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Oral Health Indicators among a sample of Hispanic Patients diagnosed with Autism Spectrum Disorder.

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Abstract: **Objective:** This study aimed to determine the oral health and the associated health disparities of pediatric patients with autism spectrum disorder (ASD). **Methods:** This non-matched, case-control study recruited 22 subjects diagnosed with ASD (cases) and 27 without ASD (controls) aged 5–18 years. Two calibrated dentists performed dental exams for caries and gingivitis on all subjects. Parents/caregivers completed sociodemographics and social determinants oral health questionnaires. As appropriate, between-group comparisons were performed using chi-square, Fisher's exact test, t-test, and Mann-Whitney test. Associations between ASD and oral health indices were determined using logistic, Poisson, and linear regression models. **Results:** Statistically significant differences were found for not easy finding dental services for ASD patients (p=0.014) and behavioral problems during dental visits (p=0.012). Children with ASD had significantly lower odds of caries (DMFT+dft>0) compared to children without ASD (OR=0.121; 95% CI: 0.023; 0.636). Age- and sex-adjusted models showed a significantly lower gingival index among those with ASD. **Conclusion:** ASD patients had better oral health indices than the control subjects. The barriers to treatment for ASD patients were lack of access to dental care and living in a rural area.

Key words: ASD, oral health, caries prevalence, gingival index, oral health social determinants.

Indicadores de salud bucal en una muestra de pacientes hispanos diagnosticados con trastorno del espectro autista.

Resumen: **Objetivo:** El objetivo de este estudio fue determinar el estado de salud oral y las desigualdades en salud oral asociadas en pacientes pediátricos con el desorden de espectro autista (TEA). **Métodos:** Este estudio es diseño caso control no pareado y reclutó 22 sujetos diagnosticados con el desorden de espectro autista (casos) y 27 sujetos sin el desorden de espectro autista (controles). Las edades de los pacientes fueron entre 5 a 18 años. Dos dentistas calibrados realizaron los exámenes dentales para caries y gingivitis. Los padres y/o cuidadores completaron un cuestionario validado sobre variables sociodemográficas y determinantes sociales de salud oral. Se realizaron comparaciones entre los grupos usando la prueba de chi-cuadrado y las pruebas estadísticas de Fisher y Mann-Whitney. Las asociaciones entre TEA y los índices de salud oral fueron determinadas usando regresión logística, Poisson y modelos de regresión lineal. **Resultados:** Se encontraron diferencias estadísticamente significativas entre no encontrar fácilmente servicios dentales para los pacientes con TEA (p=0,014) y reportar problemas de conducta durante las visitas (p=0,012). Los niños con TEA tuvieron menores tasas de caries (COPD + cod>0) comparados a los niños sin TEA (OR=0,121; 95% CI: 0,023; 0,636). Los modelos de regresión ajustados por edad y sexo mostraron que el índice gingival era menor para los niños con TEA. **Conclusión:** En este estudio los niños con TEA tuvieron mejor salud oral que los controles. Las barreras para tratamiento en los niños de TEA fueron falta de acceso a los servicios dentales y vivienda en área rural.

Palabras clave: TEA, salud bucal, prevalencia de caries, índice gingival, determinantes sociales de la salud bucal.

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Indicadores de saúde bucal em uma amostra de pacientes hispânicos diagnosticados com transtorno do espectro autista.

Resumo: **Objetivo:** Este estudo teve como objetivo determinar o estado de saúde bucal e as disparidades de saúde associadas de pacientes pediátricos com transtorno do espectro do autismo (TEA). **Métodos:** Este estudo de caso-controle não pareado recrutou 22 indivíduos com diagnóstico de TEA (casos) e 27 sem TEA (controles) com idades entre 5 e 18 anos. Dois dentistas calibrados realizaram exames odontológicos para cárie e gengivite em todos os indivíduos. Os pais/cuidadores preencheram questionários sociodemográficos e de determinantes sociais de saúde bucal. Conforme apropriado, as comparações entre grupos foram realizadas utilizando qui-quadrado, teste exato de Fisher, teste t e teste de Mann-Whitney. As associações entre TEA e índices de saúde bucal foram determinadas por meio de modelos logísticos, de Poisson e de regressão linear. **Resultados:** Foram encontradas diferenças estatisticamente significativas para dificuldade de encontrar serviços odontológicos para pacientes com TEA (p=0,014) e problemas de comportamento durante consultas odontológicas (p=0,012). Crianças com TEA tiveram chances significativamente menores de cárie (CPOD+dft>0) em comparação com crianças sem TEA (OR=0,121; IC 95%: 0,023; 0,636). Modelos ajustados por idade e sexo mostraram um índice gengival significativamente menor entre aqueles com TEA. **Conclusão:** Pacientes com TEA apresentaram melhor saúde bucal do que os controles. As barreiras ao tratamento de pacientes com TEA foram a falta de acesso a atendimento odontológico e a residência em área rural.

Palavras-chave: TEA, saúde bucal, prevalência de cárie, índice gengival, determinantes sociais da saúde bucal.

Introduction

Dental caries is one of the most prevalent diseases affecting the world's population. According to the World Health Organization[1], approximately 2.3 billion people have dental caries in one or more of their permanent teeth, and more than 530 million children have dental caries in one or more of their primary teeth. There is a high prevalence of dental caries among 12-year-olds in Puerto Rico (PR), especially in the island's central region[2]. A patient's overall oral health status is determined not only by the presence or absence of dental caries but also by that person's level of periodontal health. Gingivitis is commonly defined as gingival bleeding at least one site[3] and the presence of gingival inflammation, which is often a sign of periodontitis[4]. Changes in the color and texture of the gingiva, as well as the presence of bleeding on probing, are some of the clinical features of gingivitis.

Impaired social development, the presence of restrictive and/or repetitive interests, activities, and/or behaviors, and difficulties with either verbal and/or nonverbal communication are hallmarks of autism spectrum disorder (ASD), a lifelong neurodevelopmental condition[5]. Children with ASD often have special needs, frequently are unable to be cooperative during medical/dental procedures and might have difficulty communicating. Often, ASD patients struggle to have access to medical and dental care, which may negatively affect their oral health[5]. The dental care of an ASD patient is complex and may require the interdisciplinary work of several health professionals to provide the best possible dental treatment.

Studies on oral health status in ASD patients are inconsistent[5-12]. Some studies reported that ASD patients have higher rates of periodontal disease, but low caries rates[6,7].

In contrast, have shown no difference in the number of decayed, missing, and filled teeth (DMFT) in adults with ASD compared with individuals without ASD[6,7,10-12]. Also, the gingival bleeding index was lower in adult patients with ASD compared to adults without ASD[7]. In contrast, other studies have reported that ASD patients had a higher prevalence of caries, exhibited poor oral hygiene, and suffered from largely unmet dental treatment needs[8]. Caries in patients with ASD have been associated with higher rates of formula versus breastfeeding, higher plaque indices, and delays in the first visit to the dentist[9]. Social determinants of health, including housing, work, socioeconomic status, education and health care are known to affect oral healthcare[5].

Pediatric patients with ASD have four times higher odds of having unmet healthcare needs than children not diagnosed with ASD[13]. In a study evaluating healthcare access among children with ASD, delayed access to healthcare (including dental care) was the most prevalent problem, followed by affording care[14]. According to Alshihri[5], having medical insurance and a previous bad dental experience significantly affects finding dental treatment. Comprehensive coverage for dental sealants in children and adolescents at low-income levels was shown to reduce the prevalence of untreated dental caries and improve the use of dental sealants and regular check-ups[14]. In PR, a significant reduction in caries prevalence was observed after the 1997 implementation of the government health insurance reform program[2,3].

Given the inconsistencies in certain studies on the oral health status among ASD patients and the importance of determining whether disparities exist among ASD patients in PR, it is imperative to identify and understand their current oral health status. This study aimed to determine: (i) the oral health status of pediatric patients with ASD, (ii) whether there are oral health disparities that affect pediatric patients with ASD, and (iii) which social determinants of health are associated with the ASD pediatric population. Our hypothesis is that pediatric ASD patients have more dental disease and unmet dental needs than children without ASD and that these issues are affected by social determinants of health, such as access to dental care, among others.

Methods

Study population.

This non-matched case-control study was approved by the Institutional Review Board Human Rights Committee of the University of Puerto Rico Medical Sciences Campus (IRB# 0640122). The participants consisted of 22 children and adolescents aged 5 to 18 years with ASD (cases) and 27 children and adolescents in the same age range without ASD (controls). Parents of the subjects participated also in the study by answering a questionnaire. After our IRB approval, parents of subjects were contacted to recruit patients on both groups. An explanation of the study was given to parents and written consent approved and stamped by the UPR MSC IRB was given to parents to whom agreed to participate in the study. Also, a stamped

and UPR MSC IRB approved assent was given to children and adolescents greater than 7 years old. An explanation of the study was given to all children and adolescents who participated in the study prior to being recruited for the study. The required sample size was calculated to be 37 participants per group to achieve an 80% statistical power for a chi-square test to detect a 31% difference in caries prevalence in two groups.

Participants underwent a dental examination for caries and restorations following the International Caries Detection and Assessment System (ICDAS) criteria[15]. The Loe gingival index[16] was used in the visual examination of the gums for the presence of gingivitis. Only two alternate quadrants (maxillary and mandibular: buccal and lingual sides) were examined for gingival index measurements. Bleeding on probing was not measured because of the dental and behavioral management requirements of pediatric patients with ASD. Two calibrated dental examiners performed the ICDAS-guided dental examinations (intra-rater kappa= 0.84; inter-rater kappa = 0.83). The two dental examiners performed the training and standardization of measurements for the gingival index beforehand.

Most dental exams were performed at the UPR general dental clinic facilities. Some patients with ASD were evaluated at the Colegio Montessori de PR and the Centro Ponceño de Autismo in a dental setting prepared for the examinations. Said dental setting included a portable dental chair, a compressor for suction and air, a portable dental light, and a dental mirror. No dental explorer or probe was used. Dental caries indices were calculated and reported as dft, dfs (for primary teeth), and DMFT, DMFS (for permanent teeth). In addition, combined measures of caries extent (DMFT+dft, DMFS+dfs) were calculated. Caries prevalence was defined as having at least one decayed, filled, or missing tooth (permanent or primary). Untreated caries prevalence was defined as having at least one decayed tooth (DT+dt>0).

During the study, other criteria were evaluated, such as dental caries indices (DMFS and DMFT), combining DMFS/dfs and DMFT/dft, caries prevalence, and the presence of gingival disease in ASD children and adolescents; in addition, we explored the oral health disparities associated with them.

Also, to encourage participation in the study, oral prophylaxis and fluoride varnish were applied to participants, and instructions regarding verbal hygiene were given to participants and their caregivers after the oral exam. All the ASD patients were examined without problems.

Each participant's accompanying parent/caregiver answered 50 questions using a validated questionnaire developed by PIs of the study. This questionnaire collected information regarding the sociodemographic variables of each participant and his/her/their respective parent or caregiver, the medical history and oral hygiene practices of the participant, and the participant's barriers and access to dental care, among other data.

Statistical Analysis

Descriptive statistics (means, standard deviations, medians, interquartile ranges for continuous variables, frequencies, and percentages for categorical variables) were calculated among all participants and by ASD status. The distributions of patient characteristics and oral health indices were compared between those with and without ASD diagnosis using the chi-square test or Fisher's exact test for categorical variables and the two-sample t-test and Mann-Whitney test for continuous variables (depending on the normality of the distribution, according to Shapiro-Wilk normality test results). Logistic regression models for caries prevalence outcomes, Poisson regression models for extent measures, and generalized linear regression models for the gingival index were used to further explore the associations between the ASD diagnosis group and oral health measures. Odds ratios were estimated from logistic regression models, rate ratios (exponentiated regression coefficients) were obtained using Poisson regression models, and linear regression model coefficients were reported for the gingival index. Three different models were used for regression analysis: model 1 adjusted for age and sex; model 2 included age, sex, and residential location (urban vs. rural); model 3 additionally had toothbrushing frequency at least twice a day (yes/no). All analyses were performed using STATA software v. 17 (STATA Corp, TX, USA) and SAS v. 9.4 (SAS Institute, Cary, NC, USA); p=0.05 level was considered statistically significant[17].

Missing values: Three participants had missing information on residential location; therefore, all regression analyses excluded those participants. In addition, one participant refused a gingival examination and was excluded from the gingival index variable analysis.

Resultados

The 49 patients evaluated in the study age ranged from 5 to 18 years and consisted of 22 children with ASD and 27 without ASD. The mean age was 10.73 (±4.11) years and 10.19 (±3.41) years for the ASD patients and non-ASD patients, respectively. There were more male than female participants in the ASD group. Male and female participants were evenly distributed in the non-ASD group. Table 1

The main results of the questionnaire to determine possible oral health disparities pointed out statistically significant differences in difficulty finding dental services for ASD patients (p = 0.014), Behavioral problems during dental visits (p = 0.012), and fewer dental exams among participants with ASD diagnosis vs. the control group. The parents/caregivers of ASD patients complained that accessing dental care and services and finding dentists who provide services to pediatric ASD patients was challenging. Most of the ASD participants found brushing their teeth to be difficult and did not use dental floss or mouthwash (p < 0.05). The residential areas in which ASD parents/caregivers lived were statistically significantly different from those of the control-group parents/caregivers; ASD patients and their parents/caregivers tended to reside in rural areas in PR (p = 0.018) (Table 1).

A significantly lower prevalence of caries (45.45%) was observed in ASD patients

Table 1. *Characteristics of participants, among all and by autism status*

Characteristic	Autism Diagnosis			*p value* [1]
	Total (n=49)	Yes (n=22)	No (n=27)	
Child's Age [3]				0,616
Mean ± SD	10,43 ± 3,71	10,73 ± 4,11	10,19 ± 3,41	
Median (IQR)	11 (8; 13)	11 (8; 13)	10 (8; 12)	
Child's Sex				0,088
Female	15 (30,61)	4 (18.18)	11 (40,74)	
Male	34 (69,39)	18 (81,82)	16 (59,26)	
Child's weight at Birth [3]				0,419
Mean ± SD	5,14 ± 2,04	5,78 ± 1,28	4,5 ± 2,65	
Median (IQR)	5,25 (3,55; 6,75)	6 (4,8; 6,75)	4 (2,5; 6,5)	
Premature at Birth[2]				>0,999
Yes	8 (17.02)	4 (19.05)	4 (15.38)	
No	39 (82,98)	17 (80,95)	22 (84,62)	
Breastfed at Birth				0,266
Yes	33 (67,35)	13 (59,09)	20 (74,07)	
No	16 (32,65)	9 (40,91)	7 (25,93)	
Time Breastfeeding				0,407
6 months or less	21 (42,86)	8 (36.36)	13 (48,15)	
12 months or more	28 (57,14)	14 (63,64)	14 (51,85)	
Breastfeeding Selection[2]ǂ				>0,999
Exclusive Breastfeeding	7 (21,88)	3 (23.08)	4 (21.05)	
Combined	25 (78,13)	10 (76,92)	15 (78,95)	
Supplementation with vitamins				0,560
Yes	17 (36.17)	7 (31,82)	10 (40,00)	
No	30 (63,83)	15 (68,18)	15 (60,00)	
Type of Medical Insurance				0,825
Private	17 (34,69)	8 (36.36)	9 (33.33)	
Public	32 (65,31)(	14 (63,64)	18 (66,67)	
Dental Coverage[2]				>0,999
Yes	46 (93,88)	21 (95,45)	25 (92,59)	
Don't Know	3 (6.12)	1 (4,55)	2 (7,41)	
Asthma				0,517
Yes	22 (44,90)	11 (50,00)	11 (40,74)	
No	27 (55.10)	11 (50,00)	16 (59,26)	
ADD[2]				0.300
Yes	8 (16,67)	5 (22,73)	3 (11,54)	
No	40 (83,33)	17 (77,27)	23 (88,46)	

Table 1. *Characteristics of participants, among all and by autism status (cont.)*

Characteristic	Autism Diagnosis			*p value* [1]
	Total (n=49)	Yes (n=22)	No (n=27)	
Dermatitis[2]				0,011
Yes	7 (14,58)	0	7 (26,92)	
No	41 (85,42)	22 (100,00)	19 (73,08)	
Allergies				0,215
Yes	15 (31,91)	9 (40,91)	6 (24,00)	
No	32 (68,09)	13 (59,09)	19 (76,00)	
Easy Finding Dental Service for your child				0,014
Yes	32 (66,67)	10 (47,62)	22 (81,48)	
No	16 (33.33)	11 (52,38)	5 (18,52)	
Do you assist to a Pediatric Dentist[2]ǂ				0,779
Yes	34 (75,56)	14 (70,00)	20 (80,00)	
No	6 (13.33)	3 (15,00)	3 (12.00)	
Have visited more than 1 Dentist				0,302
Yes	28 (58,33)	14 (66,67)	14 (51,85)	
No	20 (41,67)	7 (33.33)	13 (48,15)	
Does your child present behavior problems when visiting a Dentist				0,012
Yes	12 (25,00)	9 (42,86)	3 (11.11)	
No	36 (75,00)	12 (57,14)	24 (88,89)	
Dental Exam[2]				0,084
Yes	46 (93,88)	19 (86,36)	27 (100,00)	
No	3 (6.12)	3 (13,64)	0	
Dental Restorations				0,097
Yes	22 (44,90)	7 (31,82)	15 (55,56)	
No	27 (55.10)	15 (68,18)	12 (44,44)	
Treatment under Sedation[2]				0,204
Yes	6 (12.24)	1 (4,55)	5 (18,52)	
No	43 (87,76)	21 (95,45)	22 (81,48)	
Treatment under Anesthesia[2]				0,678
Yes	6 (12.24)	2 (9.09)	4 (14,81)	
No	43 (87,76)	20 (90,91)	23 (85,19)	
Gum Problem[2]				>0,99
Yes	1 (2.04)	0	1 (3,70)	
No	48 (97,96)	22 (100,00)	26 (96,30)	
Braces[2]				>0,999
Yes	5 (10.20)	2 (9.09)	3 (11.11)	
No	44 (89,80)	20 (90,91)	24 (88,89)	

Table 1. *Characteristics of participants, among all and by autism status (cont.)*

Characteristic	Autism Diagnosis			*p value* [1]
	Total (n=49)	Yes (n=22)	No (n=27)	
Child uses toothbrush[2]				0,449
Yes	48 (97,96)	21 (95,42)	27 (10,00)	
No	1 (2.04)	1 (4,55)	0	
Type of toothbrush[2]‡				>0,999
Normal	41 (87,23)	19 (90,48)	22 (84,62)	
Electric	5 (10,64)	2 ((9,52)	3 (11,54)	
Special	1 (2.13)	0	1 ((3,85)	
Frequency of Brushing[2]‡				0,174
At least once a day	11 (22,92)	7 (33.33)	4 (14,81)	
Two or more a day	14 (66,67)	14 (66,67)	23 (85,19)	
Child presents difficulty brushing				0,041
Yes	11 (22,92)	8 (36.36)	3 (11,54)	
No	37 (77,08)	14 (63,64)	23 (88,46)	
Child uses Dental String				0,005
Yes	19 (18.18)	4 (18.18)	15 (57,69)	
No	29 (60,42)	18 (81,82)	11 (43.31)	
Child uses Mouthwash				0,020
Yes	20 (40,82)	5 (22,73)	15 (55,56)	
No	29 (59.18)	17 (77,27)	12 (44,44)	
Frequency of Mouthwash[2]‡				0,603
At least once a day	12 (60,00)	4 (80,00)	8 (53,33)	
Two or more a day	8 (40,00)	1 (20,00)	7 (46,67)	
Child uses Dental Paste[2]				0,449
Yes	48 (97,96)	21 (95,45)	27 (100,00)	
No	1 (2.04)	1 (4,55)	0	
Dental Paste has Flour[2]‡				0,480
Yes	29 (61,70)	11 (55,00)	18 (66,67)	
No	4 (8,51)	3 (15,00)	1 (3,70)	
Don't Know	14 (29,79)	6 (30,00)	8 (29,63)	
Have problems with Dentist who don't provide care for children				0,115
Yes	8 (16,67)	6 (28,57)	2 (7,41)	
No	40 (83,33)	15 (71,43)	25 (92,59)	
Type of Caregiver[2]				0,280
Father	4 (8.16)	3 (13,64)	1 (3,70)	
Mother	43 (87,76)	19 (86,36)	24 (88,89)	
Legal Guardian				
Caregiver's Age [3]				0,485
Mean ± SD	40,60 ± 9,30	41,64 ± 9,83	39,73 ± 8,92	
Median (IQR)	41 (32; 48)	42 (33; 48)	39,5 (31; 47)	

Table 1. *Characteristics of participants, among all and by autism status (cont.)*

Characteristic	Autism Diagnosis			*p value* [1]
	Total (n=49)	Yes (n=22)	No (n=27)	
Caregiver Currently Working				0,247
No	20 (40,82)	7 (31,82)	13 (48,15)	
Yes	29 (59.18)	15 (68,18)	14 (51,85)	
Caregiver's Education[2]‡				0,584
At least High School	8 (17.02)	2 (9.09)	6 (24,00)	
Technical/Associate	18 (38.30)	10 (45,45)	8 (32,00)	
Baccalaureate	13 (27,66)	6 (27.27)	7 (28,00)	
Post-Grade	8 (17.02)	4 (18.18)	4 (16,00)	
Caregiver's Income[2]‡				0,422
<$20,000	20 (52,63)	8 (44,44)	12 (60,00)	
$20,000-$39,999	11 (28,95)	5 (27,78)	6 (30,00)	
$40,000 or more	7 (18.42)	5 (27,78)	2 (10,00)	
Caregiver's Residence Area				0,018
Rural	17 (36,96)	12 (54,55)	5 (20,83)	
Urban	29 (63,04)	10 (45,45)	19 (79,17)	
Caregiver's General Health (Good Perception) [2] ‡				>0,999
Yes	44 (91,67)	20 (90,91)	24 (92,31)	
No	4 (8.33)	2 (9.09)	2 (7,69)	
Caregiver's Oral Health (Good Perception) [2] ‡				0,644
Yes	42 (89,36)	18 (85,71)	24 (92,31)	
No	5 (10,64)	3 (14.29)	2 (7,69)	
Caregiver has Dental Fillings[2]‡				0,869
Yes	32 (68,09)	14 (63,64)	18 (72,00)	
No	13 (27,66)	7 (31,82)	6 (24,00)	
Don't Know	2 (4.26)	1 (4,55)	1 (4,00)	
Caregiver Understand Child has Good Oral Health[2]‡				0,505
Yes	36 (76,00)	15 (71,43)	21 (80,77)	
No	11 (23.40)	6 (28,57)	5 (19.23)	

[1] *P*-values were obtained using chi-squared test, unless otherwise indicated.
[2] *P*-values were obtained with the Fisher's exact test.
[3] *P*-values were obtained using the T-test.
‡ Variable totals might be different of total sample population because some participants' legal guardians didn't provide information for that variable.

compared to those without ASD (81.48%, $p = 0.008$; (Table 2). Similarly, the prevalence of untreated caries was lower among ASD (27.27%) than in children without ASD (48.15%). On average, the combined measures of caries extent (DMFT+dft, DMFS+dfs) were significantly lower among children with ASD, compared to those without (Table 2). When permanent and primary dentition measures were

considered separately, there were statistically significant differences for primary extent measures (dft, dfs), with ASD patients displaying higher indices of caries extent compared to the non-ASD group (Table 2); no statistically significant differences were found for permanent dentition (DMFT, DMFS). When the gingival health measure was compared between the two groups, ASD patients presented with a slightly lower average gingival index (0.75 ± 0.59) compared to the control group (1.07 ± 0.48, Table 2); however, these differences were not statistically significant (*p*-value = 0.121).

Table 3 shows three models for the association between ASD diagnosis and oral health measures indices. The results from the age-sex-adjusted model were very similar to those from model 2 (age, sex, and place of residence adjusted). In contrast, estimates from model 3 (age, sex, place of residence, and frequency of brushing adjusted) seem slightly different.

Children with ASD had significantly lower odds of caries (DMFT+dft>0) compared to children without ASD (model 3 OR = 0.121; 95% CI: 0.023; 0.636). The direction of the association was similar for the prevalence

Table 2. *Oral health indicators, among all participants, and by autism diagnosis status (yes/no)*

Oral Health Measures	All participants	Autism Diagnosis		*p value* [1]
	(n=49)	Yes (n=22)	No (n=27)	
Caries Prevalence Measures, n (%)				
Caries prevalence (DMFT+dft>0)	32 (65,31%)	10 (45,45%)	22 (81,48%)	0,008
Untreated caries prevalence (DT+dt>0)	19 (38,78%)	6 (27,27%)	13 (48,15%)	0,136
Measures of Caries Extent				
DMFT+dft				0,008
Mean ± SD	3,20 ± 3,57	1,86 ± 2,87	4,30 ± 3,76	
Median (IQR)	2 (0; 5)	0 (0; 3)	4 (1; 7)	
DMFS+dfs				0,006
Mean ± SD	6,63 ± 7,50	3,64 ± 5,92	9,07 ± 7,85	
Median (IQR)	3 (0; 13)	0 (0; 6)	9 (1; 16)	
DMFT				0,348
Mean ± SD	1,69 ± 2,89	1,36 ± 2,61	1,96 ± 3,13	
Median (IQR)	0 (0; 3)	0 (0; 3)	1 (0; 3)	
DMFS				0,275
Mean ± SD	3,37 ± 5,82	2,41 ± 5,05	4,15 ± 6,37	
Median (IQR)	0 (0; 5)	0 (0; 3)	1 (0; 7)	
dft				0,008
Mean ± SD	1,51 ± 2,76	0,50 ± 1,68	2,33 ± 3,20	
Median (IQR)	0 (0; 1)	0 (0; 0)	0 (0; 5)	
dfs				0,011
Mean ± SD	3,27 ± 6,09	1,23 ± 3,98	4,93 ± 7,02	
Median (IQR)	0 (0; 2)	0 (0; 0)	0 (0; 11)	
Gingival Measures				
Gingival Index	(n=48)	(n=22)	(n=26)	0,121
Mean ± SD	0,92 ± 0,55	0,75 ± 0,59	1,07 ± 0,48	
Median (IQR)	0,90 (0,69 – 1,15)	0,80 (0,30; 1,08)	0,90 (0,80; 1,15)	

[1] *P*-values were obtained using chi-square test for caries prevalence measures and Mann-Whitney test for measures of caries extent and for gingival index.

outcome of untreated caries (OR = 0.332; 95% CI: 0.077; 1.426). When the caries extent measures were considered, the ASD group had 0.378 times (95% CI: 0.249; 0.574) the rate of caries-affected teeth (DMFT+dft) compared to controls after adjusting for the confounders in model 3; the association with DMFS+dfs

Table 3. *Association between autism diagnosis and oral health measures*

Variable	Model 1 [1]		Model 2 [2]		Model 3 [3]	
Caries Prevalence Measures4 (n=46)	OR (95% CI)	*p value*	OR (95% CI)	*p value*	OR (95% CI)	*p value*
Caries prevalence (DMFT+dft>0)						
Autism						
Yes	0,193 (0,049; 0,761)	0,019	0,135 (0,029; 0,634)	0,011	0,121 (0,023; 0,636)	0,013
No	Ref.		Ref.		Ref.	
Untreated caries prevalence (DT+dt>0)						
Autism						
Yes	0,309 (0,084; 1,135)	0,077	0,342 (0,086; 1,367)	0,129	0,332 (0,077; 1,426)	0,138
No	Ref.		Ref.		Ref.	
Measures of Caries Extent5 (n=46)	RR (95% CI)	*p value*	RR (95% CI)	*p value*	RR (95% CI)	*p value*
DMFT+dft						
Autism						
Yes	0,480 (0,331 ; 0,698)	0,0001	0,403 (0,268; 0,606)	<0,0001	0,378 (0,249; 0,574)	<0,0001
No	Ref.		Ref.		Ref.	
DMFS+dfs						
Autism						
Yes	0,441 (0,338 ; 0,574)	<0,0001	0,369 (0,276; 0,494)	<0,0001	0,341 (0,253; 0,458)	<0,0001
No	Ref.		Ref.		Ref.	
DMFT						
Autism						
Yes	0,766 (0,468; 1,251)	0,286	0,728 (0,436; 1,214)	0,224	0,673 (0,390; 1,161)	0,155
No	Ref.		Ref.		Ref.	
DMFS						
Autism						
Yes	0,639 (0,447; 0,913)	0,014	0,616 (0,424; 0,895)	0,011	0,548 (0,367; 0,819)	0,003
No	Ref.		Ref.		Ref.	
Gingival measures6 (n=45)	β (95% CI)	*p value*	β (95% CI)	*p value*	β (95% CI)	*p value*
Gingival index						
Autism						
Yes	-0,348 (-0,685; -0,012)	0,043	-0,351 (-0,714; 0,013)	0,058	-0,297 (-0,675; 0,080)	0,119
No	Ref.		Ref.		Ref.	

[1] Model 1 included age and sex (female, male) of the participant.
[2] Model 2 included variables from model 1, as well as residential location (rural vs. urban).
[3] Model 3 included variables from model 2, and toothbrushing at least twice a day (yes/ no).
[4] Logistic regression models were used for the association between autism diagnosis and caries prevalence measures. Odds Ratios and their 95% confidence intervals were reported.
[5] Poisson regression models were employed for the association between autism diagnosis and caries extent measures. Rate ratios (exponentiated regression coefficients) and their 95% confidence intervals were reported in the table.
[6] Linear regression (β) coefficients and their 95% confidence intervals were estimated for gingival index (n=45).

measure was similar (Table 3). When the caries extent measures were calculated based on permanent teeth only (DMFT and DMFS), the association between ASD diagnosis and DMFT index was not statistically significant in any of the three models. For the DMFS index, a statistically significant inverse association was observed in all three models. For the gingival index, the results of the age- and sex-adjusted models were statistically significant, showing a lower gingival index among those with ASD compared to those without. However, when adjusted for other confounders (residential location and further the brushing frequency), results were not significant.

Discussion

As reported in the literature, ASD is not always associated with poor oral health[6,7,10,12]. Good oral hygiene practices, access to dental care and services, routine dental treatment, and the comprehensive and empathetic participation of their parents or caregivers in oral health maintenance contribute to their systemic and dental health well-being[11].

In the present study, 65.31% of study participants had caries, which is comparable with the reported caries prevalence among 12-year-olds in PR[2,3]. In our study, ASD patients had a lower prevalence of caries (45.45%) compared to those without ASD (81.48%). Moreover, an inverse association was found between ASD diagnosis and DMFS index, but not DMFT. In 2011, a study by Elias-Boneta in PR[20] determined that the DMFT and DMFS indices of 12-year-old children were 2.5 and 3.9, respectively. Our study participants had an average DMFT index of 1.69 and DMFS index of 3.37, which are lower than the comparable data in PR obtained from previous studies by Elias-Boneta[2,3,20]. Also, other studies in literature have reported similar results as ours. Vajawat and Blomqvist[6,7] in their studies reported dmft, dmfs, and DMFT and DMFS indexes very similar to the ones found in this study for ASD children and adolescents. These studies reported lower caries indexes for ASD patients compared to non-ASD individuals. Other studies like the ones by Bagattoni[9] and Javer[8] showed that ASD patients had poor oral health. Nevertheless, these contradictory findings provide evidence that the structural and intermediary social determinants of oral health as individual circumstances and risk of oral disease impact the dental disease experience of ASD patients[18].

According to the Conceptual Framework for the Action on the Social Determinants of Health,[21]: "context, structural mechanisms, and the resultant socioeconomic position" define the structural determinants of health. Thus, intermediary determinants of health categorize the factors that provoke health inequities, such as material circumstances, psychological conditions, and behavioral and biological problems. Moreover, studies[5,14], show that common barriers to care for the parents and caregivers of ASD patients are gaining access to dental care and services and finding dentists to treat their children and adolescents, whose conditions are accompanied by behavioral issues requiring special management skills[9]. According to our study, various factors challenge the oral health status and treatment of the pediatric ASD population in PR, as

determined by the questionnaire that was taken by the parents/caregivers of our ASD participants. The literature suggests that the area of residence[2,3,20,22] is a barrier to accessing dental care, personalized/specialized care, and other services the ASD community requires for proper treatment. Rural communities—not only in PR, where this study was performed, but elsewhere, as well—have disadvantaged groups and lack available dentists and other oral health providers to give dental treatment to ASD patients[23]. Oral health public policies, dental associations, and dental schools throughout the country must encourage the participation of dentists and pediatric dentists in treating individuals with ASD, especially in communities without dental services, dentists, or specialized services for subjects with ASD. Also, the curricula at dental schools nationwide should reinforce the management skills and behavioral training of future dentists and dental assistants who will provide services to the ASD population.

In PR, an oral health crisis has been caused by the low ratio of oral health providers to the population. While dental services are needed, there are currently not enough dentists to serve the island's populace. This crisis worsens the access to dental treatment and services for ASD patients and others who require specialized care (24). In PR, both at the governmental level and in the private sector (specifically, from insurance providers), better dental services and care must be provided to individuals for whom the giving and receiving treatment is challenging.

Limitations

The primary limitation of this study can be seen in the recruitment of ASD patients. The authors had to contact ASD programs (in school centers and health institutions, among other locations) to recruit participants for our study. The challenges faced in the recruitment process may have impacted on the results because we were unable to achieve our recruitment goal. ASD patients were identified through specialized programs, schools, and institutions where the participation and commitment of parents and caregivers are promoted, which may have enriched participants who are more aware of the importance of oral health. In this study, we did not explore reasons for the low interest of parents and caregivers of ASD patients in participation in research studies; however, a greater effort to recruit ASD patients should reduce the possibility of selection bias due to low participation. In addition, we excluded ASD patients who were unable to cooperate for dental exams, who would be more likely to have a higher caries prevalence and extent, as well as a higher gingivitis risk. This may have contributed to lower oral health estimates among ASD cases. Another possible limitation to consider was that the participants in the control group came from the pediatric dentistry graduate dental clinic, patients who usually have high levels of dental disease. Future studies are needed to compare the oral health status of ASD patients with controls that are representative of children and adolescents at community levels to reduce the possibility of selection bias.

Our study also had some strengths. The researchers who completed all oral examinations were calibrated and standardized on caries diagnosis and gingival evaluations. It was the first study to explore the differences between Puerto Rican children and adolescents with and without ASD diagnosis in terms of oral health and potential barriers to oral care services.

Compared to non-ASD controls, ASD cases had significantly lower rates of caries prevalence, DMFS, and combined caries indices (DMFT+dft, DMFS+ dfs). Potential barriers for ASD patients were a lack of access to overall dental care and services and access to specialized dental treatment. In PR, public policy changes must be implemented to improve access to specialized dental care for pediatric patients, promoting alternatives that include rural communities on the island.

Conclusions

This research suggested that ASD patients had better oral health indicators that the controls subjects in this study. Although barriers such as lack of access to dental services, insurance coverage of specialized dental services and others remain a problem for ASD patients.

Conflict of interest

The authors disclosure no conflict of interest.

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