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ORIGINAL ARTICLE

Risk factors for tooth loss in community-dwelling Japanese aged 40 years and older: the Yamagata (Takahata) study

Shigeo Ishikawa[1] · Tsuneo Konta[2] · Shinji Susa[3] · Kenichiro Kitabatake[1] · Kenichi Ishizawa[3,4] · Hitoshi Togashi[5] · Atsushi Tsuya[6] · Yoshiyuki Ueno[4] · Isao Kubota[4] · Hidetoshi Yamashita[4] · Takamasa Kayama[4] · Mitsuyoshi Iino[1]

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Abstract

Objectives The aim of the present study was to investigate comprehensively the risk factors, including some lifestyle-associated factors, oral health habits, and socioeconomic status, for having less than 20 teeth in cross-sectional study in the general population of Japan.

Materials and methods The survey population was the general population of individuals aged greater than or equal to 40 years in Takahata town, Japan in 2005. A postal survey with a self-administered questionnaire was distributed, and 7542 participants were entered into the final statistical analysis. The self-administered questionnaire contained items regarding some lifestyle-associated factors, oral health, and dietary intake, including alcohol and sucrose consumption. To confirm the independent association between the number of teeth and several parameters, a multivariate logistic regression analysis was used to estimate the adjusted odds ratios (ORs) and 95% confidence intervals (95% CIs).

Results A low educational status, no dental check-ups, low frequency of brushing, older age, and smoking habit were independent risk factors for less than 20 teeth. A low educational status was a particularly significant risk factor for less than 20 teeth (OR = 1.352, 95% CI = 1.125–1.624).

Conclusion These results emphasize the importance of good oral health habits, such as frequent tooth brushing, routine dental check-ups, and no smoking, and indicate that more appropriate and compulsory education regarding oral health is needed to lessen the education level-derived differences in oral health.

Clinical relevance Poor oral health habits and low educational status are the independent risk factors for having less than 20 teeth.

Keywords Educational status · Oral health habits · Number of teeth · Cross-sectional study · Multivariate logistic regression analysis · General population

Introduction

Maintaining greater than or equal to 20 teeth is very important for mastication function. Many studies have revealed a relationship between the number of teeth and mastication function; i.e., greater than or equal to 20 teeth is associated with better mastication [1–3]. Moreover, more teeth also beneficially affect various functions other than mastication. Several studies have revealed that the presence of more teeth is associated with better cognitive function in elderly people

✉ Shigeo Ishikawa
shigeo_ishikawa2011@yahoo.co.jp

[1] Department of Dentistry, Oral and Maxillofacial Plastic and Reconstructive Surgery, Faculty of Medicine, Yamagata University, 2-2-2 Iida-nishi, Yamagata 990-9585, Japan

[2] Department of Public Health and Hygiene, Graduate School of Medicine, Yamagata University, 2-2-2 Iida-nishi, Yamagata 990-9585, Japan

[3] Department of Neurology, Hematology, Metabolism, Endocrinology and Diabetology, Faculty of Medicine, Yamagata University, 2-2-2 Iida-nishi, Yamagata 990-9585, Japan

[4] Global Center of Excellence, School of Medicine, Yamagata University, 2-2-2 Iida-nishi, Yamagata 990-9585, Japan

[5] Health Administration Center, Yamagata University, Yamagata, Japan

[6] Institute for Promotion of Medical Science Research, Faculty of Medicine, Yamagata University, Yamagata, Japan

[4–6]. Additionally, the presence of greater than or equal to 20 teeth might decrease the risk of the onset of dementia [4], turnover [7], and the requirement for nursing [8]. Several studies have provided evidence that the presence of greater than or equal to 20 teeth positively affects patients' healthy life expectancy. Therefore, a political campaign for the preservation of greater than or equal to 20 natural teeth at the age of 80 years has been initiated by the Ministry of Health, Labour and Welfare of Japan [9, 10].

The risk factors for tooth loss have already been reported. Oral health habits such as a low frequency of brushing [11] and the lack of dental check-ups [12] or the presence of oral disease such as dental caries and periodontitis are among the most well-known risk factors for tooth loss [13, 14]. Consumption of sugar [15] or alcohol [16], smoking [17], general diseases such as diabetes mellitus, and mental diseases such as depression are other reported risk factors for a poor oral health status, including tooth loss [18, 19]. Socioeconomic status is another well-known indicator of the oral health status. Socioeconomic status has been shown to be an indicator of general health and several diseases, such as obesity, diabetes mellitus, several types of cancer, acute coronary syndrome, aneurysmal subarachnoid hemorrhage, and osteoporosis [20–25]. Socioeconomic disparities in oral health have also been widely investigated in many countries, and many studies have revealed the association between a low socioeconomic status and poor oral health status [10, 11, 26, 27]. To the best of our knowledge, however, almost all previous studies were performed in countries other than Japan, and very few studies have investigated the relationship between oral health and socioeconomic status in Japan [10, 28]. In Japan, universal health insurance for all citizens was achieved in 1961 [29]. All citizens of Japan can receive most medical and dental treatments, including restorative and prosthetic treatments, for the same price at any medical or dental clinic by paying 10 to 30% of the cost [10]. Furthermore, the educational system in Japan is notable. In Japan, education is mandatory until the end of junior high school for 9 years, usually until 15 years of age. The rate of completing senior high school in Japan is higher than that in other developed countries, and almost all junior high school students in Japan subsequently attend senior high school (http://www.mext.go.jp/a_menu/shotou/kaikaku/main8_a2.htm). Moreover, most senior high school students in Japan graduate from senior high school at 18 years of age (http://www.mext.go.jp/a_menu/shotou/kaikaku/main8_a2.htm). Thus, Japanese citizens receive 12 years of education. These facts may indicate that Japan has a less marked socioeconomic differential than other developed countries [10]. However, even in this beneficial environment in Japan, whether an individual's socioeconomic status affects their number of teeth remains unclear.

Therefore, we conducted a cross-sectional study using data from a community-based cohort study, the Takahata study, to survey the risk factors for having less than 20 teeth in order to suggest effective preventive strategies and public oral health programs. To our knowledge, few studies have comprehensively investigated the risk factors for having less than 20 teeth, including some lifestyle-associated factors, oral health habits, and socioeconomic status, in a large general population in Japan.

Materials and methods

Study design and participants

This study was performed as part of the ongoing Molecular Epidemiological Study utilizing the Regional Characteristics of 21st Century Centers of Excellence (COE) Program in Japan. This study was a community-based and design-incorporated baseline survey performed using a self-administered questionnaire on some lifestyle-associated factors.

The survey population in this study was the general population of individuals aged greater than or equal to 40 years in Takahata town in Yamagata Prefecture, Japan (total population of individuals aged greater than or equal to 40 years in 2004: 15,547 [7249 men, 8298 women]). A postal survey in the form of a self-administered questionnaire was distributed to the entire population of Takahata town in 2005. The self-administered questionnaires were completed by 10,667 individuals (4971 men, 5696 women), 3125 of whom were excluded from the present analysis because of incomplete data. In total, 7542 participants were entered into the final statistical analysis.

Measurements

The self-reported questionnaire contained a survey of some lifestyle-associated factors, medical history, oral health, and dietary intake, including alcohol and sucrose consumption. We asked the participants about stressful life events during the last month as a lifestyle-associated factor using the following question: "Have you had a feeling of dissatisfaction, distress, a hard time, or stress associated with life during the last month?". The questionnaire about oral health included items regarding the number of teeth, frequency of brushing per day, troubles with tooth health, and factors to keep in mind for tooth health. Patients were asked about their number of teeth as follows: "How many teeth do you have now? (Fixed prostheses are counted, but removable prostheses are not). Note: People generally have 28 permanent teeth; some people have 29 to 32 permanent teeth (i.e., up to 4 wisdom teeth may be present)." We did not ask about pontics in dental bridges or implants. For the item "something to keep in mind for tooth health," we asked the participants about whether they went to a dental clinic to undergo dental check-ups for tooth health.

Educational status was used as an indicator of socioeconomic status. The participants were divided into two groups according to their age at their final educational status: the high educational status group (greater than 19 years of age) and the

low educational status group (less than or equal to 18 years of age). This categorization was derived from the fact that people generally graduate from high school at 18 years of age in Japan. The low educational status group comprised people who had achieved junior or senior high school graduation, and the high educational status group comprised those who had achieved any college or higher educational graduation.

We used a brief self-administered diet history questionnaire to calculate alcohol and sucrose consumption [30]. This questionnaire inquired about the frequency of consumption of 58 food and beverage items. The estimated intake of food and beverage items, energy, and selected nutrients were calculated using an ad hoc computer algorithm for the brief diet history questionnaire based on the Standard Tables of Food Composition in Japan. The validity of this brief diet history questionnaire has already been assessed, and the questionnaire has been widely used in epidemiological studies of nutrition in Japan [30–32]. Because alcohol and sucrose consumption are among the most well-known risk factors for tooth loss [15, 16, 33], alcohol and sucrose consumption were selected as representative nutritional factors in the present study.

Statistical analyses

The distribution of characteristics was analyzed by one-way analysis of variance and the chi-squared test for quantitative and qualitative variables, respectively. Crude odds ratios (ORs) for the risk of having less than 20 teeth were calculated by univariate logistic regression analysis. To examine the independent association between having less than 20 teeth and several continuous or categorical parameters, we performed a multivariate logistic regression analysis to estimate the adjusted ORs and 95% confidence intervals (95% CIs). We selected the representative variables that were significant in the univariate analysis ($p < 0.05$). Statistical significance was set at $p < 0.05$. Statistical analyses were performed with SPSS version 20.0 (IBM Corp., Armonk, NY, USA).

Results

The distributions of the clinical parameters in each group (less than 20 or greater than or equal to 20 teeth) are shown in Table 1: age, alcohol consumption, sucrose consumption, sex, educational status, history of cancer, presence of hypertension, presence of diabetes mellitus, presence of dyslipidemia, smoking habit, stressful life events during the last month, frequency of brushing per day, and dental check-ups. Participants with less than 20 teeth were significantly older than those with greater than or equal to 20 teeth. Alcohol consumption was much higher in participants with greater than or equal to 20 than less than 20 teeth. Sucrose consumption was not significantly different between the two groups. The chi-squared test also revealed significant differences in the distribution of the parameters between the two groups. The significantly different parameters were educational status, history of cancer, hypertension, diabetes mellitus, smoking habit, stressful life events during the last month, frequency of brushing per day, and dental check-ups. There was no significant difference in the distribution of sex and dyslipidemia between the two groups.

As shown in Table 2, the significant variables in the univariate logistic regression analysis were educational status, dental check-ups, tooth brushing frequency per day, age, current smoking, history of cancer, presence of hypertension, presence of diabetes mellitus, more stressful life events during the last month, and alcohol consumption. Table 2 also shows the significant variables in the multivariate logistic regression analysis using the variables found to be significant in the univariate analysis. The independent risk factors for having less than 20 teeth were a low educational status, no habit of dental check-ups, lower frequency of brushing, older age, and a smoking habit.

Individuals with low educational status had a particularly higher risk for having less than 20 teeth compared with individuals with a high educational status (OR = 1.352, 95% CI = 1.125–1.624). Moreover, individuals with no habit of dental check-ups had a 1.701-fold higher risk of having less than 20 teeth than individuals with a habit of dental check-ups (OR = 1.701, 95% CI = 1.355–2.134). A lower frequency of tooth brushing was also an independent risk factor for having less than 20 teeth.

Discussion

In this study, we comprehensively investigated the risk factors for having less than 20 teeth in the general population of Japan and found that a low educational status, no routine dental check-ups, lower frequency of tooth brushing, older age, and smoking habit were independently and significantly associated with having less than 20 teeth. No routine dental check-ups, a lower frequency of daily brushing, older age, and smoking habit are previously reported risk factors for tooth loss [11, 12, 17]. A lack of dental check-ups and lower frequency of brushing lead to periodontitis and dental caries followed by tooth loss [11, 12]. Smoking also has a strong correlation with periodontitis and tooth loss [17]. A remarkable finding in this study is that a low educational status, no routine dental check-ups, less frequent brushing, smoking habit, and age were independent risk factors. It is not unusual that these oral status factors related to tooth loss are used only as adjustment factors to investigate the associations between educational status and number of teeth, including in the above-mentioned Japanese study [10, 34]. Moreover, a Korean study showed that oral status factors, such as routine dental check-ups, became

Table 1 Characteristics of subjects

		Number of teeth				*p* value†
		< 20		≥ 20		
		Average	SD	Average	SD	
Age (years)[a]		*n* = 2524 68.9	10.9	*n* = 4752 55.2	9.9	< 0.001*
Alcohol consumption (g/day)[b]		*n* = 1952 10.4	23.4	*n* = 4121 15.3	26.8	< 0.001*
Sucrose consumption (g/day)[c]		*n* = 1952 21.1	9.6	*n* = 4121 21.0	8.9	0.565
Number of teeth						
Variable		< 20		≥ 20		
		n	%	*n*	%	*p* value‡
Sex	Male	1238	46.9	2333	47.6	0.562
	Female	1402	53.1	2569	52.4	
Educational status	High	369	14.0	1131	23.1	< 0.001*
	Low	2271	86.0	3771	76.9	
History of cancer	No	2457	93.1	4698	95.8	< 0.001*
	Yes	183	6.9	204	4.2	
Hypertension	No	1675	63.4	3844	78.4	< 0.001*
	Yes	965	36.6	1058	21.6	
Diabetes mellitus	No	2373	89.9	4614	94.1	< 0.001*
	Yes	267	10.1	288	5.9	
Dyslipidemia	No	2480	93.9	4575	93.3	0.304
	Yes	160	6.1	327	6.7	
Current smoker[d]	No	1709	75.5	3260	72.1	0.004 *
	Yes	556	24.5	1259	27.9	
Stressful life events during the last month[e]	Never	194	7.5	170	3.5	< 0.001*
	Not very often	779	30.0	920	18.9	
	Some of the time	1276	49.1	2827	58.0	
	Most of the time	350	13.5	953	19.6	
Frequency of brushing per day[f]	0	148	5.8	52	1.1	< 0.001*
	1	1275	49.8	1805	36.9	
	2	882	34.4	2285	46.7	
	3	256	10.0	746	15.3	
Dental check-ups	No	2411	91.3	4251	86.7	< 0.001*
	Yes	229	8.7	651	13.3	

SD, standard deviation

†*p* value by Student's t test

‡*p* value by chi-square test

[a] Missing information (*n* = 266) were excluded

[b] Missing information (*n* = 1469) were excluded

[c] Missing information (n = 1469) were excluded

[d] Missing information (*n* = 758) were excluded

[e] Missing information (*n* = 73) were excluded

[f] Missing information (*n* = 93) were excluded

statistically non-significant after adjustment for socioeconomic factors [11]. Furthermore, in a study from eastern Brazil, regression analysis showed that the loss of one or more teeth was associated with older age (greater than 35 years), a higher dental caries experience, severe periodontitis, and previous dental visits. However, income, education level, diabetes, smoking habit, and plaque index were not associated with the loss of one or more teeth according to the regression

Table 2 Crude and adjusted odds ratios and 95% confidence intervals of the variables associated with having < 20 teeth

Variable		Number of teeth (< 20)					
		Crude OR	95% CI	*p* value	Adjusted OR	(95% CI)	*p* value
Educational status	Low (vs. high)	1.846	(1.623–2.099)	< 0.001*	1.352	(1.125–1.624)	0.001*
Dental check-ups	No (vs. yes)	1.671	(1.428–1.954)	< 0.001*	1.701	(1.355–2.134)	< 0.001*
Frequency of brushing per day	3	1			1		
	2	1.121	(0.956–1.314)	0.159	1.360	(1.073–1.723)	0.011*
	1	2.061	(1.763–2.409)	< 0.001*	1.766	(1.392–2.241)	< 0.001*
	0	8.166	(5.831–11.435)	< 0.001*	3.351	(2.059–5.456)	< 0.001*
Sex	Female (vs. male)	1.047	(0.954–1.149)	0.330			
Age	(per 1-year increase)	1.123	(1.117–1.130)	< 0.001*	1.128	(1.119–1.137)	< 0.001*
Current smoker	Yes (vs. no)	0.838	(0.748–0.939)	0.002*	1.675	(1.407–1.993)	< 0.001*
History of cancer	Yes (vs. no)	1.724	(1.410–2.108)	< 0.001*	0.902	(0.674–1.208)	0.488
Hypertension	Yes (vs. no)	2.102	(1.898–2.329)	< 0.001*	0.999	(0.852–1.171)	0.991
Diabetes mellitus	Yes (vs. no)	1.791	(1.512–2.121)	< 0.001*	1.058	(0.828–1.353)	0.652
Dyslipidemia	Yes (vs. no)	0.899	(0.742–1.089)	0.276			
Stressful life events during the last month	Never	1			1		
	Not very often	0.717	(0.575–0.894)	0.003*	1.173	(0.833–1.650)	0.361
	Some of the time	0.382	(0.309–0.471)	< 0.001*	0.967	(0.697–1.342)	0.841
	Most of the time	0.307	(0.243–0.387)	< 0.001*	1.108	(0.772–1.591)	0.577
Alcohol consumption (g/day)	(per 1-g increase)	0.991	(0.989–0.994)	< 0.001*	0.997	(0.994–1.000)	0.054
Sucrose consumption (g/day)	(per 1-g increase)	1.002	(0.996–1.008)	0.541			

Asterisks means statistically significant

OR odds ratio, *CI* confidence interval

analysis [35]. To our knowledge, the present study is the first to reveal that a low educational status and each of the above-mentioned oral status factors are independent risk factors for having less than 20 teeth. Furthermore, to our knowledge, the present study is one of the largest-scale studies of the general population of Japan. The rich data obtained from this large-scale study should be able to reliably reveal the independent risk factors for having less than 20 teeth. Considering these points, our study is notable.

Although universal health insurance covers all citizens of Japan [10, 29], and although most people in Japan receive a relatively long education (greater than or equal to 9 years) (http://www.mext.go.jp/a_menu/shotou/kaikaku/main8_a2.htm), we found a clear difference in the number of teeth between participants with a low education versus high education. Our results suggest that the oral health education provided before senior high school in Japan may be insufficient. The main reasons for tooth loss are dental caries and periodontal disease [35–37]; however, dental caries are generally more problematic for children [38, 39]. Public and private prevention measures for dental caries are successful for children in Japan. For example, although water fluoridation is not performed in Japan, the school-based fluoride mouth-rinse has become more widespread [40], and the ratio of dentifrices containing fluoride in the Japanese market has been increasing [33, 41]. Furthermore, sugar consumption has substantially decreased since the 1970s [33]. As a result of these measures, the numbers of dental caries in elementary, junior high school, and senior high school students are dramatically decreasing in Japan. Although the education about dental caries might be sufficient, the education about periodontal disease prevention may be insufficient until senior high school. However, the cause of fewer teeth in the low educational group of the present study is unclear. Further studies are needed to clarify this issue and suggest preventive strategies or public oral health programs.

To the best of our knowledge, only a few studies in Japan have investigated the association between educational status and number of teeth [10]. In one such study, the participants were divided into three groups according to their education level: low (junior high school), middle (senior high school), and high (any college or higher education). Japanese adults with a high educational level had a 2.72-fold greater chance of having greater than or equal to 20 teeth than those with a low educational level, although the sample size was approximately one-fifth of our sample size. There is no discrepancy between the present study and the above-mentioned preceding study in terms of the relationship between educational status and tooth number. Other than the sample size, the main difference between the present study and the preceding study is the

categorization of the education status. Our participants were divided into two groups according to their educational level: low (junior and senior high school) and high (any college or higher education). Considering that almost the junior high school students in Japan go to senior high school and that most senior high school students graduate from senior high school (http://www.mext.go.jp/a_menu/shotou/kaikaku/main8_a2.htm), our categorization of the educational status, especially from the viewpoint that the reference status is less than senior high school, was very reasonable according to the actual educational system in Japan.

Oral health literacy is defined as "the degree to which individuals have the capacity to obtain, process and understand basic oral health information and services needed to make appropriate health decisions" [42]. Oral health literacy has received little attention in the dental literature, especially in Japan. This is partly because the general literacy rate in Japan is very high [42]. However, a few studies in Japan have shown that oral health literacy is associated with differences in oral health behaviors and the clinical oral health status [42]. Furthermore, fewer than half of the participants in these studies were familiar with important terms such as dental plaque, scaling, gingivitis, fluoride mouth rinsing, and denture plaque despite their high general literacy rate [42]. A positive correlation between health literacy and educational status has been reported in Japan [43]; however, no surveys have addressed the association between oral health literacy and educational status in Japan. Although further studies are needed to confirm the relationship between oral health literacy and educational status, people with high educational status may have sufficient oral health literacy. An improvement in oral health literacy may be needed to lessen the education level-derived differences in oral health.

Our study has several limitations. First, we surveyed the educational status by asking participants about their age at their final education, and we categorized the participants into two groups (low and high educational status). It is possible that some students failed the senior high school entrance examination or repeated some of their education in senior high school; however, almost all the junior high school students in Japan subsequently go to high school, and most high school students graduate from high school at the age of 18 years (http://www.mext.go.jp/a_menu/shotou/kaikaku/main8_a2.htm). Considering these facts, the age estrangement should not be problematic. Second, we surveyed the number of teeth only using a self-reported questionnaire; we did not confirm the number of teeth by clinical examinations. In the self-reported questionnaire, we did not ask about pontics in fixed partial bridges or dental implants. Although the correlation between the number of teeth determined by self-reports and that determined by clinical examinations has already been reported [44, 45], no previous studies have mentioned the number of pontics. Thus, the clinical and self-reported tooth counts might have differed in the present study, especially with respect to pontics and dental implants. The third limitation is the definition of dental check-ups. Some people may visit dental clinics not for tooth and gingival check-ups but for screening and examination or oral diseases, such as oral tumors. However, the questionnaire for dental check-ups was a questionnaire regarding tooth health. We asked about dental check-ups for tooth health, but we did not ask about dental check-ups for oral health. Therefore, we consider it likely that almost all participants thought that the dental check-ups did not include visits for oral disease, but this cannot be ensured. The fourth limitation is the possibility of selection bias for each item in the statistical analysis. This study investigated risk factors of several aspects comprehensively. However, each individual aspect had limited items. We could not use all items for the statistical analysis. Therefore, a selection bias may have existed in this study. The fifth limitation is that we did not confirm the participants' knowledge regarding oral health. It was difficult to judge whether the participants had sufficient knowledge of oral health regardless of their educational status in the present study. We used the educational status as a surrogate of oral health knowledge; however, there is a possibility that it may not represent the actual situation. The sixth limitation is that our study includes 13-year-old data. The economic situation and lifestyle may have changed during the past 13-year period. Thus, our study results might not be applicable to the present population. The seventh limitation is that the final sample may not be representative of the original target population. The original target sample comprised 15,547 participants, and the self-administered questionnaires were completed by 10,667 participants; 4880 people did not answer the questionnaires. Furthermore, the final number of participants used in the statistical analysis was 7542. Of the 10,667 participants, 3125 were excluded because they did not answer the questionnaire regarding their educational status and number of teeth. We were unable to compare the participants with the non-participants because we did not have baseline data. Therefore, the final sample might not be representative of the original target population. The eighth limitation is the study design. This was a cross-sectional study, making the causal direction of the associations difficult to ascertain. Although whether a lower educational status is derived from fewer teeth remains unclear, and although it is reasonable to consider that fewer teeth should be derived from a lower educational status, a prospective cohort study is necessary to validate the causal direction.

In conclusion, this cross-sectional study revealed that a low educational status and oral health-related factors were independently associated with tooth loss, indicating a possibility that a lower educational status, especially less than senior high school, increases the risk of having less than 20 teeth. Although the remarkable universal health insurance for all Japanese citizens and relatively long educational duration

(greater than or equal to 9 years) may indicate that Japan has a less marked socioeconomic differential than other developed countries, we found a clear difference in the number of teeth between participants with a low versus high educational status. These results emphasize the importance of good oral health habits, such as frequent tooth brushing, routine dental check-ups, and no smoking, and indicate that more appropriate and compulsory education regarding oral health is needed to lessen the education level-derived differences in oral health.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The Ethics Committee of Yamagata University approved this study protocol.

Informed consent Informed consent was obtained from all individual participants included in the study.

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