.62544372 to 40.81632653. The body mass index is calculated by the formula weight (in kg)/(height)^2 (in m).

Educational level of the father: values ranging from 0 to 5:
0: Illiterate,
1: Elementary school,
2: Gymnasium,
3: Lyceum,
4: Technical School or IEK (Institutes of Vocational Training),
5: AEI (Higher Educational Institutes) or TEI (Technological Educational Institutes).

Educational level of the mother: values ranging from 0 to 5:
0: Illiterate,
1: Elementary school,
2: Gymnasium,
3: Lyceum,
4: Technical School or IEK (Institutes of Vocational Training),
5: AEI (Higher Educational Institute) or TEI (Technological Educational Institute).

Insurance fund: values ranging from 1 to 4:
1: IKA (Social Insurance Institution),
2: Agricultural Insurance Organization,
3: Public Insurance,
4: Other.

Frequency of tooth brushing: values ranging from 0 to 3:
0: none,
1: rarely,
2: once a day,
3: more than once a day.

Use of dental floss: values 0 and 1:
0: no,
1: yes.

Consumption of sweets: values ranging from 0 to 2:
0: none,
1: at home (little or moderate consumption),
2: at home (extensive consumption).

Consumption of dairies: values ranging from 0 to 2:
0: none,
1: at home (little or moderate consumption),
2: at home (extensive consumption).

Fluoridation: values ranging from 0 to 3.
Regards fluoridation done by a dentist:
0: none,
1: rarely,
2: once a year,
3: once per semester.
Use of fluoride at home: values 0 and 1.
Regards commercial mouthwashes:
0: no,
1: yes.

Visits to the dentist: values ranging from 0 to 4:
0: never,
1: rarely,
2: once a year,
3: once per semester,
4: when I have ache.

Symbolic naming of teeth (18-39): values for every tooth range from 0 to 8:
0: healthy,
1: decayed tooth,
2: filled and receded tooth,
3: filled tooth,
4: extraction because of dental caries,
5: extraction due to another cause,
6: there is filling of foramens and scissures,
7: there is dental crown,
8: permanent tooth that hasn’t erupted.

Dental caries index DMFT2: values ranging from 0 to 2.
This index takes integer values, which are the sum of the number of decayed teeth, the number of filled and receded teeth and the number of teeth which have been extracted because of dental caries (DMFT2.1 and DMFT2.2 are also defined in the paper)
0: perfect health,
1: 1 to 4 decayed teeth,
2: more than 4 decayed teeth.

Symbolic naming of periodontal state: for each variable C1-C6 values range from 0 to 2:
0: perfect health,
1: bleeding during the examination,
2: calculus.

Index of the periodontal state CPITN: values ranging from 0 to 2.
For a positive index is enough even one area in the buccal cavity, which presents bleeding during the examination or calculus:
0: perfect health,
1: bleeding during the examination,
2: calculus.

Buccal mucosa: values 1 and 2:
1: there is no damage,
2: there is damage.

Dental and gnathic abnormalities: values ranging from 0 to 2:
0: no abnormality,
1: mild or moderate abnormality,
2: severe abnormality.

Reference to an orthodontist: values ranging from 1 to 3:
1: is referred to an orthodontist,
2: is not referred to an orthodontist,
3: is already under orthodontic treatment.

Results
Prior to the results of the statistical model presentation, descriptive statistics are presented. Descriptive statistics for all the observations of the continuous variables are shown in Table 1.
Moreover, the same variables are given separately for every school in Table 2.

According to the rest of the variables, the percentages of boys and girls are about the same (50.8% girls and 49.2% boys); the majority of the students is from the Lamia second school, whereas the percentages which correspond to the Lamia first school and the Atalanti school are 30.6% and 26.6%, respectively. Furthermore, the educational level of the parents is about the same for men and women; indiscutibly, 27.8% of men and 31.7% of women have a postgraduate degree. Concerning dental care, 13.1% of the children use dental floss, 40.1% do not make use of fluoride, a small percentage (1.6%) do not brush their teeth and the majority (47.5%) allege that they brush their teeth more than once a day. Finally, only 0.3% of the students have buccal mucosa, and the students’ majority (53.2%) do not present orthodontic abnormalities, but a large percentage must visit an orthodontist.

For the DMF, a generalized linear model – ordinal logistic regression – was used, with DMF2 as dependent variable and gender, age, school, body mass index (BMI), educational level of mother, educational level of father, insurance fund, frequency of tooth brushing, use of dental floss, consumption of sweets, consumption of dairies, fluoridation, visits to the dentist, CPFITN, buccal mucosa, dental and gnathic abnormalities, reference to an orthodontist as independent variables.

In order to find the final model, Collet’s approach was used (Table 3). In order to confirm the model’s validity, the goodness of fit test was used. In both cases the null hypothesis that the models do not have goodness of fit is rejected. Finally, for the model with DMF2.1 as a dependent variable we have the diagram (Fig. 1); the diagram for the model with dependent variable DMF2.2 is approximately the same.

In Fig. 1, it is possible to observe the models’ deviance, a similar measure to residuals in linear regression. The model has a good adaptability, since most of the predicted values have a deviance lower than 0.05, which can be observed on the Cook’s Distance axis. In order to compare the three schools, Kruskal-Wallis test was used for BMI, which is the only continuous variable, and test was used for all the categorical variables.

**Discussion and Conclusions**

The average dental caries index, DMFT, in all three of the schools is 1.46. This number is considerably low compared with the average index DMFT in Greece, as this was determined by the research implemented by Colgate multinational company in Greece, in which the average index in 12- and 15-years-old children was approximately 3. According to the results of this paper, the average index in the three schools of the prefecture of Fthiotida is significantly lower than the average DMFT index in the prefectures of Ioannina, Achaia, Naxos, Larissa, Lesbos and Chania, whereas it is at the same level as the index in the prefectures of Attica, Thessaloniki and Cephalonia. A comparison with the results of an existing study referring to Greek content by the World Health Organization indicates that the average index in the three schools is at a much lower level, while the average dental caries index, DMFT, was 4.3 in 1985, in the present work, which was carried out over the Lamia district, is below 1.5. According to data from European countries, concerning the year 2000, Greece belongs to countries with intermediate level of dental caries index. There are countries, such as Belgium, Spain and Sweden, where the average dental caries index is approximately 1, but there are also countries, such as Slovakia, Poland, Hungary, Lithuania and Latvia, where the average dental caries index is about or above 4. Consequently, the average index in the prefecture of Fthiotida, taking into consideration the average value in Greece and Europe, holds at a rather good level.

According to the results of the present study, the percentage of caries-free children was improved, in comparison to previous percentages. The percentage of children which present dental caries is 47.3%, while the respective percentage in the research conducted all over Greece was 85 %. Moreover, research abroad
shows that the percentage of children which present dental caries in 1989 reached 92.1% in France and 50% in Belgium.

The factors which affect DMFT (Table 3) are CPITN, educational level of the parents, visits to the dentist, school and consumption of sweets, while the influence of tooth brushing seems to be marginal. From the interpretation of the relevant coefficient it can be concluded that students who do not go to the dentist have approximately \(1 - \exp(-0.932) \approx 60\%\) less probability to have none at all or 1-4 decayed teeth, comparing to students who visit the dentist once a year. Moreover, students who do not consume sweets have \(\exp(-0.432) = 35\%\) higher possibility to have none at all or 1-4 decayed teeth, comparing to students who consume many sweets. Furthermore, from the interpretation of the relevant coefficients it is shown that children from the 1st and the 2nd junior high schools of Lamia have respectively \(\exp(0.888)-1=143\%\) and \(\exp(0.548)-1=72\%\) higher possibility to have experienced none at all or 1-4 decayed teeth.
all or 1-4 decayed, comparing to students from the Atalanti school. Finally, children with low values of CPITN and lower–higher frequency of tooth brushing have better DMFT values; reduced–increased possibility of none at all decayed tooth instead of 1-4 decayed teeth.

From the non-parametric test, it is observed that educational level of the mother, insurance fund, frequency of tooth brushing, use of dental floss, consumption of sweets, consumption of dairies, fluoridation and visits to the dentist do not differ from students of different schools. Moreover, the Kruskal Wallis test did not reveal any differences regarding BMI. On the contrary, statistically significant difference appeared in the variables: CPITN, DMFT and buccal mucosa. In particular, values of the variables CPITN and DMFT are considerably improved (lower) in the Atalanti school, whereas both cases of damaged buccal mucosa were found in the 1st school of Lamia. The improved oral health that children of the Atalanti school displayed is probably attributed to the fact that, contrary to children in the other two schools, they had attended lectures on oral health in elementary school and had their teeth annually fluoridated.

References
1 Adamides, A. 1983. Epidemiologic study of mouth diseases in Greek population, 6 to 18-years-old children in the prefecture of Larissa. Laboratory of School of Preventive Dentistry, University of Athens (in Greek).
15 Louloudiades, K. 1988. Dental status and habits regarding oral health in 7 to 12-years-old children in Thessaloniki (1976-1984). Laboratory of Preventive Dentistry and Periodontology, Orthodontic and Preventive Dentistry and Periodontology Department, Dentistry Department, Aristotle University of Thessaloniki, School of health Sciences (in Greek).