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Prevalence of and factors associated with fewer than 20 remaining teeth in adults with disabilities: A community-based study

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ABSTRACT

Objectives: To examine the prevalence of and the factors associated with a number of remaining teeth (NRT) <20 among adults with disabilities.

Design: A community-based, cross-sectional descriptive study.

Setting: This study was part of a health-promotion program designed for community-dwelling adults with disabilities.

Participants: A total of 549 adults with disabilities aged 20−80 years, living in the community in Chiayi County in Taiwan.

Outcome measures: Various parameters, including NRT, oral health behaviors (i.e., oral hygiene, dietary habits, and substance use), comorbidities, disability classification, and capability for performing activities of daily living were measured. Data were statistically analyzed using descriptive statistics and multivariate logistic regression analysis.

Results: The mean NRT was 18.1 (SD = 10.9); 44.9% of participants had NRT <20, and 13.7% were edentulous. Most participants had poor oral hygiene: 32% reported that they seldom brushed their teeth, 83% seldom used dental floss, and 78% did not undergo regular 6-monthly dental check-ups. After adjusting for potentially confounding variables, the factors associated with the NRT <20 were: age (odds ratio [OR]: 1.07, 95% confidence interval [CI]: 1.05−1.10, p < 0.001), comparatively lower education (OR: 1.96, 95% CI: 1.23−3.10, p = 0.004), rare use of dental floss (OR: 2.12, 95% CI: 1.21−3.71, p = 0.009), hypertension (OR: 1.73, 95% CI: 1.15−2.60, p = 0.008), and intellectual disability (OR: 2.30, 95% CI: 1.30−4.08, p = 0.004).

Conclusions: An NRT <20 was highly prevalent among adults with disabilities, who

displayed poor oral hygiene behaviors. Adults with intellectual disabilities had greater risk of an NRT <20 than those with other types of disability. In addition to unmodifiable factors, the poor use of dental floss was significantly associated with an NRT <20.

Strengths and limitations of this study

- Few studies have reported the prevalence of and factors associated with few remaining teeth among adults with disabilities, particularly in those residing in rural areas.

- Among the different types of disability, residents with intellectual disabilities had a higher risk of an NRT <20.

- A high prevalence of an NRT <20 was identified in rural community adults with disabilities; moreover, poor oral health behaviors received limited attention from healthcare providers.

- These results highlight the value of nurse-led health promotion programs and implementation of a multidisciplinary approach for the early detection of a low NRT in rural community-dwelling adults with disabilities.

- The limitations of the study include the non-randomized sampling strategy and recruitment of individuals with disabilities that did not preclude mobility to come to the examination center may hinder generalization of our findings.

INTRODUCTION

Having 20 teeth or more helps adults maintain good oral function and overall health. Teeth are recognized as calcified structures in the mouth, with the primary purpose of mastication, but act as part of the broader digestive system to help the body to obtain nutrition.[1-3] Other key functional aspects of teeth include speaking and communication, facial appearance, facilitating interpersonal relationships, enhancing quality of life, systemic health, cognitive function; teeth are also associated with disability status, and even with mortality.[3-6] Unfortunately, 3.9 billion individuals worldwide experience oral disorders, including untreated caries, severe periodontal disease, and severe tooth loss, thereby prolonging the years lived with disability.[4] In fact, as early as 1991, Japan conducted a series of oral campaigns called the "8020" to encourage citizens to maintain at least 20 remaining teeth through the age of 80.[3] Previous studies on middle-aged people also proved that the lower the number of remaining teeth (NRT), the greater the impact on individuals' health.[1,3] The issue of NRT has become an important indicator for oral and overall health for adults.

Awareness of the factors associated with an NRT <20 forms the basis for good oral care. Of all the risk factors for an NRT <20, age is probably the primary factor,[7-10] but it is not a controllable or reversible factor. Therefore, public health professionals concentrate on the risk factors that can be modified. Other factors associated with tooth loss include sex, education, unhealthy diet, smoking, harmful alcohol consumption, poor oral hygiene, hypertension, hyperlipidemia, and diabetes mellitus,[10-14] but those that are specific for individuals with disabilities remain unclear.

The oral health condition of disabled individuals is often worse than that of non-disabled adults.[2,15-18] Utilization of oral health services is also far lower than the

average for this group.[15-16,19] The World Health Organization has warned that as the population age and chronic diseases increase, there will be an increase in the rate of disability. Currently, more than a billion people worldwide (15%) live with some form of disability, with 2−4% of those over the age of 15 years having significant difficulties in functioning. In addition, owing to poverty and difficulties with mobility, the disabled are particularly vulnerable in terms of accessing satisfactory health care services. They are also more likely to engage in risky health behaviors and to be affected by more complications, more comorbidities, faster degeneration, and earlier mortality.[20] In Taiwan, there are more than 1.1 million people with disabilities (4.8% of the population).[21] Research has shown that disabled adults rarely use oral health services,[22] even though the government has already increased their oral care services. In terms of human rights, prevention of increasing levels of disability, as well as reduction of caregivers' burdens, issues relating to oral health care for vulnerable groups deserve much attention.

However, although some previous studies have focused on institution-accommodated adults with disabilities,[2,17] fewer reports have discussed disabled individuals living in rural communities. Moreover, although single group of disabilities has been discussed,[17,23-24] existing reports do not focus on diverse disability categories.[15-16] With these issues in mind, differences between the disabled and non-disabled in terms of oral hygiene, such as limitations in self-care ability, and factors potentially relevant to oral health should be recognized by health care providers. Therefore, the aim of this study was to explore the prevalence of and factors associated with an NRT <20 among adults with various disabilities in Taiwan.

METHODS

Design, sample, and setting

This study, which was part of a health-promotion program designed for community-dwelling adults with disabilities, was led by a nursing team in collaboration with a district hospital and the Bureau of Health Promotion of Chiayi County in Taiwan.[25] In Chiayi County, visual impairment, hearing impairment, intellectually disability, and physical disability affect more than 38,800 individuals, accounting for 64% of the local disabled population. This paper is part of a series of reports regarding health issues of community-based people with disabilities. A community-based health screening survey was conducted between July and December of 2013 using a cross-sectional descriptive design.

Participants were selected through convenience sampling from the registry of the government social welfare center.[21] The inclusion criteria were: (1) adults certified with either visual impairment, hearing impairment, mental illness, or physical disability; (2) age ≥20 years; (3) ability to complete the written questionnaire in either Mandarin or Taiwanese, with assistance from the interviewers; (4) ability to walk to the examination center with/without help; and (5) ability to sign the consent forms prior to recruitment. Exclusion criteria were an inability to answer questions or having a serious disease, such as dialysis or cancer.

Measurements

1. *Number of remaining teeth (NRT):* The NRT was obtained by research assistants by asking the participants to open his/her mouths and then counting the total number of natural teeth and fixed dentures, after discharging the removable dentures in the oral cavities. Root fragments without a crown were excluded.

2. *Oral health behaviors:* Oral health behaviors were measured in terms of seven habits, viz., brushing teeth, using dental floss, visiting dentists or undergoing

dental scaling, drinking alcohol, smoking, five groups of nutrition, and water intake. This information was collected through standardized personal interviews using a structured questionnaire that was based on the published literature.[7, 10] In this study, answers regarding the brushing of teeth were categorized as frequent (≥twice a day) vs. infrequent (<twice a day). As for immediate brushing teeth after a meal, participants were classified as "often" if they responded with "usually" or "frequently", or "seldom" if they responded with "never" or "sometimes". For using dental floss, responses were classified as "often" if dental floss was used to clean interdentally spaces ≥once a day, or "seldom" if the respondents' answer was "never" or "sometimes." Regarding visits to dentists, participants were classified as "regular" if they visited dentists and underwent scaling every 6 months, or "irregular" if they responded "never" or "sometimes." For questions "Do you smoke cigarettes or drink alcohol?", participants were classified as ''none or formerly'' if they had never engaged in these behaviors or had stopped doing so for 1 year, or as "current users." Regarding five groups of nutrition intake, the response was considered "balanced" if the respondents usually or always had five groups of nutrition (i.e., meat, milk, grains, vegetables, and fruit) each day, or "unbalanced" if they never or sometimes had these foods. In terms of water intake, answers were categorized as sufficient (≥1500 mL per day) vs. insufficient (< 1500 mL per day).

3. *Demographic characteristics:* We obtained data on age, sex, educational attainment (years of education received, or level of school completed), disability classification, capability of activity of daily living (ADL), and the prevalence of three common chronic diseases (i.e., hypertension, diabetes mellitus, and hyperlipidemia). Specific disabilities such as physical, hearing, vision, or

intellectual disabilities, according to the Taiwanese government's definitions,[21] were identified and confirmed prior to the interviews. ADL capability, judged using the Barthel ADL Index of feeding, grooming, bathing, mobility, toilet use, transfer, etc., reflected the dependence level of participants who required external assistance to complete these activities. "Independent" was coded if external assistance was unnecessary, or "dependent" if it was needed. Moreover, the three common chronic diseases were assessed using a medical history diagnosed by a physician and/or physiological biomarkers including blood pressure (BP), fasting blood glucose (FBG), triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL) cholesterol, and (high-density lipoprotein (HDL) cholesterol levels. Following the national standard of the Ministry of Health and Welfare,[26] blood samples were evaluated and BP was measured at the time of the study, applying standard procedures. The three common chronic diseases were defined as (1) diabetes mellitus (FBG $\geq$126 mg/dL, or if ever diagnosed by a doctor); (2) hypertension (systolic/diastolic BP $\geq$140/90 mmHg, or if ever diagnosed by a doctor); and (3) hyperlipidemia (LDL $\geq$160 mg/dL, TC $\geq$240 mg/dL, TG $\geq$200 mg/dL, or if ever diagnosed by a doctor).

Procedures and ethical considerations

This study was approved by the relevant institutional review boards, and all procedures complied with the ethical guidelines. Participants were invited to participate in the study via letters sent by the public health nurses, and were fully informed about the purposes of the study. The letter emphasized the confidentiality of all collected data. Written consent forms were appropriately explained to and signed by participants and/or their guardians before arranging free medical evaluations. These evaluations, including blood sampling and physical check-ups, were conducted

by the local hospital staff on a weekend, in a school auditorium, followed by individual interviews. To create a caring and friendly environment, each participant was accompanied by a community volunteer during the health screenings. If a participant were not an effective responder, his/her familiar caregiver was allowed to represent the participant with proper authorization.

The NRT was calculated carefully by research assistants who were trained by a research team including the investigators and a dentist. Details of the interviews and measurement procedures have been reported in our previous study.[10] Face and content validity of the instrument were judged to be good (0.88−0.91) by a panel of five experts: a faculty member in public health and health education, a dentist, a social worker in a disabled institution, and two nursing faculty members who specialize in the field of long-term care.

Statistical analyses

Quantitative data were analyzed using SPSS v. 22.0 software. Descriptive statistical data are presented as numbers and percentages for categorical variables, and as means ± standard deviations for continuous variables. Comparisons of demographic characteristics, comorbidities, and oral health behaviors between those with fewer teeth (NRT <20) or more teeth (NRT ≥20) were performed using chi-square test for categorical variables and using independent sample t-test for continuous variables, as univariate analyses.

For those data without a normal distribution, the Mann−Whitney U test was applied to compare inter-group differences. Moreover, the factors associated with fewer teeth (NRT <20) were included in a multivariable logistic regression analysis with forward stepwise selection of all the variables that were found to be significant in univariate analyses. All statistical assessments adopted two-tailed tests, and the

p-value cut-off point for statistical significance was set as 0.05.

RESULTS

Of the 549 participants enrolled in this analysis, 18 failed to complete the NRT measurement. The majority of the participants were male (54.3%), aged 20−80 years (mean age: 58.8, SD: 13.9), and were not well-educated (67.4% had ≤9 years of educational attainment), and the distribution of disabilities by type was as follows: physical (55.9%), intellectual (19.7%), hearing (15.7%), and vision (8.7%). Most participants (88.7%) did not require assistance in the activities of daily living (ADL), as they only had a mild degree of disability. In addition, the prevalence rates of hypertension, hyperlipidemia, and diabetes mellitus were 56.5%, 49.9%, and 23.9%, respectively (Table 1).

As shown in Table 2, the participants' mean NRT was 18.1 (SD: 10.9), and 44.8% had an NRT <20, including 13.7% extreme cases who were edentulous (NRT = 0). In terms of oral health behaviors, 77.4% had almost never brushed their teeth after meals, and 83.4% had no habit of using dental floss daily to clean the crevices between teeth. The participants' mean tooth brushing frequency was 1.8 (SD: 0.9) times per day; 32.2% responded that they seldom brushed their teeth twice a day. Most (78.0%) did not visit the dentist for regular inspections and dental scaling on a 6-monthly basis. Over 40% reported insufficient water intake or unbalanced nutrition. Additionally, current habits of smoking and drinking alcohol were present in 25.3% and 16.2% of participants, respectively.

Table 1. Demographic characteristics of the subjects

Variable	N (%)	Mean ± SD
Gender		
Male	298 (54.3)	
Female	251 (45.7)	

Age (years)		58.8± 13.9
<65	331 (60.3)	
≥65	218 (39.7)	
Educational attainment		
≤9 years	370 (67.4)	
>9 years	179 (32.6)	
Disability classification		
Physical disability	307 (55.9)	
Vision impairment	48 (8.7)	
Hearing impairment	86 (15.7)	
Intellectual disability	108 (19.7)	
Capability of ADL (n=548)*		
Dependent	62 (11.3)	
Independent	486 (88.7)	
Hypertension		
Yes	310 (56.5)	
No	239 (43.5)	
Diabetes mellitus		
Yes	131 (23.9)	
No	418 (76.1)	
Hyperlipidemia		
Yes	274 (49.9)	
No	275 (50.1)	

ADL, activities of daily living; *due to missing data

Table 2. Number of remaining teeth and oral health behaviors

Variables	n (%)	Mean ± SD
Group of NRT (n=531) *		18.1 ± 10.9
0	73 (13.7)	
1-19	165 (31.1)	
20-29	215 (40.5)	
≥30	78 (14.7)	
Oral hygiene		
Times of daily brushing teeth		1.8 ± 0.9
≥2	372 (67.8)	

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<2	177 (32.2)
Brushing teeth after meal	
Often	124 (22.6)
Seldom	425 (77.4)
Using dental floss	
Often (≥once a day)	91 (16.6)
Seldom (<once a day)	458 (83.4)
Visiting dentist per 6 months	
Regular	121 (22.0)
Irregular	428 (78.0)
Water intake (ml/ per day)	
≥1500	328 (59.7)
<1500	221 (40.3)
5 groups of nutrition per day	
Balanced	328 (59.7)
Unbalanced	221 (40.3)
Smoking habit	
Never or formerly	410 (74.7)
Current users	139 (25.3)
Alcohol habit	
Never or formerly	460 (83.8)
Current users	89 (16.2)

NRT, number of remaining teeth; *due to missing data

Table 3. Univariate analysis of factors associated with number of remaining teeth

Variables	NRT≥20 (n =293)	NRT<20 (n=238)	*P**
Age (years)	55 (44-63)	67 (58-74)	<0.001
Female gender	123 (42.0)	121 (50.8)	0.042
Education≤9 years	161 (54.9)	195 (81.9)	<0.001
Disability classification			0.109
Physical disability	166 (56.7)	131 (54.8)	
Vision impairment	19 (6.5)	28 (11.8)	
Hearing impairment	44 (15.0)	39 (16.4)	
Intellectual disability	64 (21.8)	40 (16.8)	
ADL dependent	30 (10.2)	28 (11.8)	0.575
Hypertension	139 (47.4)	161 (67.6)	<0.001
Diabetes mellitus	58 (19.8)	70 (29.4)	0.010
Hyperlipidemia	155 (52.9)	113 (47.5)	0.214
Oral health behaviors			
Infrequent brushing teeth[#]	89 (30.4)	78 (32.8)	0.554
Seldom using dental floss[†]	226 (77.1)	214 (89.9)	<0.001
Irregularly visit dentist	220 (75.1)	193 (81.1)	0.098
Insufficient water intake	107 (36.5)	105 (44.1)	0.075
Unbalanced nutrition	102 (34.8)	107 (45.0)	0.017
Smoking habit	75 (25.6)	59 (24.8)	0.831
Alcohol habit	48 (16.4)	36 (15.1)	0.693

NRT, number of remaining teeth; ADL, activities of daily living.

Data are expressed as median (interquartile range) or number (percent).

* Mann-Whitney U test for age; Pearson's chi-square test for others.

[#] Infrequent brushing teeth: < 2 times/day.

[†] Seldom using dental floss: < 1 time/day.

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Table 4. Multivariate logistic regression of the factors associated with NRT < 20

Variables	OR	95% CI	*P*
Disability classification			
Vision impairment	1.48	0.72-3.04	0.290
Hearing impairment	0.75	0.43-1.32	0.316
Intellectual disability	2.30	1.30-4.08	0.004
Physical disability*			
Using dental floss			
Seldom (<once a day)	2.12	1.21-3.71	0.009
Often (≥once a day) *			
Educational attainment			
≤ 9 years	1.96	1.23-3.10	0.004
>9 years*			
Hypertension			
Yes	1.73	1.15-2.60	0.008
No*			
Age	1.07	1.05-1.10	<0.001

NRT, number of remaining teeth; OR, odds ratio; CI, confidence interval.

Adjusted for all variables of the table 3 in model. * Reference group.

Chi-square and Mann−Whitney U test results (Table 3) indicated that participants

with the characteristics of increased age, female sex, less than 9 years' educational

attainment, histories of hypertension and/or diabetes, rare use of dental floss, or

unbalanced nutrition had significantly greater likelihoods of having an NRT <20 (all p

values < 0.05). Although these participants were not significantly affected by a

particular disability (p = 0.109), those with vision impairment seemed to have a

higher probability of having an NRT <20 than an NRT ≥20.

Further analysis via multivariate logistic regression (Table 4), after adjusting for

potential confounders (including all variables in Table 3), revealed that participants

with intellectual disability were at higher risk of losing teeth than those with physical

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disability (odds ratio [OR]: 2.30, 95% confidence interval [CI]: 1.30–4.08). The other associated risk factors of NRT <20 were age (OR: 1.07, 95% CI: 1.05–1.10), comparatively lower education (OR: 1.96, 95% CI: 1.23–3.10), rare use of dental floss (OR: 2.12, 95% CI: 1.21–3.71), and a history of hypertension (OR: 1.73, 95% CI: 1.15–2.60).

DISCUSSION

This study featured a nurse-led health program for promoting the oral health of disabled individuals. Four key findings emerged: first, fewer teeth were counted and there was a higher prevalence of an NRT <20 for disabled participants. According to previous reports, the average NRT for non-disabled people is approximately 25,[10] and only 16% of these individuals have an NRT <20.[2, 10] However, in this study, the average NRT in disabled individuals was 18, and 44.8% had an NRT <20, which indicated a significantly worse oral health condition. The literature supports the view that adults with disabilities commonly experience the problem of poor oral hygiene and have fewer NRT than non-disabled people, owing to their limited capabilities, in terms of cognitive comprehension, body coordination, or muscle power.[11, 18] In fact, the prevalence of NRT <20 in this study was not only higher than the figures previously reported for non-disabled people, but was also higher than that reported in a Belgian study of people with disabilities (33%).[2] Moreover, the edentulous rate of 13.7% found in this study was also higher than the edentulous rate of 8.9% reported by a study conducted in the USA.[15]

Second, most disabled participants reported having inadequate oral hygiene behaviors in general. These behaviors, including rarely brushing teeth after meals, seldom using dental floss, and irregular dental visits and scaling, were the factors

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associated with tooth loss in previous reports,[1, 7-8] and may also affect other systemic diseases.[5] The prevalence of these behaviors in this study was 77.4%, 83.4%, and 78.0%, respectively, which was much higher than in the non-disabled population (about 28–70%);[7, 10, 14-16] and were also greater than those in disabled individuals in other countries (29–51%).[15,19] Although irregular dental visits were not a significant factor for an NRT <20 in the current study, most previous studies indicated the importance of regular dental care.[1, 24, 27] As individuals with disabilities typically do not visit dentists until their dental problems become too serious to be treated, tooth extraction is often unavoidable. The issue of regular dental visits to help maintain a greater number of teeth in the disabled should be explored in future.

Third, adults with intellectual disability have a high risk of having an NRT <20. In comparison with physical disabilities, the subgroup of individuals with intellectual disabilities was found to be afflicted with severe oral diseases more commonly than the other sub-groups. This group was at higher risk of having fewer teeth, which is consistent with findings of previous studies.[2,9,17] Lindsay[28] attributes this phenomenon to their preferences for eating desserts, sweets, and drinking soft drinks; similarly, their reduced capacity for self-control owing to their cognitive impairments could also modulate this effect. These individuals often are not fully capable of independent self-care, and their caregivers may find it difficult to perform oral hygiene activities for them over the long run. In addition, adults with developmental disabilities often appear to have disorders, such as gastro-esophageal reflux disease, excessive salivation, induced xerostomia triggered by antiepileptic medications, etc., which could increase their risk of poor oral health.

Fourth, the use of dental floss is a modifiable factor associated with the NRT. Except for intellectual disabilities, the other associated factors, such as aging,

lower-level of education,[8 10] hypertension,[10 12] and rare use of dental floss, are similar to the factors associated with NRT in non-disabled individuals. Among these, dental floss instruction is the most malleable component that can be addressed by public health practitioners. This study found that most disabled adults (77.4%) lacked the habit of cleaning teeth after meals, and brushed their teeth less than twice a day. The practice of dental flossing may be a complementary oral hygiene step that can help to maintain the NRT. A previous systematic review has confirmed that brushing and flossing can significantly reduce plaque and gingivitis as compared with tooth brushing alone.[13]

It is the presence of dental plaque and food debris in the crevices between the teeth that encourage bacteria to flourish, activating the inflammatory response and the innate immune system in the human body. These bacteria induce swelling and bleeding of the gums, the destruction of periodontal tissues and alveolar bones, and the promotion of tooth mobility; thus, ultimately causing tooth loss.[29-30] The findings from some systematic reviews and animal experiments suggest that oral hygiene methods, such as tooth brushing, dental flossing, and/or interdental brushing are all effective means of extinguishing the peridontal pathogens thriving in the buccal cavity[13, 31- 32] and even in the blood.[33]

However, people with disabilities may have difficulties flossing owing to disability-related issues with self-control, movement coordination, comprehension, etc., although nearly 90% of them in this study were categorized as having basic self-care ability in ADL. Adopting a habit of dental flossing, and accuracy and thoroughness of dental cleaning processes, may even be demanding for some non-disabled people, as well as for adults with disabilities. The assistance of interdental brushing, which is recognized as an easier and more effective method for

reducing peridontal pathogens,[31] can also be considered as an alternative.

To address the problem of NRT <20, oral hygiene instruction, a commonly used clinical technique, is imperative for improving oral hygiene. Since disabled adults may not cope with regular dental visits and examinations, integration of preventive and corrective oral health in their lives is highly beneficial.[24] Routine daily teeth cleaning is undoubtedly the most economic and convenient approach to ensure oral health. It can also reduce the fear of individuals with disabilities about accessing oral health services, and even shorten the scaling time required.[34] Unfortunately, previous studies have demonstrated that community-dwelling individuals with disabilities have worse oral health than those living in institutions.[23] Since these participants were living at home with relatives, their families were generally more concerned with physiological diseases than with oral conditions, and were not aware of the importance of oral hygiene. Teeth cleaning was also typically perceived as the individuals' own responsibility, as these disabled people generally seemed to be capable of managing the task. However, they had a higher prevalence of an NRT <20, which may imply that even if the participants had basic self-care ability, it does not mean that are capable of achieving good quality oral hygiene. Their families sometimes opted to ignore these "trivial" matters, as they were already exhausted by the burden of care. Consequently, without professional guidance and tracking, daily cleaning of the teeth becomes a difficult task for community-based people with disabilities. A systematic review has concluded that additional oral hygiene instruction could help cultivate a higher quality of oral health behaviors; thus, ameliorating gingivitis and eradicating dental plaque.[27]

As many researchers claim that good oral health can improve almost every aspect of life, from overall health to self-esteem, communication, nutrition, quality of

life, savings in medical expenses, and finding employment, for people with

disabilities, in addition to relieving the burden on their care givers.[16, 35] To achieve the

oral health goal of 8020, more resources and attention should be invested to provide

good oral care matched to the individual's disability characteristics. Further

integration of the social welfare networks, oral hygiene instructions, and coordination

of medical professionals and caregivers for adults with disabilities are recommended.

Limitations

This study has some limitations. First, the participants' oral conditions were

examined by research assistants, rather than by qualified dentists, owing to constraints

on the participants' cooperation and expectations. Only superficial features, such as

the remaining number of natural and filled teeth were investigated; other thorough

evaluations, such as those of caries and periodontal tissues, were not performed. Thus,

potential oral problems may have been ignored or underestimated by the NRT figures

reported here. Second, some selection bias may have been involved as the criteria for

inclusion included the ability to travel from home to the nearby school where the

examinations were conducted. The participants were mostly categorized as having

mild disabilities, with limited variation. Their oral health conditions should thus be

presumed to be generally better than those of individuals with more severe

disabilities,[22] who were not included in this survey. The real situation of oral health

for adults with disabilities may thus be even worse than that indicated by this study.

Third, subjects with visual impairments constituted only 8.7% of all the participants,

thus comprising a minor sub-group as compared with other disabilities. Thus, the

findings regarding the prevalence of reduced dentition in this sub-group needs to be

viewed with caution. Fourth, the participants were conveniently recruited from one

location, rather than by nationwide cluster sampling. The generalizability of the study

results may therefore be limited.

CONCLUSION

For community-dwelling individuals with disabilities, living in rural areas, the prevalence of an NRT <20 was significantly greater than that reported in previous studies. Poor oral hygiene behaviors were identified as being a general characteristic of the participants. In particular, those with intellectual disabilities had higher risks of tooth loss than did those with other types of disabilities. Excluding unmodifiable factors, such as age, education level, disability classification, and hypertension, an NRT <20 in disabled adults was strongly associated with the habit of seldom using dental floss. As oral hygiene instructions are the least expensive and easiest way of integrating preventative intervention options for chronic diseases into daily activities, professionals should concentrate on this approach for individuals with disabilities and attempt to enhance their teeth cleaning awareness and capabilities. Finally, to satisfy the oral health needs of community-dwelling adults with disabilities, issues such as the risk factors associated with different types of disabilities, regular dental visits, and their particular requirements can be further explored.

Conflict of interest

The authors declare that they have no competing interests.

Authors' contributions

MYP and TCH: designing the study, collecting and analyzing data, and drafting the paper. HCT and YCL: proofreading and revising the manuscripts. MYC: initializing, conceptualizing, and supervising the research process. All authors have read and approved the final manuscript.

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Patient consent

Obtained

Ethics approval

This study was approved by the institutional review board of the ethical committee of Chang Gung Memorial Hospital (IRB 102-3331B)

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	p1−3	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	P4	Explain the scientific background and rationale for the investigation being reported
Objectives	p5	State specific objectives, including any prespecified hypotheses
Methods		
Study design	P6	Present key elements of study design early in the paper
Setting	P6	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	P6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
		Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	P6−8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	P6-8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias		Describe any efforts to address potential sources of bias
Study size		Explain how the study size was arrived at
Quantitative variables	P6-8	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	P9−10	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		Case-control study—If applicable, explain how matching of cases and controls was addressed
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results

Participants	P10	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	P10−11	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	P12-13	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	p13-15	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses		Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	p15	Summarise key results with reference to study objectives
Limitations	p19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	p16−19	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	p19−20	Discuss the generalisability (external validity) of the study results

Other information

Funding	P21	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of and factors associated with fewer than 20 remaining teeth in Taiwanese adults with disabilities: A community-based cross-sectional study

Prevalence of and factors associated with fewer than 20 remaining teeth in Taiwanese adults with disabilities: A community-based cross-sectional study

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ABSTRACT

Objectives: To examine the prevalence of and the factors associated with a number of remaining teeth (NRT) < 20 among adults with disabilities.

Design: A community-based, cross-sectional descriptive study.

Setting: This study was part of a health-promotion program designed for community-dwelling adults with disabilities.

Participants: A total of 549 adults with disabilities, aged 20−80 years, living in the community in Chiayi County in Taiwan.

Outcome measures: Various parameters, including NRT, oral health behaviors (i.e., oral hygiene, dietary habits, and substance use), comorbidities, disability classification, and capability for performing activities of daily living, were measured. Data were statistically analyzed using descriptive statistics and multivariate logistic regression analysis.

Results: The mean NRT was 18.1 (standard deviation = 10.9); 44.9% of participants had NRT < 20. Most participants had poor oral hygiene: 83% reported seldom using dental floss, 78% did not undergo regular 6-monthly dental check-ups, and 77.4% seldom brushed their teeth after meal. After adjusting for potentially confounding variables, the intellectual disability group had a significantly higher risk of an NRT < 20 than the physical disability group (odds ratio: 2.30, p = 0.004). Additionally, the rare use of dental floss and hypertension significantly increased the possibility of an NRT < 20 (odds ratio: 1.73−2.12, p = 0.008−0.009).

Conclusions: An NRT < 20 was highly prevalent among adults with disabilities, who displayed poor oral hygiene behaviors. Adults with intellectual disabilities had a greater likelihood of having an NRT < 20 than did those with physical disabilities. In

addition to unmodifiable factors, the poor use of dental floss was significantly associated with an NRT < 20.

Strengths and limitations of this study

- Few studies have reported the prevalence of and factors associated with few remaining teeth among adults with disabilities, particularly in those residing in communities.

- These results highlight the value of nurse-led health promotion programs and implementation of a multidisciplinary approach for the early detection of a low number of remaining teeth in community-dwelling adults with disabilities.

- The limitations of the study, including the non-randomized sampling strategy and recruitment of individuals with disabilities that did not preclude mobility in coming to the examination center, may hinder generalization of our findings.

1

1 **INTRODUCTION**

2   Having 20 teeth or more helps adults maintain good oral function and overall

3 health. Teeth are recognized as calcified structures in the mouth, with the primary

4 purpose of mastication, but act as part of the broader digestive system to help the

5 body obtain nutrition.[1-3] Other key functional aspects of teeth include speaking and

6 communication, facial appearance, facilitating interpersonal relationships, enhancing

7 quality of life, systemic health, and cognitive function; teeth are also associated with

8 disability status, and even with mortality.[3-6] Unfortunately, 3.9 billion individuals

9 worldwide experience oral disorders, including untreated caries, severe periodontal

10 disease, and severe tooth loss, thereby prolonging the years lived with disability.[4] In

11 fact, as early as 1991, Japan conducted a series of oral campaigns called the "8020" to

12 encourage citizens to maintain at least 20 remaining teeth through the age of 80.[3]

13 Previous studies on elderly people also proved that the lower the number of remaining

14 teeth (NRT), the greater the impact on individuals' health. These impacts include a

15 higher risk of cognitive impairments, decreased self-care capabilities, heart rate

16 acceleration , influences on the quality of life, and decreased cumulative survival

17 rate.[1, 3] The issue of the NRT has become an important indicator of oral and overall

18 health in adults.

19   Awareness of the factors associated with an NRT < 20 forms the basis for good

20 oral care. Of all the risk factors for an NRT < 20, age is probably the primary

21 factor,[7-10] but it is not a controllable or reversible factor; neither are sex and

22 education.[10-12] Therefore, public health professionals concentrate on those risk factors

23 that can be modified. Other factors associated with tooth loss include hypertension,

24 diabetes mellitus, hyperlipidemia, poor oral hygiene, unhealthy diet, smoking, and

25 harmful alcohol consumption,[10-11, 13-15] but those that are specific for individuals with

1   disabilities remain unclear.

2   The oral health condition of disabled individuals is often worse than that of

3   non-disabled adults.[2, 16-23] Utilization of oral health services is also far lower than the

4   average for this group.[16-17, 24] The World Health Organization has warned that, as the

5   population ages and chronic diseases increase, there will be an increase in the rate of

6   disability. Currently, more than a billion people worldwide (15%) live with some form

7   of disability, with 2–4% of those over the age of 15 years having significant

8   difficulties in functioning. In addition, owing to poverty and difficulties with mobility,

9   the disabled are particularly vulnerable in terms of accessing satisfactory health care

10   services. They are also more likely to engage in risky health behaviors and to be

11   affected by more complications, more comorbidities, faster degeneration, and earlier

12   mortality.[25] In Taiwan, there are more than 1.1 million people with disabilities (4.8%

13   of the population).[26] Research has shown that disabled adults rarely use oral health

14   services,[27] even though the government has already increased their oral care services.

15   These premium subsidies funded by the NHI (National Health Insurance) system

16   contain, for instance, use of fluoride gel/varnishes, more frequent dental scaling,

17   bonuses for the dentists treating patients with specific disabilities, etc.[28] In terms of

18   human rights, preventing the increase in levels of disability, as well as reducing the

19   caregivers' burdens, which are issues relating to oral health care for vulnerable groups,

20   deserve much attention.

21   However, although some previous studies have focused on

22   institution-accommodated adults with disabilities,[2,18] fewer reports have discussed

23   disabled individuals living in communities. The prevalence of NRT < 20 and factors

24   potentially relevant to oral health among non-institutional disabilities were also

25   seldom discussed. Therefore, the aims of this study were to explore the prevalence of

1   and factors associated with an NRT < 20 among community-dwelling adults with

2   disabilities in Taiwan, and explore the oral health behaviors among these participants.

3   **METHODS**

4   **Design, sample, and setting**

5   This study, which was part of a second-year health-promotion program designed

6   for community-dwelling adults with disabilities, was led by a nursing team in

7   collaboration with a district hospital and the Bureau of Health Promotion of Chiayi

8   County in Taiwan.[25] In Chiayi County, visual impairment, hearing impairment,

9   intellectually disability, and physical disability affect more than 38,800 individuals,

10 accounting for 64% of the local disabled population. This paper is part of a series of

11 reports regarding health issues of community-based people with disabilities. A

12 community-based health screening survey was conducted between July and December

13 in 2014 using a cross-sectional descriptive design.

14 Participants were selected through convenience sampling from the registry of the

15 government's social welfare center.[21] The inclusion criteria were: (1) adults certified

16 with either visual impairment, hearing impairment, intellectual disability, or physical

17 disability; (2) age $\geq$ 20 years; (3) ability to complete the written questionnaire in

18 either Mandarin or Taiwanese, with assistance from the interviewers; (4) ability to

19 walk to the examination center with/without help; and (5) ability to sign the consent

20 forms prior to recruitment. Exclusion criteria were: (1) living in institutions; (2)

21 having more than one category of disability; (3) inability to answer questions; or (4)

22 having a serious disease, such as kidney disease requiring dialysis or cancer.

23 **Measurements**

24 1. *Number of remaining teeth (NRT):* The NRT was obtained by research assistants

25   by asking the participants to open his/her mouths and then counting the total

1   number of natural teeth and fixed dentures, after discharging the removable

2   dentures in the oral cavities. Root fragments without a crown were excluded.

3   2. *Oral health behaviors:* Oral health behaviors were measured in terms of seven

4   habits, i.e., brushing teeth, using dental floss, visiting dentists or undergoing dental

5   scaling, drinking alcohol, smoking, five groups of nutrition, and water intake. This

6   information was collected through standardized personal interviews using a

7   structured questionnaire that was based on the published literature.[7, 10] The

8   participants were asked to recall their oral health behaviors up to a year previously

9   and/or when they were dentate.

10   In this study, answers regarding the brushing of teeth were categorized as frequent

11   ($\geq$ twice a day) vs. infrequent (< twice a day). As for immediate brushing teeth

12   after a meal, participants were classified as "often" if they responded with

13   "usually" or "frequently", or "seldom" if they responded with "never" or

14   "sometimes". For using dental floss, responses were classified as "often" if dental

15   floss was used to clean interdental spaces $\geq$ once a day, or "seldom" if the

16   respondents' answer was "never" or "sometimes." Regarding visits to dentists,

17   participants were classified as "regular" if they visited dentists and underwent

18   scaling every 6 months, or "irregular" if they responded "never" or "sometimes."

19   For questions "Do you smoke cigarettes or drink alcohol?", participants were

20   classified as ''none or formerly'' if they had never engaged in these behaviors or

21   had stopped doing so for the past year, or as "current users." Regarding five groups

22   of nutrition intake, the response was considered "balanced" if the respondents

23   usually or always had five groups of nutrition (i.e., meat, milk, grains, vegetables,

24   and fruit) each day, or "unbalanced" if they never or sometimes had these foods. In

25   terms of water intake, answers were categorized as sufficient ($\geq$ 1500 mL per day)

1 vs. insufficient (< 1500 mL per day). Participants, especially those with intellectual

2 and hearing disabilities, were guided to reply their habits through visual aids,

3 samples, progressive interactions, and caregivers' confirmations when necessary.

4 3. *Background information:* Background information comprised three sections. First,

5 demographic variables obtained from the questionnaires, including age, gender,

6 and educational attainment (years of education received, or level of school

7 completed). Second, prevalence of the three common chronic diseases (i.e.,

8 hypertension, diabetes mellitus, and hyperlipidemia). These three diseases were

9 assessed using medical history (diagnosed by a physician) and/or physiological

10 biomarkers, including blood pressure (BP), fasting blood glucose (FBG),

11 triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL)

12 cholesterol, and high-density lipoprotein (HDL) cholesterol levels. Following the

13 national standard of the Ministry of Health and Welfare,[29] blood samples were

14 evaluated and BP was measured at the time of the study, applying standard

15 procedures. The three common chronic diseases were defined as (1) diabetes

16 mellitus (FBG $\geq$126 mg/dL, or if ever diagnosed by a doctor); (2) hypertension

17 (systolic/diastolic BP $\geq$140/90 mmHg, or if ever diagnosed by a doctor); and (3)

18 hyperlipidemia (LDL $\geq$160 mg/dL, TC $\geq$240 mg/dL, TG $\geq$200 mg/dL, or if ever

19 diagnosed by a doctor). Third, disability classification and capability of activity of

20 daily living (ADL). Specific disabilities, such as physical, hearing, vision, or

21 intellectual disabilities, were identified and confirmed by the certificates issued by

22 the Taiwanese government[26] prior to the interviews. ADL capability, judged using

23 the Barthel ADL Index of feeding, grooming, bathing, mobility, toilet use, transfer,

24 etc., reflected the dependence level of participants who required external assistance

25 to complete these activities. "Independent" was coded if external assistance was

1 unnecessary, or "dependent" if it was needed.

2 **Procedures and ethical considerations**

3 This study was approved by the relevant institutional review board of Chang

4 Gung Memorial Hospital (IRB 102-3331B), and all procedures complied with the

5 ethical guidelines. Participants were invited to participate in the study via letters sent

6 by the public health nurses, and were fully informed about the purposes of the study.

7 The letter emphasized the confidentiality of all collected data. Written consent forms

8 were appropriately explained to and signed by participants and/or their guardians

9 before arranging free medical evaluations. These evaluations, including blood

10 sampling and physical check-ups, were conducted by the local hospital staff on a

11 weekend, in a school auditorium, followed by individual interviews. To create a

12 caring and friendly environment, each participant was accompanied by a community

13 volunteer during the health screenings. If a participant was not an effective responder,

14 a familiar caregiver, who was normally a family member(s) with whom they were

15 living, was allowed to represent the participant in answering the questions.

16 The NRT was calculated carefully by research assistants who were trained by a

17 research team that included the investigators and a dentist. Details of the interviews

18 and measurement procedures have been reported in our previous study.[10] Face and

19 content validity of the instrument were judged to be good (0.88−0.91) by a panel of

20 five experts: a faculty member in public health and health education, a dentist, a social

21 worker in a disabled institution, and two nursing faculty members who specialize in

22 the field of long-term care.

23 **Statistical analyses**

24 Quantitative data were analyzed using SPSS v. 22.0 software. Descriptive

25 statistical data are presented as numbers and percentages for categorical variables, and

1 as means ± standard deviations for continuous variables. To identify the modifiable

2 factors, factors associated with fewer teeth (NRT < 20) were identified using stepwise

3 logistic regression analysis, in three models. The first model involved univariate

4 analysis, and was unadjusted, to examine the associations between exposures and

5 NRT < 20. The second model, model 1, was partially adjusted, for three irreversible

6 confounding factors, including age, gender, and education. The third, model 2, was

7 fully adjusted for all exposures in the current study. For models 1 and 2, multivariable

8 logistic regression analysis with a forward variable entry method (entry criteria:

9 p-value < 0.05 in univariate analysis) was implemented. The odds ratio (OR) with

10 95% confidence interval (CI) and corresponding p-value were obtained by the logistic

11 regression model. All statistical assessments adopted two-tailed tests, and the p-value

12 cut-off point for statistical significance was set as 0.05.

13

14 **RESULTS**

15 Of the 603 individuals invited to participate in the study, 549 participants enrolled

16 in the analysis, but 18 failed to complete the NRT measurement. The response rate

17 was 91%. The majority of the participants were male (54.3%), aged 20–80 years

18 (mean age 58.8 ± 13.9), and were not well-educated (educational attainment ≤ 9 years:

19 67.4%). The distribution of disabilities by type was as follows: physical (55.9%),

20 intellectual (19.7%), hearing (15.7%), and vision (8.7%). Most participants (88.7%)

21 did not require assistance in the activities of daily living (ADL), as they only had a

22 mild degree of disability. In addition, the prevalence rates of hypertension,

23 hyperlipidemia, and diabetes mellitus were 56.5%, 49.9%, and 23.9%, respectively

24 (Table 1).

25 As shown in Table 2, the participants had less teeth (mean NRT 18.1 ± 10.9;

11

1   median 21.0; NRT < 20: 44.8%; NRT = 0: 13.7%), and had poor oral hygiene (seldom

2   dental floss: 83.4%; irregular dental visit: 78.0%; seldom brushed teeth after meal:

3   77.4%; daily teeth brushing: 1.8 ± 0.9 times). They also had other unfavorable

4   behaviors (insufficient water intake/unbalanced nutrition: 40.3%; smoking: 25.3%;

5   drinking alcohol: 16.2%).

6

Table 1. Background information of the subjects (n = 549)

Variables	n (%)	Mean ± SD
Gender		
Female	251 (45.7)	
Male	298 (54.3)	
Age (years)		58.8 ± 13.9
< 65	331 (60.3)	
≥ 65	218 (39.7)	
Educational attainment		
> 9 years	179 (32.6)	
≤ 9 years	370 (67.4)	
Hypertension		
No	239 (43.5)	
Yes	310 (56.5)	
Diabetes mellitus		
No	418 (76.1)	
Yes	131 (23.9)	
Hyperlipidemia		
No	275 (50.1)	
Yes	274 (49.9)	
Disability classification		
Physical disability	307 (55.9)	
Intellectual disability	108 (19.7)	
Hearing impairment	86 (15.7)	
Vision impairment	48 (8.7)	
Capability of ADL (n = 548)*		
Independent	486 (88.7)	
Dependent	62 (11.3)	

1   ADL, activities of daily living; *1 missing data

2

Table 2. Number of remaining teeth and oral health behaviors (n = 549)

Variables	n (%)	Mean ± SD
Group of NRT (n=531)*		18.1 ± 10.9[†]
0	73 (13.7)	
1-19	165 (31.1)	
20-29	215 (40.5)	
≥30	78 (14.7)	
Oral hygiene		
Times of daily brushing teeth		1.8 ± 0.9
Frequent (≥ 2 times/day)	372 (67.8)	
Infrequent (< 2 times/day)	177 (32.2)	
Brushing teeth after meal		
Often	124 (22.6)	
Seldom	425 (77.4)	
Using dental floss		
Often (≥ once a day)	91 (16.6)	
Seldom (< once a day)	458 (83.4)	
Visiting dentist per 6 months		
Regular	121 (22.0)	
Irregular	428 (78.0)	
Water intake		
Sufficient (≥ 1500 ml/day)	328 (59.7)	
Insufficient (< 1500 ml/day)	221 (40.3)	
Five nutrition groups per day		
Balanced	328 (59.7)	
Unbalanced	221 (40.3)	
Smoking habit		
Never or formerly	410 (74.7)	
Current users	139 (25.3)	
Alcohol habit		
Never or formerly	460 (83.8)	
Current users	89 (16.2)	

3   NRT, number of remaining teeth; *18 missing data; [†] median of NRT = 21.0.

1 Table 3. Prevalence of NRT < 20, univariate analyses and multivariate logistic regression of the factors associated with NRT < 20 (n = 531)

Variables/ Values	Prevalence of NRT < 20 n/N' (%)	Univariate analyses OR (95% CI)	p Value	Model 1 OR (95% CI)	p Value	Model 2 OR (95% CI)	p Value
Gender							
Female	121/244 (49.6)						
Male	117/287 (40.8)						
Age (years)							
< 65	94/322 (29.2)						
≥ 65	144/209 (68.9)						
Educational attainment							
> 9 years	43/175 (24.6)						
≥9 years	195/356 (54.8)						
Hypertension							
No*	77/231 (33.3)	-		-		-	
Yes	161/300 (53.7)	2.32 (1.62-3.31)	<0.001	1.61 (1.09-2.39)	0.018	1.73 (1.15-2.60)	0.008
Diabetes mellitus							
No*	168/403 (41.7)	-		-		-	
Yes	70/128 (54.7)	1.69 (1.13-2.52)	0.010	NE		NE	
Hyperlipidemia							
No*	125/263 (47.5)	-		-		-	
Yes	113/268 (42.2)	0.81 (0.57-1.13)	0.214	NE		NE	

14

Disability classification							
Physical disability *	131/297 (44.1)	-		-		-	
Intellectual disability	40/104 (38.5)	0.79 (0.50-1.25)	0.317	2.20 (1.26-3.84)	0.006	2.30 (1.30-4.08)	0.004
Hearing impairment	39/83 (47.0)	1.12 (0.69-1.83)	0.641	0.76 (0.44-1.32)	0.322	0.75 (0.43-1.32)	0.316
Vision impairment	28/47 (59.6)	1.87 (0.99-3.49)	0.051	1.54 (0.75-3.13)	0.237	1.48 (0.72-3.04)	0.290
Capability of ADL							
Independent*	210/473 (44.4)	-		-		-	
Dependent	28/58 (48.3)	1.17 (0.68-2.02)	0.575	NE		NE	
Oral health behaviors							
Daily brushing teeth							
Frequent*	160/364 (44.0)	-		-		-	
Infrequent	78/167 (46.7)	1.12 (0.77-1.61)	0.554	NE		NE	
Using dental floss							
Often*	24/91 (26.4)	-		-		-	
Seldom	214/440 (48.6)	2.64 (1.60-4.37)	<0.001	2.22 (1.28-3.83)	0.004	2.12 (1.21-3.71)	0.009
Visiting dentist							
Regular*	45/118 (38.1)	-		-		-	
Irregular	193/413 (46.7)	1.42 (0.94-2.16)	0.099	NE		NE	
Water intake							
Sufficient*	105/212 (49.5)	-		-		-	
Insufficient	133/319 (41.7)	1.37 (0.97-1.95)	0.076	NE		NE	
Five nutrition groups per day							
Balanced*	131/322 (40.7)	-		-		-	

15

Unbalanced	107/209 (51.2)	1.53 (1.08-2.17)	0.018	1.58(1.07-2.34)	0.022	NE
Smoking habit						
Never or formerly*	179/397 (45.1)	-		-		-
Current users	59/134 (44.0)	0.96 (0.65-1.42)	0.831	NE		NE
Alcohol habit						
Never or formerly*	202/447 (45.2)	-		-		
Current users	36/84 (42.9)	0.91 (0.57-1.46)	0.693	NE		NE

1   NRT, number of remaining teeth; ADL, activities of daily living; OR, odds ratio; CI, confidence interval.

2   N = 531 for 18 missing NRT data. *N'*: total number of each category. NE: variables were not selected into the model by the forward variable

3   entry method. Model 1: adjusted for age, gender, and education; model 2: model 1 + all variables in Table 3. * Reference group.

1   Regarding Table 3, after adjusting for all exposures (in model 2), the intellectual

2   disability group had a significantly higher likelihood of having an NRT < 20 than the

3   physical disability group (OR: 2.20, 95% CI: 1.26−3.84, p = 0.006), while the risk of

4   an NRT < 20 in the other two subgroups were not increased. From the results of the

5   three models, i.e., univariate analysis, model 1, and model 2, the demographic

6   variables seemed to confound an NRT < 20 associated with disability classifications.

7   The other factors associated with an NRT < 20 were seldom use of dental floss (OR:

8   2.12−2.64) and a history of hypertension (OR: 1.61−2.32).

9   **DISCUSSION**

10   This study featured a nurse-led health program aimed at promoting the oral

11   health of disabled individuals. Four key findings emerged: first, fewer teeth were

12   counted and there was a higher prevalence of an NRT < 20 in the present study

13   population than in those reported in the existing literature. According to previous

14   research, the average NRT for non-disabled people is approximately 25,[10] and only

15   16% of these individuals have an NRT < 20.[2, 10] However, in this study, the average

16   NRT in disabled individuals was 18.1, and 44.8% had an NRT < 20, which indicated

17   a significantly worse oral health condition. Even when ruling out the edentulous

18   individuals, the average NRT was 20.9, and prevalence of NRT < 20 was 36.0%

19   among the dentate subgroup. This slight change in the statistic from 18.1 to 20.9, and

20   from 44.8% to 36.0%, does not indicate a change in the trend. The literature supports

21   the view that adults with disabilities commonly exhibit poor oral hygiene and have

22   fewer NRT than non-disabled people, owing to their limited capabilities, in terms of

23   cognitive comprehension, body coordination, or muscle power.[11, 19] In fact, the

24   prevalence of an NRT < 20 in this study was not only higher than the figures

25   previously reported for non-disabled people, but was also higher than that reported in

1 a Belgian study of people with disabilities (33%).[2] Moreover, the edentulous rate of

2 13.7% found in this study was also higher than the edentulous rate of 8.9% reported

3 by a study conducted in the USA.[16]

4 Second, most disabled participants reported having inadequate oral hygiene

5 behaviors in general. These behaviors, including seldom using dental floss, irregular

6 dental visits and scaling, and rarely brushing teeth after meals, were factors associated

7 with tooth loss in previous reports,[1, 7-8] and may also affect other systemic diseases.[5]

8 The prevalence of these behaviors in this study was 83.4%, 78.0%, and 77.4%,

9 respectively, which was much higher than in the non-disabled population (about

10 28–70%);[7, 10, 15-17] and were also greater than those in disabled individuals in other

11 countries (29–51%).[16,24] Although irregular dental visits were not a significant factor

12 for an NRT < 20 in the current study, most previous studies indicated the importance

13 of regular dental care.[1-2, 30-31] To encourage regular dental care, the Taiwanese

14 government has provided incentives under the NHI system, by requiring only

15 payment of a registration and copayment fee, for use of oral health services by the

16 disabled.[28] However, individuals with disabilities typically do not visit dentists until

17 their dental problems become too serious to be treated, and tooth extraction is often

18 unavoidable. The issue of regular dental visits to help maintain a greater number of

19 teeth in the disabled should be explored in future.

20 Third, adults with intellectual disability have an increased possibility of having an

21 NRT < 20. In comparison with physical disability, the subgroup of individuals with

22 intellectual disabilities was at higher risk of having fewer teeth, which is consistent

23 with the findings of previous studies.[2,9,18,22] Lindsay[32] attributes this phenomenon to

24 their preferences for eating desserts, sweets, and drinking soft drinks; similarly, their

25 reduced capacity for self-control owing to their cognitive impairments could also

1   modulate this effect. These individuals often are not fully capable of independent

2   self-care, and their caregivers may find it difficult to perform oral hygiene activities

3   for them over the long run. In addition, adults with developmental disabilities often

4   appear to have disorders, such as gastro-esophageal reflux disease, excessive

5   salivation, and induced xerostomia triggered by antiepileptic medications, which

6   could increase the possibility of their poor oral health.

7   Fourth, the use of dental floss is a modifiable factor associated with the NRT.

8   Except for intellectual disabilities, other associated factors, such as the rare use of

9   dental floss' and hypertension,[1, 10, 13] are similar to the factors associated with NRT in

10   non-disabled individuals. Among these, dental floss use is the most malleable

11   component that can be addressed by instructions by public health practitioners. This

12   study found that most disabled adults (77.4%) lacked the habit of cleaning teeth after

13   meals, and brushed their teeth less than twice a day. The practice of dental flossing

14   may be a complementary oral hygiene step that can help to maintain the NRT. A

15   previous systematic review has confirmed that brushing and flossing can significantly

16   reduce plaque and gingivitis as compared with tooth brushing alone.[14]

17   It is the presence of dental plaque and food debris in the crevices between the

18   teeth that encourage bacteria to flourish, activating the inflammatory response and the

19   innate immune system in the human body. These bacteria induce swelling and

20   bleeding of the gums, the destruction of periodontal tissues and alveolar bones, and

21   the promotion of tooth mobility; thus, ultimately causing tooth loss.[33-34] The findings

22   from some systematic reviews suggest that oral hygiene methods, such as tooth

23   brushing, dental flossing, and/or interdental brushing are all effective means of

24   extinguishing the peridontal pathogens thriving in the buccal cavity[14, 35] and even in

25   the blood.[36]

1   However, people with disabilities may have difficulties flossing owing to

2   disability-related issues with self-control, movement coordination, comprehension,

3   etc., although nearly 90% of them in this study were categorized as having basic

4   self-care ability in ADL. Adopting a habit of dental flossing, and accuracy and

5   thoroughness of dental cleaning processes, may even be demanding for some

6   non-disabled people, as well as for adults with disabilities. The assistance of

7   interdental brushing, which is recognized as an easier and more effective method for

8   reducing peridontal pathogens, [35] can also be considered as an alternative approach.

9   To address the problem of NRT < 20, oral hygiene instruction, a commonly used

10   clinical technique, is imperative for improving oral hygiene. Since disabled adults

11   may not cope with regular dental visits and examinations, integration of preventive

12   and corrective oral health in their lives is highly beneficial.[30] Routine daily teeth

13   cleaning is undoubtedly the most economic and convenient approach to ensure oral

14   health. It can also reduce the fear of individuals with disabilities about accessing oral

15   health services, and even shorten the scaling time required.[37] Unfortunately, previous

16   studies have demonstrated that community-dwelling individuals with disabilities have

17   worse oral health than those living in institutions.[22 38] Since these participants were

18   living at home with relatives, their families were generally more concerned with

19   physiological diseases than with oral conditions, and were not aware of the

20   importance of oral hygiene. Teeth cleaning was also typically perceived as the

21   individuals' own responsibility, as these disabled people generally seemed to be

22   capable of managing the task. However, they had a higher prevalence of an NRT < 20,

23   which may imply that even if the participants had basic self-care ability, it does not

24   mean that are capable of achieving good quality oral hygiene. Their families

25   sometimes opted to ignore these "trivial" matters, as they were already exhausted by

20

1   the burden of care. Consequently, without professional guidance and tracking, daily

2   cleaning of the teeth becomes a difficult task for community-based people with

3   disabilities. A systematic review has concluded that additional oral hygiene instruction

4   could help cultivate a higher quality of oral health behaviors; thus, ameliorating

5   gingivitis and eradicating dental plaque.[31]

6   As many researchers claim that good oral health can improve almost every

7   aspect of life, from overall health to self-esteem, communication, nutrition, quality of

8   life, savings in medical expenses, and finding employment, for people with

9   disabilities, in addition to relieving the burden on their care givers.[17, 39] To achieve the

10 oral health goal of 8020,[3] more resources and attention should be invested to provide

11 good oral care matched to the individual's disability characteristics. Further

12 integration of the social welfare networks, oral hygiene instructions, and coordination

13 of medical professionals and caregivers for adults with disabilities are recommended.

14 **Limitations**

15   This study has some limitations. First, the participants' oral conditions were

16 examined by research assistants, rather than by qualified dentists, owing to constraints

17 on the participants' cooperation and expectations. Only superficial features, such as

18 the remaining number of natural and filled teeth were investigated; other thorough

19 evaluations like those of caries and periodontal tissues, were not performed. Thus,

20 potential oral problems may have been ignored or underestimated by the NRT figures

21 reported here. Second, some selection bias may have been involved as the criteria for

22 inclusion included the ability to travel from home to the nearby school where the

23 examinations were conducted. The participants were mostly categorized as having

24 mild disabilities, with limited variation. Their oral health conditions should thus be

25 presumed to be generally better than those of individuals with more severe

1   disabilities,[27] who were not included in this survey. The real situation of oral health

2   for adults with disabilities may thus be even worse than that indicated by this study.

3   Third, the self-report health behaviors questionnaire might trigger socially desired

4   behaviors from participants implicitly directed by the research and/or researchers.

5   Fourth, the participants were conveniently recruited from one location, rather than by

6   nationwide cluster sampling. The generalizability of the study results may therefore

7   be limited. Finally, the cross-sectional study design has inherent limits in terms of

8   investigating the causal inferences between variables. As it is a snapshot of a specific

9   moment, the cross-sectional design did not track variables over a period of time to

10 gain insight into the process. To address this limitation, we asked participants to recall

11 their oral health behavior over the past year and/or when they were dentate. However,

12 the recall process might generate another bias due to poor memory recall.

13 **CONCLUSION**

14   For community-dwelling individuals with disabilities, the prevalence of an NRT

15 < 20 was significantly greater than that reported in previous studies. Poor oral hygiene

16 behaviors were identified as being a general characteristic of the participants. Adults

17 with intellectual disability had a greater likelihood of tooth loss. The other two factors

18 strongly associated with an NRT < 20 were the habit of seldom using dental floss and

19 hypertension. As oral hygiene instructions are the least expensive and easiest way of

20 integrating preventative intervention options for chronic diseases into daily activities,

21 professionals should concentrate on this approach for individuals with disabilities and

22 attempt to enhance their teeth cleaning awareness and capabilities. Finally, to satisfy

23 the oral health needs of community-dwelling adults with disabilities, issues such as

24 the risk factors associated with different types of disabilities, regular dental visits, and

25 their special needs can be further explored.

22

1 **Conflict of interest**

2 The authors declare that they have no competing interests.

3 **Authors' contributions**

4 MYP and TCH: designing the study, collecting and analyzing data, and drafting the

5 paper. HCT and YCL: proofreading and revising the manuscripts. MYC: initializing,

6 conceptualizing, and supervising the research process. All authors have read and

7 approved the final manuscript.

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13 148).

14 **Patient consent**

15 Obtained

16 **Ethics approval**

17 This study was approved by the institutional review board of the ethical committee of

18 Chang Gung Memorial Hospital (IRB 102-3331B).

19 **Data sharing statement** No additional data are available.

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35

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	p1–3	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	P4–5	Explain the scientific background and rationale for the investigation being reported
Objectives	p5	State specific objectives, including any prespecified hypotheses
Methods		
Study design	P6	Present key elements of study design early in the paper
Setting	P6	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	P6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
		Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	P6–8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	P6-8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias		Describe any efforts to address potential sources of bias
Study size		Explain how the study size was arrived at
Quantitative variables	P6-8	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	P9–10	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		Case-control study—If applicable, explain how matching of cases and controls was addressed
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results

Participants	P10	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	P10−11	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	P12-13	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	p13-16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses		Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	p16−20	Summarise key results with reference to study objectives
Limitations	P20	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	p16−20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	P22	Discuss the generalisability (external validity) of the study results

Other information

Funding	P22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of and factors associated with fewer than 20 remaining teeth in Taiwanese adults with disabilities: A community-based cross-sectional study

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Prevalence of and factors associated with fewer than 20 remaining teeth in Taiwanese adults with disabilities: A community-based cross-sectional study

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Disabilities; number of remaining teeth; edentulous; health promotion; oral hygiene

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ABSTRACT

Objectives: To examine the prevalence of and the factors associated with a number of remaining teeth (NRT) < 20 among adults with disabilities.

Design: A community-based, cross-sectional descriptive study.

Setting: This study was part of a health-promotion program designed for community-dwelling adults with disabilities.

Participants: A total of 549 adults with disabilities, aged 20−80 years, living in the community in Chiayi County in Taiwan.

Outcome measures: Various parameters, including NRT, oral health behaviors (i.e., oral hygiene, dietary habits, and substance use), comorbidities, disability classification, and capability for performing activities of daily living, were measured. Data were statistically analyzed using descriptive statistics and multivariate logistic regression analysis.

Results: The mean NRT was 18.1 (standard deviation = 10.9); 44.9% of participants had NRT < 20 (including 13.7% edentulous participants). Most participants had poor oral hygiene: 83% reported seldom using dental floss, 78% did not undergo regular 6-monthly dental check-ups, and 77.4% seldom brushed their teeth after meal. After adjusting for potentially confounding variables, the intellectual disability group had a significantly higher risk of an NRT < 20 than the physical disability group (odds ratio: 2.30, p = 0.004). Additionally, the rare use of dental floss and hypertension significantly increased the possibility of an NRT < 20 (odds ratio: 1.73-2.12, p = 0.008-0.009).

Conclusions: An NRT < 20 and edentulism were highly prevalent among adults with disabilities, who displayed poor oral hygiene behaviors. Adults with intellectual

disabilities had a greater likelihood of having an NRT < 20 than did those with physical disability. In addition to unmodifiable factors, the poor use of dental floss was significantly associated with an NRT < 20.

Strengths and limitations of this study

- Few studies have reported the prevalence of and factors associated with few remaining teeth among adults with disabilities, particularly in those residing in communities.

- These results highlight the value of nurse-led health promotion programs and implementation of a multidisciplinary approach for the early detection of a low number of remaining teeth in community-dwelling adults with disabilities.

- The limitations of the study include the non-randomized sampling strategy and recruitment of individuals with disabilities that did not preclude mobility in coming to the examination center, may hinder generalization of our findings.

- Other shortcomings regarding self- and/or caregiver-reported behaviors are social desirability, and the recall process might involve biases due to poor memory retrieval.

4

1 **INTRODUCTION**

2   Having 20 teeth or more helps adults maintain good oral function and overall

3 health. Teeth are recognized as calcified structures in the mouth, with the primary

4 purpose of mastication, but act as part of the broader digestive system, to help the

5 body obtain nutrition.[1-3] Other key functional aspects of teeth include speaking and

6 communication, facial appearance, facilitating interpersonal relationships, enhancing

7 quality of life, systemic health, and cognitive function; teeth are also associated with

8 disability status, and even with mortality.[3-6] Unfortunately, 3.9 billion individuals

9 worldwide experience oral disorders, including untreated caries, severe periodontal

10 disease, and severe tooth loss, thereby prolonging the years lived with disability.[4] In

11 fact, as early as 1991, Japan conducted a series of oral campaigns called the "8020" to

12 encourage citizens to maintain at least 20 remaining teeth through the age of 80.[3]

13 Previous studies on elderly people also proved that the lower the number of remaining

14 teeth (NRT), the greater the impacts on individuals' health. These impacts include the

15 higher risks of cognitive impairments, decreased self-care capabilities, heart rate

16 acceleration, influences on the quality of life, and decreased cumulative survival

17 rate.[1,3] The issue of the NRT has become an important indicator of oral and overall

18 health for adults.

19   Awareness of the factors associated with an NRT < 20 forms the basis for good

20 oral care. Of all the risk factors for an NRT < 20, age is probably the primary

21 factor,[7-10] but it is not a controllable or reversible factor, neither are sex and

22 education.[10-12] Therefore, public health professionals concentrate on risk factors that

23 can be modified. Other factors associated with tooth loss include hypertension,

24 diabetes mellitus, hyperlipidemia, poor oral hygiene, unhealthy diet, smoking, and

25 harmful alcohol consumption,[10-11, 13-15] but those that are specific for individuals with

1   disabilities remain unclear.

2   The oral health condition of disabled individuals is often worse than that of

3   non-disabled adults.[2, 16-23] Utilization of oral health services is also far lower than the

4   average for this group.[16-17, 24] The World Health Organization has warned that, as the

5   population ages and chronic diseases increase, there will be an increase in the rate of

6   disability. Currently, more than a billion people worldwide (15%) live with some form

7   of disability, with 2–4% of those over the age of 15 years having significant

8   difficulties in functioning. In addition, due to poverty and difficulties with mobility,

9   the disabled are particularly vulnerable in terms of accessing satisfactory health care

10   services. They are also more likely to engage in risky health behaviors and to be

11   affected by more complications, more comorbidities, faster degeneration, and earlier

12   mortality.[25] In Taiwan, there are more than 1.1 million people with disabilities (4.8%

13   of the population).[26] Research has shown that disabled adults rarely use oral health

14   services,[27] even though the government has already increased their oral care services.

15   These premium subsidies funded by the National Health Insurance (NHI) system

16   include use of fluoride gel/varnishes, more frequent dental scaling, and a bonus for

17   the dentists treating patients with specific disabilities.[28] In terms of human rights,

18   preventing the increase in levels of disability, as well as reducing the caregivers'

19   burdens, which are issues relating to oral health care for vulnerable groups, deserve

20   much attention.

21   However, although some previous studies have focused on

22   institution-accommodated adults with disabilities,[2, 18] fewer reports have discussed

23   disabled individuals living in communities. The prevalence of NRT < 20 and factors

24   potentially relevant to the oral health among non-institutional disabilities were also

25   seldom discussed. Therefore, the aims of this study were to explore the prevalence of

1   and factors associated with an NRT < 20 among community-dwelling adults with

2   disabilities in Taiwan, and explore the oral health behaviors among the participants.

3

4   **METHODS**

5   **Design, sample, and setting**

6   This study, which was part of a second-year health-promotion program designed

7   for community-dwelling adults with disabilities, was led by a nursing team in

8   collaboration with a district hospital and the Bureau of Health Promotion of Chiayi

9   County in Taiwan.[25] In Chiayi County, visual impairment, hearing impairment,

10 intellectually disability, and physical disability affect more than 38,800 individuals,

11 accounting for 64% of the local disabled population. This paper forms part of a series

12 of reports regarding health issues of community-based people with disabilities. A

13 community-based health screening survey was conducted between July and December

14 in 2014 using a cross-sectional descriptive design.

15   Participants were selected through convenience sampling from the registry of the

16 government's social welfare center.[21] The inclusion criteria were: (1) certified adults'

17 primary disability, involving either visual impairment, hearing impairment,

18 intellectual disability, or physical disability; (2) age ≥ 20 years; (3) the ability to

19 complete the written questionnaire in either Mandarin or Taiwanese, with assistance

20 from the interviewers; (4) the ability to walk to the examination center with/without

21 help; and (5) the ability to sign the consent forms prior to recruitment. Exclusion

22 criteria were: (1) living in institutions; (2) an inability to answer questions; or (3)

23 having a serious disease, such as kidney disease requiring dialysis or cancer.

24 **Measurements**

25   1. *Number of remaining teeth (NRT):* The NRT was obtained by research

1   assistants by asking the participants to open his/her mouths and then counting the total

2   number of natural teeth and fixed dentures, after discharging the removable dentures

3   in the oral cavities. Root fragments without a crown were excluded. As edentulism is

4   an alternative measure of oral health status,[29] it was distinguished as an outcome to

5   present a fuller picture of NRT. Thus, three categories, edentulous (NRT = 0),

6   less-dentate (NRT = 1-19), and more-dentate (NRT $\geq$ 20) were defined. The

7   edentulous and less-dentate groups are referred to as those with fewer teeth (NRT <

8   20).

9   2. *Oral health behaviors:* Oral health behaviors were measured in terms of

10   seven habits, i.e., brushing teeth, using dental floss, visiting dentists or undergoing

11   dental scaling, drinking alcohol, smoking, five groups of nutrition, and water intake.

12   This information was collected through standardized personal interviews using a

13   structured questionnaire that was based on the published literature.[7, 10] The

14   participants were asked to recall their oral health behaviors up to a year previously

15   and/or when they were dentate.

16   In this study, answers regarding the brushing of teeth were categorized as

17   frequent ($\geq$ twice a day) vs. infrequent (< twice a day). As for immediate brushing

18   teeth after a meal, participants were classified as "often" if they responded with

19   "usually" or "frequently", or "seldom" if they responded with "never" or

20   "sometimes". For using dental floss, responses were classified as "often" if dental

21   floss was used to clean interdental spaces $\geq$ once a day, or "seldom" if the

22   respondents' answer was "never" or "sometimes." Regarding visits to dentists,

23   participants were classified as "regular" if they visited dentists and underwent scaling

24   every 6 months, or "irregular" if they responded "never" or "sometimes." For

25   questions "Do you smoke cigarettes or drink alcohol?", participants were classified as

1 ''none or formerly'' if they had never engaged in these behaviors or had stopped

2 doing so for the past year, or as "current users." Regarding five groups of nutrition

3 intake, the response was considered "balanced" if the respondents usually or always

4 had five groups of nutrition (i.e., meat, milk, grains, vegetables, and fruit) each day, or

5 "unbalanced" if they never or sometimes had these foods. In terms of water intake,

6 answers were categorized as sufficient (≥ 1500 mL per day) vs. insufficient (< 1500

7 mL per day). Participants, especially those intellectual and hearing disabled, were

8 guided to reply their habits through visual aids, samples, progressive interactions, and

9 caregivers' confirmations when necessary.

10   3. *Background information:* Background information comprised three

11 sections. First, demographic variables obtained from the questionnaires, including

12 age, gender, and educational attainment (years of education received, or level of

13 school completed). Second, prevalence of the three common chronic diseases (i.e.,

14 hypertension, diabetes mellitus, and hyperlipidemia). The three diseases were

15 assessed using a medical history (diagnosed by a physician) and/or physiological

16 biomarkers, including blood pressure (BP), fasting blood glucose (FBG), triglyceride

17 (TG), total cholesterol (TC), low-density lipoprotein (LDL) cholesterol, and

18 high-density lipoprotein (HDL) cholesterol levels. Following the national standard of

19 the Ministry of Health and Welfare,[30] blood samples were evaluated and BP was

20 measured at the time of the study, applying standard procedures. The three common

21 chronic diseases were defined as (1) diabetes mellitus (FBG ≥126 mg/dL, or if ever

22 diagnosed by a doctor); (2) hypertension (systolic/diastolic BP ≥140/90 mmHg, or if

23 ever diagnosed by a doctor); and (3) hyperlipidemia (LDL ≥160 mg/dL, TC ≥240

24 mg/dL, TG ≥200 mg/dL, or if ever diagnosed by a doctor). Third, disability

25 classification and capability of activity of daily living (ADL). Primary disabilities,

1 such as physical, hearing, vision, or intellectual disabilities, were identified and

2 confirmed by the certificates issued by the Taiwan government[26] prior to the

3 interviews. ADL capability, judged using the Barthel ADL Index of feeding,

4 grooming, bathing, mobility, toilet use, transfer, etc., reflected the dependence level of

5 participants who required external assistance to complete these activities.

6 "Independent" was coded if external assistance was unnecessary, or "dependent" if it

7 was needed.

8 **Procedures and ethical considerations**

9 This study was approved by the relevant institutional review board of Chang

10 Gung Memorial Hospital (IRB 102-3331B), and all procedures complied with the

11 ethical guidelines. Participants were invited to participate in the study via letters sent

12 by the public health nurses, and were fully informed about the purposes of the study.

13 The letter emphasized the confidentiality of all collected data. Written consent forms

14 were appropriately explained to and signed by participants and/or their guardians

15 before arranging free medical evaluations. These evaluations, including blood

16 sampling and physical check-ups, were conducted by the local hospital staff on a

17 weekend, in a school auditorium, followed by individual interviews. To create a

18 caring and friendly environment, each participant was accompanied by a community

19 volunteer during the health screenings. If a participant was not an effective responder,

20 a familiar caregiver, who was normally a family member(s) with whom they were

21 living, was allowed to represent the participant in answering the questions.

22 The NRT was calculated carefully by research assistants who were trained by a

23 research team that including the investigators and a dentist. Details of the interviews

24 and measurement procedures have been reported in our previous study.[10] Face and

25 content validity of the instrument were judged to be good (0.88−0.91) by a panel of

1   five experts: a faculty member in public health and health education, a dentist, a social

2   worker in a disabled institution, and two nursing faculty members who specialize in

3   the field of long-term care.

4   **Statistical analyses**

5   Quantitative data were analyzed using SPSS v. 22.0 software. Descriptive

6   statistical data are presented as numbers and percentages for categorical variables, and

7   as means ± standard deviations for continuous variables. Chi-square tests for

8   categorical variables, as univariate analyses, were performed to compare those in the

9   edentulous (NRT = 0), less-dentate (NRT = 1-19), and more-dentate (NRT ≥ 20)

10   groups in terms of their background information and oral health behaviors. Stepwise

11   logistic regression analyses, for identifying the modifiable factors associated with

12   having fewer teeth (NRT < 20), were conducted in three models. The first model,

13   model 1, a crude model without adjustment, was used to examine the associations

14   between exposures and NRT < 20. The second, model 2, was partially adjusted, for

15   three irreversible confounding factors, including age, gender, and education. The third,

16   model 3, was fully adjusted for all exposures in the current study. For models 2 and 3,

17   multivariable logistic regression analysis with a forward variable entry method (entry

18   criteria: p-value < 0.05 in univariate analysis) was implemented. The odds ratio (OR)

19   with 95% confidence interval (CI) and corresponding p-value were obtained by

20   logistic regression model. All statistical assessments adopted two-tailed tests, and the

21   p-value cut-off point for statistical significance was set as 0.05.

22   **RESULTS**

23   Of the 603 individuals invited to participate in the study, 549 participants were

24   enrolled in this analysis, but 18 failed to complete the NRT measurement. The

25   response rate was therefore 91%. The majority of the participants were male (54.3%),

1 aged 20–80 years (mean age 58.8 ± 13.9), and were not well-educated (educational

2 attainment ≤ 9 years: 67.4%). The distribution of disabilities by type was: physical

3 (55.9%), intellectual (19.7%), hearing (15.7%), and vision (8.7%). Most participants

4 (88.7%) did not require assistance in the activities of daily living (ADL), as they only

5 had a mild degree of disability. In addition, the prevalence rates of hypertension,

6 hyperlipidemia, and diabetes mellitus were 56.5%, 49.9%, and 23.9%, respectively.

7 Moreover, chi-square tests results indicated that participants who were of older age,

8 had lower education, and had histories of hypertension and/or diabetes had

9 significantly greater likelihoods of having fewer teeth and/or edentulous (Table 1).

10 As shown in Table 2, the participants had fewer teeth (mean NRT 18.1 ± 10.9;

11 median 21.0; NRT < 20: 44.8%; NRT = 0: 13.7%), and had poor oral hygiene (seldom

12 dental floss: 83.4%; irregular dental visit: 78.0%; seldom brushed teeth after meal:

13 77.4%; daily teeth brushing: 1.8 ± 0.9 times). They also had other unfavorable

14 behaviors (insufficient water intake/unbalanced nutrition: 40.3%; smoking: 25.3%;

15 drinking alcohol: 16.2%). Chi-square test results showed that participants with the

16 characteristics of rare dental floss use, irregular dentist visits, or unbalanced nutrition,

17 had a significantly higher prevalence of having fewer and/or no teeth.

18 Regarding Table 3, after adjusting for all exposures (in model 3), the intellectual

19 disability group had a significantly higher possibility of an NRT < 20 than the

20 physical disability group (OR: 2.20, 95% CI: 1.26-3.84), while the risk of an NRT <

21 20 in the other two subgroups were not increased. From the results of three models,

22 i.e., model 1, model 2, and model 3, the demographic variables seemed to confound

23 an NRT < 20 associated with disability classifications. The other modifiable factors

24 associated with an NRT < 20 were the rare use of dental floss (OR: 2.12–2.64) and a

25 history of hypertension (OR: 1.61–2.32).

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2 Table 1. Background information of the subjects, according to dentition status

| | Dentate[†] | | Edentulous[†] | |
| | NRT: ≥20 | NRT: 1-19 | NRT: 0 | Total |
Variables	(n=293)	(n=165)	(n=73)	(n=549)
Age (years)[*]	53.8±13.3	63.1±12.4	69.5±8.1	58.8±13.9
<65	228 (77.8)	81 (49.1)	13 (17.8)	331 (60.3)
≥65	65 (22.2)	84 (50.9)	60 (82.2)	218 (39.7)
Gender				
Female	123 (42.0)	83 (50.3)	38 (52.1)	251 (45.7)
Male	170 (58.0)	82 (49.7)	35 (47.9)	298 (54.3)
Educational attainment[*]				
>9 years	132 (45.1)	37 (22.4)	6 (8.2)	179 (32.6)
≤9 years	161 (54.9)	128 (77.6)	67 (91.8)	370 (67.4)
Hypertension[*]				
No	154 (52.6)	54 (32.7)	23 (31.5)	239 (43.5)
Yes	139 (47.4)	111 (67.3)	50 (68.5)	310 (56.5)
Diabetes mellitus[*]				
No	235 (80.2)	121 (73.3)	47 (64.4)	418 (76.1)
Yes	58 (19.8)	44 (26.7)	26 (35.6)	131 (23.9)
Hyperlipidemia				
No	138 (47.1)	88 (53.3)	37 (50.7)	275 (50.1)
Yes	155 (52.9)	77 (46.7)	36 (49.3)	274 (49.9)
Disability classification				
Physical disability	166 (56.7)	93 (56.4)	38 (52.1)	307 (55.9)
Intellectual disability	64 (21.8)	32 (19.4)	8 (11.0)	108 (19.7)
Hearing impairment	44 (15.0)	22 (13.3)	17 (23.3)	86 (15.7)
Vision impairment	19 (6.2)	18 (10.9)	10 (13.7)	48 (8.7)
Capability of ADL[†]				
Independent	263 (89.8)	148 (89.7)	32 (84.9)	486 (88.7)
Dependent	30 (10.2)	17 (10.3)	11 (15.1)	62 (11.3)

3 Data are expressed as number (percentages) or Mean ± SD. NRT, number of remaining teeth; ADL,

4 activities of daily living. [*] $p < 0.05$ derived from χ^2 tests. [†]Missing data: 1 in ADL, 18 in NRT.

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1 Table 2. Number of remaining teeth and oral health behaviors according to dentition status

Variables[#]	Dentate[†]		Edentulous[†]	
	NRT: ≥20 (n=293)	NRT: 1-19 (n=165)	NRT: 0 (n=73)	Total (n = 549)
Group of NRT (n=531)[†]	26.7 ±3.7(27.0)	10.8±5.5 (12.0)	-	18.1 ± 10.9 (21.0)
0				73 (13.7)
1-19				165 (31.1)
≥20				293 (55.2)
Oral hygiene				
Times of daily brushing teeth				1.8 ± 0.9
Frequent (≥ 2 times)	204 (69.5)	116 (70.3)	44 (60.3)	372 (67.8)
Infrequent (< 2 times)	89 (30.4)	49 (29.7)	29 (39.7)	177 (32.2)
Brushing teeth after meal				
Often	62 (21.2)	37 (22.4)	22 (30.1)	124 (22.6)
Seldom	231 (78.8)	128 (77.6)	51 (69.9)	425 (77.4)
Using dental floss[*]				
Often (≥ once a day)	67 (22.9)	17 (10.3)	7 (9.6)	91 (16.6)
Seldom (< once a day)	226 (77.1)	148 (89.7)	66 (90.4)	458 (83.4)
Visiting dentist per 6 months[*]				
Regular	73 (24.9)	38 (23.0)	7 (9.6)	121 (22.0)
Irregular	220 (75.1)	127 (77.0)	66 (90.4)	428 (78.0)
Water intake per day				
Sufficient (≥ 1500 ml)	186 (63.5)	98 (59.4)	35 (47.9)	328 (59.7)
Insufficient (< 1500 ml)	107 (36.5)	67 (40.6)	38 (52.1)	221 (40.3)
Five nutrition groups per day[*]				
Balanced	191 (65.2)	84 (50.9)	47 (64.4)	328 (59.7)
Unbalanced	102 (34.8)	81 (49.1)	26 (35.6)	221 (40.3)
Smoking habit				
Never or formerly	218 (74.4)	126 (76.4)	53 (72.6)	410 (74.7)
Current users	75 (25.6)	39 (23.6)	20 (27.4)	139 (25.3)
Alcohol habit				
Never or formerly	245 (83.6)	139 (84.2)	63 (86.3)	460 (83.8)
Current users	48 (15.4)	26 (15.8)	10 (13.7)	89 (16.2)

2 Data are expressed as number (percentages) or Mean ± SD (median). NRT, number of remaining teeth.

3 [#] All variables except NRT asked the edentulous subjects to recall their behaviors when dentate.

4 [*] $p < 0.05$ derived from χ^2 tests. [†]18 missing data.

5

1   Table 3. Odds ratios (95% CI) of the factors associated with NRT＜20 (n = 531[†])

Variables/ Values	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Age (years)	1.08 (1.06-1.09)[*]	1.07 (1.05-1.08)[*]	1.07 (1.05-1.10)[*]
Gender			
Female[¶]			
Male	0.70 (0.50-0.99)[*]	§	§
Educational attainment			
> 9 years[¶]			
≤ 9 years	3.72 (2.49-5.56)[*]	2.01 (1.28-3.14)[*]	1.96 (1.23-3.10)[*]
Hypertension			
No[¶]	-	-	-
Yes	2.28 (1.53-3.31)[*]	1.61 (1.09-2.39)[*]	1.73 (1.15-2.60)[*]
Diabetes mellitus			
No[¶]	-	-	-
Yes	1.69 (1.13-2.52)[*]	§	§
Hyperlipidemia			
No[¶]	-	-	-
Yes	0.81 (0.57-1.13)	§	§
Disability classification			
Physical disability[¶]	-	-	-
Intellectual disability	0.79 (0.50-1.25)	2.20 (1.26-3.84)[*]	2.30 (1.30-4.08)[*]
Hearing impairment	1.12 (0.69-1.83)	0.76 (0.44-1.32)	0.75 (0.43-1.32)
Vision impairment	1.87 (0.99-3.49)	1.54 (0.75-3.13)	1.48 (0.72-3.04)
Capability of ADL			
Independent[¶]	-	-	-
Dependent	1.17 (0.68-2.02)	§	§
Oral health behaviors[#]			
Daily brushing teeth			
Frequent[¶]	-	-	-
Infrequent	1.12 (0.77-1.61)	§	§
Using dental floss			
Often[¶]	-	-	-
Seldom	2.64 (1.60-4.37)[*]	2.22 (1.28-3.83)[*]	2.12 (1.21-3.71)[*]
Visiting dentist			
Regular[¶]	-	-	-
Irregular	1.42 (0.94-2.16)	§	§

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Water intake			
Sufficient[¶]	-	-	-
Insufficient	1.37 (0.97-1.95)	§	§
Five nutrition groups per day			
Balanced[¶]	-	-	-
Unbalanced	1.53 (1.08-2.17)[*]	1.58(1.07-2.34)[*]	§
Smoking habit			
Never or formerly[¶]	-	-	-
Current users	0.96 (0.65-1.42)	§	§
Alcohol habit			
Never or formerly[¶]	-	-	
Current users	0.91 (0.57-1.46)	§	§

1 NRT, number of remaining teeth; ADL, activities of daily living; OR, odds ratio; CI, confidence

2 interval. Model 1: crude; model 2: adjusted for age, gender, and education; model 3: model 2 + all

3 variables in Table 3. [†]18 missing data. [*]p value <0.05. [#] Variables reflects edentulous subjects' recall of

4 their behaviors when dentate. §: Variables were not selected into the model. [¶]Reference group.

5

1   **DISCUSSION**

2   This study featured a nurse-led health program aimed at promoting the oral

3   health of disabled individuals. Four key findings emerged: first, fewer teeth were

4   counted and there was a higher prevalence of an NRT < 20 and edentulism in the

5   present study population than in those reported in the existing literature. According to

6   previous research, the average NRT for non-disabled people is approximately 25,[10]

7   and only 16% of these individuals have an NRT < 20.[2, 10] However, in this study, the

8   average NRT in disabled individuals was 18.1, and 44.8% had an NRT < 20, which

9   indicated a significantly worse oral health condition. Even when ruling out the

10   edentulous, the average NRT was 20.9 and prevalence of NRT < 20 was 36.0%

11   among the dentate subgroup. The slight changes in the statistics from 18.1 to 20.9 and

12   44.8% to 36.0%, do not indicate a change in the trend. The literature supports the

13   view that adults with disabilities commonly exhibit poor oral hygiene and have a

14   lower NRT than non-disabled people, owing to their limited capabilities, in terms of

15   cognitive comprehension, body coordination, or muscle power.[11, 19] In fact, the

16   prevalence of an NRT < 20 in this study was not only higher than the figures

17   previously reported for non-disabled people, but was also higher than that reported in

18   a Belgian study of people with disabilities (33%).[2] Moreover, the edentulous rate of

19   13.7% found in this study was also higher than the edentulous rate of 8.9% reported

20   by a study conducted in the USA.[16]

21   Second, most disabled participants reported having inadequate oral hygiene

22   behaviors in general. These behaviors, including seldom using dental floss, irregular

23   dental visits and scaling, and rarely brushing teeth after meals, were factors associated

24   with tooth loss in previous reports,[1, 7-8] and may also affect other systemic diseases.[5]

25   The prevalence of these behaviors in this study was 83.4%, 78.0%, and 77.4%,

18

1 respectively, which was much higher than in the non-disabled population (about

2 28–70%);[7, 10, 15-17] and were also greater than those in disabled individuals in other

3 countries (29–51%).[16, 24] Particularly, those who were edentulous had worse oral

4 hygiene behaviors than those who were dentate. Although irregular dental visits were

5 not a significant factor for an NRT < 20 in the current study, most previous studies

6 indicated the importance of regular dental care.[1-2, 31-32] To encourage regular dental

7 care, the Taiwanese government has provided incentives under the NHI system, by

8 requiring only payment of a registration and copayment fee, for use of oral health

9 services by the disabled.[28] However, individuals with disabilities typically do not visit

10 dentists until their dental problems become too serious to be treated, and tooth

11 extraction is often unavoidable. The issue of regular dental visits to help maintain a

12 greater number of teeth in the disabled should be explored in future.

13 Third, adults with intellectual disability have an increased possibility of having an

14 NRT < 20. In this study, the extreme case, i.e., edentulous, showed a prevalence of

15 7.7% among those with intellectual disability, which was lower than that reported in

16 the USA (10.9%).[22] In comparison with those with physical disability, the subgroup of

17 individuals with intellectual disabilities had a higher likelihood of having fewer teeth,

18 which is consistent with the findings of previous studies.[2,9,18,22] Lindsay[33] attributes

19 this phenomenon to their preferences for eating desserts, sweets, and drinking soft

20 drinks; similarly, their reduced capacity for self-control owing to their cognitive

21 impairments could also modulate this effect. These individuals often are not fully

22 capable of independent self-care, and their caregivers may find it difficult to perform

23 oral hygiene activities for them over the long term. In addition, adults with

24 developmental disabilities often appear to have disorders, such as gastro-esophageal

25 reflux disease, excessive salivation, and induced xerostomia triggered by antiepileptic

1   medications, which could increase the possibility of poor oral health.

2   Fourth, the use of dental floss is a modifiable factor associated with the NRT.

3   Except for intellectual disabilities, other associated factors, such as the rare use of

4   dental floss and hypertension[1, 10, 13] are similar to the factors associated with NRT in

5   non-disabled individuals. Among these, dental floss use is the most malleable

6   component that can be addressed by instruction from public health practitioners. This

7   study found that most disabled adults (77.4%) lacked the habit of cleaning teeth after

8   meals, and brushed their teeth less often than twice a day. The practice of dental

9   flossing may be a complementary oral hygiene step that can help to maintain the NRT.

10   A previous systematic review has confirmed that brushing and flossing can

11   significantly reduce plaque and gingivitis as compared with tooth brushing alone.[14]

12   It is the presence of dental plaque and food debris in the crevices between the

13   teeth that encourage bacteria to flourish, activating the inflammatory response and the

14   innate immune system in the human body. These bacteria induce swelling and

15   bleeding of the gums, the destruction of periodontal tissues and alveolar bones, and

16   the promotion of tooth mobility; thus, ultimately causing tooth loss.[34-35] The findings

17   from some systematic reviews suggest that oral hygiene methods, such as tooth

18   brushing, dental flossing, and/or interdental brushing are all effective means of

19   eliminating the periodontal pathogens thriving in the buccal cavity[14, 36] and even in the

20   blood.[37]

21   However, people with disabilities may have difficulties flossing, due to

22   disability-related issues with self-control, movement coordination, comprehension,

23   etc., although nearly 90% of them in this study were categorized as having basic

24   self-care ability in terms of ADL. Adopting a habit of dental flossing, and accuracy

25   and thoroughness of dental cleaning processes, may even be demanding for some

1   non-disabled people, as well as for adults with disabilities. The assistance of

2   interdental brushing, which is recognized as an easier and more effective method for

3   reducing peridontal pathogens, [36] can also be considered as an alternative approach.

4   To address the problem of NRT < 20, oral hygiene instruction, a commonly used

5   clinical technique, is imperative for improving oral hygiene. Since disabled adults

6   may not cope with regular dental visits and examinations, integration of preventive

7   and corrective oral health in their lives is highly beneficial. [31] Routine daily teeth

8   cleaning is undoubtedly the most economic and convenient approach to ensure oral

9   health. It can also reduce the fear of individuals with disabilities about accessing oral

10   health services, and even shorten the scaling time required. [38] Unfortunately, previous

11   studies have demonstrated that community-dwelling individuals with disabilities have

12   worse oral health than those living in institutions. [22, 39] Since these participants were

13   living at home with relatives, their families were generally more concerned with

14   physiological diseases than with oral conditions, and were not aware of the

15   importance of oral hygiene. Teeth cleaning was also typically perceived as the

16   individuals' own responsibility, as these disabled people generally seemed to be

17   capable of managing the task. However, they had a higher prevalence of an NRT < 20,

18   which may imply that even if the participants had basic self-care ability, it does not

19   mean that they are capable of achieving good quality oral hygiene. Their families

20   sometimes opted to ignore these "trivial" matters, as they were already exhausted by

21   the burden of care. Consequently, without professional guidance and tracking, daily

22   cleaning of the teeth becomes a difficult task for community-based people with

23   disabilities. A systematic review has concluded that additional oral hygiene instruction

24   could help cultivate a higher quality of oral health behaviors; thus, ameliorating

25   gingivitis and eradicating dental plaque. [32]

1   As many researchers claim that good oral health can improve almost every

2 aspect of life, from overall health to self-esteem, communication, nutrition, quality of

3 life, savings in medical expenses, and finding employment, for people with

4 disabilities, in addition to relieving the burden on their care givers.[17, 40] To achieve the

5 oral health goal of 8020,[3] more resources and attention should be invested to provide

6 good oral care, matched to the individual's disability characteristics. Further

7 integration of the social welfare networks, oral hygiene instructions, and coordination

8 of medical professionals and caregivers for adults with disabilities are recommended.

9 **Limitations**

10   This study has some limitations. First, the participants' oral conditions were

11 examined by research assistants, rather than by qualified dentists, due to constraints

12 on the participants' cooperation and expectations. Only superficial features, such as

13 the remaining number of natural and filled teeth were investigated; other thorough

14 evaluations, such as those of caries and periodontal tissues, were not performed. Thus,

15 potential oral problems may have been ignored or underestimated by the NRT figures

16 reported here. Second, some selection bias may have been involved as the criteria for

17 inclusion included the ability to travel from home to the nearby school where the

18 examinations were conducted. The participants were mostly categorized as having

19 mild disabilities, with limited variation. Their oral health conditions should thus be

20 presumed to be generally better than those of individuals with more severe

21 disabilities,[27] who were not included in this survey. The real situation of oral health

22 for adults with disabilities may thus be even worse than that indicated by this study.

23 Third, the self-reporting health behaviors questionnaire might trigger socially desired

24 behaviors from participants implicitly directed by the research and/or researchers.

25 Fourth, the participants were conveniently recruited from one location, rather than by

22

1 nationwide cluster sampling. The generalizability of the study results may therefore

2 be limited. Finally, the cross-sectional study design has an inherent limitation in terms

3 of investigating the causal inferences between variables. As it is a snapshot of a

4 specific moment, the cross-sectional design did not track variables over a period of

5 time to gain insight into the process. To address this limitation, we asked participants

6 to recall their oral health behavior over the past year and/or when they were dentate.

7 However, the recall process might generate another bias due to poor memory recall.

8 **CONCLUSION**

9   For community-dwelling individuals with disabilities, the prevalence of an NRT

10 < 20 and edentulism were significantly greater than that reported in previous studies.

11 Poor oral hygiene behaviors were identified as being a general characteristic of the

12 participants. Adults with intellectual disability had a greater likelihood of tooth loss.

13 The other two modifiable factors strongly associated with an NRT < 20 were the habit

14 of seldom using dental floss and hypertension. As oral hygiene instructions are the

15 least expensive and easiest way of integrating preventative intervention options for

16 chronic diseases into daily activities, professionals should concentrate on this

17 approach for individuals with disabilities and attempt to enhance their teeth cleaning

18 awareness and capabilities. Finally, to satisfy the oral health needs of

19 community-dwelling adults with disabilities, issues such as the risk factors associated

20 with different types of disabilities, regular dental visits, and their special needs can be

21 further explored.

22 **Conflict of interest**

23 The authors declare that they have no competing interests.

24 **Authors' contributions**

25 MYP and TCH: designing the study, collecting and analyzing data, and drafting the

1 paper. HCT and YCL: proofreading and revising the manuscripts. MYC: initializing,

2 conceptualizing, and supervising the research process. All authors have read and

3 approved the final manuscript.

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9 148).

10 **Patient consent**

11 Obtained

12 **Ethics approval**

13 This study was approved by the institutional review board of the ethical committee of

14 Chang Gung Memorial Hospital (IRB 102-3331B)

15 **Data sharing statement** No additional data are available.

16

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	p1−3	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	P4−5	Explain the scientific background and rationale for the investigation being reported
Objectives	p5	State specific objectives, including any prespecified hypotheses
Methods		
Study design	P6	Present key elements of study design early in the paper
Setting	P6	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	P6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
		Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	P6−8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	P6-8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias		Describe any efforts to address potential sources of bias
Study size		Explain how the study size was arrived at
Quantitative variables	P6-8	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	P9−10	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		Case-control study—If applicable, explain how matching of cases and controls was addressed
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results

Participants	P10	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	P10−11	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	P12-13	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	p13-16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses		Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	p16−20	Summarise key results with reference to study objectives
Limitations	P20	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	p16−20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	P22	Discuss the generalisability (external validity) of the study results

Other information

Funding	P22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of and factors associated with fewer than 20 remaining teeth in Taiwanese adults with disabilities: A community-based cross-sectional study

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Prevalence of and factors associated with fewer than 20 remaining teeth in Taiwanese adults with disabilities: A community-based cross-sectional study

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Keywords

Disabilities; number of remaining teeth; edentulous; health promotion; oral hygiene

Word count: 4614

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ABSTRACT

Objectives: To examine the prevalence of and the factors associated with a number of remaining teeth (NRT) < 20 among adults with disabilities.

Design: A community-based, cross-sectional descriptive study.

Setting: This study was part of a health-promotion program designed for community-dwelling adults with disabilities.

Participants: A total of 549 adults with disabilities, aged 20−80 years, living in the community in Chiayi County in Taiwan.

Outcome measures: Various parameters, including NRT, oral health behaviors (i.e., oral hygiene, dietary habits, and substance use), comorbidities, disability classification, and capability for performing activities of daily living, were measured. Data were statistically analyzed using descriptive statistics and multivariate logistic regression analysis.

Results: The mean NRT was 18.1 (standard deviation = 10.9); 44.8% of participants had NRT < 20 (including 13.7% edentulous participants). Most participants had poor oral hygiene: 83.4% reported seldom using dental floss, 78% did not undergo regular 6-monthly dental check-ups, and 77.4% seldom brushed their teeth after meal. After adjusting for potentially confounding variables, the intellectual disability group had a significantly higher risk of an NRT < 20 than the physical disability group (odds ratio: 2.30, 95% CI: 1.30−4.08). Additionally, the rare use of dental floss and hypertension significantly increased the possibility of an NRT < 20 (odds ratio: 1.73−2.12, 95% CI: 1.15−3.71).

Conclusions: An NRT < 20 and edentulism were highly prevalent among adults with

disabilities, who displayed poor oral hygiene behaviors. Adults with intellectual disabilities had a greater likelihood of having an NRT < 20 than did those with physical disability. In addition to unmodifiable factors, the poor use of dental floss was significantly associated with an NRT < 20.

Strengths and limitations of this study

- Few studies have reported the prevalence of and factors associated with few remaining teeth among adults with disabilities, particularly in those residing in communities.

- These results highlight the value of nurse-led health promotion programs and implementation of a multidisciplinary approach for the early detection of a low number of remaining teeth in community-dwelling adults with disabilities.

- The limitations of the study include the non-randomized sampling strategy and recruitment of individuals with disabilities that did not preclude mobility in coming to the examination center, which may hinder generalization of our findings.

- Other shortcomings regarding self- and/or caregiver-reported behaviors are social desirability, and the recall process might involve biases due to poor memory retrieval.

INTRODUCTION

Having 20 teeth or more helps adults maintain good oral function and overall health. Teeth are recognized as calcified structures in the mouth, with the primary purpose of mastication, but act as part of the broader digestive system, to help the body obtain nutrition.[1-3] Other key functional aspects of teeth include speaking and communication, facial appearance, facilitating interpersonal relationships, enhancing quality of life, systemic health, and cognitive function; teeth are also associated with disability status, and even with mortality.[3-6] Unfortunately, 3.9 billion individuals worldwide experience oral disorders, including untreated caries, severe periodontal disease, and severe tooth loss, thereby prolonging the years lived with disability.[4] In fact, as early as 1991, Japan conducted a series of oral campaigns called the "8020" to encourage citizens to maintain at least 20 remaining teeth through the age of 80.[3] Previous studies on elderly people also proved that the lower the number of remaining teeth (NRT), the greater the impacts on individuals' health. These impacts include the higher risks of cognitive impairments, decreased self-care capabilities, heart rate acceleration, influences on the quality of life, and decreased cumulative survival rate.[1,3] NRT has become an important indicator of oral and overall health for adults.

Awareness of the factors associated with an NRT < 20 forms the basis for good oral care. Of all the risk factors for an NRT < 20, age is probably the primary factor,[7-10] but it is not a controllable or reversible factor, neither are sex and education.[10-12] Therefore, public health professionals concentrate on risk factors that can be modified. Other factors associated with tooth loss include hypertension, diabetes mellitus, hyperlipidemia, poor oral hygiene, unhealthy diet, smoking, and harmful alcohol consumption,[10-11, 13-15] but those that are specific for individuals with disabilities remain unclear.

1   The oral health condition of disabled individuals is often worse than that of

2   non-disabled adults.[2, 16-23] Utilization of oral health services is also far lower than the

3   average for this group.[16-17, 24] The World Health Organization has warned that, as the

4   population ages and chronic diseases increase, there will be an increase in the rate of

5   disability. Currently, more than a billion people worldwide (15%) live with some form

6   of disability, with 2–4% of those over the age of 15 years having significant

7   difficulties in functioning. In addition, due to poverty and difficulties with mobility,

8   the disabled are particularly vulnerable in terms of accessing satisfactory health care

9   services. They are also more likely to engage in risky health behaviors and to be

10   affected by more complications, more comorbidities, faster degeneration, and earlier

11   mortality.[25] In Taiwan, there are more than 1.1 million people with disabilities (4.8%

12   of the population).[26] Research has shown that disabled adults rarely use oral health

13   services,[27] even though the government has already increased their oral care services.

14   These premium subsidies funded by the National Health Insurance (NHI) system

15   include use of fluoride gel/varnishes, more frequent dental scaling, and a bonus for

16   the dentists treating patients with specific disabilities.[28] In terms of human rights,

17   preventing the increase in levels of disability, as well as reducing the caregivers'

18   burdens, which are issues relating to oral health care for vulnerable groups, deserve

19   much attention.

20   However, although some previous studies have focused on

21   institution-accommodated adults with disabilities,[2, 18] fewer reports have discussed

22   disabled individuals living in communities. The prevalence of NRT < 20 and factors

23   potentially relevant to oral health among non-institutional disabilities were also

24   seldom discussed. Therefore, the aims of this study were to explore the prevalence of

25   and factors associated with an NRT < 20 among community-dwelling adults with

6

1 disabilities in Taiwan, and explore the oral health behaviors among the participants.

2

3 **METHODS**

4 **Design, sample, and setting**

5   This study, which was part of a second-year health-promotion program designed

6 for community-dwelling adults with disabilities, was led by a nursing team in

7 collaboration with a district hospital and the Bureau of Health Promotion of Chiayi

8 County in Taiwan.[25] In Chiayi County, visual impairment, hearing impairment,

9 intellectually disability, and physical disability affect more than 38,800 individuals,

10 accounting for 64% of the local disabled population. This paper forms part of a series

11 of reports regarding health issues of community-based people with disabilities. A

12 community-based health screening survey was conducted between July and December

13 in 2014 using a cross-sectional descriptive design.

14   Participants were selected through convenience sampling from the registry of the

15 government's social welfare center.[21] The inclusion criteria were: (1) certified adults'

16 primary disability, involving either visual impairment, hearing impairment,

17 intellectual disability, or physical disability; (2) age $\geq$ 20 years; (3) the ability to

18 complete the written questionnaire in either Mandarin or Taiwanese, with assistance

19 from the interviewers; (4) the ability to walk to the examination center with/without

20 help; and (5) the ability to sign the consent forms prior to recruitment. Exclusion

21 criteria were: (1) living in institutions; (2) an inability to answer questions; or (3)

22 having a serious disease, such as kidney disease requiring dialysis or cancer.

23 **Measurements**

24   1. *Number of remaining teeth (NRT):* The NRT was obtained by research

25 assistants by asking the participants to open his/her mouths and then counting the total

1   number of natural teeth and fixed dentures, after discharging the removable dentures

2   in the oral cavities. Root fragments without a crown were excluded. As edentulism is

3   an alternative measure of oral health status,[29] it was distinguished as an outcome to

4   present a fuller picture of NRT. Thus, three categories, edentulous (NRT = 0),

5   less-dentate (NRT = 1-19), and more-dentate (NRT $\geq$ 20) were defined. The

6   edentulous and less-dentate groups are referred to as those with fewer teeth (NRT <

7   20).

8   2. *Oral health behaviors:* Oral health behaviors were measured in terms of

9   seven habits, i.e., brushing teeth, using dental floss, visiting dentists or undergoing

10   dental scaling, drinking alcohol, smoking, five groups of nutrition, and water intake.

11   This information was collected through standardized personal interviews using a

12   structured questionnaire that was based on the published literature.[7, 10] The

13   participants were asked to recall their oral health behaviors up to a year previously

14   and/or when they were dentate.

15   In this study, answers regarding the brushing of teeth were categorized as

16   frequent ($\geq$ twice a day) vs. infrequent (< twice a day). As for immediate brushing

17   teeth after a meal, participants were classified as "often" if they responded with

18   "usually" or "frequently", or "seldom" if they responded with "never" or

19   "sometimes". For using dental floss, responses were classified as "often" if dental

20   floss was used to clean interdental spaces $\geq$ once a day, or "seldom" if the

21   respondents' answer was "never" or "sometimes." Regarding visits to dentists,

22   participants were classified as "regular" if they visited dentists and underwent scaling

23   every 6 months, or "irregular" if they responded "never" or "sometimes." For

24   questions "Do you smoke cigarettes or drink alcohol?", participants were classified as

25   "none or formerly" if they had never engaged in these behaviors or had stopped

1   doing so for the past year, or as "current users." Regarding five groups of nutrition

2   intake, the response was considered "balanced" if the respondents usually or always

3   had five groups of nutrition (i.e., meat, milk, grains, vegetables, and fruit) each day, or

4   "unbalanced" if they never or sometimes had these foods. In terms of water intake,

5   answers were categorized as sufficient ($\geq$ 1500 mL per day) vs. insufficient (< 1500

6   mL per day). Participants, especially those intellectual and hearing disabled, were

7   guided to reply their habits through visual aids, samples, progressive interactions, and

8   caregivers' confirmations when necessary.

9   3. *Background information:* Background information comprised three

10   sections. First, demographic variables obtained from the questionnaires, including

11   age, gender, and educational attainment (years of education received, or level of

12   school completed). Second, prevalence of the three common chronic diseases (i.e.,

13   hypertension, diabetes mellitus, and hyperlipidemia). The three diseases were

14   assessed using a medical history (diagnosed by a physician) and/or physiological

15   biomarkers, including blood pressure (BP), fasting blood glucose (FBG), triglyceride

16   (TG), total cholesterol (TC), low-density lipoprotein (LDL) cholesterol, and

17   high-density lipoprotein (HDL) cholesterol levels. Following the national standard of

18   the Ministry of Health and Welfare,[30] blood samples were evaluated and BP was

19   measured at the time of the study, applying standard procedures. The three common

20   chronic diseases were defined as (1) diabetes mellitus (FBG $\geq$126 mg/dL, or if ever

21   diagnosed by a doctor); (2) hypertension (systolic/diastolic BP $\geq$140/90 mmHg, or if

22   ever diagnosed by a doctor); and (3) hyperlipidemia (LDL $\geq$160 mg/dL, TC $\geq$240

23   mg/dL, TG $\geq$200 mg/dL, or if ever diagnosed by a doctor). Third, disability

24   classification and capability of activity of daily living (ADL). Primary disabilities,

25   such as physical, hearing, vision, or intellectual disabilities, were identified and

1   confirmed by the certificates issued by the Taiwan government[26] prior to the

2   interviews. ADL capability, judged using the Barthel ADL Index of feeding,

3   grooming, bathing, mobility, toilet use, transfer, etc., reflected the dependence level of

4   participants who required external assistance to complete these activities.

5   "Independent" was coded if external assistance was unnecessary, or "dependent" if it

6   was needed.

7   **Procedures and ethical considerations**

8   This study was approved by the relevant institutional review board of Chang

9   Gung Memorial Hospital (IRB 102-3331B), and all procedures complied with the

10   ethical guidelines. Participants were invited to participate in the study via letters sent

11   by the public health nurses, and were fully informed about the purposes of the study.

12   The letter emphasized the confidentiality of all collected data. Written consent forms

13   were appropriately explained to and signed by participants and/or their guardians

14   before arranging free medical evaluations. These evaluations, including blood

15   sampling and physical check-ups, were conducted by the local hospital staff on a

16   weekend, in a school auditorium, followed by individual interviews. To create a

17   caring and friendly environment, each participant was accompanied by a community

18   volunteer during the health screenings. If a participant was not an effective responder,

19   a familiar caregiver, who was normally a family member(s) with whom they were

20   living, was allowed to represent the participant in answering the questions.

21   The NRT was calculated carefully by research assistants who were trained by a

22   research team that including the investigators and a dentist. Details of the interviews

23   and measurement procedures have been reported in our previous study.[10] Face and

24   content validity of the instrument were judged to be good (0.88–0.91) by a panel of

25   five experts: a faculty member in public health and health education, a dentist, social

1   worker in a disabled institution, and two nursing faculty members who specialize in

2   the field of long-term care.

3   **Statistical analyses**

4   Quantitative data were analyzed using SPSS v. 22.0 software. Descriptive

5   statistical data are presented as numbers and percentages for categorical variables, and

6   as means ± standard deviations for continuous variables. Chi-square tests for

7   categorical variables, as univariate analyses, were performed to compare those in the

8   edentulous (NRT = 0), less-dentate (NRT = 1-19), and more-dentate (NRT $\geq$ 20)

9   groups in terms of their background information and oral health behaviors. Stepwise

10   logistic regression analyses, for identifying the modifiable factors associated with

11   having fewer teeth (NRT < 20), were conducted in three models. The first model,

12   model 1, a crude model without adjustment, was used to examine the associations

13   between exposures and NRT < 20. The second, model 2, was partially adjusted, for

14   three irreversible confounding factors, including age, gender, and education. The third,

15   model 3, was fully adjusted for all exposures in the current study. For models 2 and 3,

16   multivariable logistic regression analysis with a forward variable entry method (entry

17   criteria: p-value < 0.05 in univariate analysis) was implemented. The odds ratio (OR)

18   with 95% confidence interval (CI) and corresponding p-value were obtained by

19   logistic regression model. All statistical assessments adopted two-tailed tests, and the

20   p-value cut-off point for statistical significance was set as 0.05.

21   **RESULTS**

22   Of the 603 individuals invited to participate in the study, 549 participants were

23   enrolled in this analysis, but 18 failed to complete the NRT measurement. The

24   response rate was therefore 91%. The majority of the participants were male (54.3%),

25   aged 20−80 years (mean age 58.8 ± 13.9), and were not well-educated (educational

1 attainment ≤ 9 years: 67.4%). The distribution of disabilities by type was: physical

2 (55.9%), intellectual (19.7%), hearing (15.7%), and vision (8.7%). Most participants

3 (88.7%) did not require assistance in the activities of daily living (ADL), as they only

4 had a mild degree of disability. In addition, the prevalence rates of hypertension,

5 hyperlipidemia, and diabetes mellitus were 56.5%, 49.9%, and 23.9%, respectively.

6 Moreover, chi-square tests results indicated that participants who were of older age,

7 had lower education, and had histories of hypertension and/or diabetes had

8 significantly greater likelihoods of having fewer teeth and/or edentulous (Table 1).

9

10 Table 1. Background information of the subjects, according to dentition status

	Dentate[†]		Edentulous[†]	
	NRT: ≥20	NRT: 1-19	NRT: 0	Total
Variables	(n=293)	(n=165)	(n=73)	(n=549)
Age (years)[*]	53.8±13.3	63.1±12.4	69.5±8.1	58.8±13.9
<65	228 (77.8)	81 (49.1)	13 (17.8)	331 (60.3)
≥65	65 (22.2)	84 (50.9)	60 (82.2)	218 (39.7)
Gender				
Female	123 (42.0)	83 (50.3)	38 (52.1)	251 (45.7)
Male	170 (58.0)	82 (49.7)	35 (47.9)	298 (54.3)
Educational attainment[*]				
>9 years	132 (45.1)	37 (22.4)	6 (8.2)	179 (32.6)
≤9 years	161 (54.9)	128 (77.6)	67 (91.8)	370 (67.4)
Hypertension[*]				
No	154 (52.6)	54 (32.7)	23 (31.5)	239 (43.5)
Yes	139 (47.4)	111 (67.3)	50 (68.5)	310 (56.5)
Diabetes mellitus[*]				
No	235 (80.2)	121 (73.3)	47 (64.4)	418 (76.1)
Yes	58 (19.8)	44 (26.7)	26 (35.6)	131 (23.9)
Hyperlipidemia				
No	138 (47.1)	88 (53.3)	37 (50.7)	275 (50.1)
Yes	155 (52.9)	77 (46.7)	36 (49.3)	274 (49.9)
Disability classification				

Physical disability	166 (56.7)	93 (56.4)	38 (52.1)	307 (55.9)
Intellectual disability	64 (21.8)	32 (19.4)	8 (11.0)	108 (19.7)
Hearing impairment	44 (15.0)	22 (13.3)	17 (23.3)	86 (15.7)
Vision impairment	19 (6.2)	18 (10.9)	10 (13.7)	48 (8.7)
Capability of ADL[†]				
Independent	263 (89.8)	148 (89.7)	32 (84.9)	486 (88.7)
Dependent	30 (10.2)	17 (10.3)	11 (15.1)	62 (11.3)

1   Data are expressed as numbers (percentages) or means ± SD. NRT, number of remaining teeth; ADL,

2   activities of daily living. [*] $p < 0.05$ derived from χ^2 tests. [†]Missing data: 1 in ADL, 18 in NRT.

3

4   As shown in Table 2, the participants had fewer teeth (mean NRT 18.1 ± 10.9;

5   median 21.0; NRT < 20: 44.8%; NRT = 0: 13.7%), and had poor oral hygiene (seldom

6   dental floss: 83.4%; irregular dental visit: 78.0%; seldom brushed teeth after meal:

7   77.4%; daily teeth brushing: 1.8 ± 0.9 times). They also had other unfavorable

8   behaviors (insufficient water intake/unbalanced nutrition: 40.3%; smoking: 25.3%;

9   drinking alcohol: 16.2%). Chi-square test results showed that participants with the

10 characteristics of rare dental floss use, irregular dentist visits, or unbalanced nutrition,

11 had a significantly higher prevalence of having fewer and/or no teeth.

12

13 Table 2. Number of remaining teeth and oral health behaviors according to dentition status

	Dentate[†]		Edentulous[†]	
	NRT: ≥20	NRT: 1-19	NRT: 0	Total
Variables[#]	(n=293)	(n=165)	(n=73)	(n = 549)
Group of NRT (n=531)[†]	26.7 ±3.7(27.0)	10.8±5.5 (12.0)	-	18.1 ± 10.9 (21.0)
0				73 (13.7)
1-19				165 (31.1)
≥20				293 (55.2)
Oral hygiene				
Times of daily brushing teeth				1.8 ± 0.9
Frequent (≥ 2 times)	204 (69.5)	116 (70.3)	44 (60.3)	372 (67.8)
Infrequent (< 2 times)	89 (30.4)	49 (29.7)	29 (39.7)	177 (32.2)

Brushing teeth after meal				
Often	62 (21.2)	37 (22.4)	22 (30.1)	124 (22.6)
Seldom	231 (78.8)	128 (77.6)	51 (69.9)	425 (77.4)
Using dental floss[*]				
Often (≥ once a day)	67 (22.9)	17 (10.3)	7 (9.6)	91 (16.6)
Seldom (< once a day)	226 (77.1)	148 (89.7)	66 (90.4)	458 (83.4)
Visiting dentist per 6 months[*]				
Regular	73 (24.9)	38 (23.0)	7 (9.6)	121 (22.0)
Irregular	220 (75.1)	127 (77.0)	66 (90.4)	428 (78.0)
Water intake per day				
Sufficient (≥ 1500 ml)	186 (63.5)	98 (59.4)	35 (47.9)	328 (59.7)
Insufficient (< 1500 ml)	107 (36.5)	67 (40.6)	38 (52.1)	221 (40.3)
Five nutrition groups per day[*]				
Balanced	191 (65.2)	84 (50.9)	47 (64.4)	328 (59.7)
Unbalanced	102 (34.8)	81 (49.1)	26 (35.6)	221 (40.3)
Smoking habit				
Never or formerly	218 (74.4)	126 (76.4)	53 (72.6)	410 (74.7)
Current users	75 (25.6)	39 (23.6)	20 (27.4)	139 (25.3)
Alcohol habit				
Never or formerly	245 (83.6)	139 (84.2)	63 (86.3)	460 (83.8)
Current users	48 (15.4)	26 (15.8)	10 (13.7)	89 (16.2)

1 Data are expressed as numbers (percentages) or means ± SD (medians). NRT, number of remaining

2 teeth. [#] All variables except NRT asked the edentulous subjects to recall their behaviors when dentate.

3 [*] $p < 0.05$ derived from χ^2 tests. [†]18 missing data.

4

5   Regarding Table 3, after adjusting for all exposures (in model 3), the intellectual

6 disability group had a significantly higher possibility of an NRT < 20 than the

7 physical disability group (OR: 2.30, 95% CI: 1.30–4.08), while the risk of an NRT <

8 20 in the other two subgroups were not increased. From the results of three models,

9 i.e., model 1, model 2, and model 3, the demographic variables seemed to confound

10 an NRT < 20 associated with disability classifications. The other modifiable factors

11 associated with an NRT < 20 were the rare use of dental floss (OR: 2.12–2.64, 95%

12 CI: 1.21–4.37) and a history of hypertension (OR: 1.61–2.32, 95% CI: 1.09–3.31).

14

1   To exempt the risk of over adjustment, further analyses of correlations between

2   three variables of hypertension, diabetes and hyperlipidemia were done as they are

3   common comorbidities. Results showed lower correlations were identified (r =

4   0.11−0.16, p > 0.05, not shown in tables) that they did not influence the model 3.

5

6   Table 3. Odds ratios (95% CI) of the factors associated with NRT < 20 (n = 531[†])

Variables/ Values	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Age (years)	1.08 (1.06-1.09)[*]	1.07 (1.05-1.08)[*]	1.07 (1.05-1.10)[*]
Gender			
Female[¶]			
Male	0.70 (0.50-0.99)[*]	§	§
Educational attainment			
> 9 years[¶]			
≤ 9 years	3.72 (2.49-5.56)[*]	2.01 (1.28-3.14)[*]	1.96 (1.23-3.10)[*]
Hypertension			
No[¶]	-	-	-
Yes	2.32 (1.62-3.31)[*]	1.61 (1.09-2.39)[*]	1.73 (1.15-2.60)[*]
Diabetes mellitus			
No[¶]	-	-	-
Yes	1.69 (1.13-2.52)[*]	§	§
Hyperlipidemia			
No[¶]	-	-	-
Yes	0.81 (0.57-1.13)	§	§
Disability classification			
Physical disability[¶]	-	-	-
Intellectual disability	0.79 (0.50-1.25)	2.20 (1.26-3.84)[*]	2.30 (1.30-4.08)[*]
Hearing impairment	1.12 (0.69-1.83)	0.76 (0.44-1.32)	0.75 (0.43-1.32)
Vision impairment	1.87 (0.99-3.49)	1.54 (0.75-3.13)	1.48 (0.72-3.04)
Capability of ADL			
Independent[¶]	-	-	-
Dependent	1.17 (0.68-2.02)	§	§
Oral health behaviors[#]			
Daily brushing teeth			

15

Frequent[¶]	-	-	-
Infrequent	1.12 (0.77-1.61)	§	§
Using dental floss			
Often[¶]	-	-	-
Seldom	2.64 (1.60-4.37)[*]	2.22 (1.28-3.83)[*]	2.12 (1.21-3.71)[*]
Visiting dentist			
Regular[¶]	-	-	-
Irregular	1.42 (0.94-2.16)	§	§
Water intake			
Sufficient[¶]	-	-	-
Insufficient	1.37 (0.97-1.95)	§	§
Five nutrition groups per day			
Balanced[¶]	-	-	-
Unbalanced	1.53 (1.08-2.17)[*]	1.58(1.07-2.34)[*]	§
Smoking habit			
Never or formerly[¶]	-	-	-
Current users	0.96 (0.65-1.42)	§	§
Alcohol habit			
Never or formerly[¶]	-	-	
Current users	0.91 (0.57-1.46)	§	§

1 NRT, number of remaining teeth; ADL, activities of daily living; OR, odds ratio; CI, confidence

2 interval. Model 1: crude; model 2: adjusted for age, gender, and education; model 3: model 2 + all

3 variables in Table 3. [†]18 missing data. [*]p value <0.05. [#] Variables reflects edentulous subjects' recall of

4 their behaviors when dentate. [¶]Reference group. §: Variables were not selected into the model.

5

6

1 **DISCUSSION**

2   This study featured a nurse-led health program aimed at promoting the oral

3 health of disabled individuals. Four key findings emerged: first, fewer teeth were

4 counted and there was a higher prevalence of an NRT < 20 and edentulism in the

5 present study population than in those reported in the existing literature. According to

6 previous research, the average NRT for non-disabled people is approximately 25,[10]

7 and only 16% of these individuals have an NRT < 20.[2, 10] However, in this study, the

8 average NRT in disabled individuals was 18.1, and 44.8% had an NRT < 20, which

9 indicated a significantly worse oral health condition. Even when ruling out the

10 edentulous, the average NRT was 20.9 and prevalence of NRT < 20 was 36% among

11 the dentate subgroup. The slight changes in the statistics from 18.1 to 20.9 and 44.8%

12 to 36% do not indicate a change in the trend. The literature supports the view that

13 adults with disabilities commonly exhibit poor oral hygiene and have a lower NRT

14 than non-disabled people, owing to their limited capabilities, in terms of cognitive

15 comprehension, body coordination, or muscle power.[11, 19] In fact, the prevalence of an

16 NRT < 20 in this study was not only higher than the figures previously reported for

17 non-disabled people, but was also higher than that reported in a Belgian study of

18 people with disabilities (33%).[2] Moreover, the edentulous rate of 13.7% found in this

19 study was also higher than the edentulous rate of 8.9% reported by a study conducted

20 in the USA.[16]

21   Second, most disabled participants reported having inadequate oral hygiene

22 behaviors in general. These behaviors, including seldom using dental floss, irregular

23 dental visits and scaling, and rarely brushing teeth after meals, were factors associated

24 with tooth loss in previous reports,[1, 7-8] and may also affect other systemic diseases.[5]

25 The prevalence of these behaviors in this study was 83.4%, 78%, and 77.4%,

1 respectively, which was much higher than in the non-disabled population (about

2 28−70%);[7, 10, 15-17] and were also greater than those in disabled individuals in other

3 countries (29−51%).[16, 24] Particularly, those who were edentulous had worse oral

4 hygiene behaviors than those who were dentate. Although irregular dental visits were

5 not a significant factor for an NRT < 20 in the current study, most previous studies

6 indicated the importance of regular dental care.[1-2, 31-32] To encourage regular dental

7 care, the Taiwanese government has provided incentives under the NHI system, by

8 requiring only payment of a registration and copayment fee, for use of oral health

9 services by the disabled.[28] However, individuals with disabilities typically do not visit

10 dentists until their dental problems become too serious to be treated, and tooth

11 extraction is often unavoidable. The issue of regular dental visits to help maintain a

12 greater number of teeth in the disabled should be explored in future.

13 Third, adults with intellectual disability have an increased possibility of having an

14 NRT < 20. In this study, the extreme case, i.e., edentulous, showed a prevalence of

15 7.7% among those with intellectual disability, which was lower than that reported in

16 the USA (10.9%).[22] In comparison with those with physical disability, the subgroup of

17 individuals with intellectual disabilities had a higher likelihood of having fewer teeth,

18 which is consistent with the findings of previous studies.[2,9,18,22] Lindsay[33] attributes

19 this phenomenon to their preferences for eating desserts, sweets, and drinking soft

20 drinks; similarly, their reduced capacity for self-control owing to their cognitive

21 impairments could also modulate this effect. These individuals often are not fully

22 capable of independent self-care, and their caregivers may find it difficult to perform

23 oral hygiene activities for them over the long term. In addition, adults with

24 developmental disabilities often appear to have disorders, such as gastro-esophageal

25 reflux disease, excessive salivation, and induced xerostomia triggered by antiepileptic

1   medications, which could increase the possibility of poor oral health.

2   Fourth, the use of dental floss is a modifiable factor associated with the NRT.

3   Except for intellectual disabilities, other associated factors, such as the rare use of

4   dental floss and hypertension[1, 10, 13] are similar to the factors associated with NRT in

5   non-disabled individuals. Among these, dental floss use is the most malleable

6   component that can be addressed by instruction from public health practitioners. This

7   study found that most disabled adults (77.4%) lacked the habit of cleaning teeth after

8   meals, and brushed their teeth less often than twice a day. The practice of dental

9   flossing may be a complementary oral hygiene step that can help to maintain the NRT.

10   A previous systematic review has confirmed that brushing and flossing can

11   significantly reduce plaque and gingivitis as compared with tooth brushing alone.[14]

12   It is the presence of dental plaque and food debris in the crevices between the

13   teeth that encourage bacteria to flourish, activating the inflammatory response and the

14   innate immune system in the human body. These bacteria induce swelling and

15   bleeding of the gums, the destruction of periodontal tissues and alveolar bones, and

16   the promotion of tooth mobility; thus, ultimately causing tooth loss.[34-35] The findings

17   from some systematic reviews suggest that oral hygiene methods, such as tooth

18   brushing, dental flossing, and/or interdental brushing are all effective means of

19   eliminating the periodontal pathogens thriving in the buccal cavity[14, 36]and even in the

20   blood.[37]

21   However, people with disabilities may have difficulties flossing, due to

22   disability-related issues with self-control, movement coordination, comprehension,

23   etc., although nearly 90% of them in this study were categorized as having basic

24   self-care ability in terms of ADL. Adopting a habit of dental flossing, and accuracy

25   and thoroughness of dental cleaning processes, may even be demanding for some

1 non-disabled people, as well as for adults with disabilities. The assistance of

2 interdental brushing, which is recognized as an easier and more effective method for

3 reducing peridontal pathogens, [36] can also be considered as an alternative approach.

4   To address the problem of NRT < 20, oral hygiene instruction, a commonly used

5 clinical technique, is imperative for improving oral hygiene. Since disabled adults

6 may not cope with regular dental visits and examinations, integration of preventive

7 and corrective oral health in their lives is highly beneficial.[31] Routine daily teeth

8 cleaning is undoubtedly the most economic and convenient approach to ensure oral

9 health. It can also reduce the fear of individuals with disabilities about accessing oral

10 health services, and even shorten the scaling time required.[38] Unfortunately, previous

11 studies have demonstrated that community-dwelling individuals with disabilities have

12 worse oral health than those living in institutions.[22, 39] Since these participants were

13 living at home with relatives, their families were generally more concerned with

14 physiological diseases than with oral conditions, and were not aware of the

15 importance of oral hygiene. Teeth cleaning was also typically perceived as the

16 individuals' own responsibility, as these disabled people generally seemed to be

17 capable of managing the task. However, they had a higher prevalence of an NRT < 20,

18 which may imply that even if the participants had basic self-care ability, it does not

19 mean that they are capable of achieving good quality oral hygiene. Their families

20 sometimes opted to ignore these "trivial" matters, as they were already exhausted by

21 the burden of care. Consequently, without professional guidance and tracking, daily

22 cleaning of the teeth becomes a difficult task for community-based people with

23 disabilities. A systematic review has concluded that additional oral hygiene instruction

24 could help cultivate a higher quality of oral health behaviors; thus, ameliorating

25 gingivitis and eradicating dental plaque.[32]

1   As many researchers claim that good oral health can improve almost every

2 aspect of life, from overall health to self-esteem, communication, nutrition, quality of

3 life, savings in medical expenses, and finding employment, for people with

4 disabilities, in addition to relieving the burden on their care givers.[17, 40] To achieve the

5 oral health goal of 8020,[3] more resources and attention should be invested to provide

6 good oral care, matched to the individual's disability characteristics. Further

7 integration of the social welfare networks, oral hygiene instructions, and coordination

8 of medical professionals and caregivers for adults with disabilities are recommended.

9 **Limitations**

10   This study has some limitations. First, the participants' oral conditions were

11 examined by research assistants, rather than by qualified dentists, due to constraints

12 on the participants' cooperation and expectations. Only superficial features, such as

13 the remaining number of natural and filled teeth were investigated; other thorough

14 evaluations, such as those of caries and periodontal tissues, were not performed. Thus,

15 potential oral problems may have been ignored or underestimated by the NRT figures

16 reported here. Second, some selection bias may have been involved as the criteria for

17 inclusion included the ability to travel from home to the nearby school where the

18 examinations were conducted. The participants were mostly categorized as having

19 mild disabilities, with limited variation. Their oral health conditions should thus be

20 presumed to be generally better than those of individuals with more severe

21 disabilities,[27] who were not included in this survey. The real situation of oral health

22 for adults with disabilities may thus be even worse than that indicated by this study.

23 Third, the self-reporting health behaviors questionnaire might trigger socially desired

24 behaviors from participants implicitly directed by the research and/or researchers.

25 Fourth, the participants were conveniently recruited from one location, rather than by

1 nationwide cluster sampling. The generalizability of the study results may therefore

2 be limited. Finally, the cross-sectional study design has an inherent limitation in terms

3 of investigating the causal inferences between variables. As it is a snapshot of a

4 specific moment, the cross-sectional design did not track variables over a period of

5 time to gain insight into the process. To address this limitation, we asked participants

6 to recall their oral health behavior over the past year and/or when they were dentate.

7 However, the recall process might generate another bias due to poor memory recall.

8 **CONCLUSION**

9   For community-dwelling individuals with disabilities, the prevalence of an NRT

10 < 20 and edentulism were significantly greater than that reported in previous studies.

11 Poor oral hygiene behaviors were identified as being a general characteristic of the

12 participants. Adults with intellectual disability had a greater likelihood of tooth loss.

13 The other two modifiable factors strongly associated with an NRT < 20 were the habit

14 of seldom using dental floss and hypertension. As oral hygiene instructions are the

15 least expensive and easiest way of integrating preventative intervention options for

16 chronic diseases into daily activities, professionals should concentrate on this

17 approach for individuals with disabilities and attempt to enhance their teeth cleaning

18 awareness and capabilities. Finally, to satisfy the oral health needs of

19 community-dwelling adults with disabilities, issues such as the risk factors associated

20 with different types of disabilities, regular dental visits, and their special needs can be

21 further explored.

22 **Conflict of interest**

23 The authors declare that they have no competing interests.

24 **Authors' contributions**

25 MYP and TCH: designing the study, collecting and analyzing data, and drafting the

1   paper. HCT and YCL: proofreading and revising the manuscripts. MYC: initializing,

2   conceptualizing, and supervising the research process. All authors have read and

3   approved the final manuscript.

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9   148).

10   **Patient consent**

11   Obtained

12   **Ethics approval**

13   This study was approved by the institutional review board of the ethical committee of

14   Chang Gung Memorial Hospital (IRB 102-3331B)

15   **Data sharing statement** No additional data are available.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	p1−3	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	P4−5	Explain the scientific background and rationale for the investigation being reported
Objectives	p5	State specific objectives, including any prespecified hypotheses
Methods		
Study design	P6	Present key elements of study design early in the paper
Setting	P6	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	P6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
		Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	P6−8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	P6-8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias		Describe any efforts to address potential sources of bias
Study size		Explain how the study size was arrived at
Quantitative variables	P6-8	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	P9−10	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		Case-control study—If applicable, explain how matching of cases and controls was addressed
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results

Participants	P10	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	P10−11	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	P12-13	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	p13-16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses		Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	p16−20	Summarise key results with reference to study objectives
Limitations	P20	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	p16−20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	P22	Discuss the generalisability (external validity) of the study results

Other information

Funding	P22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.