



# Simple predictive model for early childhood caries of chilean children

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SIMPLE PREDICTIVE MODEL FOR EARLY CHILDHOOD CARIES OF CHILEAN CHILDREN  
*MODELO SENCILLO PARA PREDICCIÓN DE CARIES TEMPRANA DE LA INFANCIA EN NIÑOS CHI-  
LENOS*

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### Abstract

**Introduction:** Early Childhood Caries (ECC), in both industrialized and developing countries, is the most prevalent chronic disease in childhood and it is still a health public problem, affecting mainly populations considered as vulnerable, despite being preventable.

**Objective** The purpose of this study was to obtain a simple predictive model based on risk factors for improving public health strategies for ECC prevention for 3-5 year-old children.

**Methods** - Clinical, environmental and psycho-socio-cultural data of children (n=250) aged 3-5 years, of both genders, from the Health Centers, were recorded in a Clinical History and Behavioral Survey. **Results**-24% of children presented behavioral problems (bizarre behavior was the main feature observed as behavioral problems). The variables associated to dmf  $\geq 4$  were: bad children temperament (OR=2.43 [1.34, 4.40]) and home stress (OR=3.14 [1.54, 6.41]). It was observed that the model for male gender has higher accuracy for ECC (AUC= 78%, p-value=0.000) than others.

**Conclusions**- Based on the results, we proposed a model where oral hygiene, sugar intake, male gender, and difficult temperament are main factors for predicting ECC. This model could be a promising tool for cost-effective early childhood caries control.

### Keywords

Early childhood caries; prevention; health primary care

### Resumen

**Introducción:** Las caries temprana de la infancia (CTI), a pesar de ser una enfermedad prevenible, permanece como uno de los problemas de salud pública, tanto en países industrializados como en los que están en vías de desarrollo, afectando principalmente a poblaciones vulnerables.

**Objetivo:** el objetivo de este trabajo fue generar un modelo sencillo basado en factores de riesgo que sea predictivo del riesgo de CTI en niños de 3-5 años de edad a fin de mejorar las estrategias preventivas a nivel de salud pública.

**Métodos:** Se recolectaron datos clínicos, del hogar y psico-socio-cultural de niños (n=250) de ambos sexos que concurren a centros de salud en la región del Bio Bio –Chile mediante historia clínica y encuesta de comportamiento.

**Resultados:** 24% de los niños presentó problemas de comportamiento (un comportamiento extraño fue la principal característica observada como problema de comportamiento). Las variables asociadas a ceo  $\geq 4$  fueron: mal temperamento del niño (OR=2,43 [1,34; 4,40]) y estrés del hogar

(OR=3,14 [1,54; 6,41]). Se observe que el modelo estratificado por género masculino fue el que presentó la mayor precisión diagnóstica de CTI (AUC= 78%, p-valor=0.000); además Conclusiones: Proponemos un modelo donde la higiene oral, el consumo de azúcar, el género masculino y el mal temperamento son los principales factores de predictivos de CTI. Este modelo podría ser una herramienta promisoría para el costo-efectividad del control de caries temprana.

#### Palabras claves

Caries temprana de la infancia, atención primaria de la salud, prevención

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### Introduction

Early Childhood Caries (ECC), in both industrialized and developing countries, is the most prevalent chronic disease in childhood and it is still a health public problem, affecting mainly populations considered as vulnerable, despite being preventable. In the development of ECC, several factors, such as oral hygiene procedures, fluoride drinking water, infant feeding habits, dietary cariogenic habits, and psycho-social factors, are involved.<sup>1-3</sup>

The goal in the development of dental interventions is to build theoretical and empirical models for health prevention. Authors such as Giannoni et al.<sup>4</sup> carried out a review of studies on prediction methods to evaluate caries risk factors in order to establish context-related oral health programs. Pine et al.<sup>5</sup> reported that critical areas to be considered in these models were social and cultural aspects surrounding child development, such as family stress, nutrition, access to fluoride and use of sugars, composition and activity of oral microflora, as well as recognition of behavioral and biological impacts on health. In addition, family stresses, difficult temperaments of the children and dysfunctional parenting behaviors may lead to a child being at risk for ECC.<sup>6</sup> Several conceptual models have been suggested, although the clinical practice of caries risk assessment has no model that is sufficiently simple for children aged 3-5 years and applicable at health primary care services.<sup>6,7</sup>

The purpose of this study was to obtain a simple predictive model based on risk factors for improving public health strategies for ECC

prevention for 3-5 year-old children.

### Materials and Methods

#### Study design

Children (n=250) aged 3-5 years, both genders, were recruited from the Health Centers belonging to the Municipality of Concepción included in the health insurance system, National Health Fund. Cases were children aged 5 years or less, at least had four caries; one or more affecting maxillary incisors. Children who presented systemic pathologies, mental diseases or disabilities and children without adults, and/or taking any medicines were excluded. Inclusion criteria were that children were medically healthy, had full primary dentition, and were without systemic chronic diseases. Successive children who fulfilled inclusion criteria were enrolled. The study was approved by the Research and Ethics Committee, and followed the guidelines of the Declarations of Nuremberg, Helsinki, and Tokyo of the World Medical Association. Informed consent forms were signed by the parents or guardians of all children.

Cluster sampling was carried out according to the population distribution of the Health Service of Concepcion, Department of Health Information, of those attending every health center (<http://www.minsal.cl>). Significance level and efficiency were  $\alpha=0.05$  and 80%, respectively. The number of children was calculated as  $n = \frac{p}{c} \left( z + \frac{z^2}{4p} \right)^2$ , where p is the a priori supposed response, c is the amplitude of the confidence interval and z represents the probability obtained from a normal distribution with expectation 0 and va-

Variable	Categories	Cut-off criteria
ECC (outcome)	0: dmf with values between 0 and 3 (controls); 1: dmf with values $\geq 4$ (cases)	According to American Academy of Pediatric Dentistry 8
Child education	0: kindergarten 1: child care	Via anamnesis
Gender	0: male 1: female	Via anamnesis
Child behavior	0: the score < percentile 90 means without problems 1: the score > percentile 90 means with problems	According to Survey developed by Rodriguez et al.12
Mother Stress	0: the score < percentile 90 means without problems 1: the score > percentile 90 means with problems	According to Survey developed by Rodriguez et al.12
Home Environment	0: the score < percentile 90 means without problems 1: the score > percentile 90 means with problems	According to Survey developed by Rodriguez et al. 12
Bottle	0: no consumption 1: yes consumption	Via anamnesis
Oral Hygiene	0: acceptable; 1: deficient and insufficient	According to the simplified Greene and Vermillion index 14

**Table 1. Criteria and cut-off points of study variables**

riance<sup>1</sup>. The study variables and their corresponding cut-off points are shown in Table 1.

### Study Measures

#### Behavioral and Socioeconomic Measures

The instrument performed and validated by Rodriguez et al.<sup>9</sup> for Chilean population was used to assess of the behavioral and socio-emotional problems of children. This survey consists of three parts evaluating: a) behaviour and emotions of the children; b) perceptions and emotions of the mother, and c) socioeconomic conditions of the child's home. A score  $\geq$  percentile 90 means difficult temperaments of the children, home stress and mother stress.

The socioeconomic level was evaluated through the GRAFFAR Index 10, an international outline for clustering children and adolescents based on the social characteristics of family, father's profession, education level, sources of income, kind of house and features of geographic area. Families are classified into five strata: Class I and II: higher level status; Class II and III: medium level; and Class IV and V: relative and critical poverty.

#### Dental clinical exam

Oral health examinations were performed by a specialist in pediatric dentists previously training with psychologist. The study involved

routine instrumental exploration with artificial light after cleaning teeth with a toothbrush and drying them. The following variables were observed: oral hygiene (OH), following the simplified Greene and Vermillion index 11; and dmf (decayed-missing-filled in temporary teeth), following the WHO criteria.<sup>12</sup>

#### Statistical Analysis and Models

The free software R 2.15.3 ([www.r-project.org](http://www.r-project.org)) was used. Data analysis was as follows, and critical level for establishing statistical significance was set at  $p < 0.05$ :

- Estimated association among variables was performed by table 2x2, odd ratios (OR) and 95% confidence intervals (CI95%); and Cochran-Mantel-Haenszel test for stratification analysis;
- Logistic models were built to estimate the predictive values (only significant variables were included in the models);
- The accuracy of each model built was assessed by the Area Under the Receiver Operating Characteristic (ROC) Curve (AUC) estimated by non-parametric methods.

### Results

#### Biodemographic aspects

Of the total of children observed, 51.0% were male, 82% went to kindergarten and their me-

dian age was 4 years. Usually, the family composition was one or two children, mothers had a median age of 30 years and a high percentage (94%) had secondary or university studies, and 52% had no partner.

Child dentistry aspects

In relation to the dentistry clinic characteristics and habits associated with oral health, it was observed that a 47% of children used a bottle and 47% of the total had deficient oral hygiene. 53% of the children consumed sugar 4 or more times per day. In the children study population, 163 (65%) had presence of dmf < 4, and 87 (35%) had dmf ≥ 4. The variables associated to dmf ≥ 4 were inappropriate oral hygiene (OR=4.03[2.28, 7.12]); bottle use (OR=1.89[1.12, 3.19]); sugar intake ≥ 4 times per day (OR=3.75[2.10, 6.70]) (Table 2).

Behavioural and socio-economic aspects

The majority of families belonged to Class IV (56%), and Class III (42%) Graff Index (Table 1). 24% of children presented behavioral problems, and unusual/bizarre behavior was

the main feature observed (38%) as behavioral problems. The variables associated to dmf ≥ 4 were: bad children temperament (OR=2.43 [1.34, 4.40]) and home stress (OR=3.14 [1.54, 6.41]). The associated variables of survey to children behavior with dmf ≥ 4 were aggressiveness, reticence, immaturity, diminished imagination, gender temperament, and fear (Table 3).

Logistic Models

It was built two models: a) model without stratification, and b) model split by gender. It was observed that the model for male gender has higher accuracy (AUC= 78%, p-value=0.000) than others. And it was observed in the model for male gender that the child behavior variable was associated with the presence of early decay (Table 4).

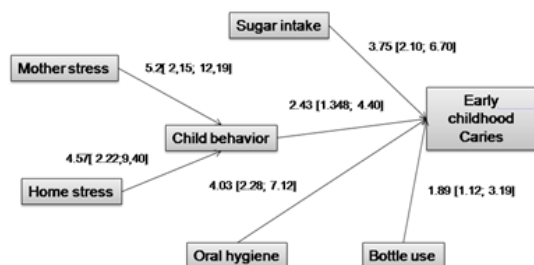
The Figure 1 shows a final graph model built in order to explain the associations and magnitude of association (OR and 95%CI) among studied variables.

Variables	Categories	Total subjects (n=250)		χ2 test p-value(*)	Crude OR; (CI95%)
		RF (AF) dmf ≥ 4 (n=87)	dmf < 4 (n=163)		
Gender	Female	37 (30.3)	85 (69.7)	0.1473	1.47; (0.87, 2.48)
	Male	50 (39.1)	78 (60.9)		
Schooling level- child	Kindergarten	68 (78.2)	137 (84.0)	0.2484	0.68; (0.35, 1.30)
Schooling level-mother	Primary	6(6.9)	8 (4.9)	0.2149	-----
	Secondary	53 (60.9)	117 (71.8)		
	University	28 (32.2)	38 (23.3)		
Oral Hygiene	Appropriate	22 (25.3)	94 (57.7)	0.0000	4.03; (2.28, 7.12)
	Inappropriate	65 (74.7)	69 (42.3)		
Bottle Use	No	60 (69.0)	83 (73.5)	0.0175	1.89; (1.12, 3.19)
	Yes	27 (31.0)	30 (26.5)		
Sugar intake frequency per day	< 4	48 (55.2)	134 (82.2)	0.0000	3.75; (2.10, 6.70)
	≥ 4	39 (44.8)	29 (17.8)		
Socio Economic Status (Graff Index)	IG-II	4 (4.6)	2 (1.2)	0.1658	-----
	IG-III	32 (36.8)	72 (44.2)		
	IG-IV	51 (58.6)	89 (54.6)		
Children behavior	Score ≥ percentile 90	30 (34.5)	29 (17.8)	0.0031	2.43; (1.34, 4.40)
Mother stress	Score ≥ percentile 90	12 (13.8)	11 (6.7)	0.0664	2.21; (0.95, 5.16)
Environment stress	Score ≥ percentile 90	21 (24.1)	15 (9.2)	0.0014	3.14; (1.54, 6.41)

Table 2. Biodemographic and Behavioral and Socioeconomic features, clinical dental exam and oral habits measured. RF: relative frequencies; AF: absolute frequencies. (\*) Association statistical significance set at p ≤ 0.05 between dmf ≥ 4 (outcome) and other variables.

Respondent	Survey questions	Proportion (dmf $\geq$ 4)	p-value $\chi^2$	OR	LB 95%	UB 95%	p-value CMH	OR MH	L 95%	B 95%	UB 95%
Child	Aggressiveness	0.24	0.0158	2.28	1.16	4.45	0.0173	2.27	1.26	4.10	
	Reticence	0.24	0.0234	2.15	1.11	4.18	0.0334	2.08	1.17	3.70	
	Immaturity	0.41	0.0081	2.10	1.21	3.64	0.0183	1.98	1.23	3.20	
	Rare behavior	0.42	0.0000	3.54	2.06	6.10	0.0000	3.43	2.41	4.89	
	No sphincter control	0.21	0.1985	1.54	0.80	2.97	0.2750	1.45	0.84	2.47	
	Anxiety	0.16	0.1052	1.89	0.88	4.08	0.1329	1.83	0.94	3.53	
	Diminished imagination	0.17	0.0053	3.19	1.39	7.32	0.0070	3.15	1.45	6.82	
	Gender Behavior	0.10	0.0171	3.65	1.23	10.78	0.0116	4.07	1.39	11.88	
	Fear	0.31	0.0036	2.48	1.34	4.61	0.0041	2.48	1.43	4.29	
Mother	Depression	0.14	0.0064	3.40	1.38	8.38	0.0049	3.48	1.48	8.16	
	Partner relationship	0.24	0.0014	3.14	1.54	6.41	0.0016	3.05	1.59	5.86	
	Abandon	0.11	0.1368	1.99	0.81	4.88	0.1338	2.00	0.91	4.39	
	Isolation	0.08	0.2191	1.95	0.68	5.56	0.2155	1.94	0.77	4.88	
	Problem	0.21	0.0005	3.86	1.77	8.44	0.0006	3.79	1.80	7.96	

**Table 3. Association among survey questions and dmf $\geq$ 4. Significant level was fixed 5%. CMH: Cochran-Mantel-Haenszel test. MH: Mantel-Haenszel test OR: Odd ratios, CI95%:95% confidential intervals, UB: upper bound; LB: low bound. Reference category: first. Bold letter: indicate significant association.**



**Figure 1. Graph model for risk of early childhood caries. Arrows indicated a direction of association and the numbers correspond to Odd Ratios and its respective 95% confidence intervals.**

## Discussion

The high prevalence of ECC produces adverse health effects, as well as high rates and costs of restorative and surgical procedures. ECC is the most preventable complex disease in children younger than 5 years, but is influenced by multiple factors.<sup>13, 14</sup>

In our study, the main identified variables are risk known factors of ECC: sugar intake, oral hygiene, and bottle use. In addition mother stress, child behavior, and home stress were

observed related to mentioned variables. Numerous studies have described risk factors of ECC such as social status, behavior, oral hygiene, among others.<sup>6-7, 15-16</sup>

Severe caries in preschool children has long been considered as "nursing caries" or "bottle caries" and is attributed to prolonged bottle-feeding with sweetened liquids.<sup>17</sup> The latest literature suggests that use of a sugar-containing liquid in a bottle may be an important, although not necessarily the only, etiological factor.<sup>18</sup> In agreement with the majority of studies, we observed a significantly association with ECC.

Furthermore, 53% of the children consumed sugar 4 or more times per day. A significant association was seen between dmf  $\geq$  4 and higher frequency of sugar intake (4 or more). Related to this result, studies by Palmer et al.<sup>18</sup> stated that sugar food frequency, among other factors, was associated with severe ECC. Prakash et al.<sup>19</sup> also showed that decay increased significantly when snacks were consumed between meals.

Approximately 47% of children presented



Stratification by	Parameter	Estimated	SE	CI 95%			$\chi^2$	p-value	ROC		
				OR	LB	UB			Area	Std. Err.	p-value
	Constant	1.45	0.53	4.25	1.51	11.95	7.51	0.0061			
	Sugar intake	-0.85	0.33	0.43	0.23	0.81	6.78	0.0092		0.0305	0.000
	Bottle use	-0.11	0.31	0.90	0.49	1.64	0.13	0.7208	0.7449		
Without	OH	-1.07	0.31	0.34	0.19	0.63	11.75	0.0006			
	Children Behav	-0.34	0.35	0.71	0.36	1.41	0.94	0.3330			
	Mother stress	-0.38	0.50	0.69	0.26	1.81	0.58	0.4478			
	Home stress	-0.48	0.41	0.62	0.27	1.40	1.34	0.2475			
	Constant	0.62	0.75	1.87	0.43	8.15	0.69	0.4062			
	Bottle use	-1.19	0.46	0.30	0.12	0.75	6.67	0.0098			
Female	OH	-1.14	0.46	0.32	0.13	0.78	6.21	0.0127	0.7618	0.0291	0.000
	Home stress	0.08	0.72	1.08	0.26	4.41	0.01	0.9138			
	Mother stress	-1.29	0.80	0.27	0.06	1.31	2.64	0.1044			
	Children Behav	0.94	0.76	2.57	0.58	11.34	1.55	0.2125			
	sugar intake	-0.02	0.52	0.98	0.35	2.72	0.001	0.9697			
	Constant	2.58	0.85	13.2	2.50	69.7	9.22	0.0024			
Male	Bottle use	0.88	0.49	2.40	0.93	6.24	3.25	0.0714			
	OH	-1.16	0.48	0.31	0.12	0.81	5.76	0.0164	0.7825	0.0282	0.000
	Home stress	-1.21	0.64	0.30	0.09	1.03	3.66	0.0558			
	Mother stress	-0.33	0.72	0.72	0.18	2.92	0.22	0.6414			
	Chil Behav	-1.03	0.47	0.36	0.14	0.90	4.78	0.0288			
	Sugar intake	-1.60	0.48	0.20	0.08	0.52	10.94	0.0009			

Table 4. Logistic Regression Models, reference category: last. OR: Odd ratios, CI95%:95% confidential intervals, UB: upper bound; LB: low bound. The critical level was set at  $p < 0.05$  for establishing statistical significance.

inappropriate OH. Several studies have associated OH habits qualitatively and quantitatively with oral microbiota<sup>17</sup>, and quality (protein profiles) and quantity of saliva (salivary flow per minute)<sup>20</sup>. 30% of male children were observed to have difficult temperament and  $dmf \geq 4$ .

Moreover, a significant association was found between  $dmf \geq 4$  in males and difficult temperament and home stress. In studies on alimentary practices and children's temperament, O'Hughes et al.<sup>21</sup> observed that negative emotions of parents were directly related to problems in feeding their children. These

authors considered that temperament plays an important role in parent-child relationship, because parents may react differently to children who are more internally controlled as compared to those who are more reactive in their temperaments. Suglia et al. observed an association between soda consumption and negative behavior in 5 year old children. Those authors performed an adjusted for socio-demographic factors analysis and observed that different consumed amounts of soda was associated with a higher aggressive behavior score compared with consuming no soda.<sup>22</sup> Authors as Zhou et al.<sup>23</sup> reported that relation-

ship among socioeconomic, behavioral and biological factors and ECC and they consider early life factors play an important role in the development of ECC.

Generally, the proposed models of ECC in literature are highly complex and not easy to apply at primary health care level.<sup>5-7</sup> Our focus is based on identifying the main variables that can be easily monitored at primary health care; when the risk models include a few variables, it could be enabled the screening of a large number of children. Petersen considers that certain behavioral patterns or lifestyles influence outcomes via physiological processes, and they are risks over which an individual has at least some control.<sup>24</sup>

Based on the results, we proposed a model where oral hygiene, sugar intake, male gender, and difficult temperament are main factors for predicting ECC. This model could be a promising tool for cost-effective caries control and evidence-based treatment planning.

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