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Breastfeeding biology, milk bioactive components, and probiotics as cancer-relevant mechanisms influencing maternal psychological wellbeing

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CITATION

Qian H, Wang Y, Hu Y.
Breastfeeding biology, milk bioactive components, and probiotics as cancer-relevant mechanisms influencing maternal psychological wellbeing. *Psycho-Oncologie*. 2026; 20(1): 5626.
<https://doi.org/10.18282/po5626>

ARTICLE INFO

Received: 19 November 2025
Revised: 4 January 2026
Accepted: 9 January 2026
Available online: 29 January 2026

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Abstract: Breastfeeding is a complex psychobiological process involving hormonal regulation, immune modulation, microbial transfer, and the activity of diverse bioactive components, all of which have implications for maternal health and cancer-relevant pathways. Evidence indicates that lactational hormones such as prolactin and oxytocin, together with breast milk constituents including immunoglobulins, lactoferrin, cytokines, antioxidants, and commensal microbes, participate in anti-inflammatory, antioxidant, and endocrine-regulatory mechanisms associated with reduced cancer risk in mothers. Probiotics may further enhance these processes by influencing maternal gut microbiota, improving immune resilience, and potentially modulating pathways implicated in carcinogenesis. Beyond these biological interactions, mothers frequently encounter cancer-related information through clinical, digital, and social channels, shaping psychological responses that influence breastfeeding behaviors, risk perception, and emotional wellbeing. Some mothers derive reassurance from perceived protective effects of breastfeeding, while others experience heightened anxiety, confusion, or pressure to breastfeed due to incomplete or conflicting information. Integrating biological and psychological perspectives is therefore essential within psycho-oncology to support informed decision-making, reduce misinformation-driven distress, and promote healthier maternal experiences. This narrative review synthesizes current evidence on breastfeeding biology, bioactive milk components, probiotic effects, and cancer-associated mechanisms, while examining the psychological implications for mothers and outlining communication strategies for clinicians and public health practitioners. By bridging physiological pathways with maternal emotional experiences, the review aims to inform more effective, empathetic, and evidence-based approaches to supporting breastfeeding women.

Keywords: breastfeeding; breast milk bioactive components; probiotics; maternal psychology; lactation and cancer risk; maternal wellbeing

1. Introduction

Breastfeeding is a complex and biologically sophisticated process integral to maternal and child health. Beyond its nutritional role, breast milk contains a dynamic mixture of hormones, immunological factors, antioxidants, and microbial components that interact to influence maternal physiology and long-term health outcomes. Recent scientific attention has focused on how these bioactive elements contribute not only to infant development but also to maternal health, particularly regarding cancer risk and psychological wellbeing. These multidimensional interactions highlight breastfeeding as both a biological and psychosocial experience, linking physiological mechanisms with cognitive, emotional, and behavioral responses in mothers [1–3].

Biologically, breast milk is enriched with components such as human milk oligosaccharides, immunoglobulins, lactoferrin, cytokines, antimicrobial peptides, and a diverse microbiota. Collectively, these factors contribute to immune modulation, anti-inflammatory activity, oxidative stress reduction, and cellular regulation mechanisms that intersect with pathways influencing cancer development and progression [2,4]. Evidence suggests that breastfeeding may lower the risk of several hormonally mediated cancers, including breast and ovarian cancer, through hormonal suppression, cellular differentiation, and enhanced immune surveillance [4,5]. As public understanding of these biological mechanisms grows, mothers are increasingly exposed to information connecting breastfeeding with cancer protection or prevention, which shapes their beliefs, motivations, and emotional responses throughout the postpartum period [3,6].

Probiotics have emerged as an additional factor in this landscape, as maternal supplementation has the potential to influence both the gut microbiome and the composition of breast milk. By modifying microbial communities and enhancing immune function, probiotics may augment some of the anti-inflammatory and immune-regulatory pathways associated with breastfeeding [3,7]. These biological effects have sparked interest in whether probiotics could further contribute to cancer-related mechanisms or improve maternal physiological resilience [8]. At the same time, probiotics are often perceived by mothers as a health-enhancing intervention, which may positively influence psychological wellbeing by increasing confidence in breastfeeding, reducing anxiety about infant immunity, or alleviating concerns about their own health risks [6].

The psychological dimensions of breastfeeding are closely interconnected with these biological processes. Many mothers experience varying degrees of stress, uncertainty, or fear related to milk production, nutritional adequacy, or long-term health implications. Cancer-related information such as discussions about hormones, inflammation, immunity, or family cancer history can amplify emotional responses, particularly when mothers encounter conflicting or incomplete information. For some, breastfeeding may be viewed as a protective behavior that enhances their own health or reduces future cancer risk; for others, it may generate anxiety about hormonal changes, perceived vulnerability, or potential exposures. Understanding these psychological reactions is essential for supporting maternal wellbeing, improving breastfeeding experiences, and guiding evidence-based communication within psycho-oncological care [4–6].

Despite the growing body of research on breastfeeding biology, breast milk composition, probiotics, and cancer-related mechanisms, these topics are rarely integrated within a psychological framework. This gap is particularly relevant to psycho-oncology, where integrating biological processes with emotional responses is crucial for understanding maternal behavior and wellbeing. Integrating biological and psychological perspectives can help clinicians and researchers address mothers' concerns, reduce misinformation-driven anxieties, and support healthier breastfeeding practices [6].

This narrative review aims to synthesize current evidence on the biological foundations of breastfeeding and breast milk bioactive components, the role of probiotics in modulating maternal physiology, and the cancer-related mechanisms

potentially influenced by these factors. Additionally, the review examines how such biological information shapes maternal attitudes, fears, and wellbeing within the broader context of psycho-oncology. By bridging biological pathways with psychological implications, this work seeks to advance a more holistic understanding of breastfeeding and maternal health while informing supportive communication strategies for clinicians working with diverse maternal populations [1–3].

2. Biological foundations of breastfeeding

Breastfeeding is not solely a nutritional act but a complex biological process involving hormonal regulation, immune activation, microbial transfer, and biochemical signaling. These elements interact to shape maternal physiology and may influence cancer-related mechanisms, including inflammation, cellular regulation, and endocrine signaling. The following sections examine the core biological foundations of breastfeeding that provide a scientific basis for understanding potential protective effects against cancer and their psychological significance for mothers [9–13].

2.1. Hormonal regulation of lactation

Lactation is orchestrated by a coordinated hormonal network comprising prolactin, oxytocin, estrogen, and cortisol [14]. Prolactin is central to milk synthesis and mammary epithelial cell differentiation. Beyond its lactogenic role, prolactin modulates immune activity and cellular proliferation, pathways that intersect with mechanisms implicated in breast and endocrine-related cancers [15,16]. Elevated prolactin has been associated with proliferative effects in mammary tissue, whereas sustained breastfeeding appears to downregulate lifetime prolactin exposure, potentially contributing to reduced cancer risk [10,13,17].

Oxytocin facilitates milk ejection by stimulating myoepithelial contraction, but its influence extends into psychological regulation, stress reduction, and anti-inflammatory signaling. Oxytocin has been shown to counteract cortisol-mediated stress responses and exert inhibitory effects on cellular proliferation in mammary tissues. These properties may underlie epidemiological findings suggesting that prolonged lactation confers protective benefits against hormone-sensitive cancers [11,13].

Estrogen plays a dual role: it is essential for mammary development yet strongly linked to carcinogenesis through estrogen receptor signaling and DNA damage pathways. Lactation suppresses estrogen levels via lactational amenorrhea, reducing lifetime estrogen exposure and thereby lowering risk for estrogen-dependent malignancies. Cortisol reflects maternal stress physiology and influences immune and inflammatory responses. Dysregulation of cortisol has been associated with increased oxidative stress and immune suppression conditions relevant to tumorigenesis. By moderating cortisol fluctuations through oxytocin release and physiological feedback loops, breastfeeding may indirectly support healthier immune surveillance [16].

Together, these hormonal interactions provide biological plausibility for the observed association between breastfeeding and lower incidence of certain cancers

[10,13]. They also form the foundation for many mothers' perceptions accurate or not regarding breastfeeding's protective value, which can influence psychological well-being and health decision-making [6,11]. **Figure 1** illustrates how nipple mechanosensory stimulation triggers the release of oxytocin (OXT) and prolactin (PRL), supporting milk ejection, milk production, reduced inflammation, macrophage activity, and maternal immune resilience.

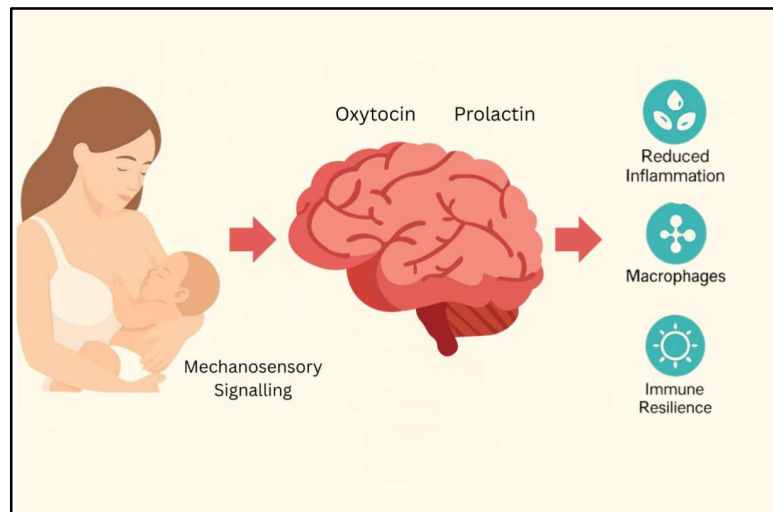


Figure 1. Mechanosensory signaling in breastfeeding and downstream hormonal–immune pathways.

2.2. Breast milk bioactive components

Breast milk is a rich bioactive matrix containing immunological, biochemical, and microbial constituents with potential anti-inflammatory and anti-carcinogenic effects. Among the most extensively studied components are human milk oligosaccharides, which function as prebiotics, immune modulators, and microbial regulators [18–20]. HMOs promote beneficial bacterial colonization while inhibiting pathogen binding, supporting an immune environment less conducive to chronic inflammation a recognized precursor to cancer development [9,11].

Immunoglobulins, particularly secretory IgA, provide mucosal protection and contribute to immune maturation [21]. These antibodies can neutralize pathogens and modulate immune activation, reducing exposure to inflammatory stimuli and oxidative stress. IgG and IgM complement this defense system by targeting systemic infections and shaping antigen–antibody responses that support immune surveillance [10].

Lactoferrin, one of the most significant bioactive proteins in breast milk, demonstrates antiviral, antibacterial, anti-inflammatory, and anti-proliferative properties. Experimental evidence suggests lactoferrin can induce apoptosis in malignant cells, suppress angiogenesis, and modulate iron metabolism in ways that inhibit tumor growth [22]. Lysozyme and various cytokines including IL-10 and TGF- β further contribute to anti-inflammatory signaling, creating an immunological environment that may reduce cancer-related risk [9].

Antioxidants and antimicrobial peptides in breast milk reduce oxidative damage, protect against DNA mutations, and support cellular repair mechanisms. As

oxidative stress is a well-established driver of carcinogenesis, these compounds though naturally intended to protect infants may also indirectly influence maternal biology through systemic absorption and immunomodulation [9,23,24].

The presence of these bioactive components also carries psychological meaning for mothers. Awareness of breast milk's protective qualities may enhance breastfeeding motivation, while misconceptions or uncertainties about milk composition can generate anxiety. In psycho-oncology contexts, these perceptions influence emotional responses to cancer-related information and shape maternal beliefs about long-term health [6].

2.3. Microbial composition of breast milk

Breast milk contains a diverse microbiome comprising *Lactobacillus*, *Bifidobacterium*, *Streptococcus*, and other commensal species [25,26]. This microbiota is influenced by maternal gut, skin, and environmental exposures and varies across lactation stages. The presence of these microbial communities challenges the earlier assumption that breast milk is sterile and underscores its active role in immune and metabolic programming [9].

A key mechanism underlying microbial transfer is the entero-mammary pathway, in which maternal gut bacteria translocate to mammary tissue and are secreted into breast milk. This process facilitates the transfer of beneficial microbes that modulate immune responses, promote anti-inflammatory activity, and inhibit pathogen colonization. These functions overlap with pathways relevant to cancer biology, particularly in relation to immune regulation and chronic inflammation [9].

While the primary function of the milk microbiome is to support infant health, maternal microbial ecology may also be shaped by lactation. Shifts in microbial composition have been linked to systemic immune tone and metabolic status, factors that influence cancer susceptibility. Mothers who understand these microbial benefits may experience greater reassurance regarding breastfeeding, while those exposed to misinformation may develop heightened anxiety about contamination or milk quality, reinforcing the need for psycho-oncological support [9,11].

3. Probiotics in maternal health and lactation

Probiotics have gained increasing attention as a non-pharmacological approach to supporting maternal health during lactation. By modulating gut microbial composition, influencing immune responses, and interacting with hormonal and inflammatory pathways, probiotics may contribute to biological processes that intersect with cancer-relevant mechanisms. At the same time, probiotic use carries psychological significance for mothers, particularly regarding health beliefs, anxiety regulation, and breastfeeding confidence. This chapter synthesizes current evidence on the role of probiotics in maternal physiology, breast milk composition, anti-cancer biological pathways, and psycho-behavioral outcomes [27–31].

3.1. Modulation of the maternal gut microbiome

Probiotics exert their primary biological effects through the modulation of the gut microbiome, enhancing the abundance of beneficial species such as

Lactobacillus and *Bifidobacterium*. In lactating mothers, these shifts influence systemic immunity through improved epithelial barrier integrity, balanced cytokine signaling, and reduced intestinal permeability [27,32]. Strengthening the gut barrier limits translocation of pro-inflammatory molecules such as lipopolysaccharides, thereby reducing chronic inflammation, a key driver of carcinogenesis [27,30,33].

Enhanced microbial diversity is also associated with improved immune resilience, leading to more efficient pathogen recognition and controlled inflammatory responses [32,33]. These processes overlap with cancer biology, as dysbiosis is increasingly recognized as a contributor to malignancy through oxidative stress, immune suppression, and metabolic disruptions [27,29,33]. By restoring microbial equilibrium, probiotics may therefore mitigate systemic conditions associated with elevated cancer risk [29,30,32].

For mothers, the perception that probiotics support immunity and overall health can reduce anxiety related to illness susceptibility both for themselves and their infants [28,34]. This psychological reassurance may positively influence breastfeeding continuity and maternal well-being.

3.2. Effects on breast milk composition

Emerging evidence suggests that maternal probiotic supplementation can alter breast milk composition in ways that enhance immune-protective functions [35,36]. Probiotics may increase levels of immunoglobulins, particularly secretory IgA, which plays a central role in mucosal defense [28,31]. Enhanced IgA responses contribute to improved pathogen neutralization and reduced inflammatory activation, mechanisms that intersect with cancer-related immune surveillance [37].

Probiotics can also influence the diversity and abundance of microbial species present in breast milk. Through the entero-mammary pathway, probiotic-associated microbes may be transferred from the maternal gut to the mammary gland, enriching the milk microbiome with bacterial strains that support anti-inflammatory activity [32].

Additionally, probiotic supplementation has been linked to elevated concentrations of anti-inflammatory cytokines and bioactive molecules. These shifts may further support immune regulation, reduce oxidative stress, and enhance the anti-carcinogenic properties of breast milk's biochemical environment. For many mothers, improvements in milk quality perceived or actual can alleviate concerns about adequacy, purity, and health benefits, contributing to improved psychological outcomes [28,32].

3.3. Anti-cancer mechanisms associated with probiotics

Probiotics are increasingly studied for their potential anti-cancer effects. One key mechanism involves modulation of the NF- κ B signaling pathway, a major regulator of inflammation and cell survival. Dysregulation of NF- κ B is associated with tumor initiation and progression; probiotics have been shown to inhibit inflammatory signaling and modulate immune responses, thereby potentially reducing pro-tumorigenic processes in various tissues [38–41].

Probiotics may also reduce oxidative stress by enhancing antioxidant enzyme

activity and lowering reactive oxygen species (ROS) levels. Oxidative damage contributes to DNA mutations, cellular aging, and oncogenic transformation, making probiotics a potential adjunct for reducing systemic cancer risk. Experimental studies have demonstrated that certain probiotic strains can induce apoptosis in malignant cells, modulate oncogene expression, and suppress the growth of carcinogen-producing bacteria in the gut [26,40,42].

While many findings originate from laboratory and animal models, they offer biologically plausible pathways linking probiotics to cancer modulation. These mechanisms also shape maternal perceptions, as mothers who believe that probiotics provide protective benefits may experience increased health confidence and reduced fear of future cancer risk [26,28,40].

3.4. Psychophysiological effects of probiotics

Beyond their biological effects, probiotics influence maternal well-being through the gut–brain axis. Probiotics can modulate neurotransmitter production, regulate vagal signaling, and reduce systemic inflammation, collectively contributing to improvements in mood, stress tolerance, and emotional stability [43]. Clinical research has shown that probiotic supplementation may reduce symptoms of anxiety and depressive mood, likely through lowered cortisol levels and enhanced production of gamma-aminobutyric acid (GABA) [26,34].

For breastfeeding mothers, reduced psychological distress can have meaningful behavioral consequences. Lower stress levels may improve milk let-down reflexes, enhance breastfeeding satisfaction, and increase the likelihood of sustained lactation. Mothers who perceive probiotics as beneficial often report greater confidence in their health choices, which can further reinforce positive psychological outcomes [34].

These psychophysiological effects highlight the relevance of probiotics within psycho-oncology. By influencing both biological pathways relevant to cancer and emotional processes that shape maternal decision-making, probiotics occupy a unique position at the intersection of physiology, psychology, and preventive health [34].

4. Breastfeeding as a potential protective factor against cancer

Breastfeeding has long been associated with reduced cancer risk in mothers, with evidence spanning epidemiological studies, hormonal and immune biology, and the actions of specific bioactive components in breast milk [4,13]. Although the protective mechanisms are multifactorial, converging lines of research suggest that lactation contributes to favorable hormonal profiles, enhanced immune regulation, reduced oxidative stress, and improved cellular differentiation all of which align with pathways known to influence cancer initiation and progression [4,9]. Understanding these processes is essential not only for biological insight but also for appreciating how mothers interpret cancer-related messaging in ways that influence their psychological wellbeing and breastfeeding behaviors [9].

4.1. Epidemiological evidence

Large-scale epidemiological studies have consistently demonstrated an inverse association between breastfeeding and maternal cancer risk, particularly for breast and ovarian cancers [4,5]. Meta-analyses indicate that each additional 12 months of cumulative breastfeeding is associated with a measurable reduction in breast cancer incidence, regardless of socioeconomic or reproductive background [13]. The protective effect appears strongest for hormone receptor-negative and premenopausal breast cancers, suggesting that breastfeeding may act through multiple biological pathways beyond simple hormonal suppression [5].

For ovarian cancer, breastfeeding has been shown to reduce lifetime risk through mechanisms involving ovulation suppression and modulation of inflammatory activity within ovarian tissue [4,44]. Similar trends, though less extensively studied, have been reported for endometrial cancer and certain gastrointestinal malignancies, where reproductive hormones and chronic inflammation contribute to tumorigenesis [45]. These epidemiological findings provide a foundation for maternal perceptions that breastfeeding may “protect” against cancer, a belief that influences emotional responses and health behaviors. However, without clear mechanistic explanations, such information can also generate confusion or unrealistic expectations, underscoring the importance of integrating biological evidence with psycho-oncology.

4.2. Biological mechanisms for cancer protection

- **Lactational amenorrhea and hormonal suppression**

One of the best-established mechanisms involves lactational amenorrhea, during which ovulation is temporarily suppressed. This reduces lifetime exposure to estrogen and progesterone hormones strongly implicated in the development of breast, ovarian, and endometrial cancers. Lower cumulative months of ovulation translate into fewer cycles of epithelial proliferation and DNA replication, reducing opportunities for malignant transformation [4].

- **Reduction of estrogen exposure**

Breastfeeding is associated with a prolonged hypoestrogenic state. High estrogen levels promote cell division in mammary tissue and can drive tumorigenic processes through estrogen receptor signaling. By reducing estrogen exposure during lactation, breastfeeding may slow proliferation of mammary epithelial cells, decreasing the likelihood of genetic mutations and tumor initiation [4].

- **DNA repair and cellular differentiation**

During pregnancy and lactation, mammary epithelial cells undergo terminal differentiation, a process believed to confer resistance to carcinogenic insults. Differentiated cells are less susceptible to DNA damage and less likely to proliferate inappropriately. Lactation may also enhance DNA repair pathways, improve genomic stability and reduce the accumulation of oncogenic mutations [9].

- **Immune modulation and anti-inflammatory pathways**

Breastfeeding enhances immunological activity in the mammary gland and systemically. Lactation promotes a shift toward anti-inflammatory cytokine profiles and supports T-cell regulation. Chronic inflammation is a well-known driver of

tumorigenesis, and breastfeeding's ability to lower inflammatory signaling may contribute to long-term cancer protection. Additionally, immune surveillance may be enhanced during and after lactation, supporting early detection and clearance of abnormal cells [9,11].

Collectively, these mechanisms provide biologically plausible explanations for epidemiological patterns and contribute to mothers' health beliefs and psychological interpretations of breastfeeding's protective value.

4.3. Breast milk components with anti-carcinogenic properties

Breast milk contains numerous bioactive compounds with properties relevant to cancer prevention.

- **Lactoferrin and apoptosis regulation**

Lactoferrin is one of the most extensively studied milk proteins for its anti-cancer potential. It has demonstrated the ability to induce apoptosis in malignant cells, inhibit angiogenesis, and modulate immune responses. Lactoferrin's iron-binding capacity limits free iron availability, reducing oxidative stress and the formation of DNA-damaging free radicals [22].

- **Anti-inflammatory cytokines**

Breast milk is rich in cytokines such as IL-10 and TGF- β , which promote immune tolerance and suppress inflammatory pathways. Since chronic inflammation is a central driver of many cancers, sustained exposure to anti-inflammatory signaling may benefit maternal immune balance, particularly during postpartum recovery [35].

- **Antioxidant systems and free-radical control**

Antioxidants, including glutathione, vitamins A and E, and enzymatic scavengers, reduce oxidative stress and protect against DNA mutations. By lowering oxidative damage, these constituents contribute to maintaining cellular integrity and may decrease cancer susceptibility [24].

While these components primarily protect the infant, emerging research suggests that systemic absorption and maternal physiological changes during lactation may offer indirect benefits to mothers as well. Importantly, awareness of breast milk's "anti-cancer" properties can shape maternal psychology sometimes enhancing breastfeeding motivation, but at times creating pressure or anxiety about producing "protective" milk.

5. Psychological implications for mothers

The psychological experience of breastfeeding is shaped not only by physiological demands but also by mothers' perceptions of health, disease risk, and the biomedical information they encounter. As public awareness of cancer-related mechanisms such as inflammation, hormones, and immunity continues to grow, breastfeeding increasingly becomes framed as a behavior with potential implications for long-term maternal health. This framing can influence maternal emotions, cognitive patterns, and breastfeeding decisions. Understanding these psychological dimensions is essential for psycho-oncology, which aims to address how health-related beliefs and fears interact with biological processes to influence wellbeing

[46].

5.1. Maternal perceptions of breastfeeding and cancer risk

Many mothers interpret breastfeeding as an activity that may reduce their lifetime cancer risk, particularly for breast and ovarian cancers [47,48]. This perception is shaped by epidemiological messaging, public health campaigns, and informal discussions in social and digital communities [49]. For some mothers, this belief provides reassurance and reinforces their motivation to breastfeed for longer durations [46]. The sense that breastfeeding “protects the body” can also generate feelings of agency and control over health, which may buffer against anxiety [46].

Conversely, mothers with a family history of cancer or heightened health vigilance may experience increased uncertainty [50]. When confronted with complex biological explanations such as hormonal suppression and immune modulation some mothers may worry about whether they are breastfeeding “enough” to obtain cancer-protective effects [51]. These concerns may heighten health anxieties, particularly if breastfeeding is interrupted or becomes difficult [52]. Perceptions of inadequate protection can generate guilt, fear, or pressure to continue breastfeeding despite physical or emotional strain [46].

5.2. Emotional responses to biological information

The quality and clarity of information mothers receive significantly influence their emotional responses [53]. Conflicting messages about breastfeeding can lead to confusion and psychological overload [51,53]. Online sources sometimes amplify fears by suggesting exaggerated links between hormones, inflammation, and cancer, often providing insufficient scientific context [6]. Exposure to such information can result in stress, mistrust of medical guidance, and increased health-related rumination [53].

Concerns about milk adequacy, purity, and bioactive value further contribute to emotional distress [54]. Mothers may fear that their milk lacks the “protective components” necessary for their infant’s wellbeing or their own health. This anxiety may be intensified by societal expectations that breastfeeding is inherently superior or required for disease prevention [46,55]. For mothers unable to breastfeed or facing challenges such as low milk supply, these beliefs may trigger feelings of inadequacy or personal failure [56,57].

5.3. Impact on breastfeeding behavior and mental health

Psychological distress plays a direct role in breastfeeding outcomes. High anxiety levels can impair milk let-down reflexes, reduce milk output, and exacerbate breastfeeding difficulties, creating a self-reinforcing cycle of stress and perceived failure [58,59]. Mothers who internalize cancer-related messaging may feel pressured to breastfeed for longer durations, even when experiencing fatigue, pain, or emotional exhaustion. This pressure can strain maternal mental health and contribute to depressive symptoms or reduced bonding [46].

Conversely, when mothers feel confident in their understanding of breast milk’s biological benefits including immune and anti-inflammatory properties, they may

experience enhanced breastfeeding self-efficacy. Higher self-efficacy is associated with longer breastfeeding duration, improved mood, and stronger mother–infant bonding [60]. Probiotics may also indirectly influence mental health by modulating the gut–brain axis, improving mood, and reducing perceived stress factors that support a more positive breastfeeding experience [34].

5.4. Implications for psycho-oncology

Understanding mothers’ psychological responses to breastfeeding and cancer-related information is crucial for psycho-oncological practice. Health professionals should adopt communication strategies that present biological evidence accurately while avoiding overstated claims that could induce guilt or anxiety [61]. Clear explanations of hormonal and immune pathways can empower mothers without overwhelming them with technical details [55].

Addressing cancer-related fears requires validating maternal concerns while providing reassurance grounded in evidence. Psycho-oncology practitioners can help mothers differentiate between realistic health information and misconceptions, reducing unnecessary stress and supporting informed decision-making [61]. In addition, psychological support may be beneficial for mothers experiencing heightened anxiety, especially those with personal or family cancer histories [53].

Ultimately, supporting maternal psychological wellbeing requires an integrated approach that acknowledges both biological mechanisms and emotional experiences. By promoting balanced information, reducing fear-driven interpretations, and strengthening maternal resilience, psycho-oncology can play a meaningful role in enhancing both breastfeeding outcomes and maternal mental health [60].

6. Integrative conceptual framework

Breastfeeding is a biological process with far-reaching implications for immune regulation, hormonal balance, and microbial ecology. It is also a deeply psychological experience shaped by maternal beliefs, emotions, and interpretations of cancer-related information. An integrative framework is therefore necessary to understand how breastfeeding biology, probiotics, and maternal psychology intersect within the broader context of cancer-relevant mechanisms. This chapter synthesizes the biological and psychological pathways described earlier and presents a conceptual model to guide psycho-oncological research and clinical communication.

6.1. Biological pathways connecting breastfeeding, bioactive components, probiotics, and cancer protection

Breastfeeding activates multiple biological systems that contribute to potential cancer-protective effects [62]. Lactational hormones such as prolactin and oxytocin are involved in cellular regulation and immune modulation [16,63]. These hormonal shifts, particularly reduced estrogen exposure, have been associated with lower risks of hormonally mediated cancers, such as estrogen receptor-negative breast cancer [64–66].

Breast milk bioactive components including lactoferrin, immunoglobulins, cytokines, antioxidants, and antimicrobial peptides support anti-inflammatory and

anti-proliferative pathways. Their combined actions help stabilize immune surveillance, reduce oxidative stress, and maintain mucosal homeostasis. These mechanisms align with established pathways that mitigate carcinogenesis [66].

Probiotics complement these processes by modifying the maternal gut microbiome, enhancing epithelial barrier function, and reducing systemic inflammation. Some probiotic strains also directly influence oncogenic pathways, including NF- κ B inhibition and apoptosis regulation. Taken together, these biological systems form a network through which breastfeeding and probiotics may contribute to cancer-relevant protection [28,30].

6.2. Psychological pathways influencing maternal beliefs, anxiety, and behavior

Maternal psychological responses play a pivotal role in shaping breastfeeding behaviors. Beliefs about cancer prevention, hormone regulation, immunity, or the “quality” of breast milk can influence emotional states, breastfeeding confidence, and decision-making. When mothers perceive breastfeeding as protective, they may experience reassurance and enhanced motivation. Conversely, exposure to ambiguous or exaggerated information can trigger fear, guilt, or confusion [62,67].

These emotional interpretations can influence behavioral outcomes such as breastfeeding duration, probiotic use, and engagement with health professionals. High anxiety can impair physiological functions such as milk let-down, reinforcing stress and potentially reducing breastfeeding success. Conversely, positive beliefs about probiotics and breast milk bioactivity can improve mood and increase maternal resilience. Psychological pathways therefore act not only as reactions to biological information but as active contributors to health behavior, influencing whether mothers derive the full benefits associated with breastfeeding and probiotic practices [62,67].

6.3. Interaction between biological and psychological processes

Biological and psychological pathways do not operate in isolation. Rather, they interact in bidirectional and mutually reinforcing ways. Breastfeeding biology for example, oxytocin release can reduce stress, improve mood, and strengthen social bonding, thereby enhancing psychological well-being. This improved emotional state may support more effective lactation physiology and prolonged breastfeeding, amplifying biological benefits [64,65].

Similarly, probiotics act on the gut–brain axis, where microbial metabolites and immune signaling influence neurological and emotional responses. Improvements in mood or stress tolerance can encourage continued probiotic use, reinforce positive health behaviors, and indirectly contribute to physiological stability [28,29].

Cancer-related beliefs mediate this biological–psychological interface. Mothers concerned about cancer risk may interpret biological information through heightened emotional filters, potentially amplifying stress and undermining breastfeeding confidence. Conversely, balanced scientific explanations can reduce fear, strengthen motivation, and foster health-enhancing behaviors [62,64,68].

This dynamic interplay highlights the importance of integrated psycho-

biological communication when supporting breastfeeding mothers, particularly those with heightened health anxieties or familial cancer concerns [68].

6.4. Proposed integrated model for psycho-oncology

The proposed integrated model conceptualizes breastfeeding as a psychobiological process in which biological, cancer-relevant, and psychological mechanisms converge. At the biological level, lactational hormonal shifts, the diverse bioactive components of breast milk, and probiotic-mediated microbial and immune regulation work together to shape maternal physiology. These processes connect directly to cancer-relevant mechanisms, including reduced estrogen exposure, enhanced immune surveillance, anti-inflammatory signaling, and decreased oxidative stress and cellular proliferation. Such pathways help explain why breastfeeding is often perceived to confer protective effects against certain cancers, particularly estrogen receptor-negative breast cancer. However, psychological processes strongly influence how mothers interpret and respond to this biological information. Health beliefs, cancer-related cognitions, and emotional reactions such as anxiety, reassurance, or confusion shape breastfeeding behavior, probiotic use, and overall well-being. These psychological processes interact bidirectionally with biological systems: oxytocin release during breastfeeding can reduce stress and enhance emotional stability, while elevated anxiety or stress can impair milk let-down and disrupt hormonal balance. This dynamic interplay highlights the need for psycho-oncology to address breastfeeding from an integrated perspective that recognizes both the biological mechanisms that may influence cancer risk and the psychological experiences that shape maternal behavior and health outcomes [64,65,68].

7. Clinical and public health implications

The intersection of breastfeeding biology, breast milk bioactive components, probiotics, and cancer-relevant pathways carries significant implications for clinical practice and public health communication. Mothers often interpret biological information through psychological filters shaped by personal beliefs, family history, cultural expectations, and exposure to digital sources, which can lead to misunderstanding or unnecessary anxiety. For this reason, evidence-based, psychologically sensitive counselling is essential. Health professionals including clinicians, lactation consultants, and public health practitioners must provide guidance that not only conveys biological accuracy but also supports maternal emotional wellbeing. The following subsections present practical, narrative-based recommendations aligned with psycho-oncological principles [69–71]. **Figure 2** visually summarizes these clinical and public health considerations, illustrating how communication strategies influence maternal interpretations, emotional responses, and health behaviors.

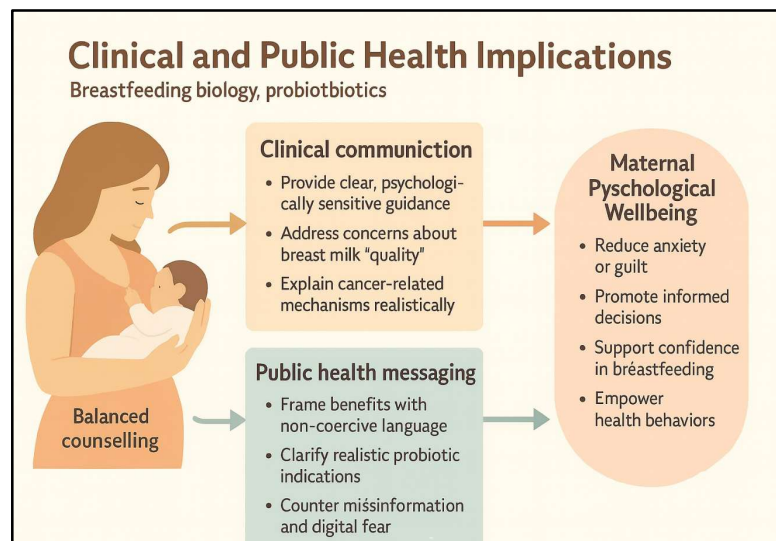


Figure 2. Clinical and public health implications.

7.1. Guidance for clinicians and lactation consultants

Clinicians play a crucial role in translating complex hormonal, immune, and microbial processes into clear and supportive explanations for mothers. Because breastfeeding is a highly emotional experience, non-technical and empathetic communication is essential. Mothers benefit from explanations that normalize the variability of lactation physiology and clarify how breastfeeding's potential protective effects on cancer risk arise from long-term hormonal shifts and immune modulation rather than from immediate or absolute prevention. This helps prevent misconceptions that might otherwise intensify anxiety or pressure. When mothers express worries about breast milk "quality" or adequacy, clinicians should respond with reassurance grounded in scientific evidence, reducing guilt or self-blame among those facing challenges with supply, latching, or physical discomfort. Equally important is the recognition that psychological wellbeing influences physiological success; therefore, personalized feeding plans that respect maternal preferences and emotional needs should be encouraged. By approaching breastfeeding holistically, clinicians can ensure mothers feel informed, supported, and empowered in their decision-making [69,70].

7.2. Counselling mothers on breastfeeding, probiotics, and cancer-related information

As probiotic use becomes increasingly popular among breastfeeding mothers, clinicians must integrate microbiological understanding with psychological sensitivity. Mothers should receive balanced explanations of how probiotics interact with maternal gut microbiota, immune activity, and inflammatory pathways without implying unrealistic cancer-preventive benefits. Likewise, discussions of breast milk bioactive components such as immunoglobulins, lactoferrin, and anti-inflammatory molecules should highlight the body's natural capacity for immune regulation so that mothers do not feel pressured to use supplements unnecessarily. Cancer-related information requires particular care: clinicians must clarify that statements about inflammation or oxidative stress refer to mechanistic pathways and do not translate

into predictable cancer outcomes for individual mothers. Encouraging open dialogue allows mothers to express fears or confusion, enabling clinicians to correct misconceptions and provide targeted reassurance. When presented thoughtfully, probiotic counselling becomes part of a broader conversation about maternal health behavior, helping mothers integrate biological information without amplifying worry or internalizing undue responsibility [69–71].

7.3. Addressing psychological concerns and preventing unnecessary fear

Cancer-related information can evoke strong emotional responses, especially in mothers with personal or family cancer histories. Psycho-oncological sensitivity is therefore essential when discussing hormonal pathways, immune mechanisms, or breast milk components linked directly or indirectly to cancer biology. Effective strategies begin with validating maternal emotions, acknowledging the legitimacy of their concerns before offering scientific clarification. Clinicians should help mothers differentiate between realistic risk factors and common misinterpretations, particularly regarding estrogen exposure, inflammation, or genetic predisposition. It is critical to emphasize that breastfeeding difficulties such as low supply, early cessation, or mixed feeding do not imply an increased cancer risk, countering guilt-based interpretations that may burden mothers emotionally. When anxiety significantly disrupts maternal functioning, sleep, bonding, or feeding behavior, clinicians should consider referral for psychological support. By prioritizing emotional reassurance alongside biological explanation, clinicians can promote informed decision-making while safeguarding maternal mental health [64,70].

7.4. Recommendations for public health messaging

Public health communication must reflect scientific evidence while remaining sensitive to its psychological impact on mothers. Effective messaging avoids coercive or fear-based language and instead presents breastfeeding benefits in a balanced and respectful manner. Explanations of breast milk bioactive components should be accessible, scientifically accurate, and contextualized within a broader understanding of maternal health, ensuring that breastfeeding is not portrayed as a moral or medical obligation. Similarly, messaging about probiotics should clarify realistic benefits, appropriate indications, and safety considerations to prevent exaggerated expectations. Given the prevalence of digital misinformation, public health campaigns should prioritize reliable online resources, transparent clarification of scientific uncertainties, and culturally inclusive communication that acknowledges diverse maternal beliefs. Integrating psychological awareness into public health strategy ensures that breastfeeding promotion supports rather than pressures mothers, fostering a healthier and more empathetic maternal care environment [70,71].

The clinical and public health implications of these intersecting biological and psychological processes are illustrated in **Figure 2**, which synthesizes the key considerations for practitioners. The figure highlights how clear communication, balanced public health messaging, and psycho-oncological awareness collectively shape maternal understanding, emotional resilience, and breastfeeding-behavior. By visually linking clinical guidance with psychological outcomes, it underscores the

importance of integrating scientific evidence with empathetic, mother-centered care [70].

8. Conclusion

Breastfeeding represents a uniquely interconnected biological and psychological process that holds important implications for maternal health. Through coordinated hormonal regulation, the transfer of bioactive milk components, and the influence of the maternal microbiome, lactation activates mechanisms that align with recognized pathways of cancer protection, including reduced estrogen exposure, enhanced immune surveillance, and modulation of inflammatory and oxidative processes. Probiotics may complement these effects by further supporting immune regulation and microbial balance, offering an additional avenue through which mothers may experience physiological resilience during the postpartum period. While these mechanisms provide a compelling scientific foundation, their impact is shaped significantly by maternal perceptions, emotional responses, and the quality of communication provided by healthcare professionals. Psychological wellbeing remains central to how mothers interpret biological information, navigate breastfeeding challenges, and make informed decisions about lactation and probiotic use.

For psycho-oncology, these insights highlight the necessity of integrating biological evidence with empathetic, psychologically sensitive counselling. Clear explanations, balanced messaging, and validation of maternal concerns can help prevent anxiety, reduce guilt, and support healthier breastfeeding experiences. This review underscores the importance of approaching breastfeeding not as a purely biological act, but as a complex psychobiological system in which hormonal, immune, and microbial pathways interact with cognitive and emotional processes to shape maternal health outcomes. Continued interdisciplinary research and improved clinical communication will be essential for advancing maternal wellbeing and strengthening supportive practices within psycho-oncology and women's health.

Author contributions: Conceptualization, HQ and YW; methodology, HQ; software, H Q; validation, HQ, YW and YH; formal analysis, HQ; investigation, HQ; resources, HQ; data curation, HQ; writing—original draft preparation, HQ; writing—review and editing, HQ; visualization, HQ; supervision, HQ; project administration, HQ; funding acquisition, YH. All authors have read and agreed to the published version of the manuscript.

Funding: None.

Ethical approval: Not applicable.

Informed consent statement: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

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