Dental caries determinants in an adult Portuguese population and a comparison with Norwegian adults

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Eriksen HM, Marques MD, Bjertness E, Moe B. Dental caries determinants in an adult Portuguese population and a comparison with Norwegian adults. Acta Odontol Scand 1996;54:49–54. Oslo. ISSN 0001–6357.

The present epidemiologic dental caries study indicates a high number of decayed surfaces (mean, 13.5 ± 11.8 (SD)) in a Portuguese population of 30- to 39-year-olds from Porto. The most influential determinants for variation in carious surfaces were oral hygiene, gender, salivary buffer capacity, and missing teeth. By entering the most influential independent variables in a final multiple classification analysis, the total explained variance in carious surfaces was 27%. A comparison with results from a similar Norwegian dental health study showed that the biologic factors of importance for number of carious surfaces were the same, whereas the sociocultural determinants differed. □ *Dental caries; epidemiology; Portugal*

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The prevailing concept of dental caries emphasizes biomedical determinants among the most important etiologic factors (1). However, there is an increasing interest in the comprehension of dental caries as a multifactorial disease with biologic, psychosocial, and cultural dimensions (2–5).

By means of the multifactorial approach, a socioecologic, conceptual dental health model has been proposed and tested (6) on the basis of the health field concept in accordance with Blum & Lalonde (7).

According to the socioecologic concept, disease prevalence is influenced by the social and cultural context in which it appears. Relationships and interactions between various items are basic assumptions associated with the concept applied. One might therefore expect that differences in dental caries prevalence between societies could in part be explained by differences in social, cultural, and psychological characteristics in addition to possible differences related to biomedical factors. Differences in attendance and utilization of dental health services may also explain differences in oral health between societies. The aim of the present investigation was to test the socioecologic concept in a Portuguese population and to compare similarities/differences with Norwegian data available from 50-year-olds (6, 8).

Dental health registrations in Portugal (8) have shown that the caries prevalence differs from Norway in a lower total DMF scores but a higher D (decayed) component. The Portuguese data were supplied with information on social conditions, health behavior, and psychologic status in accordance with the socioecologic dental health model (6). A correlation with socioecologic variables might therefore offer possibilities for studying variations in—and the relative importance of—dental health determinants in a Portuguese population compared with Norwegian conditions.

Materials and methods

Material

During 1990 a random sample of 30- to 39-year-olds from the region of Porto in Portugal were drawn on the basis of local electorate lists. Of a total of 322 persons (that is, 0.5% of the total number of individuals in the selected cohort), 196 attended the present dental health investigation (61%). Unknown address and lack of time or interest were the major reasons for not attending (8, 9), which gives a final attendance rate of 76%. Results from a similar study on 50-year-old citizens of Oslo, Norway, were available for comparison with the Portuguese data. The Norwegian sample constituted 200 randomly selected individuals with an attendance rate of 60% (119 individuals) (6).

Methods

Dependent variable. The number of carious surfaces, recorded both clinically and radiographically, was used as the dependent variable. A carious surface was recorded when a softened floor or wall of a cavity could

Table 1. Bivariate analysis of the independent variables used with operationalization, distribution of individuals, mean and standard deviation (SD) of carious surfaces and statistical significance indicated

Independent variable	Carious surfaces (mean)	SD	*n*	*p*	(*p*)†
Environment					
Years at school					
<10 years	14.5	12.7	127	0.12^{NS}	(0.03*)
≥10 years	11.7	10.8	69		
Social class (30)					
Class 1	12.6	11.1	36	0.12^{NS}	(0.01*)
Class 2	12.4	11.6	97		
Class 3	15.7	13.2	63		
Economy					
Unsatisfied	14.6	13.6	102	0.21^{NS}	(0.19^{NS})
Satisfied	12.4	10.1	94		
Behavioral factors					
Smoking					
No	12.4	10.9	106	0.17^{NS}	(0.001***)
Yes	14.8	13.3	90		
Psychologic status (31)					
Unsatisfied (≤5)	12.4	11.9	32	0.56^{NS}	(0.01*)
Satisfied (>5)	13.7	12.1	164		
Eating between meals					
Seldom (≤once/day)	13.2	12.7	87	0.75^{NS}	(0.04*)
Often (>once/day)	13.8	11.6	109		
Tooth cleaning (OHI-S) (15)					
OHI-S: ≤3	9.5	8.5	87	0.001***	(0.00***)
OHI-S: >3	16.7	13.5	109		
Brushing					
≤Once/day	22.0	17.0	32	0.001**	(0.06^{NS})
>Once/day	11.9	10.2	164		
Interdental cleaning					
No	13.7	12.1	129	0.73^{NS}	(0.04*)
Yes	13.1	12.2	67		
Use of fluoride toothpaste					
No	14.4	13.0	61	0.48^{NS}	(0.01*)
Yes	13.1	11.7	135		
Human biology					
Sex					
Woman	11.6	10.6	97	0.03*	(0.00***)
Man	15.3	13.2	99		
Physical fitness					
Unsatisfied	14.7	13.8	47	0.43^{NS}	(0.32^{NS})
Satisfied	13.1	11.5	149		
Weight status					
Unsatisfied	13.7	12.8	52	0.90^{NS}	(0.43^{NS})
Satisfied	13.4	11.9	144		
Buffer capacity (13)					
Low	19.6	15.1	19	0.03**	(0.002**)
Medium	14.3	13.8	74		
High	11.8	9.6	102		
Missing teeth					
≤5	11.6	9.2	160	0.001**	(0.004**)
>5	22.0	18.4	36		
Saliva secretion (13)					
<1.0 ml/min stim.	13.8	12.2	47	0.87^{NS}	(0.16^{NS})
≥1.0 ml/min stim.	13.4	12.1	148		
Chronic disease					
No	13.6	12.4	158	0.81^{NS}	(0.61^{NS})
Yes	13.1	11.1	38		
Medication					
No	13.2	11.5	152	0.47^{NS}	(0.74^{NS})
Yes	14.7	13.9	44		
Health care organization					
Regular dental visits					
No	14.8	12.9	139	0.02*	(0.00***)
Yes	10.5	9.3	57		

* $0.05 > p > 0.01$; ** $0.01 > p > 0.001$; *** $p < 0.001$; NS = statistically not significant at the 0.05 level.
† *P* values in parentheses are from the Norwegian study of 50-year-olds (6) included for comparison.

Table 2. Multiple classification analysis (MCA) of the independent variables related to 'Environment'. Two per cent of the total variation in decayed surfaces could be explained by these variables

Variable	Eta	Beta
Social class	0.12^{NS}	0.11^{NS}
Economy	0.09^{NS}	0.06^{NS}

$R^2 = 0.019$; NS = statistically not significant at the 0.05 level.

Table 3. Multiple classification analysis (MCA) of the independent variables related to behavioral factors. Fifteen per cent of the variation in decayed surfaces could be explained by behavioral variables

Variable	Eta	Beta
Brushing	0.31***	0.25**
Tooth cleaning (OHI-S)	0.30***	0.24**
Smoking	0.10^{NS}	0.05^{NS}
Interdental cleaning	0.03^{NS}	0.04^{NS}
Psychological status	0.04^{NS}	0.02^{NS}
Use of fluoride toothpaste	0.05^{NS}	0.00^{NS}
Eating between meals	0.02^{NS}	0.00^{NS}

$R^2 = 0.153$; ** $0.01 > p > 0.001$; *** $p < 0.001$; NS = statistically not significant at the 0.05 level.

Table 4. Multiple classification analysis (MCA) of the independent variables related to human biology. Nineteen per cent of the variation in decayed surfaces could be explained by biologic factors

Variable	Eta	Beta
Missing teeth	0.33***	0.34***
Sex	0.15*	0.22**
Buffer capacity	0.19*	0.17*
Physical fitness	0.06^{NS}	0.10^{NS}
Weight status	0.01^{NS}	0.00^{NS}

$R^2 = 0.187$; * $0.05 > p > 0.01$; ** $0.01 > p > 0.001$; *** $p < 0.001$; NS = statistically not significant at the 0.05 level.

be registered by probing (10) and radiographically, in accordance with criteria described by Hollender & Koch (11), on the basis of intraoral bitewing radiographs. To compare the results with similar Norwegian dental health data, a thorough calibration between the Portuguese (M. D. Marques) and the Norwegian investigator (E. Bjertness) was performed both before and during the present investigation (8).

Independent variables. The independent variables represent a combination of clinical registrations and questions asked through a questionnaire/interview session. The information obtained was grouped under the four main items: 'Environment', 'Behavior', 'Human biology', and 'Health care organization' (6). The method represents a combined psychosocial/behavioral and biomedical approach previously presented as the socioecologic model and tested on 50-year-old Oslo citizens (6). The independent variables used are presented in Table 1, with relevant references included. In addition to caries registrations in accordance with the DMF index (10) with adjustments indicated (11, 12), saliva tests including stimulated secretion rate and buffer capacity (13) were carried out. Periodontal disease variables (CPITN) (14) and the oral hygiene status (15) were also recorded.

Statistical methods. Analysis of variance (F-test) was used for statistical evaluation of the bivariate relationships with the dependent variable. Multiple classification analysis (MCA) (16, 17) was the method chosen for multivariate evaluation. MCA was chosen in part because of the test's ability to handle grouped independent variables to determine 'the explained variance' and to facilitate a direct comparison with the analysis of caries data from the Norwegian cohort (6).

On the basis of the bivariate analyses (Table 1), the independent variables under each of the four main items having the lowest p values when correlated with the number of carious surfaces were entered for further multiple analyses (Tables 2–5). The adjusted multiple regression coefficients squared (R^2) indicate the part of the variation of the dependent variable which might be explained by all the independent variables included, thereby indicating the fit of the collected data to the model. Thus the relative explanatory power of the four main items in the socioecologic model can be estimated. The final fit of the model was estimated by a further selection of the most influential variables recorded under each of the four main items by the MCA (Table 6). When independent variables showed high mutual correlation (Pearson's correlation coefficient exceeding ± 0.35), only one was entered, to prevent colinearity.

Results

The mean number of carious surfaces (DS + D_FS) was 13.5 (SD, 11.8), composed of 9.2 diagnosed clinically (8) and an additional 4.3 from examination of the bitewing radiographs. The bivariate correlations between the independent variables and carious surfaces are presented in Table 1.

None of the variables classified under the main item 'Environment' (education, social class, economy) showed a statistically significant bivariate correlation with the dependent variable in the Portuguese sample.

Among the 'Behavioral factors' there was a statistically significant difference in carious surfaces related to oral hygiene and frequency of brushing. Smoking habits, psychologic status, between-meal eating, and the use of fluoride dentifrice did not show a statistically significant correlation with the number of carious lesions.

Missing teeth was the 'Human biology' variable showing the strongest correlation with the number of

Table 5. Multiple classification analysis (MCA) of the independent variable related to 'Health Care Organization'. Three per cent of the variation in carious surfaces could be explained by this factor

Variable	Eta	Beta
Regular dental visits	0.16*	0.16*

$R^2 = 0.026$; * $0.05 > p > 0.01$.

Table 6. Multiple classification analysis (MCA) of the most influential independent variables from each of the four categories in the Socio-ecologic Model (6). Twenty-seven per cent of the variation in carious surfaces could be explained by these factors

Variable	Eta	Beta
Social class	0.12^{NS}	0.08^{NS}
Tooth cleaning (OHI-S)	0.30***	0.016*
Brushing frequency	0.31***	0.18**
Missing teeth	0.33***	0.30***
Buffer capacity	0.19*	0.17*
Sex	0.15*	0.12^{NS}
Regular dental visits	0.16*	0.09^{NS}

$R^2 = 0.274$; * $0.05 > p > 0.01$; ** $0.01 > p > 0.001$; *** $p < 0.001$; NS = statistically not significant at the 0.05 level.

carious surfaces, whereas gender and saliva buffer capacity showed a weaker but statistically significant correlation ($0.05 > p > 0.01$). Women presented with less caries than men. Physical fitness, weight status, chronic disease, and other general health variables did not show any correlation with dental caries. Regular dental visits showed a statistically significant inverse correlation with the number of carious lesions ($p < 0.01$).

In the MCA (Tables 2–6) the independent variables showing the strongest bivariate correlation with the dependent variable under each main item were selected. The eta values indicate correlation coefficients with no adjustment for possible relationship with other independent variables, whereas beta values indicate the relationship between the independent and the dependent variable with adjustment for possible intervariable relationships.

The explained variance for the item 'Environment' was only 2% ($R^2 = 0.016$) (Table 2). 'Behavioral factors' (Table 3) and 'Human biology' (Table 4) each explained 15% ($R^2 = 0.153$) and 19% ($R^2 = 0.187$), respectively, of the total variance recorded. 'Health care organization' (regular dental treatment) explained only 3% of the total variance in carious surfaces ($R^2 = 0.026$) (Table 5).

The most important determinants under each of the main items for variation in carious surfaces were then selected for testing of the fit of the final model by MCA in accordance with the socioecologic dental health concept (Table 6). The total explained variance was 27% ($R^2 = 0.274$), with the variables presented in Table 6 giving the best fit of the model. The strongest correlation was found for oral hygiene variables, saliva buffer capacity and missing teeth, the latter having a strong and independent effect.

Discussion

The attendance in the present investigation was 61%, all participants included. However, the attendance rate was estimated to be 76% after exclusion of 65 persons with unknown addresses. Of the remaining non-attenders, most did not participate because of lack of time or interest. The Norwegian population consisted of 50-year-olds, whereas the Portuguese were 30- to 39-year-olds. To what extent this age difference influences the results is not known.

The dependent variable

In the present investigation carious surfaces ($DS + D_FS$) have been calculated on the basis of a combined clinical and radiographic registration. This gave higher values for the dependent variable, carious surfaces, than reported previously (8). However, total DMFS/T scores were similar to scores reported in other Portuguese epidemiologic studies (8, 9).

The independent variables

A detailed discussion of operationalization of the independent variables used is given in Refs. 6, 9, and 17. The use of ordinal scales for the independent variables was chosen to obtain rough estimates of the determinants and to minimize problems with outliers. Equal distribution of individuals and commonly accepted separation of values were applied as guidelines for operationalization of the variables.

Carious surfaces and environmental variables

The lack of correlation between dental caries and various socioeconomic variables was surprising (Tables 1, 2) (18) and in contrast to what was found in a Norwegian investigation of 50-year-olds (9). An explanation may be that Portugal represents a society in which the advantageous effects of high income/high education as seen in highly industrialized countries are counteracted by the inverse effect found in less affluent societies (19–21).

Carious surfaces and behavioral variables

Of the behavioral factors, oral hygiene showed a statistically significant correlation with carious surfaces (Tables 1, 3). The impact of oral hygiene has, however, also been repeatedly linked to low prevalence of carious

surfaces in recently published epidemiologic investigations in Norway (22, 23). This is in contrast to previously published investigations indicating an uncertain relationship between oral hygiene and dental caries (24).

Smoking has been adversely linked to dental caries both bivariately and multivariately in some investigations (6, 25, 26). However, the present investigation showed no statistically significant correlation between smoking and dental caries when dividing the study sample into smokers and non-smokers (Tables 1, 3). More detailed analyses of the smoking habits among the Portuguese participants may be necessary before more definite conclusions are drawn. There was also a surprising lack of correlation between the use of fluoride toothpaste and dental caries recorded in the present investigation. Seventy-seven per cent of the participants used fluoride toothpaste on a regular basis. Knowledge about fluoride exposure from other sources (drinking water, fish consumption) was not available.

Carious surfaces and human biology

Gender, buffer capacity, and missing teeth were the three biologic factors most closely correlated with carious surfaces in the Portuguese population (Tables 1, 4).

Carious surfaces and the use of dental health services

Dental health visiting habits had only a minor impact on the variation in the number of decayed surfaces (Tables 1, 5). However, only one variable was used in the present study. The number of regular visitors was much lower in Portugal than in Norway (29% versus 89% of the samples investigated). On the basis of the high number of decayed surfaces even among the regular attenders, the treatment patterns must be different. This might explain why the impact of regular attendance on the number of carious lesions was greater in a Norwegian (6) than in the present Portuguese population.

Carious surfaces and the socioecologic concept

In the final model the independent variables giving the highest explanatory power (highest beta values) were included (Table 6). Twenty-seven per cent of the total variance in carious surfaces could be explained by the factors included. This was lower than what was obtained in the Norwegian investigation (6) (42%) but in accordance with results from many other multifactor analyses of dental caries determinants (2, 3, 27). Missing teeth was a stronger indicator in Portugal than in Norway, reflecting differences in the treatment pattern in the two societies. The relative importance of oral hygiene seemed also to be dominant in the Portuguese investigation. On the other hand, factors related to sociocultural qualities—that is, alcohol problems, smoking, and psychologic status—played a greater role in Norwegian society than in Portugal. This may indicate that factors linked to stress and 'coping' may be more discriminatorily related to the prevalence of dental caries in Norwegian than Portuguese society. Smoking, alcohol consumption, and psychosocial status do not describe the same social characteristics in the two societies. According to the investigator (M. D. Marques), reliable information related to alcohol consumption and related problems were difficult to collect in Portugal and were omitted from the present investigation. This might explain the difference in total explained variance between the two societies.

The relative explanatory power of biologic factors and factors related to behavior was similar in the two societies: 28% versus 19% for biology and 25% versus 15% for behavioral factors. This supports the concept of a multifactorial etiology of dental caries with almost equal influence from these two main items. Furthermore, the biologic determinants were similar in Portugal and Norway, whereas the behavioral determinants of greatest importance differed, indicating differences in the sociocultural context in which dental caries develop.

From a pragmatic point of view, it is discouraging to register the low level of explained variance in carious surfaces. This may indicate that we have not been able to include the most relevant determinants in our set of criteria. On the other hand, with the multifactorial etiology demonstrated and complex interactions and covariance between determinants, it might be difficult to reach a higher level of explained variance (28). On the basis of epidemiologic features of dental caries it has also been speculated that caries may in part develop at random (29). The low level of explained variance and the disclosure of partly different determinants from many studies, the present one included, may therefore support the concept of a complex nature of the etiology of dental caries.

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Received for publication 3 March 1995
Accepted 22 May 1995