

# Prevalence and risk factors of dry eye among middle school students in Nantong

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## 南通市中学生干眼的患病率及危险因素调查

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### 摘要

**目的:**了解南通市中学生干眼(DE)的患病率及危险因素。  
**方法:**于2021-01对南通市1939名中学生进行横断面调查,采用分层随机整群抽样计算样本量,采用干眼问卷调查DE的患病率和危险因素。DE患病被定义为经常或总是存在一种或以上干眼症状(如:干燥感、沙砾感、烧灼感、眼红、疲劳感、分泌物增多)。通过Logistics回归分析评估与DE相关的危险因素。

**结果:**南通市中学生DE的患病率为19.55%。干眼症状中疲劳感出现最多,占60.95%。多因素Logistics回归分析显示,女性( $OR:1.287, 95\%CI:1.018-1.626, P=0.035$ )、近距离电子屏幕使用时间 $>2h$ ( $OR:1.927, 95\%CI:1.260-2.947, P=0.002$ )、课后读写时间 $>3h$ ( $OR:1.588, 95\%CI:1.214-2.079, P=0.001$ )、频繁使用滴眼液( $OR:1.908, 95\%CI:1.359-2.680, P<0.001$ )、全身使用抗过敏药物( $OR:1.787, 95\%CI:1.220-2.618, P=0.003$ )和关节痛( $OR:1.688, 95\%CI:1.128-2.524, P=0.011$ )是中学生DE患病的独立危险因素,而充足的睡眠时间( $>6-8h, OR:$

$0.627, 95\%CI:0.477-0.823, P=0.001$ ;  $>8h, OR:0.511, 95\%CI:0.283-0.922, P=0.026$ )是独立保护因素。

**结论:**中学生DE的患病率较高不应被忽视。针对各种危险因素采取积极预防措施将有助于降低中学生DE的患病率并对学生健康产生积极影响。

**关键词:**干眼;患病率;危险因素;中学生

### Abstract

• **AIM:** To investigate the prevalence and risk factors of dry eye (DE) among middle school students in Nantong.

• **METHODS:** A cross-sectional study was conducted among 1939 middle school students in January 2021. The minimum sample size was calculated by cluster random sampling. A dry eye questionnaire was used to assess the prevalence and risk factors of DE in middle school students. DE was defined as often or all the time presence of one or more DE symptoms (*i. e.* "eye dryness" "grittiness" "burning sensation" "redness" "crusting of lashes" "eyelids getting stuck"). The risk factors associated with DE were evaluated by Logistics regression analysis.

• **RESULTS:** The prevalence of DE was 19.55%. The most reported dry eye symptom was "eyelids getting stuck", accounting for 60.95%. Female ( $OR: 1.287, 95\%CI: 1.018-1.626, P=0.035$ ), the daily time of electrical appliances use at near distance  $>2h$  ( $OR: 1.927, 95\%CI: 1.260-2.947, P=0.002$ ), the daily time of reading and writing after class  $>3h$  ( $OR: 1.588, 95\%CI: 1.214-2.079, P=0.001$ ), frequent use of eye drops ( $OR: 1.908, 95\%CI: 1.359-2.680, P<0.001$ ), use of systemic anti-allergic drugs ( $OR: 1.787, 95\%CI: 1.220-2.618, P=0.003$ ) and joint pain ( $OR: 1.688, 95\%CI: 1.128-2.524, P=0.011$ ) were independent risk factors for DE among middle school students. Sufficient sleep ( $>6-8h, OR: 0.627, 95\%CI: 0.477-0.823, P=0.001$ ;  $>8h, OR: 0.511, 95\%CI: 0.283-0.922, P=0.026$ ) was an independent protective factor for the disease.

• **CONCLUSION:** The prevalence of DE among middle school students is high and should not be ignored. Preventive measures against risk factors may help to reduce the prevalence of DE and have a positive impact on the health of students.

• **KEYWORDS:** dry eye; prevalence; risk factors; middle school students

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## INTRODUCTION

Dry eye (DE) is a common eye disease that causes eye discomfort, even eye tissue damage, and severe visual impairment. Although the prevalence of DE is increasing, there has been a relatively lack of epidemiological investigations of DE in children and adolescents. According to a study of Japanese high school students, the prevalence of DE is 21.6%<sup>[1]</sup>, which is higher than that reported by the elderly population in developed countries<sup>[2]</sup>. It suggests that we should not ignore the diagnosis and treatment of DE in young people.

Significant changes have taken place in the life and learning styles of children and adolescents today, such as long-term wearing of masks, online learning prolonging the use of electronic terminal equipment, reduced outdoor activities, and so on. These changes may have an impact on the occurrence and development of DE<sup>[3-4]</sup>. Therefore, it is urgent and necessary to investigate the prevalence of DE in children and adolescents.

Symptoms of dry eye can appear when there is no obvious damage to the ocular surface, causing eye discomfort, reducing the quality of life, interfering with daily activities, and reducing the ability to perform various tasks that require continuous visual concentration<sup>[5]</sup>. This can cause particularly serious problems for students, or even lead to psychological disorders such as depression<sup>[6]</sup>. One of the goals of DE treatment is to improve symptoms. Therefore, the evaluation of symptoms is of great significance for the diagnosis and prevention of DE. The purpose of this study was to investigate the prevalence and related risk factors of DE among middle school students in Nantong.

## SUBJECTS AND METHODS

**Sample Size Calculation** A total of 100 junior and senior high school students were randomly selected for pre-survey, and the results showed that the prevalence rate of DE was 25.0%. The sample size was calculated by the formula:  $n = t^2pq/d^2$  (Assuming  $\alpha = 0.05$ ,  $t = 2$ ,  $p = 25\%$ ,  $q = 1 - p = 75\%$ ,  $d = 0.1 \times p = 2.5\%$ ). Considering a conservative design effect of 1.5 for cluster sampling, and a non-response rate of 5%, as a result, at least about 1894 students were needed. This sample size was considered sufficient to identify risk factors in multivariate analysis.

**Sampling Survey** The present study was an observational cross-sectional study. It was carried out in 15 junior and senior high schools in Nantong City, Jiangsu Province, China in January 2021 (average temperature 0°C–8°C). Through multi-stage stratified random cluster sampling, two classes (clusters) of each grade (stratified) in each school

(stratified) were randomly selected, and 2005 students in the selected 45 classes were obtained. The obtained samples are more representative in terms of gender, learning conditions, learning intensity, outdoor activities, and use of visual display terminals. After listening to the description of the research content, the participants signed an informed consent form, and the structured questionnaire with clear questions and answer options was completed by the participants themselves under the supervision and guidance of the researchers. We excluded those who did not complete the questionnaire, and the final response rate was 96.71% (1939/2005). This study followed the principles of the Helsinki Declaration and was approved by the Medical Ethics Committee of the Second Affiliated Hospital of Nantong University. The study was obtained from the consent of the guardians.

**Questionnaire** A self-designed questionnaire was employed for the present study, which is mainly composed of three different sections. The first part was the basic information of subjects, including gender, age, height and weight. The second part was the Chinese version of the Salisbury Eye Evaluation Questionnaire for the assessment of dry eye symptoms<sup>[7]</sup>. It includes six kinds of symptoms (*i.e.* “eye dryness” “grittiness” “burning sensation” “redness” “crusting of lashes” “eyelids getting stuck”) and the frequency of occurrence for each symptom (*i.e.* “none” “sometimes” “often” “all the time”). The third part was a self-designed questionnaire focusing on factors which might cause DE, including daily near distance electronic screen use time, watching TV time, after-class reading and writing time, outdoor exercise time, sleeping time, contact lens wear history, past history of DE, eye medication history, eye disease history, DE history, dry skin history, anti-allergic drug use history, joint pain and so on.

**Definition of DE** In this study, we counted the frequency of DE (*i.e.* “eye dryness” “grittiness” “burning sensation” “redness” “crusting of lashes” “eyelids getting stuck”). The frequency was divided into none (Less than once 3mo), sometimes (at least once 2wk), often (at least once 1wk), all the time, and at least one symptom that often or all the time occurs was defined as DE<sup>[8]</sup>.

**Definition of Risk Factors** Daily time of electrical appliances use at near distance (mobile phones, iPads, computers): 1) 0h; 2) >0–0.5h; 3) >0.5–1h; 4) >1–2h; 5) >2h. Daily TV watching time: 1) 0h; 2) >0–0.5h; 3) >0.5–1h; 4) >1–2h; 5) >2h. Daily reading and writing time after class (homework and book reading): 1) ≤0.5h; 2) >0.5–1h; 3) >1–2h; 4) >2–3h; 5) >3h. Daily outdoor activities or exercise time (Monday to Friday): 1) ≤0.5h; 2) >0.5–1h; 3) >1–2h; 4) >2–4h; 5) >4h. Daily outdoor activities or exercise time (Saturday and Sunday): 1) ≤1h; 2) >1–2h; 3) >2–4h; 4) >4–6h; 5) >6h. Daily sleep time: 1) ≤6h; 2) >6–8h; 3) >8h. Contact lens wearing was defined as the use of contact lenses at least once 1wk in the

past 3mo. Frequent use of eye drops was defined as the use of eye drops at least once 1d in the past 3mo. The use of atropine drugs for myopia was defined as the use of atropine eye drops or ointment at least once 1wk in the past 3mo. Allergic conjunctivitis was defined as itchy eyes in the past 3mo and was diagnosed as allergic conjunctivitis by an ophthalmologist. The use of systemic anti-allergic drugs was defined as the use of systemic anti-allergic drugs at least once 1wk in the past 3mo. Joint pain and medication use was defined as having joint pain in the past 3mo and using medication at least once 1wk.

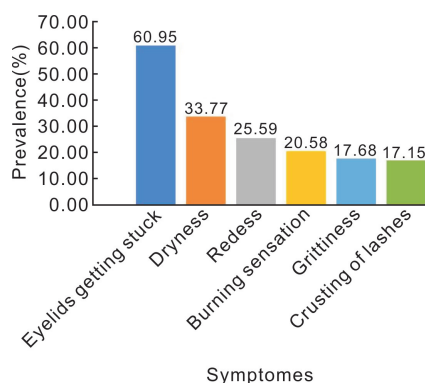
**Statistical Analysis** All the statistical analysis was performed using IBM-SPSS 22.0. Counting data are expressed as frequency and percentage. The prevalence of DE was calculated and the association between DE and various risk factors was evaluated. The risk factors significantly associated with DE in the univariate analysis were included in the multivariate multinomial Logistic regression model which was further conducted to identify the independent risk factors. The odds ratios (OR) and 95% confidence intervals (95% CI) were calculated. P value less than 0.05 was considered statistically significant.

**RESULTS**

This study included 1939 participants, aged from 13 – 19 years, including 1295 junior high school students, accounting for 66.79%, and 644 senior high school students, accounting for 33.21%. There were 990 males, accounting for 51.06%, and 949 females, accounting for 48.94%.

Among the respondents, 1450 (74.78%) none felt “dryness”, 361 (18.62%) sometimes felt “dryness”, 93 (4.80%) often felt “dryness”, and 35 (1.81%) all the time felt “dryness”. As the frequency of dryness changed from low to high, the number of middle school students showed a significant downward trend. The other five symptoms (“grittiness” “burning sensation” “redness” “crusting of lashes” “eyelids getting stuck”) also showed the same trend (Table 1).

There were 379 middle school students reported that one or more of the six eye symptoms occurred often or all the time, and the prevalence rate of DE was 19.55%. There were 231 students reported having “Eyelids getting stuck” (the highest prevalence, 60.95%), 128 students reported having “Dryness” (33.77%), 97 students reported having “Redness” (25.59%), 78 students reported having “Burning sensation” (20.58%), 67 students reported having “Grittiness” (17.68%), and 65 students reported having “Crusting of lashes” (the lowest prevalence, 17.15%). There were 209 students reported having only one symptom, 100 students reported having two symptoms, 43 students reported having three symptoms, 16 students reported having four symptoms, 8 students reported having five symptoms, and 4 students reported having six symptoms at the same time. The distribution in 379 middle school students with DE is shown in Figure 1.



**Figure 1 Symptom distribution of 379 middle school students with DE.**

Univariate analysis of DE in middle school students showed that the prevalence rate in females was significantly higher than that in males (22.13% vs 17.07%, P = 0.005). The prevalence rate of senior high school students is significantly higher than that of junior high school students (22.36% vs 18.15%, P = 0.028). The prevalence rate increased significantly with the prolongation of the use of electronic screens at near distance (P < 0.001). The prevalence rate increased significantly with the extension of reading and writing time after class (P < 0.001). Students who had enough sleep time had a significant decline in DE (P < 0.001). In addition, frequent use of eye drops, allergic conjunctivitis, use of systemic anti-allergic drugs, and joint pain are all risk factors for the disease (P < 0.01). The time of outdoor exercise and the time of watching TV in the middle distance had no significant effect on the prevalence rate (P > 0.05). Wearing contact lenses and using atropine drugs to control myopia also had no significant effect on the disease (P > 0.05) (Table 2). The significant risk factors obtained from univariate analysis were introduced into multivariate Logistics regression analysis, and the results showed that female (OR: 1.287, 95% CI: 1.018–1.626, P = 0.035), electronic screen use time at near distance greater than 2h (OR: 1.927, 95% CI: 1.260–2.947, P = 0.002), reading and writing time after class greater than 3h (OR: 1.588, 95% CI: 1.214 – 2.079, P = 0.001). Frequent use of eye drops (OR: 1.908, 95% CI: 1.359 – 2.680, P < 0.001), use of systemic antiallergic drugs (OR: 1.787, 95% CI: 1.220 – 2.618, P = 0.003) and arthralgia (OR: 1.688, 95% CI: 1.128 – 2.524, P = 0.011) were independent risk factors for DE in middle school students, while sufficient sleep (>6–8h, OR: 0.627, 95% CI: 0.477–0.823, P = 0.001; >8h, OR: 0.511, 95% CI: 0.283–0.922, P = 0.026) was an independent protective factor for the disease (Table 3).

**DISCUSSION**

Most of the participants in previous DE studies were adults, especially those over 40 years of age, and there were relatively fewer researches on children and adolescents<sup>[9]</sup>. This study found that the prevalence rate of DE among middle school students in Nantong was 19.5% , which was

**Table 1 Frequency of DE in 1939 middle school students**

n (%)

Symptomes	None	Sometimes	Often	All the time
Dryness	1450 (74.78)	361 (18.62)	93 (4.80)	35 (1.81)
Grittiness	1651 (85.15)	221 (11.40)	46 (2.37)	21 (1.08)
Burning sensation	1650 (85.10)	211 (10.88)	54 (2.78)	24 (1.24)
Redness	1556 (80.25)	286 (14.75)	66 (3.40)	31 (1.60)
Crusting of lashes	1651 (85.15)	223 (11.50)	50 (2.58)	15 (0.77)
Eyelids getting stuck	1246 (64.26)	460 (23.72)	174 (8.97)	57 (2.94)

None; Less than once 3mo; Sometimes; At least once 2wk; Often; At least once 1wk.

similar to that of previous studies of middle school students in Lanzhou (24.5%)<sup>[10]</sup>, Shou County high school students in Shandong (23.7%)<sup>[11]</sup> and Japanese high school students (21.6%)<sup>[1]</sup>. This showed that the prevalence of DE among middle school students is not low, and we should arouse more attention of families and society.

The prevalence of DE in this study was significantly higher compared to that of middle school students in Hengxian County, Guangxi Province (6.66%)<sup>[12]</sup>. The reasons may be explained as follows. First, subjects with both symptoms and signs at the same time were diagnosed as DE in the study conducted in Hengxian County. Second, environmental factors may explain the difference. There are obvious differences in temperature, wind speed, relative humidity, air pollution and air pressure in different latitudes, all of which can affect the prevalence of DE<sup>[13-14]</sup>. For example, in the Singapore Malay Eye study, the low incidence of DE may be associated with high environmental humidity throughout the year<sup>[15]</sup>.

A significantly higher prevalence of DE in senior high school students than in junior high school students was observed in our study. Previous studies have illustrated that age was a risk factor for DE<sup>[16]</sup>, in particular middle-aged and elder population. With the continuous growth of age, the level of hormone secretion decreased significantly, the function of human organs gradually declined, and lacrimal glands, meibomian glands and conjunctival goblet cells atrophied<sup>[17]</sup>, resulting in qualitative changes in the quality and quantity of tear film, which provoke the DE diseases. Some DE studies in adolescents also have reported a significant increase of the prevalence with age<sup>[18]</sup>, and we believe that this was not caused by the decline of organ function, but may be related to the increased learning tasks of senior students and the prolongation of close eye use time.

Studies have shown that sex hormones may affect the ocular surface environment and cause DE by affecting the density of conjunctival goblet cells, subbrow gland, lacrimal gland and corneal sensitivity<sup>[19]</sup>. Schaumberg *et al*<sup>[20]</sup> found that women generally experience more frequent and severe DE than men, and report that DE has a greater impact on daily activities. Our study, like the study of Japanese high school students and college students in Brazil and South Korea, found that the

prevalence of DE in female students was significantly higher than that in male students, suggesting that sex hormones may play a role in DE in both young and older women<sup>[21-23]</sup>.

In this study, with the extension of near distance eye use time, including watching electronic screen, reading and writing after class, the prevalence rate of DE in middle school students showed a significant increasing trend. However, there was no significant correlation between the time of watching TV at moderate distance or the time of outdoor exercise and DE prevalence. This suggests that schools and parents should focus on controlling the time students use eyes at near distance in order to prevent DE. Prolonged use of eyes at near distances can cause instability of the tear film on the ocular surface and reduced tear secretion, resulting in DE<sup>[24]</sup>. Under continuous gaze, patients with DE will slow down their reading speed, and the reading time will be longer than normal<sup>[25-27]</sup>, this cycle aggravates the occurrence and development of DE.

Sufficient sleep time was a protective factor for DE. A close relationship between sleep and DE have been confirmed by different studies<sup>[28-29]</sup>. The reason why some students have not enough sleep could be explained for the following reasons. First, intensive educational activities prolonged the learning hours and reduced sleep time. Second, excessive levels of competitive pressure could cause the presence of insomnia. Short sleep time may increase exposure to dry and high permeable stress environments<sup>[30]</sup>, then produce ocular surface inflammation and reduce tear secretion by lowering androgen level<sup>[31]</sup>. According to one recent study in Japan<sup>[32]</sup>, not only short sleep time, but also poor sleep quality was also a risk factor for high prevalence of DE.

Frequent use of antifatigue eye drops could be both the reason and result of DE. Students with DE and visual fatigue often use eye drops to relieve symptoms, while most eye drops on the market contain preservatives such as benzalkonium chloride, which can cause ocular surface inflammation and tissue damage to aggravate DE<sup>[33]</sup>. Besides, systemic inflammation such as allergy and arthritis had been reported to have a close relationship with DE<sup>[34-36]</sup>. A growing number of studies have shown that DE is a kind of chronic inflammatory disease<sup>[37]</sup> and could have the same pathological changes with

**Table 2 Univariate analysis for the prevalence of DE among 1939 middle school students**

Risk factors	Total	No DE	DE	$\chi^2$	<i>P</i>
Gender				7.88	0.005
Male	990	821(82.93)	169(17.07)		
Female	949	739(77.87)	210(22.13)		
Grade				4.86	0.028
Junior high school	1295	1060(81.85)	235(18.15)		
Senior high school	644	500(77.64)	144(22.36)		
Electrical appliances use at near distance				13.15	<0.001
0h	511	424(82.97)	87(17.03)		
>0-0.5h	799	658(82.35)	141(17.65)		
>0.5-1h	314	245(78.03)	69(21.97)		
>1-2h	146	111(76.03)	35(23.97)		
>2h	169	122(72.19)	47(27.81)		
Watching TV				2.89	0.089
0h	1165	944(81.03)	221(18.97)		
>0-0.5h	487	396(81.31)	91(18.69)		
>0.5-1h	161	125(77.64)	36(22.36)		
>1-2h	66	52(78.79)	14(21.21)		
>2h	60	43(71.67)	17(28.33)		
Reading/writing after class				19.81	<0.001
≤1h	823	689(83.72)	134(16.28)		
>1-3h	491	408(83.10)	83(16.90)		
>3h	625	463(74.08)	162(25.92)		
Outdoor exercise (at workday)				0.15	0.697
≤0.5h	644	506(78.57)	138(21.43)		
>0.5-1h	825	674(81.70)	151(18.30)		
>1-2h	299	247(82.61)	52(17.39)		
>2-4h	113	89(78.76)	24(21.24)		
>4h	58	44(75.86)	14(24.14)		
Outdoor exercise (at weekend)				2.74	0.098
≤0.5h	763	579(75.88)	184(24.12)		
>0.5-1h	734	622(84.74)	112(15.26)		
>1-2h	296	249(84.12)	47(15.88)		
>2-4h	90	67(74.44)	23(25.56)		
>4h	56	43(76.79)	13(23.21)		
Sleeping time				26.15	<0.001
≤6h	399	283(70.93)	116(29.07)		
>6-8h	1428	1181(82.70)	247(17.30)		
>8h	112	96(85.71)	16(14.29)		
Wearing contact lens				0.62	0.432
No	1856	1496(80.60)	360(19.40)		
Yes	83	64(77.11)	19(22.89)		
Frequent use of antifatigue eye drops				29.10	<0.001
No	1738	1427(82.11)	311(17.89)		
Yes	201	133(66.17)	68(33.83)		
Atropine drugs to control myopia				2.15	0.143
No	1884	1520(80.68)	364(19.32)		
Yes	55	40(72.72)	15(27.28)		
Allergic conjunctivitis				8.96	0.003
No	1863	1509(81.00)	354(19.00)		
Yes	76	51(67.11)	25(32.89)		
Use of systemic anti-allergy agents				21.60	<0.001
No	1789	1461(81.67)	328(18.33)		
Yes	150	99(66.00)	51(34.00)		
Joint pain				11.20	0.001
No	1801	1464(81.29)	337(18.71)		
Yes	138	96(69.57)	42(30.43)		

DE: dry eye.

**Table 3 Multivariable logistic regression analysis for the prevalence of DE among 1939 middle school students**

Risk factors		B	S.E.	Wald	P	OR	95% CI
Electrical appliances use at near distance	>0-0.5h	0.033	0.155	0.047	0.829	1.034	0.763-1.401
	>0.5-1h	0.365	0.186	3.837	0.050	1.440	1.000-2.075
	>1-2h	0.456	0.236	3.742	0.053	1.577	0.994-2.503
	>2h	0.656	0.217	9.157	0.002	1.927	1.260-2.947
Reading/writing after class	>1-3h	0.043	0.157	0.075	0.784	1.044	0.767-1.420
	>3h	0.463	0.137	11.356	0.001	1.588	1.214-2.079
Sleeping time	>6-8h	-0.467	0.139	11.270	0.001	0.627	0.477-0.823
	>8h	-0.672	0.301	4.978	0.026	0.511	0.283-0.922
Frequent use of antifatigue eye drops		0.646	0.173	13.925	<0.001	1.908	1.359-2.680
Allergic conjunctivitis		0.323	0.273	1.403	0.236	1.382	0.809-2.359
Use of systemic anti-allergy agents		0.580	0.195	8.872	0.003	1.787	1.220-2.618
Joint pain		0.523	0.205	6.492	0.011	1.688	1.128-2.524
Grade(senior high school)		0.084	0.127	0.439	0.507	1.088	0.848-1.395
Gender(female)		0.252	0.119	4.454	0.035	1.287	1.018-1.626
Constant		-2.179	0.400	29.654	<0.001	0.113	

systemic inflammation disease as the serum inflammatory factors (IL-6, IL-1 $\beta$ , and TNF- $\alpha$ ) was elevated in DE patients compared to normal people<sup>[38]</sup>.

This study has some limitations: 1) This study was conducted only in urban schools in Nantong, but no middle school students in rural schools participated in the survey, and did not consider the impact of this environmental factor on DE, while Galor *et al*<sup>[39]</sup> found that the prevalence of DE was higher in metropolitan areas; 2) This study did not investigate the effect of inadequate refractive correction on DE of middle school students; 3) Some of the eye drops frequently used by middle school students are used to treat DE, which may cover up the DE and reduce the prevalence rate.

In conclusion, the prevalence of DE among middle school students in Nantong was high in this study. The risk factors include too long eye-using time at near distance, not enough sleep time and frequent use of antifatigue eye drops. Based on these results, the high prevalence of DE in middle school students should be taken seriously. Attention should be paid to reducing the time of near distance eye use, ensuring the quality and time of sleep, and through other intervention measures such as publicity and education to achieve the best prevention and treatment of DE in middle school students.

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