The basis for clinicians' caries risk grouping in children

Sigurður Rúnar Sæmundsson, Cand Odont, MPH, PhD Gary D. Slade, BDSc, DDPH, PhD
A. John Spencer, MDSc, MPH, PhD Michael J. Davies, BA, MPH

Abstract

Despite the growing emphasis on targeting care to high-risk groups, little is known about the factors used by clinicians to designate risk. This study investigates the degree to which factors measured in a typical dental health survey are used by clinicians in assigning children to dental disease risk groups. A random sample of 9690 children aged 5–15 years was selected from the South Australian School Dental Service. Dentists or dental therapists judged each child as low-, medium-, or high-risk for dental disease. Clinicians recorded caries experience (DMFS/dmfs), and children's parents completed a questionnaire on dental behaviors and socioeconomic status (SES). Two binary logistic models were fitted using the risk grouping as the outcome variable, one comparing low- with moderate-risk and the other comparing moderate- with high-risk. Sixty percent of children were judged as moderate-risk, 27% as low-risk, and only 13% as high-risk. In the logistic models, proximal DMFS/dmfs were stronger predictors of assignment to the higher-risk groups than were factors indicating past occlusal caries, while factors describing caries on buccal or lingual surfaces appeared unimportant. Untreated lesions on permanent and primary teeth were among the strongest predictors of assignment to the higher-risk groups. Other significant factors (P < 0.05) were: exposure to professionally applied fluoride and sealants, country of birth, frequency of toothbrushing, and exposure to fluoridated water. No SES factors reached significance. The models explained nearly one-half the variation in the risk predictions. Clinical markers of past caries experience explained the greatest variation in the judgments, showing that clinicians base their risk predictions largely on children's past disease. The three types of surfaces contribute unevenly to the judgments and unrestored caries was the largest contributor to the decision. (Pediatr Dent 19:331–38, 1997)

Due to improvements in the dental health of children in many countries in recent decades, the need for targeted prevention has increased. With only a small minority of the children in a given population having the majority of dental caries, there is a need to find the individuals who are at increased risk of developing dental caries. The reduction in caries has lead to attempts to identify reliable risk predictors, and a large body of research has been generated on risk markers including previous caries experience, salivary buffering capacity, bacterial counts, dietary factors, fluoride exposure, and many more. More recently, attempts have been directed at building statistical models composed of several or multiple risk predictors in the hope of improving the predictive capability.[1]

The North Carolina risk assessment study by Disney et al.,[2] studied many predictors of caries risk among children. Of the risk predictors studied, the clinicians' subjective estimate of a child's caries risk was the single best predictor of DMFS increment in a logistical regression model. Many experienced clinicians would agree with the contention that caries risk can be predicted reasonably well with information typically available to clinicians at the time of examination, without resorting to expensive or time-consuming methods. This belief is supported by two studies from Finland[3,4] where, on average, clinicians predicted children's risk of developing carious lesions reasonably well. The study by Alanen et al.[3] showed that as a group, the specificity of the dentists' predictions was high (Sp = 90%) but sensitivity was low (Sn = 44%), hampering precision. Some dentists, however, reached a high level of precision in predicting caries in individuals, closely approximating levels of accuracy that have been set forth by Stamm et al.[5] as the lower limits of usefulness in public or private caries prevention programs (Sp = 85%, Sn = 75%). It is therefore likely that benefit can be derived from understanding the basis of the decision-making process when clinicians assess caries risk in children. Very little is known about clinicians' risk designation in real world or nonexperimental conditions. In public health settings, where allocation of often scarce resources is of prime importance, it is important to understand how many children may be designated by clinicians into different risk groups. This would affect the amount of money available for preventive services per individual in each risk group. In addition, the fact that individuals have unequal probabilities of developing caries indicates that appropriate management of caries will depend increasingly on accurate risk prediction.

Although there continues to be a need for longitudinal risk-assessment studies in which potential risk factors are identified and validated against subsequently observed disease progression, we believe that there is enough indication that clinicians can do a reasonably good job of assessing risk. However, in order to understand how clinicians assess risk, it is necessary to conduct a cross-sectional study, where data on the clinicians' risk groupings are available simultaneously with the factors that might enter into the clinicians' decision process when assigning risk. This study aims to investigate the way dentists and dental therapists assign children to risk groups and the degree to which factors measured in a typical dental health surveys are used as the basis for the risk prediction.

Methods and materials

This analysis used cross-sectional data from the Child Fluoride Study—a collaborative project between the Australian Institute of Health and Welfare, Dental Statistics and Research Unit and the School Dental Services of two Australian states, Queensland and South Australia. The study examined caries experience in the primary and permanent teeth of children aged 5–12 and 5–15 years old in the two states, respectively. The main purpose of the study was to examine the relationships between exposure to fluoride from a number of vehicles and children's caries experience in Australia.[6] The School Dental Services provide free dental care to more than 90% of the child population in these two states. Dental examinations are conducted regularly by dentists and dental therapists, who also provide routine preventive, restorative, or oral surgical services. Data used in this project were obtained from the baseline cross-sectional stage of the Child Fluoride Study in South Australia, because only in that state were the clinicians asked to assess the child's risk status.

Sample and data collection

Subjects eligible for inclusion in the study were children 5–15 years of age who were being provided with regular dental care in the school dental clinics throughout South Australia, which has a population of approximately 200,000 in the 5- to 15-year-old age group. Children were selected at random based on their date of birth. A sampling ratio of 1:12 was used

TABLE 1. EXPLANATORY VARIABLES INCLUDED IN THE FULL LOGISTIC REGRESSION MODELS

Demographic and SES variables(questionnaire)	
1. Age [5–15 years]	
2. Gender; boy=1, girl=0	
3. Race; Aborigine or Torres Strait Islander=1, other=0	
4. Education of mother	1 = Some primary school
	2 = Completed primary school
	3 = Some secondary school
	4 = Completed secondary school
	5 = Some University or College
	6 = Completed University or College
5. Education of father	1 = Some primary school
	2 = Completed primary school
	3 = Some secondary school
	4 = Completed secondary school
	5 = Some University or College
	6 = Completed University or College
6. Annual household income	1 = Up to $12,000
	2 = $12,001 to $16,000
	3 = $16,001 to $20,000
	4 = $21,001 to $25,000
	5 = $25,001 to $30,000
	6 = $30,001 to $35,000
	7 = $35,001 to $40,000
	8 = $40,001 to $50,000
	9 = $50,001 to $60,000
	10 = More than $60,000
7. Country of birth; born in Australia=0, elsewhere=1	
Oral hygiene and fluoride exposure variables (questionnaire)	
8. Brushing frequency [0–21 times per week]	
9. Age when brushing was started [0–10 years]	
10. Mouthrinse use currently; yes=1, no=0	
11. Fluoride tablet use; ever=1, never=0	
12. Percent of lifetime that F-water was consumed [0–100%]	
Use of preventive dental services (examination)	
13. Exposed to professionally applied fluoride; ever=1, never=0	
14. Sealants used on permanent teeth; yes=1, no=0	
15. Sealants used on primary teeth; yes=1, no=0	
Clinical variables (examination)	
16. Caries free in permanent dentition? No=0, Yes=1	
17. DMFS among occlusal surfaces of permanent teeth	
18. DMFS among proximal surfaces of permanent teeth	
19. DMFS among buccal and lingual surfaces of permanent teeth	
20. D-proportion of DMFS on permanent teeth	
21. Caries free in primary dentition? No=0, Yes=1	
22. dmfs among occlusal surfaces of primary teeth	
23. dmfs among proximal surfaces of primary teeth	
24. dmfs among buccal and lingual surfaces of primary teeth	
25 d-proportion of dmfs on primary teeth	

for Adelaide (the capital city of South Australia) and 1:5 was used for the remainder of the state. Children were sampled at their regular check-up time, when they also received an oral examination from which clinical data were recorded for this study. Questionnaires were sent to the parents of the sampled children after the examination, and up to two reminder notes were sent to nonrespondents. Completed questionnaires were sent directly to the researchers, so clinicians were unaware of the answers at the time of examination. The sampled children for whom a completed questionnaire was obtained were included in the analysis. The data were collected in the period between June 1991 and May 1992.

The parental questionnaire asked about oral hygiene habits, sources of fluoride exposure, past dental care, dental problems, birthplace and residence history, race, and socioeconomic characteristics of the child's household. Variables that were used for the current analysis are presented in Table 1.

The clinical data were gathered by a dental therapist or dentist at the time of the regular check-up at the school dental clinic. The data collected included tooth- and surface-specific components of the dmfs and DMFS indices, presence of sealants, and number of past fluoride treatments. The clinicians were given written instructions on the criteria to use in recording the clinical factors. Visual and tactile criteria were used following the guidelines of WHO for the DMFS and dmfs indices.[7] Beyond the written instructions, no attempts were made to standardize the examiners, nor were there attempts to assess examiner reliability.

In 1991, a policy decision was made in the South Australia School Dental Services to target preventive services to the children who were at highest risk. In the absence of any acceptable diagnostic tests to assign children to risk groups, the policy was to leave the risk assignment to the dentist or dental therapist who took care of the child. Accordingly, after the dental examination, the clinicians assigned the child to a risk group according to their perception of the child's risk of needing dental care. The policy called for assigning the children to groups of a low, medium or high risk, and no effort was made to standardize this measure as it was supposed to utilize the clinicians own expertise to the fullest.

Analysis

The analysis aimed to identify clinical and questionnaire variables that were associated with clinicians' risk designation. Initial analysis using ordinal logistic regression found that the assumption of proportional odds among the three risk groups was not tenable. Therefore, the decision was made to fit individual binary logistic models as proposed by Begg and Gray.[8] This resulted in two separate models, one comparing medium risk with low risk and the other comparing high risk with medium risk using standard logistic regression methods for binary outcome.

The goal of the model fitting was to maximize the explanatory power of the model. A full model including all available explanatory variables was fitted and then reduced by eliminating variables that were not significant predictors ($P \geq 0.05$). Once no further reductions were possible, all deleted variables were given a second chance to enter the model at the $P \leq 0.05$ level to assess their significance in terms of the reduced model. Once a final set of main effects variables were obtained, squared main effect terms were tested for entry into the model using a stepwise procedure ($P \leq 0.05$).

Logistic regression calculates odds ratios, which indicate the direction and strength of association between a child's attribute (for example, being caries free) and the child's outcome (for example, being designated medium risk instead of low risk). A significant odds ratio in this analysis indicates that the attribute is likely to have entered into the decision to assign the child to the risk group in question. Odds ratios greater than 1.0 mean that the attribute is associated with assignment to the higher risk group, while an odds ratio less than 1.0 means that the attribute is associated with assignment to the lower risk group.

The proportion of the variance explained was calculated using the method of McKelvey and Zavoina[9] modified for logistic regression.[10]

Results

The total number of participants was 9690 of 13,911 sampled, resulting in a participation rate of 69.7%. Children with no missing values for any parameters used in the logistic regression numbered 9295.

Descriptive statistics among risk groups are shown in Tables 2 and 3. Table 2 shows that 27.3% of children were classified in the low-risk category, 59.9% in the moderate-risk category, while only 12.9% were classified as high risk. Mean age was slightly different among the children according to risk groups, with older children more likely to be in the lower risk groups.

Fluoride had been applied professionally to only a third (36.5%) of the child population in this sample. Children in the higher risk groups were more likely to have had professionally applied fluoride. Sealants had been applied to the permanent teeth of a third (33.4%) of the children, while sealants were used rarely in the primary dentition (1.1%). Children in the higher risk categories were more likely to have had sealants applied to their teeth. In general, the three variables describing past professionally applied preventive measures showed a tendency for the children in the higher risk groups to have received more preventive services.

Table 3 shows clinical data for two age groups. Children's caries experience was low as evidenced by the mean DMFS of 1.14 at age 12 years. This, however, varied considerably among the three risk groups, with children in the higher risk groups having higher mean DMFS. This pattern of higher risk categories having

TABLE 2. DESCRIPTIVE STATISTICS BY RISK GROUP, FOR ALL THE CHILDREN

	RiskGroup			*Total*
	Low N=2534 (27.3%)	*Moderate* N=5565 (59.9%)	*High* N=1196 (12.9%)	N=9295 (100%)
		Mean (sd)		
Age	10.2 (3.0)	9.4 (2.9)	8.1 (2.6)	9.4 (3.0)
% of lifetime F-water consumed	47.1 (44.4)	51.1 (45.2)	47.1 (45.2)	49.5 (4.5.1)
Brushing frequency	11.5 (4.2)	10.8 (4.3)	10.6 (4.5)	11.0 (4.3)
		Percent		
Country of birth; not born in Australia	3.0	4.7	5.9	4.4
Sealants used on permanent teeth	28.5	35.7	33.6	33.4
Sealants used on primary teeth	0.3	1.1	2.5	1.1
Exposed to professionally applied fluoride	24.3	36.6	61.8	36.5
Caries on permanent teeth (DMFS>0)	17.0	29.5	29.8	26.2
Caries on primary teeth (dmfs>0)	11.2	43.3	84.9	39.9

TABLE 3. DESCRIPTIVE STATISTICS BY RISK CATEGORY, FOR CHILDREN IN TWO REPRESENTATIVE AGE GROUPS

	Risk group			*Total*
	Low *Mean (sd)*	*Moderate* *Mean (sd)*	*High* *Mean (sd)*	*Mean (sd)*
12 year olds	*n=256 (34%)*	*n=448 (60%)*	*n=40 (5%)*	*n=744(100%)*
DMFS on permanent teeth at 12 yrs	0.50 (1.10)	1.35 (1.87)	2.85 (3.83)	1.14 (1.89)
DMFS among occlusal surfaces of permanent teeth at 12 yrs	0.50 (0.60)	1.15 (1.56)	1.68 (1.98)	0.93 (1.46)
DMFS among proximal surfaces of permanent teeth at 12 yrs	0.04 (0.22)	0.13 (0.48)	0.75 (1.85)	0.13 (0.60)
D-proportion of DMFS on permanent teeth at 12 yrs	0.03 (0.20)	0.21 (0.54)	0.65 (1.12)	0.17 (0.52)
6 year olds	*n=201 (21%)*	*n=583 (60%)*	*n=192 (20%)*	*976 (100%)*
DMFS on permanent teeth at 6 yrs	0.01 (0.16)	0.04 (0.24)	0.14 (0.51)	0.05 (0.31)
DMFS among occlusal surfaces of permanent teeth at 6 yrs	0.01 (0.16)	0.03 (0.24)	0.13 (0.49)	0.04 (0.29)
DMFS among proximal surfaces of permanent teeth at 6 yrs	0.00 (0.00)	0.00 (0.00)	0.01 (0.10)	0.00 (0.05)
D-proportion of DMFS on permanent teeth at 6 yrs	0.01 (0.07)	0.03 (0.23)	0.09 (0.39)	0.04 (0.25)
dmfs on primary teeth at 6 yrs	0.20 (0.98)	1.85 (3.58)	9.91 (9.11)	3.09 (5.99)
dmfs among occlusal surfaces of primary teeth at 6 yrs	0.12 (0.64)	0.96 (1.73)	4.19 (2.90)	1.42 (2.35)
dmfs among proximal surfaces of primary teeth at 6 yrs	0.05 (0.31)	0.65 (1.50)	4.28 (4.43)	1.24 (2.75)
d-proportion of dmfs on primary teeth at 6 yrs	0.02 (0.19)	0.46 (1.17)	2.30 (2.61)	0.73 (1.67)

more evidence of past caries experience was repeated in the various breakdowns of the DMFS and dmfs indices for other age groups not shown in Table 3.

Table 4 presents odds ratios from two logistic regression models. Model I compares the odds of being in a moderate-risk category with the odds of being in a low-risk category, and model II compares the odds of being in a high-risk category with the odds of being in a moderate-risk category. Variables that are listed in Table 1, but are not in either of the models in Table 4, did not reach statistical significance in the model building process. Blank cells in Table 4 indicate statistical nonsignificance in the corresponding model.

Squared terms of main effects are included in the tables where such terms reached significance, indicating that there was not a simple linear relationship between the variable and the logit of the outcome variable. Other main effects that have no squared term associated with them satisfied the assumption of linearity in the logit.

The effects of age in the models were strong, and also nonlinear in the logit. As an example, the odds of going

Table 4. Odds ratios (OR) with 95% lower and upper confidence bounds (L95,U95) of increased risk

Predictors	*Model I* Comparing "low" to "moderate" risk (N = 8099) OR	L95	U95	*Model II* Comparing "moderate" to "high" risk (N = 6910) OR	L95	U95
Age at examination; in years [5–15]	**0.74**	0.65	0.84	**0.33**	0.27	0.40
— squared	**1.01**	1.00	1.01	**1.05**	1.04	1.06
Country of birth; born in Australia=0, elswhere=1	**1.45**	1.08	1.93			
Times brushed per week [0–21]	**0.98**	0.96	0.99			
Proportion of lifetime F^- water consumed [0.0–1.0]	**0.53**	0.28	0.97	**1.55**	1.30	1.84
— squared	**1.01**	1.00	1.02			
Exposure to professionally applied fluoride. Ever=1 Never=0	**1.36**	1.19	1.56	**2.09**	1.74	2.50
Sealant use on permanent teeth. No sealant=0, One+ sealant=1	**1.42**	1.24	1.62			
Sealant use on primary teeth. No sealants=0, One+ sealant=1				**1.50**	1.11	2.02
Caries free in permanent dentition? No=0, Yes=1	**0.70**	0.56	0.87			
DMFS on occlusal surfaces of permanent teeth	**1.30**	1.20	1.41	**1.14**	1.06	1.22
DMFS on proximal surfaces of permanent teeth	**1.52**	1.18	1.95	**2.06**	1.70	2.50
— squared				**0.96**	0.94	0.98
D-portion of DMFS in permanent teeth	**7.42**	4.26	12.93	**1.97**	1.70	2.28
— squared	**0.65**	0.52	0.81			
Caries free in primary dentition? No=0, Yes=1	**0.44**	0.35	0.56	**0.48**	0.34	0.62
dmfs on occlusal surfaces of primary teeth	**1.17**	1.06	1.29	**1.12**	1.07	1.17
dmfs on proximal surfaces of primary teeth	**1.39**	1.20	1.62	**1.34**	1.25	1.45
— squared	**0.97**	0.96	0.99	**0.99**	0.99	1.00
d-portion of dmfs in primary teeth	**2.69**	2.01	3.61	**1.56**	1.45	1.68
— squared	**0.93**	0.91	0.96	**0.98**	0.98	0.99
$L_0 - L_1$	10065.2-8272.3 = 1792.8			6429.6-4355.9 = 2073.7		
Pseudo R-Squared•	0.41			0.45		

• R2-Measure proposed by McKelvey and Zavoina,[9] modified for logistic regression.[10]

from moderate to high risk was 0.25 (= $0.33^{12-6} * 1.05^{144-36}$), indicating that a 6-year-old was 4.0 (= 1/0.25) times more likely to be in the high-risk group than was a 12-year-old, holding all other variables constant. Similar odds of going from the low-risk group to the moderate-risk group comparing a 6-year-old child with a 12-year-old were 0.35, indicating that a 6-year-old was 2.9 (= 1/0.35) times more likely to be in the moderate-risk group than was a 12-year-old, holding all other variables constant.

The models were both dominated by main effect terms that are measures of past or present dental caries, as evidenced by the large numbers of clinical terms that reached significance in each of the two models. These terms also tended to have stronger associations in the models, as evidenced by larger odds ratios. Three clinical factors, other than such markers of past dental caries, entered the models. Those were variables describing past use of dental sealants in both dentitions and a variable describing past exposure to professionally applied fluoride. However, no socioeconomic variables achieved statistical significance.

By using the method of McKelvey and Zavoina,[9] modified for logistic regression,[10] the variance explained by the two models was 41% for model I and 45% for model II.

Discussion

The clinicians in this study were given freedom to assign children to risk groups based on their own intuition, using clinical experience as their primary guide. Left to their own premises, they assigned only about an eighth (12.9%) of the children to the high-risk group. The low-risk group comprised another fourth of the children leaving the moderate-risk group as the largest by far. This is significant in public programs where limited resources are being distributed on the basis of risk assignment by clinicians.

The proportion of children placed in the high-risk group conforms with the distribution of caries in low caries populations where typically a small minority of the population has the great majority of dental disease.[11] It must, however, be emphasized that the risk groups in this study were not actual or statistical risks of dental disease in the children, but risk assignment by clinicians. It will be necessary to analyze longitudinal data to determine whether the clinicians predict the risks of future disease accurately or not, as well as whether they target their care correspondingly.

At the outset of the logistic regression model-building, all the variables in Table 1 were available. Of the variables that did enter the models, those derived from the DMFS and dmfs indices were the most numerous, representing eight of 14 main effects in model I and seven of 11 main effects in model II. The odds ratios associated with these DMFS/dmfs terms, also tend to be slightly higher than the other terms in the models. This suggests that the clinicians in this study based their decisions to a large extent on children's previous caries experience. This is not surprising because past dental disease has often been shown to be the best single predictor of future dental disease. It appears that the clinicians are using this information as the principal basis of their determination of risk status.

Of the variables describing past dental caries, there appears to be slightly higher odds ratios for those that describe past disease on permanent teeth than on primary teeth. This is consistent with clinicians being more likely to place a child in a higher risk group if the child had experienced caries on permanent teeth than if the past caries experience was on primary teeth. Similarly, a greater emphasis seemed to be placed on proximal caries experience than on occlusal caries experience. Caries on buccal and lingual surfaces are often considered by clinicians to be evidence of advanced and severe disease, but in this study, past caries experience on these surfaces did not reach statistical significance in the multivariate models. This may show that the clinicians are not basing their decisions on past caries on these surfaces, or that the number of individuals who had dental caries on those surfaces is simply too low for that factor to reach statistical significance in the model-building process.

Of the variables derived from the DMFS and dmfs indices, the decayed component seemed to be the most influential when clinicians assigned children to a risk group. This component is, of course, measuring unrestored decay (whether active or arrested), and in a public dental health system where dental care is provided on a regular basis, may be a better indicator of perceived risk of future disease than the other components of the index. As an example, a child with one decayed surface in a permanent tooth (D = 1) was 4.8 ($= 7.42^{1-0} * 0.65^{1-0}$) times more likely to be placed in the moderate-risk group than a child having no such decayed surface (D = 0). This variable does not have a linear relationship with the logit of the outcome, so different odds ratios are derived at different levels of decay. For example the previous example comparing D = 1 with D = 0 resulted in an odds ratio of 4.8, whereas comparing D = 2 with D = 1, although still a one-unit increase, results in an odds ratio of 2.0, indicating that a child with two unrestored decayed surfaces was twice as likely to be placed in the moderate-risk category than a child with one such surface. This indicates that the increment from no decay to one decayed surface is more important in the clinicians' risk group assignment than is the increment from one decayed surface to two decayed surfaces. Similar differences can be demonstrated for other variables that have a squared term associated with the main effect term.

Three variables that reached significance in the models were designated clinical variables, although they are not based on the DMFS and dmfs indices. These variables described sealant use on permanent and primary teeth and exposure to professionally applied fluoride. It is of note that all these variables describing past exposure to professionally applied preventive measures have odds ratios larger than the one associated with them, indicating that the children who have been exposed to these measures were more likely to be placed in the higher-risk groups than children who had never been exposed to such measures. This may indicate that the clinicians in South Australia are targeting their preventive services at children who are perceived at higher risk of developing dental disease, an appropriate use of these preventive measures. These factors might also be surrogate measures of previous decisions made by clinicians about children's risk for oral disease. Previous decisions about risk are probably a good predictor of the present risk grouping. Furthermore, a child previously identified to be at high risk may have received more intensive diagnosis and treatment, therefore creating potential for a cascade effect, whereby risk status leads to a greater number of fillings, which leads to an increased likelihood that the child will be identified as high risk. However, it should be emphasized that this study coincided with the first occasion in which clinicians in the South Australian Dental Service formally designated and recorded risk status. Hence, any earlier cascade effects probably would have been limited, as practitioners were not required to assess risk or use risk status in formulating treatment plans. Of the demographic and SES variables, only age and country of birth reached significance. This is not surprising as age is known to be strongly associated with dental caries, and immigrant populations in many developed countries are recognized to have severe caries problems. Country of birth was, however, only marginally significant in model I, and not significant in model II.

The proportion of lifetime that the child lived in an area with fluoridated water was a statistically significant variable in both the models. Children who had lived in a fluoridated area all their life were almost twice as likely to be placed in the low-risk group than in the medium-risk group. The reverse association was found in model II, where the odds of being placed in the higher risk group increased with increasing exposure to fluoridated water. This unexpected result could indicate that clinicians base their risk assessments on factors related to children's residence history. Because urban areas are much more likely to have fluoridated water supplies, it is possible that this association is confounded by the clinicians' judgments about nonfluoride-related urban/rural differences in caries experience and caries risk.

While the clinicians know the race and gender of the child at the time of examination, neither entered into the decision-making process when clinicians were assigning a child to a risk group. Similarly, clinicians can often guess the SES of many children's families through interaction with parents. However, neither parents' education nor household income enter into the risk assessment decision, at least after clinical factors are controlled for. This indicates either that the clinicians do not consider the SES factors important, or that they do not know enough about the child's background to make use of those factors. It is also possible that the influence of SES factors on the decision is already captured by other factors that did enter into the models, as past disease experience is associated with SES.

The amount of variance explained by the models was substantial, with 41% of the variance explained in model I and 45% in model II. It must be noted, however, that there is no universally accepted method of estimating the variance explained by a logistic model, in contrast to the use of R^2 for linear regression. The previously quoted percentages must therefore be interpreted cautiously, and are only to be taken as an approximation of the variance explained. Nevertheless, the models explain more than 40% of the variance, which indicates that clinicians base their allocation to risk groups, to a large extent, on factors that are measured in a typical oral health survey such as the Child Fluoride Study.

This study did not address clinician variability as a source of variation in the risk grouping. Alanen et al.[3] showed that there are great differences between the performance of individual clinicians in their attempts to predict caries. Thus it may be important in future studies to attempt to understand what information the superior clinicians are using as the basis for their prediction.

There is, however, the major proportion of the variance that is still unexplained. Factors that are available to clinicians at the time of examination but were not in this survey are numerous. These include, among others, factors accurately describing oral hygiene, plaque accumulation, tooth morphology and position, fissure morphology, saliva viscosity, child personality, and general personal hygiene. The only measure that relates to this unknown ensemble of variables is the self-reported brushing frequency, which was significant in one of the models. This variable indicates general oral hygiene behavior, and may indicate plaque accumulation to some extent. Additional unexplained variance may be due to factors of past caries experience that are not fully captured by the DMFS and dmfs indices. For example, initial caries lesions or white spot lesions are not included in the indices, and the severity of the carious lesions are not fully described by the indices.

Conclusions

1. In this cross-sectional study of South Australian children aged 5–15 years, clinicians placed most children in the moderate-risk category, a third in the low-risk category, and only 12.9% in the high-risk category.
2. More than 40% of the variability in risk group assignment could be accounted for by logistic models using data available in this typical oral health survey.
3. The majority of factors that were shown to be of importance in modeling the risk-group assignment were clinical factors that were markers for past caries experience. Three other clinical factors of importance in the models were markers for past exposure to professionally applied preventive measures. Of all SES, demographic, oral hygiene and fluoride variables only country of birth, frequency of toothbrushing and previous exposure to fluoridated water proved to be of importance in the models. None of the SES factors reached significance in the models.
4. Clinicians based their assignment decisions to a larger extent on caries experience in permanent teeth than on caries experience in primary teeth. Factors indicating history of proximal caries were stronger predictors of assignment to the higher risk groups than were factors indicating past history of occlusal caries, while factors describing caries on buccal and lingual surfaces appeared unimportant. Untreated lesions in the permanent and primary dentitions were among the strongest predictors of assignment to the higher risk groups.

Dr. Sæmundsson is a Fellow and Dr. Slade is an Assistant Professor, both in the Department of Dental Ecology, School of Dentistry, University of North Carolina-Chapel Hill. Dr. Spencer is a Professor and Mr. Davies is a Research Officer, both with the AIHW Dental Statistics and Research Unit at the University of Adelaide in Australia.

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