Reported gum disease as a cardiovascular risk factor in adults with intellectual disability

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Abstract

Background Several risk factors for cardiovascular disease (CVD) have been identified among adults with intellectual disabilities (ID). Periodontitis has been reported to increase the risk of developing a cardiovascular disease in the general population. Given that individuals with ID have been reported to have a higher prevalence of poor oral health than the general population, the purpose of this study was to determine whether adults with ID with **informant reported** gum disease present greater reported CVD than those who do not have **reported** gum disease and whether gum disease can be considered a risk factor for CVD.

Methods Using baseline data from the Longitudinal Health and Intellectual Disability Study (LHIDS) **from which informant survey data were collected**, 128 participants with reported gum disease and 1,252 subjects without gum disease were identified. A series of univariate logistic regressions was conducted to identify potential confounding factors for a multiple logistic regression.

Results The series of univariate logistic regressions identified age, Down syndrome, hypercholesterolemia, hypertension, reported gum disease, daily consumption of fruits and vegetables, and the addition of table salt as significant risk factors for reported CVD. When the significant factors from the univariate logistic regression were included in the **multiple** logistic analysis, **reported** gum disease remained as an independent risk factor for reported CVD after adjusting for the remaining risk factors. Compared to the adults with ID without reported gum disease, adults in the gum disease group demonstrated a significantly higher prevalence of reported CVD (19.5% vs. 9.7%; p =.001).

Conclusion: After controlling for other risk factors, reported gum disease among adults with ID may be associated with a higher risk of CVD. However, **further research that also includes clinical indices of periodontal disease and CVD for this population is needed to determine if there is a causal relationship between gum disease and CVD.**

Cardiovascular disease (CVD) or "heart disease" has become increasingly common over the past few decades. The term CVD refers to several types of heart conditions including coronary heart disease, stroke, hypertensive heart disease, coronary artery disease, congenital heart disease, rheumatic heart disease, etc. According to the American Heart Association, atherosclerotic vascular disease, a form of CVD, is the leading cause of death around the world; in the United States, the disease accounts for about 1 in 3 deaths (Lockhart et al., 2012; WHO, 2016). This rise in CVD may be attributed to increased life expectancy coupled with worsening diet and exercise habits (Persson & Persson, 2008). Studies have shown that adults with intellectual disabilities (ID) exhibit a similar, if not higher, prevalence of CVD than the general population (Janicki et al., 2002; Morin, Mérineau-Côté, Ouellette-Kuntz, Tassé, & Kerr, 2012). In fact, CVD is now the leading cause of death for people with ID (Hsieh, Heller, & Miller, 2001; Janicki et al., 2002; Kung, Hoyert, Xu, & Murphy, 2008; Patja, Molsa, & Iivanainen, 2001).

Many studies have been conducted to determine risk factors for CVD. Studies of the general population have not only identified risk factors for CVD (e.g., family history of CVD, obesity, hypertension, diabetes, metabolic syndrome, high total cholesterol, poor diet, low physical activity, smoking), but also demonstrated the beneficial effects of specific preventive measures (e.g., healthy lifestyle choices) in lowering the risk and burden of CVD (Stampfer, 2000; Terry et al., 2005; Wayne et al., 2008; Winkleby & Cubbin, 2004). In 2004, INTERHEART, a large, wide-sweeping case-control study spanning 52 countries, found that over 90 percent of attributable risks for coronary heart disease could be reduced to nine potentially modifiable factors (i.e., abnormal lipids, smoking, hypertension, abdominal obesity,

psychosocial factors, low fruit and vegetable consumption, alcohol, and physical inactivity) (Yusuf et al., 2004).

Analogous risk factors for CVD have been found across the general and ID populations although prevalence varies across the two groups. The assessment of these factors in adults with ID reveals lower prevalence rates of smoking and alcohol consumption than in the general population, but higher rates of obesity, poor diet, and physical inactivity (Bhaumik, Watson, Thorp, Tyrer, & McGrother, 2008; Draheim, Stanish, Williams, & McCubbin, 2007; Hsieh, Rimmer, & Heller, 2014). With regard to metabolic syndrome as a risk factor for CVD, a Dutch study reported a higher prevalence rate in Dutch women with ID aged 50-70 than in older Dutch women without ID. However, the same study found that Dutch men with ID aged 50-70 had a lower rate of metabolic syndrome than men in the general older Dutch population (de Winter, Bastiaanse, Hilgenkamp, Evenhuis, & Echteld, 2012).

Over the past three decades, there has been a growing interest in assessing whether an association between CVD and severe periodontal (gum) diseases exists. The implication of chronic inflammation—a symptom of periodontal disease—in the etiology of CVD provoked the hypothesis and has provided a large impetus for research in this area (Berkey & Scannapieco, 2013; Humphrey, Fu, Buckley, Freeman, & Helfand, 2008; Johansson, Ravald, Pagonis, & Richter, 2013; Persson & Persson, 2008; Renvert, Ohlsson, Pettersson, & Persson, 2010; Ridker, Hennekens, Buring, & Rifai, 2000). Thus far, the results are mixed and the association is still not well understood. Meta-analyses in the area reveal that there have been a wide range of studies conducted: case-control, cross-sectional, and longitudinal (Beck & Offenbacher, 2005; Meurman, Sanz, & Janket, 2004). Some of these studies claim association, whereas others report statistically insignificant correlations and point to inconclusive evidence. Inconsistent findings

may be in part due to broad definitions of both CVD—a term encompassing a spectrum of disease including stroke, myocardial infarction, and coronary heart disease—and periodontal disease (Bahekar, Singh, Saha, Molnar, & Arora, 2007; Beck & Offenbacher, 2005; Meurman et al., 2004; Persson & Persson, 2008). Other factors could include the relatively small quantity of studies exploring the association between CVD and periodontal disease (Bahekar et al., 2007; Humphrey et al., 2008; Meurman et al., 2004; Mustapha, Debrey, Oladubu, & Ugarte, 2007) and insufficient adjustment for confounding factors given the multifactorial nature of CVD (Bahekar et al., 2007; Humphrey et al., 2008; Meurman et al., 2004). **The most recent review demonstrates an association between periodontal disease and CVD and beneficial outcomes of periodontal treatment by reducing the risk of CVD (Holmstrup et al., 2017).**

Some studies have suggested a linkage between periodontitis and hypertension (Borges-Yanez, Irigoyen-Camacho, & Maupome, 2006; Inoue, Kobayashi, Hanamura, & Toyokawa, 2005). Periodontitis and hypertension share common risk factors, such as increasing age, smoking, stress and socio-economic status (Inoue et al., 2005). Hence, the presence of hypertension should be taken into account while examining the link between CVD and periodontal disease. Additionally, changes in the serum cholesterol levels of some patients have been attributed to severe periodontitis. It has been suggested that the inflammation due to periodontitis has a potential effect on lipid metabolism (D'Aiuto et al., 2006).

Evidence shows that individuals with ID not only have poorer oral hygiene, but also higher prevalence and severity of periodontal disease than the general population. One recent study which reviewed 4,732 dental records of adults 20 years or older with intellectual and developmental disabilities found 80.3% had periodontitis (Morgan et al., 2012). There is a long established association between Down syndrome and gum disease (Frydman & Nowzari, 2012;

Khocht et al., 2012; Komatsu et al., 2013; Tanaka et al., 2012), and adults with Down syndrome are more susceptible to periodontitis leading to periodontitis-associated interproximal bone loss than adults without Down syndrome (Frydman & Nowzari, 2012; Khocht et al., 2012). One of the suggested factors leading to the clinical features of Down syndrome is high oxidative stress (Komatsu et al., 2013). **A systematic review confirmed individuals with ID had poorer oral hygiene, higher rates and greater severity of periodontal disease, and higher rates of untreated caries although rates of caries were no different as the general population (Anders & Davis, 2010). Therefore, there is a need to further examine oral hygiene practices and use of oral health services.**

Despite a high rate of gum disease among adults with ID, no existing studies have investigated the association between gum disease and CVD. Our study sought to shed some light on this research gap. The purpose of the present study was **trifold**: **(1) to investigate the oral practices and receipt of oral health services, (2)** to compare the prevalence of **reported** CVD between those with and without **reported** gum disease in adults with ID aged 18 and over, and **(3)** to determine the association between **reported** gum disease and **reported** CVD after adjusting for cardiovascular risk factors identified in other studies (e.g., age, gender, Down syndrome, hypertension, hypercholesterolemia, diabetes, chronic bronchitis/emphysema, obesity smoking, diet, and physical activity).

Methods

Procedure

This study used baseline data from a large-scale study entitled *Longitudinal Health and Intellectual Disability Study* (Hsieh, Rimmer, & Heller, 2012). Adults with ID (aged 18 and older) were recruited through various organizations (e.g., Special Olympics, Easter Seals, The

Arc, and managed care organizations in the Midwest) across all 50 states in the United States from March 2010 to January 2011. **Inclusion in the study was limited to key informants of adults with ID who were 18 years and older. Key informants of adults with ID under 18 years were not included in the study**. Fifty-four percent participants were from the Midwest, followed by 17.8% from the South, 6.2% from the West, and 21.1% from the Northeast. Informants (e.g., caregivers, agency staff, residential staff, nurses, etc.) familiar with the adults with ID were invited to participate in the study as proxies to complete the survey. **Approximately 46% of informants were parents; 22% were healthcare providers/Managed Care Organization (MCO) staff; 13.5% were residential/day programme/social service staff; 8.3% were relatives; 3.8% were non-related live-in caregivers; less than 3% were others; and 4.9% did not report.** To broaden the participant sample, a mixed method (mail and online survey) data collection procedure was used. A total of 2,841 surveys were distributed (2,182 paper, 659 online) and 1,619 surveys were completed and returned (1,183 paper, 436 online) with an overall response rate of 56.9%. The response rate for paper surveys was 54%; the rate for the online survey was 66.2%. After excluding missing data for gum disease, a total sample of 1,380 was used for analysis. A full description of the survey development, study design, participant recruitment and description of the sample has been published elsewhere (Hsieh, et al., 2012).

Measures

The dependent variable in the present study was **reported** cardiovascular disease status. We asked the informants "Does he/she have a heart condition based on a diagnosis from a doctor?" Those who answered "Don't know" were excluded from the analysis. The variable was defined as 1 (yes) for heart condition and 0 (no) for no heart condition. In addition to the

presence of **reported** gum disease, the independent variables included a range of non-modifiable and modifiable personal risk factors described below.

Independent Variables

Non-modifiable Personal Factors

Demographic characteristics included age, sex, and Down syndrome. Age was divided into two groups (18-44; 45 and over). The level of ID was not included in the model because nearly 23% of informants—of which the majority were parents—did not know the participant's level of ID.

Modifiable Risk Factors

***Reported** gum disease.* We asked the informants "Does he/she have gum disease?" Those who answered "Don't know" were excluded from the analysis. The variable was defined as 1 (yes) for gum disease and 0 (no) for no gum disease. **Only four (3.1%) of those who reported having gum disease reported having no teeth, while 62 (5%) of those who did not report having gum disease reported having no teeth.**

Reported chronic health conditions. The following chronic conditions **that were reported by informants** based on a diagnosis from a doctor were also included**.** *Hypercholesterolemia, Hypertension, Diabetes, Chronic bronchitis/Emphysema.* All variables were coded as 1 (yes) or 0 (no).

Obesity. Obesity status was determined by Body Mass Index (BMI) as calculated using the formula: BMI = (Weight in Pounds / (Height in inches)^2) x 703. Obesity was defined as a BMI equal to or greater than 30 kg/m^2. Weight and height were informant reported.

Smoking. Smoking was defined as 1 (yes), for a current smoker and 0 (no) for a non-current smoker.

Physical activity. Physical activity was categorised into three groups: (1) never or rarely engages in any moderate or vigorous physical activity at least 30 minutes a week, (2) engages in some level of moderate and/or vigorous physical activity, and (3) meets physical activity guidelines for Americans. According to the Physical Activity Guidelines for Americans (U.S. Department of Health and Human Services, 2008), adults with disabilities who are able to should get 150 minutes of moderate-intensity physical activity a week, 75 minutes of vigorous-intensity physical activity a week, or an equivalent combination of moderate and vigorous-intensity aerobic activity.

Fruit and vegetable daily intake. Fruit and vegetable daily intake was coded into three categories: 2 or fewer servings a day, 3-4 servings a day, and 5 or more servings a day.

High fat food daily consumption. High fat food daily consumption was coded into three categories: 2 or fewer servings a day, 3-4 servings a day, and 5 or more servings a day.

Addition of table salt to food. We asked "How often does he/she add table salt to his/her food?" The variable was coded into four categories: rarely/never, sometimes, most of the time, and all of the time.

Data Analysis

Descriptive statistics were used to examine the sample distribution of the prevalence of cardiovascular disease, and Chi-square tests were employed to examine group differences in distribution. A series of univariate logistic regression analyses was employed to select significant independent variables using a p-value ≤ 0.20 cutoff to be included for the final **multiple** logistic regression model. A **multiple** logistic regression was conducted to examine whether **reported** gum disease is an associated risk factor for **reported** CVD after adjusting for non-modifiable risk factors (**i.e.,** age and Down syndrome diagnosis) and modifiable personal risk factors (**i.e.,**

hypercholesterolemia, hypertension, chronic bronchitis/emphysema, daily consumption of fruit and vegetable intake, and the addition of table salt to food) that were significant in the univariate logistic regression. **In addition, we tested for significant collinearity using car (Comparison to Applied Regression) package 2.1-5, vif function in R 3.4.1 (R Core Team, 2017) to calculate Generalized Variance Inflation Factor (GVIF) among independent variables in the final model. The results show no significant collinearity with GVIF values ranging from 1.02 – 1.24 using a maximum GVIF value of 4 as a cutoff (Fox & Monette, 1992; Fox & Weisberg, 2011).** We also conducted the Hosmer and Lemeshow goodness-of-fit test to confirm that the final model is a good fit (p = .22) (Hosmer & Lemeshow, 1980; Hosmer & Lemeshow, 1989). A significance level at a p-value of .05 was used for all the analyses.

Results

Description of participants

Participant demographics are shown in Table 1. The mean age of participants was 37.1 years (SD = 14.35, range = 18-86 years; 69.9% between 18-44 years; 30.1% 45 years and older). There was a slightly higher percentage of males than females overall (55.4% vs. 44.6%). The overall prevalence of **reported** CVD was 10.7%. The mean body mass index (BMI) was 28.78 (SD = 7.37). Thirty-seven percent of participants were obese, approximately a quarter of participants had Down syndrome, and the majority of participants neither smoked (96.1%) nor met recommended amount of physical activity (77%). There were no group differences in age, BMI, obesity, Down syndrome diagnosis, and health risk behaviors, but Chi-square tests revealed significant differences between participants with and without reported gum disease in gender and smoking status. Participants with reported gum disease had a higher percentage of

females (56.3% vs. 43.5%), $X^2(1, N = 1381) = 7.70$, $p < .01$ and current smokers (7.9% vs. 3.5%), $X^2(1, N = 1381) = 5.78$, $p < .05$ than participants without gum disease.

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Insert Table 1

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As illustrated in Figure 1, there were 128 (9.3%) participants with reported gum disease and 1,252 (90.7%) without gum disease. The prevalence of gum disease was 8.4% for the age group 18-44 years and 11.3% for ages 45 years and older. Nearly one-fifth of the participants who had reported gum disease also had cardiovascular disease (19.5% or 25 participants). Of 1,252 participants without gum disease, 122 participants (or 9.7%) had **reported** CVD.

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Insert Figure 1

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Oral Hygiene Practices and Receipt of Dental Services

Among the 1,380 participants, 66 did not have teeth. Among those who had teeth, more than half (59.6%) brushed two or more times a day, 32.2% brushed one time a day, 6.6% brushed a few times a week, and 1.6% never or rarely brushed. Almost two-thirds (65.4%) of the participants with teeth never or rarely flossed their teeth, 18.1% flossed a few times a week, 12.2% flossed one time a day, and only 4.3% flossed two or more times a day. Over four-fifths (83.7%) of the participants with teeth got their teeth cleaned by a

dental hygienist or a dentist within a year; 1.3% never had their teeth cleaned. Only 12.3% of the participants with or without teeth used mouthwash two or more times a day, whereas more than half (54.5%) never or rarely used mouthwash, 13.4% used mouthwash a few times a week and 19.9% one time a day. Almost one-tenth (8.7%) of the participants had their teeth removed because of tooth decay or reported gum disease within the last year; less than 1% responded "don't know". More than four-fifths (81.3%) of the participants had dental insurance: 18% had prepaid dental insurance, 15.8% had Medicare and Medicaid, 5% had Medicare only, 4.9% had prepaid and Medicaid, 1.3% had prepaid or other dental insurance, and 1% had prepaid and Medicare. However, 18.7% of participants did not have dental insurance.

Comorbidities of reported gum disease

Table 2 compares the percentage of the comorbidities between participants with and without reported gum disease. Participants with reported gum disease had a higher percentage of diagnosis of cardiovascular disease (19.5% vs. 9.7%), $X^2(1, N = 1380) = 11.69$, $p < .01$ and hypercholesterolemia (19.5% vs. 13.1%), $X^2(1, N = 1381) = 4.07$, $p < .05$ than those without gum disease.

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Insert Table 2

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Univariate logistic regressions revealed that adults with ID with reported gum disease were 2.25 times more likely to have cardiovascular disease (*OR* = 2.25, 95% *CI* = 1.40 – 3.62) and 1.6

times more likely to have hypercholesterolemia (*OR* = 1.61, 95% *CI* = 1.01 – 2.57) than those who did not report gum disease.

Associated factors and cardiovascular disease

Table 3 presents the results of a series of univariate logistic regressions and Table 4 presents the results of the final model of **multiple** logistic regression. Significant variables using a p-value ≤ 0.20 cutoff from univariate logistic regressions included: age (*OR* = 1.45, 95% *CI* = 1.02 – 2.07), Down syndrome (*OR* = 2.57, 95% *CI* = 1.80 – 3.67), hypercholesterolemia (*OR* = 1.65, 95% *CI* = 1.06 – 2.56), hypertension (*OR* = 1.76, 95% *CI* = 1.13 – 2.74), chronic bronchitis/emphysema (*OR* = 2.44, 95% *CI* = 0.79 – 7.50), reported gum disease (*OR* = 2.25, 95% *CI* = 1.40 – 3.62), fruit and vegetable consumption of 5 or more servings a day (*OR* = 1.95, 95% *CI* = 1.13 – 3.36), and the addition of table salt to food sometimes (*OR* = 0.62, 95% *CI* = 0.38 – 1.00). These variables were included in the final multiple logistic regression model.

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Insert Table 3

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The results of a multiple logistic regression indicated the following variables were significant: Down syndrome (*OR* = 3.02, 95% *CI* = 2.06 – 4.44), hypertension (*OR* = 2.07, 95% *CI* = 1.24 – 3.44), and gum disease (*OR* = 2.11, 95% *CI* = 1.27 – 3.49). The findings show that having reported gum disease increases **is associated with higher rates of reported CVD** after controlling for other factors.

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Insert Table 4

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Discussion

We identified two significant comorbidities with **reported** gum disease—cardiovascular disease and hypercholesterolemia. **Reported** gum disease is **significantly associated with reported** CVD after accounting for age, Down syndrome, and hypertension. In our study sample, less than 10% of participants had **reported** gum disease which is much lower than the findings of other studies. In 2012, Morgan and colleagues used clinical data, reporting the prevalence of caries was 32% and 80% for periodontitis among adults with intellectual and developmental disabilities 20 years or older (Morgan et al., 2012). Using data from the National Health and Nutrition Examination Survey (2009-2010), Eke and colleagues reported an estimated prevalence of periodontal diseases of 47% in the U.S. population and an estimated prevalence of 70.1% for those older than 65 years (Eke, Dye, Wei, Thornton-Evans, & Genco, 2012). The present study relied on informant reports which might be underreported.

Although the literature on gum disease as a risk factor for CVD in people with ID is lacking, research focusing on the general population is more common. Thus far, the association between CVD and gum disease remains somewhat tenuous in the literature due in part to research design and definitional variance. Nonetheless, like many studies on the general population (Berkey & Scannapieco, 2013; Humphrey et al., 2008b; Persson & Persson, 2008; Renvert et al., 2010), we were able to establish a statistically significant association between **reported** gum disease and **reported** CVD. Our findings support the association between gum disease and CVD, enriching the current literature with a unique examination of the association as found in adults with ID. **However, caution is necessary when discussing the findings as gum**

disease in the present study is reported by informants and not based on medical records or clinical examination. Given the need for more research, our study is not only important to the ID community, but it will also be an important voice in the ongoing examination of the association between **clinically diagnosed** gum disease and **clinically reported** CVD.

The establishment of causation could lead to studies examining whether the successful treatment of gum disease could decrease the risk of cardiovascular disease (Beck & Offenbacher, 2005). Some biomarkers have been identified as risk indicators for cardiovascular events including: C-reactive protein (CRP), fibrinogen and serum alpha amyloid A, and proinflammatory cytokines such as IL-1beta, interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-alpha) (D'Aiuto et al., 2006; Offenbacher et al., 2009). Chronic inflammation, a symptom of periodontal disease, was implicated as a causal factor of CVD (Berkey & Scannapieco, 2013; Humphrey et al., 2008; Johansson et al., 2013). Severe periodontitis is associated with elevated inflammatory markers, though the nature of the association is undetermined. Some studies have shown that a decrease in these inflammatory markers, such as C-reactive Protein (CRP) and Interleukin-6 (IL-6) in response to periodontal therapy, contributed to a decrease in systemic inflammatory burden (D'Aiuto et al., 2004). Further research is required to understand the etiology of CVD and periodontal diseases and to establish causal relationships through definitive biochemical markers.

Evidence shows that dental floss is able to remove some interproximal plaque (Asadoorian & Locker, 2006), hence that frequent regular dental flossing will reduce interproximal caries and periodontal disease risks (Hujoel, Cunha-Cruz, Banting, & Loesche, 2006). Daily dental flossing in combination with tooth brushing for the prevention of caries and periodontal diseases is frequently recommended (Asadoorian & Locker, 2006; Bagramian,

Garcia-Godoy, & Volpe, 2009). However, less than 60% of our study participants with teeth brushed teeth two times a day; almost two-thirds of them rarely or never flossed. A high proportion of adults with intellectual and developmental disabilities receive assistance with daily oral hygiene. Providing oral care, particularly flossing, for them is challenging (Minihan et al., 2014). The challenges of at-home oral care for adults with intellectual and developmental disabilities can be escalated by the severity of physical impairments, uncooperative behaviors, and difficulty communicating. Hence, simplified instructions and prompts are recommended to assist individuals with ID in learning new oral hygiene skills. Demonstrations by carers should be used to help persons with ID gain familiarity with oral health procedures (Grant, Carlson, & Cullen-Erickson, 2004). The continuing support of carers who monitor the implementation of an oral health intervention for persons with ID is crucial.

It is of great concern that dental care among adults with intellectual disability is not documented adequately and the quality of dental care is lower than the general population (Anders & Davis, 2010; Kancherla, Van Naarden Braun, & Yeargin-Allsopp, 2013). There are gaps in dental care among adults with ID (Anders & Davis, 2010), and low expectations, fear of treatment, lack of awareness among caregivers, and problems in access to oral health care services may contribute to the unmet need (Cumella, Ransford, Lyons, & Burnham, 2000). Lack of education and employment status also play a great role in access to dental care (Kancherla et al., 2013) as does availability or lack of dental care insurance. The situation is further complicated when the adults with ID have mobility limitation issues or need constant supervision. A comprehensive understanding of the barriers to oral health care is needed to implement successful health promotion strategies. As the ID population ages, a need exists to

tailor health promotion strategies toward older adults who are more likely to suffer from gum disease as shown by our study.

The present study relies on informant-reported gum disease. Due to the nature of the present study, it is possible that adults with ID who were reported to have gum disease may have received more regular dental care leading to a diagnosis of gum disease. Similarly, they might also have received other healthcare more regularly that lead them to receive a diagnosis of CVD. Hence, there is an urgent need for **developing better research to include clinical indices of periodontal and cardiovascular health** and further explore the relationship between gum disease and CVD.

The strengths of the study are having a large sample size, recruiting participants across states and various settings, and using a multiple regression analysis to explore the associations of various factors to reported CVD. However, several limitations must be acknowledged. As the data are cross-sectional, definite causations cannot be established. Long-term follow-up and longitudinal data analysis is required. Furthermore, the informant-based nature of the **survey** study may result in recall bias or inaccuracy in **all the** reporting data; **hence, the findings need to be interpreted cautiously. There is a likelihood of misclassification of the variable measures, particularly the 'gum disease' measure, given that they were based solely on informant reports to one single question. It is possible that some of adults with ID were classified as "without gum disease" did have gum disease and vice versa although the latter is less likely. The survey question on 'gum disease' did not include instructions to guide respondents to a more accurate response, e.g., an observable characteristic like 'swollen or bleeding gums,' or 'based on a diagnosis from a dental professional' thereby making the recognition of gum disease by informants potentially problematic. Usually a general dentist**

or periodontist clinically diagnoses periodontal disease by examining tooth loss, recession, clinical attachment loss, periodontal pocket probing, tooth mobility, and radiographic bone loss (Mosley, Offenbacher, Phillips, Granger, & Wilder, 2014). Performing these diagnosis procedures can be challenges to general dentists or periodontist due to communication limitations and behavioural issues of persons with ID and inability to cooperate for dental care. While diagnosis of periodontal disease is challenging for the clinicians themselves the recognition of symptoms by informants might be unreliable. We did not provide any information with some objective measure such as the gum disease symptoms (e.g., red or swollen gums, tender or bleeding gums, loose teeth) for informants to report on gum disease; therefore, the criterion validity couldn't be assessed. Additionally, although the dependent variable (CVD) was based on a general question on whether the participant had a heart condition or not based on a diagnosis from a doctor, the assumption that a heart condition represents CVD is a limitation in the study. We are aware of that the validity of the data of the reported gum disease and reported CVD is impossible to establish and can be questionable. Therefore, it is crucial to collaborate with dentists who are specialised in developmental disability to identify gum disease and to link the health care administration data to verify chronic health conditions in the future study. Another limitation is the issue of generalizability as people with Down syndrome are overrepresented in our sample.

Conclusion

Adults with ID who have reported gum disease may be associated with a reported cardiovascular disease. This study is cross-sectional, thus, it is impossible to determine temporal relationships. Therefore, further research studies that include a longitudinal study design and clinical indices of periodontal and cardiovascular health are needed to

improve internal validity of measures and to determine the relations between gum disease and cardiovascular disease for people with ID. Our analysis on oral hygiene indicates there is a great need to improve oral health care of adults with ID through oral health education on adults with ID, their caregivers, and dental professionals.

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Figure 1. Frequency of **Reported** Cardiovascular Disease in Presence of **Reported** Gum Disease

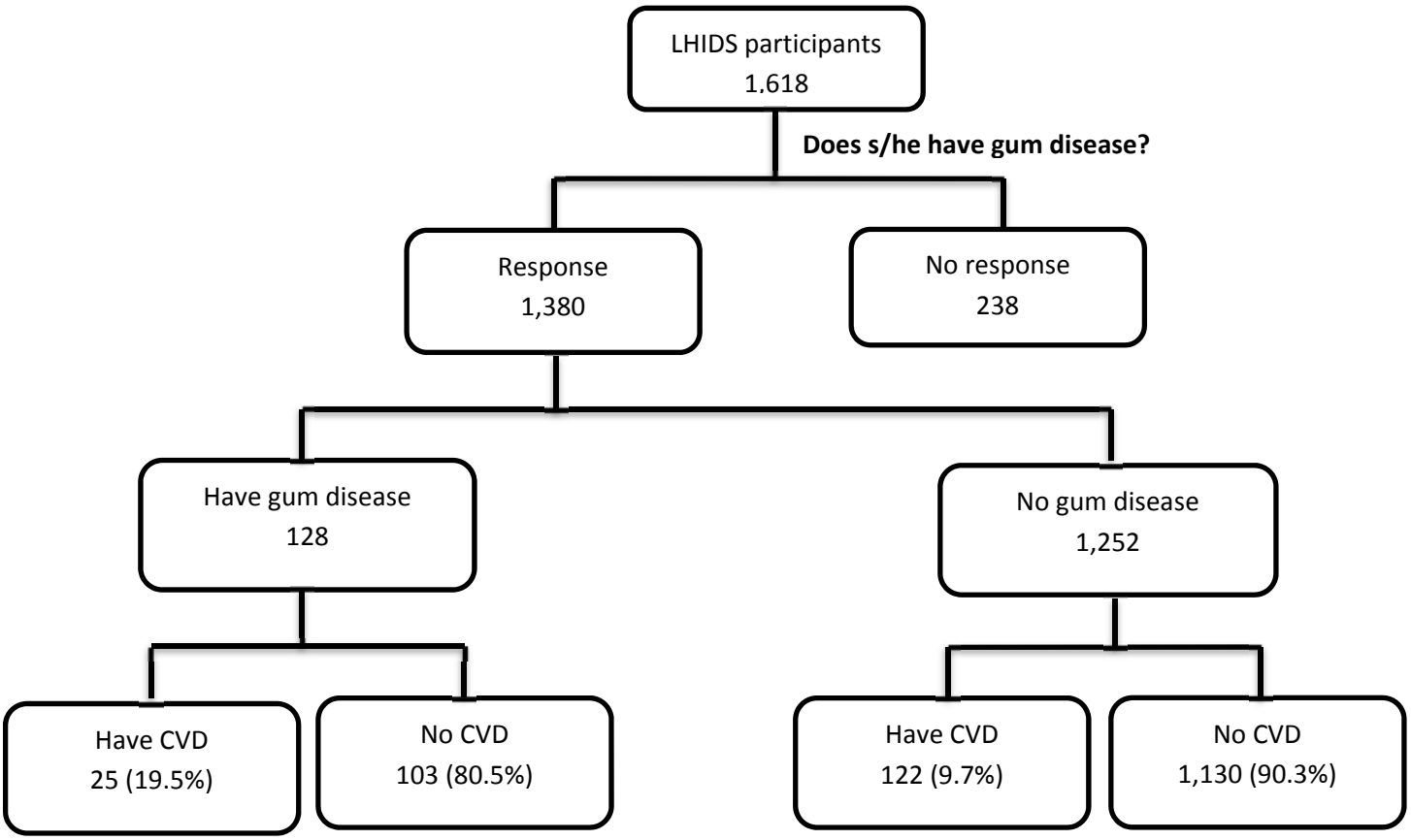

Table 1. Participant Characteristics **by Reported Gum Disease Status**

	Reported gum disease			Total
	Yes (N=128)	No (N=1253)		
	Mean ± SD		χ^2or t	Mean ± SD
Average age (years)	38.84 ± 13.69	36.87 ±14.41	-1.55	37.05 ± 14.35 *(Range=18-86)*
BMI	29.77 ± 7.58	28.68 ±7.35	-1.51	28.78 ± 7.37
	n (%)	n (%)		n (%)
Age group (years)			2.96	
18-44	81 (63.3)	884 (70.6)		965 (69.9)
≥45	47 (36.7)	368 (29.4)		415 (30.1)
Gender			7.70**	
Male	56 (43.8)	708 (56.5)		764 (55.4)
Female	72 (56.3)	544 (43.5)		616 (44.6)
Obesity			1.37	
Yes	51 (42.1)	444 (36.8)		495 (37.2)
No	70 (57.9)	764 (63.2)		834 (62.8)
Down syndrome			0.08	
Yes	33 (26.8)	301 (25.6)		334 (25.8)
No	90 (73.2)	873 (74.4)		963 (74.2)
Lifestyle factors				
Current smoker			5.79*	
No	117 (92.1)	1204 (96.5)		1321 (96.1)
Yes	10 (7.9)	44 (3.5)		54 (4.0)
Physical activity			0.92	
No PA	37 (29.6)	321 (25.9)		358 (26.2)
Engaged in some PA	62 (49.6)	631 (50.9)		693 (50.8)
Met PA recommendation	26 (20.8)	288 (23.2)		314 (23.0)
Fruit & vegetable intake			2.35	
≤ 2 servings a day	72 (57.1)	625 (50.4)		697 (51.0)
3-4 servings a day	43 (34.1)	508 (41.0)		551 (40.3)
≥ 5 servings a day	11 (8.7)	107 (8.6)		118 (8.6)
High fat food consumption			1.02	
≤ 2 servings a day	89 (70.1)	895 (72.1)		984 (71.9)
3-4 servings a day	35 (27.6)	302 (24.3)		337 (24.6)
≥ 5 servings a day	3 (2.4)	44 (3.5)		47 (3.4)
Addition of table salt to food			1.11	
Rarely/never	95 (75.4)	940 (75.4)		1035 (75.4)
Sometimes	24 (19.0)	251 (20.1)		275 (20.0)
Most of the time	3 (2.4)	32 (2.6)		35 (2.6)
All of the time	4 (3.2)	23 (1.8)		27 (2.0)

Note. * $p<0.05$, ** $p<0.01$

Table 2. Prevalence of Comorbidities of **Reported** Gum Disease

Comorbidities[a]	**Reported gum** disease Yes (N=128)	No (N=1253)	χ^2	Total (N=1381)
	n (%)			n (%)
Cardiovascular disease	25 (19.5)	122 (9.7)	11.69**	147 (10.7)
Chronic bronchitis/Emphysema	1 (0.8)	17 (1.4)	0.30	18 (1.3)
Diabetes	13 (10.2)	74 (5.9)	3.54	87 (6.3)
Hypercholesterolemia	25 (19.5)	164 (13.1)	4.07*	189 (13.7)
Hypertension	21 (16.4)	159 (12.7)	1.41	180 (13.0)
Obesity	51 (42.1)	444 (36.8)	1.37	495 (37.2)
Osteoporosis	9 (7.0)	67 (5.4)	0.63	76 (5.5)
Stroke	3 (2.3)	15 (1.2)	1.18	18 (1.3)

Note. [a]**Comorbidities are informant reports and based on a diagnosis from a doctor.**
* $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Table 3. Results of Univariate Logistic Regression Analysis of **Reported** Cardiovascular Disease Risk Factors

Risk Factors	Univariate		
	OR	95% CI	P
Age group (years)			
18-44	Reference		
≥ 45	1.45	1.02-2.07	0.041
Male	1.19	0.84-1.69	0.325
Down syndrome	2.57	1.80-3.67	0.000
Hypercholesterolemia	1.65	1.06-2.56	0.026
Hypertension	1.76	1.13-2.74	0.012
Diabetes	1.37	0.73-2.59	0.328
Obesity	0.86	0.59-1.24	0.406
Chronic bronchitis/Emphysema	2.44	0.79-7.50	0.121
Reported gum disease	2.25	1.40-3.62	0.001
Current smoker	1.05	0.44-2.51	0.905
Physical activity (PA)			
No PA	Reference		
Engaged in some PA	0.86	0.57-1.29	0.453
Met PA recommendation	1.00	0.62-1.61	0.996
Fruit & vegetable intake			
≤ 2 servings a day	Reference		
3-4 servings a day	1.17	0.81-1.69	0.409
≥ 5 servings a day	1.95	1.13-3.36	0.016
High fat food consumption			
≤ 2 servings a day	Reference		
3-4 servings a day	0.89	0.59-1.34	0.578
≥ 5 servings a day	1.20	0.50-2.89	0.685
Addition of table salt to food			
Rarely/never	Reference		
Sometimes	0.62	0.38-1.00	0.052
Most of the time	0.45	0.11-1.91	0.282
All of the time	0.60	0.14-2.56	0.489

Note. All the chronic health conditions are informant reports and based on a diagnosis from doctor.

Table 4. Results of **Multiple** Logistic Regression Analysis of Reported Cardiovascular Disease Risk Factors

Risk Factors	AOR	95% CI	P
Age group (years)			
18-44	Reference		
≥ 45	1.21	0.81-1.80	0.350
Down syndrome	3.02	2.06-4.44	0.000
Hypercholesterolemia	1.50	0.92-2.44	0.101
Hypertension	2.07	1.24-3.44	0.005
Chronic bronchitis/Emphysema	2.87	0.84-9.77	0.093
Fruit & vegetable intake			
≤ 2 servings a day	Reference		
3-4 servings a day	1.12	0.76-1.65	0.558
≥ 5 servings a day	1.67	0.93-3.01	0.089
Addition of table salt to food			
Rarely/never	Reference		
Sometimes	0.71	0.43-1.19	0.194
Most of the time	0.44	0.10-2.07	0.301
All of the time	0.98	0.22-4.43	0.982
Reported gum disease	2.11	1.27-3.49	0.004

Note. All the chronic health conditions are informant reports and based on a diagnosis from doctor.