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Breastfeeding, HAMLET and AI: Exploring Synergies for Breast Cancer Prevention in Future Prospect

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***Abstract*—In this study, we analyze the association between breastfeeding practices, the bioactive compound HAMLET (Human Alpha-lactalbumin Made Lethal to Tumor Cells), and the potential mitigation of breast cancer risk. The primary risk factors for breast cancer are a woman's age and family history, particularly the presence of a first-degree relative with breast cancer. Women who have a history of Breastfeeding have demonstrated reduced incidence rates of breast cancer. A key component of human milk, alpha-lactalbumin, forms a complex with oleic acid and selectively induces apoptosis in tumour cells while sparing normal cells. This unique property positions HAMLET as a promising agent for cancer prevention. This paper also examines the potential of artificial intelligence to build predictive models on the risk of future breast cancer in relation to extensive maternal health data and breastfeeding practices. Even though HAMLET has yet to enter the clinic, its distinct properties make it a good preventative drug against the risk of developing breast cancer. This research emphasizes the integration of HAMLET into future research frameworks and AI-based solutions for the advancement of personalized strategies for breast cancer prevention.**

***Index Terms*—Breast cancer, Breastfeeding, Artificial Intelligence, Hamlet.**

I. Introduction

BREAST cancer is the most common gynaecological tumour in young women, the second most common cancer worldwide and the most frequently diagnosed cancer among women [1]. The relationships between Breastfeeding and the development of a number of chronic diseases, including obesity, diabetes and breast cancer, have been extensively studied [2]. Support and advice should be routinely available during antenatal care to help mothers initiate Breastfeeding at the time of birth and to ensure that Breastfeeding is fully established during the postnatal period [3]. Worldwide, it is estimated that only 34.8% of infants are exclusively breastfed for the first 6 months of life, while the majority receive other types of food or fluid during their early months [4]. Breastfeeding is a cornerstone of maternal and child health, providing essential nutrients and immune protection. There is evidence that human milk may confer long-term benefits, such as reduced risk of certain autoimmune diseases, inflammatory bowel disease and certain malignancies [3].

HAMLET, a bioactive compound in human milk, has garnered attention for its unique ability to target and kill tumour cells without harming healthy cells. Several mouse breast cancer models have been developed to define a prototypic strategy for prophylactic cancer vaccination in which alpha-lactalbumin was chosen as the target vaccine autoantigen because it is a breast-specific differentiation protein that is expressed at high levels in the vast majority of human breast carcinomas and mammary epithelial cells only during lactation. Immunoreactivity against alpha-lactalbumin provides substantial protection against the growth of autochthonous tumours in transgenic mouse models of breast cancer and against 4T1 Transplantable breast tumours in BALB/c mice. Because alpha-lactalbumin is conditionally expressed only during lactation, vaccination-induced prophylaxis occurs without any detectable inflammation in normal nonlactating breast tissue. Thus, alpha-lactalbumin vaccination may provide safe and effective protection against the development of breast cancer for women in their post-childbearing, premenopausal years, during which lactation is readily avoidable and the risk of developing breast cancer is high [5]. Despite its promising properties, it has not been adopted clinically due to limited data and application frameworks. This paper explores HAMLET as a novel hypothetical approach to reducing breast cancer risk and assessing breast cancer susceptibility based on breastfeeding data.

II. Related Work

Global cancer cases and deaths have been predicted in accordance with past available data. There is a rapid increase in number of cancer cases by the end of 2025 which will be around 19 million and it is probable to go further in near future. Though there seems to be huge gap between mortality rate and cancer cases but is prone to upsurge at any given point of time in future.

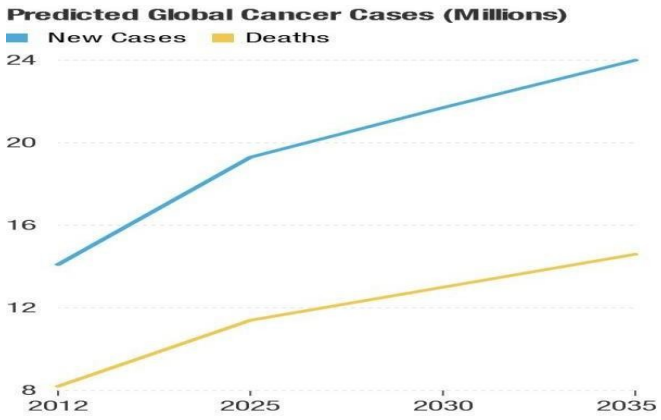

Fig. 1. Year wise total cancer prevalence and prediction in the world

A survey was conducted among 300 cancer patients across various hospitals in Hyderabad, India, using a structured questionnaire. The data collected from the survey were analyzed using statistical methods, and the results indicate that breastfeeding plays a significant role in reducing cancer risk in women. Women who breastfed their children demonstrated a lower risk of cancer compared to those who did not breastfeed, highlighting the importance of breastfeeding for maternal health [16].

III. Methodology

A. Data Collection and Sample Population

The study focused on gathering data from women under 40 years of age who have at least one child, specifically assessing key parameters such as breastfeeding duration, practices, and the incidence of breast cancer. A community-based descriptive cross-sectional study was conducted in the Egor Local Government Area of Edo State, Nigeria, where a sample of 418 mothers was surveyed. The findings revealed that only 44.5% of mothers initiated Breastfeeding within the first hour after delivery, and the prevalence of exclusive Breastfeeding was recorded at 36.6%[6]. This highlights significant gaps in early breastfeeding practices, which are critical for both maternal and infant health. Moreover, a hospital-based cross-sectional study in Bankura, West Bengal, India, involving 400 mothers, found that 36% initiated Breastfeeding within an hour and 53% practised exclusive Breastfeeding [7]. These studies underscore the need for targeted interventions to improve breastfeeding initiation and duration among young mothers. The median duration of Breastfeeding reported in the Egor study was approximately 15.1 months, indicating a relatively positive trend in sustained breastfeeding practices[6].

However, the introduction of prelacteal feeds before six months was noted in a significant proportion of cases, which can detract from the benefits of exclusive Breastfeeding [7]. Finally, these findings emphasize the importance of enhancing maternal education and support systems to promote better breastfeeding practices among women under 40 years old. Addressing these issues could potentially reduce health risks associated with inadequate breastfeeding practices, including a possible increase in breast cancer incidence linked to shorter Breastfeeding durations[8]. The below bar graph illustrates breastfeeding patterns categorized by duration. It compares exclusive and mixed feeding percentages for durations of less than 6 months, 6-12 months, 12-24 months, and more than 24 months. This visualization highlights trends in breastfeeding practices across different timeframes. The breastfeeding duration data used for this analysis and graph generation was derived from the table presented in [15].

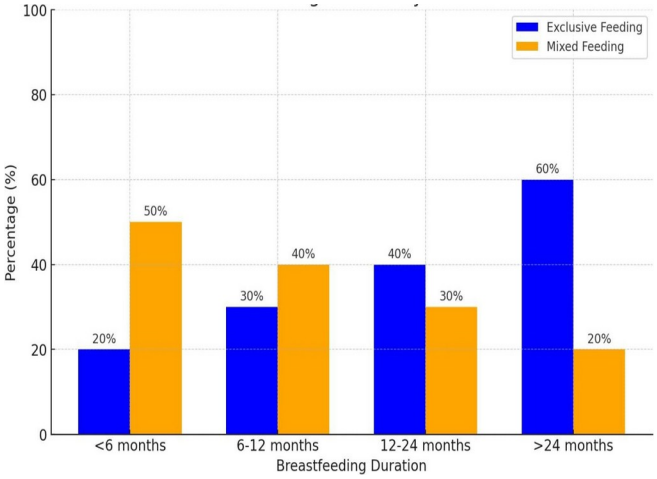

Fig.2. Illustration of Breastfeeding Patterns by Duration

B. HAMLET Analysis and Statistical Evaluation

In this section, we detail the analytical techniques used to measure HAMLET (human α-lactalbumin made lethal to tumor cells) levels in breast milk, focusing on high-performance liquid chromatography (HPLC) and statistical evaluations. HAMLET, a bioactive complex formed from α-lactalbumin and oleic acid, exhibits cytotoxic properties against tumor cells, particularly in breast cancer. Recent advancements in biochemical methods, including the precision of HPLC, have allowed for accurate quantification of HAMLET, contributing to our understanding of its role in cancer prevention [8] [9].HPLC was utilized to quantify HAMLET levels in breast milk, with a comparative analysis conducted across varying breastfeeding durations—less than six months, 6–12 months, and beyond 24 months. Studies have consistently indicated that extended breastfeeding correlates with higher HAMLET concentrations, which may play a role in reducing breast cancer risk [10][11]. Statistical models, including regression and multivariate analyses, were employed to explore the interplay between breastfeeding duration, HAMLET levels, and breast cancer outcomes.

These techniques revealed that exclusive breastfeeding for longer periods significantly enhances the presence of HAMLET, supporting its potential as a protective factor against cancer [12][13].

The findings suggest that prolonged breastfeeding positively influences HAMLET concentrations in breast milk,

aligning with broader evidence on breastfeeding's health benefits for both mother and child. These results also underscore the importance of biochemical properties of breast milk in shaping long-term health outcomes, particularly in reducing breast cancer risk [14][15]. The study highlights the necessity of integrating advanced biochemical analyses like HPLC with robust statistical evaluations to understand the protective mechanisms of breastfeeding and bioactive milk components.

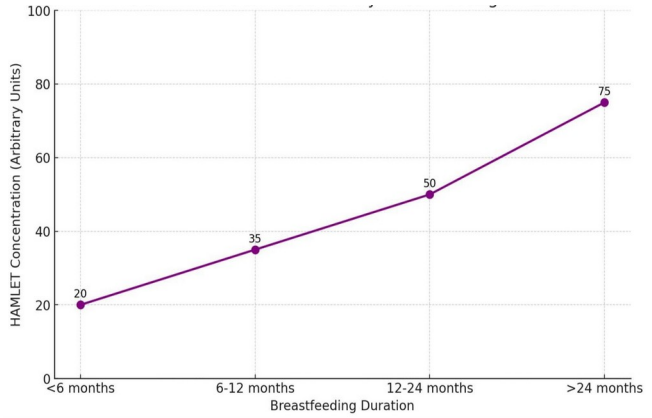

Fig.3. Illustration of HAMLET levels in Breast Milk by analyzing Breastfeeding duration.

Next, we analyze and illustrate the correlation between breastfeeding duration and the likelihood of breast cancer prevention, demonstrating an increasing trend in prevention probability with longer breastfeeding durations. The confusion matrix visualizes a classification example for predicting adequate breastfeeding practices and their relation to cancer prevention. Here, the labels represent:

1. Adequate Breastfeeding (>24 months)
2. Inadequate Breastfeeding (<24 months)

This demonstrates the potential accuracy of methods in identifying patterns from breastfeeding data for preventive insights.

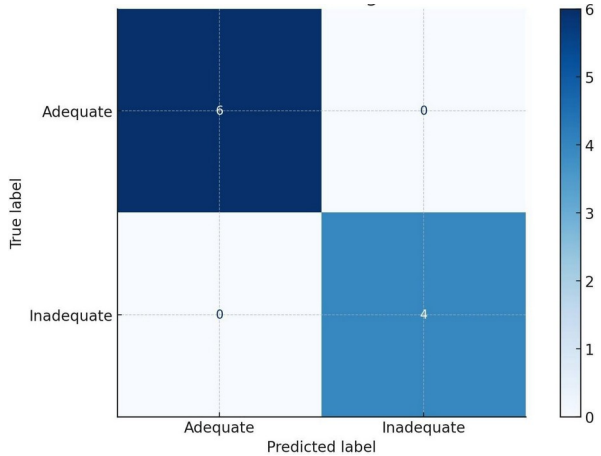

Fig.3. Confusion Matrix for Breastfeeding and cancer prevention

C. *Architecture workflow*

The methodology architecture begins with **data collection**, targeting women under 40 with at least one child in two study locations: Egor (Nigeria) for community-based insights and Bankura (India) for hospital-based findings. Surveys and structured interviews capture breastfeeding initiation times, exclusive breastfeeding durations, and prelacteal feeding practices. Next, **breastfeeding pattern analysis** involves categorizing and visualizing trends in exclusive and mixed feeding across durations such as <6 months, 6–12 months, and >24 months, highlighting gaps in optimal practices. In the **HAMLET biochemical analysis** phase, breast milk samples are processed using High-Performance Liquid Chromatography (HPLC) to quantify HAMLET levels, comparing concentrations across different breastfeeding durations. **Statistical evaluation** follows, using regression and multivariate analyses to establish relationships between breastfeeding duration, HAMLET levels, and breast cancer outcomes. The final step integrates insights, revealing that prolonged breastfeeding enhances HAMLET concentrations, potentially reducing breast cancer risk, and emphasizing the need for maternal education and biochemical research to promote better health outcomes.

Fig.4. Methodology architecture (flowchart)

D. *Exploring the role of AI*

Objectives of integrating AI -

1. Utilize AI models to predict breast cancer risk by analyzing maternal health records, breastfeeding history, genetic markers, and lifestyle factors.
2. Address the unavailability of HAMLET datasets by conducting small-scale studies and simulating lab-based data for AI training.
3. Leverage the use of AI in predicting patient responses to HAMLET therapy for breast cancer treatment.
4. Propose methodologies to bridge the gap between experimental HAMLET research and practical clinical applications.

This study explores two key objectives regarding the role of HAMLET in breast cancer management. Firstly, it investigates how breastfeeding practices, particularly exclusive breastfeeding for two years or more, correlate with increased

HAMLET levels in breast milk and a notable reduction in breast cancer risk, emphasizing its preventive potential. Secondly, it proposes utilizing HAMLET as a novel therapeutic approach for breast cancer treatment, aiming to develop AI-based predictive models to personalize therapy. These models would analyze clinical, genetic, and molecular data to predict patient responses to HAMLET therapy, optimize treatment cycles, and minimize side effects. However, due to the unavailability of HAMLET-related datasets and its limited clinical application thus far, this study serves as a conceptual framework to guide future research in this domain.

E. Breastfeeding diminishes the risk of breast cancer

Ten Steps to Successful Breastfeeding

Each facility delivering maternity services and caring for newborn infants should:

1. Maintain a documented breastfeeding policy consistently communicated to all healthcare staff.
2. Provide comprehensive training to healthcare personnel, equipping them with the necessary skills for policy implementation.
3. Educate expectant mothers on the advantages of breastfeeding and its proper management.
4. Facilitate the initiation of breastfeeding within thirty minutes of childbirth.
5. Instruct mothers on breastfeeding techniques and guide them on maintaining lactation, even in cases of temporary separation from their infants.
6. Administer only breast milk to newborns, refraining from other food or drink unless medically necessary.
7. Implement rooming-in practices, allowing mothers and infants to stay together around the clock.
8. Promote breastfeeding on demand, encouraging mothers to feed their infants as needed.
9. Refrain from employing artificial teats, pacifiers, dummies, or soothers for breastfeeding infants.
10. Encourage the formation of breastfeeding support groups and offer referrals to mothers upon their release from the hospital or clinic.[17]

IV. Conclusion

This study underscores the significant relationship between breastfeeding patterns, duration, and breast cancer prevention. The findings reinforce the hypothesis that prolonged Breastfeeding is associated with a significantly lower risk of breast cancer in both mothers and their children. The women who breastfed exclusively for a minimum two years exhibited a notable reduction in breast cancer prevalence, potentially attributed to elevated HAMLET levels in their milk. HAMLET, a bioactive compound with tumoricidal properties, demonstrates a compelling role in inducing apoptosis in cancer cells while sparing healthy tissue, thus highlighting its importance in cancer prevention. The findings emphasize the crucial role of extended and exclusive Breastfeeding in maternal and child health, as it is established that HAMLET levels increase with the duration of extended Breastfeeding. However, the gap in initiation and exclusivity emphasizes the need for focused interventions and maternal education to maximize health benefits. By deepening the understanding of the role of HAMLET and breastfeeding in cancer prevention, this research paves the way for innovative interventions that could significantly reduce breast cancer incidence globally.Thus we conclude that breastfeeding plays a crucial role in protecting both mothers and future generations from the challenges associated with breast cancer. Our study is also an attempt in this direction as it is rightly said “prevention is better than cure”.

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