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RESEARCH ARTICLE

# Breastfeeding patterns in infants are associated with a later diagnosis of autism Spectrum disorder

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**Abstract**

Breastfeeding is associated with medical and developmental benefits. This study aimed to assess associations between nutritional patterns in the first year of life and the likelihood of autism spectrum disorder (ASD). 270 children diagnosed with ASD (cases) and 500 neurotypical children (controls) matched to cases by sex, ethnicity, and birth date (± 3 months) were included in this retrospective case–control study. Both groups were ascertained from children born between 2014 and 2017 whose development/nutrition were monitored at mother–child health clinics in southern Israel. Conditional logistic regression was used to determine the independent association of nutritional patterns with ASD while adjusting for socio-demographic and clinical characteristics. Both exclusive and partial breastfeeding modes were associated with decreased odds of ASD diagnosis (aOR = 0.221, 95%CI = 0.136–0.360; aOR = 0.494, 95%CI = 0.328–0.743, respectively). A breastfeeding duration of >12 months was associated with lower ASD odds (aOR = 0.418, 95%CI = 0.204–0.855), while the introduction of solids after 6 months of age was associated with higher ASD odds than the introduction of solids at 6 months (aOR = 2.455, 95%CI = 1.116–4.201). These findings suggest that a longer period of exclusive breastfeeding is associated with a subsequent reduced likelihood of ASD diagnosis, thus reiterating the importance of proper post-natal nutrition for infant neurodevelopment.

**Lay Summary**

Our findings suggest that a longer period of exclusive or partial breastfeeding during infancy is associated with a lower likelihood of autism spectrum disorder (ASD). Future prospective studies should elucidate the underlying mechanisms of this association, whether non-exclusive breastfeeding contributes to the development of autistic traits or whether certain developmental characteristics among infants later diagnosed with ASD lead to non-exclusive breastfeeding.

**KEYWORDS**

autism spectrum disorder, breastfeeding, development, epidemiology, nutrition

## INTRODUCTION

Breastmilk is the most common nutritional source for children in their first year of life (World Health Organization, 2023a). The American Academy of Pediatrics, UNICEF, and World Health Organization are but a few of the many global organizations that advocate the exclusive use of breastmilk for the first six months of life by virtue of the myriad of short- and long-term medical and neurodevelopmental advantages it confers on infants (Eidelman et al., 2012; UNICEF, 2023; WHO, 2023a). Exclusive breastfeeding is defined as a child receiving

only breastmilk from his/her mother and/or wet nurse, or expressed breastmilk, without the consumption of any other liquids or solids, except oral rehydration solutions, drops or syrups to provide vitamins, mineral supplements, or medicines (WHO, 2009). Nonetheless, from 2015 to 2020, it was estimated that globally only 44% of infants 0–6 months of age were exclusively breastfed (WHO, 2023b). This trend constitutes cause for concern, since optimal nutrition in the first two years of life is associated with lowered morbidity and mortality, a diminished risk of chronic disease, and enhanced biopsychosocial development (WHO, 2023b). The lack of breastfeeding—or suboptimal post-natal nutrition in any form—may also contribute to the emergence of neurodevelopmental disorders (Crawford et al., 1993).

The most common neurodevelopmental disorder is autism spectrum disorder (ASD), which is characterized by persistent social communication deficits that undermine the capacity for sustained reciprocal social interactions and by the pervasive presence of repetitive and inflexible thought and behavior patterns that are significantly atypical in both age and socio-cultural contexts (American Psychiatric Association, 2013). These characteristics of ASD manifest in all life settings and typically present with sufficient intensity to cause impairment across multiple functional areas of life (National Institute of Mental Health, 2023). The presentation of ASD—being a spectrum disorder—can be highly variable from person to person and may occur alongside additional deficits in language and intellectual functioning (NIMH, 2023).

Accumulating evidence suggests breastfeeding as a possible protective factor for ASD. A number of studies have indicated that the absence of breastfeeding (Chen et al., 2021; Jenabi, Bashirian, et al., 2022; Schultz et al., 2006; Steinman & Mankuta, 2013) and delayed breastfeeding initiation (Al-Farsi et al., 2012; Brown et al., 2014; Ravi et al., 2016) are indeed associated with a later diagnosis of ASD. One of the studies within this body of evidence reported that a significant proportion of ASD participants had been weaned within one week of breastfeeding (Tanoue & Oda, 1989), although another study found no significant differences between ASD and non-ASD individuals in terms of breastfeeding initiation rate (Soke et al., 2019). Controls in the latter study sample were, however, not selected from the same source population, thus introducing a possible selection bias (Soke et al., 2019). A dose–response relationship between breastfeeding duration and ASD was, however, demonstrated in two studies reporting lower rates of ASD diagnosis in children who were breastfed for an extended duration (Lemcke et al., 2018; Shafai et al., 2014) Similarly, a meta-analysis indicated that every 6 months of breastfeeding was associated with a 54% decrease in ASD likelihood, with breastfeeding up to 12–24 months conferring the highest level of protection (Ghozy et al., 2020).

Despite the substantial literature regarding an association between breastfeeding and ASD, most of the published studies have focused on the existence (yes/no) and duration of breastfeeding, while there is almost no data regarding the effects of breastfeeding modes (exclusive vs. partial breastfeeding) and the timing of the introduction of solids into the diet of the infant. In the present study, we thus examined various aspects of nutritional patterns during the first year of life and their association with a later diagnosis of ASD.

## METHODS

We conducted a nested case–control study in a population of children living in the Negev region of southern Israel. For this population, comprising ~ 50% Bedouin Arabs, ~ 50% Jews, and <1% other ethnic backgrounds, there are approximately 16,000 live births each year (Central Bureau of Statistics of Israel, 2016). These two ethnic groups vary considerably in their socioeconomic status, maternal education, and birth rate in the studied population (Israel Central Bureau of Statistics, 2018, 2019). In addition, differences in breastfeeding duration (Daoud & Shoham-Vardi, 2015; Israel Center for Disease Control, 2014) and ASD diagnosis rates (Levaot et al., 2019) were reported between these two ethnic groups.

The growth, development, and nutrition of these children are monitored regularly at regular age milestones from birth until age six years by trained nurses at 47 government-funded Mother and Child Health Clinics (MCHCs) distributed across the region (Bin Nun et al., 2010; Israel Ministry of Health, 2023). Adherence to these regular monitoring meetings at 6 weeks, and 3, 6, 9, 12, 18, 24, 36 and 60 months of age is particularly high (>95%), since they are timed to coincide with the standard childhood immunization program (Bin Nun et al., 2010; Israel Ministry of Health, 2023). Importantly, at each of these visits, the nurses inquire about the nutrition of the child and provide recommendations based on pediatric dietary guidelines issued by the Israel Ministry of Health. Mothers thus report breastfeeding outcomes at each of these visits.

### Case–control ascertainment

Both cases and controls were drawn from the population of children born in southern Israel between 2014 and 2017 whose development and nutrition were monitored at the MCHCs operated by the Ministry of Health. Cases comprised children diagnosed with ASD and registered in the database of the Azrieli National Center for Autism and Neurodevelopment Research (ANCAN) (Dinstein et al., 2020). All cases of ASD were diagnosed according to DSM-5 criteria (APA, 2013) by a child developmental

psychologist and either a child psychiatrist or pediatric neurologist at the Child Development Center of Soroka University Medical Center (SUMC). Controls were children not diagnosed with any developmental disorder, including ASD, and frequency matched to cases by date of birth (± 3 months), sex (male/female), and ethnicity (Jewish/Arab-Bedouin). To reduce the possibility of potential confounding, exclusion criteria for both cases and controls were children lost to follow-up (missing >2 checkups) and children born preterm (<37 weeks of pregnancy). In addition, we excluded children who had been referred for further assessment due to possible developmental delay, but who had not been diagnosed with ASD at the time of data collection. Overall, 770 children (270 cases/500 controls) were included in the final study sample.

## Data collection

Data collection was conducted prospectively by trained MCHC nurses, while data analysis was performed retrospectively from the medical records of the children in the study sample in the electronic database of the MCHCs. Demographic, birth, and nutritional data collected from the database included the following variables: ethnicity (Jewish/Arab-Bedouin), sex, date of birth, birth delivery method, gestational age, birth weight, and Apgar scores. Breastfeeding parameters consisted of breastfeeding mode (exclusive, partial, none) classified based on the mode provided to the child over the course of the 1st year, and breastfeeding duration (<6 months, 6–12 months, >12 months). In addition, we classified the age at which solids were introduced according to the WHO recommended 6 months of age (WHO, 2023b) as "before", "at", and "after" 6 months (<6 months, 6–6.5 months, and >6.5 months respectively).

## Data analysis

Mean and standard deviation (SD) values were calculated for continuous variables, while percentages were calculated for nominal variables. Univariate analysis was performed by either two-tailed t-tests or Mann–Whitney U tests for continuous variables, and two-sided $\chi 2$ tests for nominal variables. Multivariate analysis consisted of logistic regression to determine the independent association of early nutritional characteristics in the first 18 months of life with ASD likelihood, while adjusting for various socio-demographic and clinical characteristics. The regression models were run separately for males and females and for Jewish and Bedouin children to assess the differential contribution of nutritional patterns to ASD diagnosis based on sex and ethnicity. The Breslow-Day test was used to determine the homogeneity of the odds ratios (OR) across these groups. All statistical analyses were performed with SPSS version 28.0. Statistically significant results were determined at $p < 0.05$.

## Ethics

The research was prospectively reviewed and approved by the ethics committee of the Ministry of Health of Israel (Approval #: MOH-199,2017).

# RESULTS

Socio-demographic and clinical characteristics of the study sample are presented in Table 1. For both the ASD and non-ASD study groups, 78.1% of the children were male and 75.5% were Jewish (as cases and controls were matched based on these variables). Overall, no significant differences were found between the study groups for birth delivery method, gestational age, and Apgar scores. Nevertheless, the birth weight of children in the ASD group was, on average, 80 g lower than that of their non-ASD counterparts (3250 ± 458 vs. 3330 ± 382 g, respectively; $p = 0.037$).

Breastfeeding patterns of the two study groups are presented in Figure 1. Less than half of the children with ASD had ever been breastfed compared to >75% of children without ASD ($p < 0.001$; Figure 1A). This difference between the groups was due mainly to the remarkably lower rate of exclusive breastfeeding in cases compared to controls (12.7% vs. 36.3% respectively, $p < 0.001$). Children with ASD were also breastfed for a shorter time, on average, than their counterparts (6.6 ± 0.47 months vs. 8.7 ± 0.36 months respectively, $p = 0.025$; Figure 1B). In addition, children with ASD were less likely to be breastfed beyond 12 months of age compared to non-ASD children (12.8% vs. 22.9%, $p = 0.018$; Figure 1C).

Ages at which solids were introduced to the diet of ASD and non-ASD children are presented in Figure 2. On average, solids were introduced into the diets of the ASD children approximately 0.8 months later than for children without ASD (6.5 ± 0.19 months vs. 5.7 ± 0.04 months, respectively, $p = 0.002$; Figure 2A). Furthermore, higher rates of children with ASD were introduced to solids after the WHO-recommended age of 6 months when compared to children without ASD (14.5% vs. 5.7% respectively, $p = 0.005$; Figure 2B).

Finally, we used logistic regression models to assess the independent association of early nutritional patterns with later ASD diagnosis. The results of these analyses are presented in Table 2. Similar results were obtained for the crude and adjusted models. Specifically, breastfeeding was associated with a reduced likelihood of an ASD diagnosis in a dose-dependent manner, in that partial and exclusive breastfeeding were associated with two and four times lower odds of ASD, respectively

**TABLE 1** Baseline sociodemographic and clinical characteristics of children diagnosed with autism spectrum disorder (ASD) and non-ASD controls.

| Variables | ASD $n = 270$ | Non-ASD $n = 500$ | $p$-value |
|---|---|---|---|
| Sex (male), *n* (%) | 213 (78.1%) | 389 (78.1%) | 1[a] |
| Ethnicity (Jewish), *n* (%) | 207 (75.5%) | 375 (75.5%) | 1[a] |
| Birth delivery method, *n* (%) | | | |
| Spontaneous | 149 (75.6%) | 344 (77.7%) | 0.088[a] |
| Cesarean | 43 (21.8%) | 74 (16.7%) | |
| Instrumental | 5 (2.5%) | 25 (5.6%) | |
| Gestational age (weeks), mean (SD) | 39.5 (1.245) | 39.6 (1.204) | 0.137[b] |
| Birth weight (g), mean (SD) | 3250 (458) | 3330 (382) | 0.037[b] |
| Apgar 1-min ≤7, *n* (%) | 11 (4.7%) | 21 (4.3%) | 0.821[a] |
| Apgar 5-min ≤7, *n* (%) | 3 (1.3%) | 3 (0.6%) | 0.364[a] |

[a]Chi-Square test;
[b]*t*-test.

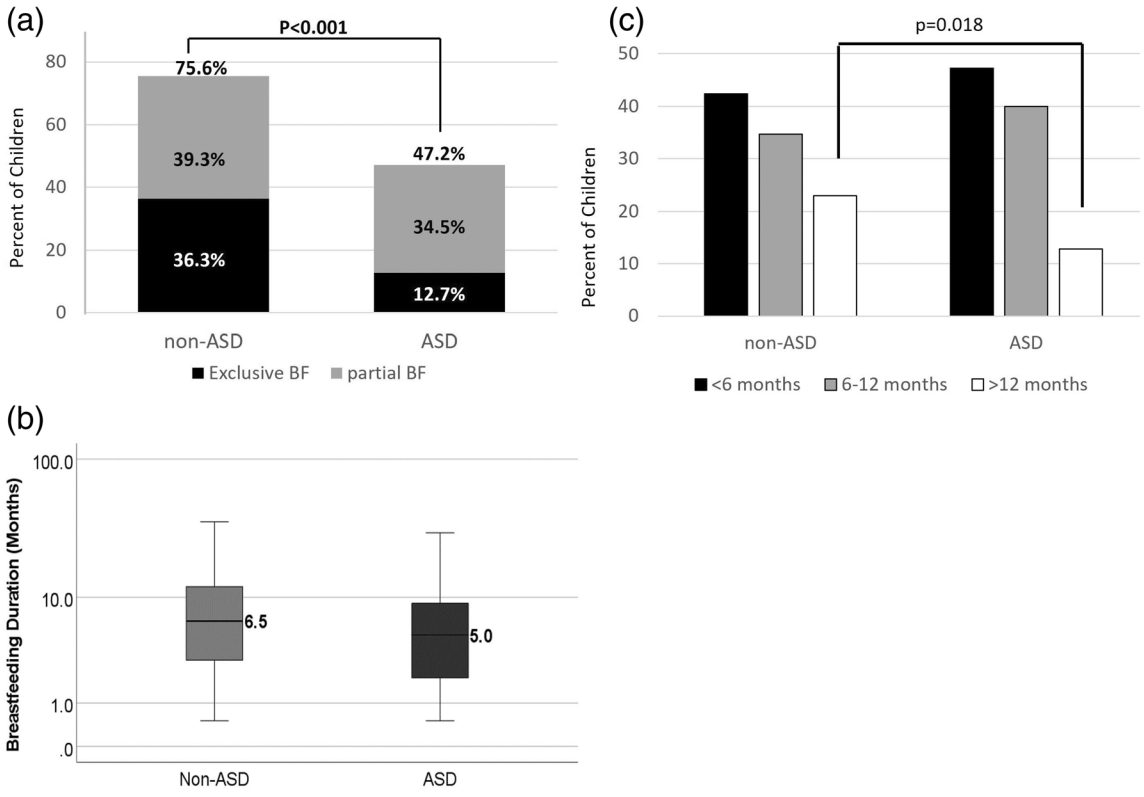


**FIGURE 1** Breastfeeding (BF) patterns during the first year of life in children with and without ASD. (a) Rates of exclusive and partial breastfeeding in ASD and non-ASD children. (b) Breastfeeding duration in ASD and non-ASD children. (c) Rates of children who were breastfed <6, 6–12, and >12 months across study groups.

(aOR = 0.494, 95%CI = 0.328–0.743 for partial breastfeeding and aOR = 0.22, 95%CI = 0.136–0.360 for exclusive breastfeeding). Breastfeeding for longer than 12 months was also associated with lower odds of an ASD diagnosis (aOR = 0.418, 95%CI = 0.204–0.855), while breastfeeding for 6–12 months did not have an apparent effect on ASD likelihood. Finally, children introduced to solids after 6 months of age were twice as likely to be diagnosed with ASD than those introduced at 6 months of age (on time) (aOR = 2.455, 95% CI = 1.116–4.201), while the introduction to solids before 6 months was not associated with an increased likelihood of ASD (0.845, 95%CI = 0.414–1.972). No interaction was detected between breastfeeding status and solids introduction (Supplementary Table S1).

To assess the differential contribution of nutritional patterns to ASD across sexes and ethnic backgrounds, we re-applied the same logistic regression models separately

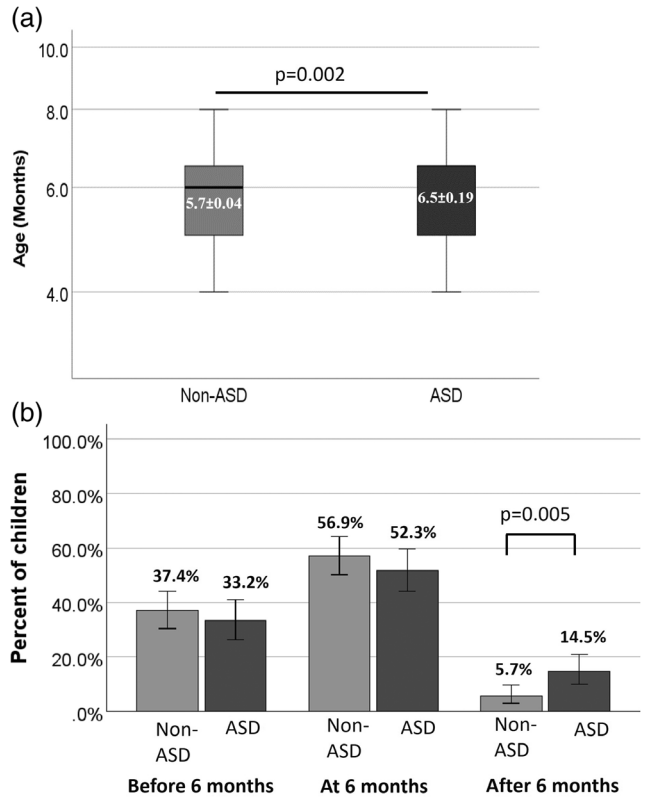


**FIGURE 2** Introduction of solids into infant nutrition. (a) Age at which solids were introduced into the nutrition of ASD and non-ASD children. (b) Rates of children for whom solids were introduced before, at, and after 6 months of age.

to males and females and to Jewish and Arab Bedouin children. The results of these analyses are presented in Supplementary Tables S2 and S3. Overall, the same associations as those obtained for the whole sample were also observed in these groups, although the significance of the findings was slightly reduced due to the smaller sample sizes. Interestingly, there was a significant interaction between breastfeeding duration and sex, in that for a breastfeeding duration of 6–12 months males had increased odds for a later diagnosis of ASD, while females exhibited decreased odds (Supplementary Table S2, Breslow-Day $p = 0.017$). This interaction was driven by the fact that most (57.5%) ASD males were breastfed for at least 6 months, while the majority (65.4%) of ASD females ceased breastfeeding before 6 months of age (Supplementary Figure S1).

## DISCUSSION

The findings of the present study suggest that nutritional practices in early childhood are associated with a later diagnosis of ASD. We found that children ever breastfed were less likely to be later diagnosed with ASD, with both the duration and the mode (complete/partial) breastfeeding affecting this association in a dose-dependent manner (longer and/or more breastfeeding were associated with lower likelihood of ASD).

These findings are consistent with a number of recent reports in the literature. For example, a recent meta-analysis showed an approximately twofold increase in ASD likelihood to be associated with a lack of breastfeeding (Jenabi, Bashirian, et al., 2022). A different meta-analysis identified a 58% and 76% decrease in ASD likelihood associated with ever breastfeeding and exclusive breastfeeding, respectively (Ghozy et al., 2020). This large effect of breastfeeding patterns associated with the likelihood of a later diagnosis of ASD was similar to the effects found in the present study, thus further affirming our findings regarding the relationship between breastfeeding patterns in the first year of life and a subsequent ASD diagnosis. Another study that differentiated exclusive breastfeeding from partial breastfeeding also showed that while both breastfeeding modes were associated with a decreased likelihood of ASD, the effect was stronger in the exclusive breastfeeding group (Tseng et al., 2019). The findings of these studies are in keeping with our data showing that both exclusive and partial breastfeeding were associated with a diminished likelihood of ASD diagnosis, with exclusive breastfeeding conferring a higher level of protection. It is important to note that not all studies reached the same conclusions as the current investigation. A few recent studies suggested breastfeeding initiation frequency in children with ASD to be comparable to that of the general population (Peries et al., 2023), while also indicating that breastfeeding practices, such as duration and ever breastfeeding, were not associated with ASD (Peries et al., 2023; Zhan et al., 2023). While the previous study was limited by recall bias, with retrospective parental questionnaires collected when the study children were, on average, 10 years old, the latter study showed potential trends that supported breastfeeding's protective effects, despite wide confidence intervals that limited precision of the results.

The present study's findings regarding breastfeeding duration and ASD diagnosis were nonetheless generally consistent with the current literature. For example, the survey of Shafai et al. found that, similarly to our findings, children breastfed for more than 12 months were less likely to be diagnosed with ASD than children breastfed for less than 12 months (2014). The study of Jenabi et al. revealed that each month of breastfeeding was associated with a 5% reduction in the odds of a later ASD diagnosis (Jebabi, Seyedi, et al., 2022) a dose–response pattern confirmed by other studies (Al-Farsi et al., 2012; Ghozy et al., 2020).

We also found that the introduction of solids after six months of age was significantly associated with increased odds of a later diagnosis of ASD, a pattern of results that is in accordance with data from other studies. For example, one study indicated transition to solid food intake at a later age in children with ASD than in those with typical development (10.67 months vs. 8.47 months

**TABLE 2** Results of logistic regression models assessing the association between of early nutritional patterns in the first year of life and a subsequent ASD diagnosis.

| | Crude model | | Adjusted model[a] | |
|---|---|---|---|---|
| **Variables** | **Crude OR** | **99%CI** | **Adjusted OR** | **99%CI** |
| BF status from birth ($n = 770$) | | | | |
| Non-BF ($n = 264$) | [Ref] | | [Ref] | |
| Partial BF ($n = 290$) | 0.404 | (0.256–0.637) | 0.494 | (0.289–0.845) |
| Exclusive BF ($n = 216$) | 0.162 | (0.091–0.288) | 0.221 | (0.117–0.420) |
| BF duration (months) ($n = 506$) | | | | |
| <6 months ($n = 220$) | [Ref] | | [Ref] | |
| 6 ≤ x ≤ 12 months ($n = 182$) | 1.068 | (0.579–1.846) | 1.043 | (0.540–1.901) |
| >12 months ($n = 104$) | 0.496 | (0.225–0.981) | 0.418 | (0.158–0.881) |
| Introduction of solids (months) ($n = 506$) | | | | |
| At 6 months ($n = 247$) | [Ref] | | [Ref] | |
| Before 6 months ($n = 191$) | 0.970 | (0.517–1.853) | 0.845 | (0.414–1.927) |
| After 6 months ($n = 68$) | 2.345 | (1.013–4.657) | 2.455 | (1.116–4.201) |

Abbreviation: BF, breastfeeding.
[a]Adjusted for sex, ethnicity, birth delivery method, gestational age, birth weight.

respectively) (Şahan et al., 2021), while another study found infants later diagnosed with ASD had experienced late introduction of solids (after 6 months of age) (Emond et al., 2010). It should be noted, however, that in both studies feeding and dietary data were based on parent reporting, with no observational validation by a clinician. Another study suggested that early introduction of solids interferes with children being breastfed exclusively until 6 months, exposing them to several health concerns (Chiang, 2023), ASD possibly being among these. However, such an association was not seen in our study. Thus, our findings support the WHO recommendation that solid foods should be introduced at 6 months of age, although earlier introduction of solids into the diet without changing the breastfeeding ritual is also possible.

Interestingly, our results suggest that both early cessation of breastfeeding and late introduction of solids to the infant's nutrition are associated with an increased likelihood for a later diagnosis of ASD. These findings might be perceived as contradictory, but they also may suggest that children with a higher likelihood of being diagnosed with ASD are exposed to milk replacement formulas for a longer duration than other children. The lower odds of ASD associated with exclusive breastfeeding compared to partial breastfeeding observed in our study supports this premise. Breastfeeding, compared to formula feeding, has also been suggested to have better metabolic and immune benefits through the ingestion of maternal milk metabolites (Schultz et al., 2006). Many of these vital components for infant development are present in human breastmilk in a higher concentration than those in bovine milk (used in many formulas) (Al-Farsi et al., 2012). As discussed in further detail below, some of these milk metabolites are considered essential substrates for neurodevelopment (Makrides et al., 2009) and immune system function (Yaqoob, 2004). Unfortunately, since our data did not include specific information about formula feeding, we could not explore such specific associations in the present study.

While the pathophysiological mechanism underlying the reported association between breastfeeding and ASD remains unclear, research has pointed to both the nutritive content of breastmilk and the physical act of breastfeeding as potential explanations (Al-Farsi et al., 2012; Ghozy et al., 2020). Breastfeeding facilitates the direct transfer from the mother to the infant of micro- and macro-nutrients, including long-chain polyunsaturated ω-3 and ω-6 fatty acids and casein peptides, alongside trophic hormones, such as insulin-like growth factors (IGF) I and II, and white blood cells, antibodies (immunoglobulin A), and humoral elements (Grote et al., 2016). These breastmilk components support physical growth, immune system development, gastro-intestinal development, and brain maturation (Deoni et al., 2018; Grote et al., 2016). Taken together, studies in the literature indicate that a lack of breastfeeding may deprive infants of essential nutrients that may make them vulnerable to various illnesses and developmental problems (Andersson et al., 2009; Ghozy et al., 2020).

The physical act of breastfeeding may also activate pathways that work to diminish ASD likelihood. Direct skin-to-skin contact with the mother during breastfeeding has been shown to increase secretion of oxytocin in the infant (Carter, 2003; Grewen et al., 2010), inducing a soothing state, reducing stress, and initiating mother–child bonds that enhance child attachment security and promote social–emotional development (Bartels & Zeki, 2004; Sharma et al., 2020). Several meta-analyses have indicated that children with ASD have lower blood oxytocin levels than neurotypical children, suggesting

that such early bonding between the mother and infant could affect ASD manifestation (John & Jaeggi, 2021; Ooi et al., 2017; Vanya et al., 2017). Taken together, both the physical act of breastfeeding and composition of breastmilk are likely to create a multi-pathway network that helps to reduce ASD in infants.

Alternatively, the association between breastfeeding and ASD reported in this study and others could entail a reverse causation, whereby infants who have a higher likelihood of being diagnosed with ASD may have more feeding difficulties due to symptoms of the disorder. For example, the range of feeding behaviors that have been reported in young autistic children, such as food selectivity, food refusal, poor oral motor function, and disruptive feeding habits (van 't Hof et al., 2021; Ashley et al., 2020; Brzóska et al., 2021; Vasilakis et al., 2023) could also impede breastfeeding. This may further elucidate whether ASD symptoms lead parents to introduce solids to their autistic children after 6 months of age. Therefore, studies are needed to assess such traits in relation to both non-exclusive breastfeeding and the late introduction of solids in ASD. Further prospective longitudinal studies are needed to causally determine whether the late introduction of solids contributes to ASD onset or whether symptoms of ASD may inhibit the successful introduction of solids in these children.

Finally, our stratified analyses suggested that the association between breastfeeding duration and ASD was modified by sex, whereby the protective effect associated with breastfeeding duration was more substantial and seen earlier in females than in males. A few other studies have examined the effect of breastfeeding on ASD across sex. One such study reported a similar sex-specific effect by pointing to the possible stronger beneficial effects of breastfeeding duration on ASD in females (Boucher et al., 2017). However, our findings are also in keeping with those of other studies confirming a lack of significant interactions between breastfeeding status (yes/no), sex, and ASD (Tseng et al., 2019; van 't Hof et al., 2020), as well as between breastfeeding mode (exclusive, partial, none), sex, and ASD (Huang et al., 2022). The paucity of the scientific literature and the inconsistent findings regarding the modifying effect of sex on the association between breastfeeding duration and ASD likelihood call for further research on this specific issue.

To the best of our knowledge, this study is one of the first to assess nutritional patterns of ASD across ethnicity in this population. Our data indicated no effects of ethnicity on the association of early nutritional patterns with ASD in the first year of life. This finding is particularly important considering the well-evidenced ethnic bias in ASD diagnosis (Levaot et al., 2019; Meiri et al., 2017) and in breastfeeding patterns (Gabay et al., 2022) in the studied population.

A notable limitation of the current study is that it was based on an existing dataset and, therefore, is missing data on some important confounders such as maternal age, parental education, and parental socioeconomic status. To address this limitation, we adjusted to the ethnicity of the participants (Bedouin/Jewish), which has been shown to be a good proxy for the socioeconomic status and maternal education in the studied population (Israel Central Bureau of Statistics, 2018, 2019). Bedouin mothers are also more likely to give birth to their first and second children at younger ages than their Jewish counterparts (Halperin et al., 2014; Sharaby & Peres, 2021). Thus, the adjustment for ethnicity also partially accounts for the confounding of maternal age. Nevertheless, replications of our findings using datasets that include these important confounders are warranted to obtain more robust conclusions regarding the association between breastfeeding and a later diagnosis of ASD.

Another potential limitation of the study may include bias in case–control ascertainment; nonetheless, cases and controls were selected from the same pool and were assessed at the MCHCs at approximately the same ages. Finally, while the sample size of the study was sufficiently large for the main analyses, it had limited power to determine statistically significant findings in our stratified analyses for females and Bedouins, which both comprised <25% of our study sample.

## CONCLUSIONS

The findings of the present study indicate that both breastfeeding mode and duration are associated with a later ASD diagnosis, thus highlighting the importance of proper post-natal nutrition for infant neurodevelopment. Additional studies are needed to substantiate these findings and, specifically, to elucidate the mechanism underlying these associations so as to facilitate causal explanations. Such research may inform policy and clinical practice regarding nutritional recommendations for infants with a higher likelihood of developing ASD.

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### CONFLICT OF INTEREST STATEMENT

The author has no conflict of interest to declare.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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