

## ORIGINAL RESEARCH

# Disparity in the dental care of children and adolescents with autism spectrum disorder in Korea: a national population-based cross-sectional study

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## 1. Introduction

Children and adolescents with autism spectrum disorder (ASD) have trouble accessing dental care [1, 2]. ASD is a neurodevelopmental disorder that occurs in infancy or adolescence and is characterized by a limited and repetitive pattern of behavior, interest or activity, and deficiency in social communication and social interaction [3–5]. These traits can cause poor coordination and communication disorders, which lead to difficulties in dental treatment and oral hygiene management [6–9]. Dental care access for individuals with ASD is impeded by various factors, as evidenced by prior research [1, 2, 10]. These barriers stem primarily from the substantial financial burdens imposed by the elevated medical costs associated with accommodating patients with disabilities through the utilization of supplementary personnel and specialized equipment.

Furthermore, the dearth of specialized facilities equipped with competent medical personnel who profoundly comprehend both the required equipment and the specific needs arising from disabilities compounds the issue. Consequently, the overall oral hygiene maintenance of patients with ASD is detrimentally impacted. Poor oral hygiene can cause dental caries and periodontal disease, resulting in tooth loss and aesthetic and functional occlusal disorders. Furthermore, proper dental care becomes even more important as inadequate oral hygiene at a younger age could cause systemic diseases such as cardiovascular disease, rheumatoid arthritis, pancreatic cancer, colorectal cancer, stroke and diabetes [11–18]. However, studies on whether patients with ASD receive proper dental care are lacking. Therefore, it can be said that those with ASD are blind spots for dental care [19].

The global prevalence of ASD appears to have risen grad-

## Abstract

Individuals with autism spectrum disorders (ASD) have difficulty accessing dental care. We aim to verify whether individuals with ASD are properly managed by checking the frequency of dental visits, cost and severity of dental treatment compared with those without ASD. This cross-sectional study used the Korean Health Insurance Database to analyze the frequency, cost and severity of dental treatment in 209,780 people under the age of 19 with or without ASD in 2020. The average frequency of dental visits for individuals without ASD was 2.98 times, which was significantly higher ( $p < 0.001$ ) than the 2.89 times for those with ASD. However, the average dental cost for individuals with ASD was USD 132.63, which was significantly higher ( $p < 0.001$ ) than USD 116.57 for those without ASD. Additionally, the average number of times that individuals without ASD received severe dental treatment was 1.23 times, significantly higher than the 1.15 times for those with ASD. Further, per 10,000 people, we found that trauma treatment was recorded for an average of 21.90 individuals with ASD, significantly higher than the 7.75 recorded for those without ASD ( $p < 0.001$ ). Individuals with ASD encounter significant disparities in accessing dental care, as evidenced by their relatively infrequent dental visits. This discrepancy can be attributed to various barriers including the financial burden compared with those without ASD.

## Keywords

Autistic spectrum disorder; Dentistry; National health insurance; Cross-sectional study; Oral hygiene

ually and is estimated to be approximately 0.1% [20, 21]. Additionally, the number of patients with ASD in Korea in 2018 was approximately 25,000, according to the Ministry of Health and Welfare [22].

Therefore, aligned with previous research findings, our conjecture was that individuals with ASD would exhibit a reduced frequency of dental visits in comparison to those without ASD, while simultaneously encountering a higher incidence of more invasive dental treatment, such as tooth extraction, attributable to the insufficient maintenance of oral hygiene. This study aims to use large-scale data to compare the frequency of dental visits, cost and severity of dental treatments in children and adolescents with ASD compared to those without ASD to determine whether patients with ASD are receiving adequate dental care.

## 2. Materials and methods

### 2.1 Data resource

The data used in this study were taken from the National Health Insurance Database, which is managed by the National Health Insurance Service of the Republic of Korea and contains the data of approximately 97.2% of Koreans [23].

### 2.2 Study design and variables

This cross-sectional study comprised the data of 209,780 participants under the age of 19 in 2020. ASD was defined by ASD diagnosis codes (F48.0, F48.1, F48.5, F48.8 and F48.9) in the International Classification of Diseases-10 (ICD-10) until 31 December 2019 [24, 25].

Age and sex were used in the claim data. The income level in the claim data was divided into 10 deciles and three groups (high, medium and low). Residential areas were classified into the Seoul Capital Area, metropolitan cities and other areas. Additionally, age was divided into four groups of five years each.

The frequency of dental visits was checked for patients who had never visited or had visited a dental facility once, twice, thrice or more times a year. The average dental costs were also checked by group. Moreover, the average cost of medical treatment according to hospitals, that is, tertiary and general hospitals, dental hospitals and dental clinics, was identified.

Lastly, the severity of dental treatment was determined according to ASD. Dental treatment was defined as per the treatment code of the Korean Standard Classification of Diseases and Causes of Death-7 (KCD-7) and classified into severe, mild and dental treatment for trauma, depending on the level of severity. The frequency of treatment codes between the first registered ASD diagnosis code and 31 December 2019, was confirmed. Severe dental treatment was defined using endodontic treatment (U0012, U0020, U0050, U0060, U0074, U0075, U0090, U0101, U0111, U0116, U0121, U0126 and U0210), tooth extraction treatment (U4412, U4413, U4414, U4420), and incision and drainage treatment codes (U4454, U4455, U4456, U4457, U4464, U4465 and U4467). Mild dental treatment was defined by conservative treatment (U0131, U0132, U0133, U0134, U0135, U0136, U0137, U0138, U0239, U0240, U0241, U0200, U0151,

U0152, U0153 and U0154), periodontal treatment (U2221, U2222, U2231, U2232, U2233, U2240, U1010, U1020, U1030, U1040, U1051, U1052, U1060 and UY101), and preventive treatment codes (U2390, IB761, IB762). The dental treatment for trauma was defined by the following codes: U4474, U4475, U4476, U4477 and U4690. The severity of dental treatment according to patient age was also analyzed. The analysis of treatment costs and severity of dental treatment determined that patients who were untreated or were not treated were excluded to avoid bias caused by untreated patients.

### 2.3 Statistical analysis

Statistical analysis was conducted by matching the gender and age of individuals with ASD to those without ASD at 1:3 using simple random sampling. The *t*-test analysis of variance was conducted. All statistical analyses were performed using SAS Enterprise Guide 8.2. (SAS Institute, Cary, NC). Statistical significance was defined as  $p < 0.05$ .

## 3. Results

### 3.1 Participant characteristics

A total of 209,780 patient records, consisting of 157,335 individuals without ASD and 52,445 individuals with ASD were included in the study. The high-income group comprised 81,226 (51.6%) and 26,311 (50.2%), the medium income comprised 46,443 (29.5%) and 14,123 (26.9%), and the low-income group comprised 29,666 (18.9%) and 12,011 (22.9%) individuals without ASD and with ASD, respectively. The numbers of individuals living in the Seoul Capital Area, metropolitan cities and other areas were 78,599 (50.0%), 30,087 (19.1%) and 48,649 (30.9%) for individuals without ASD, respectively, and 26,824 (51.1%), 10,434 (19.9%), and 15,187 (29.0%) for those with ASD, respectively. The income level and residential area of the two groups, besides the gender and age that were matched, showed significant differences ( $p < 0.001$ ) (Table 1).

### 3.2 Annual dental visits according to ASD

Regarding the annual frequency of dental visits of individuals without ASD, 73,871 (47.0%) had never visited, 26,409 (16.8%) had visited once, 18,447 (11.7%) had visited twice, and 38,608 (24.5%) had visited more than three times. A total of 26,381 (50.3%) individuals with ASD had never visited, 8250 (15.7%) had visited once, 5989 (11.4%) had visited twice, and 11,825 (22.6%) had visited more than three times. The average frequency of dental visits was 1.58 in those without ASD and 1.44 in those with ASD. The average frequency of dental visits, excluding patients who did not visit the hospital, was 2.98 in those without ASD and 2.89 in those with ASD, respectively. The results showed significant differences between the groups ( $p < 0.001$ ) (Table 2).

**TABLE 1. Characteristics of individuals of autism spectrum disorder.**

	Individuals without ASD	Individuals with ASD	<i>p</i> -value
Total (N)	157,335	52,445	
Sex (N, %)			
Male	116,715 (74.2%)	38,905 (74.2%)	1.000
Female	40,620 (25.8%)	13,540 (25.8%)	
Income (N, %)			
High (8–10 decile)	81,226 (51.6%)	26,311 (50.2%)	<0.001
Medium (4–7 decile)	46,443 (29.5%)	14,123 (26.9%)	
Low (0–3 decile)	29,666 (18.9%)	12,011 (22.9%)	
Area (N, %)			
Seoul capital area	78,599 (50.0%)	26,824 (51.1%)	<0.001
Metropolitan cities	30,087 (19.1%)	10,434 (19.9%)	
Other area	48,649 (30.9%)	15,187 (29.0%)	
Age (yr, %)			
0–4	8838 (5.6%)	2946 (5.6%)	1.000
5–9	53,856 (34.2%)	17,952 (34.2%)	
10–14	56,595 (36.0%)	18,865 (36.0%)	
15–18	38,046 (24.2%)	12,682 (24.2%)	

ASD: autism spectrum disorders.

**TABLE 2. Annual dental visits according to autism spectrum disorder.**

	Individuals without ASD	Individuals with ASD	<i>p</i> -value
Total (N, %)	157,335 (100%)	52,445 (100%)	
0	73,871 (47.0%)	26,381 (50.3%)	<0.001
1	26,409 (16.8%)	8250 (15.7%)	
2	18,447 (11.7%)	5989 (11.4%)	
More than 3	38,608 (24.5%)	11,825 (22.6%)	
Mean (N, sd)	1.58 (1.57–1.59)	1.44 (1.42–1.46)	<0.001
Mean (except 0) (N, sd)	2.98 (2.96–2.99)	2.89 (2.86–2.92)	<0.001

ASD: autism spectrum disorders; sd: standard deviation.

### 3.3 Annual cost according to the type of healthcare facility

The annual average cost of dental visits was determined. Total average medical costs for individuals without ASD were USD 116.57 and USD 130.01 in tertiary, general hospital, USD 112.87 in dental hospital, USD 113.09 in dental clinics, respectively. Total average medical cost for individuals with ASD were USD 132.63 and USD 173.15 in tertiary, general hospital, USD 176.13 in dental hospital, USD 114.19 in dental clinics, respectively. Annual average costs were significantly higher for individuals with ASD ( $p < 0.001$ ), except for the average costs of dental clinics ( $p = 0.269$ ) (Table 3).

### 3.4 Severity of dental treatment according to ASD

The average number of times that individuals without and with ASD received severe dental treatment per year were 1.23 and 1.15 times, respectively. The average number of times that individuals without and with ASD received mild dental

treatment per year were 3.37 and 3.42 times, respectively. Moreover, the average number of times that individuals without and with ASD received severe dental treatment per year were 7.75 and 21.90 times per 10,000 people, respectively. The number of severe dental treatments and dental treatments for trauma significantly differed ( $p < 0.001$ ), except for mild dental treatment ( $p = 0.092$ ) (Table 4).

### 3.5 Severity of dental treatment according to age

The frequency of receiving dental treatment according to age was confirmed. Regarding mild and severe dental treatments, individuals with ASD were more frequent in age group 1, whereas those without ASD were more frequent in age group 2. Moreover, the frequency among those with and without ASD was similar in age groups 3 and 4. Regarding dental treatment for trauma, individuals with ASD were more frequent in age groups 1 and 2, whereas those without ASD were more frequent in age groups 3 and 4 (Table 5).

**TABLE 3. Annual cost according to type of healthcare facility.**

	Individuals without ASD	Individuals with ASD	<i>p</i> -value
Total (USD) <sup>†</sup>	116.57	132.63	<0.001
Tertiary hospital and general hospital	130.01	173.15	<0.001
Dental hospital	112.87	176.13	<0.001
Dental clinic	113.09	114.19	0.269

<sup>†</sup>USD, 1 USD/1300 won.

Except for individuals without dental visits in Table 2.

ASD: autism spectrum disorders.

**TABLE 4. Severity of dental treatment according to autism spectrum disorder.**

	Individuals without ASD	Individuals with ASD	<i>p</i> -value
Total (Times)	4.60	4.58	0.526
Severe dental treatment <sup>†</sup>	1.23	1.15	<0.001
Mild dental treatment <sup>‡</sup>	3.37	3.42	0.092
Trauma <sup>¶</sup>	7.75	21.9	<0.001

<sup>†</sup>Severe dental treatment—Endodontic treatment, Tooth Extraction, Incision and drainage.

<sup>‡</sup>Mild dental treatment—Restorative treatment, Periodontic treatment, Preventive treatment, Prosthesis deletion.

<sup>¶</sup>per 10,000 individuals.

Only for individuals who have had dental treatment or have been treated for trauma.

ASD: autism spectrum disorders.

**TABLE 5. Severity of dental treatment according to age.**

	Severe dental treatment		Mild dental treatment		Trauma	
	without ASD	with ASD	without ASD	with ASD	without ASD	with ASD
0–4 (group 1)	707 (2.8%)	406 (5.9%)	839 (1.6%)	456 (3.1%)	6 (15.4%)	6 (19.4%)
5–9 (group 2)	16,748 (65.5%)	4306 (62.2%)	25,108 (48.8%)	6740 (46.1%)	20 (51.3%)	17 (54.8%)
10–14 (group 3)	5052 (19.8%)	1429 (20.7%)	17,996 (35.0%)	5310 (36.3%)	10 (25.6%)	6 (19.4%)
15–18 (group 4)	3066 (12.0%)	779 (11.3%)	7506 (14.6%)	2126 (14.5%)	3 (7.7%)	2 (6.5%)

ASD: autism spectrum disorders.

## 4. Discussion

### 4.1 Principal findings

In accordance with data obtained from the Health Insurance Review and Assessment Service in 2020, the comprehensive utilization rate of dental services exhibited approximately 3.4 times [26]. More specifically, the utilization rate was observed to be approximately 3.1 times in those below the age of 9, 2.5 times for teenagers, and approximately 2.5–3 times for the children and adolescents. These results are similar to ours, indicating a notable similarity in their respective patterns of dental service utilization. The average frequency of dental visits for individuals with ASD was significantly lower than that for individuals without ASD. This result was consistent with the hypothesis that the frequency of dental visits for individuals with ASD would be lower than that for individuals without ASD. On the contrary, individuals with ASD incur higher costs of dental treatment than those without ASD. In particular, the average cost for individuals with ASD was 1.5 times more than that for those without ASD in dental hospitals. This could be due to the additional workforce or

equipment required for individuals with ASD and emergency-related treatment caused by trauma. Furthermore, treatment costs increase by 30% for individuals with ASD. Additionally, depending on the dentist, for patients with ASD, SS (stainless steel) crown restoration or root canal treatment is strategically implemented in cases that would normally be treated with conservative restoration or even in initial caries. Our findings indicated that the difference in frequency of dental visits based on ASD was not based on income differences or differences in residential area (which would lead to accessibility issues) between the two groups.

Additionally, it was confirmed that the need for severe dental treatment (not trauma dental treatment), owing to a lack of dental care for individuals with ASD, was not higher than predicted. However, the dental treatment for trauma indicated a significant difference of almost three times with 21.90 times for individuals with ASD per 10,000 people and 7.75 times for individuals without ASD. Adults or pediatric patients diagnosed with ASD often tend to act impulsively, leading to trauma [27, 28]. Accordingly, there is a high probability that individuals with ASD would experience unexpected trauma. Therefore, the treatment related to trauma would be relatively

high.

## 4.2 Interpretation within the context of prior literature

Individuals with ASD were expected to have a high risk of dental caries because they prefer to hold food in their mouth rather than swallowing, have difficulty brushing and flossing owing to functional restrictions, and have toothpaste sensitivity [2, 4, 29, 30]. Although we expected that severe treatments such as endodontic treatment or tooth extraction would be more necessary for such individuals, our results showed that the number of individuals without ASD requiring severe treatment was significantly higher, which was similar to the results of other studies [31]. One of the reasons for these results might be the relatively high frequency of tooth extractions during dental visits for tooth exchange. However, further research is needed to analyze the exact cause [4]. Conversely, individuals with ASD, although this finding was not significant, showed a relatively high frequency of conservative, preventive dental treatment. Additional research is imperative to accurately determine the risk of dental caries and periodontal problems that are often encountered by individuals with ASD due to functional impairments or medication-related adverse effects [32].

The frequency of dental treatment was the highest in age group 2 in both groups (Table 5). In particular, more than 60% of severe dental treatment cases involved individuals between the ages of 5 and 9 in both groups, which seems to be owing to the inclusion of extraction for tooth exchange in mixed dentition, as this study included extraction as a severe dental treatment [4]. Age group except 1 showed a similar frequency of severe and mild dental treatment in both groups. In individuals with ASD, dental treatment conducted in the 0–4 group was about 2% higher than that in individuals without ASD and twice as frequent. ASD is a lifelong neurodevelopmental disorder characterized by its appearance within three years of birth [5]. ASD in children is often diagnosed because of late language acquisition and poor communication skills after birth [5]. Consequently, individuals with ASD visit large hospitals early and are spontaneously leads to other departments such as dentistry, which is considered a reason for the relatively high rate of visits among these individuals.

Numerous investigations have demonstrated that individuals with ASD encounter various impediments to accessing appropriate dental care. These hindrances encompass patient-related factors such as deficits in social and communication skills, challenges in behavior regulation, and difficulties in maintaining adequate oral hygiene. Economic factors, including supplementary expenses and disparities in financial resources, as well as structural factors such as the availability of equipped medical personnel and specialized facilities, further contribute to the barriers. Moreover, parental factors such as parental educational attainment and insufficient knowledge regarding proper oral care, act as additional deterrents to receiving optimal dental care. Consequently, the implementation of supplementary preventive measures and supportive interventions emerges as a crucial imperative [33].

## 4.3 Strengths and limitations

Although comparing the frequency may not be significant because of the small sample size in this study, dental trauma among individuals with ASD showed a relatively high frequency at an early age in age groups 1 and 2. The frequency of trauma in children is known to be the highest at the ages of about 2–4 and 8–10 years, when they usually start walking and external activities increase, respectively [34]. Likewise, in this study, both those with and without ASD received the most trauma-related treatment in age group 2. However, although it is difficult to determine the exact trend or difference owing to the small sample size in the study, this study is meaningful because it examined all patients diagnosed with ASD, unlike prior studies, which only conducted a few investigations on the dental care of individuals with ASD.

Furthermore, this study enables us to ascertain the actual requirements of individuals with ASD, thereby serving as a significant dataset for evidence-based policymaking in the future concerning those with ASD. However, to enhance the accuracy of the current assessment, supplementary information encompassing age-specific prevalence rates and nationwide distribution is imperative. Such additional data would contribute to a more comprehensive understanding of the present landscape and aid in formulating informed policies tailored to the unique needs of individuals with ASD [35].

## 5. Conclusions

Individuals with ASD face inequality in dental care, with a relatively low frequency of dental visits owing to barriers such as the cost of dental treatment compared with individuals without ASD. In addition, the frequency of trauma is relatively high owing to the characteristics of ASD.

## AVAILABILITY OF DATA AND MATERIALS

Not applicable.

## AUTHOR CONTRIBUTIONS

HJB, JY—conceptualization, data curation, methodology, writing-original draft; HJB, HL—formal analysis; HL, HJY, JYL, KSK—project administration, writing-review & editing. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by the Institutional Review Board (IRB) of Seoul National University Bundang Hospital (IRB No. X-2109-709-902). The requirement for informed consent was waived because retrospective anonymized data were used.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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