

## Cross-sectional study of the factors associated with the number of teeth in middle-aged and older persons with intellectual disabilities

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### Abstract

**Background** We investigated the number of teeth in middle-aged and older individuals with intellectual disability and evaluated the related factors.

**Methods** A questionnaire survey on oral health was administered to 604 persons over 40 years old with intellectual disabilities in Aichi Prefecture, Japan. The questionnaire designed for this study included items on diagnosis of disability, severity of intellectual disability and type of residence. As oral-health-related factors, the proxy-reported number of teeth, family dentist, regular dental check-ups, problems during dental treatment and tooth-brushing frequency were evaluated. A multinomial logistic regression analysis was performed using the proxy-reported number of teeth ( $\geq 20$ , 10–19 or 0–9) as the dependent variable, and the odds ratios (ORs) and 95% confidence intervals (CIs) of independent variables were calculated. In addition, linear regression analysis was performed using the proxy-reported number of teeth as the dependent variable.

**Results** In the multivariate multinomial logistic regression analysis, age, diagnosis of disability and

type of residence were significantly associated with having 10–19 versus  $\geq 20$  teeth. Participants with autism spectrum disorder had a significantly lower OR for 10–19 teeth compared with those with intellectual disability [OR (95% CI): 0.49 (0.22–1.08)]. Age, diagnosis of disability, regular dental check-ups and tooth-brushing frequency were significantly associated with having 0–9 versus  $\geq 20$  teeth. Participants with Down syndrome had a significantly higher OR for 0–9 teeth compared with those with intellectual disability [OR (95% CI): 3.17 (1.09–9.23)]. The ORs for 0–9 teeth of participants who did not attend regular dental check-ups and who brushed their teeth 1 time/day compared with  $\geq 3$  times/day were significantly high, and the OR (95% CI) was 2.37 (1.06–5.30) and 4.76 (1.09–20.77), respectively. [Corrections made on 22 August 2022, after first online publication: in the previous sentence, “who attend” has been changed to “who did not attend”.] In the multivariate linear regression analysis, age, diagnosis of disability and regular dental check-ups were significantly associated with the proxy-reported number of teeth. The proxy-reported number of teeth was  $-0.42$  less with each 1-year increase in age. With autism spectrum disorder, the proxy-reported number of teeth was 0.74 more compared with intellectual disability. In Down syndrome, the proxy-reported number of teeth was  $-0.93$  less compared with intellectual disability. The proxy-reported number of teeth

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was  $-2.12$  less for those who did not have regular dental check-ups.

**Conclusions** The number of teeth in middle-aged and older individuals with intellectual disability was related to age and the type of disability. Regular dental visits may be effective at preventing tooth loss in middle-aged and older persons with intellectual disability.

**Keywords** Intellectual disability, Middle-aged and older persons, Number of teeth, Regular dental check-ups, Toothbrushing frequency

## Introduction

Due to the ageing of its population, the proportion of older individuals among those with intellectual disability (ID) is increasing in Japan (Cabinet Office 2020). To maintain health, it is necessary to manage age-related diseases, together with any pre-existing disabilities and congenital diseases.

The number of teeth decreases with age (Ando *et al.* 2013; Ministry of Health, Labour and Welfare 2016; Furuta *et al.* 2021). Especially in older persons, the number of teeth also affects nutritional status (Okamoto *et al.* 2019) and the risk of dementia (Oh *et al.* 2018; Saito *et al.* 2021), heart disease (Bokhari *et al.* 2012), pneumonia (Suma *et al.* 2018) and mortality (Aida *et al.* 2011; Hiratsuka *et al.* 2020). Similarly, among individuals with ID, tooth loss can affect their nutritional status and systemic health. However, as a result of the small proportion of the total older population with ID, there is little information on their oral-health status.

Retaining as many teeth as possible is important for maintaining systemic health in both normal persons and people with ID. The number of teeth is associated with various health conditions. For example, in a 15-year follow-up study, the risk of mortality was higher for those with 0–9 and 10–19 teeth compared with those with  $\geq 20$  teeth (Yu *et al.* 2021). People with 10–19 teeth were not as frail as those with 0–9 teeth (Yun *et al.* 2020). The incidence of social isolation was higher for those with 10–19 and 0–9 teeth compared with those with  $\geq 20$  teeth (Abbas *et al.* 2022). These studies imply that better information can be obtained by analysing the number of teeth not only as a continuous index but also as a category. It is important to analyse the state of tooth loss by type of ID.

Older people with ID are more likely to be edentulous than those without ID and many do not use dentures, even if they have no teeth (Mac Giolla Phadraig *et al.* 2015). Dental caries and periodontal disease are the main causes of tooth loss in Japanese individuals (8020 Promotion Foundation 2018). These diseases are the main causes of tooth loss among persons with ID (Gabre *et al.* 1999, 2001) and are associated with oral-health behaviours such as tooth-brushing habits (Lertpimonchai *et al.* 2017; Ishikawa *et al.* 2019; Edman *et al.* 2021) and regular dental visits (Drachev *et al.* 2017; Ishikawa *et al.* 2019). People with ID have poor oral conditions, including the presence of many untreated teeth (Petrovic *et al.* 2016). Among children and adults with ID, tooth-brushing habits and dental visits have been associated with oral-hygiene status (Waldron *et al.* 2019). However, there are few reports on the number of teeth and oral health behaviours of middle-aged and older individuals with ID, who generally experience a decrease in the number of teeth. Therefore, we investigated factors related to the number of teeth among persons with ID.

## Methods

### Participants

The Aichi Prefectural Association on Intellectual Disability was established in 1961, with the goal of promoting the welfare of persons with ID and improving the quality of member facilities in Aichi Prefecture. The facilities that belong to this association provide services to those with ID, mainly daily life support and vocational support for children and adults. In this study, a questionnaire survey was sent to 39 of the 132 member facilities (participation rate, 29.5%) that had agreed to participate in the survey. The questionnaires were mailed to the facilities in September 2019, and facility staff members asked the relatives of facility users or facility caregivers to respond. The questionnaire survey was conducted anonymously, such that the participants could not be identified. We indicated the purpose of this study in the questionnaire and judged that the respondents to the questionnaire had consented. Of the 1318 respondents, 841 were included in the study, excluding 477 under the age of 40 years old (Fig. 1).

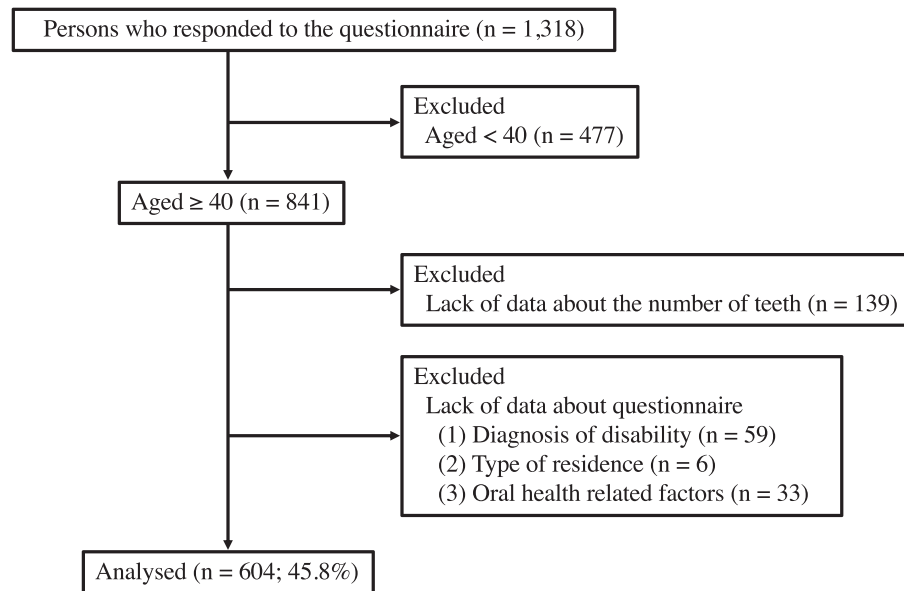


Figure 1. Flowchart of the study participants

### Questionnaires

Participants responded to the questionnaire at each facility, although many facility users considered the questionnaire survey difficult to complete due to their disabilities. In such cases, the relatives of the facility users or facility caregivers answered the questions for the participants.

We created the study questionnaire, although many of the questions are general questions used in previous studies (Pradhan *et al.* 2009; Pini *et al.* 2016). The questionnaire survey inquired about basic characteristics, including age, sex, disability diagnosis, severity of ID and type of residence (living at home with family, residential care home or community group home). As oral-health-related factors, the proxy-reported number of teeth, family dentist (absence or presence), regular dental check-ups at least once a year (yes or no), problems during dental treatment (absence, presence or never treated) and tooth-brushing frequency (1, 2 or  $\geq 3$  times/days) were evaluated.

### Diagnosis of disability

The questionnaire survey included an item on physician-diagnosed disability. All study participants were individuals with ID. Based on the diagnosis, the

participants were identified as having autism spectrum disorder (ASD), Down syndrome (DS), cerebral palsy (CP) or other disability. Those without ASD, DS, CP or other disability were classified as ID. The severity of the ID was assessed using the government-issued Intellectual Disability Certificate (Ryoiku Techo) as severe [intelligence quotient (IQ) < 35], moderate (IQ 36–50) or mild (IQ 51–75).

### Number of teeth

The questionnaire confirmed the proxy-reported number of teeth. As many people with ID have difficulty answering questions, we asked their relatives or facility caregivers to complete the questionnaire. The minimum number of teeth reported was zero, and 18 participants reported being edentulous. When analysing the number of teeth as a categorical variable, it was classified as 0–9, 10–19 or  $\geq 20$  based on previous studies (Yun *et al.* 2020; Yu *et al.* 2021; Abbas *et al.* 2022).

### Statistical analysis

To identify factors associated with proxy-reported number of teeth among persons with ID, the analysis included persons aged  $\geq 40$  years.

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In terms of participant characteristics, we evaluated sex according to age group (40–49, 50–59, 60–69 and  $\geq 70$  years), disability diagnosis, severity of disability and type of residence. Regarding oral-health-related factors, we evaluated family dentist, regular dental check-ups, problems during dental treatment and tooth-brushing frequency according to sex. The participant characteristics and oral-health-related

factors were analysed according to the proxy-reported number of teeth. Categorical variables were compared by chi-squared test.

A multinomial logistic regression analysis was performed using proxy-reported number of teeth ( $\geq 2, 0; 10-19, 1; 0-9, 2$ ) as the dependent variable, and odds ratio (OR) and 95% confidence interval (CI) were calculated. Multivariate linear regression analysis was used to examine the effect of each variable on the proxy-reported number of teeth as a continuous dependent variable, and the partial regression coefficient (B) and 95% CIs of independent variables were calculated. Variables associated with the proxy-reported number of teeth in a univariate analysis ( $P < 0.2$ ) were entered as independent variables in the multivariate analysis. Spearman's rank correlation was used for multicollinearity among the explanatory variables, and variables with correlation coefficients  $\geq 0.4$  were excluded from the analysis. No variable in this study had a correlation coefficient  $\geq 0.4$ .

The statistical analysis was performed using SPSS for Apple Macintosh™ (Ver. 23.0j, IBM Corp, Tokyo, Japan). Statistical significance was set at  $P < 0.05$ .

## Results

Of the 841 participants aged  $\geq 40$  years, 604 (352 males, 252 females) were analysed, excluding 139 participants who did not respond to the number of teeth and 98 who lacked data to analyse their association with the number of teeth (Fig. 1). The mean  $\pm$  standard deviation age of the participants was  $54.2 \pm 11.0$  years. Males averaged  $52.8 \pm 10.2$  years and females  $56.6 \pm 11.7$  years.

Table 1 shows the characteristics and oral-health-related factors of the participants according to sex. Among males, the proportion of those aged 40–49 years was higher than among females, whereas in females, the proportion of those aged  $\geq 70$  years was higher than in males. The proportion of ID was higher in females than among in males, and the proportion of ASD was higher in males than in females. Regarding oral-health-related factors, the rates of regular dental check-ups and dental treatment without problems were significantly higher in females than in males.

Table 2 shows the relationship of proxy-reported number of teeth according to participant characteristics and oral-health-related factors. Sex,

**Table 1** Characteristics and oral health related factors of the study participants

	Male (n = 352)	Female (n = 252)	P
n (%)			
Characteristics			
Age (years old)			
40–49	177 (50.3)	85 (33.7)	<0.01
50–59	92 (26.1)	71 (28.2)	
60–69	52 (14.8)	48 (19.0)	
$\geq 70$	31 (8.8)	48 (19.0)	
Diagnosis of disability			
Intellectual disability	191 (54.3)	172 (68.3)	<0.01
Autism spectrum disorder	103 (29.3)	33 (13.1)	
Down syndrome	27 (7.7)	17 (6.7)	
Cerebral palsy	19 (5.4)	21 (8.3)	
Other diagnosis	12 (3.4)	9 (3.6)	
Severity level of intellectual disability			
Severe (IQ: $\geq 35$ )	287 (81.5)	193 (76.6)	0.14
Moderate (IQ: 36–50)	53 (15.1)	53 (21.0)	
Mild (IQ: 51–70)	12 (3.4)	6 (2.4)	
Type of residence			
Living at home with family	66 (18.8)	48 (19.0)	0.06
Residential care home	233 (66.2)	182 (72.2)	
Community group home	53 (15.1)	22 (8.7)	
Oral-health-related factors			
Family dentist			
Presence	323 (91.8)	239 (94.8)	0.14
Absence	29 (8.2)	13 (5.2)	
Regular dental check-ups ( $\leq 1$ year)			
Yes	298 (84.7)	235 (93.3)	<0.01
No	54 (15.3)	17 (6.7)	
Problems during dental treatment			
Absence	264 (75.0)	215 (85.3)	<0.01
Presence	77 (21.9)	34 (13.5)	
Never treated	11 (3.1)	3 (1.2)	
Tooth-brushing frequency			
$\geq 3$ times/day	236 (67.0)	182 (72.2)	0.22
2 times/day	104 (29.5)	66 (26.2)	
1 time/day	12 (3.4)	4 (1.6)	

IQ, intelligence quotient.

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**Table 2** Associations between each variable and proxy-reported number of teeth

	Proxy-reported number of teeth			P
	0–9 (n = 81)	10–19 (n = 91)	≥20 (n = 432)	
	Average (±SD)			
Characteristics				
Age	65.4 (±10.2)	62.0 (±10.8)	50.5 (± 8.7)	<0.01
Sex				
Male	40 (11.4)	42 (11.9)	270 (76.7)	<0.01
Female	41 (16.3)	49 (19.4)	162 (64.3)	
Age (years old)				
40–49	5 (1.9)	13 (5.0)	244 (93.1)	<0.01
50–59	14 (8.6)	28 (17.2)	121 (74.2)	
60–69	34 (34.0)	25 (25.0)	41 (41.0)	
≥70	28 (35.4)	25 (31.6)	26 (32.9)	
Diagnosis of disability				
Intellectual disability	60 (16.5)	67 (18.5)	236 (65.0)	<0.01
Autism spectrum disorder	5 (3.7)	9 (6.6)	122 (89.7)	
Down syndrome	8 (18.2)	6 (13.6)	30 (68.2)	
Cerebral palsy	8 (20.0)	7 (17.5)	25 (62.5)	
Other diagnosis	0 (0.0)	2 (9.5)	19 (90.5)	
Severity level of intellectual disability				
Severe (IQ: ≥35)	65 (13.5)	73 (15.2)	342 (71.3)	0.81
Moderate (IQ: 36–50)	14 (13.2)	17 (16.0)	75 (70.8)	
Mild (IQ: 51–70)	2 (11.1)	1 (5.6)	15 (83.3)	
Type of residence				
Living at home with family	9 (7.9)	3 (2.6)	102 (89.5)	<0.01
Residential care home	66 (15.9)	80 (19.3)	269 (64.8)	
Community group home	6 (8.0)	8 (10.7)	61 (81.3)	
Oral health related factors				
Family dentist				
Presence	73 (13.0)	86 (15.3)	403 (71.7)	0.50
Absence	8 (19.0)	5 (11.9)	29 (69.0)	
Regular dental check-ups (≤1 year)				
Yes	65 (12.2)	85 (15.9)	383 (71.9)	0.03
No	16 (22.5)	6 (8.5)	49 (69.0)	
Problems during dental treatment				
Absence	67 (14.0)	72 (15.0)	340 (71.0)	0.83
Presence	12 (10.8)	18 (16.2)	81 (73.0)	
Never treated	2 (14.3)	1 (7.1)	11 (78.6)	
Tooth-brushing frequency				
≥3 times/day	62 (14.8)	75 (17.9)	281 (67.2)	<0.01
2 times/day	15 (8.8)	16 (9.4)	139 (81.8)	
1 time/day	4 (25.0)	0 (0.0)	12 (75.0)	

IQ, intelligence quotient.

age, disability diagnosis and type of residence were significantly associated with the proxy-reported number of teeth. Regarding oral-health-related factors, regular dental check-ups and tooth-brushing frequency were significantly associated with the proxy-reported number of teeth.

The results of the multivariate logistic regression analysis show the relationship between proxy-reported number of teeth and each variable (Table 3). The ORs for 10–19 teeth versus ≥20 teeth in the 50–59, 60–69 and ≥70 years' age groups relative to the 40–49 years' age group were significantly

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**Table 3** Associations between each variable and proxy-reported number of teeth using univariate and multivariate multinomial logistic regression analyses

Dependent variable: Proxy-reported number of teeth ( $\geq 20 = 0$ , $10-19 = 1$ , $0-9 = 2$ )								
Independent variable	10-19 (n = 91) vs. $\geq 20$ (n = 432)				0-9 (n = 81) vs. $\geq 20$ (n = 432)			
	Crude OR (95% CI)	P	Adjusted OR (95% CI)	P	Crude OR (95% CI)	P	Adjusted OR (95% CI)	P
Characteristics								
Sex								
Male	1		1		1		1	
Female	1.94 (1.23-3.07)	<0.01	1.36 (0.82-2.27)	0.24	1.71 (1.06-2.75)	0.03	1.14 (0.64-2.03)	0.66
Age (years old)								
40-49	1		1		1		1	
50-59	4.34 (2.17-8.69)	<0.01	3.18 (1.55-6.51)	<0.01	5.65 (1.99-16.04)	<0.01	5.26 (1.77-15.65)	<0.01
60-69	11.45 (5.42-24.17)	<0.01	7.00 (3.20-15.31)	<0.01	40.47 (14.96-109.49)	<0.01	37.85 (12.74-112.43)	<0.01
$\geq 70$	18.05 (8.25-39.48)	<0.01	9.62 (4.15-22.31)	<0.01	52.55 (18.69-147.78)	<0.01	54.62 (16.94-176.18)	<0.01
Diagnosis of disability								
Intellectual disability	1		1		1		1	
Autism spectrum disorder	0.26 (0.13-0.54)	<0.01	0.49 (0.22-1.08)	0.04	0.16 (0.06-0.41)	<0.01	0.41 (0.15-1.15)	0.09
Down syndrome	0.70 (0.28-1.76)	0.45	1.90 (0.68-5.29)	0.26	1.05 (0.46-2.41)	0.91	3.17 (1.09-9.23)	0.03
Cerebral palsy	0.99 (0.41-2.38)	0.98	1.11 (0.42-2.94)	0.84	1.26 (0.54-2.93)	0.59	1.44 (0.53-3.94)	0.48
Other diagnosis	0.37 (0.08-1.63)	0.19	0.25 (0.05-1.35)	0.22	-	-	-	-
Severity level of intellectual disability								
Severe (IQ: $\geq 35$ )	1		1		1		1	
Moderate (IQ: 36-50)	1.06 (0.59-1.90)	0.84			0.98 (0.52-1.84)	0.96		
Mild (IQ: 51-70)	0.31 (0.04-2.40)	0.26			0.70 (0.16-3.14)	0.64		
Type of residence								
Living at home with family	1		1		1		1	
Residential care home	10.11 (3.12-32.74)	<0.01	5.38 (1.55-18.67)	<0.01	2.78 (1.34-5.79)	0.01	1.33 (0.48-3.67)	0.59
Community group home	4.46 (1.14-17.45)	0.03	3.89 (0.92-16.38)	0.06	1.12 (0.38-3.29)	0.84	0.76 (0.20-2.81)	0.68
Oral health related factors								
Family dentist								
Presence	1		1		1		1	
Absence	0.81 (0.30-2.15)	0.67			1.52 (0.67-3.46)	0.32		
Regular dental check-ups ( $\leq 1$ year)								
Yes	1		1		1		1	
No	0.55 (0.23-1.33)	0.19	0.73 (0.28-1.95)	0.53	1.92 (1.03-3.59)	0.04	2.37 (1.06-5.30)	0.04

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Table 3. (Continued)

		Dependent variable: Proxy-reported number of teeth ( $\geq 20 = 0$ , $10-19 = 1$ , $0-9 = 2$ )							
		10-19 ( $n = 91$ ) vs. $\geq 20$ ( $n = 432$ )				0-9 ( $n = 81$ ) vs. $\geq 20$ ( $n = 432$ )			
Problems during dental treatment									
Absence	1					1			
Presence	1.05	0.87			0.75	0.40			
	(0.59-1.86)				(0.39-1.46)				
Never treated	0.43	0.42			0.92	0.92			
	(0.06-3.38)				(0.20-4.26)				
Tooth-brushing frequency									
$\geq 3$ times/day	1		1		1		1		
2 times/day	0.43	<0.01	0.58	0.10	0.49	0.02	0.79	0.53	
	(0.24-0.77)		(0.31-1.11)		(0.27-0.89)		(0.39-1.62)		
1 time/day	-	-	-	-	1.51	0.49	4.76	0.04	
					(0.47-4.84)		(1.09-20.77)		

CI, confidence interval; IQ, intelligence quotient; OR, odds ratio.

higher, and the ORs (95% CIs) were 3.18 (1.55-6.51), 7.00 (3.20-15.31) and 9.62 (4.15-22.31), respectively. The OR for 10-19 teeth versus  $\geq 20$  teeth of the ASD group relative to the ID group was significantly lower, and the OR (95% CI) was 0.49 (0.22-1.08). The OR for 10-19 teeth versus  $\geq 20$  teeth of the residential care home group relative to the living at home with family group was significantly higher, and the OR (95% CI) was 5.38 (1.55-18.67). The ORs for 0-9 teeth versus  $\geq 20$  teeth in the 50-59, 60-69 and  $\geq 70$  years' age groups relative to the 40-49 years' age group were significantly higher, and the ORs (95% CIs) were 5.26 (1.77-15.65), 37.85 (12.74-112.43) and 54.62 (16.94-176.18), respectively. The OR for 0-9 versus  $\geq 20$  teeth of the DS group relative to the ID group was significantly higher, and the OR (95% CI) was 3.17 (1.09-9.23). The OR (95% CI) for 0-9 teeth versus  $\geq 20$  teeth of those who did not undergo regular dental check-ups, relative to those who did, was significantly higher, and the OR (95% CI) was 2.37 (1.06-5.30). The OR for 0-9 teeth versus  $\geq 20$  teeth of those with a tooth-brushing frequency of 1 versus  $\geq 3$  times/day was significantly higher, and the OR (95% CI) was 4.76 (1.09-20.77).

Table 4 shows the results of the linear regression analyses of the effect of each variable on the proxy-reported number of teeth. The number of teeth decreased by -0.42 as age increased by 1 year ( $P < 0.01$ ). ASD had 0.74 more teeth than ID

( $P < 0.05$ ), and DS had -0.93 fewer teeth than ID ( $P = 0.01$ ). Those who did not undergo regular dental check-ups had -2.12 fewer teeth than those who did ( $P = 0.02$ ).

## Discussion

In this study, about 30% of those with ID aged  $\geq 40$  years old had fewer than 20 teeth, and the percentage increased with age. The number of teeth was also significantly associated with the type of disability and regular dental check-ups.

According to the 2016 National Dental Survey of Japan, the rates of having  $\geq 20$  teeth were 98.9, 94.1, 79.6 and 59.1% among persons aged 40-49, 50-59, 60-69 and  $\geq 70$  years, respectively (Ministry of Health, Labour and Welfare 2016). Individuals with ID may be at greater risk of losing many teeth compared with the general population, especially at  $\geq 50$  years of age. Tooth loss is reportedly associated with age-related pathological conditions, such as dementia (Takeuchi *et al.* 2017; Tsai *et al.* 2020) and frailty (Albani *et al.* 2021). If persons with ID lose a large number of teeth earlier than healthy individuals, they will likely also experience systemic effects of tooth loss earlier. Difficulty in chewing occurs when there are fewer than 20 teeth due to the loss of many teeth (Ueno *et al.* 2008). The loss of many teeth is associated with poorer nutritional status (Zelig

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**Table 4** Association between each variable and the proxy-reported number of teeth using univariable and multivariate linear regression analyses

Dependent variable: Proxy-reported number of teeth				
Characteristics	Crude		Adjusted	
	B (95% CI)	P	B (95% CI)	P
Age (years old)	-0.44 (-0.49, -0.39)	<0.01	-0.42 (-0.47, -0.36)	<0.01
Sex				
Male	Reference		Reference	
Female	-2.20 (-3.57, -0.83)	<0.01	-0.41 (-1.57, -0.76)	0.50
Diagnosis of disability				
Intellectual disability	Reference		Reference	
Autism spectrum disorder	2.46 (1.64, 3.27)	<0.01	0.74 (0.01, 1.47)	<0.05
Down syndrome	-0.00 (-0.87, 0.86)	0.99	-0.93 (-1.67, -0.19)	0.01
Cerebral palsy	-0.24 (-0.92, 0.43)	0.48	-0.31 (-0.88, 0.26)	0.28
Other diagnosis	0.60 (0.08, 1.12)	0.02	0.35 (-0.09, 0.79)	0.12
Severity level of intellectual disability				
Severe (IQ: $\geq 35$ )	Reference		Reference	
Moderate (IQ: 36–50)	-0.14 (-1.04, 0.75)	0.75		
Mild (IQ: 51–70)	0.82 (-0.52, 2.15)	0.23		
Type of residence				
Living at home with family	Reference		Reference	
Residential care home	-1.99 (-2.85, -1.12)	<0.01	-0.26 (-1.07, 0.54)	0.52
Community group home	-0.21 (-1.02, 0.60)	0.61	0.21 (-0.47, 0.90)	0.54
Oral health related factors				
Family dentist				
Presence	Reference		Reference	
Absence	-0.74 (-3.41, 1.93)	0.59		
Regular dental check-ups ( $\leq 1$ year)				
Yes	Reference		Reference	
No	-1.72 (-3.83, 0.39)	0.11	-2.12 (-3.86, -0.39)	0.02
Problems during dental treatment				
Absence	Reference		Reference	
Presence	0.13 (-0.75, 1.01)	0.77		
Never treated	0.46 (-1.05, 1.98)	0.55		
Tooth-brushing frequency				
$\geq 3$ times/day	Reference		Reference	
2 times/day	1.41 (0.67, 2.17)	<0.01	-1.62 (-5.16, 1.91)	0.37
1 time/day	0.47 (-3.75, 4.68)	0.83	0.50 (-0.14, 1.15)	0.12

B, partial regression coefficient; CI, confidence interval; IQ, intelligence quotient.

*et al.* 2020). Retaining as many teeth as possible can improve quality of life (Park *et al.* 2019). Persons with ID who have lost many teeth are less likely to be able to wear dentures than members of the general population (Mac Giolla Phadraig *et al.* 2015). Preventing tooth loss and retaining a large number of teeth would stabilise mastication, improve nutritional status and quality of life and promote maintenance of general health in persons with ID. Because tooth loss begins

earlier in individuals with ID than in the general adult population, measures to prevent tooth loss in the former group after middle age should be applied as early as possible.

Our participants with DS had significantly fewer teeth than those with ID. Individuals with ID, including DS, reportedly lose multiple teeth as a result of periodontal disease (Gabre *et al.* 2001). Persons with DS have a high prevalence of



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periodontal disease and considerable attachment loss (López-Pérez *et al.* 2002; Khocht *et al.* 2010; Scalioni *et al.* 2018). The loss of many teeth among persons with DS may result from their high risk of periodontal disease. Oral-hygiene status influences the onset and progression of periodontal disease (Lertpimonchai *et al.* 2017), and individuals with DS reportedly have poor oral hygiene (Sakellari *et al.* 2005). Therefore, improving oral hygiene in adults with DS could prevent tooth loss. Our participants with ASD tended to have more teeth than those with ID. Adults with ASD have a lower caries rate than members of the general population and persons with other disabilities (Orellana *et al.* 2012). Also, children with ASD have a lower caries rate than those in the general population (Loo *et al.* 2008; Kuter and Guler 2019). The low caries prevalence in childhood and adulthood among individuals with ASD may be associated with a large number of teeth. However, persons with ASD require more treatments for oral disease requiring general anaesthesia compared with those with other ID (Loo *et al.* 2008), so measures to prevent the onset of oral disease are needed. In this study, the oral condition, in terms of dental caries and periodontal disease, for example, was unknown. Further studies should identify the causes of tooth loss among persons with ID via longitudinal analysis of their oral condition and dental treatments.

In this study, participants who attended regular dental check-ups had many teeth. Regular oral cleaning at a dental clinic attenuates the progression of periodontal disease in persons with DS (Yoshihara *et al.* 2005). In addition, regular dental check-ups by persons with ID were associated with the number of lost teeth (Pradhan *et al.* 2009). The finding that regular dental check-ups were associated with the loss of fewer teeth implies that professional dental care can prevent tooth loss. Compared with participants who brushed their teeth at least three times per day, those who brushed their teeth only once had fewer teeth. Because the participants had ID, daily tooth brushing was likely to be performed by relatives or caregivers. In any case, appropriate daily tooth brushing according to the severity of disability is important for preventing tooth loss. Therefore, it is necessary to provide information and health education to the relatives and caregivers of persons with ID.

Although the number of teeth is often analysed as a categorical variable (Yun *et al.* 2020; Yu *et al.* 2021;

Abbas *et al.* 2022), we analysed the number of teeth as both categorical and continuous variables to show the strength of the influence of factors on the number of teeth. Therefore, we analysed the categorical variables of the number of teeth using the age group category. For the 10-year age groups, the CI of the OR was large. This is thought to indicate that there is a large individual difference in the number of teeth within the same age groups. Because the relationship between the number of teeth and age is predominant, even when both are analysed as continuous values, it was shown that age has a significant effect on tooth loss, even in people with ID.

The two types of multivariate analysis showed that there were variables that had a common result in relation to the number of teeth, although tooth-brushing frequency did not show significant results in the linear regression analysis. Few people brushed their teeth once a day in this study, and the lack of information about the participant's actual oral status may have influenced the results. People who brush their teeth more frequently have been reported to have less tooth loss (Fatima Del Carmen *et al.* 2021; Al-Harhi *et al.* 2022). Because people with ID have poor oral hygiene (Petrovic *et al.* 2016), improving the oral hygiene of people with ID is considered important for preventing tooth loss.

This study had several limitations. Because they were obtained via a questionnaire survey, the data may have been biased. Some participants did not report how many teeth they had, and the accuracy of the proxy-reported number of teeth could not be confirmed. The number of teeth may have a misattribution bias caused by the subjectivity and circumstances of the person reporting. Although the self-reported number of teeth in adult population has previously shown reliability (Matsui *et al.* 2016; Margozzini *et al.* 2019), our proxy-reported data of persons with ID may be less valid than the simple self-reported data of the general population. The responses provided may have differed according to whether the respondent was a relative or a caregiver. The diagnosis of disability and tooth-brushing frequency may generate false positives due to the small number of people in the category. Because this was a cross-sectional study, we could not evaluate the causality of the relationships of the factors of interest with the number of teeth. It is difficult to generalise the results because of the selection bias caused by the

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study being conducted in facilities for persons with ID in a single prefecture, as well as the low participation rate. Regarding tooth brushing, the relationship between the number of teeth and tooth-brushing frequency differed between the two different analyses; even with significant results, the CI was wide. We did not investigate the use of toothpaste when brushing teeth. Further research needs to examine the effect of tooth brushing on the number of teeth in people with ID. However, few studies have evaluated the factors related to the number of teeth in middle-aged and elderly persons with ID.

One strength of this study was the finding that persons with ID lost more teeth at an earlier age compared with members of the general population, which indicates that earlier intervention is needed to maintain oral health. Longitudinal studies of persons with ID are needed to identify factors associated with maintenance of the oral health of individuals with ID.

## Conclusion

Middle-aged and older individuals with ID typically lose many teeth, the number of which is linked to the type of disability. Regular dental visits may be effective for preventing tooth loss in middle-aged and older persons with ID.

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## Conflict of interest

The authors declare no conflict of interest.

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## Ethics statement

The purpose of the study was explained to the heads of the participating facilities for persons with intellectual disabilities, and only those facilities whose heads consented to participate were included in the survey. This study was approved by the Institutional

Review Board of the School of Dentistry of Aichi Gakuin University (approval number 539).

## Data availability statement

Data are not shared.

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