



# Dental utilization and expenditures by children and adolescents with autism spectrum disorders: A population-based cohort study

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## ABSTRACT

**Objectives:** It is understood that children and adolescents with autism spectrum disorders (ASDs) have difficulty in receiving dental treatment. This study explores the differences in dental utilization and expenditure between two groups: children and adolescents with and without ASD. Different conditions that affect these results will be examined, including area of residence, category of treatment, and preferences concerning type of dental institution in Taiwan. **Materials and Methods:** The health service research database of the National Health Research Institutes, which features population-based, randomly selected samples collected from 2001 to 2010, was utilized in this study. In particular, we recruited samples from 2005 in accordance with the codes of the International Classification of Diseases, 9<sup>th</sup> revision, Clinical Modification from 299.0 to 299.9. The population-based cohort study measured mean expenditures and mean numbers of medical visits with regard to different dental institution classifications, areas of residence, and categories of dental treatment for children (under 18 years old) with and without ASD. **Results:** The mean number of annual visits was 6.58 and 5.70 for children and adolescents with and without ASD, respectively, with mean annual visit expenditures of NT\$2401.20 and NT\$1817.99, respectively. A higher percentage of children (91.32%) and adolescents (72.66%) with ASD had experienced dental treatment than those without ASD. Children (93.23%) and adolescents (90.83%) without ASD visited dental clinics more often than those with ASD. The percentage of dental visits to academic medical centers in Eastern Taiwan was significantly lower for the ASD group than visits to other types of dental institutions. The use of restorative treatment was significantly higher among all samples, with periodontology having the lowest percentage. **Conclusions:** Children and adolescents with ASD had greater dental utilization, expenditures, and preferences for high-level dental institutions. The discrepancies in dental utilization indicate differences in the distribution of medical resources in different dental institution levels and residence areas in Taiwan.

**KEYWORDS:** *Autism spectrum disorder, Children and adolescents, Dental expenditures, Dental utilization, Health insurance*

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## INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by pervasive difficulties evident from early childhood in reciprocal social communication, restricted, repetitive interests, and behaviors [1-6]. There is great international variation in the prevalence of ASD, with evidence showing that this prevalence is increasing. Both genetic and environmental factors play important roles in the etiology of childhood ASD, and evidence suggests that genetic susceptibility to the effects of air pollution is also a factor [7].

It is now recognized that 1% of the population worldwide has ASD. In the United States of America, the prevalence is 1

in every 88 children [8]. In Taiwan, the number of individuals with ASD among all individuals with disabilities has increased annually, from 1549 in 1999 to 13,293 in 2015, accounting for 1.15% of disabled individuals. There were 11,587 males and 1705 females with autism [5,9,10]. More than half of individuals with ASD (63.69%) were children and adolescents

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younger than 18 years old [9]. In previous studies, residential care or supportive living accommodation and individual productivity loss contributed the highest costs for patients with ASD and their families [11-15]. Previous research has shown health-care utilization and expenditures for children and adolescents with ASD grew annually at a higher rate than those for children and adolescents without ASD [3,5,15-20]. In Taiwan, the national health insurance (NHI) expenditure for children and adolescents with ASD is used in disease control and has been increasing annually [16]. This study explored the differences between children and adolescents with and without ASD in areas of residence, dental institution levels, and categories of dental treatment in Taiwan.

## MATERIALS AND METHODS

### Sample sources

Taiwan's current NHI coverage rate has reached more than 99%, making highly representative empirical health insurance data available in the field of medical and health research. These data can be used as a reference for influencing medical and health policy, as well as being an important research resource. The National Health Research Institutes provides a database of 1,000,000 randomly selected individuals for health service research, creating a population-based, random sample study using data from 2001 to 2010. Medical report data (including outpatient, hospital, and special pharmacies) are then captured each year.

This population-based cohort research has investigated trends in dental utilization and expenditures among children and adolescents with and without ASD in different situations. We selected samples from 2005 to track their medical situations from 2001 to 2010. The ASD diagnosis of individuals was identified according to the codes of the International Classification of Diseases, 9<sup>th</sup> Revision, Clinical Modification (ICD-9-CM) from 299.0 to 299.9, and participants without ASD were matched at a 1:4 ratio as the control group [Table 1].

The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee of the institution. Informed written consent was waived because the study was a retrospective data analysis. This study has been approved by the Research Ethics Committee of Buddhist Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation (IRB102-172).

### Measures

The demographic data for the study, including age, sex, and follow-up duration, were obtained from the NHI database and were then stratified. Age was stratified into two categories: children (0-5 years) and adolescents (6-17 years). The geographic distribution was stratified into four areas: Northern, Central, Southern, and Eastern according to the residential classification used in the NHI database. The dental institution levels were stratified into academic medical centers, metropolitan hospitals, local community hospitals, and dental clinics according to the classification in the NHI database. Dental treatments were stratified into five categories: restorative treatment, endodontic treatment, periodontal treatment, oral and

maxillofacial surgical treatment, and other. The number of visits and percentages of different treatments were also derived from the NHI database. We identified that restorative treatment was the intersection of ICD-9-CM from 521.0 to 521.9 and medical order from 89001c to 89113c; endodontic treatment was the intersection of ICD-9-CM from 522.0 to 522.9 and medical order from 90001C to 90112C; periodontal treatment was the intersection of ICD-9-CM from 523.0 to 523.9 and medical order from 91001C to 91114C; oral and maxillofacial surgical treatment was the medical order from 92013C to 92016C.

### Statistical analyses

We used Chi-square test for categorical variables and the two-sample *t*-test for continuous variables. The alpha level was set at 0.05 for significance. Mean and standard deviation were used to present continuous variables, and number and percentage were used to present categorical variables. We used ANOVA to evaluate the correlates associated with different dental institutions and samples. We used SAS 9.3 for Windows (SAS Institute Inc., Cary, NC, USA) for statistical analyses in this study. The NHI provided all identification information with personal details deleted.

## RESULTS

There were 1418 children and adolescents with ASD and 866,281 children and adolescents without ASD from 2001 to 2010. We selected samples from 2005 to track their medical situation from 2001 to 2010. Table 1 shows the results after 1:4 matching and excluding individuals over 18 years of age. The sample size of children and adolescents with ASD was 1305, and the sample size of children and adolescents without ASD was 5220. No variable achieved statistical significance after matching was conducted ( $P > 0.05$ ). The mean age, follow-up duration, and number of boys and girls among children and adolescents with ASD and without ASD are presented in Table 1.

The results shown in Table 2 indicate that the mean number of visits and health-care expenditures were significantly higher among children and adolescents with ASD than those without ASD ( $P < 0.05$ ). There were 6.58 (2.63 + 3.95) and 5.70 (2.15 + 3.55) annual visits for children and adolescents with and without ASD, respectively, with mean annual visit expenditures of NT\$2401.20 (NT\$991.40 + NT\$1409.80) and NT\$1817.99 (NT\$780.49 + NT\$1037.50), respectively.

Table 3 shows that a higher percentage of children (91.32%) and adolescents (72.66%) with ASD had experienced dental treatment than children (87.06%) and adolescents (65.76%) without ASD ( $P < 0.01$ ). Table 4 shows that a higher percentage of children (93.23%) and adolescents (90.83%) without ASD visited dental clinics as opposed to children (84.64%) and adolescents (78.31%) with ASD, who visited medical centers, metropolitan hospitals, and local community hospitals more frequently.

Regardless of residential area, visits to dental clinics were significantly higher among children (84.64%) and adolescents (78.31%) with ASD, as opposed to academic medical centers, which were visited the least among

**Table 1: Characteristics of the study samples**

|                            | Children (0-5 years) |              |        | Adolescents (6-17 years) |              |     |
|----------------------------|----------------------|--------------|--------|--------------------------|--------------|-----|
|                            | ASD                  | Without ASD  | P      | ASD                      | Without ASD  | P   |
| Age (years)                | 3.2 (1.21)           | 3.25 (1.25)  | 0.8515 | 10.20 (3.48)             | 10.20 (3.48) | 1.0 |
| Follow-up duration (years) | 6.04 (2.70)          | 6.17 (2.63)  | 0.2887 | 4.09 (2.74)              | 4.09 (2.73)  | 1.0 |
| Boys                       | 490 (81.80)          | 1960 (81.80) | 0.8    | 575 (81.44)              | 2300 (81.44) | 1.0 |
| Girls                      | 109 (18.20)          | 436 (18.20)  | 0.8    | 131 (18.56)              | 524 (18.56)  | 1.0 |
| Total                      | 599                  | 2396         |        | 706                      | 2824         |     |

ASD: Autism spectrum disorder

**Table 2: Expenditures and numbers of visits**

|                         | Children with ASD |         | Children without ASD |        | P     | Adolescents with ASD |         | Adolescents without ASD |        | P     |
|-------------------------|-------------------|---------|----------------------|--------|-------|----------------------|---------|-------------------------|--------|-------|
|                         | Mean              | SD      | Mean                 | SD     |       | Mean                 | SD      | Mean                    | SD     |       |
| Mean expenditure (NT\$) | 991.40            | 1626.80 | 780.49               | 724.80 | <0.05 | 1409.80              | 2474.70 | 1037.50                 | 953.20 | <0.05 |
| Mean number of visits   | 2.63              | 3.70    | 2.15                 | 3.58   | <0.05 | 3.95                 | 3.85    | 3.55                    | 4.32   | <0.05 |

SD: Standard deviation, ASD: Autism spectrum disorder

**Table 3: Dental treatment experience**

|       | Children with ASD, n (%) | Children without ASD, n (%) | P     | Adolescents with ASD, n (%) | Adolescents without ASD, n (%) | P     |
|-------|--------------------------|-----------------------------|-------|-----------------------------|--------------------------------|-------|
| Yes   | 547 (91.32)              | 2086 (87.06)                | <0.05 | 513 (72.66)                 | 1857 (65.76)                   | <0.05 |
| No    | 52 (8.68)                | 310 (12.94)                 |       | 193 (27.34)                 | 967 (34.24)                    |       |
| Total | 599                      | 2396                        |       | 706                         | 2824                           |       |

ASD: Autism spectrum disorder

children (9.46%) and adolescents (12.64%) with ASD. Compared with other areas in Taiwan, the percentage of visits to academic medical centers in Eastern Taiwan was significantly lower for children (0.6%) and adolescents (0.4%) with ASD [Table 5].

Among the categories of the dental treatment, restorative treatment was significantly higher among children and adolescents with and without ASD, and all population ratios were >30%, followed by oral and maxillofacial surgical treatment. Periodontal treatment was the least common procedure among children and adolescents with and without ASD [Table 6].

## DISCUSSION

Taiwan's NHI program offers comprehensive, consistent, and universal health insurance for all nationals [10,16]. The results of this study showed that dental utilization and expenditures differed between children and adolescents with and without ASD, with different factors including mean expenditures, visits, dental institution choices, and categories of dental treatment in different areas of residence. There were about four times more boys than girls among children and adolescents with ASD ( $[490 + 575]/[109 + 131] = 4.44$ ), which corresponds with previous research [1,2,6,10,14,19].

Previous studies have revealed significantly greater medical utilization by children and adolescents with ASD (especially in outpatient costs) than those without ASD in other countries. However, investigations of dental utilization and expenditures were limited [11,16-20]. Dental expenditures are divided into health insurance pay and

self-pay, and self-pay items were excluded in this study because of price variations in different medical institutions, resulting in difficulties in statistics and analysis. In Taiwan, a small number of studies on medical utilization and expenditures have been conducted, some of which have shown that health-care expenditures, and the mean number of annual visits were higher for children and adolescents with ASD than for those without ASD. Our results are consistent with this pattern (2.63 times vs. 2.15 times; NT\$991.40 vs. NT\$780.49) [16,21]. Compared with those without ASD, a higher percentage of children and adolescents with ASD utilized dental care (72.66% vs. 91.32%), suggesting that this population has more dental needs and the care providers of the control group paid much more attention to children and adolescents with ASD in Taiwan.

The results also suggested an evident tendency for children and adolescents with and without ASD to visit dental clinics rather than hospitals, a phenomenon that was different from previous studies [16,21]. The widespread distribution of dental clinics in Taiwan was a probable reason for this choice. More in the control groups (93.23% and 90.83%) than the ASD groups (84.64% and 78.31%) received dental treatments at dental clinics, showing that those with ASD were more inclined to use hospitals than dental clinics.

The second choice for dental visits for children and adolescents with ASD in Northern, Central, and Southern Taiwan was academic medical centers, with a significantly lower percentage (0.6%, 0.4%) in Eastern Taiwan. This phenomenon may be associated with the fact that those with ASD need better care, but there is only one academic medical center in Eastern Taiwan.

No previous research has investigated the association between various dental treatments in children and adolescents with ASD. In our study, the highest percentage of visits for dental treatment by those with and without ASD was for restorative treatment, whereas periodontal treatment was utilized least often. These results are consistent with dental epidemiology in populations of children and adolescents [9].

**Table 4: Visits by level dental institution**

|                           | Children with ASD, n (%) | Children without ASD, n (%) | P     | Adolescents with ASD, n (%) | Adolescents without ASD, n (%) | P     |
|---------------------------|--------------------------|-----------------------------|-------|-----------------------------|--------------------------------|-------|
| Academic medical centers  | 1596 (9.46)              | 1751 (2.97)                 | <0.05 | 3599 (12.64)                | 879,908 (3.7)                  | <0.05 |
| Metropolitan hospitals    | 755 (4.48)               | 1424 (2.41)                 |       | 2096 (7.36)                 | 906,258 (3.81)                 |       |
| Local community hospitals | 239 (1.42)               | 819 (1.39)                  |       | 479 (1.68)                  | 391,697 (1.65)                 |       |
| Dental clinics            | 14,227 (84.35)           | 55,016 (93.23)              |       | 22,291 (78.31)              | #2.16E+07 (90.83)              |       |
| Total                     | 16,867                   | 59,010                      |       | 28,465 (0.12)               | #2.38E+07 (99.88)              |       |

ASD: Autism spectrum disorder

**Table 5: Visits according to residence area**

|                           | Children with ASD |                |                 |                | P     | Adolescents with ASD |                |                 |                | P     |
|---------------------------|-------------------|----------------|-----------------|----------------|-------|----------------------|----------------|-----------------|----------------|-------|
|                           | Northern, n (%)   | Central, n (%) | Southern, n (%) | Eastern, n (%) |       | Northern, n (%)      | Central, n (%) | Southern, n (%) | Eastern, n (%) |       |
| Academic medical centers  | 1065 (13.6)       | 298 (13.6)     | 375 (15.5)      | 2 (0.6)        | <0.05 | 236 (6.4)            | 244 (22.0)     | 234 (12.4)      | 1 (0.4)        | <0.05 |
| Metropolitan hospitals    | 656 (8.4)         | 255 (11.6)     | 41 (1.7)        | 17 (4.8)       |       | 234 (6.4)            | 21 (1.9)       | 2 (0.1)         | 18 (7.7)       |       |
| Local community hospitals | 65 (0.8)          | 13 (0.6)       | 23 (1.0)        | 19 (5.4)       |       | 100 (2.7)            | 18 (1.6)       | 3 (0.2)         | 29 (12.5)      |       |
| Dental clinics            | 6061 (77.2)       | 1627 (74.2)    | 1976 (81.8)     | 314 (89.2)     |       | 3109 (84.5)          | 825 (74.5)     | 1644 (87.3)     | 185 (79.4)     |       |
| Total                     | 7847              | 2193           | 2415            | 352            |       | 3679                 | 1108           | 1883            | 233            |       |

ASD: Autism spectrum disorder

**Table 6: Dental treatment**

| Dental treatment                          | Children with ASD, n (%) | Children without ASD, n (%) | P     | Adolescents with ASD, n (%) | Adolescents without ASD, n (%) | P     |
|---|--------------------------|-----------------------------|-------|-----------------------------|--------------------------------|-------|
| Restorative treatment                     | 4416 (31.47)             | 20,785 (39.37)              | <0.05 | 5887 (34.9)                 | 24,065 (40.78)                 | <0.05 |
| Endodontic treatment                      | 1738 (12.39)             | 6745 (12.78)                |       | 1468 (8.7)                  | 6461 (10.95)                   |       |
| Periodontal treatment                     | 679 (4.84)               | 1668 (3.16)                 |       | 1977 (11.72)                | 4851 (8.22)                    |       |
| Oral and maxillofacial surgical treatment | 2818 (20.08)             | 10,727 (20.32)              |       | 3228 (19.14)                | 11,518 (19.52)                 |       |
| Other                                     | 4382 (31.23)             | 12,864 (24.37)              |       | 4307 (25.54)                | 12,115 (20.53)                 |       |
| Total                                     | 14,033                   | 52,789                      |       | 16,867                      | 59,010                         |       |

ASD: Autism spectrum disorder

**CONCLUSIONS**

Dental utilization and expenditures for children and adolescents with ASD were higher than those for those without ASD. Children and adolescents with ASD seek dental treatment more frequently than those without ASD. Restorative treatment was the most common and periodontal treatment was the least common treatment in all individuals. Dental clinics provided the majority of dental services for children and adolescents with and without ASD in Taiwan. Those with ASD had a higher tendency to receive dental treatment in hospitals compared with the control group, revealing that treatment for children and adolescents with ASD was not universal in dental clinics. In comparison with other residential areas, Eastern Taiwan had the lowest frequency of visits to academic medical centers among children and adolescents with ASD, which suggests a correlation between the unequal distribution of medical resources and the population in Eastern Taiwan.

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**Conflict of interest**

There is no conflict of interest.

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