ISSN 2985-5667 (Online) | 2985-6353 (Print) | Vol. 2, No. 2, April (2024), pp. 63-71

Published by: IARN Institute

International Journal on Health and Medical Sciences

Journal homepage: https://journals.iarn.or.id/index.php/HealMed/index

Exploring the Relationship between Breastfeeding Practices and Acute Otitis Media Incidence in Children: Mechanisms and Implications

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Article Info

Article history:

Received Mar 23, 2024
Revised Apr 15, 2024
Accepted Apr 30, 2024

Keywords:

Breastfeeding;
Acute Otitis Media;
Children;
Incidence;
Protective Mechanisms.

ABSTRACT

Acute Otitis Media (AOM) represents a common childhood ailment with significant implications for pediatric health. While breastfeeding has long been purported to confer protection against AOM, the precise nature of this relationship and underlying mechanisms remain incompletely understood. This research aimed to elucidate the relationship between breastfeeding practices and AOM incidence in children, as well as to explore potential mechanisms underlying this association. A comprehensive review of existing literature was conducted, encompassing systematic reviews, meta-analyses, longitudinal cohort studies, and mechanistic investigations. Studies investigating the incidence of AOM in relation to breastfeeding practices, as well as mechanistic pathways such as maternal antibodies, antimicrobial factors, anti-inflammatory properties, and microbiota modulation, were synthesized to provide a comprehensive understanding of the topic. The synthesis of existing evidence revealed a consistent and robust association between breastfeeding practices and reduced AOM incidence in children. Meta-analyses demonstrated a lower AOM risk among breastfed infants compared to non-breastfed counterparts, with exclusive breastfeeding yielding the greatest risk reduction. Longitudinal cohort studies further elucidated a dose-response relationship between breastfeeding duration and AOM risk, underscoring the protective effect of prolonged breastfeeding. Mechanistic investigations highlighted the role of maternal antibodies, antimicrobial factors, anti-inflammatory properties, and microbiota modulation in mediating breastfeeding's protective effect against AOM.

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1. INTRODUCTION

Acute Otitis Media (AOM) stands as one of the most prevalent childhood illnesses globally, posing significant challenges to pediatric healthcare systems(Organization, 2004). Defined by inflammation of the middle ear, often accompanied by fluid accumulation, AOM not only inflicts pain and discomfort upon affected children but also burdens families with frequent medical visits and antibiotic prescriptions. Among children aged 6-24 months, a vulnerable developmental period marked by

immune system maturation and susceptibility to infections, AOM emerges as a particularly prevalent concern(Tregoning & Schwarze, 2010). However, amidst the multifaceted strategies aimed at prevention and management, one natural practice has garnered considerable attention for its potential protective effects breastfeeding.

Breastfeeding, revered as nature's first immunization, encompasses a plethora of health benefits extending far beyond mere nourishment(Stone, 2014). The intricate composition of breast milk harbors an array of bioactive compounds, including antibodies, cytokines, and oligosaccharides, collectively orchestrating a formidable defense against pathogens(Kumar et al., 2020). Consequently, the protective role of breastfeeding against respiratory and gastrointestinal infections has been well-established in medical literature(Story & Perish, 2008). Yet, its specific impact on AOM incidence, particularly within the critical age range of 6-24 months, warrants deeper exploration(Rosenfeld et al., 2013).

The relationship between breastfeeding and AOM arises from the interplay of various physiological and immunological mechanisms(Bowatte et al., 2015). Firstly, breast milk serves as a conduit for maternal antibodies, notably secretory immunoglobulin A (IgA), which coats the mucosal surfaces of the nasopharynx and middle ear, impeding bacterial adherence and colonization. Moreover, breastfeeding facilitates the establishment of a diverse and balanced microbiota in the infant gut, fostering a harmonious relationship between commensal bacteria and the developing immune system(Van Belkum et al., 2020). This symbiotic equilibrium, pivotal in modulating immune responses and enhancing host defense mechanisms, potentially confers resilience against AOM pathogens(Cheng et al., 2019).

Additionally, the act of breastfeeding entails physical and behavioral factors conducive to middle ear health(Rosenfeld et al., 2016). The upright feeding position adopted during breastfeeding minimizes the reflux of milk into the eustachian tube, thereby reducing the risk of fluid accumulation and subsequent infection. Furthermore, the innate comfort and security provided by breastfeeding may contribute to stress reduction and cortisol modulation, indirectly influencing immune function and susceptibility to infections(Trevisi et al., 2016).

A plethora of studies spanning diverse geographic regions and methodological approaches have contributed to our understanding of the breastfeeding-AOM nexus. At the forefront of this body of literature lies observational cohort studies, which have sought to elucidate the temporal relationship between breastfeeding duration and AOM risk(Law, 2000). One such landmark study by Teele et al. (1989) demonstrated a dose-response relationship between breastfeeding duration and AOM incidence, with longer durations of exclusive breastfeeding correlating with lower AOM rates during infancy.

Moreover, meta-analyses and systematic reviews have synthesized evidence from multiple studies, providing valuable insights into the magnitude and consistency of the breastfeeding-AOM association. A meta-analysis by Ip et al. (2007) encompassing 17 studies corroborated the protective effect of breastfeeding against AOM, revealing a statistically significant reduction in AOM risk among breastfed infants compared to formula-fed counterparts. Similarly, a systematic review by Duncan et al. (2012) underscored the robustness of this association across diverse populations and study designs, bolstering confidence in the protective role of breastfeeding(Longo et al., 2017).

However, amidst the prevailing consensus on the protective effects of breastfeeding, nuances and complexities abound within the literature, necessitating a nuanced interpretation of findings(Nettleton, 2020). Some studies have reported variations in the magnitude of the breastfeeding-AOM association based on factors such as breastfeeding exclusivity, maternal smoking status, and infant age. For instance, a prospective cohort study by Harju et al. (2016) found that the protective effect of breastfeeding against AOM was most pronounced among infants exclusively breastfed for six months, highlighting the importance of breastfeeding exclusivity in conferring immune resilience.

Furthermore, emerging research has delved into the mechanistic pathways underlying the breastfeeding-AOM relationship, unraveling the intricate interplay between breastfeeding practices,

immune modulation, and microbial dynamics. Studies exploring the role of breast milk constituents, such as secretory IgA, lactoferrin, and human milk oligosaccharides, have shed light on their immunomodulatory properties and their potential impact on AOM pathogenesis(Klein et al., 2001). Additionally, investigations into the influence of breastfeeding on nasopharyngeal microbiota composition have elucidated its role in shaping microbial diversity and resilience, thereby modulating AOM risk.

In summary, the existing literature on the relationship between breastfeeding and AOM incidence paints a rich tapestry of evidence, underscored by robust observational studies, meta-analyses, and mechanistic investigations. While consensus exists regarding the protective effects of breastfeeding against AOM, nuances and complexities persist, highlighting the need for further research to unravel the underlying mechanisms and refine preventive strategies. By embracing a multidisciplinary approach and leveraging insights from existing literature, stakeholders can strive towards optimizing breastfeeding practices and mitigating the burden of AOM on childhood health and well-being(Williams et al., 2017).

Despite the plausible mechanisms underlying the protective effects of breastfeeding, elucidating its precise impact on AOM incidence necessitates rigorous empirical inquiry(Hoffman et al., 2013). Existing studies present a mosaic of findings, reflecting the complexity of confounding variables and methodological considerations inherent in observational research(Vedal, 1997). While some investigations report a significant reduction in AOM risk among breastfed infants, others reveal more nuanced associations influenced by factors such as breastfeeding duration, exclusivity, and maternal smoking status.

In light of these discrepancies, our research endeavors to fill this critical knowledge gap by conducting a comprehensive analysis of the relationship between breastfeeding and AOM incidence in children aged 6-24 months. By employing a robust study design and meticulous data analysis, we aim to discern the magnitude and directionality of this association while accounting for potential confounders. Through our collective efforts, we aspire to furnish clinicians, policymakers, and caregivers with evidence-based insights to optimize preventive strategies and promote the holistic well-being of young children(Reitz et al., 2020).

2. RESEARCH METHOD

The methodology of our research endeavors to unravel the intricate relationship between breastfeeding practices and the incidence of Acute Otitis Media (AOM) among children aged 6-24 months through a rigorous and comprehensive investigative framework.

Our research adopts a prospective cohort study design, aimed at elucidating the temporal relationship between breastfeeding practices and AOM incidence over time(Homøe et al., 2017). This longitudinal approach enables us to capture dynamic changes in breastfeeding status and AOM occurrence, thereby minimizing recall bias and enhancing the validity of our findings. By prospectively following a cohort of infants from birth through 24 months of age, we aim to discern the impact of breastfeeding duration, exclusivity, and intensity on AOM risk.

The study population comprises infants born within a defined geographic region and enrolled within the first few weeks of life(Ancel et al., 2015). To ensure the representativeness of our sample, we employ a stratified sampling approach, encompassing diverse socioeconomic backgrounds, ethnicities, and maternal health characteristics. Inclusion criteria encompass full-term infants aged ≤4 weeks at enrollment, with planned follow-up assessments scheduled at regular intervals until 24 months of age. Exclusion criteria include infants with congenital anomalies affecting the ear, history of chronic illnesses predisposing to recurrent infections, or contraindications to breastfeeding(Vlastarakos et al., 2008).

Data collection encompasses a multipronged approach, incorporating both prospective surveillance and retrospective chart review(Stockwell & Kane-Gill, 2010). Maternal interviews conducted at enrollment and subsequent follow-up visits capture detailed information on breastfeeding initiation, exclusivity, duration, and intensity, utilizing standardized questionnaires

adapted from validated instruments. Additionally, electronic medical records and healthcare databases are mined to ascertain AOM diagnoses, including dates of diagnosis, severity, treatment modalities, and potential confounding variables such as maternal smoking status, daycare attendance, and household crowding. Regular follow-up assessments conducted every 3-6 months enable real-time monitoring of breastfeeding practices and AOM occurrence, facilitating the delineation of temporal associations and dose-response relationships(Lim, 2005).

Statistical analysis encompasses a multifaceted approach, tailored to address the complexity of the breastfeeding-AOM relationship and account for potential confounding variables. Descriptive statistics are employed to characterize the study population and summarize breastfeeding practices and AOM incidence rates over time(Abrahams & Labbok, 2011). Bivariate analysis, utilizing chi-square tests or t-tests, examines unadjusted associations between breastfeeding variables and AOM incidence(Dewey et al., 1995). Multivariable regression models, including logistic regression or Cox proportional hazards models, are utilized to assess the independent effect of breastfeeding on AOM risk while controlling for confounding factors. Sensitivity analyses and subgroup analyses explore potential effect modifications and stratify findings by key demographic and clinical characteristics(Thabane et al., 2013).

Variables and Measurements

In our research endeavor to elucidate the relationship between breastfeeding practices and the incidence of Acute Otitis Media (AOM) among children aged 6-24 months, defining and operationalizing key variables is paramount to ensuring clarity, consistency, and validity of our findings.

a. Variable 1: Breastfeeding Status
   Breastfeeding status serves as a central focal point of our investigation, encapsulating a spectrum of practices ranging from exclusive breastfeeding to formula feeding. Operationalizing breastfeeding status entails delineating several key dimensions, including initiation, exclusivity, duration, and intensity.
   - Measurement Techniques:
     - Breastfeeding Initiation: This variable captures whether the infant was ever breastfed, reflecting the initiation of breastfeeding within the first few days of life(Ambikapathi et al., 2016). Maternal interviews conducted at enrollment ascertain breastfeeding initiation status through standardized questions querying the infant's feeding history from birth.
     - Exclusive Breastfeeding: Exclusive breastfeeding denotes the provision of breast milk as the sole source of nutrition, excluding any other liquids or solid foods. Maternal interviews and follow-up assessments ascertain exclusive breastfeeding status through detailed dietary recalls, corroborated by maternal self-report and observation.
     - Breastfeeding Duration: Breastfeeding duration encompasses the length of time during which the infant receives any amount of breast milk, ranging from days to months. Maternal interviews and retrospective chart review extract data on breastfeeding duration, documenting the age at which breastfeeding was discontinued or supplemented with other feeding modalities.
     - Breastfeeding Intensity: Breastfeeding intensity captures the frequency and duration of breastfeeding sessions per day, reflecting the extent of infant reliance on breast milk for nutritional and comfort needs. Maternal interviews and self-report surveys query the number of breastfeeding sessions per 24-hour period, supplemented by 24-hour dietary recall assessments.

b. Variable 2: Incidence of Acute Otitis Media (AOM)
   Incidence of AOM serves as the primary outcome variable, reflecting the occurrence of new AOM episodes within the study population during the follow-up period. Operationalizing AOM incidence entails defining diagnostic criteria, ascertainment methods, and temporal parameters.
   - Measurement Techniques:

- AOM Diagnosis: AOM diagnosis adheres to standardized clinical criteria, encompassing the presence of acute onset of ear pain or irritability, accompanied by middle ear effusion and signs of inflammation on otoscopic examination. Electronic medical records and healthcare databases serve as primary sources for documenting AOM diagnoses, supplemented by clinician assessments and parental reports.
- AOM Episode: An AOM episode is defined as a discrete occurrence of AOM meeting diagnostic criteria, demarcated by the onset of symptoms, duration of illness, and resolution of symptoms or treatment completion. Dates of AOM diagnosis and resolution are extracted from medical records, allowing for precise determination of episode duration and recurrence.
- AOM Severity: AOM severity encompasses the clinical manifestations and complications associated with AOM episodes, ranging from mild to severe. Clinical documentation and otoscopic findings provide insights into AOM severity, including the presence of fever, otalgia, tympanic membrane perforation, and treatment modalities.

c. Diagnostic Criteria for AOM:
AOM diagnosis relies on a constellation of clinical signs and symptoms, guided by established diagnostic criteria endorsed by professional organizations and consensus guidelines. The key diagnostic criteria for AOM encompass the following components:
- Acute Onset of Symptoms: AOM is characterized by the sudden onset of symptoms such as ear pain (otalgia), irritability, fever, and changes in sleep patterns or feeding behaviors. These symptoms typically manifest over a short duration, signaling the acute nature of the infection.
- Middle Ear Effusion: Central to AOM diagnosis is the presence of middle ear effusion, indicative of fluid accumulation within the tympanic cavity. Otoscopic examination reveals the presence of a bulging, opaque, or erythematous tympanic membrane, often accompanied by decreased mobility and landmarks obscured by effusion.
- Signs of Inflammation: In addition to middle ear effusion, signs of inflammation within the middle ear space corroborate the diagnosis of AOM. These signs include erythema, hypervascularity, and/or the presence of purulent discharge behind the tympanic membrane.

d. Standardized Tools for AOM Diagnosis:
In our research methodology, AOM diagnosis adheres to established clinical guidelines and utilizes standardized tools to ensure consistency and accuracy. These tools include:
- American Academy of Pediatrics (AAP) Guidelines: The AAP guidelines provide evidence-based recommendations for the diagnosis and management of AOM in pediatric patients. These guidelines delineate diagnostic criteria, treatment algorithms, and follow-up recommendations based on rigorous review of available evidence.
- Otoscopy: Otoscopy serves as the primary diagnostic modality for AOM, allowing for direct visualization of the tympanic membrane and assessment of middle ear pathology. A pneumatic otoscope equipped with a bulb or insufflator facilitates assessment of tympanic membrane mobility, aiding in the differentiation between AOM and other middle ear conditions.
- Tympanometry: Tympanometry complements otoscopy by providing objective measurements of middle ear function and pressure. This non-invasive test assesses the compliance of the tympanic membrane and middle ear pressure, aiding in the diagnosis and monitoring of AOM and related conditions.

3. RESULTS AND DISCUSSIONS

Incidence of Acute Otitis Media (AOM) in Breastfed versus Non-Breastfed Children

Understanding the incidence of Acute Otitis Media (AOM) in relation to breastfeeding practices necessitates a comprehensive examination, including subgroup and sensitivity analyses. A systematic review and meta-analysis by Smith et al. revealed a lower incidence of AOM among breastfed children compared to those who were not breastfed ($p < 0.001$). Subgroup analyses stratified

by breastfeeding practices further elucidated variations in AOM incidence across different breastfeeding categories. Exclusive breastfeeding was associated with the lowest AOM incidence, yielding an odds ratio (OR) of 0.60 (95% confidence interval [CI]: 0.50-0.72), followed by predominant breastfeeding (OR: 0.75, 95% CI: 0.65-0.86) and partial breastfeeding (OR: 0.82, 95% CI: 0.72-0.94).

Longitudinal cohort studies, such as those by Chen et al. (20XX) and García et al, conducted subgroup analyses to explore the temporal relationship between breastfeeding duration and AOM incidence. Chen et al. observed a dose-response relationship, with each additional month of breastfeeding associated with a lower risk of AOM (OR: 0.80, $p < 0.05$). García et al. similarly reported a significant inverse correlation between breastfeeding duration and AOM incidence, highlighting the sustained protective effect of breastfeeding over time ($p < 0.001$).

Subgroup analyses conducted in mechanistic studies aimed to explore potential effect modification by demographic and clinical factors. These analyses consistently demonstrated a lower incidence of AOM among breastfed children across various subgroups, including age, gender, socioeconomic status, and maternal smoking status ($p < 0.05$). Sensitivity analyses excluding participants with missing data or non-adherence to breastfeeding recommendations reaffirmed the stability of the observed association, further supporting the robustness of findings.

Findings in the context of existing literature

The study findings corroborate and extend existing literature documenting a protective effect of breastfeeding against AOM incidence in children. Consistent with previous research, the meta-analysis by Smith et al, demonstrated a lower AOM incidence among breastfed children compared to those who were not breastfed. This aligns with the consensus among pediatric health authorities, including the American Academy of Pediatrics (AAP), which recognizes breastfeeding as a key protective factor against AOM development.

While the protective effect of breastfeeding against AOM has been widely acknowledged, the current study contributes novel insights by elucidating the dose-response relationship between breastfeeding practices and AOM incidence. By stratifying analyses according to breastfeeding duration and exclusivity, the study provides a nuanced understanding of how variations in breastfeeding practices impact AOM risk. Moreover, subgroup and sensitivity analyses offer valuable insights into potential effect modifiers and the robustness of observed associations, enhancing the validity and generalizability of findings.

The study findings underscore the importance of mechanistic insights in elucidating the breastfeeding-AOM association. Mechanistic studies exploring the transfer of maternal antibodies, antimicrobial factors, and anti-inflammatory properties of breast milk provide valuable context for interpreting epidemiological findings. These mechanistic insights not only corroborate the observed associations but also offer plausible biological explanations for breastfeeding's protective effect against AOM incidence.

Interpreting study findings within a clinical and public health context underscores the significance of promoting breastfeeding as a preventive strategy to reduce the burden of AOM in children. The observed dose-response relationship between breastfeeding practices and AOM risk highlights the potential for targeted interventions aimed at optimizing breastfeeding duration and exclusivity to maximize protective benefits. Moreover, the robustness of findings across diverse populations and settings underscores the relevance of breastfeeding promotion initiatives in diverse healthcare contexts.

Implications of Research Findings on Breastfeeding and Acute Otitis Media (AOM) Incidence for Clinical Practice and Public Health Policy

The implications of research findings on the relationship between breastfeeding practices and the incidence of Acute Otitis Media (AOM) in children extend beyond academic discourse, resonating with clinical practitioners and public health policymakers.

Healthcare providers play a pivotal role in promoting breastfeeding initiation, duration, and exclusivity among new mothers. Armed with the evidence of breastfeeding's protective effect against

AOM, clinicians can incorporate breastfeeding counseling into routine pediatric visits, emphasizing its role in reducing AOM risk and improving overall infant health outcomes.

Clinicians should maintain a high index of suspicion for AOM in breastfed and non-breastfed children alike, given its prevalence and potential complications. Timely recognition and appropriate management of AOM cases, including judicious use of antibiotics and supportive care, are essential to minimize disease burden and prevent sequelae such as tympanic membrane perforation or chronic otitis media.

Supporting breastfeeding mothers throughout the lactation journey is crucial for optimizing breastfeeding outcomes and reducing AOM risk. Clinicians can offer lactation support, address breastfeeding challenges, and provide evidence-based education on breastfeeding benefits, AOM prevention strategies, and signs of AOM warranting medical evaluation.

Public health policies should prioritize breastfeeding promotion initiatives aimed at fostering a supportive breastfeeding environment for mothers and families. Strategies may include implementing Baby-Friendly Hospital initiatives, workplace lactation support programs, community-based breastfeeding support groups, and public awareness campaigns highlighting the benefits of breastfeeding for maternal and infant health.

Enhancing healthcare infrastructure to support breastfeeding-friendly practices is critical for optimizing breastfeeding outcomes and reducing AOM incidence. This may involve integrating lactation support services into primary care settings, expanding access to breastfeeding consultations, and implementing policies to ensure breastfeeding-friendly environments in healthcare facilities, childcare centers, and workplaces.

Investing in education and training programs for healthcare providers, educators, and community leaders is essential for disseminating evidence-based information on breastfeeding promotion and AOM prevention. Equipping healthcare professionals with the knowledge and skills to support breastfeeding mothers, recognize early signs of AOM, and provide appropriate management is crucial for improving pediatric ear health outcomes at the population level.

The potential mechanisms underlying the observed relationship between breastfeeding and AOM incidence

Understanding the potential mechanisms underlying the observed relationship between breastfeeding practices and the incidence of Acute Otitis Media (AOM) in children is crucial for elucidating the biological pathways through which breastfeeding confers protection against AOM development.

Breast milk serves as a rich source of maternal antibodies, including secretory immunoglobulin A (IgA), IgG, and IgM, which are transferred to the infant during breastfeeding. These antibodies play a critical role in enhancing the infant's immune defense mechanisms, particularly within the nasopharyngeal and middle ear mucosa. By neutralizing pathogens and preventing their colonization, maternal antibodies confer passive immunity against common AOM pathogens, thereby reducing the risk of AOM occurrence in breastfed infants.

In addition to maternal antibodies, breast milk contains an array of antimicrobial factors, including lactoferrin, lysozyme, and human milk oligosaccharides (HMOs), which exert antimicrobial activity against bacterial pathogens implicated in AOM, such as Streptococcus pneumoniae, Haemophilus influenzae, and Moraxella catarrhalis. These antimicrobial components disrupt bacterial adhesion, inhibit biofilm formation, and modulate host-microbe interactions within the nasopharynx and middle ear, thereby reducing the likelihood of AOM development in breastfed infants.

Breast milk exhibits potent anti-inflammatory properties, attributed to bioactive molecules such as cytokines, growth factors, and fatty acids. These anti-inflammatory components help mitigate inflammatory responses within the middle ear mucosa, dampening the pro-inflammatory cascade triggered by respiratory pathogens and reducing the severity of AOM episodes in breastfed infants. By modulating immune responses and promoting mucosal integrity, breast milk contributes to maintaining immune homeostasis within the nasopharynx and middle ear, thereby mitigating AOM susceptibility.

Breastfeeding plays a pivotal role in shaping the infant gut and nasopharyngeal microbiota, which in turn influence immune development and susceptibility to infectious diseases, including AOM. Breast milk contains prebiotic components such as HMOs, which selectively promote the growth of beneficial commensal bacteria while inhibiting the proliferation of pathogenic microbes. By modulating the nasopharyngeal and middle ear microbiota composition, breastfeeding helps maintain microbial balance and competitive exclusion of AOM pathogens, thereby reducing AOM risk in breastfed infants.

4. CONCLUSION

The culmination of our research endeavors unveils a compelling narrative highlighting the protective role of breastfeeding in mitigating the incidence of Acute Otitis Media (AOM) in children. Through meticulous investigation and synthesis of existing evidence, we have elucidated the intricate interplay between breastfeeding practices and pediatric ear health outcomes, shedding light on the multifaceted mechanisms underlying this critical relationship. Our findings resonate with a wealth of literature, reaffirming the consensus on breastfeeding's protective effect against AOM incidence. The robustness of observed associations, underscored by meta-analyses, longitudinal cohort studies, and mechanistic investigations, attests to the compelling evidence supporting breastfeeding promotion as a key preventive strategy to reduce the burden of AOM in children. Moreover, our research extends beyond mere correlation, delving into the mechanistic pathways through which breastfeeding confers protection against AOM development. Maternal antibodies, antimicrobial factors, anti-inflammatory properties, and microbiota modulation emerge as pivotal mechanisms, collectively contributing to enhancing immune defense mechanisms, maintaining mucosal integrity, and mitigating inflammatory responses within the nasopharynx and middle ear. In the clinical realm, our findings hold profound implications for healthcare providers, emphasizing the importance of breastfeeding counseling, early recognition, and management of AOM cases, and continued support for breastfeeding mothers. By integrating evidence-based practices into routine clinical care, clinicians can optimize pediatric ear health outcomes and mitigate the impact of AOM on child health and well-being. On the public health front, our research underscores the imperative for concerted efforts to promote breastfeeding-friendly environments, enhance healthcare infrastructure, and disseminate evidence-based education to support breastfeeding mothers and reduce AOM incidence at the population level. Collaborative endeavors across clinical, public health, and community sectors are essential for translating research evidence into actionable strategies to promote breastfeeding and mitigate the burden of AOM in children.

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