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Original Research

Dental Caries Predictors in Countries with Different Human Development Index: A Review of Articles

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Abstract:

Background: The aim of this study was to compare the positive tested dental caries predictive factors conducted from very high human development countries (VHHDC) and not VHHDC (NVHHDC).

Methods: A comprehensive review of the available longitudinal studies on predictors of dental caries was undertaken using MEDLINE (PubMed) and Cochran database. Keywords for the search were: Dental caries, dental caries susceptibility with combination with the terms prognosis, forecasting, susceptibility, and predict*. Abstracts (n = 410) identified from an MEDLINE, and Cochrane registry and international journals. Search was screened independently by two investigators to exclude articles not in English, published prior to 2004, or containing no information on predictors of dental caries. Data from these included studies (n = 50) were extracted and compiled into evidence tables for further considerations.

Results: 50 articles were selected for data extraction. Follow-up time of the published studies was between 6 months and 27 years (median = 4.72); articles sample size ranged from 30 to 51000, and 89% articles started at childhood (before 12 years). Variables most frequently tested as caries predictors in included articles (n = 53), were: Baseline caries (46%), diet (26%), and tooth brushing habit (22%). Baseline caries was shown as the strongest single predictor in VHHDC and NVHHDC. Caregiver's education was found to be a significant predictive factor in NVHHDC in compare with VHHDC. The predictive ability of tooth brushing and diet (20%) were more significant in VHHDC.

Conclusions: Although finding predictive factors has been conducted in many VHHDC, research in the field of dental caries prediction in NVHHDC is inconclusive and insufficient as confirmed in this review. According to the various differences between these two groups of countries, it is important to develop more evidence in this field in different countries.

Key Words: Dental caries, human developing index, prediction

Introduction

Dental caries is one of the most common chronic diseases in childhood and the primary cause for oral pain and tooth loss for all countries.[1-3] Predicting the future incidence of dental caries is still a major challenge between epidemiologists.[4] Knowing that prediction is a statement or claim that a particular event will occur in future, cohort longitudinal studies specially birth cohorts, that focus on the time changing incidence of dental caries can be the best studies indicating the predictors of dental caries in future. Cross-sectional studies have shown that dental caries is a multifactorial disease and can be established by genetic and environmental, social, and behavioral determinants.[5] These factors can also be influenced by culture, habits, income, education, access and even environmental factors such as the fluoride intake of each resident that can be different from person to person or place to place. Focusing on longitudinal studies, help us to find caries determinants that can influence the future incidence of dental caries for predictors. Knowing that the risk of dental caries can be influenced by different factors strengthens the theory that dental caries predicting factors can differ region by region or country by country.

Current evidence from literature indicating a relationship between caries level and risk factors is mainly based on studies conducted in developed or industrialized countries. Therefore, the relationship might not be applicable to countries at different stages of development. Besides, dental caries is a heavy burden particularly on certain minority and economically disadvantaged countries,[6] and interventions at the population and policy levels are highly cost-effective.[7] These facts urge us to classify these studies according to their countries to have a more clear view of dental caries predictors in countries with different developmental levels.

One of the most widely recognized tools for measuring development and comparing the progress of developing countries is the UNDP's human development index (HDI). The HDI scores and ranks each country's level of development based on three categories of development indicators: Income, health, and education.[8]

In this review, we confirm that there are several studies done on biological, behavior, and social factors predicting dental caries mostly in developed countries and their relation with the prevalence of dental caries.[9] Furthermore, we try to report a descriptive analyze of the predictors of dental caries in very high human development countries (VHHDC) and not VHHDC (NVHHDC) to understand the best cost-effective intervention for preventing dental caries in different countries.

Methods

Literature search and selection of articles

The electronic literature search was performed by a specialist and included the databases PubMed, and The Cochrane Reviews from January 2004 to December 2014. Articles in English were accepted. The initial search utilized medical subject headings (MeSH) terms or keyword searches of: Dental caries, dental caries susceptibility with combination with the terms prognosis, forecasting, susceptibility, and predict*. As caries predictors relations were defined after a period of time, our study was focused on cohort and longitudinal studies. The search strategy is shown in Table 1.

In addition to the electronic search, a hand search was made, and references from narrative reviews, textbooks, and articles in international journals not identified in the main search were included. Gray literature was not included. The abstracts were evaluated independently by two reviewers according to pre-determined inclusion criteria. An article was read in full text if one reviewer considered the abstract to be of potential relevance. All full text articles were assessed independently by the same two reviewers. Any disagreement about inclusion or exclusion of an article was solved by a third reviewer. Full-text articles that did not fulfill the inclusion criteria were excluded from further analysis. A flow chart showing the details and results of the search strategy is given in Figure 1.

For the purpose of this study, according to HDI, the results of these articles were classified into two groups. The first group was the studies conducted from VHHDC and the second those from NVHHDC.

Data from these included studies were extracted and compiled into evidence tables for further considerations.

Results

The initial broad electronic search identified 398 articles that were possibly relevant. Subsequently, an additional 12 references were identified, from the references lists in those 89 articles, narrative reviews, textbooks, and articles in international journals published from January 2004 through December 2014. By the "title-and-abstract" review-stage 308 (86.7%) of those 410 articles were rejected, resulting in the identification of 102 "most pertinent" articles. Finally, by a "full text" review, this set of 102 "most pertinent" articles was finally reduced to a set of 50 studies. The electronic search strategies are presented in Figure 1.

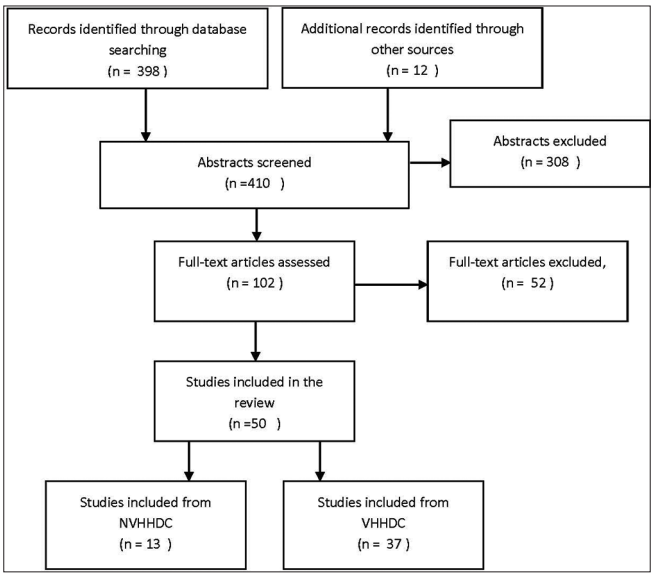


Figure 1: Flow chart showing strategy, numbers of included and excluded articles.

Table 1: Search strategies for PubMed-MEDLINE and Cochrane-CENTRAL databases.

Search	Query	Items found
1	Search ((((“Dental Caries”[Mesh]) or “Dental Caries Susceptibility”[Mesh])) or dental caries[Title/Abstract])	42608
2	Search ((((“Prognosis”[Mesh]) or “Forecasting”[Mesh])) or ((((suseptibility[Title/Abstract]) or predict*[Title/Abstract]) or forecasting[Title/Abstract]) or prognos*[Title/Abstract]))	2315410
3	Search ((((“Cohort Studies”[Mesh]) or “National Longitudinal Study of Adolescent Health”[Mesh])) or ((((((cohort[Title/Abstract]) or longitudinal[Title/Abstract]) or follow-up[Title/Abstract]) or follow-up[Title/Abstract]) or follow-up[Title/Abstract]) or prospective[Title/Abstract]))	2103335
4	Search (((((((“Dental Caries”[Mesh]) or “Dental Caries Susceptibility”[Mesh])) or dental caries[Title/Abstract]))) and (((((“Prognosis”[Mesh]) or “Forecasting”[Mesh])) or ((((suseptibility[Title/Abstract]) or predict*[Title/Abstract]) or forecasting[Title/Abstract]) or prognos*[Title/Abstract])))) and (((((“Cohort Studies”[Mesh]) or “National Longitudinal Study of Adolescent Health”[Mesh])) or ((((((cohort[Title/Abstract]) or longitudinal[Title/Abstract]) or follow-up[Title/Abstract]) or follow-up[Title/Abstract]) or follow-up[Title/Abstract]) or prospective[Title/Abstract])))	879
5	Search (((((((“Dental Caries”[Mesh]) or “Dental Caries Susceptibility”[Mesh])) or dental caries[Title/Abstract]))) and (((((“Prognosis”[Mesh]) or “Forecasting”[Mesh])) or ((((suseptibility[Title/Abstract]) or predict*[Title/Abstract]) or forecasting[Title/Abstract]) or prognos*[Title/Abstract])))) and (((((“Cohort Studies”[Mesh]) or “National Longitudinal Study of Adolescent Health”[Mesh])) or ((((((cohort[Title/Abstract]) or longitudinal[Title/Abstract]) or follow-up[Title/Abstract]) or follow-up[Title/Abstract]) or follow-up[Title/Abstract]) or prospective[Title/Abstract]))) Filters: Full text; published in the last 10 years; English	398

Table 2: Variables examined, modeling strategy, and key findings for the articles included in VHHDC.

Author name	Year of publication	Population studied	Sample size	Age start (years)	Observation time	Positive tested predictors
Markowitz *et al.*[21]	2012	USA	227	12.2±1.6	6 months-2 years	Molars with initial color changes
Nelson *et al.*[18]	2012	USA	224	3	14 years	Low SES, ethnicity, Mothers education, oral hygiene, yearly dental visits
Ferreira Zandoná *et al.*[22]	2012	USA	338	Kindergarten to 9th grade	4 years	ICDAS severity/activity at baseline
Morou-Bermudez *et al.*[10]	2011	USA	80	3-6 and 6-9	2-3 years	Saliva urease, baseline caries, *Mutans streptococci* in saliva
Fontana *et al.*[23]	2011	USA	395	5-13	2 years	Prediction models based on multiple questions including CG oral health belief, filled teeth soda beverage, and visiting dentist
Chankanka *et al.*[24]	2011	USA	198	5	3 years	Snack time intake of processed starches, toothbrushing, SES
Ditmyer *et al.*[25]	2011	USA	51000	13	5 years	A multifactorial prediction model consisting of ten variables
Fontana *et al.*[26]	2011	USA	329	26±6 months	1 year	Family caries experience, Transmission-related behaviors, dietary factors, health beliefs, and lower income
Nelson *et al.*[27]	2010	USA	224	Birth	14 years	Weight
Ismail *et al.*[28]	2009	USA	788	0-5 mean=2.6	2 years	Soda drinks, age, weight-for-age, dental treatment visits, baseline caries of children and their caregivers, dental fatalism, and neighborhood disadvantage status
Warren *et al.*[11]	2009	USA	212	6-24 months	18 months	MS and sugar-sweetened beverages
Maserejian *et al.*[29]	2009	USA	4293	6-11	5 years	Age, number of baseline caries surfaces, and toothbrushing frequency
Ekbäck *et al.*[30]	2012	Sweden	1985	3	16 years	A poor correlation between active caries disease at 6 and 19 years A stronger correlation between dental caries experience at 6 and 12 years
Petersson *et al.*[31]	2010	Sweden	392	11	2 years	Cariogram
Holgerson *et al.*[32]	2009	Sweden	103	2	5 years	Cariogram
Nordlund *et al.*[33]	2009	Sweden	30	14	2 years	Biological multimarkers and previous caries
Alm *et al.*[34]	2008	Sweden	539	1 and 3	14 years	Mother's self-estimation of her oral health care, gender, plaque on maxillary incisors at 1 year, father being less satisfied with his social situation. Tooth brushing with fluoride toothpaste just once a day
Brennan and Spencer[35]	2014	Australia	7673	13	17 years	Baseline caries, SES
Hooley *et al.*[36]	2012	Australia	4149	4-5	2 years (wave 2) and 4 years (wave 3)	Weight, sweet beverage, and fat diet
MacRitchie *et al.*[37]	2012	UK	697-784	1	4 years	DCRAM
Bernabé E[38]	2011	UK	886	11-12	4 years	Social support
Ito *et al.*[12]	2011	Japan	442	20-64	3 years	A model including age, number of caries teeth, numbers of cariogenic bacteria, the secretion rate and buffer capacity of saliva, and compliance with a prevention program
Kishi *et al.*[39]	2009	Japan	54	2.5	2 years	Mothers *Streptococcus mutans* and *Streptococcus sorbinus* and child's *S. mutans*
Tamaki *et al.*[40]	2009	Japan	560	5-6	2.5 years	Prediction model
Nishimura *et al.*[41]	2008	Japan	1206	Born	3.5 years	Caries activity test
Motohashi *et al.*[42]	2006	Japan	98	5	5.5 years	Baseline caries prevalence (dmft)
Hietasalo *et al.*[43]	2008	Finland	497	11-12	3.4 years	Brushing with fluoride toothpaste twice/day, eating candy ≥5 times/day
Mattila *et al.*[19]	2005	Finland	1074	1.5-3 years	7-9 years	Child's nocturnal juice drinking at 18 months, frequent consumption of sweets; infrequent tooth brushing; plaque and caries on teeth, father's young age at birth of the child; mother's education; mother's caries, and father's infrequent tooth brushing
Shearer *et al.*[44]	2011	New Zealand	835	5	27 years	Mothers self-rating oral health, edentulous mothers
Broadbent *et al.*[45]	2005	New Zealand	663	5	4 years	Primary maxillary incisors caries and opacities
Skeie *et al.*[46]	2008	Norway	354	3	2 years	Immigrant status, attitude to diet, and baseline caries
Skeie *et al.*[47]	2006	Norway	186	5	5 years	Baseline caries
Meller *et al.*[48]	2012	Germany	44	8	2 years	Baseline deft, cavitated active caries lesions, and filled teeth
Campus *et al.*[49]	2012	Italy	957	7-9	2 years	Cariogram
Gao *et al.*[50]	2010	Singapore	1782	3-6	1 year	Predicting model
Gao *et al.*[51]	2013	Hong Kong	544	3	1 year	Cariogram and NUS-CRA
Jeppesen and Foldspang[52]	2006	Denmark	3705	7-12	1 year	Baseline initial caries

VHHDC: Very high human development countries, DCRAM: Dundee caries risk assessment model, SES: Socio-economic status

Relevant Findings and Interpretations

Overview

A summary of the reviewed articles including the population studied, sample size, and key findings for the studies is shown in Tables 2 and 3. There was no disagreement between investigators at the data extraction phase. Follow-up time of the published studies ranged from 6 months to 27 years (median = 4.72) with 80% having a period of 6-month-5 year, and only six having an observation period longer than 10-year; sample size ranged from 30 to 51000 (interquartile range = 271; mean ± SD = 264 ± 203; median = 261); most analysis used logistic regression statistics (Graphs 1 and 2). The significant predictive variables also varied substantially among articles.

In the 50 eligible studies, 37 article (74%) were from VHHD, and 13 (26%) from NVHHDC (Graph 1). 72% articles were conducted after 2009 and 28% were done between 2004 and 2009. 44 out of 50 (88%) articles started at childhood (before 12 years) and only 6 out of 50 (12%) started after 12 years.

Characteristics of reviewed studies in VHHDC

The results of individual studies in VHHDC are summarized in Table 4. The review revealed that the highest percentage of identified studies, conducted in the VHHDC, were based in USA (32.5%), followed by Sweden and Japan (13.5%).

Only 13.5% of the studies started in adolescent versus 86.5% that started in childhood (before 12 years). The maximum follow-up period was 27-year in a study from New Zealand.

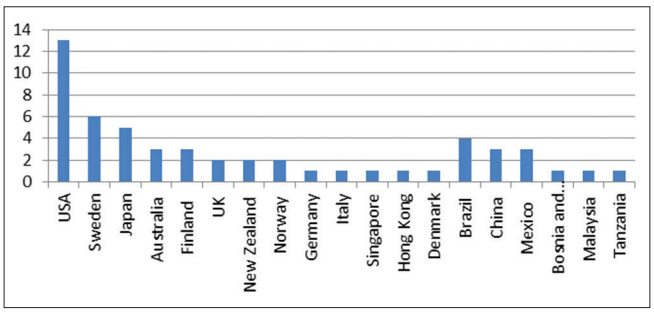
The majority of the articles (81%) assessed the predictors of dental caries using single variables of risk, others (9%), utilized risk assessment models to determine the predictors of dental caries.

Out of the nine identified areas of focus, baseline caries was examined as dental predictors in 15 out of 37 (40%) of studies in VHHDC from this number all were positively related to each other (Graph 2).

Cariogenic bacteria were proven to be a strong predictor in all of the eight studies (20%) examining this relationship.

Out of 37 articles, 10 (27%) assessed diet habits as a predictor of dental caries, and 9 out of these 10 (90%) identified it as a significant predictor.

Parent's education level was accessed in 7 (19%) of the studied articles that in 3 (43%), proved to be a significant predictor of dental caries.



Graph 1: List of countries according to the number of released papers on caries predicting factors.

Table 3: Variables examined, modeling strategy, and key findings for the articles included in not VHHDC (NVHHDC).

Author name	Year of publication	Population studied	Sample size	Age start (years)	Observation time (years)	Positive tested predictors
Kassawara[53]	2010	Brazil	765	7-8 and 9-10	2	Baseline initial active lesions
Peres *et al.*[4]	2009	Brazil	359	6	6	Baseline caries and gingival bleeding
Tagliaferro *et al.*[16]	2008	Brazil	206	6-8	7	Baseline caries, mothers' educational level up to 8 years of schooling, clinical, and socio-economic variables
Oliveira *et al.*[54]	2006	Brazil	226	birth	2 and 3	enamel defects, night breast feeding, and poor oral hygiene habits were predictors of dental caries at 2 years; enamel defect was predictor at 3 years
Zhou *et al.*[14]	2012	China	225	8 months	2	Mothers education, Income, Enamel hyperplasia, Visible plaque, MS
Wong *et al.*[17]	2011	China	358	3-4	2	Nursing bottles, beginning toothbrushing time, snack frequency, parents education
Zhang and van Palenstein Helderman[55]	2006	China	433	4-5	2	Baseline caries
Chaffee *et al.*[56]	2014	Mexico	243	During pregnancy	3	Maternal salivary bacterial challenge
Sánchez-Pérez[57]	2009	Mexico	110	6	4	Caries experience Snyder test, and fissure morphology
Vallejos- Vallejos-Sánchez *et al.*[58]	2006	Mexico	580	6-9	2	Baseline premolars caries prevalence
Zukanović[59]	2013	Bosnia and Herzegovina	109	12	3	Cariogram
Masood *et al.*[60]	2012	Malaysia	1830	6	5	Caries in permanent teeth at age 6 years
Scheutz *et al.*[61]	2007	Tanzania	122	7	2	Flow rate of saliva, count of lactobacilli

VHHDC: Very high human development countries, NVHHDC: Not very high human development countries

Table 4: A summary of the variables tested and their significance frequency.

Author name	Baseline caries	Cariogenic bacteria	Parent education	SES	Income	Tooth brushing	Access	Diet	Weight	Models
Markowitz *et al.*[21]	A/S	NA	N/A	NA	NA	NA	NA	NA	NA	NA
Nelson *et al.*[18]	N/A	NA	A/S	NA	NA	NA	NA	NA	NA	NA
Ferreira Zandoná *et al.*[22]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Morou-Bermudez *et al.*[10]	A/S	A/S	NA	NA	NA	NA	NA	A/NS	NA	NA
Fontana *et al.*[23]	NA	NA	A/S	NA	NA	A/NS	NA	A/S	NA	NA
Chankanka *et al.*[24]	NA	NA	NA	A/S	NA	A/S	NA	A/S	NA	NA
Ditmyer *et al.*[25]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Fontana *et al.*[26]	NA	NA	A/NS	NA	A/S	NA	NA	A/S	NA	NA
Nelson *et al.*[27]	NA	NA	N/A	NA	N/A	NA	NA	NA	A/S	NA
Ismail *et al.*[28]	NA	NA	A/NS	NA	A/NS	A/NS	A/S	A/S	A/S	NA
Warren *et al.*[11]	NA	A/S	N/A	A/NS	N/A	A/NS	NA	A/S	NA	NA
Maserejian *et al.*[29]	A/S	NA	A/NS	NA	A/NS	A/S	NA	NA	NA	NA
Ekbäck *et al.*[30]	A/S	A/S	NA	NA	NA	NA	NA	NA	NA	NA
Petersson *et al.*[31]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Holgerson *et al.*[32]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Nordlund *et al.*[33]	A/S	A/S	NA	NA	NA	NA	NA	NA	NA	NA
Alm *et al.*[34]	NA	NA	A/NS	NA	NA	A/S	NA	NA	NA	NA
Brennan and Spencer[35]	NA	NA	NA	A/S	NA	NA	NA	NA	NA	NA
Hooley *et al.*[36]	NA	NA	NA	NA	NA	NA	NA	A/S	A/S	NA
MacRitchie *et al.*[37]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Ito *et al.*[12]	A/S	A/S	NA	NA	NA	NA	NA	NA	NA	NA
Kishi *et al.*[39]	N/A	A/S	NA	NA	NA	NA	NA	NA	NA	NA
Tamaki *et al.*[40]	A/S	A/S	NA	NA	NA	NA	NA	NA	NA	NA
Nishimura *et al.*[41]	N/A	A/S	NA	NA	NA	NA	NA	NA	NA	NA
Motohashi *et al.*[42]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hietasalo *et al.*[43]	A/S	NA	NA	NA	NA	A/S	NA	A/S	NA	NA
Mattila *et al.*[19]	A/S	NA	A/S	A/S	NA	A/S	NA	A/S	NA	NA
Shearer *et al.*[44]	N/A	NA	NA	A/S	NA	NA	NA	NA	NA	NA
Broadbent *et al.*[45]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Skeie *et al.*[46]	N/A	NA	NA	NA	NA	NA	NA	A/S	NA	NA
Skeie *et al.*[47]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Meller *et al.*[48]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Campus *et al.*[49]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Gao *et al.*[50]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Gao *et al.*[51]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Jeppesen and Foldspang[52]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Assessed	15	8	7	5	3	8	1	10	3	7
Significant	15	8	3	4	1	5	1	9	3	7
Not significant	0	0	4	1	2	3	0	1	0	0

A: Assessed, NA: Not Assessed, S: Significant, NS: Not significant, SES: Socio-economic status

Socio-economic as a predictive variable was studied in 5 (13%) of the articles that four of them (80%) showed a positive relationship between SES and future dental caries. Most of these studies used self or parent occupation as an identical factor for SES. In Fontana's study, in 2009, the relationship between oncoming tooth decay and income was shown significant.

There were 10 studies that assessed diet as a predictor of dental caries. Except for Markowitz's study, all showed a positive relationship between these two variables.

Weight and BMI were examined specifically as a predictive factor in all of the 3 articles including (Graph 2).

In addition to the single predictors, models were also designed and positively assessed in 18% of the 37 studies. Cariogram as a known predictive model was assessed in more than half (57%) of these studies that in all it showed to be predictive for dental caries.

Characteristics of reviewed studies in NVHHDC

The results of individual studies in NVHHDC are summarized in Table 5. The review revealed that the highest percentage of identified studies that were conducted in the NVHHDC countries was based in Brazil (31%) followed by China and Mexico (23%). Other countries had fewer studies on predicting dental caries.

All the studies started before 12 years old and with a mean follow-up of 3 years.

Table 5: A summary of the variables tested and their significance frequency.

Author name	Baseline caries	Cariogenic bacteria	Caregiver education	SES	Income	Tooth brushing	Access	Diet	Weight	Models
Kassawara[53]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Peres *et al.*[4]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tagliaferro *et al.*[16]	A/S	NA	A/S	NA	A/NS	A/NS	A/NS	A/NS	NA	NA
Oliveira *et al.*[54]	A/S	NA	NA	NA	NA	A/NS	NA	A/NS	NA	NA
Zhou *et al.*[14]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wong *et al.*[17]	NA	NA	A/S	NA	A/NS	A/S	NA	A/S	NA	NA
Zhang and van Palenstein Helderman[55]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chaffee *et al.*[56]	NA	A/S	NA	NA	NA	NA	NA	NA	NA	NA
Sánchez-Pérez[57]	A/S	A/NS	NA	NA	NA	NA	NA	NA	NA	NA
Vallejos- Vallejos-Sánchez *et al.*[58]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zukanović[59]	NA	NA	NA	NA	NA	NA	NA	NA	NA	A/S
Masood *et al.*[60]	A/S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Scheutz *et al.*[61]	NA	A/S	NA	NA	NA	NA	NA	NA	A/S	NA
Assessed	8	3	2	0	2	3	1	3	1	1
Significant	8	2	2	0	0	1	0	1	1	1
Not significant	0	1	0	0	2	2	1	2	0	0

A: Assessed, NA: Not assessed, S: Significant, NS: Not significant, SES: Socio-economic status

Among these 13 articles, only Zukanovic in 2013 assessed cariogram as a predictive model for dental caries. His study showed this model can be a predictive model in Bosnia's population.

Baseline caries was the best single predictor in more than half of the reviewed articles (61%), with the remaining articles dispersed among the other eight areas of focus.

The presence of cariogenic bacteria was conducted in 3 out of 13 (23%) studies and in 2 (67%) it was positively significant (Graph 3).

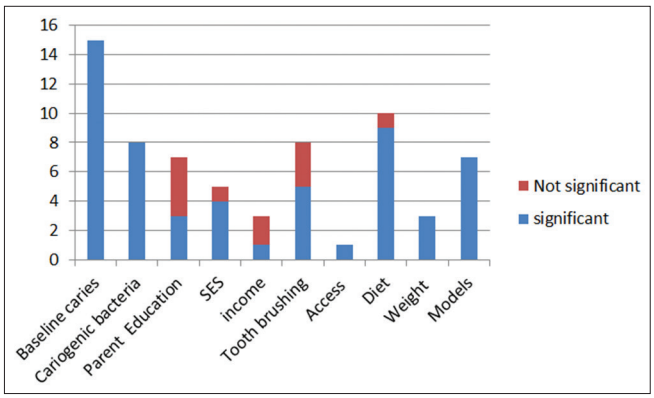
Income was included in 2 out of 13 studies; However, none of them were statistically significant.

Caregiver's education was examined as a predictive factor in 2 (15%) of the studies and in both, it showed a significant relationship.

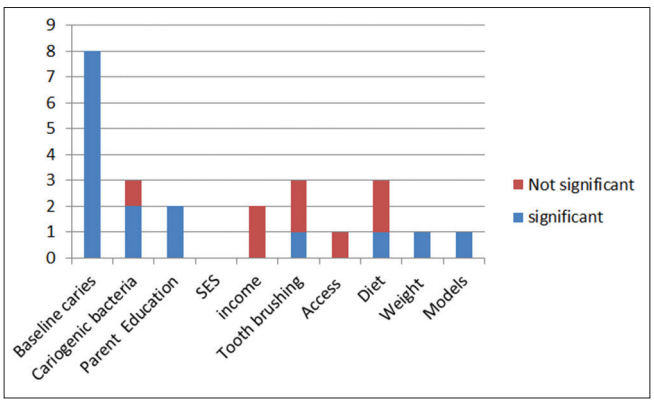
There were 3 (23%) articles that focused on diet as a predictive factor for dental caries but only in one (33%) it showed to be statistically significant.

Habitual tooth brushing was also conducted in 3 out of 13 (23%) studies and in two it was shown as a predictive factor for dental caries.

Only one article (Sánchez-Pérez *et al.*) examined weight as a predictor of dental caries that was statistically significant (Graph 2).



Graph 2: The proportion of significancy of caries predictors in very high human development countries.



Graph 3: The proportion of significancy of caries predictors in not very high human development countries.

Discussion

Dental caries is a preventable oral disease that affects a growing number of people, especially children. Its prevention can be optimized if predictors of dental caries are known in the target population.

According to the UNDP's HDI, we have 38 VHHDC versus 108 NVHHDC. But in the case of articles defining predictors of dental caries, it has been shown that the number of papers derived from VHHDC is more than the ones from the NVHHDC. This fact emphasizes on the lake of research in developing countries. Knowing that research on predictors of

dental caries requires data from longitudinal studies such as birth cohorts that needs more costly and time-consuming data collection, it is obvious that NVHHDC need more organized data planning for having the ability to increase their studies in this field.

Past caries experience was shown to be the best predictor in both developed and developing countries. Morou-Bermudez *et al.*,[10] Warren *et al.*,[11] Ito *et al.*,[12] Meurman *et al.*,[13] and Zhou *et al.*[14] showed that cariogenic bacteria such as the count of *Streptococcus mutans* and Lactobacilli were both predictive factors in VHHD and NVHHDC. This finding confirms that cariogenic bacteria is one of the main players in the etiology of this disease in all populations.[15] The difference between the number of articles conducting cariogenic bacteria as a caries predictor in VHHD and NVHHDC can be due to the cost of this analysis that makes it more limited in NVHHDC.

SES is defined with different indicators such as income and occupation in different countries.

Income was assessed as a predictive factor in articles revealed from VHHD and NVHHDC. Ismail and Masereijan from the USA and Tagliaferro and Oliveira from Brazil examined income as a variable to predict dental caries but in none of the studies, a statistically significant relationship was found. Only in one study from USA (Fontana *et al.*), it showed the predictive effect on dental caries. Maybe this is due to this fact that income is mostly expressed by the study group as a question in a questionnaire, and it might not be reliable and comparative.

Caregiver's education was shown to be a strong predictive factor in NVHHDC,[14,16,17] but only 3 out of the 7 studies (47%) in VHHDC positively tested such a relationship between present and future dental caries.[18,19] Referencing to the WHO literacy statistics that developed countries have a higher education level especially for females, we can justify the fact that caregiver's education as a predictive factor can't be a significant predictive factor in VHHDC that have a high level of education for their female population.

This review showed that diet including cariogenic foods and frequency of sugar intake was indicated to be a predictive factor in 9 of the 10 studies conducted in VHHDC though in studies from NVHHDC only one study (Wong *et al.*) from the three studies showed prediction effect on dental caries. This can be due to this fact that the consumption of sugary diet is increasing in developed countries through recent years.[20] With the difference between the numbers of papers from NVHHDC and VHHDC, it seems that further studies are needed to test this relationship more.

From the variables examined as caries predictors, tooth brushing showed different results in VHHD and NVHHDC. The percentage of studies that tested habitual tooth brushing as a predictive factor in both developed and developing countries were similar but in VHHDC 62% and in NVHHDC 33% of them showed a significant association between these two variables. This shows that tooth brushing is a better predictor for dental caries in VHHDC but in NVHHDC, the predictive effect of tooth brushing is faded by other factors such as mother's education and income.

By indicating caries predictors in countries with different developmental index, we can implement cost-effective preventive management systems in different populations according to the significancy of predictive factors in each population. However, the heterogeneity of the studies made it difficult to synthesize data. Study design varied and represented different population characteristics, different ages, follow-up times, and sample sizes. In summary, there is a great need of more sufficient and conclusive studies on caries predictors in different countries to make the results conducted from these countries more comparable.

Conclusions

In this article, we emphasized on the lack of studies in NVHHDC. Although the number of NVHHDC is more than the VHHDC, the research on predictive factors of dental caries is fewer in NVHHDC. Furthermore, some variables such as SES and predictive models have not been conducted inconclusively and insufficiently as confirmed in this review.

In conclusion, NVHHDC are urged to promote evidence for predicting dental caries factors aiming to find effective prevention strategies in order to target funds in interventions required for better oral health and to significantly reduce dental caries in the population at large.

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