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A special needs dentistry study of institutionalized individuals with intellectual disability in West Sumatra Indonesia

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People with intellectual disability have a higher risk of oral health problems. This study assessed the clinical oral health status and behaviors and treatment needs of people living in an institution in Padang, West Sumatra, Indonesia. We quantified oral health status of 65 individuals with intellectual disability using Oral Hygiene Index Simplified (OHIS), Angle's classification of malocclusion, Community Periodontal Index and Treatment Need (CPITN), and decay index and also recorded their brushing behavior. We found that males had significantly lower OHIS ($p < 0.001$), more malocclusion ($p < 0.001$), greater caries number ($p < 0.001$), greater CPITN ($p = 0.001$) and higher need of dental treatment ($p < 0.01$) than females. Additionally, we found that high caries number was associated with poor OHIS, malocclusion, periodontal disease, and dependent brushing behavior ($p < 0.001$). The findings of this study imply that there is a gap in appropriate oral health care in individuals with intellectual disability. There should be a greater focus on providing appropriate oral health education to people with intellectual disability, improving the health literacy and quality of care of caregivers, and providing more dentists with specialized training in special needs dentistry.

Intellectual disability (ID) is a neurodevelopmental disorder. People with ID have impaired intellectual and adaptive functioning with an intelligence quotient (IQ) below 70. The American Association on Intellectual and Developmental Disabilities (AAIDD) divides ID into four categories according to IQ: mild (55–69), moderate (36–54), severe (20–35), and profound (< 20). People with ID have difficulty in understanding, learning, and applying new or complex skills. They experience a higher risk of health problems due to an inability to properly perform activities of daily living (ADL)¹. However, the secondary health problems created by low ADL capacity can be prevented by improving the environment and skills of these individuals, developing caregivers' health literacy, and strengthening the special needs training of medical professionals involved with their care.

Systematic reviews and meta-analyses on the oral health status of people with ID reveal the poor oral health of these individuals and the great need for dentistry practices geared to them^{2,3}. Individuals with ID encounter oral health problems, such as caries⁴, poor oral hygiene⁵, periodontal disease^{6,7}, and malocclusion⁴. Children with ID have high DMF-T (decay, missing, filling-tooth) scores⁴. It has been reported that 44.3% of people with ID had signs of gingival disease⁷, while 84.8% have incisal segment crowding⁴. The prevalence of malocclusion in children with Down's syndrome and cerebral palsy is 20.4%; among these individuals, 21.5% have anterior cross-bite, 21.5% have posterior crossbite, and 29.8% have anterior open bite⁸. Several risk factors cause secondary oral health problems in people with ID. These include low ADL capacity⁹, which makes them unable to brush the teeth adequately⁶, favoring cariogenic foods¹⁰, and lack of special health education training.¹¹ The inadequate quality of care given by caregivers¹² and lack of special needs dentistry training of dental professionals also contribute to this issue¹³. In addition, the oral health perception of specialized institutions affects the oral health status of people who live there¹⁴.

Few papers discuss the current oral health care needs of institutionalized individuals with ID in Indonesia. As a basis for improving oral health care and quality of life in this population, this study assessed the clinical

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Character	Gender			
	Female N = 34		Male N = 31	
	N	%	N	%
Degree of Intellectual disability				
Mild	4	11.8	4	12.9
Moderate	30	88.2	27	87.1
Age group				
Adolescent (13y–18y)	9	26.5	11	35.5
Young adult (19y–24y)	15	44.1	11	35.5
Adult (25y–45y)	10	29.4	9	29.0
Mean age (±SD)	22 (±4.916)		22 (±5.891)	

Table 1. The demographic data of the study participants.

Items	Variable		Gender				p
			Female N = 34		Male N = 31		
			N	%	N	%	
Oral health status	OHIS	Good	2	5.9	0	0.0	<0.001***
		Fair	32	94.1	3	9.7	
		Poor	0	0.0	28	90.3	
	Occlusion	Class 1	26	76.5	1	3.2	<0.001***
		Class 2	8	23.5	21	67.7	
		Class 3	0	0.0	9	29.0	
	CPITN	Healthy	9	26.5	0	0.0	0.001**
		Bleeding on Probing	24	70.6	23	74.2	
		Calculus	1	2.9	8	25.8	
		Pocket 4–5 mm	0	0.0	0	0.0	
	Pocket >6 mm	0	0.0	0	0.0		
Brushing behavior	Brushing capability	Independent	34	100.0	13	41.9	<0.001***
		Dependent	0	0.0	18	58.1	
	Brushing Frequency	Once a day	18	52.9	0	0.0	<0.001***
		Twice a day	16	47.1	31	100.0	
Dental treatment needs	Scaling Needs	No	9	26.5	0	0.0	0.002**
		Yes	25	73.5	31	100.0	
	Restoration Needs	No	14	41.2	4	12.9	0.011*
		Yes	20	58.8	27	87.1	
	Orthodontic Needs	No	26	76.5	1	3.2	<0.001***
		Yes	8	23.5	30	96.8	

Table 2. Comparison of the oral health status, brushing behavior, and dental treatment needs between male and female study participants. Chi-squared test *p < 0.05, p** < 0.005, ***p < 0.001.

oral health status of individuals with ID living in the only institution in Padang, West Sumatra Indonesia geared towards them.

Results

Participant characteristics. The demographics of the participants are listed in Table 1. This study enrolled 65 participants with ID, 34 females and 31 males. The mean age of the group was 22 years. Most participants had a moderate degree of intellectual disability (87.7%) while the remaining 12.3% of individuals had a mild degree of intellectual disability. None of the participants had a severe ID.

Differences in oral health status between the sexes. Oral health status, brushing behavior, and dental treatment needs were determined separately for males and females (Table 2). The parameters of oral health status included OHIs, occlusion classification, and CPITN. A higher proportion of males than females had poor OHI (90.3% vs. 0%), class 2 or 3 malocclusion (96.7% vs. 23.5%), and periodontal bleeding or calculus (100% vs. 73.5%). Brushing ability was measured in terms of whether individuals could brush their teeth independently and

	Caries number			
	N	Mean	SD	p
Female	34	3.00	1.923	<0.001***
Male	31	7.55	2.862	

Table 3. The mean caries number of the individuals with ID. unpair t-test *** $p < 0.001$.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	p value
a	0.840	0.706	0.701	1.813	<0.001***
b	0.888	0.789	0.782	1.549	<0.001***
c	0.928	0.861	0.854	1.267	<0.001***
d	0.938	0.880	0.872	1.185	<0.001***
e	0.947	0.897	0.888	1.109	<0.001***
f	0.951	0.904	0.895	1.076	<0.001***
g	0.950	0.902	0.894	1.079	<0.001***

Table 4. Multiple linear regression analysis of association factors to dental caries. a. Predictors: (Constant), Occlusion. b. Predictors: (Constant), Occlusion, OHIS. c. Predictors: (Constant), Occlusion, OHIS, Age. d. Predictors: (Constant), Occlusion, OHIS, Age, Brushing capacity. e. Predictors: (Constant), Occlusion, OHIS, Age, Brushing capacity, CPITN. f. Predictors: (Constant), Occlusion, OHIS, Age, Brushing capacity, CPITN, Brushing Frequency. g. Predictors: (Constant), OHIS, Age, Brushing skill, CPITN, Brushing Frequency.

the number of times they brushed their teeth per day. All females (100%), but not all males (41.9%), brushed their teeth independently, either once or twice a day. Treatment needs in terms of scaling, restoration, and orthodontic treatment, were determined. The male participants showed significantly greater treatment needs than females in all three items: scaling (100% vs. 73.5%) ($p < 0.001$), restoration (87.1% vs. 58.8%) ($p < 0.05$), and orthodontic treatment (96.8% vs. 23.5%) ($p < 0.001$). Males had a significantly higher mean caries number than females (7.55 mean caries number vs. 3.5 mean caries number, $p < 0.001$) (Table 3). Thus, the oral health status, occlusion classification, and brushing ability was significantly worse in males than in females, and male participants required more dental treatment.

Independent predictors of caries and their correlation. Stepwise multiple linear regression analysis revealed that age, oral hygiene, periodontal disease, malocclusion (class 2 and class 3), brushing capacity, and brushing frequency were predictors of the caries number ($p < 0.001$). The increased adjusted R square indicated the independent variables predict the caries number (Table 4). Table 5 shows the coefficients of the multiple linear regression analysis. The variance inflation factors were less than 10 indicating the absence of multicollinearity between independent variables.

Participants who had poor oral health status and dependent brushing capacity are at high risk to have caries. Simple odds ratios were calculated to determine the association of different components of brushing behavior and oral health on dental caries (Table 6). Poor OHIS status increased the odds of developing caries 66.1 times while an inability to brush teeth independently increased the odds of developing caries 5.8 times.

Discussion

The quality of life of individuals with ID can markedly improve by addressing issues regarding their oral health. However, few papers on the oral health of individuals with ID in Indonesia exist. Therefore, we assessed the clinical oral health status of people with ID living in specialized institutions in Indonesia. We found that males had significantly worse health status and required more extensive dental treatment than females. Additionally, we found that different aspects of brushing teeth and oral health such as ability to brush one's teeth independently and periodontal health significantly affected caries number.

The participants in the present study had mild to moderate ID. This is because the institution in Padang does not admit individuals with severe ID¹⁵. In our study, poor oral health status and malocclusion were more prevalent in males than in females, and males more often required assistance to brush their teeth. This may be because, in individuals with ID, males exhibit more responsive behavior and have a higher prevalence of visual impairments, like strabismus and refractive errors, than females^{16–18}.

Individuals with ID have deficits in mental abilities, social skills, and lower ADL ability compared to their same-aged peers. Approximately one-fourth of cases of ID may be attributable to genetic causes and the indelible nature of the condition makes it necessary for health care workers and caregivers to be more accommodating to them, particularly when promoting self-care. Individuals with ID may take longer to learn to brush their teeth and rinse their mouth. Some of them are unable to chew and swallow food adequately, and thus food debris accumulates in the oral cavity. Furthermore, the prevalence of enamel defects and malocclusion is high in individuals with ID^{19,20}.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.277	0.325		6.996	<0.001		
Occlusion	4.000	0.325	0.840	12.288	<0.001	1.000	1.000
(Constant)	-0.218	0.577		-0.377	0.708		
Occlusion	2.499	0.412	0.525	6.063	<0.001	0.455	2.197
OHIS	2.557	0.519	0.427	4.931	<0.001	0.455	2.197
(Constant)	-4.856	0.950		-5.112	<0.001		
Occlusion	1.432	0.387	0.301	3.702	<0.001	0.346	2.892
OHIS	3.353	0.447	0.560	7.499	<0.001	0.410	2.441
Age	0.191	0.034	0.310	5.627	<0.001	0.751	1.331
(Constant)	-3.839	0.947		-4.055	<0.001		
Occlusion	1.114	0.376	0.234	2.964	0.004	0.320	3.122
OHIS	2.816	0.452	0.470	6.230	<0.001	0.350	2.854
Age	0.171	0.032	0.277	5.251	<0.001	0.720	1.389
Brushing skill	1.548	0.496	0.211	3.120	0.003	0.438	2.281
(Constant)	-3.439	0.896		-3.840	<0.001		
Occlusion	0.647	0.383	0.136	1.688	0.097	0.270	3.702
OHIS	2.592	0.429	0.433	6.036	<0.001	0.340	2.939
Age	0.123	0.034	0.199	3.601	0.001	0.572	1.750
Brushing skill	1.625	0.465	0.221	3.495	0.001	0.437	2.288
CPITN	1.301	0.423	0.208	3.078	0.003	0.382	2.617
(Constant)	-3.142	0.880		-3.570	0.001		
Occlusion	0.431	0.385	0.091	1.119	0.268	0.252	3.972
OHIS	2.291	0.440	0.382	5.212	<0.001	0.306	3.269
Age	0.108	0.034	0.175	3.182	0.002	0.547	1.829
Brushing skill	1.887	0.467	0.257	4.038	<0.001	0.408	2.454
CPITN	1.180	0.414	0.189	2.848	0.006	0.375	2.667
Brushing Frequency	0.926	0.430	0.126	2.154	0.035	0.481	2.078
(Constant)	-3.433	0.842		-4.076	<0.001		
OHIS	2.456	0.415	0.410	5.916	<0.001	0.344	2.903
Age	0.111	0.034	0.180	3.289	0.002	0.551	1.814
Brushing skill	2.054	0.444	0.279	4.628	<0.001	0.454	2.203
CPITN	1.339	0.390	0.214	3.433	0.001	0.425	2.352
Brushing Frequency	1.051	0.416	0.143	2.527	0.014	0.516	1.937

Table 5. The coefficient of the multiple linear regression analysis. Dependent Variable: Caries. VIF: variance inflation factor.

Variables	Odds ratio	95% CI
Poor OHIS	66.11	2.74-1596.19
Malocclusion	23.27	1.25-433.57
Periodontal disease	209.85	9.72-4531.71
Dependent brushing behavior	5.79	0.31-108.34
Once a day brushing behavior	49.4	2.60-937.44

Table 6. The odds ratio of the caries among individuals with ID.

The main oral health problems in the ID group are periodontal disease, caries, and malocclusion. Due to inadequate chewing and swallowing, and consequent food debris accumulation in the oral cavity, as well as poor self-brushing capacity, periodontal disease^{3,21,22} and caries frequently occur in individuals with ID¹⁷. Periodontal disease could be caused by the accumulation of dental plaque as well as a hyperactive immunological response. Environmental stress could further exacerbate this immunological response. Residing in this institution may be more stressful for these individuals than living at home and attending a special school because family time may be restricted. Additionally, because there is only 1 caregiver per 7 individuals, there may be insufficient care, particularly oral care, increasing the chances of periodontal disease and caries. It has been reported that individuals living in such institutions are more prone to having periodontal disease and that this predilection is reduced after being de-institutionalized²³. The study population had a high prevalence of malocclusion as well as dental caries.

The acquired enamel defects can have an impact on caries development¹⁹ and tooth loss^{24,25}. Previous literature has shown that caries development in adults with physical and intellectual disabilities is associated with diet, frequency of dental visits, absence of oral hygiene assistance, career-contact hours, and transportation problems²⁶. We found that in this population, malocclusion, OHIS, age, CPITN, brushing fewer than two times per day, and inability to brush one's teeth independently correlated with caries number. Increasing or altering oral hygiene assistance in individuals that cannot brush their teeth independently may decrease caries numbers.

We consider that improving the oral health status among individuals with ID can be grouped into three categories: improving health education methods and creating a friendly environment for individuals with ID, enhancing oral health literacy and quality of care among caregivers, and establishing a special needs dentistry course for dentists who would like to treat individuals with ID.

In this special care institution in Padang, the caregivers teach residents how to bathe. Residents have to rely on oral hygiene skills acquired from their family members as they were growing up. This is because this institution does not formally train caregivers to promote oral hygiene. To enhance oral health skills among individuals with ID, dental health education can be taught through a peer-mediated time-delay approach where peers model appropriate brushing techniques and habits and prompt individuals with ID to carry out this behavior. This has been shown to be an effective approach to teaching science in such individuals²⁷. In order to promote better oral hygiene habits, a brief motivational interview (lasting 15–20 minutes) can be conducted prior to dental education. Rating performance, and providing feedback on daily toothbrushing and oral health are feasible means to improve education²⁸. Additionally, audiotapes can be used to consolidate the information that is taught.

Financial barriers and a lack of parental awareness are major factors preventing individuals with ID to receive dental care^{21,25,29}. The poor oral health status of people with ID has been associated with poverty^{6,22}. Overcoming this financial barrier by social insurance should be considered. The responsive behavior of people with ID presents a further challenge to normal dental treatment procedures³⁰. The teaching-family model can help to reduce physical and verbal aggression³¹.

According to previous reports, 65% of people with ID are under the supervision of a caregiver³². The lack of understanding of the importance of oral health and inadequate ADL support from the caregiver can increase the predilection of oral health problems in people with ID³³. Appropriate support for brushing teeth more than once a day among people with ID could significantly reduce periodontal disease and caries indices^{34–38}. This can only occur with increasing the oral health literacy of caregivers³⁹.

The findings of this study are not generalizable to all individuals with ID and may only apply to institutionalized individuals with ID in Indonesia. Additionally, this study did not look at other factors that are more common in individuals with ID, which may affect oral health like bruxism, tongue thrusting, and responsive behavior. None the less, this study may offer some insight on the necessity to enhance special needs dentistry in Indonesia. Dental care significantly improves the oral health and quality of life of individuals with ID⁴⁰. However, special needs dentistry is a challenging dental field. Dentists need to be equipped with adequate knowledge and skills to address the special needs of these patients. Treatment and admission protocols that do not accommodate these individuals and an unfriendly environment lower the quality of care for these individuals⁴¹. Therefore, a special training course for people involved in dental care should be established where special needs dentistry units are lacking, to train dentists who will devote themselves to dental care of individuals with special needs.

Materials and Methods

Ethical considerations. This study was approved by the committee of the research ethics of the faculty of medicine, Andalas University in Padang with the approved number of 014/KEP/FK/2019. Written informed consent was obtained from the guardians of participants with ID, and those ID participants who were willing to join this study. Consent to publish open access journal was obtained from guardians. The information letter describing the rationale of the study and individual rights was handed to the guardians. All clinical survey was performed in accordance with the guidelines of the Declaration of Helsinki.

Study participants. The participants were residents at the only institution for the mentally disabled in Padang, West Sumatra, Indonesia. The ID classification data of each participant were provided by the school. Sixty-five participants met the inclusion criterion of good general health (ASA Physical Status Classification I and II)⁴². Exclusion criteria were as follows: parents declined participation, systemic diseases, and responsive behavior.

Oral examination. The oral examination was performed by five well-trained examiners. The reliability of examiners was assessed based on the data of seven participants. The intraclass coefficients for intra-examiner and inter-examiner reliabilities were 1 and 0.91, respectively¹⁰. All oral assessments were performed in daylight in the school classrooms using flashlights for further visualization. During the assessment, the study participant was seated on a chair. Meticulous oral examination was carried out with a guardian assisting when necessary to provide comfort to the participant. During the examination, a disposable dental kit (sonde, mirror, and excavator) and BPWHO dental probe (Osung, Pearland, TX, USA) was used. Tooth-brushing behavior was determined by asking participants questions about the number of times they brushed their teeth per day (tooth brushing frequency) and whether they required assistance from their caregivers when brushing their teeth (tooth brushing skills). The guardians assisted with communication during the interview process.

Oral hygiene index. Oral hygiene was quantified using the simplified oral hygiene index (OHI)⁴³. The OHI has two components, the debris index simplified, and the calculus index simplified. Six surfaces were examined to determine this score: teeth 16, 11, 26, 36, 31, and 46. Oral hygiene was classified as good (score: 0–1.2), fair (1.3–3), and poor (3.1–6).

Caries number. The caries number was scored using the oral health survey of the World Health Organization (WHO) (2013). The caries number was expressed as the total number of teeth that were decayed in an individual. When caries or both caries and a restoration were present, the tooth was recorded as decayed.

Community periodontal index. The community periodontal index of treatment needs (CPITN) was examined according to the WHO methodology (1997)⁴⁴. The CPITN procedure employed a WHO probe and mouth mirror. The dentition was divided into six sextants: Upper right (tooth 17 to 14), upper anterior (tooth 13 to 23), upper left (tooth 24 to 27), lower right (tooth 47 to 44), lower anterior (tooth 43 to 33), and lower left (tooth 34 to 37). The probe was moved around the gingival sulcus, and the highest score recorded for each sextant was scored, as follows:

0 = healthy 1 = bleeding during probing 2 = supra- and/or subgingival calculus, filling or crown excesses 3 = gingival pockets 4 to 5 mm 4 = pockets deeper than 6 mm.

Malocclusion angle's classification. The Malocclusion Angle's classification was based on the relationship of the first molars⁴⁵. Class 1 malocclusion was defined when the mesiobuccal cusp of the permanent maxillary first molar approximated the buccal groove of the permanent mandibular first molar. Class 2 malocclusion was defined when the maxillary mesiobuccal cusp fell anterior to the buccal groove of the mandibular molar and class 3 define as the maxillary mesiobuccal cusp fell distal to the buccal groove of the mandibular molar. In this article, we categorized the class 2 and class 3 as positive malocclusion and class 1 as negative malocclusion.

Statistical analysis. Data analysis was performed using the Statistical Package for the Social Sciences software version 23.0 for Windows (IBM Corp, New York, NY, USA). Continuous variables were analyzed using the *t*-test while categorical variables were analyzed using Fisher's exact test. In order to determine whether sex, periodontal status, malocclusion, age, brushing frequency, brushing skill and oral hygiene were predictors for caries number, stepwise multiple linear regression analysis was carried out. $P < 0.05$ was considered statistically significant. In Table 4, we analyzed the multiple linear regression with several categorical variables. The reference category of occlusion is class 2 and class 3, the reference category of OHIS is fair and poor oral hygiene, the reference category of age is 26–36 years, the reference category of brushing capacity is dependent tooth brushing, the reference category of CPITN is bleeding on probing and calculus, and the reference category of brushing frequency is once a day or less.

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References

- King, E. *et al.* Activities of daily living and transition to community living for adults with intellectual disabilities. *Scand J Occup Ther* **24**, 357–365, <https://doi.org/10.1080/11038128.2016.1227369> (2017).
- Anders, P. L. & Davis, E. L. Oral health of patients with intellectual disabilities: a systematic review. *Spec Care Dentist* **30**, 110–117, <https://doi.org/10.1111/j.1754-4505.2010.00136.x> (2010).
- Zhou, N., Wong, H. M., Wen, Y. F. & McGrath, C. Oral health status of children and adolescents with intellectual disabilities: a systematic review and meta-analysis. *Dev Med Child Neurol* **59**, 1019–1026, <https://doi.org/10.1111/dmcn.13486> (2017).
- Vellappally, S. *et al.* The prevalence of malocclusion and its association with dental caries among 12–18-year-old disabled adolescents. *BMC Oral Health* **14**, 123, <https://doi.org/10.1186/1472-6831-14-123> (2014).
- Makkar, A., Indushekar, K. R., Saraf, B. G., Sardana, D. & Sheoran, N. A cross sectional study to evaluate the oral health status of children with intellectual disabilities in the National Capital Region of India (Delhi-NCR). *Journal of intellectual disability research: JIDR* **63**, 31–39, <https://doi.org/10.1111/jir.12553> (2019).
- Pezzementi, M. L. & Fisher, M. A. Oral health status of people with intellectual disabilities in the southeastern United States. *Journal of the American Dental Association* (1939) **136**, 903–912, <https://doi.org/10.14219/jada.archive.2005.0291> (2005).
- Fernandez, C., Declerck, D., Dedecker, M. & Marks, L. Treatment needs and impact of oral health screening of athletes with intellectual disability in Belgium. *BMC Oral Health* **15**, 170–170, <https://doi.org/10.1186/s12903-015-0157-9> (2015).
- Oliveira, A. C., Paiva, S. M., Martins, M. T., Torres, C. S. & Pordeus, I. A. Prevalence and determinant factors of malocclusion in children with special needs. *Eur J Orthod* **33**, 413–418, <https://doi.org/10.1093/ejo/cjq094> (2011).
- Kancherla, V., Van Naarden Braun, K. & Yeargin-Allsopp, M. Dental care among young adults with intellectual disability. *Res Dev Disabil* **34**, 1630–1641, <https://doi.org/10.1016/j.ridd.2013.02.006> (2013).
- Shrout, P. E. & Fleiss, J. L. Intraclass correlations: uses in assessing rater reliability. *Psychological bulletin* **86**, 420–428 (1979).
- Rawlinson, S. R. The Dental and Oral Care Needs of Adults with a Learning Disability Living in a Rural Community: Consideration of the Issues. *Journal of Learning Disabilities* **5**, 133–156, <https://doi.org/10.1177/146900470100500205> (2001).
- Totsika, V., Hastings, R. P. & Vagenas, D. Informal caregivers of people with an intellectual disability in England: health, quality of life and impact of caring. *Health Soc Care Community* **25**, 951–961, <https://doi.org/10.1111/hsc.12393> (2017).
- Ummer-Christian, R. *et al.* Access to dental services for children with intellectual and developmental disabilities – A scoping review. *Research in Developmental Disabilities* **74**, 1–13, <https://doi.org/10.1016/j.ridd.2017.12.022> (2018).
- Petrovic, B. B. *et al.* Unmet oral health needs among persons with intellectual disability. *Research in Developmental Disabilities* **59**, 370–377, <https://doi.org/10.1016/j.ridd.2016.09.020> (2016).
- Bourke, J., de Klerk, N., Smith, T. & Leonard, H. Population-Based Prevalence of Intellectual Disability and Autism Spectrum Disorders in Western Australia: A Comparison With Previous Estimates. *Medicine (Baltimore)* **95**, e3737, <https://doi.org/10.1097/MD.0000000000003737> (2016).
- Desvarieux, M. *et al.* Gender differences in the relationship between periodontal disease, tooth loss, and atherosclerosis. *Stroke* **35**, 2029–2035, <https://doi.org/10.1161/01.STR.0000136767.71518.36> (2004).
- Dziwak, M. *et al.* Dental health and odontogenic infections among 6- to 16-year-old German students with special health care needs (SHCN). *Clin Oral Investig* **21**, 1997–2006, <https://doi.org/10.1007/s00784-016-1988-8> (2017).
- Schulze, A. & Busse, M. Gender Differences in Periodontal Status and Oral Hygiene of Non-Diabetic and Type 2 Diabetic Patients. *Open Dent J* **10**, 287–297, <https://doi.org/10.2174/1874210601610010287> (2016).
- Alalusa, S. Defining Developmental Enamel Defect-associated Childhood Caries: Where Are We Now? *Journal of Dental Research* **91**, 525–527, <https://doi.org/10.1177/0022034512445634> (2012).
- Borges-Oliveira, A. C., Paiva, S., Martins, M., Silva Torres, C. & Pordeus, I. Prevalence and determinant factors of malocclusion in children with special needs. *Vol.* **33** (2010).

21. Hennequin, M., Allison, P. J. & Veyrune, J. L. Prevalence of oral health problems in a group of individuals with Down syndrome in France. *Dev Med Child Neurol* **42**, 691–698, <https://doi.org/10.1017/s0012162200001274> (2000).
22. Trihandini, I., Wiradidjaja Adiwoso, A., Erri Astoeti, T. & Marks, L. Oral health condition and treatment needs among young athletes with intellectual disabilities in Indonesia. *Int J Paediatr Dent* **23**, 408–414, <https://doi.org/10.1111/ipd.12010> (2013).
23. Gabre, P., Wikström, M., Martinsson, T. & Gahnberg, L. Move of Adults with Mental Retardation from Institutions to Community-based Living: Changes in the Oral Microbiological Flora. *Journal of Dental Research* **80**, 421–426, <https://doi.org/10.1177/00220345010800020401> (2001).
24. Da'ameh, D. Reasons for permanent tooth extraction in the North of Afghanistan. *J Dent* **34**, 48–51, <https://doi.org/10.1016/j.jdent.2005.02.009> (2006).
25. McCaul, L. K., Jenkins, W. M. & Kay, E. J. The reasons for the extraction of various tooth types in Scotland: a 15-year follow up. *J Dent* **29**, 401–407, [https://doi.org/10.1016/s0300-5712\(01\)00036-7](https://doi.org/10.1016/s0300-5712(01)00036-7) (2001).
26. Ferraro, M. & Vieira, A. R. Explaining gender differences in caries: a multifactorial approach to a multifactorial disease. *Int J Dent* **2010**, 649643, <https://doi.org/10.1155/2010/649643> (2010).
27. Jimenez, B. A., Browder, D. M., Spooner, F. & Dibiasi, W. Inclusive Inquiry Science Using Peer-Mediated Embedded Instruction for Students with Moderate Intellectual Disability. *Exceptional Children* **78**, 301–317, <https://doi.org/10.1177/001440291207800303> (2012).
28. Almomani, F., Williams, K., Catley, D. & Brown, C. Effects of an Oral Health Promotion Program in People with Mental Illness. *Journal of Dental Research* **88**, 648–652, <https://doi.org/10.1177/0022034509338156> (2009).
29. Morgan, J. P. et al. The oral health status of 4,732 adults with intellectual and developmental disabilities. *Journal of the American Dental Association (1939)* **143**, 838–846, <https://doi.org/10.14219/jada.archive.2012.0288> (2012).
30. Han, J. H. et al. Dental treatment under general anesthesia in an intellectually disabled child with intellectually disabled parents. *J Dent Anesth Pain Med* **16**, 213–216, <https://doi.org/10.17245/jdamp.2016.16.3.213> (2016).
31. De Wein, M. & Miller, L. K. The Teaching-Family Model: A Program Description and Its Effects on the Aggressive Behaviors and Quality of Life of Two Adults With Intellectual Disabilities. *Journal of Positive Behavior Interventions* **11**, 235–251, <https://doi.org/10.1177/1098300709332344> (2009).
32. Shivakumar, K., Patil, S., Kadashetti, V. & Raje, V. Oral health status and dental treatment needs of 5Ó12-year-old children with disabilities attending special schools in Western Maharashtra, India. *Int J App Basic Med Res*, **8**, 24–29, https://doi.org/10.4103/ijabmr.IJABMR_57_17 (2018).
33. Phlypo, I. et al. The perception of oral health and oral care needs, barriers and current practices as perceived by managers and caregivers in organizations for people with disabilities in Flanders, Belgium. *Clin Oral Invest*. <https://doi.org/10.1007/s00784-019-03071-z> (2019).
34. Amano, K., Miyake, K., Borke, J. L. & McNeil, P. L. Breaking biological barriers with a toothbrush. *J Dent Res* **86**, 769–774, <https://doi.org/10.1177/154405910708600816> (2007).
35. ElSalhy, M., Honkala, S., Soderling, E., Varghese, A. & Honkala, E. Relationship between daily habits, Streptococcus mutans, and caries among schoolboys. *J Dent* **41**, 1000–1006, <https://doi.org/10.1016/j.jdent.2013.08.005> (2013).
36. Kobayashi, Y. et al. Oral health behavior and metabolic syndrome and its components in adults. *J Dent Res* **91**, 479–484, <https://doi.org/10.1177/0022034512440707> (2012).
37. Kumar, S., Tadakamadla, J. & Johnson, N. W. Effect of Toothbrushing Frequency on Incidence and Increment of Dental Caries: A Systematic Review and Meta-Analysis. *J Dent Res* **95**, 1230–1236, <https://doi.org/10.1177/0022034516655315> (2016).
38. Peffley, G. E. & Muhler, J. C. The effect of a commercial stannous fluoride dentifrice under controlled brushing habits on dental caries incidence in children: preliminary report. *J Dent Res* **39**, 871–874, <https://doi.org/10.1177/00220345600390052001> (1960).
39. Mac Giolla Phadraig, C., Guerin, S. & Nunn, J. Train the trainer? A randomized controlled trial of a multi-tiered oral health education programme in community-based residential services for adults with intellectual disability. *Community dentistry and oral epidemiology* **41**, 182–192, <https://doi.org/10.1111/cdoe.12006> (2013).
40. Hillebrecht, A. L., Hrasky, V., Anten, C. & Wiegand, A. Changes in the oral health-related quality of life in adult patients with intellectual disabilities after dental treatment under general anesthesia. *Clin Oral Invest* **23**, 3895–3903, <https://doi.org/10.1007/s00784-019-02820-4> (2019).
41. Scrine, C., Durey, A. & Slack-Smith, L. Providing oral care for adults with mental health disorders: Dental professionals' perceptions and experiences in Perth, Western Australia. *Community dentistry and oral epidemiology* **47**, 78–84, <https://doi.org/10.1111/cdoe.12427> (2019).
42. Daabiss, M. American Society of Anaesthesiologists physical status classification. *Indian J Anaesth* **55**, 111–115, <https://doi.org/10.4103/0019-5049.79879> (2011).
43. Greene, J. C. & Vermillion, J. R. THE SIMPLIFIED ORAL HYGIENE INDEX. *Journal of the American Dental Association (1939)* **68**, 7–13 (1964).
44. Organization, W. H. (<https://apps.who.int/iris/bitstream/handle/10665/41905/9241544937.pdf?sequence=1&isAllowed=y>, Geneva, 1997).
45. Angle, E. H. Classification of malocclusion. *Dental Cosmos* **41**, 248–264 (1899).

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Author contributions

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Competing interests

The authors declare no competing interests.

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