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Behavioral Changes During COVID-19 Omicron Variant Infection on Children with Autism Spectrum Disorder in China

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Purpose: The objective of this study was to investigate the behavioral changes in the core features and challenging behaviors of children with Autism Spectrum Disorder (ASD) during the COVID-19 Omicron wave (from December 2022 to January 2023) in China.

Patients and Methods: A total of 515 caregivers of children with ASD completed an online survey. This survey was designed to assess the sociodemographic characteristics of the children and their caregivers, the clinical features of COVID-19, the manifestation of core ASD features and challenging behaviors, and the alterations in daily life following the COVID-19 Omicron variant wave.

Results: The children with ASD had an average age of 5.4 years, with 79.6% being male. After the Omicron wave, the proportions of participants with worsening core ASD features and challenging behaviors were 22.9% and 37.1%, respectively. Sleep disorders (20.0%), eating problems (18.6%), and inattentive symptoms (17.5%) were the most frequently reported worsening behaviors. The factors associated with the worsening of core ASD features included infection with the Omicron variant of COVID-19, reduced outdoor activity, and a lower score of caregiver health-related quality of life (HRQoL). The worsening of challenging behaviors was associated with infection with the Omicron variant of COVID-19, a lower frequency of rehabilitation training, and a lower score of HRQoL.

Conclusion: The outbreak of the COVID-19 Omicron variant had an impact on the behaviors of autistic children. The behavior changes in core ASD features and challenging behaviors differed and were associated with COVID-19 infection and other factors.

Keywords: core feature, challenging behavior, behavior worsening, infection, autism spectrum disorder

Introduction

Between December 2022 and January 2023, China witnessed a surge in Omicron variant infections following three years of strict pandemic prevention and control measures implemented since December 2019. These measures had considerable nationwide and global impacts, leading to substantial changes in people's daily lives.

During the COVID-19 pandemic, numerous studies have reported a high incidence of anxiety, depression, and psychological stress in the general population, indicating a substantial deterioration in mental health.[1,2] A systematic review of 43 studies reveals that the symptoms of mental health disorders in the general population slightly worsened during the first two months of the pandemic. However, the changes in symptoms across study populations ranged from very detrimental to somewhat beneficial, with high heterogeneity that could not be attributed to population or country

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characteristics.[3] Children, in particular, are more vulnerable to the negative effects of external environmental changes on their mental and behavioral health. The pandemic has resulted in reduced opportunities for outdoor activities, disruptions to sleep patterns, and increased screen time for children. Among these vulnerable children, those with autism spectrum disorder (ASD) are at an even greater risk of experiencing negative psychological impacts.[4] A recent review indicated that six out of eight included studies reported an increase in behavioral problems in children with ASD during the pandemic. These studies were conducted in different countries such as Portugal, Italy, the United Kingdom, Turkey, and Spain, covering various time periods from January to June 2020.[5–11] Compared to children without ASD, children with ASD are disproportionately affected by stressful environments. Previous research has shown the significant impact of the pandemic on ASD populations.[12] Due to their restricted and repetitive behaviors, difficulties in communication and social interaction, and co-occurring psychological and behavioral symptoms, they may be at greater risk for negative outcomes.[13–16] During the early stages of the pandemic (from May 18th to July 5th, 2020 in Germany and Austria), an online survey of 216 families with autistic children found that nearly 50% reported an aggravation of autistic symptoms along with heightened parental stress. There were also disruptions in therapy, increased intrafamilial conflicts, and an increase in the child's psychopharmacological medication.[17] A study focused on the relationship between routine disruption, specifically in the sleep-wake cycle, and aggressive behaviors in adults with ASD during the lockdown.[18] The study of 43 parents of adults with ASD through a web-based questionnaire showed that the lockdown-induced disruption of routines was related to negative emotional states, which in turn were related to aggressive behaviors. Prolonged quarantine or isolation severely impacted children with ASD, resulting in restricted access to education training,[14,19,20] which may further hamper their overall skill development. Based on the Shanghai Autism Early Developmental Cohort, Zhang et al investigated the impact of lockdowns on ASD children.[21] It was found that compared to lockdown-free children, those under longer strict lockdowns had less clinical improvement, especially in social cognition. However, parental agreeableness was identified as a protective factor, and this protective effect was enhanced in children with larger grey matter volumes in certain brain regions related to social cognition.

After the initial outbreak of COVID-19 in December 2019, China implemented strict "zero-COVID" policies for nearly three years. As of December 7, 2022, the government adopted a new strategy with more targeted measures. Between December 2022 and January 2023, the Omicron variant spread widely across the country. Despite an increasing number of studies on the impact of the COVID-19 pandemic on children with ASD since 2020, there is a lack of national multi-center studies on the Omicron wave from the end of 2022 to the beginning of 2023 in the country. Moreover, most studies do not differentiate between the core ASD features and challenging behaviors of autistic children.

The current study had two main objectives. First, we aimed to investigate whether autistic children experience behavioral changes in the context of the large-scale outbreak of the COVID-19 Omicron variant across the country. Based on previous COVID-19 research, parents of children on the autism spectrum and typically developing (TD) children reported more behavioral problems. In this study, we further categorize the behavioral problems into two major groups: core ASD features (stereotypical behavior, restricted interest, eye contact, and delayed speech) and challenging behaviors (aggressive behavior, self-injury, inattention symptoms, sleep disorders, and eating problems). It was hypothesized that the behavior change would be different between core ASD features and challenging behaviors. Second, if there are behavior changes, are these changes related to COVID-19 infection? Besides infection with the COVID-19 Omicron variant, are there any other influencing factors? It was hypothesized that behavior change would be correlated with infection with the COVID-19 Omicron variant and other influencing factors.

Materials and Methods

This was a cross-sectional study. Children with ASD, aged between 3 and 8 years and receiving care in outpatient settings, were enrolled. The primary caregivers of these children were invited to complete a structured questionnaire. An additional inclusion criterion was that the participants should have been in China from December 2022 to January 2023. Exclusion criteria included children who had been infected with COVID-19 before December 2022, those whose caregivers declined to participate in this study, and those whose caregivers were unable to read or understand the questionnaire items. This study adhered to the Declaration of Helsinki. The Ethics Committee of China-Japan Friendship Hospital approved this study (2022-KY-195). All caregivers provided electronic informed consent, which contained

information regarding the study's purpose, procedures, benefits of participation, and voluntary participation. Regarding the personal information involved in this study, the research group will keep it strictly confidential and will conceal the personal information during result analysis. All data were anonymized and stored securely to prevent any unauthorized access.

Participants were enrolled through four WeChat groups, which served as communication systems used by the medical centers to provide information to ASD patients, at three tertiary hospitals: one in Beijing, one in Xi'an (northwest China), one in Yunnan (southwest China), and another in Guangzhou (southeast China). The outpatient follow-up groups consisted of all caregivers of children with ASD. Out of 590 approached families, 523 agreed to participate, resulting in a participation rate of 88.6%. The main reasons for refusal were lack of interest or time. Data were collected from January 1 to January 10, 2023. Participants were distributed across nearly all provinces, with the exception of Qinghai, Tibet, and Taiwan provinces (Figure 1).

Instrument

An anonymous structured questionnaire comprising six groups of multiple-choice questions was administered. The questionnaire covered the following areas:

1. Sociodemographic characteristics of children with ASD and their caregivers: Variables included age, sex, diagnostic age, diagnostic methods of ASD, and diagnostic institution of ASD for the children, as well as age, sex, household size, family structure, educational level, and occupational type of the caregivers.
2. Clinical characteristics of COVID-19 Omicron variant infection: This part of the questionnaire focused on the clinical aspects of COVID-19 Omicron variant infection, such as whether the child was infected with the virus, the date of infection, the symptoms experienced, the treatment received after infection, and the vaccination status.
3. Behavioral performance before the COVID-19 Omicron wave: Caregivers were asked to retrospectively report on the behavioral performance of their children before the COVID-19 Omicron wave (before December 2022). Variables related to behavioral performance included (1) core ASD features (stereotypical behavior, restricted interest, eye contact, and delayed speech) and (2) challenging behaviors (aggressive behavior, self-injury, inattention symptoms, sleep disorders, and eating problems). Caregivers rated these variables as either yes or no based on daily observations or, in case of uncertainty, consultations with outpatient medical records.
4. Behavioral change after the COVID-19 Omicron wave: Caregivers were asked to report on changes in behavioral performance after a short period of the COVID-19 Omicron wave (from December 2022 to January 2023). As mentioned in the previous part, variables related to behavioral change included (1) core ASD features and (2) challenging behaviors. In this part, caregivers were asked about their perspectives on how the children's behavior

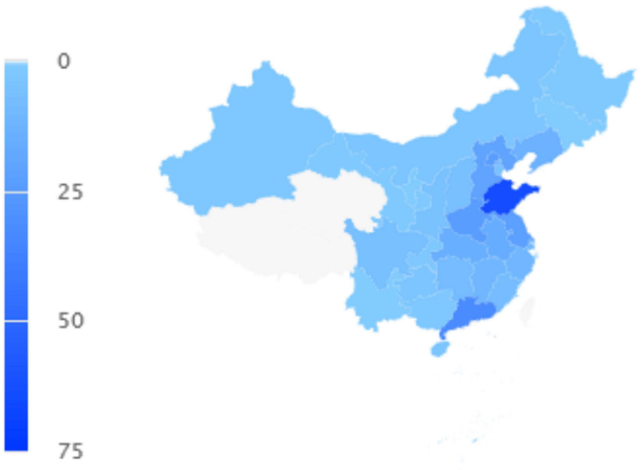

Figure 1 Participants distribution in different regions of China.

changed (using the 1 to 5 Likert scale, ie, 1 = behavior significantly worsened, 2 = mildly worsened, 3 = stayed the same, etc).

5. Changes in daily life during the COVID-19 Omicron wave: Variables related to changes in daily life included rehabilitation training (frequency and duration) and outdoor activities (frequency and duration) before and after the pandemic.
6. Health-related quality of life (HRQoL) of caregivers: The Euro-Qol visual analog scale (EQ-VAS) was used to assess the current health-related quality of life of caregivers.[22] The scale ranges from 100 ("the best imaginable health state" or "the best health state you can imagine") to 0 ("the worst imaginable health state" or "the worst health you can imagine").

To minimize possible observation errors or subjective biases from a single caregiver, in families with more than one caregiver, for each question, multiple caregivers were required to discuss together before reporting. Moreover, to ensure the quality of the questionnaire, we set the core questions as required answers, applied logical jumps and restrictions to key questions, and enforced filling within the specified scope. The electronic questionnaire was distributed to participants via the Chinese online survey platform WJX.CN (https://www.wjx.cn/app/survey.aspx).

Sample Size

To assess the adequacy of the sample size of 515, we calculated it using Power Analysis and Sample Size (PASS) software with the normal approximation method. The parameters used in the calculation included a difference (P_1-P_0) of 0.386, representing the proportion of the worsening of at least one behavioral problem after the pandemic. This was a two-sided exact test with a significance level (alpha) of 0.05, assuming that the population proportion under the null hypothesis was P_1-P_0= 0.

Statistical Analysis

A descriptive analysis was carried out to reveal demographic profiles, behavioral changes, and potential influencing factors. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as the means and standard deviations for normally distributed data or medians and interquartile ranges for skewed data. Univariate analysis was utilized to analyze the correlation between potential risk factors and outcome variables, and chi-square tests were used to compare differences between groups infected and not infected with COVID-19. All reported p-values were two-tailed, with a significance level of 0.05 indicating statistical significance.

In addition, Chi-square automatic interaction detection (CHAID) decision tree analysis was employed to identify potential factors contributing to the worsening of behavior and determine their specific effects. In identifying relevant factors, understanding the variable importance relative to the result is crucial. The decision-tree in the CHAID model can calculate the contribution degree of each variable during tree construction to determine the importance ranking, which helps focus on substantial factors and exclude secondary or interfering ones. Moreover, the CHAID model can handle continuous and discrete data without complex pre-processing conversions, directly incorporating different data types into the analysis framework without compatibility issues. Furthermore, since many influencing factors may have non-linear relationships, the CHAID model can effectively capture these by dividing the data space into sub-regions to accurately identify such complex relationships.[23,24]

The steps in the CHAID decision tree model represented different characteristics or factors within the population of children with autism. If Factor A was present to a greater extent than Factor B, it suggests that subpopulations within Factor A may differ in their performance on a specific outcome based on the characteristics of Factor B. In this model, the worsening of behavior was defined as the target variable, while risk factors were considered explanatory variables in the CHAID analysis. Pearson's chi-square test and maximum likelihood classification were used to compare various categorical variables, which were categorized into binary or multiple series based on the most significant predictor. Patients within each subgroup were further analyzed for the second most significant predictor, and the analysis continued until the last significant predictors were identified. The accuracy of the analysis was presented as a percentage. The significance level for node splitting in the CHAID decision tree analysis was set at $p < 0.05$. Descriptive analysis,

univariate analysis, and CHAID decision tree analysis were conducted using SPSS version 18.0 (SPSS, Inc., Chicago, Illinois, USA).

Results

A total of 531 caregivers participated in the survey; however, 16 of them had substantial missing data and were excluded. Ultimately, 515 parents participated in this study.

Sociodemographic Characteristics of the Participants

Table 1 presents a summary of the sociodemographic characteristics of the participants. The median age of the children was 5.4 years, and the majority were male (79.6%). The median household size was 4. The median ages of the mothers and fathers were 36 and 37 years, respectively. A total of 85.8% of the participants (442 out of 515) had been infected with COVID-19 Omicron variant.

Core ASD Features and Challenging Behaviors Before and After the COVID-19 Pandemic

Table 2 shows the proportion of both core ASD features and challenging behaviors before and after the pandemic reported by the caregivers. Before the pandemic, the most commonly reported core ASD features were poor eye contact (82.3%) and language delay (81.4%). The most commonly reported challenging behaviors were inattention symptoms (75.0%) and eating problems (74.4%).

After the pandemic, the most commonly reported worsening behaviors were sleep disorders (20.0%, significantly worsened by 6.8% and mildly worsened by 13.2%), eating problems (18.7%, significantly worsened by 7.2% and mildly worsened by 11.5%), and inattention symptoms (17.5%, significantly worsened by 7.0% and mildly worsened by 10.5%), which were all challenging behaviors.

Some children exhibited improvements in core ASD features such as eye contact (17.3%, significantly improved by 3.9% and mildly improved by 13.4%) and language delay (19.9%, significantly improved by 4.9% and mildly improved by 15.0%). Challenging behaviors such as self-injury behavior (85.4%) and aggressive behavior (81.7%) tended to remain unchanged. More detailed information on the behavioral changes is presented in Table 2.

Table 1 Demographic Characteristics of Participants

Median (IQR)/N (%)		Infected by COVID-19 (n=442)	Not Infected by COVID-19 (n=73)	*p*-value
Age (years)		5.4 (3.6)	4.9 (2.6)	0.339[a]
Gender	Male	347 (78.5%)	63 (86.3%)	0.126[b]
	Female	95 (21.5%)	10 (13.7%)	
Household size		4.0 (3.0)	3.0 (3.0)	0.561[a]
Mother age		36.0 (7.0)	35.0 (8.0)	0.294[a]
Father age		37.0 (9.0)	36.0 (7.0)	0.618[a]
Outdoor activities	Reduced	224 (50.7%)	37 (50.7%)	0.897[b]
	Same as before	149 (33.7%)	26 (35.6)	
	Increased	69 (15.6%)	10 (13.7%)	
Frequency of outdoor activities		3.0 (3.0)	3.0 (3.0)	0.511[a]
Rehabilitation training reduced	Reduced	305 (69.0%)	44 (60.3%)	0.207[b]
	Same as before	111 (25.1%)	21 (28.8%)	
	Increased	26 (5.9%)	8 (11.0%)	
Frequency of rehabilitation training		3.0 (5.0)	4.0 (5.0)	0.313[a]
EQ-VAS score of caregiver		66.2j±18.9[c]	65.0±21.9[c]	0.619[d]
Vaccination of COVID-19	Yes	246 (55.7%)	41 (56.2%)	0.935[b]
	No	196 (44.3%)	32 (43.8%)	

Notes: [a]Mann–Whitney test; [b]Chi-square test; [c]mean±standard deviation; [d]student's *t* test.
Abbreviation: IQR, Inter quartile range.

Table 2 Behavioral Performance Before the Pandemic and Behavioral Change After the Pandemic of Children with ASD

	Before the pandemic (n=515)	After the Pandemic (n=515)				
		Behavior Significantly Worsened	Behavior Mildly Worsened	Behavior Stayed Same	Behavior Mildly Improved	Behavior Significantly Improved
Core ASD features						
Eye contact	424 (82.3%)	16 (3.1%)	42 (8.2%)	368 (71.5%)	69 (13.4%)	20 (3.9%)
Language delay	419 (81.4%)	19 (3.7%)	37 (7.2%)	357 (69.3%)	77 (15.0%)	25 (4.9%)
Restricted interest	409 (79.4%)	15 (2.9%)	42 (8.2%)	384 (74.6%)	56 (10.9%)	18 (3.5%)
Stereotype behavior	280 (54.4%)	26 (5.0%)	48 (9.3%)	392 (76.1%)	34 (6.6%)	15 (2.9%)
Challenging behaviors						
Inattention symptoms	386 (75.0%)	36 (7.0%)	54 (10.5%)	362 (70.3%)	51 (10.1%)	11 (2.1%)
Eating problems	383 (74.4%)	37 (7.2%)	59 (11.5%)	364 (70.7%)	40 (7.8%)	15 (2.9%)
Aggressive behavior	324 (62.9%)	21 (4.1%)	32 (6.2%)	421 (81.7%)	17 (3.3%)	24 (2.7%)
Sleep disorders	318 (61.7%)	35 (6.8%)	68 (13.2%)	342 (66.4%)	47 (9.1%)	23 (4.5%)
Self-injury behavior	82 (15.9%)	16 (3.1%)	13 (2.5%)	440 (85.4%)	15 (2.9%)	31 (6.0%)

Table 3 Univariate Analysis of Influencing Factors on Participants' Core ASD Features

Median (IQR)/N (%)		At Least One of the Core ASD Features Became Worse (n_1=118)	None of the Core ASD Features Became Worse (n_2=397)	*p*-value
Infection of COVID-19	Yes	109 (92.4%)	333 (83.9%)	0.020[b]
	No	9 (7.6%)	64 (16.1%)	
Age		5.9 (4.3)	5.3 (3.0)	0.090[a]
Gender	Male	93 (78.8%)	317 (79.8%)	0.806[b]
	Female	25 (21.2%)	80 (20.2%)	
Household size		3.0 (3.0)	3.0 (2.0)	0.457[a]
Mother age		36.0 (8.0)	36.0 (8.0)	0.933[a]
Father age		37.0 (10.0)	37.0 (8.0)	0.972[a]
Frequency of outdoor activities		2.0 (3.0)	3.0 (3.0)	0.010[a]
Frequency of rehabilitation training		2.0 (5.0)	3.0 (5.0)	0.136[a]
EQ-VAS score of caregiver		59.4 ± 21.6[c]	68.0 ± 18.3[c]	<0.001[d]
Vaccination of COVID-19	Yes	64 (54.2%)	223 (56.2%)	0.710[b]
	No	54 (45.8%)	174 (43.8%)	

Notes: [a]Mann–Whitney test; [b]Chi-square test; [c]mean±standard deviation; [d]Student's *t*-test.
Abbreviation: IQR, Inter quartile range.

Univariate Analysis of Influencing Factors on Participants' Behaviors

Tables 3 and 4 present the univariate analysis of influencing factors on participants' behaviors. The frequency of outdoor activities was lower in group n1 compared to that in group n2 (p=0.010, as shown in Table 3). The frequency of rehabilitation training was lower in group n1 compared to that in group n2 (p=0.015, as shown in Table 4). The EQ-VAS score of the caregiver was significantly lower in group n1 in both Tables 3 and 4, when compared to group n2 (all p<0.001). The proportion of COVID-19 infection was higher in groups n1 compared to the other group in Tables 3 and 4.

Multivariate Analysis of Influencing Factors on Participants' Behaviors

Figures 2 and 3 show the results of multivariate analysis of influencing factors on participants' behaviors. According to the results of the CHAID analysis, 22.9% of the participants experienced worsening of at least one of the core ASD features behaviors (Figure 2). Two classifications of variables, including "EQ-VAS score of the caregiver" (p = 0.001) and "Frequency of outdoor activities every week" (p = 0.014) explained a greater percentage of children's worsening

Table 4 Univariate Analysis of Influencing Factors on Participants' Challenging Behaviors

Median (IQR)/N (%)		At Least One of the Challenging Behaviors Became Worse (n_1=191)	None of the Challenging Behaviors Became Worse (n_2=324)	*p*-value
Infection of COVID-19	Yes	178 (93.2%)	264 (81.5)	<0.001[b]
	No	13 (6.8%)	60 (18.5%)	
Age		5.6 (3.5)	5.3 (3.1)	0.267[a]
Gender	Male	151 (79.1%)	259 (79.9%)	0.811[b]
	Female	40 (20.9%)	65 (20.1%)	
Household size		3.0 (2.0)	3.0 (2.0)	0.776[a]
Mother age		36.0 (7.0)	35.0 (8.0)	0.251[a]
Father age		38.0 (8.0)	37.0 (8.0)	0.234[a]
Frequency of outdoor activities		3.0 (3.0)	3.0 (3.0)	0.108[a]
Frequency of rehabilitation training		2.0 (5.0)	3.0 (5.0)	0.015[a]
EQ-VAS score of caregiver		61.3 ± 21.1[c]	68.8 ± 17.6[c]	<0.001[d]
Vaccination of COVID-19	Yes	113 (59.2%)	174 (53.7%)	0.228[b]
	No	78 (40.8%)	150 (46.3%)	

Notes: [a]Mann–Whitney test; [b]Chi-square test; [c]mean ± standard deviation; [d]Student's *t*-test.
Abbreviation: IQR, Inter quartile range.

behaviors. Children whose caregivers reported a lower EQ-VAS score had a greater percentage of core ASD features worsening (44.2%, node 1). The estimated risk of error in the model was 0.229, and the standard error was 0.019.

According to Figure 3, 37.1% of the participants experienced a worsening of at least one of the challenging behaviors. Three classifications of variables, including "Infection of COVID-19" ($p < 0.001$), "EQ-VAS score of the caregiver" ($p = 0.006$), and "Frequency of rehabilitation training every week" ($p = 0.003$) explained a greater percentage of children's worsening behaviors. Children who were infected with COVID-19 and whose caregivers reported a low EQ-VAS score had a greater percentage of challenging behaviors worsening (56.5%, node 3). The estimated risk of error in the model was 0.346, and the standard error was 0.021.

Discussion

COVID-19 has drawn national and global attention. Numerous studies have explored behavioral changes during the COVID-19 pandemic in various aspects of health. This study is the first to examine the influence of the Omicron variant in China from December 2022 to January 2023 on individuals with Autism Spectrum Disorder (ASD). Among the existing studies on the impact of COVID-19 on health aspects, this research on this specific period and variant fills a gap in the current research. Moreover, previous studies often failed to separately study core ASD features and challenging behaviors. This separation aids in more precisely understanding the mechanisms of different aspects of behavioral changes in ASD children under the pandemic's influence.

Our study corroborated the findings of prior research and extended them in multiple ways. Firstly, the proportions of caregiver-reported worsening in core ASD features and challenging behaviors were 22.9% and 37.1%, respectively. Our results were similar to those of two studies in China.[25,26] In Zhao's research, 22.31% of ASD children showed a decrease in emotional and behavioral issues during the lockdown.[13] Huang et al reported that more than a third of children's social and emotional status had worsened.[26] However, our findings were slightly lower than those of two studies in other countries.[6,27] Vasa reported that 45% of the sample had a worsening of their pre-existing psychiatric disorder.[27] Colizzi reported that 35.5% and 41.5% of ASD children presented with more intense and frequent behavior problems, respectively.[6] Different populations and the relatively short study period (from December 2022 to January 2023) might have led to underestimation. It should be noted that these studies did not distinguish between core ASD features and challenging behaviors. A recent published review showed that the overall prevalence of behavioral problems in the analyzed 1004 individuals was 51.9%.[12] Our study, which focused on the Omicron wave in China from December 2022 to January 2023, also found an increase in the worsening of core ASD features (22.9%) and challenging behaviors (37.1%). The consistency of findings across different regions and time periods implies that the pandemic generally had

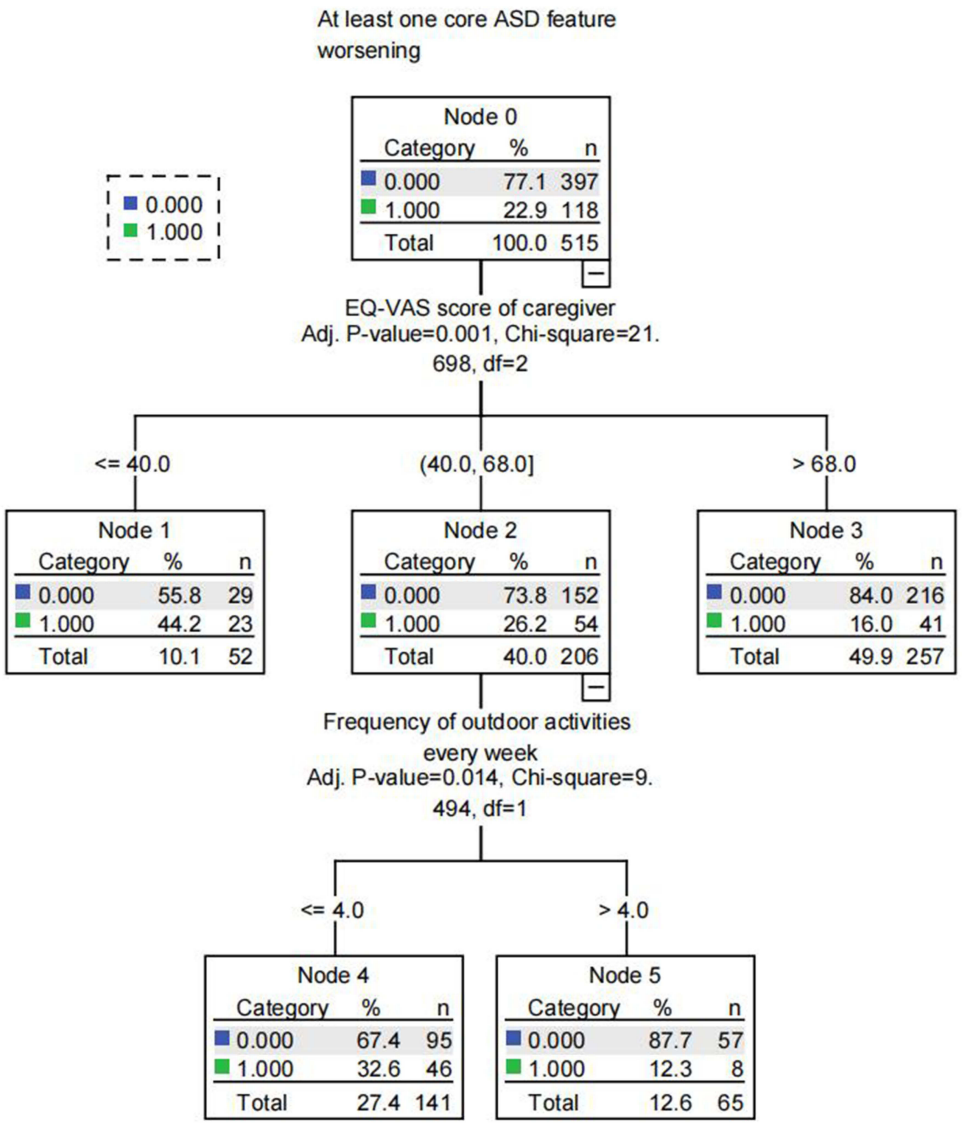

Figure 2 A CHAID analysis to identify the factors of at least one of the core ASD features worsening after the COVID-19 Omicron variants pandemic.

a negative impact on the behavior of ASD children. However, differences in prevalence could be due to various factors such as the specific virus variant, the stringency of pandemic-related measures, and the characteristics of the study populations. For example, in our study, the relatively short investigation period after December 2022 might have resulted in a different prevalence compared to other studies. An interesting finding showed a substantial percentage of autistic children appeared happier and calmer during the pandemic.[28] This could be attributed to the removal of stressors like school and social interactions because of quarantine restrictions. In our study, 19.9% and 17.3% of autistic children showed improvements in language delay and eye contact, respectively. In the context of development, younger children may be more adaptable in their development. Pandemic-related changes, such as increased parental attention at home due to lockdowns (although not directly measured in this study), could potentially have a positive impact on language development. However, it is important to note that the majority still had these core ASD features, indicating that the overall developmental trajectory of these children is still significantly affected by their ASD diagnosis. The fact that these improvements were not uniform across all children also highlights the complexity of development. Different children may have different genetic, environmental, and individual factors that interact with the pandemic situation. For instance, a child with a more severe ASD diagnosis may not have shown the same level of improvement as a child with a milder

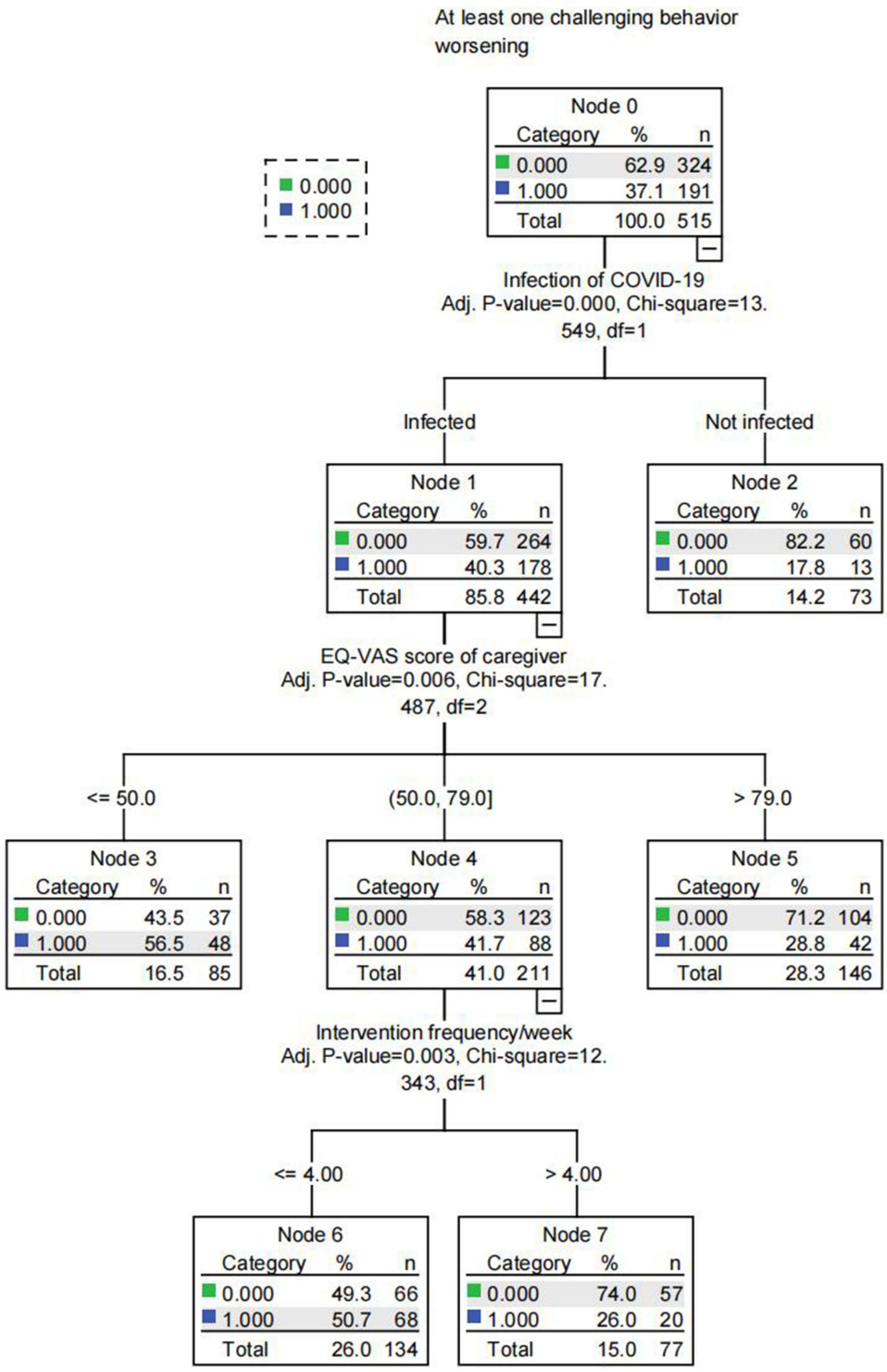

Figure 3 A CHAID analysis to identify the factors of at least one of the challenging behaviors worsening after the COVID-19 Omicron variants pandemic.

form, suggesting that the pre-existing developmental state of the child plays a role in how they respond to external factors like the pandemic.

Secondly, we further explored potential influencing factors. Firstly, as per a prior study, individuals with ASD experienced significant life changes due to strict quarantine measures.[16] However, after the quarantine period, the effects on their behavior were uncertain. One notable finding was that COVID-19 infection was the primary predictor in the

decision tree of challenging behaviors, with almost half of the children experiencing negative impacts on their challenging behaviors. This suggested that COVID-19 was the most significant risk factor for the worsening of challenging behaviors, even among those infected with the Omicron variant. Overall, our results indicated that individuals with ASD might be at high risk of experiencing behavioral issues during and after quarantine, especially if they are infected with the virus.

Thirdly, our study results revealed that the risk factors differed for core ASD features and challenging behaviors. The worsening of core ASD features was associated with fewer outdoor activities, while the worsening of challenging behaviors was associated with less rehabilitation training. Since the data collection in our study occurred after the lifting of lockdown policies, the direct impact of these restrictive measures was minimal. This is an important aspect as it provides the context for our findings regarding the behavioral impact of the COVID-19 Omicron variant on ASD children. However, it is crucial to recognize that the long-term effects of the previous pandemic situation on the overall health and support systems of these children might have some indirect influence. For example, during the pandemic, many ASD children faced disruptions in their regular therapy schedules. Lockdowns and associated restrictions might have caused a hiatus in regular therapy schedules, which could potentially have long-term consequences for the children's development. The reduction in outdoor activities due to COVID-19 mitigation measures likely led to social distancing, resulting in a loss of social interaction opportunities and restrictions on approaching others. For some individuals with ASD, this may have caused significant social isolation, particularly for those with difficulties in social communication and interaction. Such isolation may have worsened pre-existing behavioral difficulties. Additionally, reduced access to healthcare services and educational support can pose significant challenges for individuals with autism. Limited access to healthcare services may lead to delays in assessments or diagnostic evaluations, interruptions to therapy, and a reduction in mental health services.[14] Our data showed that more than a third of participants withdrew from rehabilitation training during the pandemic. These findings were consistent with research indicating that the COVID-19 pandemic has led to a reduction in rehabilitation training for ASD children.[29] Many families were unable or unwilling to attend in-person therapy sessions due to concerns about the risk of infection or restrictions on movement. Therefore, the rehabilitation training progress of ASD children may be influenced by the COVID-19 pandemic, causing potential delays in achieving developmental milestones or setbacks in behavioral improvements.[15]

Finally, our study examined the correlation between caregivers' health-related quality of life and the behavior of their children, as emphasized in previous research.[16] The results indicated that caregivers with lower EQ-VAS scores had a greater proportion of worsening behavior in their children. These findings suggest that both the overall health status of caregivers and the behavior of the children themselves might influence each other. Moreover, the ongoing pandemic has placed a huge burden on families and caregivers who are facing the challenging task of managing work, caregiving, and the risks associated with COVID-19. Such stress could be affecting the behavior of individuals with ASD, who are highly sensitive to the emotional cues of their caregivers and other family members.[30] The fact that ASD children and their parents are among the most affected during the pandemic in terms of loss of routine, support network, and mood and behavior changes has important implications. In our study, we also noted the impact on caregivers, such as the association between the caregiver's health-related quality of life and the behavior of their children. The correlation between caregivers' HRQoL and children's behavioral outcomes further emphasizes the interconnectedness of family dynamics in the pandemic context. Similar to the Malaysian study, which found significant correlations between parent and child variables in the ASD group, our findings suggest that the psychological well-being of caregivers plays a crucial role in mitigating the adverse effects of the pandemic on ASD children.[31] A Chilean study also highlighted the family aspect.[32] Parents in the Chilean study valued the integration of the family into therapies during confinement and also reported the need for professional support in behavioral and emotional management. This suggests that family-centered support and professional assistance are crucial for ASD children during the pandemic. To help caregivers handle these challenges, professional advice should focus on meeting the child's educational and mental health needs. In the context of our study, this could mean providing support for caregivers to maintain or improve their own well-being, which in turn could benefit the children. Additionally, creating opportunities for home learning and maintaining connections with the support network, such as teachers, could be beneficial for ASD children during and after the pandemic.

It should be noted that during the investigation period, which took place after China discontinued its strict quarantine policy, we observed changes in routine and disruptions to daily life for ASD children. Our research found that more than half reduced their outdoor activities. Despite the relaxed quarantine policy, caregivers still decreased outdoor activities for both infected and non-infected ASD children, highlighting the ongoing concerns regarding the pandemic. Additionally, the disruption to daily routines and activities had negative effects on some ASD individuals, particularly those who rely heavily on routine and structure. This led to increased stress and anxiety, potentially causing an increase in disruptive behaviors and emotional dysregulation, as suggested by Mitra and Carroll.[33,34] Previous research has indicated that ASD children may experience increased irritability, anxiety, and sensory processing issues as a result of changes in social isolation, daily routine, and reduced access to healthcare services and educational support.[13] Overall, the COVID-19 pandemic has had a profound impact on the mental health and well-being of individuals with ASD worldwide. Further research is needed to comprehensively understand the magnitude of this impact and to determine effective measures for supporting the unique needs of individuals with ASD during these periods. Practitioners should remain vigilant of these potential effects and establish communication with the families of ASD patients throughout the pandemic to provide necessary interventions and support.

Limitations

The study has the following limitations. First, it is important to recognize that even before the outbreak, there were considerable restrictions on rehabilitation, outdoor activities, and interpersonal interactions in China due to epidemic control measures. These restrictions may have had both short-term and long-term impacts on children with ASD. Therefore, in addition to potential influencing factors reported in this study, there may have been other factors contributing to behavioral changes in children with autism during the COVID-19 outbreak on individuals with ASD. In addition, due to the retrospective nature of this study, there may have been recall bias in parents' responses regarding their children's behavioral changes. Furthermore, this study employed a cross-sectional design. While this design provided a snapshot of the pandemic during a specific period, it may have limited our ability to fully understand the temporal dynamics of the pandemic and its relationship with children with autism. Additionally, there was a possibility of confounding factors and bias influencing the results, which should be considered when interpreting the findings. To better capture changing trends and patterns over time, further studies using a longitudinal approach are necessary. It is also recommended that multiple research approaches be employed to comprehensively address research questions related to the COVID-19 Omicron variant wave.

Conclusion

This study provides evidence that the COVID-19 Omicron variant outbreak had an impact on the behavior of autistic children. The behavior changes were complex, with differences between core ASD features and challenging behaviors, and were associated with COVID-19 infection as well as other factors such as caregiver-related and activity-related factors. Future research could further explore the mechanisms underlying these relationships and develop more targeted interventions for autistic children in the context of similar public health events.

Abbreviations

ASD, Autism spectrum disorders; CHAID, Chi-squared automatic interaction detection; CI, confidence interval; DSM-V, Diagnostic and Statistical Manual, Fifth Edition; EQ-VAS, Euro-Qol visual analog scale; HRQoL, Health-related quality of life; IQR, inter-quartile range; OR, crude odds ratio; PASS, Power Analysis and Sample Size; SPSS, Statistical Product and Service Solutions.

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Disclosure

The authors report no conflicts of interest in this work.

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