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Analysis of factors influencing delayed treatment seeking for dental caries in preschool children: a cross-sectional study

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Abstract

Objective This study investigated the prevalence of treatment delays among preschoolers with dental caries, identified the associated influencing factors, and predicted the risk of delayed treatment. The findings of this study provide an evidence base for future interventions designed to reduce treatment delays in this population.

Methods A convenience sample of 264 preschool children with dental caries and their parents who visited the paediatric dental department between October 2023 and May 2024 was surveyed. Data were collected using a general information questionnaire, a medical status questionnaire, the Children's Fear Survey Schedule-Dental Subscale, the Modified Version Dental Anxiety Scale, the Short-Form Health Literacy Dental Scale, and the Illness Perception Questionnaire Revised for Dental. Influencing factors were analysed using univariate analysis and binary logistic regression, whereas the risk of occurrence was predicted using the receiver operating characteristic (ROC) curve.

Results The prevalence of delayed treatment among preschool children with dental caries was 71.21%, with an average delay of 117.5 days. Binary logistic regression analysis identified several independent factors significantly associated with delayed treatment ($P < 0.05$), including the primary caregiver, initial symptom recognition, children's dental fear, parental dental anxiety, and parental oral health literacy. Predictive analyses indicated that children's dental fear (AUC: 0.765, 95%CI: 0.707–0.823) and parental oral health literacy (AUC: 0.738, 95%CI: 0.673–0.802) demonstrated relatively high predictive values for delayed treatment.

Conclusion Efforts to reduce delayed treatment should prioritise addressing children's dental fear and improving parental oral health literacy. Targeted and effective strategies in these areas may facilitate early prevention, diagnosis, and intervention, thereby minimising treatment delays, reducing disease burden, and promoting oral health among preschoolers.

Keywords Preschoolers, Dental caries, Treatment delays, Influencing factors, Cross-sectional study

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Background

Early childhood caries (ECC) is one of the most prevalent childhood diseases worldwide and is recognised as a significant public health concern [1, 2]. A global analysis conducted between 1995 and 2019 reported a prevalence of 46.2% of dental caries in deciduous teeth [3]. According to the Global Burden of Disease Study (2017), approximately 532 million children have untreated caries in their primary teeth [4]. Findings from China's fourth national oral health epidemiological survey indicated that the prevalence of caries among three-, four-, and five-year-old children was 50.8, 63.6, and 71.9%, respectively, with untreated rates reaching 98.5, 97.1, and 95.9%, respectively [5]. These data point out the high prevalence and low treatment rates of ECC.

Dental caries is a biofilm-mediated, sugar-driven, multifactorial, and dynamic disease characterised by cycles of demineralisation and remineralisation of dental hard tissues. Its development involves complex interactions between several factors, including the host (primarily teeth and saliva), microbiota (acid-producing bacteria such as *Streptococcus mutans*), dietary carbohydrates (particularly frequent sugar intake), and environmental influences [6]. Additionally, behavioural and social determinants such as oral hygiene practices and socioeconomic status play crucial roles in disease progression [7].

Patient treatment delay is defined as "the time interval from the initial recognition of symptoms by the patient to their first visit to a medical institution," a concept introduced by Pack and Gallo in 1938 [8]. Existing research has predominantly focused on diseases such as stroke [9], heart disease [10], and cancer [11], demonstrating that patients with these conditions experience varying degrees of delay in seeking medical treatment. Studies have identified several factors significantly associated with delayed treatment-seeking behaviour, including female sex, economic barriers, larger family size, lack of disease knowledge, misconceptions about disease incurability, and anxiety [12–14]. However, the factors contributing to treatment delays for dental caries in preschool children remain inadequately explored.

In its early stages, ECC is often asymptomatic and difficult for parents to notice. If left untreated, pain may develop, and biofilm retention in carious lesions along with inadequate oral hygiene can accelerate disease progression. When caries reach the dental pulp, bacterial infiltration can lead to pulpitis, periapical diseases, pulp necrosis, and eventual tooth loss [15]. Moreover, untreated dental caries can increase the risk of developing future caries in permanent teeth [16]. The consequences of untreated dental caries extend beyond discomfort; they contribute to chronic pain, oral inflammation, malnutrition, poor sleep quality, reduced learning efficiency, impaired cognitive development, and diminished physical and social skills, ultimately lowering the overall quality of life of preschool children [17, 18].

Approximately one-third of preschool children worldwide experience dental fear, a condition strongly associated with the presence of dental caries and heightened parental dental anxiety [19, 20]. Caregivers with lower oral health literacy often engage in behaviours detrimental to children's oral health, such as nighttime feeding, the use of sweetened bottles, and inadequate oral hygiene practices, all of which significantly contribute to ECC development [21]. Clinical observations indicate that many preschoolers not only suffer from severe caries but also experience treatment delays because of parental decisions. As a vulnerable population, young children lack the awareness and autonomy to seek dental treatment independently, making them reliant on their parents' decisions [22]. Therefore, a systematic analysis of the factors influencing treatment delays among preschoolers with dental caries is essential. Such an analysis can enhance parental awareness of children's oral health, provide a scientific basis for improving healthcare-seeking behaviours, safeguard children's health rights more effectively, improve treatment outcomes, and ultimately reduce the economic burden on families and society.

Methods

Study design and population

This cross-sectional study was conducted from October 2023 to May 2024. A convenience sampling method was used to recruit paediatric patients and their parents visiting the Department of Pediatric Stomatology at the Stomatological Hospital of China Medical University. The inclusion criteria were as follows: (1) children aged 3–6 years; (2) children diagnosed with dentin caries, pulpitis, or periapical periodontitis due to dental caries, on the basis of a comprehensive clinical examination, including visual inspection, palpation with dental instruments, radiographic assessment, and dmft index examination [23]; (3) children who were fully conscious and their parents, possessed normal expressive and comprehension abilities, and could complete the questionnaire independently or with assistance from the researcher; and (4) first-time visitors to the hospital for treatment. The exclusion criteria included (1) previous participation in related research and (2) children with comorbid serious illnesses, such as systemic diseases or genetic disorders.

Sample size and ethical considerations

The sample size was determined using the standard formula for calculating sample size in cross-sectional studies: $n = \frac{\mu^2_{\alpha/2}}{\delta^2}\pi\ (1-\pi\ )$. In this study, π was set at 81% on the basis of preliminary tests and related research findings, $\mu_{\alpha/2}$ was determined to be 1.96, and δ was set

at 0.05. To account for a potential 10% loss due to sample dropout and invalid responses, the minimum required sample size was calculated to be 263 cases. Ultimately, a total of 264 children and 264 parents were recruited.

Ethical considerations were strictly adhered to in accordance with the principles outlined in the Declaration of Helsinki regarding human medical research. Informed consent was obtained from all participants, who were also informed of their right to withdraw from the study at any time without providing a reason. Verbal assent was obtained from the children, while written informed consent was provided by their parents or guardians. Participation was entirely voluntary, and children who exhibited persistent distress were not compelled to participate. This study was approved by the Ethics Committee of the Stomatological Hospital of China Medical University (Approval No. K2023-027).

Definition of interval and delay

Because of the absence of standardised definitions of treatment delay in paediatric dental caries, consultations were conducted with four clinical experts. Based on their input, patient delay in this study was defined as a time interval exceeding two weeks from the initial recognition of symptoms to the first hospital visit among preschool children with deciduous tooth caries, as reported by the child or their parents.

Survey tools

A structured questionnaire was developed on the basis of a comprehensive review of the relevant literature and specific considerations related to paediatric dental caries [12, 24, 25]. The questionnaire encompassed sections on sociodemographic factors, disease-related factors, psychological factors, parental oral health literacy, and caregivers' disease perception.

Sociodemographic characteristics

Sociodemographic data were categorised into child-specific and family-specific information. Variables included age, sex, place of residence, primary caregiver, number of children in the family, parental age, parental occupation, parental education level, and average monthly household income.

Medical history

Medical history data included details on disease diagnosis, initial symptom recognition, time of symptom onset, time of first medical consultation, and primary motivation for seeking treatment.

Measurement of dental fear in children

The Children's Fear Survey Schedule-Dental Subscale (CFSS-DS), originally developed by Cuthbert [26] in 1982, is a widely used instrument for assessing dental fear in children. In 2011, Jiaxuan Lu et al. [27] adapted the CFSS-DS for use in China by incorporating a facial expression scale to enhance its usability. The Chinese version demonstrated strong reliability, with a Cronbach's α coefficient of 0.85, and good validity, as indicated by a test-retest reliability of 0.73 [27]. The scale consists of four dimensions and 17 items, rated on a 5-point Likert scale ranging from 1 (not at all afraid) to 5 (extremely afraid), yielding a total score between 17 and 85. Higher scores indicate greater dental fear. The inclusion of the facial expression scale improved comprehensibility and response accuracy in younger children. The Cronbach's α coefficient was 0.935.

Measurement of dental anxiety in parents

The Modified Dental Anxiety Scale (MDAS), revised by Humphris [28] in 1995, is a widely used instrument for assessing dental anxiety. In 2022, Surong Ye et al. [29] adapted the MDAS for use in China. The Chinese version has demonstrated strong psychometric properties, with a Cronbach's α coefficient of 0.853 and a test-retest reliability of 0.877 [29]. The scale comprises five items, rated on a 5-point Likert scale ranging from 1 (no anxiety) to 5 (extreme anxiety), yielding a total score between 5 and 25. A cutoff score of 15 is used to classify respondents: scores < 15 indicate non-anxiety, while ≥ 15 indicate anxiety. In this study, the Cronbach's α coefficient for the scale was 0.917.

Measurement of oral health literacy in parents

The Short Form Health Literacy Dental Scale (HeLD-14) was developed by Australian researcher Jones [30] in 2015 and subsequently adapted into Chinese by Wen Yan et al. [31] in 2021. The Chinese version has demonstrated strong reliability for assessing oral health literacy in the Chinese population, with a Cronbach's α coefficient of 0.908, and a test-retest reliability of 0.988 [31]. The scale comprises 14 items across seven dimensions, rated on a 5-point Likert scale ranging from 0 (unable to do) to 4 (no difficulty). Total scores range from 0 to 56, with higher scores indicating greater oral health literacy. In this study, the Cronbach's α coefficient for the scale was 0.908.

Measurement of disease perception in caregivers

The Illness Perception Questionnaire Revised for Dental (IPQ-RD), developed by Nelson [32] in 2016, was adapted into Chinese by Xue Feng et al. [33] in 2019. The Chinese version has demonstrated strong reliability, with a Cronbach's α coefficient of 0.914, and good validity, as indicated by item Content Validity Index (CVI) values ranging from 0.80 to 1.00 (average CVI = 0.948) and a split-half reliability of 0.746 [33]. The scale includes

eight dimensions and 31 items, rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), with total scores ranging from 31 to 155. Higher scores indicate worse illness perception among caregivers. In this study, the Cronbach's α coefficient was 0.965.

Data collection

The electronic questionnaire was distributed via Wenjuanxing using a QR code provided by the researcher, ensuring immediate completion and submission by participants. The first page of the questionnaire contained standardised instructions, including an informed consent statement, study objectives, important notes, and detailed instructions for completing the questionnaire. The researcher remained available throughout the process to address any questions or concerns that participants might have raised.

To maintain data integrity while allowing participants to respond candidly, the questionnaire was administered anonymously. All questions were mandatory, and submission was possible only after providing complete responses. To minimise recall bias, the researcher reconfirmed the initial symptoms and the timing of the child's dental issues. Disease diagnoses were recorded on the basis of the attending physician's documentation.

For the CFSS-DS assessment, a colour-printed paper board displaying facial expression scales was used. After establishing rapport with the child, the researcher guided them through the questionnaire in a face-to-face manner, while parents selected the corresponding responses via Wenjuanxing. Upon completion, the system automatically exported the data to an Excel spreadsheet, eliminating potential biases associated with manual data entry. Two investigators reviewed the dataset to identify and exclude invalid questionnaires, such as those exhibiting patterned responses, completion times less than five minutes, or inconsistencies in answers.

Statistical analysis

Data analysis was performed using SPSS 26.0 statistical software. The normality of the data was assessed using the Kolmogorov-Smirnov test. Given that the data did not follow a normal distribution, measurement data were expressed as median (M) and quartiles (P25, P75), and intergroup comparisons were conducted using the rank sum test. Categorical and ordinal data were presented as frequencies and percentages, with intergroup differences analysed using the chi-square test or the Mann–Whitney U test. Variables that demonstrated statistical significance in the univariate analysis were incorporated into a binary logistic regression model to examine their influence on delays in seeking medical treatment for children. Additionally, the receiver operating characteristic (ROC) curve was used to assess the predictive efficacy of each risk factor associated with treatment delay. Statistical significance was set at $P < 0.05$ for all tests.

Results

Current status of delay in medical treatment and general information

A total of 264 children and their parents participated in this study, with 87 fathers and 177 mothers among the respondents. The duration of medical treatment for the 264 children ranged from 0 to 1,178 days, with a median of 57.5 days. Of these children, 188 (71.21%) experienced treatment delays, with a median delay duration of 117.5 days. The remaining 76 children (28.79%) did not experience delays, with a median treatment duration of 5.0 days. For further details, see Table 1. (Table 1).

Analysis of factors influencing delayed treatment seeking for preschool children with dental caries

Binary logistic regression analysis was conducted to identify statistically significant factors that influence the outcome. The analysis revealed that the primary caregiver, initial observed symptoms, children's dental fear, parental dental anxiety, and parental oral health literacy were independent factors contributing to treatment delay in preschool children with dental caries ($P < 0.05$). For detailed results, see Table 2.

Analysis of the receiver operating characteristic (ROC) curve in the context of medical treatment delay

The severity of initial observed symptoms and parental oral health literacy were identified as key factors influencing delays in seeking medical treatment. As both factors are protective, they were reverse-coded so that higher values indicate a greater risk of treatment delay. An ROC curve was constructed, and the area under the curve (AUC) was calculated to evaluate the predictive value of the primary caregiver, initial observed symptoms, children's dental fear, parental dental anxiety, and parental oral health literacy in treatment delay. The results indicated that children's dental fear (AUC = 0.765, 95%CI: 0.707–0.823) and parental oral health literacy (AUC = 0.738, 95%CI: 0.673–0.802) had the highest predictive values, with the combined diagnostic model yielding the best predictive performance. The detailed predictive values of the other factors are presented in Table 3. The ROC curve for delayed treatment among preschoolers with dental caries is presented in Fig. 1.

Discussion

The current study identified a treatment delay rate of 71.21% for dental caries among preschool children, with 40% of affected children experiencing delays exceeding 90 days. Similar findings were reported by Wang et al. [34], who noted that ECC exhibited a moderate level

Table 1 Comparison of general data of preschool children with dental caries

Variable	*N*(%)	medical delay group(*n* = 188)	Non medical delay group (*n* = 76)	χ^2 /Z value	*P* value
Children's sex				4.340(1)	0.037
Boy	148(56.1)	113(76.4)	35(23.6)		
Girl	116(43.9)	75(64.7)	41(35.3)		
Children age				-1.177(2)	0.239
3	35(13.3)	23(65.7)	12(34.3)		
4	70(26.5)	55(78.6)	15(21.4)		
5	96(36.4)	71(74.0)	25(26.0)		
6	63(23.9)	39(61.9)	24(38.1)		
Residence				5.610(1)	0.018
City	133(50.4)	86(64.7)	47(35.3)		
Township	131(49.6)	102(77.9)	29(22.1)		
Primary caregiver				12.101(1)	0.001
Parents	202(76.5)	133(65.8)	69(34.2)		
Grandparents	62(23.5)	55(88.7)	7(11.3)		
Number of children				-2.080(2)	0.038
Only child	185(70.1)	125(67.6)	60(32.4)		
Two children	74(28.0)	58(78.4)	16(21.6)		
Multiple children	5(1.9)	5(100.0)	0(0.0)		
Father's age				-0.220(2)	0.826
≤ 30	12(4.5)	7(58.3)	5(41.7)		
31–40	207(78.4)	151(72.9)	56(27.1)		
> 40	45(17.0)	30(66.7)	15(33.3)		
Mother's age				-0.213(2)	0.831
≤ 30	25(9.5)	17(68.0)	8(32.0)		
31–40	206(78.0)	149(72.3)	57(27.7)		
> 40	33(12.5)	22(66.7)	11(33.3)		
Average monthly household income(CNY)				4.135(1)	0.042
≤ 10,000	174(65.9)	131(75.3)	43(24.7)		
>10,000	90(34.1)	57(63.3)	33(36.7)		
Father's occupation				1.643(1)	0.896
Civil servant/Career staff	66(25.0)	46(69.7)	20(30.3)		
Enterprise employees	75(28.4)	56(74.7)	19(25.3)		
Farmer	5(1.9)	3(60.0)	2(40.0)		
Worker	40(15.2)	30(75.0)	10(25.0)		
Unemployed	5(1.9)	3(60.0)	2(40.0)		
Self-employed	73(27.7)	50(68.5)	23(31.5)		
Mother's occupation				3.818(1)	0.576
Civil servant/Career staff	66(25.0)	46(69.7)	20(30.3)		
Enterprise employees	67(25.4)	49(73.1)	18(26.9)		
Farmer	5(1.9)	4(80.0)	1(20.0)		
Worker	21(8.0)	16(76.2)	5(23.8)		
Unemployed	46(17.4)	36(78.3)	10(21.7)		
Self-employed	59(22.3)	37(42.0)	22(37.3)		
Father's education level				-1.162(2)	0.245
Primary school degree or below	1(0.4)	1(100.0)	0(0.0)		
Junior high school degree	12(4.5)	9(75.0)	3(25.0)		
High school degree	43(16.3)	26(60.5)	17(39.5)		
University degree or above	208(78.8)	152(73.1)	56(26.9)		
Mother's education level				-0.434(2)	0.664
Primary school degree or below	0(0.0)	0(0.0)	0(0.0)		
Junior high school degree	12(4.5)	9(75.0)	3(25.0)		
High school degree	42(15.9)	28(66.7)	14(33.3)		
University degree or above	210(79.5)	151(71.9)	59(28.1)		
Disease diagnosis classification				16.991(1)	0.001

Table 1 (continued)

Variable	*N*(%)	medical delay group(*n* = 188)	Non medical delay group (*n* = 76)	χ^2 /Z value	*P* value
Superficial Caries	23(8.7)	14(60.9)	9(39.1)		
Intermediate Caries	53(20.1)	32(60.4)	21(39.6)		
Deep Caries	87(33.0)	76(87.4)	11(12.6)		
Secondary Pulpitis and Periapical Periodontitis	101(38.3)	66(65.3)	35(34.7)		
Initial observed symptoms				-2.700(2)	0.007
Symptoms of Superficial Caries	88(33.3)	74(84.1)	14(15.9)		
Symptoms of Intermediate Caries	51(19.3)	33(64.7)	18(35.3)		
Symptoms of Deep Caries	23(8.7)	14(60.9)	9(39.1)		
Symptoms of Pulpitis and Periapical Periodontitis	102(38.6)	67(65.7)	35(34.3)		
Primary motivations for the visit				22.851(1)	< 0.001
Yellowish brown spots/Small black dot	22(8.3)	16(72.7)	6(27.3)		
Yellowish brown light hole	36(13.6)	21(58.3)	15(41.7)		
Black deep caries cavity	56(21.2)	51(91.1)	5(8.9)		
Toothache	133(50.4)	93(69.9)	40(30.1)		
Dental examination and others	17(6.4)	7(41.2)	10(58.8)		
CFSS-DS score[*M(P25,P75)*]	62.00(50.00,73.00)	67.00(56.00,76.00)	52.00(48.00,57.75)	-6.747(2)	< 0.001
Dental anxiety in parents				23.819(1)	< 0.001
Non Anxiety	70(26.5)	34(48.6)	36(51.4)		
Anxiety	194(73.5)	154(79.4)	40(20.6)		
Parents' HeLD-14 score[*M(P25,P75)*]	62.00(50.00,73.00)	47.00(41.00,50.00)	50.50(48.00,53.75)	-6.060(2)	< 0.001
IPQ-RD score[*M(P25,P75)*]	66.50(56.25,86.75)	69.00(58.25,90.75)	63.00(48.75,73.75)	-3.035(2)	0.002

(1) χ^2 value; (2) Z value

Table 2 Regression model of factors influencing medical delay

Variable	β	SE	Waldχ^2	*P* value	OR value	95%CI	VIF
Constant	0.121	2.458	0.002	0.961	1.129	-	
Primary caregiver	1.476	0.639	5.343	0.021	4.377	1.252 ~ 15.307	1.101
Initial observed symptoms(Symptom 1[a])	-	-	12.899	0.005	-	-	2.078
Symptom 2	-3.315	1.000	11.000	0.001	0.036	0.005 ~ 0.258	-
Symptom 3	-4.043	1.286	9.877	0.002	0.018	0.001 ~ 0.218	-
Symptom 4	-3.681	1.308	7.919	0.005	0.025	0.002 ~ 0.327	-
CFSS-DS score	0.090	0.019	22.015	< 0.001	1.094	1.054 ~ 1.136	1.385
Dental anxiety in parents	1.380	0.539	6.556	0.010	3.974	1.382 ~ 11.428	1.289
Parents' HeLD-14 score	-0.163	0.041	15.996	< 0.001	0.850	0.784 ~ 0.920	1.279

Note: *β* adjusted coefficient of the regression; *SE* standard error; *OR* odd sratio; 95% CI: 95% Confidence Interval; VIF (Variance Inflation Factor); Primary caregivers: 1 for Parents, 2 for Grandparents; Initial observed symptoms: Symptom 1 for Superficial caries, Symptom 2 for Intermediate Caries, Symptom 3 for Deep caries, Symptom 4 for Secondary pulpitis and periapical periodontitis; [a] represents the control group; Dental Anxiety in Parents: 1 for Non-anxiety, 2 for Anxiety. In this study, the goodness-of-fit of the model was evaluated using the Hosmer-Lemeshow test, with a p-value of 0.845, indicating an excellent fit

of treatment delay. These findings underscore the widespread and severe nature of delayed dental treatment among preschoolers, highlighting an urgent need for attention and intervention. Potential contributing factors may include inefficiencies in healthcare resource allocation in China, regional disparities in healthcare distribution, and imbalances in comprehensive medical capabilities [35]. Previous research has demonstrated that regional economic conditions and access to healthcare resources significantly impact treatment delays [36]. Furthermore, the limited coverage of China's basic medical insurance policy for paediatric oral healthcare may exacerbate this issue [37].

The findings also indicate that delays in seeking medical treatment among preschoolers with dental caries are significantly associated with the identity of the primary caregiver. Specifically, children under the care of grandparents are more likely to experience delayed medical treatment than those under the care of their parents. In China, where strong family ties and traditional values prevail, grandparents play a crucial role within families [38]. The increasing prevalence of dual-income households has led to an increase in intergenerational caregiving arrangements [39]. However, because of factors such as lower educational attainment, cultural background, and limited exposure to modern dental practices, grandparents may exhibit insufficient awareness and attention toward the management of deciduous tooth caries [40].

The severity of initial symptoms is another key factor contributing to treatment delay in preschool children

Table 3 Assess the predictive significance of diverse influencing factors on the incidence of medical delay

Variable	Sensitivity	Specificity	AUC	*P* value	95%CI
Primary caregiver	0.293	0.908	0.600	0.011	0.529 ~ 0.671
Initial observed symptoms	0.394	0.816	0.612	0.004	0.539 ~ 0.685
CFSS-DS score	0.702	0.829	0.765	< 0.001	0.707 ~ 0.823
Dental anxiety in parents	0.819	0.474	0.646	< 0.001	0.569 ~ 0.723
Parents' HeLD-14 score	0.633	0.711	0.738	< 0.001	0.673 ~ 0.802
Joint diagnosis	0.766	0.908	0.895	< 0.001	0.854 ~ 0.936

with dental caries, consistent with previous findings [9]. When symptoms are pronounced, medical care is sought more promptly, whereas mild or vague symptoms often lead to delayed treatment [13]. In this study, children presenting with initial symptoms of shallow caries exhibited the highest rate of treatment delay. At this stage, no obvious cavities or significant subjective symptoms were present, making it difficult for children and their parents to recognise the issue or consider it a serious concern. However, as dental caries progress and cause pain, particularly when exacerbated by exposure to cold, hot, sour, or sweet stimuli, daily activities and learning may be significantly affected, prompting more immediate medical intervention.

Preschool children are particularly susceptible to dental fear and anxiety [41], and they often attempt to avoid or delay dental treatment [42]. A study conducted in Saudi Arabia reported that 67.4% of children experienced dental fear during examinations and identified a significant correlation between untreated dental caries and dental fear [43]. These findings align with those of the present study. Here, each one-point increase in the CFSS-DS total score was associated with a 1.094-fold increase in the likelihood of treatment delay. Negative perceptions of the dental clinic environment and prior adverse experiences may further intensify dental fear and anxiety.

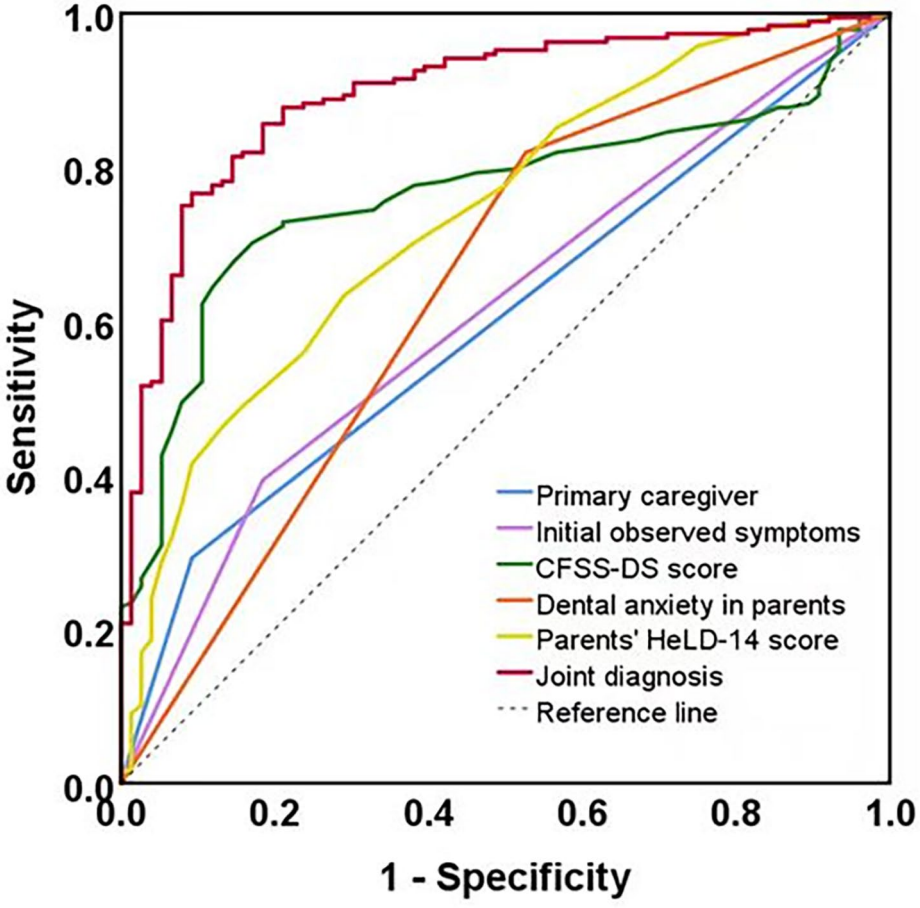

Fig. 1 Under the background of treatment delay, the receiver operating characteristic (ROC) curve

Establishing a positive and harmonious relationship between the child, dentist, and dental clinic may enhance the success of dental treatment. A child-friendly clinical environment, along with appropriate dental attire, can effectively alleviate children's fear and promote positive dental behaviour [44].

Parental attitudes and experiences also play a crucial role in shaping children's dental behaviours. Parents who inadvertently convey negative dental experiences may instil dental anxiety in their children prior to their first visit [45], directly influencing their treatment-seeking behaviour [46]. This study further confirmed that parental dental anxiety has a detrimental effect on children's attitudes toward dental care. Compared to children whose parents did not exhibit dental anxiety, children with anxious parents were found to be 3.974 times more likely to experience treatment delays. Addressing parental dental anxiety and preventing its transmission are essential to reduce children's fear and foster positive dental care behaviours. This can be achieved through parental education, psychological preparation for dental visits as advised by dentists, and increased awareness of the importance of oral hygiene and preventive dental procedures [47].

Brega et al. [48] noted that parents with low oral health literacy often lack adequate knowledge about oral health practices, underestimate the severity of dental caries, and tend to rely on dentists or external factors for their children's oral health maintenance. Conversely, parents with higher oral health literacy are more proactive in oral care and place greater emphasis on fostering good oral hygiene habits in their children [49]. In this study, each one-point increase in the total score of parents' oral health literacy was associated with a 15% decrease in the likelihood of treatment delay. The findings of this study highlighted the significant impact of parental oral health knowledge on shaping children's oral health outcomes [50]. Additionally, mothers demonstrated significantly higher scores than fathers in oral health literacy, healthcare-seeking behaviours, and communication skills. This finding is consistent with those of Ansari et al. [51], who reported that mothers typically possess greater knowledge and more positive attitudes regarding the health of children's primary teeth. These results highlight the need for targeted interventions to enhance fathers' oral health literacy because improving overall parental literacy can lead to better symptom recognition, improved communication with healthcare providers, and reduced delays in seeking care.

The ROC curve, a key diagnostic tool, quantitatively evaluates model predictive performance through the AUC. Using the Youden Index method, the following optimal cutoff points were identified: a CFSS-DS score of 60.5 and a HeLD-14 score of 48.5. The likelihood of delayed treatment in children with dental caries increases when the CFSS-DS score exceeds 60.5 and the HeLD-14 score falls below 48.5. At these cutoff points, the sensitivity for identifying children with dental fear was 0.702, and the specificity was 0.829, demonstrating strong predictive capability. These thresholds may serve as effective screening criteria for the early identification of children at risk of delayed dental treatment.

Addressing treatment delays requires targeted interventions to reduce children's dental fear and enhance parental oral health awareness and literacy. Effective strategies include oral health education, psychological support, and optimisation of the healthcare environment to facilitate early intervention and timely treatment. Primary preventive measures for ECC are equally essential. Increasing awareness and promoting prevention directly contribute to reducing dental fear and anxiety. Interventions such as regular dental checkups, fluoride application, and fissure sealants play a critical role in preventing complications, including infection and tooth loss, ultimately supporting children's overall well-being and healthy development.

Limitations

This study has limitations. This was a single-centre, cross-sectional survey conducted in the Northeast region, which may limit the generalisability of the findings. Future research should incorporate a multicentre, large-sample design to enhance representativeness. Additionally, the definition of delayed treatment used in this study is subjective, and the range of considered factors is limited, potentially omitting other relevant influences. Consequently, the identified risk factors and predictive model warrant further validation to ensure their robustness and applicability. Future studies should investigate a broader range of risk factors and employ longitudinal or randomised controlled trials to examine causal relationships more comprehensively.

Conclusion

The current study underscores the high prevalence and severity of treatment delays among preschoolers with dental caries, highlighting the urgent need for intervention. Comprehensive strategies, including preventive care, psychological support, improvement of the family environment, and enhanced caregiver awareness, are essential for mitigating treatment delays. Strengthening parental oral health literacy and fostering early and routine dental visits can improve oral health outcomes. These efforts are critical for promoting the overall well-being and healthy development of children.

Abbreviations

ECC	Early childhood caries
CFSS-DS	Children's Fear Survey Schedule-Dental Subscale

MDAS	Modified Version Dental Anxiety Scale
HeLD-14	Short Form Health Literacy Dental Scale
IPQ-RD	Illness Perception Questionnaire Revised for Dental
CVI	Content Validity Index
QR codes	Quick Response codes
P25	25th percentile (first quartile)
P75	75th percentile (third quartile)
M	Median
ROC Curve	Receiver Operating Characteristic Curve
AUC	Area Under the Curve
95%CI	95% Confidence Interval

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Author contributions
HZ and JSH collaboratively formulated the research concept and designed the study protocol. JSH, CYC, and ZYY were responsible for distributing the questionnaires and collecting data. JQS and YJ performed the usability and normative checks on the questionnaire data. JSH led the data analysis and interpretation and was the primary contributor to drafting the manuscript. The initial draft and revisions were jointly completed by JSH and HZ. All authors participated in reviewing subsequent versions of the manuscript and provided valuable feedback. The final version of the manuscript was critically revised by all authors and unanimously approved.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This study adhered strictly to the principles outlined in the Helsinki Declaration and received approval from the Ethics Committee of the School of Stomatology, China Medical University (Approval No. K2023-027). All participants, including children aged 3–6 and their parents, provided written informed consent after thoroughly understanding the research content and their rights. Participants were explicitly informed of their right to withdraw from the study at any time and were assured of anonymity throughout the research process. All research methods were conducted in strict compliance with relevant guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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