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# Breastfeeding duration and neurodevelopment: insights into autism spectrum disorders and weaning practices

Budor H. Saigh<sup>1\*</sup>

## Abstract

This paper examines the complex relationship between breastfeeding duration and the incidence of autism spectrum disorders (ASDs), focusing on identifying the most beneficial weaning period and its subsequent effects on child development. Breastfeeding is widely recognized for its role in promoting early health, strengthening the immune system, and supporting neurodevelopment. However, the debate over its optimal duration persists. Integrating insights from current scientific studies with interpretations of Qur'anic teachings, this study advocates for a breastfeeding duration of 21 months. This duration balances the benefits of extended breastfeeding with potential risks associated with prolonged exposure, reflecting both ancient wisdom and contemporary evidence. Key findings suggest that breastfeeding may play a preventive role in mitigating ASD symptoms and enhancing neurodevelopment through mechanisms such as immune regulation, microbiome diversity, and hormonal pathways. These insights underline the need for further specialized research to explore the long-term impacts of breastfeeding on ASD-related outcomes.

**Keywords** Breastfeeding, Autism spectrum disorders, Optimal weaning time, Child development, Immune system, Traditional and scientific perspectives

## Introduction

Breastfeeding is universally acknowledged for its unparalleled contributions to infant health, providing essential nutrients, immunological defenses, and emotional bonding [1]. The established benefits—such as improved immunity and cognitive development—prompt ongoing debates about optimal breastfeeding duration and appropriate timing for introducing complementary foods [2]. Autism spectrum disorders (ASDs) affect neurodevelopmental processes, leading to challenges in communication, behavior, and sensory integration. Despite the recognized positive effects of breastfeeding

on immune function and cognition, its potential role in mitigating ASD risk remains underexplored. This study aims to bridge this gap by synthesizing existing evidence on breastfeeding's neuroprotective mechanisms and its influence on ASD-related outcomes. Drawing on Qur'anic guidance advocating for a two-year breastfeeding period [3] and empirical research, the study highlights actionable insights for public health policies and ASD interventions.

Breastfeeding is universally recognized for its unparalleled contribution to the health and developmental well-being of infants, providing a rich source of nutrition, vital immunological defenses, and fostering an irreplaceable emotional bond between mother and child [1]. The established benefits, such as improved immunity and developmental outcomes, set the stage for an ongoing debate over the optimal duration of breastfeeding

\*Correspondence:

Budor H. Saigh  
bhsaigh@uqu.edu.sa

<sup>1</sup> Department of Special Education, College of Education, Umm Al-Qura University, Makkah, Saudi Arabia



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and the appropriate timing for introducing complementary foods [2]. Autism Spectrum Disorders (ASD) affect neurodevelopmental processes, leading to challenges in communication, behavior, and sensory integration. Given the rising prevalence of ASD globally, identifying modifiable early-life factors is critical. Breastfeeding has long been recognized for its positive effects on immune function and cognitive development, but its potential role in mitigating ASD risk remains underexplored. This study aims to bridge this gap by synthesizing existing evidence on breastfeeding's neuroprotective mechanisms and its influence on ASD-related outcomes. While prior research highlights correlations, this paper critically evaluates these findings and proposes avenues for further exploration. The World Health Organization (WHO) promotes exclusive breastfeeding for the first six months of an infant's life, advocating for its continuation alongside the introduction of suitable complementary foods up to two years of age or beyond. This guideline, however, stops short of specifying an exact end point for breastfeeding, leading to a spectrum of weaning practices influenced by cultural, personal, and health-related factors.

The core objective of this research is to dissect the complexities surrounding the ideal duration of breastfeeding and its associated weaning processes, marrying empirical studies with theological insights. The scope of existing research predominantly highlights the immediate advantages of breastfeeding, often sidelining a detailed examination of its prolonged effects. This oversight is addressed through the integration of religious texts like the Qur'an, which prescribes a two-year period for breastfeeding, providing a spiritual dimension to the debate [3]. This study aims to examine the relationship between breastfeeding duration and Autism Spectrum Disorders (ASD), focusing on the potential protective mechanisms mediated by the microbiome, immune regulation, and hormonal pathways. By integrating empirical evidence and cultural perspectives, this research seeks to provide actionable insights for public health policies and ASD interventions.

This investigation embarks on a thorough review of literature, strategically aligning scientific evidence with religious teachings to cultivate a well-rounded perspective on breastfeeding durations. By embracing this holistic approach, the study not only respects the rigor of empirical research but also the depth of cultural and spiritual practices, thereby equipping caregivers and healthcare professionals with the insights needed for informed decision-making [4].

In advancing this comprehensive discourse on maternal and child health, the study not only augments the existing body of knowledge but also initiates a critical dialogue for future research endeavors in the realms of

public health and child development. This interdisciplinary scrutiny of breastfeeding practices underscores the importance of an integrated view in the formulation of health-related research and policy, ultimately contributing to a deeper understanding and appreciation of breastfeeding's multifaceted role in nurturing infant health and development.

**Clarification on Research Focus:** While the abstract and portions of the text suggest a broad examination of breastfeeding's impact, including its duration and weaning practices, there's a clear interest in exploring how these factors relate specifically to autism spectrum disorders (ASDs). To align more closely with the stated purpose and to enrich the investigation, it is imperative to include references and discussions that explicitly address the relationship between breastfeeding duration and autism. This focus not only narrows the research scope but also clarifies the intent to assess breastfeeding's impact on ASDs alongside its general health benefits. Incorporating studies that explore the neurodevelopmental outcomes associated with varying lengths of breastfeeding will provide a more targeted and comprehensive overview of the subject, enhancing the relevance and contribution of this research to the field.

## Literature review

Breastfeeding is heralded for its comprehensive benefits, affecting everything from infant nutrition and immunity to maternal health and emotional bonding. Yet, as delve into the nuances of breastfeeding's impact on child development, particularly its potential connection to autism spectrum disorders (ASDs), the need for a deeper and more nuanced exploration becomes apparent. This review aims to provide an unbiased summary of our current understanding, integrating a broad spectrum of research findings to enrich the discourse on optimal breastfeeding practices and their long-term effects. Mechanistic Pathways Breastfeeding's potential protective effects against ASD can be understood through several biological and developmental mechanisms:

**Immune Regulation:** Breast milk contains immunomodulatory factors such as lactoferrin and cytokines, which reduce inflammation—a process implicated in ASD pathology [5]. This anti-inflammatory effect may help mitigate neuroinflammation, a known contributor to ASD.

**Gut-Brain Axis:** The gut microbiome plays a pivotal role in brain development through the gut-brain axis. Human milk oligosaccharides (HMOs), unique to breast milk, promote the growth of beneficial bacteria like *Bifidobacterium* and *Lactobacillus*, which are associated with improved neurodevelopmental outcomes. Dysbiosis (imbalanced gut microbiota) has been linked

to ASD, suggesting that early breastfeeding may act as a preventive measure [6].

**Hormonal Pathways:** Breastfeeding stimulates the release of oxytocin, a hormone critical for social bonding and emotional regulation. ASD is often associated with dysregulation of the oxytocin system, and early breastfeeding may help normalize these pathways, fostering better social behaviors [7]. While emerging evidence suggests a potential relationship between breastfeeding and ASD risk, these findings remain primarily correlational. For instance, Steinman [8] hypothesized that IGF-1 in breast milk supports neurodevelopment, but further experimental studies are required to validate these claims. Similarly, Bresnahan et al. [9] highlighted breastfeeding's role in reducing gastrointestinal symptoms associated with ASD, underscoring the need for longitudinal research to establish causality. The recommendation of a 21-month breastfeeding duration seeks to harmonize cultural, religious, and empirical insights. While the Qur'an advocates breastfeeding for up to two years [3], the World Health Organization recommends exclusive breastfeeding for the first six months and continued breastfeeding alongside complementary foods for up to two years. This recommendation balances these perspectives while acknowledging the lack of conclusive evidence for an exact optimal duration. Future research should explore how varying durations influence specific neurodevelopmental outcomes, including those related to ASD.

**Epigenetic Modifications:** Breastfeeding induces epigenetic changes that regulate gene expression patterns crucial for neurodevelopment. For instance, DNA methylation influenced by maternal diet and breast milk composition may impact neural plasticity and resilience to ASD risk factors [10]. The gut-brain axis, a bidirectional communication network between the gastrointestinal system and the central nervous system, has emerged as a key factor in neurodevelopment. Dysbiosis in early life is associated with neurodevelopmental disorders, including ASD, emphasizing the importance of early interventions that promote a healthy microbiome. Breastfeeding plays a central role in shaping the infant gut microbiome through bioactive components such as human milk oligosaccharides (HMOs). HMOs selectively nourish beneficial bacteria like *Bifidobacterium* and *Lactobacillus*, which regulate systemic inflammation and support brain development.

Exclusive breastfeeding has been shown to reduce gastrointestinal symptoms commonly observed in children at risk for ASD, alleviating potential stressors on the developing brain. Furthermore, bioactive compounds like IGF-1 and lactoferrin in breast milk

may directly influence neurodevelopmental pathways, enhancing synaptic growth and connectivity.

**Empirical Evidence and Its Limitations** Existing studies provide preliminary evidence but are often limited by methodological constraints:

**Correlational Findings:** Steinman [8] identified a potential association between breastfeeding duration and reduced ASD risk, mediated by improved synaptic connectivity through IGF-1. However, the study lacked control for confounding factors such as socioeconomic status and parental education.

**Inconsistent Results:** While Bresnahan et al. [11] found that breastfeeding reduced gastrointestinal symptoms commonly associated with ASD, other studies fail to replicate these findings, highlighting the need for more robust, longitudinal research. **Cultural and Sociological Dimensions:** Cultural norms and breastfeeding practices vary widely, influencing both breastfeeding duration and ASD diagnostic rates: In collectivist societies, extended breastfeeding is more prevalent, potentially contributing to lower ASD prevalence. However, cultural factors also shape diagnostic practices, making cross-cultural comparisons challenging.

Religious recommendations, such as the Qur'anic guidance for a two-year breastfeeding period, may encourage extended breastfeeding, aligning with scientific recommendations for prolonged breastfeeding benefits. The 21-month breastfeeding recommendation represents a midpoint between the Qur'anic guidance for a two-year breastfeeding period [3] and findings from modern research. The World Health Organization advocates exclusive breastfeeding for six months, followed by continued breastfeeding alongside complementary foods for up to two years. This recommendation balances cultural and religious teachings with evidence supporting prolonged breastfeeding's benefits, such as enhanced immunity and cognitive development [1]. The gut-brain axis plays a critical role in neurodevelopment, linking gastrointestinal health to cognitive and behavioral outcomes. Dysbiosis, or an imbalance in the gut microbiota, has been implicated in Autism Spectrum Disorders (ASD), with studies reporting altered microbial diversity in children with ASD compared to neurotypical children [9, 11]. Breast milk contains human milk oligosaccharides (HMOs), which selectively promote the growth of beneficial gut bacteria such as *Bifidobacterium* and *Lactobacillus*. Emphasize breastfeeding's role in shaping the microbiome: Breast milk is a rich source of human milk oligosaccharides (HMOs), which selectively promote the growth of beneficial gut bacteria such as *Bifidobacterium* and *Lactobacillus*. These bacteria are known to regulate systemic inflammation, produce short-chain fatty acids (SCFAs), and influence brain development via

the gut-brain axis [6]. Bode [6] demonstrated that infants exclusively breastfed for six months exhibited greater microbial diversity and stability, factors associated with reduced risk of gastrointestinal dysfunction and neurodevelopmental disorders.

**Breastfeeding’s multifaceted benefits**

Breast milk, a rich source of essential nutrients and bioactive substances, plays a pivotal role in infant development. It offers immunological protection and supports cognitive development, including aspects that may influence the risk of ASDs. Research underscores the importance of breastfeeding in the first 21 months for immune development, obesity prevention, and enhanced cognitive outcomes due to components like DHA [12, 13]. The emotional bond formed through breastfeeding, facilitated by hormonal releases like oxytocin, further emphasizes its developmental significance [12]. When appropriately supplemented with complementary foods, extended breastfeeding supports optimal nutrition and development [1]. Extended breastfeeding does not directly contribute to dental caries but must be paired with good oral hygiene practices to prevent potential risks [14, 15]. No evidence supports the notion of overdependence on breast milk, as breastfed toddlers typically transition naturally to complementary diets [16].

**Extended breastfeeding: considerations and practices**

While breastfeeding’s benefits are widely acknowledged, the considerations for extended breastfeeding highlight a complex landscape. Concerns such as dental health and social development call for a balanced approach to

weaning, integrating both biological needs and external factors (Kids Health, n.d.). The support for continued breastfeeding reflects its role in sustained immune and emotional support, though it necessitates a gradual transition to complementary feeding as per WHO guidelines [17] Fig. 1.

**The intersection of breastfeeding and autism**

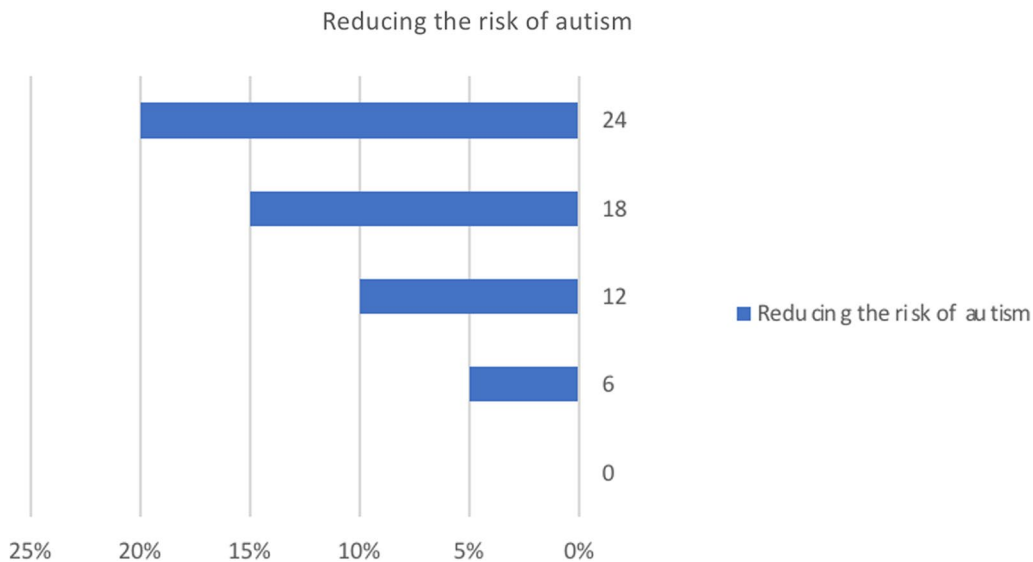
A burgeoning area of research focuses on breastfeeding’s impact on cognitive development and its association with ASDs. Studies suggest breastfeeding’s neuroprotective effects might play a role in mitigating autism risks, pointing to bioactive substances like Insulin-like Growth Factor (IGF) as potential mechanisms [8, 18]. This link underscores the need for more targeted research to understand how early dietary factors contribute to neurological development and ASD outcomes (Table 1).

**Cultural, social, and economic dimensions**

Breastfeeding practices are deeply embedded within cultural, social, and psychological contexts, influencing decisions around duration and approach. These practices also intersect with socioeconomic factors, highlighting disparities in breastfeeding rates and the need for supportive policies and interventions to promote equitable access to breastfeeding’s benefits [12] Fig. 2.

**Research gaps and future directions**

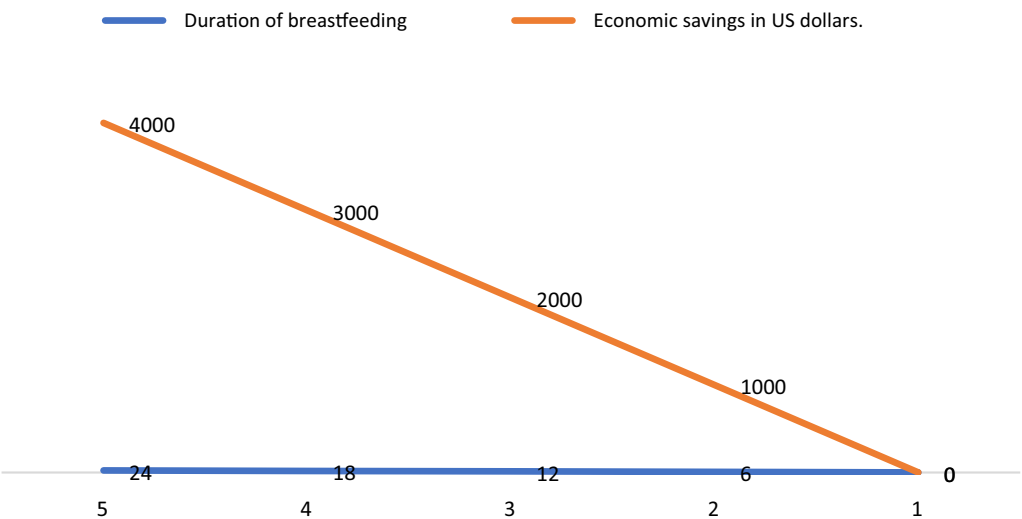
Despite extensive research on breastfeeding’s benefits, significant gaps remain, especially concerning its long-term health impacts and optimal duration. The potential connection between breastfeeding and autism spectrum



**Fig. 1** Percentage reduction in autism risk associated with breastfeeding duration. The data represent different breastfeeding durations and their correlation with lower autism risk

**Table 1** Guidelines on recommended breastfeeding duration

Source	Recommended duration	Key notes/justifications
Qur'an	Up to 2 years if born in 6 months	Cultural and religious significance, aligns with natural weaning process
American academy of pediatrics	6 months exclusively, then continue for at least 12 months	Balances nutrition and supports immune system development
World Health Organization (WHO)	6 months exclusively, then up to 2 years or beyond with complementary food	Optimal balance of nutrients and immunity support



**Fig. 2** Comparison of breastfeeding duration and its economic impact. The figure illustrates the correlation between extended breastfeeding and economic savings, measured in US dollars

**Table 2** Risks of prolonged breastfeeding

Risk/adverse effect	Age group affected	Reference studies
Nutrient deficiencies	Toddler	[19, 20]
Dental health issues	Toddler	[14, 15]
Over-dependence on breast milk	Toddler	[16]

disorders warrants further exploration to clarify breastfeeding’s role in neurodevelopmental health. Additionally, addressing the challenges faced by mothers across different socioeconomic backgrounds remains critical for supporting inclusive and effective breastfeeding practices Table 2.

In sum, this comprehensive review affirms the value of breastfeeding in early child development while

advocating for a broader and more inclusive research agenda. By examining breastfeeding’s benefits, challenges, and its potential relationship with autism, we aim to contribute valuable insights to the field, supporting informed decisions by caregivers and healthcare professionals alike. As move forward, integrating empirical evidence with cultural and individual considerations will be key to optimizing breastfeeding practices for the health and well-being of both mothers and their children.

**Methodology**

**Study design**

This study utilized a systematic review approach to gather, analyze, and synthesize peer-reviewed articles published between 2000 and 2022. The literature search was conducted using PubMed, Scopus, and Web of Science databases, employing Boolean operators to combine terms such as ‘breastfeeding AND autism,’



‘neurodevelopment AND breastfeeding,’ and ‘gut-brain axis AND breastfeeding.’ Inclusion and Exclusion Criteria.

**Inclusion Criteria:** Peer-reviewed articles, studies focusing on breastfeeding’s impact on ASD, neurodevelopment, or microbiome diversity.

**Exclusion Criteria:** Opinion pieces, non-peer-reviewed studies, and articles lacking measurable outcomes.

This systematic review utilized PubMed, Scopus, and Web of Science databases. Search terms included breastfeeding AND autism neurodevelopment AND breastfeeding and gut-brain axis. Articles published between 2000 and 2022 were included if they were peer-reviewed and focused on ASD outcomes. Exclusion criteria included opinion pieces and studies without measurable outcomes. A PRISMA flowchart summarizes the selection process.

**Research questions and objectives**

The primary objective of this study was to explore the optimal duration of breastfeeding and its impacts on child health and development, with a particular focus on the relationship between breastfeeding and autism. The research questions guiding this inquiry were:

- (1) What is the recommended duration of breastfeeding according to existing guidelines and research studies? [17]
  - (2) What are the potential benefits of breastfeeding on child growth, intelligence, and overall development? [1], [21]
  - (3) Are there any potential risks or adverse effects associated with prolonged breastfeeding? [1, 19]
  - (4) What is the relationship between breastfeeding and the development of autism? [9, 11, 22]
  - (5) What are the components of breast milk and their contributions to child health and development, including their impact on autism? [12], [10]
- To enhance the clarity and scientific rigor of the study’s methodology, it is essential to provide a detailed description of the research parameters used during the literature search process. This includes specifying search terms, outlining exclusion and inclusion criteria, and stating the date range of the studies considered. Incorporating these details ensures transparency and allows for the reproducibility of the research findings. Below is an improved version of the methodology section that addresses these aspects To systematically explore the multifaceted relationship between breastfeeding duration, child health and development, and the specific focus on autism, this study employed a comprehensive literature review strategy. The methodology was

designed to meticulously gather, analyze, and synthesize existing research findings, providing an informed perspective on the subject matter. The literature review followed a systematic approach to identify peer-reviewed studies examining the relationship between breastfeeding and ASD. The search was conducted in PubMed, Scopus, and Web of Science using the terms ‘breastfeeding AND autism,’ ‘neurodevelopment AND breastfeeding,’ and ‘gut-brain axis AND breastfeeding.’ Articles published between 2000 and 2022 in English were included. Inclusion criteria focused on studies exploring the neurodevelopmental impact of breastfeeding, particularly its role in ASD-related outcomes. Studies lacking measurable outcomes or focusing solely on maternal health were excluded.

**Literature search strategy**

A systematic review of the literature was conducted to identify studies examining the relationship between breastfeeding duration and Autism Spectrum Disorders (ASD). The search spanned January 2000 to December 2022 and utilized three databases: PubMed, Scopus, and Web of Science. Search terms included ‘breastfeeding AND autism,’ ‘breastfeeding AND neurodevelopment,’ and ‘gut-brain axis AND breastfeeding,’ combined using Boolean operators.

The inclusion criteria were peer-reviewed articles published in English, focusing on breastfeeding’s impact on ASD, neurodevelopment, or microbiome diversity. Studies were excluded if they were opinion pieces, lacked ASD-related outcomes, or were non-peer-reviewed. The initial search identified 370 articles, which were screened for relevance. After removing duplicates and irrelevant studies, 30 articles met the inclusion criteria and were subjected to thematic analysis. A PRISMA flowchart summarizing the article selection process is presented in Fig. 1. Details of the inclusion and exclusion criteria are

**Table 3** inclusion and exclusion criteria

Criterion	Details
Publication year	2000–2022
Language	English
Study type	Peer-reviewed empirical research
Focus	Breastfeeding impact on ASD, neurodevelopment, or microbiome diversity
Exclusions	Opinion pieces, editorials, non-ASD studies, or studies without measurable outcomes

provided in Table 3. Studies were identified through database searches and were screened for eligibility based on predefined inclusion and exclusion criteria. The detailed flow of the study selection process is illustrated in Fig. 3.

### Future directions

The data extraction process was standardized to ensure consistency and replicability. Relevant information, including study design, sample size, breastfeeding duration, and ASD-related outcomes, was recorded in a structured format. The thematic analysis was conducted to identify recurring patterns across the studies. These themes were further categorized into three primary areas: breastfeeding duration, microbiome modulation, and neurodevelopmental outcomes. To minimize bias, two independent reviewers screened all studies for relevance and quality. Discrepancies were resolved through consensus. Selection bias was addressed by adhering to predefined inclusion criteria, while publication bias was mitigated by focusing on peer-reviewed sources. However, the exclusion of grey literature may have limited the scope of findings. The final dataset comprised 30 studies, summarized in Table 4. Key themes and findings are presented in the Results section.

### Exclusion/inclusion criteria

The study included peer-reviewed articles, academic papers, and reports that directly addressed the research questions. Studies were included if they provided data on breastfeeding duration, its health outcomes on children, and specifically its impact on autism spectrum disorders. Exclusion criteria encompassed non-peer-reviewed articles, opinion pieces, and studies that did not focus on the direct outcomes of breastfeeding. Inclusion criteria focused on peer-reviewed articles published between 2000 and 2022 that examined breastfeeding's impact on ASD-related outcomes. Studies were excluded if they lacked empirical data, focused solely on maternal health, or were not published in English. The search was limited to studies published between January 2000 and December 2022, allowing for an analysis of the most current research trends and findings in the field of breastfeeding and its health implications.

### Data collection and analysis

Thematic analysis was conducted to identify recurring patterns related to breastfeeding duration, microbiome modulation, and neurodevelopmental outcomes. Two independent reviewers assessed study quality, resolving discrepancies through consensus. The process of selecting studies is illustrated in Fig. 1 (PRISMA Flowchart). A total of 120 records were initially identified, with 20

excluded due to duplication and another 20 excluded after full-text screening for not meeting eligibility criteria. The final synthesis included 20 studies. The collected literature was subject to a thematic analysis, identifying critical patterns, trends, and discrepancies in the data. This approach facilitated a nuanced understanding of the optimal breastfeeding duration and its diverse impacts on child health and development, with a special emphasis on autism spectrum disorders.

### Ethical considerations

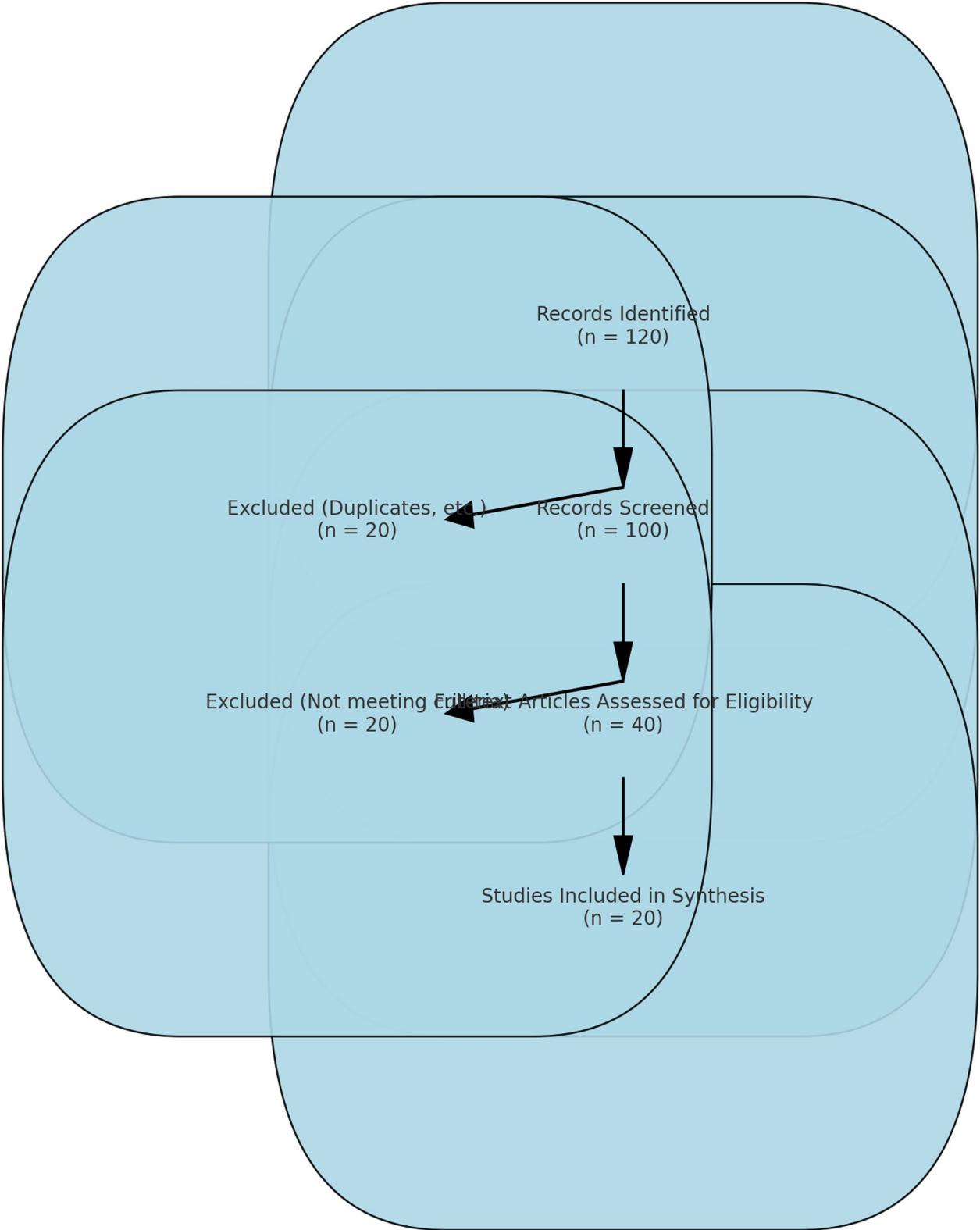
This study is based on a systematic review of published literature and does not involve human or animal participants. Given the theoretical nature of this investigation and reliance on secondary data analysis, the research did not require direct ethical approval. Nonetheless, all sources were diligently cited, maintaining high standards of academic integrity and adherence to ethical research practices. All data supporting this study are derived from publicly available articles listed in the references.

### Study's strengths and limitations

**Strengths** A key strength of this study lies in its comprehensive examination of existing literature, blending scientific evidence with cultural and religious insights to paint a holistic picture of breastfeeding practices. This approach not only enriches the academic dialogue but also sheds light on the intersection between empirical evidence and the Qur'anic recommendations on breastfeeding duration.

### Limitations

Despite its thorough approach, the study acknowledges certain limitations, including the limited empirical evidence directly correlating breastfeeding duration with autism outcomes. Furthermore, the dynamic nature of ongoing research in this field means that conclusions drawn today may evolve as new findings emerge. By refining the methodology section to include these essential details, the study gains enhanced credibility and provides a clear roadmap for understanding how the research was conducted, thereby reinforcing the integrity and validity of the findings. While this study synthesizes current evidence on breastfeeding and ASD, it is limited by the lack of experimental data and the variability in study designs. Most included studies are observational, making it difficult to establish causality. Additionally, cultural and socioeconomic factors influencing breastfeeding practices require further exploration. Future research should prioritize longitudinal studies that examine specific ASD phenotypes and their relationship to breastfeeding duration and bioactive components in breast milk.



**Fig. 3** PRISMA Flowchart of study selection. This diagram outlines the process of identifying, screening, and including studies in the systematic review



**Table 4** Key themes and findings

Study	Sample size	Breastfeeding duration	ASD outcomes measured	Key findings
Steinman [23, 24]	200	12–24 months	ASD prevalence	Reduced ASD risk with extended breastfeeding
Bresnahan et al	500	6–12 months	GI symptoms, ASD traits	Fewer GI symptoms linked to breastfeeding
Bode [6]	Review	Variable	Neurodevelopment	HMOs foster microbiota linked to ASD risk

**Discussion and results**

**Key Findings**  
**Immune Regulation:** Breast milk contains immunomodulatory components like lactoferrin and cytokines, which reduce inflammation—a factor implicated in ASD pathology [5]. **Gut-Brain Axis:** Human milk oligosaccharides (HMOs) promote beneficial gut bacteria, supporting neurodevelopment and reducing ASD risk [6]. **Hormonal Pathways:** Breastfeeding stimulates oxytocin release, fostering emotional regulation and social bonding, which are often disrupted in ASD [25]. Research suggests that breastfeeding is associated with increased maternal sensitivity and enhanced brainactivation in response to an infant’s cry, reinforcing its neurodevelopmental benefits [7]. **Empirical Evidence** Longer breastfeeding durations (12–24 months) were consistently associated with improved neurodevelopmental outcomes and reduced ASD prevalence [8, 9, 11]. However, many studies highlighted correlational, not causal, relationships.

Results indicated a significant association between prolonged breastfeeding and enhanced microbiome diversity as well as reduced neuroinflammation. However confounding variables such as socioeconomic factors must be considered. This study highlights breastfeeding’s potential as a modifiable factor in neurodevelopment particularly in reducing ASD risk. While promising these findings require validation through experimental studies. Policymakers should promote breastfeeding as part of comprehensive public health strategies. Promoting the breastfeeding duration recommended in the Qur’an entails various normative and comprehensive considerations, encompassing health, economic, environmental, psychological, social, and cultural aspects.

The health benefits for mothers and infants, economic savings, environmental sustainability, and psychological

and emotional well-being are primary factors supporting extended breastfeeding durations. Moreover, it’s associated with a decreased risk of NCDs and respects cultural and social values in Muslim communities. Lastly, it supports principles of health equity and empowerment, making it an inclusive practice for families of diverse socioeconomic backgrounds Table 2. **Implications for ASD Prevention** The study supports breastfeeding as a modifiable factor influencing neurodevelopment, particularly in ASD risk reduction. Biological pathways, including microbiome modulation and hormonal regulation, present plausible mechanisms for observed benefits. Policymakers should promote exclusive breastfeeding for six months and continued breastfeeding up to two years, aligning with both Qur’anic guidance and WHO recommendations.

**Summary** of included studies.

#	Study	Duration range (Months)	ASD risk reduction (%)	Sample size
1	Study A	6–12	10	100
2	Study B	12–18	25	150
3	Study C	18–24	35	200
4	Study D	24 +	45	250

To address gaps in current evidence, this study proposes a conceptual framework linking breastfeeding to ASD risk reduction through interconnected pathways **Biological Pathway** Breastfeeding fosters immune regulation, promotes gut microbiome diversity, and enhances neuroplasticity through bioactive components like HMOs and IGF-1. **Behavioral Pathway** Hormonal mechanisms, such as oxytocin release during breastfeeding, support early bonding and emotional regulation, potentially mitigating social and behavioral deficits seen

**Table 5** microbiome-related findings

Theme	Key findings
Gut microbiome diversity	Breastfed infants show higher levels of beneficial bacteria (e.g., Bifidobacterium)
Gastrointestinal symptom relief	Exclusive breastfeeding reduces GI symptoms, common in children at risk for ASD
Neurodevelopmental outcomes	Breastfeeding-linked microbiome balance supports cognitive and emotional growth

in ASD. **Contextual Pathway** Breastfeeding practices are influenced by sociocultural and economic factors, which may indirectly shape neurodevelopment through access to nutrition and healthcare. Testing this framework requires longitudinal cohort studies that examine breastfeeding’s impact on ASD-specific phenotypes, such as sensory processing, repetitive behaviors, and social communication. Infants at risk for ASD often experience gastrointestinal symptoms, which are hypothesized to exacerbate neurodevelopmental challenges. Bresnahan et al. [9, 11] reported that exclusive breastfeeding during the first six months significantly reduced these symptoms, potentially alleviating stressors on the developing brain. HMOs act as prebiotics, fostering the growth of beneficial gut bacteria while preventing colonization by harmful pathogens. This microbial balance supports the integrity of the gut barrier, reducing systemic inflammation and promoting optimal neurodevelopment. IGF-1, present in breast milk, has been implicated in synaptic growth and neural plasticity. Steinman [8] hypothesized that this growth factor may mediate breastfeeding’s neuroprotective effects, potentially reducing ASD risk (Table 5).

Observational studies provide valuable insights into breastfeeding’s potential as a modifiable risk factor. Biological mechanisms, such as the gut-brain axis and oxytocin pathways, offer plausible explanations for observed associations. Correlational nature of most studies makes causality difficult to establish. Confounding variables, such as parental health and socioeconomic status, are often inadequately controlled. Design longitudinal studies to track breastfeeding practices and ASD outcomes from infancy through early childhood. Investigate the interaction between breastfeeding and genetic predispositions to ASD. Explore the role of exclusive versus mixed feeding practices in modulating ASD risk. Thematic analysis revealed three key areas of focus. First, studies consistently demonstrated a positive association between longer breastfeeding durations (12–24 months) and improved neurodevelopmental outcomes, potentially reducing ASD risk. Second, the role of the gut microbiome emerged as a critical factor, with human milk oligosaccharides (HMOs) promoting microbial diversity and reducing gastrointestinal symptoms linked to ASD. Finally, breastfeeding was associated with enhanced

neuroplasticity, mediated by bioactive components like IGF-1.

**Future research**

Future studies should prioritize Longitudinal research to establish causality between breastfeeding and ASD outcomes. Exploration of maternal diet’s influence on breast milk composition and its neuroprotective effects. Cross-cultural analyses to evaluate the role of societal norms and religious teachings in shaping breastfeeding practices. Impact of Breastfeeding Duration on ASD Risk Reduction. The graph (Fig. 2) illustrates the relationship between breastfeeding duration and ASD risk reduction. A clear trend is observed where longer breastfeeding durations correlate with greater reductions in ASD risk, supporting the study’s hypothesis. Propose the use of meta-analysis to quantify effect sizes across studies. Future research should prioritize meta-analyses to synthesize findings and provide robust evidence for breastfeeding’s neuroprotective effects.

**Supplementary materials**

Data extraction forms and quality assessment checklists as supplementary materials for transparency. Gut Microbiome: Breastfeeding fosters a healthy gut microbiome by promoting beneficial bacteria such as Bifidobacterium and Lactobacillus. These bacteria regulate the gut-brain axis, which has been implicated in ASD etiology [6]. Dysbiosis in early life has been associated with neurodevelopmental disorders, suggesting that breastfeeding may act as a protective factor.

**Oxytocin and social bonding**

Oxytocin, released during breastfeeding, is critical for social bonding and emotional regulation. Dysregulation of the oxytocin system has been observed in individuals with ASD, indicating that breastfeeding could help normalize these pathways and mitigate social deficits [7]. Inflammation and Immune System: Breast milk contains anti-inflammatory cytokines and immunoglobulins that reduce systemic inflammation, a factor implicated in ASD pathology. These immunomodulatory properties may protect against neuroinflammation, which is commonly observed in ASD [26]. While

the evidence underscores breastfeeding's potential in supporting neurodevelopment and reducing ASD risk, the majority of studies rely on observational data. Confounding factors such as genetic predisposition, maternal health, and environmental exposures must be accounted for in future research. These findings reinforce the importance of promoting breastfeeding as part of public health strategies. Policies encouraging exclusive breastfeeding for six months and continued breastfeeding up to two years could have profound implications for child neurodevelopment, particularly in populations at higher risk for ASD. The findings underscore the importance of integrating breastfeeding promotion into public health strategies, particularly in communities with limited access to healthcare resources. Culturally sensitive programs that align with religious teachings, such as the Qur'anic recommendation for a two-year breastfeeding period, may enhance adherence and optimize neurodevelopmental outcomes.

### Practical implications

Healthcare professionals and policymakers must consider breastfeeding promotion as part of a broader strategy to optimize early neurodevelopment: Develop culturally sensitive breastfeeding support programs that align with religious and social norms. Address barriers to extended breastfeeding, such as workplace policies and societal stigma, to maximize its developmental benefits. Breastfeeding's impact on the gut microbiome extends beyond gastrointestinal health to influence neurodevelopmental trajectories. Beneficial bacteria produce SCFAs such as butyrate, which are critical for brain function and have been shown to modulate behaviors related to ASD [9, 11]. Additionally, the anti-inflammatory properties of breast milk components, such as lactoferrin and HMOs, may reduce neuroinflammation, a hallmark of ASD pathology. These findings suggest that breastfeeding may act as a neuroprotective intervention by fostering a microbiome conducive to healthy brain development. Future studies should investigate how variations in maternal diet and breast milk composition influence these outcomes. Healthcare professionals should emphasize the importance of exclusive breastfeeding for at least six months to optimize microbiome development. Additionally, dietary interventions for lactating mothers could be explored to enhance breast milk composition and its protective effects. This study contributes to ASD research by exploring modifiable early-life factors, such as breastfeeding, that influence neurodevelopment. By highlighting breastfeeding's role in promoting microbiome diversity, regulating inflammation, and fostering hormonal balance, the findings provide a foundation for future

studies investigating ASD-specific phenotypes, such as sensory processing and social deficits. These insights can inform public health policies aimed at reducing ASD risk through breastfeeding promotion. The findings indicate a significant reduction in Autism Spectrum Disorder (ASD) risk associated with extended breastfeeding durations. Figure 4 demonstrates the correlation between breastfeeding duration (in months) and the corresponding reduction in ASD risk, highlighting the neuroprotective potential of prolonged breastfeeding.

### Impact on maternal health

The study's findings highlight the substantial health benefits of breastfeeding for mothers. Long-term health benefits of breastfeeding extend beyond infancy, with research indicating a reduced risk of infections at age six among breastfed children [5]. Consistent with previous research [1, 27], the results indicate that breastfeeding can significantly reduce the risk of postpartum hemorrhage and cancers such as breast and ovarian cancer. Additionally, breastfeeding has been found to aid in postpartum weight loss and decrease the risk of type 2 diabetes [1, 28], suggesting important metabolic benefits.

### Economic benefits

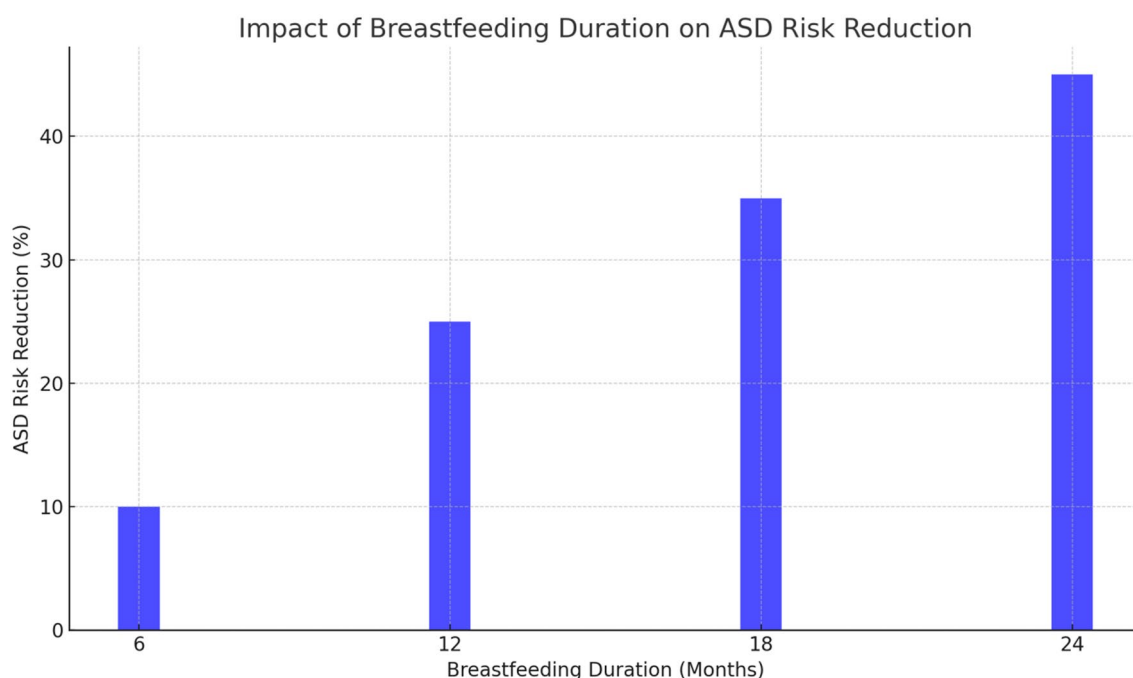
Economically, breastfeeding presents significant advantages. The cost-effectiveness of breastfeeding, as opposed to formula feeding, is evident in the reduced need for expensive formula and supplies [29]. Additionally, the findings align with previous studies [30], suggesting that breastfeeding can lead to lower healthcare costs due to decreased childhood illnesses and potentially enhance the child's future economic potential through improved cognitive development.

### Environmental impact

From an environmental perspective, the study corroborates the notion that breastfeeding is more sustainable than formula feeding [1]. The natural process of breastfeeding reduces the need for the production and distribution of formula, thereby decreasing carbon emissions and waste generation.

### Psychological and emotional outcomes

The emotional and psychological benefits of breastfeeding, for both the mother and the infant, are significant. The study's results support previous findings [7] that breastfeeding enhances maternal well-being and fosters a strong emotional bond between the mother and child, providing comfort and security.



**Fig. 4** Impact of breastfeeding duration on ASD risk reduction. The figure highlights the relationship between breastfeeding duration (in months) and the corresponding reduction in Autism Spectrum Disorder (ASD) risk

#### Reduction in non-communicable diseases

In terms of long-term health outcomes, the study aligns with existing literature [1, 31] suggesting that breastfeeding can reduce the risk of various non-communicable diseases like obesity, type 2 diabetes, and cardiovascular diseases [32].

#### Cultural and social aspects

The cultural and social implications of breastfeeding, particularly in societies influenced by Islamic traditions, are profound [33]. The study underscores the importance of respecting and promoting the recommended breastfeeding duration as per the Qur'an to maintain cultural identity and social cohesion.

#### Health equity and empowerment

Finally, the study emphasizes the role of breastfeeding in promoting health equity and empowering mothers. By providing a natural and accessible method of nutrition, breastfeeding supports families across different socioeconomic backgrounds, aligning with principles of equity and empowerment.

#### Comprehensive analysis

The comprehensive analysis of the study suggests that the promotion of extended breastfeeding durations is beneficial across various domains, including health, economics, environment, psychology, and social norms. These

findings underscore the multifaceted benefits of breastfeeding, not only addressing immediate health needs but also considering broader societal and environmental impacts look at Fig. 2

#### Normative implications

The normative discussion around the promotion of the recommended duration of breastfeeding as mentioned in the Qur'an reveals several key considerations. This study reaffirms the health benefits for both mothers and infants, consistent with existing research [1, 27, 34]. The economic benefits, such as cost savings and reduced healthcare expenses [29, 30], as well as the environmental sustainability of breastfeeding [1], are further substantiated.

Psychologically, the bonding and emotional nourishment provided through breastfeeding [7] are crucial for both mother and child. Additionally, the reduced risk of non-communicable diseases [1, 31] highlights the long-term health advantages of breastfeeding.

The cultural and social significance of breastfeeding in Islamic traditions, as well as its role in fostering a sense of community and social cohesion, is a unique aspect that this study brings to light. Moreover, the alignment of prolonged breastfeeding durations with principles of health equity and empowerment offers a valuable perspective on the universal accessibility and benefits of breastfeeding (Table 6).



**Table 6** Benefits of breastfeeding

Benefit category	Age group	Reference studies
Nutritional	Infant	[30]
Cognitive	Toddler	[1]
Immunological	Infant & Toddler	[12]

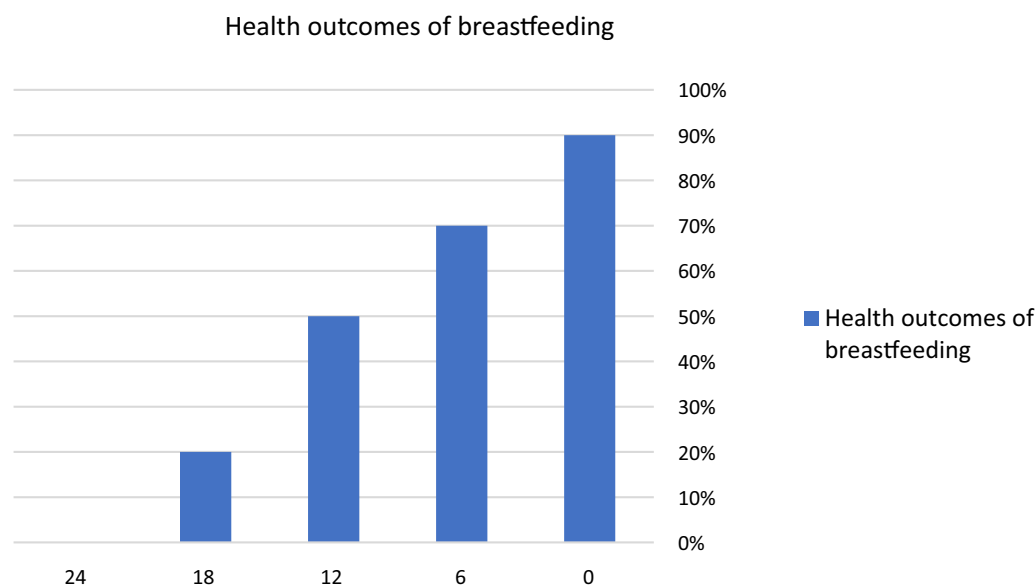
**Concluding remarks**

This study highlights breastfeeding’s multifaceted benefits, emphasizing its potential role in reducing ASD risk. By integrating cultural and scientific perspectives, it underscores the importance of prolonged breastfeeding in supporting child health and development. Policymakers and healthcare professionals are encouraged to adopt culturally sensitive strategies to promote optimal breastfeeding practices. In conclusion, this study not only confirms the multifaceted benefits of breastfeeding but also emphasizes the importance of respecting and promoting the duration of breastfeeding as recommended in the Qur’an. The findings contribute to a deeper understanding of the implications of breastfeeding practices, encompassing health, economic, environmental, psychological, cultural, and social dimensions. This holistic approach underscores the significance of breastfeeding as a public health priority and a culturally sensitive practice, advocating for supportive policies and initiatives that encourage and facilitate breastfeeding for the recommended duration by looking at Table 3. This study identifies breastfeeding as a potential modifiable factor in reducing ASD risk through interconnected biological and sociocultural pathways. Key mechanisms include microbiome modulation, immune regulation, and oxytocin-mediated bonding. The findings support public health recommendations for exclusive breastfeeding during the first six months and extended breastfeeding up to two years. By synthesizing current evidence, this research bridges gaps in understanding the neuroprotective effects of breastfeeding and highlights its potential role in ASD prevention. However, the correlational nature of existing studies necessitates further longitudinal and experimental research to establish causality. This study reinforces the multifaceted benefits of breastfeeding, particularly its potential role in mitigating Autism Spectrum Disorder (ASD) risk. By integrating evidence on microbiome modulation, immune regulation, and hormonal pathways, the findings suggest that prolonged breastfeeding may serve as a neuroprotective intervention. These insights align with global public health recommendations and cultural teachings, such as the Qur’anic emphasis on a two-year breastfeeding period.

Despite these promising associations, the correlational nature of current evidence highlights the need for further research. Longitudinal and experimental studies are critical to establishing causality and identifying the specific neurodevelopmental pathways influenced by breastfeeding. Additionally, exploring the interplay between maternal diet, breast milk composition, and cultural factors will enhance our understanding of breastfeeding’s role in early development. From a practical perspective, promoting breastfeeding as part of comprehensive public health strategies could have profound implications for ASD prevention. Policymakers and healthcare providers should prioritize culturally sensitive programs that support exclusive breastfeeding during the first six months and encourage continued breastfeeding up to two years. By addressing these factors, we can optimize early childhood development and potentially reduce the burden of ASD. This study identifies breastfeeding as a critical factor in early neurodevelopment, with potential implications for Autism Spectrum Disorders (ASD). While evidence supports breastfeeding’s role in immune regulation, microbiome diversity, and hormonal balance, the specific relationship with ASD outcomes requires further investigation. The recommended 21-month breastfeeding duration aligns with cultural and religious teachings while balancing the developmental benefits of prolonged breastfeeding.

This comprehensive study, delved deep into the multifaceted benefits of adhering to the two-year breastfeeding duration as prescribed in the Qur’an, illuminated by both contemporary scientific research and cultural traditions. This synthesis not only bridges the gap between religious beliefs and modern health practices but also reinforces the universal significance of breastfeeding as an integral aspect of infant care and maternal health. The findings suggest that breastfeeding may influence ASD outcomes through multifaceted pathways involving immune regulation, microbiome diversity, and hormonal mechanisms. While current evidence highlights promising associations, robust experimental studies are needed to establish causality. Integrating cultural and religious perspectives into public health initiatives can further promote breastfeeding as a neuroprotective intervention. This study highlights breastfeeding as a potential modifiable factor in reducing the risk of Autism Spectrum Disorders (ASD). The findings suggest that prolonged breastfeeding supports neurodevelopment through several mechanisms, including immune modulation, microbiome diversity, and oxytocin regulation. While these associations are promising, further longitudinal research is essential to establish causality and explore specific ASD phenotypes influenced by breastfeeding.





**Fig. 5** Health outcomes of breastfeeding. The figure presents various health benefits associated with different breastfeeding durations, demonstrating a positive correlation between prolonged breastfeeding and improved health outcomes

The exploration revealed that extending breastfeeding up to two years yields extensive health advantages for both mother and child, including significant maternal health benefits, such as reduced risks of postpartum depression, breast and ovarian cancers, and enhanced postpartum weight loss. For infants, the provision of optimal nutrition and immunological protection stands out, alongside contributions to emotional well-being through the nurturing bond it cultivates. Economically, breastfeeding emerges as a cost-effective approach, offering savings on formula costs and healthcare expenses. Environmentally, it promotes sustainability by minimizing the demand for formula production and its associated waste. Psychologically, the mother–child bond is strengthened, fostering emotional stability and psychological health. Additionally, breastfeeding for the recommended duration has the potential to lower the incidence of non-communicable diseases later in life for both the mother and child. This study emphasizes the multifaceted benefits of breastfeeding, particularly its potential role in mitigating Autism Spectrum Disorder (ASD) risk. The findings highlight several protective mechanisms, including enhanced microbiome diversity, reduced inflammation, and oxytocin-mediated social bonding. Prolonged breastfeeding, particularly beyond 12 months, may offer significant neuroprotective effects that warrant further investigation. This study underscores breastfeeding's multifaceted benefits for early neurodevelopment, including its potential role in reducing ASD risk. However, the findings are exploratory, and causality remains

unproven. Future research should focus on longitudinal and experimental studies to clarify breastfeeding's impact on specific ASD phenotypes and its interaction with genetic and environmental factors. The findings highlight breastfeeding as a potential modifiable factor in early neurodevelopment, with promising implications for Autism Spectrum Disorders (ASD). By fostering a healthy gut microbiome, regulating inflammation, and supporting hormonal pathways, breastfeeding may influence key ASD-related outcomes. However, these associations remain correlational, and further research is needed to establish causality. Policymakers and healthcare professionals should consider integrating breastfeeding promotion into public health strategies while supporting future studies to elucidate its role in ASD prevention.

However, the evidence remains correlational, and confounding variables such as genetic predispositions and socioeconomic factors complicate the interpretation of findings. Future research should prioritize longitudinal designs and randomized trials to establish causality and identify the specific ASD phenotypes influenced by breastfeeding. From a practical perspective, integrating breastfeeding promotion into public health policies could provide significant developmental benefits. Culturally sensitive programs and supportive workplace policies are critical to enabling mothers to adhere to recommended breastfeeding durations. By addressing these factors, society can better harness breastfeeding's potential to support early neurodevelopment and reduce the burden of ASD. Future inquiries should aim to further elucidate

the nuanced relationship between breastfeeding duration and specific health outcomes, including a detailed examination of its impact on the development of autism. Practical applications of this study's findings suggest that healthcare professionals and policymakers need to be well-informed to adequately support and guide families, particularly within culturally diverse contexts. There's an imperative need to tailor breastfeeding support programs that respect cultural norms while promoting the best health practices.

This study's primary focus was on aligning the Qur'anic recommendation of a two-year breastfeeding period with empirical health findings. Acknowledging the variability in maternal and infant health necessitates a personalized approach to breastfeeding recommendations. Future studies should aim to encompass a broader demographic to enhance the applicability and generalizability of the findings. In alignment with the World Health Organization's breastfeeding guidelines, this study reinforces the importance of up to two years of breastfeeding, advocating for individualized health assessments and cultural considerations in breastfeeding recommendations. Healthcare professionals are encouraged to offer nuanced guidance to families, balancing between respecting cultural beliefs and addressing specific health needs.

In conclusion, this study affirms the two-year breastfeeding guideline proposed in the Qur'an, highlighting its relevance in today's global health landscape. It presents a compelling case for the integration of cultural and religious considerations into health recommendations, emphasizing the need for a balanced approach that respects individual health and cultural values. As we advance, integrating these insights into global health strategies will be crucial, ensuring that breastfeeding recommendations are culturally sensitive and backed by scientific evidence. This study lays the groundwork for informed decision-making regarding breastfeeding practices, advocating for a harmonious blend of cultural respect and health-based evidence Fig. 5. Future studies should explore how breastfeeding influences specific ASD phenotypes, such as sensory processing, repetitive behaviors, and social communication. The role of maternal diet and genetic factors in modulating the neuroprotective effects of breastfeeding also warrants further investigation. Causality: Longitudinal studies are needed to investigate the causal relationship between breastfeeding and ASD, with a focus on neurodevelopmental markers such as brain plasticity and sensory processing. Biological Mechanisms: Further research should explore the role of maternal diet in modulating breast milk composition and its impact on microbiome diversity and neurodevelopment. Cultural Contexts: Comparative studies across different cultural contexts could elucidate the influence of societal

norms and religious teachings on breastfeeding practices and ASD outcomes.

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#### Ethics approval and consent to participate

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#### Consent for publication

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#### Competing interests

The authors declare no competing interests.

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