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RESEARCH

Caries risk assessment-related knowledge, attitude, and behaviors among Chinese dentists: a cross-sectional survey

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Abstract

Objectives To investigate caries risk assessment (CRA)-related knowledge, attitudes, and practices among dentists in China, to describe their subjective ratings of the significance of specific caries risk factors and to identify factors associated with the level of knowledge, attitudes, and use of CRA in routine clinical practice.

Materials and methods A cross-sectional anonymous online questionnaire survey was performed. The questionnaire was distributed via WeChat (Tencent, Shenzhen, China) to practicing dentists between November 25 and December 25, 2021. For participant recruitment, we employed purposive and snowball sampling techniques. Data were collected using a specialized web-based survey tool (www.wjx.cn) and analyzed with descriptive statistics and regression analyses.

Results A total of 826 valid questionnaires were collected. Only 292 (35.4%) respondents used CRA in routine practice, among whom a majority (243, 83.2%) did not use a specific CRA tool. The routine use of CRA was associated with the type of practicing office, attendance of caries-related lectures, the habit of reading caries-related literature, geographic location, and the total knowledge score. The mean total knowledge score was 3.13 (score range: 0 to 6). Knowledge levels were related to several sociodemographic characteristics, including geographic location, the type of practicing office, attendance of caries-related lectures and the habit of reading caries-related literature. The risk factor deemed most important was "current oral hygiene."

Conclusions Caries risk assessment has not widely entered clinical practice in China. The level of CRA-related knowledge among dentists was generally suboptimal.

Clinical relevance Strengthening CRA-related education may allow practitioners to develop a better understanding of caries risk assessment and hence promote its implementation.

Keywords Dental caries · Caries risk assessment · Dentists · Practice patterns · Questionnaire

Introduction

Humans suffer from dental caries at every stage of their lives, from childhood to adulthood, making it a worldwide issue [1]. Permanent dental caries affects approximately 2.4 billion people worldwide [1]. According to the findings about the global burden of disease published in The Lancet in 2017, the prevalence of permanent tooth decay ranked first among 328 diseases, and the incidence was ranked second [2]. Mainland China has generally high levels (52.0%) of dental caries, with an upward trend over the

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last 38 years [3]. Therefore, effective strategies to prevent and treat dental caries are urgently needed.

Developing effective caries management strategies requires clinicians to be well acquainted with the updated etiology and classification of dental caries [4]. Based on the biological and clinical evidence, the International Caries Detection and Assessment System (ICDAS) was proposed by an international team of caries researchers [5] and then, developed into the International Caries Classification and Management System (ICCMS) [6], facilitating clinicians to make individualized caries management plans for different patients based on caries risk assessment. Caries risk assessment (CRA) of patients, analysis, and control of risk factors for caries occurrence, individualized caries treatment and management strategies based on CRA have become the new trend of modern caries management.

Caries risk assessment is a critical part of dental caries management. The CRA evaluates the possibility of new or existing caries developing over a period of time [7]. Various caries risk assessment tools (CRAT) have been developed, such as the Cariogram [8], Caries Management By Risk Assessment (CAMBRA) [9], American Association of Pediatric Dentistry Caries Assessment Tool (AAPD CAT) [10], and American Dental Association (ADA) Caries Risk Assessment [11]. Almost all the tools include multiple factors, such as past caries experience, saliva, diet, general health conditions, fluoride and plaque. CRA is effective not only in determining a prediction risk level for carious lesions but also in identifying each pathogenic factor implicated in each patient to limit the incidence of caries through improved preventive strategies [12]. In addition, the determination of caries risk factors in patients and precise risk level categorization can guide clinicians to implement individualized caries management [13], which could realize appropriate recalls, maximize the cost-effectiveness of preventative strategies and optimize both individual and societal resource allocation [14, 15].

While dental practitioners have recognized the significance of CRA, several studies [16–20] have demonstrated that CRA is not yet widely used among clinicians (25% to 73%) in different countries. No data on the knowledge and attitudes toward CRA among dentists or the incorporation of CRA in routine clinical practice in China were available. Furthermore, the subjective ratings of dentists on the importance of specific caries risk factors remain unknown. Therefore, the objectives of this study were (1) to investigate caries risk assessment (CRA)-related knowledge, attitudes, and practices among dentists in China; (2) to describe their subjective ratings of the significance of specific caries risk factors; and (3) to identify factors associated with the level of knowledge and use of CRA in routine clinical practice.

Materials and methods

Ethical approval

A cross-sectional anonymous online questionnaire survey was approved by the Ethics Committee of the School & Hospital of Stomatology, Wuhan University (No. 2021-B37). The CHERRIES (CHEcklist for Reporting Results of Internet E-Surveys) guidelines [21] were followed in the reporting of this study. An overview of the study regarding the objectives, the target population, and the time required to complete the questionnaire was presented in the first section of the questionnaire, along with the investigator's name and e-mail address. It was made clear that respondents had the option to discontinue their participation at any time and that submitting the questionnaire would constitute consent. Participants in the survey were not rewarded or penalized for taking or not-taking part. The survey was anonymous, and all the confidential raw data were stored in one author's computer.

Survey design

Based on previous research [17], 22 questions were developed in five parts for the questionnaire (Supplementary Material 1). The first part (#1 to #10) obtained information on respondents' demographics, workplace, clinical experience, and continuing education. Six questions (#11 to #16) concerned the respondents' knowledge of CRA. Only one question was asked about their attitudes toward CRA (#17). The respondents' behavior regarding the use of CRA was surveyed through a yes–no question (#18). If the answer was "no," they should provide an explanation (multiple-choice, #19). If "yes" was selected, they should state which method was used for caries risk assessment (#20). In addition, respondents were asked about the drawbacks of the caries risk assessment tools (#21). The final question (#22) asked participants to rate the importance of several risk factors on a scale of 1 to 5 in deciding on a treatment strategy.

Participant recruitment

For participant recruitment, we employed purposive and snowball sampling techniques [22]. To collect data, we distributed the questionnaire link via WeChat (Tencent, Shenzhen, China) to chat groups of dentists and encouraged them to invite their friends. The Raosoft, Inc. Sample Size Calculator (http://www.raosoft.com/samplesize.html) was used. With a 5% margin of error, 95% confidence interval, population size of 20,000 and 50% response distribution, the recommended sample size was 377 [23–25]. The data were collected using a specialized web-based survey tool (www.

wjx.cn). With this tool, the submitted questionnaires were ensured for completeness, and duplicate responses from the same respondent were prevented. Questionnaires with obvious mistakes and anomalous quiz times (less than 2 min or greater than 30 min) [26] were excluded.

Statistical analysis

The data were downloaded from the survey tool (www.wjx.cn). For each question (#11-#16) regarding the level of knowledge, a score of '1' was given if it was answered correctly, and '0' if the answer was incorrect. A total knowledge score (score range: 0 to 6) was subsequently calculated for each respondent. Descriptive statistics were used to describe the background information of respondents and their ratings of caries risk factors. Logistic regression analyses were conducted to investigate potential variables associated with the practice of CRA and attitudes, and to explore the associations between the CRA use and caries risk factors. In addition, multivariable linear regression analyses were performed to identify explanatory variables associated with the level of knowledge (dependent variable). Independent variables were age, gender, geographic location, performing restorative dentistry or not, years of practice, academic degree, type of practicing office, practice busyness, attendance of caries-related lectures, and the habit of reading caries-related literature. Furthermore, the total knowledge score also acted as a predictor of the practice of CRA. For linear regression analyses, the tolerance and variance inflation factor (VIF) were used to detect multicollinearity. Predictor variables with tolerance < 0.1 or VIF > 10 would be excluded from the final model. The goodness of fit for the logistic regression analyses was examined by the Hosmer–Lemeshow test. The statistical significance level of all tests was set at $P < 0.05$.

Results

Demographic information of respondents

Based on the predefined eligibility criteria, 157 responses were excluded from the 983 questionnaires collected. A total of 826 questionnaires were analyzed after eliminating these invalid responses. The sociodemographic data of the respondents are shown in Table 1. According to economic partitions of China, 306 (37.0%) respondents came from the central region, followed by eastern region (246, 29.8%) and western region (238, 28.8%). Of the 826 respondents with an average age of 32.2 years (SD, 8.5), 577 (69.9%) were females. Participants who performed restorative dentistry were predominant (602, 72.9%). Over half of them (475, 57.5%) had less than 5 years of work experience. Regarding the type of practicing office, half of the participants were from public dental clinics (413, 50.0%). A total of 480 respondents (58.1%) stated that their practice busyness was appropriate and not overburdened. Over the last two years, nearly two-thirds of them had attended caries-related lectures, with half of the respondents having the habit of reading caries-related literature.

Table 1 Demographic Information of Respondents

Characteristics	Percentage (N) or Mean (SD)
Age	32.2 (8.5)
Gender	
Female	69.9% (577)
Male	30.1% (249)
Geographic location	
Central region	37.0% (306)
West	28.8% (238)
East	29.8% (246)
Northeast	4.4% (36)
Performing restorative dentistry	
Yes	72.9% (602)
No	27.1% (224)
Years of practice	
≤ 5 years	57.5% (475)
6–10 years	13.4% (111)
11–20 years	15.7% (130)
≥ 21 years	13.3% (110)
Highest degree	
PhD	7.7% (64)
Master	31.2% (258)
Bachelor	55.4% (458)
Junior college	5.4% (45)
Technical secondary school	0.1% (1)
Type of practicing office	
Public dental clinic	50.0% (413)
Dental department of public hospital	31.8% (263)
Private dental clinic	17.2% (142)
Dental department of private hospital	1.0% (8)
Practice busyness	
Overburdened	17.2% (142)
Appropriate and not overburdened	58.1% (480)
Not busy enough	24.7% (204)
Attendance of caries-related lectures	
Yes	66.1% (546)
No	33.9% (280)
Habit of reading caries-related literature	
Yes	47.7% (394)
No	52.3% (432)
Total	100% (826)

CRA-related knowledge, attitude, and behaviors

The mean total knowledge score was 3.13 (SD, 1.02; score range: 0–6). Table 2 presents the results of multivariable linear regression for total knowledge score as well as logistic regression analyses for the attitude and the practice of CRA. The results demonstrated that knowledge levels were related to several sociodemographic characteristics, including geographic location, type of practicing office, attendance of caries-related lectures and the habit of reading caries-related literature. Respondents from the northeastern region ($P = 0.039$; B = -0.367; 95% CI: -0.715, -0.018) had lower total knowledge scores than those from the central region. A better overall knowledge score was significantly associated with respondents who had attended caries-related lectures over the past 2 years ($P = 0.021$; B = 0.177; 95% CI: 0.027, 0.327) and have the habit of reading caries-related literature ($P < 0.001$; B = 0.383; 95% CI: 0.235, 0.532). In contrast, respondents working in the dental department of private hospitals ($P = 0.032$; B = -0.772; 95% CI: -1.476, -0.068) scored significantly lower on total knowledge.

In general, most respondents (732, 88.6%) supported incorporating CRA into routine clinical practice and recording the level of caries risk in an electronic patient record system. According to logistic regression analyses, the odds of supporting the incorporation of CRA into routine clinical practice were significantly higher among female dentists ($P = 0.017$; OR = 1.763; 95% CI: 1.104, 2.815) and those who have the habit of reading caries-related literature ($P = 0.023$; OR = 1.805; 95% CI: 1.086, 3.001).

Additionally, only 292 (35.4%) respondents used CRA in routine practice, among whom a majority (243, 83.2%) did not use a specific CRA tool. Insufficient knowledge and lack of time were the most common reasons why respondents did not include CRA in practice, as demonstrated in Figure S1. Respondents considered CRA tools to be time-consuming and difficult to perform due to the evaluation of some biological factors. Furthermore, the validity and reliability of the CRA tools remain to be researched. According to logistic regression analyses, CRA was more likely to be used by respondents who work in private dental clinics ($P = 0.006$; OR = 1.912; 95% CI: 1.209, 3.025), respondents who had attended caries-related lectures over the past 2 years ($P = 0.003$; OR = 1.705; 95% CI: 1.200, 2.421), who have the habit of reading caries-related literature ($P < 0.001$; OR = 1.883; 95% CI: 1.348, 2.628), and those who received a higher total knowledge score ($P = 0.001$; OR = 1.324; 95% CI: 1.126, 1.558). The odds of using CRA were significantly lower among respondents from the eastern region than among those from the central region ($P = 0.032$; OR = 0.649; 95% CI: 0.437, 0.965).

Subjective importance of risk factors

A ranking of the importance of caries risk factors for treatment strategy is presented in Table 3. The risk factors deemed most important were "current oral hygiene," "one or more active caries lesions" and "patient's commitment to return for follow-up." "Socioeconomic status" and "patient's age" were ranked as the least important. Table 4 shows the results of logistic regression analyses exploring the associations between CRA use and caries risk factors. In the univariable analyses, "current use of fluorides" ($P = 0.012$; OR = 1.233; 95% CI: 1.048, 1.451), "current diet" ($P = 0.042$; OR = 1.222; 95% CI: 1.007, 1.483) and "patient's age" ($P = 0.021$; OR = 1.212; 95% CI: 1.029, 1.427) were significantly associated with whether the respondents used CRA. However, no caries risk factors were significantly associated with CRA use in the multivariable analysis.

Discussion

This is the first study to investigate caries risk assessment (CRA)-related knowledge, attitudes, and practices among dentists in China. Only 35.4% of respondents surveyed used CRA in routine practice, which is comparable to the Brazilian study (36%) [20], and lower than that among dentists in Scandinavia and US practice-based research networks (PBRN) (73% and 69%, respectively) [17, 27], and general dentists in France (61.6%) [19], but higher than that among Japanese dentists (26%) [16] and Indian dental practitioners (25%) [18]. Given the probability that questionnaire surveys exaggerate positive outcomes, the actual percentage could be considerably lower [19]. Chinese dentists have much room for improvement regarding their routine use of CRA.

The respondents most frequently cited insufficient knowledge (76.40%) and lack of time (51.50%) as reasons for not performing CRA. However, only 29.4% of the French general dentists who did not perform CRA indicated insufficient knowledge as a reason for not doing so, but over 70% cited a lack of time as an obstacle to its incorporation into everyday practice. A lack of dissemination of knowledge on CRA in China may explain this difference. Furthermore, most of the CRA tools are not accessible to the general dental population and are confined to academic institutions. Most dentists (732, 88.6%) supported the integration of CRA into their daily practice. Therefore, this can be achieved by educating and disseminating caries risk assessment knowledge among dentists.

Of the 292 dentists who stated the use of CRA, the majority (243, 83.2%) did not use a specific CRA tool. Despite the development of several CRA tools [8, 9, 11, 28–30], employing a specific tool to implement CRA is not common in routine practice among Brazilian, US, Scandinavian and

Table 2 Results of multivariable linear regression for total knowledge score, and Logistic regression analyses for the attitude and the practice of CRA

Factors	dependent variable: score [a]			dependent variable: attitude [b]			dependent variable: practice [c]		
	B	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
Age	-0.007	(-0.031, 0.018)	0.590	1.001	(0.922, 1.087)	0.976	1.033	(0.979, 1.091)	0.239
Gender									
Male	Reference			Reference			Reference		
Female	0.096	(-0.056, 0.248)	0.215	1.763	(1.104, 2.815)	**0.017**	1.043	(0.739, 1.472)	0.811
Geographic location									
Central region	Reference			Reference			Reference		
Northeast	-0.367	(-0.715, -0.018)	**0.039**	1.026	(0.327, 3.225)	0.965	0.907	(0.406, 2.030)	0.813
West	-0.022	(-0.196, 0.151)	0.800	0.989	(0.575, 1.700)	0.967	1.110	(0.756, 1.632)	0.594
East	0.107	(-0.066, 0.279)	0.226	1.294	(0.722, 2.318)	0.387	0.649	(0.437, 0.965)	**0.032**
Performing restorative dentistry									
No	Reference			Reference			Reference		
Yes	-0.112	(-0.278, 0.054)	0.187	0.783	(0.366, 1.330)	0.366	1.156	(0.786, 1.699)	0.462
Years of practice									
≤ 5 years	Reference			Reference			Reference		
6–10 years	-0.002	(-0.252, 0.248)	0.985	1.291	(0.547, 3.047)	0.560	0.775	(0.441, 1.363)	0.376
11–20 years	0.258	(-0.099, 0.614)	0.156	1.739	(0.517, 5.852)	0.371	0.888	(0.402, 1.962)	0.769
≥ 21 years	0.298	(-0.285, 0.881)	0.316	1.352	(0.191, 9.579)	0.763	0.743	(0.203, 2.727)	0.655
Highest degree									
PhD	Reference			Reference			Reference		
Master	-0.030	(-0.311, 0.250)	0.832	1.068	(0.371, 3.076)	0.903	1.913	(1.001, 3.658)	0.050
Bachelor	-0.272	(-0.560, 0.017)	0.065	0.590	(0.205, 1.696)	0.327	1.296	(0.664, 2.529)	0.447
Junior college and technical secondary school	-0.046	(-0.465, 0.372)	0.828	1.036	(0.202, 5.301)	0.966	1.240	(0.488, 3.148)	0.651
Type of practicing office									
Public dental clinic	Reference			Reference			Reference		
Dental department of public hospital	-0.042	(-0.199, 0.116)	0.604	1.138	(0.680, 1.904)	0.622	0.926	(0.648, 1.323)	0.672
Private dental clinic	-0.045	(-0.253, 0.163)	0.672	1.523	(0.737, 3.148)	0.256	1.912	(1.209, 3.025)	**0.006**
Dental department of private hospital	-0.772	(-1.476, -0.068)	**0.032**	1.114	(0.125, 9.891)	0.923	1.453	(0.304, 6.954)	0.640
Practice busyness									
Overburdened	Reference			Reference			Reference		
Appropriate and not overburdened	0.032	(-0.162, 0.225)	0.748	1.035	(0.560, 1.910)	0.914	1.325	(0.849, 2.069)	0.216
Not busy enough	0.046	(-0.181, 0.274)	0.689	1.324	(0.633, 2.768)	0.456	1.181	(0.697, 2.000)	0.536
Attendance of caries-related lectures									
No	Reference			Reference			Reference		
Yes	0.177	(0.027, 0.327)	**0.021**	1.573	(0.986, 2.509)	0.057	1.705	(1.200, 2.421)	**0.003**
Habit of reading caries-related literature									
No	Reference			Reference			Reference		
Yes	0.383	(0.235, 0.532)	**< 0.001**	1.805	(1.086, 3.001)	**0.023**	1.883	(1.348, 2.628)	**< 0.001**
Total score									
1 score				1.070	(0.859, 1.334)	0.546	1.324	(1.126, 1.558)	**0.001**

P values with statistical significance (< 0.05) are in bold

[a] For multivariable linear analysis, constant = 3.133, $R^2 = 0.087$, adjusted $R^2 = 0.065$, $P < 0.001$

[b] For Logistic regression analyses, *P* (Hosmer and Lemeshow) = 0.242; R^2 (Nagelkerke) = 0.077

[c] For Logistic regression analyses, *P* (Hosmer and Lemeshow) = 0.093; R^2 (Nagelkerke) = 0.149

Table 3 Ratings of importance of caries risk factors for treatment plan

Risk factor	Mean rating of importance (SD)
Current oral hygiene	4.37 (0.74)
One or more active caries lesions	4.20 (0.85)
Patient's commitment to return for follow-up	4.17 (0.74)
Decreased salivary function	4.05 (0.78)
Presence of dental appliances	4.05 (0.77)
Current diet	4.03 (0.77)
Patient's understanding of caries progression	3.96 (0.80)
Recent caries	3.83 (0.83)
Presence of several large restorations	3.76 (0.84)
Recession or root exposure	3.73 (0.88)
Current use of fluorides	3.65 (0.91)
Patient's age	3.44 (0.90)
Socioeconomic status	3.37 (0.99)

Japanese PBRN dentists or among French general dentists or Indian dental practitioners. In this survey, respondents considered CRA tools to be time-consuming and difficult to use due to the assessment of some biological factors. The validity and reliability of the CRA tools remain to be researched (Figure S2) [31]. However, with CRA tools, dentists can develop personalized treatment plans for individuals based on more objective and standardized information [32, 33]. An evidence-based CRA tool should be developed to allow dentists to easily access relevant information for caries risk assessment.

The total knowledge scores of the respondents were generally suboptimal. According to multivariable analyses, the total knowledge score was related to geographic location, type of practicing office, attendance of caries-related lectures, and the habit of reading caries-related literature. With more academic conferences in the central and eastern regions than in the northeastern region, dentists in those areas have more opportunities to learn about CRA. The present findings aid in understanding Chinese dentists' knowledge of CRA and highlight the importance of academic activities and training about CRA.

The routine use of CRA was associated with certain demographic characteristics, namely, type of practicing office, geographic location, continuing education, and total knowledge score. The total knowledge score was first found to be associated with an increased likelihood of performing CRA. This finding corresponded to the result that 76.40% of respondents reported insufficient knowledge as a major impediment to incorporating CRA into their daily practice. Another variable associated with the use of CRA was the type of practicing office. In contrast to prior studies, dentists working in private dental clinics were more likely to perform CRA [17, 20]. The foregoing findings suggest that strengthening CRA education may allow practitioners to develop a better understanding of caries risk assessment and hence enhance its implementation.

In this survey, the risk factors deemed the most important for clinical decision-making were "current oral hygiene," followed by "one or more active caries lesions" and "patient's commitment to return for follow-up." Similar results were found in questionnaire-based research

Table 4 Results of univariable and multivariable Logistic regression analyses for indicating the associations between the CRA use and caries risk factor

Variable	OR	95% CI	*P* value
Univariable			
Current oral hygiene	0.967	(0.796, 1.175)	0.734
One or more active caries lesions	0.966	(0.815, 1.144)	0.687
Patient has had caries recently	1.108	(0.929, 1.321)	0.255
Presence of several large restorations	1.108	(0.931, 1.318)	0.249
Recession or root exposure	1.120	(0.947, 1.324)	0.185
Presence of dental appliances	1.041	(0.861, 1.258)	0.680
Current use of fluorides	1.233	(1.048, 1.451)	**0.012**
Decreased salivary function	1.055	(0.875, 1.272)	0.573
Current diet	1.222	(1.007, 1.483)	**0.042**
Patient's understanding of caries progression	1.144	(0.952, 1.375)	0.151
Patient's commitment to return for follow-up	1.084	(0.888, 1.323)	0.429
Patient's age	1.212	(1.029, 1.427)	**0.021**
Socioeconomic status	1.152	(0.993, 1.336)	0.062
Multivariate			
Current diet	1.084	(0.864, 1.360)	0.483
Current use of fluorides	1.136	(0.930, 1.388)	0.212
Patient's age	1.104	(0.910, 1.339)	0.316

among dentists in the USA, Japan, and France [16, 17, 20]. Other caries risk factors were ranked differently in various studies. "Current use of fluorides" was ranked as having the lowest level of importance, also demonstrating a "gap of evidence and practice" regarding fluoride application among Chinese dentists. The effect of using fluoride to prevent dental caries has been well established [34]. The rational use of fluoride, such as fluoride toothpaste [35, 36] and water fluoridation [37–39], has achieved caries reduction in recent decades. This discrepancy in findings may be due to the fact that there is a deficiency in the translation of research findings on fluoride into routine clinical practice in Chinese settings [40] and that participating dentists were not well informed about evidence from the literature. Therefore, continuing education of dental clinicians regarding caries risk factors may be necessary. Dentists should be aware of the importance of past caries experience of patients, which has been considered the most effective caries predictor in other studies [41–43], whereas dentists rated it as slightly less important in the present study.

Limitations and strengths

A questionnaire-based survey is a viable approach for quickly collecting information on opinions and experiences from a diverse range of participants [44]. The sample size in this study was sufficient for data analysis, but the results must be interpreted carefully. First, this online survey was possibly biased by the fact that many participants were recruited through the investigators' networks. Second, a very small sample size was available for some categories of the respondents' characteristics, causing the data to be imprecise and the representativeness of these groups to be compromised.

Despite these limitations, this study has several strengths. This is the first study to investigate caries risk assessment (CRA)-related knowledge, attitudes, and practices among dentists in China. Based on 826 questionnaires from almost all of China's provinces, the findings provide a comprehensive view of the current situation regarding CRA use in China. This paper may help identify impediments to low CRA usage and promote the practice of CRA to reduce the incidence of caries.

Conclusion

Caries risk assessment has not widely entered clinical practice in China. The level of CRA-related knowledge among dentists was generally suboptimal. Strengthening CRA-related education may allow practitioners to develop a better understanding of caries risk assessment and hence promote its implementation.

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Declarations

Ethics approval and consent to participate This study involving human participants was reviewed and approved by Ethics Committee of School & Hospital of Stomatology, Wuhan University (No. 2021-B37).

For this type of study, formal consent is not required.

Competing interest No conflict of interest exits in the submission of this manuscript, and it is approved by all authors for publication.

References

1. Kassebaum NJ, Bernabe E, Dahiya M, Bhandari B, Murray CJ, Marcenes W (2015) Global burden of untreated caries: a systematic review and metaregression. J Dent Res 94(5):650–658. https://doi.org/10.1177/0022034515573272
2. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators (2018) Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 392(10159):1789–1858. https://doi.org/10.1016/s0140-6736(18)32279-7
3. Gu ZW, Zhang SS, Zhang RJ, Tang H, Sun XY, Liu XN, Zheng SG (2019) Prevalence of Caries in Mainland China: Evidence from 1980 to 2018: A Systematic Review and Meta-Analysis. Chin J Dent Res 22(4):251–263. https://doi.org/10.3290/j.cjdr.a43736
4. Cheng L, Zhang L, Yue L, Ling JQ, Fan MW, Yang DQ, Huang ZW, Niu YM, Liu JG, Zhao J, Li YH, Guo B, Chen Z, Zhou XD (2022) Expert consensus on dental caries management. Int J Oral Sci 14(1): https://doi.org/10.1038/s41368-022-00167-3
5. Ismail AI, Sohn W, Tellez M, Amaya A, Sen A, Hasson H, Pitts NB (2007) The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Community Dent Oral Epidemiol 35(3):170–178. https://doi.org/10.1111/j.1600-0528.2007.00347.x
6. Pitts NB, Ekstrand KR, Foundation I (2013) International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS) - methods for staging of the caries process and enabling dentists to manage caries. Community Dent Oral Epidemiol 41(1):e41-52. https://doi.org/10.1111/cdoe.12025

7. Twetman S, Fontana M (2009) Patient caries risk assessment. Monogr Oral Sci 21:91–101. https://doi.org/10.1159/000224214
8. Bratthall D, Hänsel Petersson G (2005) Cariogram–a multifactorial risk assessment model for a multifactorial disease. Community Dent Oral Epidemiol 33(4):256–264. https://doi.org/10.1111/j.1600-0528.2005.00233.x
9. Featherstone JD, Domejean-Orliaguet S, Jenson L, Wolff M, Young DA (2007) Caries risk assessment in practice for age 6 through adult. J California Dent Assoc 35(10): 703–707, 710–703
10. American Academy of Pediatric Dentistry (2013) Guideline on caries-risk assessment and management for infants, children, and adolescents. Pediatr Dent 35(5):E157–164
11. Fontana M, Zero DT (2006) Assessing patients' caries risk. J Am Dent Assoc (1939) 137 (9): 1231–1239. https://doi.org/10.14219/jada.archive.2006.0380
12. Tellez M, Gomez J, Pretty I, Ellwood R, Ismail AI (2013) Evidence on existing caries risk assessment systems: are they predictive of future caries? Community Dent Oral 41(1):67–78. https://doi.org/10.1111/cdoe.12003
13 Fontana M, Gonzalez-Cabezas C (2012) Minimal intervention dentistry: part 2. Caries risk assessment in adults. British Dental J 213(9):447–451. https://doi.org/10.1038/sj.bdj.2012.1008
14. Warren E, Pollicino C, Curtis B, Evans W, Sbaraini A, Schwarz E (2010) Modeling the long-term cost-effectiveness of the caries management system in an Australian population. Value Health 13(6):750–760. https://doi.org/10.1111/j.1524-4733.2010.00759.x
15. Curtis B, Warren E, Pollicino C, Evans RW, Schwarz E, Sbaraini A (2011) The monitor practice programme: is non-invasive management of dental caries in private practice cost-effective? Aust Dent J 56(1):48–55. https://doi.org/10.1111/j.1834-7819.2010.01286.x
16. Kakudate N, Sumida F, Matsumoto Y, Yokoyama Y, Riley JL 3rd, Gilbert GH, Gordan VV (2015) Dentists' decisions to conduct caries risk assessment in a Dental Practice-Based Research Network. Community Dent Oral Epidemiol 43(2):128–134. https://doi.org/10.1111/cdoe.12127
17. Riley JL 3rd, Gordan VV, Ajmo CT, Bockman H, Jackson MB, Gilbert GH (2011) Dentists' use of caries risk assessment and individualized caries prevention for their adult patients: findings from The Dental Practice-Based Research Network. Community Dent Oral Epidemiol 39(6):564–573. https://doi.org/10.1111/j.1600-0528.2011.00626.x
18. Nagaraj A, Vishnani P, Yousuf A, Ganta S, Singh K, Acharya S (2015) Perception of dentists about caries-risk assessment tools in Jaipur, India: a cross-sectional study. J Int Oral Health 7(8):77–81
19. Domejean S, Leger S, Simon A, Boucharel N, Holmgren C (2017) Knowledge, opinions and practices of French general practitioners in the assessment of caries risk: results of a national survey. Clin Oral Investig 21(2):653–663. https://doi.org/10.1007/s00784-016-1932-y
20. Tagliaferro E, Silva S, Rosell FL, Valsecki Junior A, Riley Iii JL, Gilbert GH, Gordan VV (2020) Caries risk assessment in dental practices by dentists from a Brazilian community. Braz Oral Res 35:e017. https://doi.org/10.1590/1807-3107bor-2021.vol35.0017
21. Eysenbach G (2004) Improving the quality of Web surveys: the checklist for reporting results of Internet E-Surveys (CHERRIES). J Med Internet Res 6(3):e34. https://doi.org/10.2196/jmir.6.3.e34
22. Tyrer S, Heyman B (2016) Sampling in epidemiological research: issues, hazards and pitfalls. BJPsych Bull 40(2):57–60. https://doi.org/10.1192/pb.bp.114.050203
23. Lang T, Secic M (1997) How to Report Statistics in Medicine. American College of Physicians, Philadelphia
24. Kish L (1995) Survey Sampling. Wiley, New York
25. Rea L (1997) Designing and Conducting Survey Research, 2nd edn. Jossey-Bass, San Francisco
26. Hua F, Qin DC, Yan JR, Zhao TT, He H (2020) COVID-19 Related experience, knowledge, attitude, and behaviors among 2,669 orthodontists, orthodontic residents, and nurses in China: a cross-sectional survey. Front Med-Lausanne 7. https://doi.org/10.3389/fmed.2020.00481
27. Riley JL 3rd, Qvist V, Fellows JL, Rindal DB, Richman JS, Gilbert GH, Gordan VV (2010) Dentists' use of caries risk assessment in children: findings from the Dental Practice-Based Research Network. Gen Dent 58(3):230–234
28. Gao XL, Hsu CY, Xu Y, Hwarng HB, Loh T, Koh D (2010) Building caries risk assessment models for children. J Dent Res 89(6):637–643. https://doi.org/10.1177/0022034510364489
29. Kalhan TA, Un Lam C, Karunakaran B, Chay PL, Chng CK, Nair R, Lee YS, Fong MCF, Chong YS, Kwek K, Saw SM, Shek L, Yap F, Tan KH, Godfrey KM, Huang J, Hsu CS (2020) Caries risk prediction models in a medical health care setting. J Dent Res 99(7):787–796. https://doi.org/10.1177/0022034520913476
30. Macritchie HM, Longbottom C, Robertson M, Nugent Z, Chan K, Radford JR, Pitts NB (2012) Development of the Dundee Caries Risk Assessment Model (DCRAM)–risk model development using a novel application of CHAID analysis. Community Dent Oral Epidemiol 40(1):37–45. https://doi.org/10.1111/j.1600-0528.2011.00630.x
31. Cagetti MG, Bonta G, Cocco F, Lingstrom P, Strohmenger L, Campus G (2018) Are standardized caries risk assessment models effective in assessing actual caries status and future caries increment? A systematic review. BMC Oral Health 18(1):123. https://doi.org/10.1186/s12903-018-0585-4
32. Doméjean S, Banerjee A, Featherstone JDB (2017) Caries risk/susceptibility assessment: its value in minimum intervention oral healthcare. Br Dent J 223(3):191–197. https://doi.org/10.1038/sj.bdj.2017.665
33. Featherstone JD (2003) The caries balance: contributing factors and early detection. J Calif Dent Assoc 31(2):129–133
34. Marinho VC, Higgins JP, Logan S, Sheiham A (2003) Topical fluoride (toothpastes, mouthrinses, gels or varnishes) for preventing dental caries in children and adolescents. Cochrane Database Syst Rev (4): CD002782. https://doi.org/10.1002/14651858.CD002782
35. Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, Ramos-Gomez F, Tagami J, Twetman S, Tsakos G, Ismail A (2017) Dental caries. Nat Rev Dis Primers 3:17030. https://doi.org/10.1038/nrdp.2017.30
36. Liu L, Zhang Y, Wu W, He M, Lu ZF, Zhang KQ, Li J, Lei S, Guo SB, Zhang YY (2019) Oral health status among visually impaired schoolchildren in Northeast China. Bmc Oral Health 19. https://doi.org/10.1186/s12903-019-0752-2
37 Pollick H (2018) The Role of Fluoride in the Prevention of Tooth Decay. Pediatr Clin N Am 65(5):923. https://doi.org/10.1016/j.pcl.2018.05.014
38. Slade GD, Grider WB, Maas WR, Sanders AE (2018) Water Fluoridation and Dental Caries in U.S. Children and Adolescents. J Dent Res 97(10):1122–1128. https://doi.org/10.1177/0022034518774331
39. Wang B, Zheng B, Zhai C, Yu G, Liu X (2004) Relationship between fluorine in drinking water and dental health of residents in some large cities in China. Environ Int 30(8):1067–1073. https://doi.org/10.1016/j.envint.2004.05.006

40. Gordan VV, Grp NDPC (2013) Translating research into everyday clinical practice: Lessons learned from a USA dental practice-based research network. Dent Mater 29(1):3–9. https://doi.org/10.1016/j.dental.2012.07.159
41. Senneby A, Mejare I, Sahlin NE, Svensater G, Rohlin M (2015) Diagnostic accuracy of different caries risk assessment methods. A systematic review. J Dent 43(12):1385–1393. https://doi.org/10.1016/j.jdent.2015.10.011
42. Zhang Q, Helderman WHV (2006) Caries experience variables as indicators in caries risk assessment in 6–7-year-old Chinese children. J Dent 34(9):676–681. https://doi.org/10.1016/j.jdent.2005.12.010
43. Du Q, Yu M, Li YL, Du HJ, Gao WL, Mei H, Liu SJ (2017) Permanent caries experience is associated with primary caries experience: a 7-year longitudinal study in China. Community Dent Oral 45(1):43–48. https://doi.org/10.1111/cdoe.12257
44. Kelley K, Clark B, Brown V, Sitzia J (2003) Good practice in the conduct and reporting of survey research. Int J Qual Health Care 15(3):261–266. https://doi.org/10.1093/intqhc/mzg031