Scientific Article

Risk Factors for Severe Early Childhood Caries in Children Younger Than 4 Years Old in Beijing, China

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Abstract: ***Purpose:*** *The purpose of this study was to compare cariogenic factors and acidogenic ability of bacteria between severe early childhood caries (S-ECC) and caries-free children in Beijing, China.* ***Methods:*** *The study consisted of 117 S-ECC children and 129 caries-free children < 4 years old. A questionnaire was designed to collect background information, feeding habits, and oral hygiene practices. Dental plaque samples were collected to test acidogenic ability of bacteria.* ***Results:*** *Compared with the mothers of caries-free children, those of S-ECC children had a lower education level and poorer knowledge of oral hygiene (P<.05). Night-feeding and eating sweets several times a day were significantly more common in S-ECC children than in caries-free children (P<.001). Forty-six S-ECC children but only 2 caries-free children received prechewed food (P<.001). The results of the Cariostat test showed that the majority of the caries-free children (81%) were at a low risk level, and most of the S-ECC children (78%) were at a high risk level (P<.001).* ***Conclusions:*** *There was strong relationship between high acidogenic ability of bacteria and S-ECC. A lower maternal education level, poor knowledge of oral hygiene, night-feeding, and excessive sugar intake were important contributors to the development of S-ECC. (Pediatr Dent 2008;30:122-8) Received March 20, 2007 / Last Revision July 29, 2007 / Revision Accepted August 13, 2007.*

KEYWORDS: SEVERE EARLY CHILDHOOD CARIES (S-ECC), ORAL HEALTH BEHAVIORS, ACIDOGENIC ABILITY OF BACTERIA

The concepts of early childhood caries (**ECC**) and severe early childhood caries (**S-ECC**) have been used for nearly 10 years to describe caries status present in children younger than 6 years old.[1,2] S-ECC has been defined in children younger than 3 years old as any sign of smooth surface caries. It is defined for children 3 to 5 years as 1 or more cavitated, missing (due to caries), or filled surfaces in primary maxillary teeth or as a decayed, missing, or filled surface with a score ≥4 at age 3, ≥5 at age 4, or ≥6 at age 5.[2]

ECC is a chronic, transmissible, infectious disease with a complex and multifactorial etiology. Factors attributed to the etiology of ECC include: excessive bottle-feeding with sugar-containing liquids; breast-feeding on demand and/or falling asleep while feeding; and nursing beyond the recommended age for weaning.[3-4] Other factors associated with ECC include: genetic predisposition; parental education; and nutritional, environmental, socioeconomic, and parental style factors.[5-6] Although the risk factors for ECC have been well reported in many countries, the status and health behaviors associated with ECC in Chinese children, particularly those younger than 5 years old, are not yet clear. One reason is that children < 5 years old are not included in the National Oral Health Survey.

Furthermore, an early cariogenic bacterial infection is one of the important predisposing factors of ECC.[7] As mutans streptococci (**MS**) metabolize nutrients, they produce acidic byproducts that penetrate the enamel pellicle. Lactobacilli present in dental plaque can also colonize damaged areas, producing more acid byproducts and further damaging the interior of the tooth.[8] It is reported that MS and lactobacilli are closely related to incipient caries and to caries progression.[9-10] A caries activity test is designed to test the acidogenic ability of dental plaque, including MS and lactobacilli.

The Cariostat test medium (Cariostat, Sankin Co, Tokyo, Japan) is a commercial product containing highly concentrated sucrose and 2 kinds of pH indicators to show the continuous pH decrease of the test medium caused by bacteria, including MS and lactobacilli, in plaque samples.[11] Cariostat scores of 0, 1, 2, and 3 correspond to the pH values of 5.8-7.2, 5.4±0.3, 4.7±0.3, and <4.4, respectively. The test does not measure bacteria directly, but it does measure their acidogenic ability, which indicates the infection levels of MS and lactobacilli in the plaque.[12] The test has high sensitivity and specificity and is recognized as a screening method for primary caries.[13]

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The aims of the present study were to:

1. characterize and compare behavioral and environmental factors potentially associated with caries in children with S-ECC and caries-free children <4 years old in Beijing, China; and
2. compare the acidogenic ability of dental plaque collected from S-ECC children and caries-free children by using the Cariostat test.

Methods

Subjects. Five hundred fourteen children <4 years old, recruited from the Pediatric Dental Clinic of Peking University Stomatological Hospital, Beijing, China, and 5 kindergarteners located within 5 km of the hospital were invited to participate in the study. A total of 117 children with >5 decayed teeth were placed into the S-ECC group, and 129 caries-free children were placed in the control group. Children with discernible enamel hypoplasia were not included in the study. The ethical approval of this study was obtained from the Human Research Ethics Committee of Peking University Medical Science Centre, Beijing, China.

Parental interview. The study was explained to the parents and legal guardians, and an informed consent was obtained from those who agreed to answer a detailed questionnaire and allow their children to undergo a dental examination and dental plaque collection. No more than 20 parents were interviewed at one time. The content of the questionnaire was described to the parents, and only the mothers were asked to complete the questionnaire in the interview room. The questionnaire was designed to collect information regarding the mother's education and knowledge of basic dental care and her child's birth weight, feeding practices, dental care, and hygiene behaviors.

Dental examination. A dental examination was performed by 2 pediatric dentists using a mirror and probe at the dental chair in the clinic with a knee-to-knee approach for the kindergarteners. The examiners were calibrated for caries detection by examining 20 children younger than <4 years old. The degree of agreement was assessed with the kappa statistic. Both examiners decided if a child was excluded due to enamel hypoplasia. The teeth were cleaned, and no radiographs were taken. Decayed, missing, and filled primary teeth (dmft) and surfaces (dmfs) and decayed teeth (dt) and surfaces (ds) were assessed according to the dental caries diagnostic criteria of the World Health Organization (WHO).[14] Restored teeth with recurrent caries were considered decayed.

Cariostat test. The plaque samples were collected from primary maxillary and mandibular buccal surfaces using a sterile cotton swab before cleaning the teeth. The swab was scrubbed across the tooth surface 3 or 4 times with a wiping movement. The cotton swab was placed into an ampule containing 2 mL of the Cariostat test medium. The sample was incubated at 37°C for 48 hours. The Cariostat score was evaluated by referencing the sample with 4 standard color tubes (provided by the manufacturer). In this study, a modified scale was used, where the interval between 0 and 1.0, 1.0 and 2.0, and 2.0 and 3.0 were divided into halves.

Statistical analysis. The data were analyzed by the Working Group of Medical Statistics, Peking University Medical College, Beijing, China. Data were divided into S-ECC and caries-free groups and calculated by descriptive statistics using SPSS v. 10.0 software for Windows (SPSS, Inc, Chicago, Ill). Pearson's chi-square test was used to analyze the difference in psychosocial, behavioral, and environmental factors between S-ECC children and caries-free children. Fisher's exact test was used when the *t* value was within the range of 1% to 5%. The Cariostat test scores of the S-ECC children and caries-free children were compared using the Mann-Whitney test. Differences were regarded as statistically significant if $P<.05$.

Results

Clinical findings. The kappa score for the interexaminer calibration was 0.91, indicating very good examiner agreement. The caries experience of the S-ECC children is summarized in Table 1. The mean dmft and dmfs were similar to the mean dt and ds, respectively.

Table 1. CARIES SCORES OF CHINESE CHILDREN IN THE SEVERE EARLY CHILDHOOD CARIES GROUP

Age (mos)	N	dmft±SD	dt±SD	dmfs±SD	ds±SD
<24	23	9.2±3.6	8.8±3.6	15.5±7.7	14.8±7.7
24-35	67	9.3±3.6	8.8±3.6	15.6±7.8	15.0±7.8
36-48	27	9.2±3.6	8.8±3.6	15.5±7.8	14.9±7.7
Total					
29.84±7.69	**117**	**9.2±3.6**	**8.8±3.6**	**15.5±7.7**	**14.9±7.7**

Basic information of children and parents. The general information of the children and their parents is presented in Table 2. The differences in birth weight between S-ECC children and caries-free children were not significant ($P=.156$). The mother's education level for caries-free children was higher than that for S-ECC children ($P=.023$). More S-ECC children were cared for by grandparents or a nursery maid than caries-free children ($P=.041$). Thirty-nine percent of S-ECC children had received prechewed food, of which one third received prechewed food from their grandparents and two thirds had received prechewed food from their parents. Only 2 caries-free children, however, had received prechewed food from their parents. This difference was statistically significant ($P<.001$). Among the 46 children who received prechewed food, 43 had

Table 2. INFORMATION ABOUT CHINESE CHILDREN AND THEIR PARENTS ENROLLED IN THE STUDY

	Severe early childhood caries group*	Caries-free group†	*P*-value of chi-square test
	N (%)	N (%)	
Female	53 (45)	60 (47)	
Birth weight			.156
<2,500 g	5 (4)	3 (2)	
2,500-3,000 g	11 (9)	24 (19)	
>3,000 g	101 (86)	102 (79)	
Mother's education level‡			.023
Elementary	7 (6)	2 (2)	
High school	34 (29)	21 (16)	
College and higher	76 (65)	106 (82)	
Person(s) taking care of the child			.041
Parent(s)	39 (33)	49 (38)	
Parent(s) and grandparent(s)	34 (29)	53 (41)	
Grandparent(s)	24 (21)	15 (11)	
Nursery maid(s)	20 (17)	12 (10)	
Fed with prechewed food			<.001
No	71 (61)	127 (99)	
Yes	46 (39)	2 (2)	
Fed by parent(s)	35 (30)	2 (2)	
Fed by grandparent(s)	11 (9)	0	
Fed by others	0	0	
Reason for first dental visit			<.001
Routine dental examination	2 (2)	32 (25)	
Dental caries	86 (74)	0	
Toothache or/and gingival abscess	25 (21)	0	
Dental trauma	4 (3)	3 (2)	
Never see a dentist	0	94 (73)	

* Average age in mos±(SD)=26.6±8.9.

† Average age in mos±(SD)=41.6±4.5.

‡ Fisher's exact test was used because the T value was within the 1%-5% range in Pearson's chi-square.

mothers with a high school or lower education level. Ninety-four of 129 caries-free children never saw a dentist before this dental examination, while 32 of them received routine dental examinations. Most S-ECC children (95%) did not visit a dentist until either serious caries decay was observed or they suffered a toothache, while only 2 children had their first dental visit as a routine dental examination (*P*<.001).

Table 3. COMPARISON OF FEEDING HABITS BETWEEN CHINESE CHILDREN WITH SEVERE EARLY CHILDHOOD CARIES (S-ECC) AND CARIES-FREE CHILDREN

	S-ECC group N (%)	Caries-free group N (%)	*P*-value of chi-square test
Feeding habit before 6 mos old			.002
Breast-feeding	65 (56)	65 (50)	
Milk without sugar	4 (3)	23 (18)	
Milk with sugar	48 (41)	41 (32)	
Feeding habit for 6- to 12-mos-olds			
Breast-feeding	39 (33)	25 (19)	
Milk without sugar	8 (7)	39 (30)	
Milk with sugar	70 (60)	65 (50)	
Sleeping while feeding after 12 mos old			<.001
No	40 (34)	112 (87)	
Yes	77 (66)	17 (13)	
Milk without sugar	65 (55)	4 (3)	
Milk with sugar	12 (11)	13 (10)	
Drinking habit			<.001
Water only	12 (10)	19 (14)	
Mainly water, a small amount of sugar-containing beverages	53 (45)	79 (61)	
Mainly sugar-containing beverages, a little water	15 (13)	17 (14)	
Sugar-containing beverages only	37 (32)	14 (11)	
Bottle-feeding by age (mos)			.23
No bottle-feeding	14 (12)	10 (8)	
<12	0	2 (2)	
12-18	7 (6)	18 (14)	
18-24	19 (16)	11 (8)	
<24	77 (66)	88 (68)	
Frequency of eating sweets or snacks every day			<.001
Never	6 (5)	4 (3)	
Rarely	17 (15)	53 (41)	
1-2x/day	25 (21)	52 (40)	
>2x/day	69 (59)	20 (16)	

Feeding habits and dental health behaviors. Information on feeding habits and dental health behaviors of the children are presented in Tables 3 and 4. The feeding habits from birth to 12 months of age were significantly different between S-ECC children and caries-free children (*P*<.001). The S-ECC children were fed with milk containing more sugar than were the caries-free children, though S-ECC children seemed to receive more breast-feeding. Compared with 66% of S-ECC children who drank milk at night, 87% of caries-free children did not drink milk at night (*P*<.001).

Table 4. COMPARISON OF DENTAL HEALTH BEHAVIORS BETWEEN CHINESE CHILDREN WITH SEVERE EARLY CHILDHOOD CARIES (S-ECC) AND CARIES-FREE CHILDREN

	S-ECC group N (%)	Caries-free group N (%)	*P*-value of chi-square test
Mother's knowledge about when to begin cleaning her child's mouth or brushing the child's teeth			<.001
Before the first tooth erupted	8 (7)	6 (5)	
By the time the first tooth erupted	21 (18)	25 (19)	
After all primary teeth erupted	49 (41)	84 (65)	
Do not know/no idea	39 (34)	14 (11)	
Frequency of toothbrushing			6.58
≥1x/day	43 (37)	38 (29)	
≥3x/week	14 (12)	28 (22)	
<3x/week	33 (28)	44 (34)	
Never	27 (23)	19 (15)	
How to clean child's mouth			.87
Parent(s) brush for the child	54 (46)	40 (31)	
Brushing by the child	10 (9)	44 (35)	
Rinse with water only	27 (23)	29 (22)	
None	26 (22)	16 (12)	

Table 5. COMPARISON OF THE CARIOSTAT SCORE BETWEEN CHINESE CHILDREN WITH SEVERE EARLY CHILDHOOD CARIES (S-ECC) AND CARIES-FREE CHILDREN

	S-ECC GROUP		Caries-free group		Mann-Whitney test	
Cariostat score	**N**	**%**	**N**	**%**	***Z***	***P*-value**
0-0.5	0	0	43	33		
1.0	6	5	62	48		
1.5	20	17	24	19		
2.0	40	34	0	0		
2.5-3.0	51	44	0	0		
Total	**117**	**100**	**129**	**100**	**12.66**	**<.001**

Sixty-six percent of S-ECC children and 68% of caries-free children continued bottle-feeding beyond 24 months old. The difference in bottle-feeding age between S-ECC children and caries-free children was not significant (*P*=.231). Seventy-five percent of caries-free children drank only water daily, or primarily water and a small amount of sugar-containing beverages, while 44% of S-ECC children drank only sugar-containing beverages or sugar-containing beverages and a little water (*P*<.001). Eighty-four percent of caries-free children had sweets less than twice a day, while 59% of S-ECC children had sweets several times a day (*P*<.001). In addition, the results showed that the mothers of S-ECC children had a poor knowledge of their children's oral hygiene. Mothers of S-ECC children also did not know when to begin cleaning their children's teeth, compared to 89% of mothers of caries-free children who knew that they should begin cleaning their children's mouths or brushing their children's teeth no later than when all primary teeth erupt. The difference was statistically significant (*P*<.001). No significant difference was observed in the frequency of tooth-brushing and the method of mouth cleaning between S-ECC children and caries-free children.

Acidogenic ability of dental bacteria. The results of the Cariostat test are shown in Table 5. The difference between S-ECC children and caries-free children was statistically significant (*P*<.001). Most caries-free children (81%) were at a low risk level (value ≤1.0, pH >5.5), and none were at a high risk level (value ≥2.0, pH <5.0). Alternatively, most of the S-ECC children (78%) were at a high risk level. Seventeen percent of S-ECC children and 19% of caries-free children were at a medium risk level (value=1.5, pH=5.5-5.0).

Discussion

In this study, dt was the major component of the dmft score of the S-ECC children. Although these S-ECC children had a very serious dental condition, most (95%) did not visit a dentist until serious decay was observed or they suffered a toothache. Their parents may have been unaware of the need for treatment or perhaps felt that their children were too young to attend a dental clinic until pain was experienced.[15] The same observations were reported by Wong et al[16,17] among 5- to 6-year-old children in China in 1997 and 2001.

Poor knowledge of oral hygiene and dental care by the parents was also related to the development of S-ECC.[18-20] One third of the mothers of S-ECC children did not know when they should begin to take care of their children's teeth, while most (89%) of the caries-free children's mothers knew that they should clean their children's mouths or brush their teeth no later than the eruption of all primary teeth. Although the mothers of the caries-free children had a better understanding of oral hygiene, no relationship was found between oral hygiene habits and dental caries in this study.

Because of the difficulties in brushing the children's teeth, most mothers let their children brush their teeth themselves, with less than half of both the S-ECC children and caries-free children receiving effective dental care (toothbrushing by caregivers everyday). Riedy et al[21] reported a similar phenomenon and argued that expectations about tooth cleaning behavior should be realistic, stressing persistence and the encouragement of children to cooperate with repeated, regular practice. In addition, for parents with very young children, it might be helpful to show how tooth brushing can be a kind of game. The fact that more S-ECC children were cared for by grandparents or a nursery maid than were caries-free children (*P*=.041) reflected a poor knowledge of oral hygiene among grandparents and their low opinion of primary teeth. In China,

some adults believe that a child under school age is too young for toothbrushing. They believe that primary teeth are transitional and that the decay of primary teeth will not affect permanent teeth. Therefore, they believe that it is unnecessary to care for primary teeth. It is imperative to improve public knowledge of oral hygiene to correct traditional norms and to promote dental care for young children in the fight against ECC in China.

It is well recognized that a low education level among parents is a risk factor associated with ECC.[2,6] The situation of ECC in mainland China is unclear, since few studies have been undertaken to evaluate the epidemiology and etiology of ECC. Bu et al[22] investigated 551 preschool children in Guangzhou, a city in south China. Their results showed that a parent's low education level and young age were risk factors for children to suffer caries. Huang,[23] however, investigated 890 preschool children in Guangxi, a province in southwest China, and found an opposite result. His study showed that the mother's education level did not significantly associate with ECC. In his study, 80% of children in high-income families suffered ECC, compared to 48% of children in low-income families. In this study, 65% of mothers of S-ECC children and 82% of mothers of caries-free children claimed to have a college or higher education. It seemed that mothers of both S-ECC children and caries-free children belonged to a population of higher education because less than 10% of people receive college or higher education in China. Nevertheless, the education level of S-ECC children's mothers was significantly lower than that for caries-free children, and a mother's lower education level is still a risk factor associated with their children suffering caries.

Improper feeding habits were thought to be important attributive factors for S-ECC. Frequent consumption of liquids containing fermentable carbohydrates (juice, milk, infant formula, soda) was reported to increase the risk of caries due to prolonged contact between sugars in the consumed liquid and cariogenic bacteria on the susceptible teeth.[24] Parents are encouraged to use bottle-feeding appropriately, have infants drink from a cup as they approach their first birthday, and wean children from the bottle at 12 to 14 months of age.[25] This recommendation is based on the belief that prolonged use of the baby bottle is an underlying cause of caries among young children. Nevertheless, some studies indicate that the relationship between prolonged use of the baby bottle and caries is weak, and that feeding at night and misuse of sugar seem to be the major contributors to the development of S-ECC.[26-29] Similar results were observed in this study.

Giving a child prechewed food is thought to increase the risk for dental caries because it could transmit cariogenic microorganisms directly to a child. This feeding behavior was rarely mentioned in previous studies. Feeding prechewed food is sometimes seen in China, particularly in the traditional practices of elderly Chinese. In this study, 39% of S-ECC children received prechewed food, compared to 2% of caries-free children. Forty-three of 46 S-ECC children who received prechewed food belonged to mothers with a lower education level. The acidogenic ability of dental plaque of the 46 S-ECC children was not significantly different from the other S-ECC children who did not receive prechewed food. The relationship between receiving prechewed food, the level of micro-organisms, and the acidogenic ability of dental plaque in S-ECC children was not clear because the prechewed food behavior is random; it is very difficult to determine its frequency and duration.

Low birth weight is reported to be a risk factor related to S-ECC, since low birth weight could result in a higher prevalence of enamel hypoplasia.[30,31] In this study, birth weight was not significantly different between S-ECC children and caries-free children. This might be a result of the fact that children suffering discernible enamel hypoplasia were excluded from the study. Fluoride exposure is an important factor related to ECC. Fluoride has 3 principle topical mechanisms of action: (1) inhibiting bacterial metabolism; (2) inhibiting demineralization; and (3) enhancing remineralization.[32,33] In this study, the fluoride exposure of the 2 groups was at the same baseline. Fluoride concentration in the drinking water in Beijing is below 0.4 ppm. Also, fluoride supplements are not available.

The topical application of fluoride is not carried out until "the first dental examination" provided by the Health Office for Women and Infants, a local governmental health unit. In fact, the dental examination in the study was part of their "first dental examination." In addition, only 6 of 117 S-ECC children had received dental treatment, but no topical application of fluoride was found in their dental records. Fluoridated toothpaste is available in Beijing stores and is recommended for children older than 3 to 4 years old. In this study, no mother declared giving her child fluoridated toothpaste regularly due to the risk of swallowing fluoridated toothpaste.

At least 3 categories of risk factors are associated with caries development: (1) microorganisms; (2) substrate/oral environment; and (3) host/teeth. Several lines of evidence strongly suggest that the first step in the development of ECC is MS infection. MS initiate the colonization and demineralization of tooth enamel; dietary factors contribute to the severity of ECC, but do not initiate the process.[32-36] Ansai et al[37] studied the relationship between dental caries experience (dfs) of 4- and 5-year-old Japanese children and the results of caries activity tests. These included salivary levels of MS (the Mucount test) and the acidogenic ability of dental plaque bacteria (the Cariostat test). They reported a significant positive correlation between the results of the Mucount test and the Cariostat tests in the total group of subjects.

In this study, a strong association between microorganisms and S-ECC was shown using the Cariostat test. Most caries-free children (81%) were at a low risk level (pH>5.5), and none was at a high-risk level (pH<5.0). Most of the S-ECC children (78%), however, were at a high risk level. In both groups, nearly one fifth of the children showed a medium level of acidogenic ability of dental bacteria. Six children with more than 8 decayed teeth were observed at the critical risk level of acidogenic ability of dental bacteria. The common variables among these 6 subjects were being male, prolonged bottle-feeding beyond 24 months, and sweet drinks at night.

It might be that microorganisms were not the sole cariogenic factor at the time, but that the host/teeth and dietary factors contributed together to the etiology of caries. Further studies should observe the caries risk in caries-free children with a medium level of acidogenic ability of dental bacteria.

Conclusions

Based on this study's results, the following conclusions can be made:

1. There was strong relationship between high acidogenic ability of bacteria and severe early childhood caries (S-ECC).
2. A lower maternal education level, poor knowledge of oral hygiene, night-feeding, and excessive sugar intake were important contributors to the development of S-ECC in young children. Giving child prechewed food should be considered a potential caries risk factor among children in Beijing, China.
3. Health promotion strategies that target new and expectant mothers, and that promote a more positive attitude towards oral health in China should be established.

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Abstract of the Scientific Literature

Psychological outcome of orthodontic treatment

The purpose of this study was to investigate oral health, social, and psychological effects of malocclusion, and the effectiveness of orthodontic treatment. This study began in 1981 with 1018 participants ages 11-12 years. Assessments of dental health and psychosocial well-being were conducted based on facial and dental photographs, study casts, and questionnaires. The photos and casts were rated for attractiveness and treatment need. Questionnaires were given at the beginning of the study as well as at each subsequent visit, investigating the relationships between occlusal status, attractiveness, psychological well-being, social status and achievement, and quality of life. Individual interviews were also conducted. No recommendations regarding orthodontic treatment were made and the subjects were observed over time. The subjects either received orthodontic treatment or not based on their own volition. At the third follow-up in 2001, 337 subjects between the ages of 30–31 were reexamined and one-way ANOVA was used to explore difference between 4 groups: treatment need vs. no need, and treatment received vs. no treatment. Although participants with a prior need who obtained treatment had better tooth alignment and satisfaction, when self-esteem at baseline was controlled for, orthodontic treatment had little positive impact on psychological health and quality of life in adulthood.

Comments: *This is the first in a series of articles from a 20-year cohort study of health gain from orthodontic treatment conducted in the United Kingdom. It is interesting to know that when pre-treatment self-esteem was accounted for, all the health gains in the psychological aspect vanished. It would seem that the potential impact of orthodontic treatment on psychological health has more to do with the patient's initial self-esteem rather than whether the patient received treatment. In the United States, where the youth might be more image-conscious, it is possible that a duplicate study will affirm the results expressed here.* ***RHH***

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Shaw WC, Richmond S, Kenealy PM, Kingdon A, Worthington H. A 20-year cohort study of health gain from orthodontic treatment: Psychological outcome. Am J Orthod Dentofacial Orthop 2007;132:146-57.

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