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Determinants and Facilitators of Exclusive Breastfeeding in Haryana, India

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Abstract

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By Sara Elizabeth Hendrix

Background: Exclusive breastfeeding throughout the first six months of life is recommended to ensure optimal infant growth and development. However, despite strong evidence and existing programs exclusive breastfeeding in Haryana, India remains suboptimal.

Objective: The purpose of this study is to determine key determinants of exclusive breastfeeding practices among mothers with an infant aged 2-4 months in Haryana, India.

Methods: Household surveys were administered 232 mother-infant dyads from Haryana, India with infants 2-4 months of age. A multivariate logistic regression was used to identify associations between potential determinants and three primary outcome variables: exclusive breastfeeding as determined by dose-to-mother (EBF DTM) stable isotope technique, exclusive breastfeeding (EBF) determined by the mother's recall of feeding practices in last 24 hrs, and early initiation of breastfeeding (within first hour of birth). We examined the role of key sociodemographic, mother-infant dyad characteristics, and breastfeeding experience/perception/support covariates, such as family type, maternal age, and perception of low milk volume.

Results: In the EBF DTM model, negative associations were found with maternal perceived low milk volume (OR 0.17, CI 0.07, 0.41), breastfeeding support from family and/or friends compared to no support (OR 0.32, CI 0.13, 0.74) as well as having ever experienced breastfeeding difficulty (OR 0.24, CI 0.06, 0.95). In the recall EBF model, mothers who were married at a young age (less than 18 years old) (OR 0.43, CI 0.22, 0.83) and mothers with perceived low milk volume (OR 0.35, CI 0.15, 0.78) had lower rates of exclusive breastfeeding. In addition, infants receiving prelacteal feeds was negatively associated with early initiation of breastfeeding (OR 0.24, CI 0.13, 0.37).

Conclusion: Maternal perceptions of low milk volume in addition to breastfeeding difficulties were significant barriers to the practice of exclusive breastfeeding in this context. Further research to design lactation support programs to address these barriers may be merited.

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This has been an unexpected, greatly impactful journey, and I couldn't have done it without all of you. Thank you so much!

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Chapter 1: Introduction

1.1 Introduction and rationale

Early childhood nutrition has an enormous impact on a person's lifelong health. It is during the first 1000 days, defined as the period from conception through age two, that the foundation for a child's development and future health are cemented [2]. It's during this time that the immune system, brain, metabolism, and body undergo crucial development steps. Without adequate nutrition during this 1000-day window, the child's body and brain suffer irreparable damage that can lead to poor adult health outcomes and even reduced human capital later in life [3]. Sufficient breastfeeding is a key component of this 1000-day period. The WHO recommends that early initiation of breastfeeding be started within 1 hour of birth, and that infants be exclusively breastfed for the first 6 months of life [4]. Exclusive breastfeeding reduces the risk of all-cause mortality when compared to predominantly formula-fed, partially breastfed, and non-breastfed infants [5, 6]. There is also extensive evidence demonstrating that exclusive breastfeeding also reduces the risk of gastrointestinal tract infection [7], respiratory morbidity [8], and lower incidence of obesity during childhood and adolescence [9].

Infants are not exclusively breastfed at ideal rates globally. Less than half of infants worldwide receive early, exclusive, or continued breastfeeding [10] This is far from the UNICEF exclusive breastfeeding coverage goal of 100% [11]. This phenomenon is even more marked in low- and middle-income countries (LMICs). In 2016, it was estimated that 101.1 million children in LMICs were not breastfed in alignment with the international standards set by the WHO and UNICEF [6]. In India specifically, only 54.9% of children under 6 months of age are exclusively breastfed [12]. While this is higher than the overall rate of 37% across LMICs [6], it's far from the ideal full-coverage rate.

The ramifications of poor breastfeeding practices in LMICs are extensive. Various early studies on the benefits of breastfeeding note its significant influence on the cognitive development of a child [6, 13-15]. At ages 3, 5, and 7 breastfed children scored higher on cognitive development testing measures compared to children who were exclusively formula-fed [16]. When academic achievement and cognitive ability from ages 8-18 are compared in children breastfed for at least 8 months versus those who were not, it is found that breastfeeding is associated with increases in academic achievement as well as cognitive ability [17]. Increased rates of breastfeeding also carry significant economic benefits for LMICs. Breastfeeding and early nutrition interventions are among the most effective possible health policies available, with an estimated social return of $35 USD per dollar invested [18]. If 100% adherence to breastfeeding recommendations was achieved globally, it's estimated that >$300 billion dollars would be saved annually [19].

1.2 Problem Statement

Despite various programs in policies in place to facilitate higher rates of breastfeeding, India remains one of the LMICs where rates of exclusive breastfeeding remain subpar. Despite having a relatively stable economy, with a GDP higher than 60% of the other Indian states [20], health and social inequalities in the state of Haryana remain high [21]. These inequalities are reflected in key breastfeeding indicators. For example, in Haryana only 42.4% of children are being breastfed within 1 hour of birth [22]. Additionally, the rate of infants under 6 months of age who are exclusively breastfed has remained 70% from the National Family Health Survey 4 was taken in 2015-2016, to the most recent completed survey in 2019-2021 [21, 23]. Understanding why breastfeeding practices have not improved with the recent decrease in

poverty is necessary to inform public health policy and programming, which can in turn improve early childhood nutrition, mortality rates, and health outcomes later in life.

1.3 Purpose Statement

A quantitative analysis will be completed to determine key determinants of exclusive breastfeeding practices among mothers with an infant aged 2-4 months in Haryana.

1.4 Significance Statement

It's important that effective programming and policies are implemented to raise exclusive breastfeeding rates, especially in LMICs like India. A quantitative analysis specifically will be a valuable addition to the qualitative analysis previously completed with this population which also investigated key facilitators and barriers to exclusive breastfeeding. The results from this study will help inform targeting and design of interventions and policy adaptations to ensure that the key influencing factors of exclusive breastfeeding rates are being addressed in Haryana.

Chapter 2: Review of the Literature

2.1 Nutrition in the First 1000 Days

Adequate nutrition during the first 1000 days of a child's life is essential. Traditionally, these first 1000 days for a child is considered to be the period between conception and 2 years of age. During this critical window, nutrition heavily influences both short and long term health outcomes and developmental abilities [2]. In the short term, the consequences of insufficient nutrition during this time period can include stunting, increased risk of adiposity, and higher risk of all-cause mortality [15]. In the long term, early childhood malnutrition negatively impacts brain development, human capital potential, and heightens risk of non-communicable diseases as an adult [3].

The timing of peak rates of development in the brain varies by anatomical region [24]. For example, the hippocampus begins it's "growth spurt" at approximately 32 weeks gestation and doesn't slow down until at least the first 18 postnatal months while the prefrontal cortex experiences its peak period of rapid growth in the first 6 postnatal months [25]. However, the large majority of these periods of peak development rates occur during the first 1000 days window. The brain depends on key micro- and macronutrients to fully complete these development processes, thus adequate nutrition during this 0-2 years old period is essential to ensuring optimal brain development [26].

In addition to overall brain development, a marked long-term outcome of substantial early-life nutrition is improved adult human capital and economic productivity [27]. Between the years of 1969-1977 a nutritional supplement containing protein and various micronutrients, Atole, was given to children under 7 years old, pregnant women, and lactating women in two randomly assigned villages in Guatemala. It was found that reading, schooling, and intelligence

were improved in Atole villages, but only in children who had received the supplement before 3 years of age. [28] Additionally, the wages of men who received Atole through the age of 2 were increased by 46% compared to those who didn't [27].

2.2 Exclusive Breastfeeding

The WHO and UNICEF recommend **early initiation of breastfeeding (EIBF)**, and that a child is **exclusively breastfed** for the for the first six months of life [4]. Early initiation of breastfeeding is defined as "the provisions of mothers' breast milk to infants within the first hour of birth and ensures that the newborn receives colostrum" [29]; and exclusive breastfeeding (EBF) means feeding the child only breast milk and no other foods or liquids (including infant formula or water), except for medications or vitamin and mineral supplements.

The terms women, mothers, and breastfeeding will be used throughout this project for brevity and because most people who breastfeed identify was women and mothers; we recognize that not all people who breastfeed or chestfeed identify as such.

These recommendations are built from a wealth of evidence detailing short- and long-term health benefits of EBF for both the mother and child. Some of these short-term benefits for the child include favorable weight increase, lower adiposity, lower total cholesterol values, and better cognitive and behavioral development in the early years of life [13]. EBF until at least 4 months of age is also associated with a significant reduction of respiratory and gastrointestinal morbidity in infants [8]. A longer term prospective cohort study examining a cohort of 5000 children from fetal life until young adulthood supports this conclusion, showing that breastfeeding for 6 months or longer was significantly associated with a reduced risk of lower respiratory tract infections up to 4 years of age [30]. Additionally, formula-fed infants are twice as likely to die from SIDS [31]. These differences in health-outcomes between formula-fed and

breastfed infants extends past the first six months of life, as a meta-analysis of 15 studies showed a significant difference in body composition between formula-fed infants and breastfed infants at both 6 and 12 months of age [32] Body adiposity in early life has a major impact on later disease risks such as obesity and related disorders [33]. Along these lines, breastfeeding is associated with a lower incidence of obesity during childhood and adolescence [9], as well as reduced risk of obesity and chronic disease in adulthood [34].

There are also notable long-term neurodevelopmental health benefits of breastfeeding. Various systematic reviews have concluded that children who are breastfed for longer than 6 months have better cognitive outcomes, lower risk of developing attention deficit/hyperactivity disorder, and may have lower risk of being diagnosed with autism spectrum disorder, although additional longitudinal prospective research is needed to further examine these complex relationships [35, 36]. Breastfeeding is particularly associated with improved cognitive development in children born preterm; differences in cognitive development testing scores of 5 year old children who were preterm infants suggest that the breastfed cohort are up to 6 months ahead in development compared to the non-breastfed cohort [37].

The benefits of EBF for the mother are marked. Return to pre-pregnancy weight is earlier in breastfeeding mothers during the 6 months after delivery, and breastfeeding is associated with a decreased risk of breast and ovarian cancer in the premenopausal period [9]. Additionally, a meta-analysis conducted in developed countries showed that a history of lactation was associated with a reduced risk of type 2 diabetes, as well as breast and ovarian cancer [38]. Early cessation of breastfeeding (before the infant is 6 months old) or not breastfeeding was associated with an increased risk of maternal postpartum depression [38].

While many studies show health benefits for the child after only 3-4 months of EBF, the optimal duration of EBF is six months. A meta-analysis comparing mother-infant dyads who exclusively breastfed for 6 months or longer to dyads who partially breastfed for 3-4 months found that within the 6 month duration group, the infants experience less morbidity from gastrointestinal infection and no deficits in growth [39]. Additionally, the mothers in this group have more prolonged lactational amenorrhea [39].

Despite the WHO recommendations, many infants and young children are not optimally fed. Over the period of 2015-2020, only about 44% of infants aged 0-6 months were exclusively breastfed worldwide [4]. The consequences of suboptimal rates of exclusive breastfeeding affect not only the health of the mother and child, but also have significant economic implications. Globally, an estimated $3141.3 billion USD is lost each year from the unrealized benefits of breastfeeding to health and human development due to inadequate investment in breastfeeding initiatives and support [40]. Economically, it is in our interest to pursue reducing this loss as increasing breastfeeding rates is among the most effective possible health policies available, with an estimated social return of $35 USD per dollar invested [18].

To investigate why exclusive breastfeeding rates are lower than the global goal and to subsequently address the issue, healthcare, social, and behavioral barriers must be identified and addressed. The framework below (**Figure 1**), adapted from the 2023 *Lancet* breastfeeding series as well as Idris et al., illustrates components of the socioecological model effecting the behavior of exclusive breastfeeding[14, 41]. Here, the determinants of exclusive breastfeeding are grouped into four primary categories: the mother-infant dyad, sociodemographic context, breastfeeding experience/perceptions/support, and the structural environment.

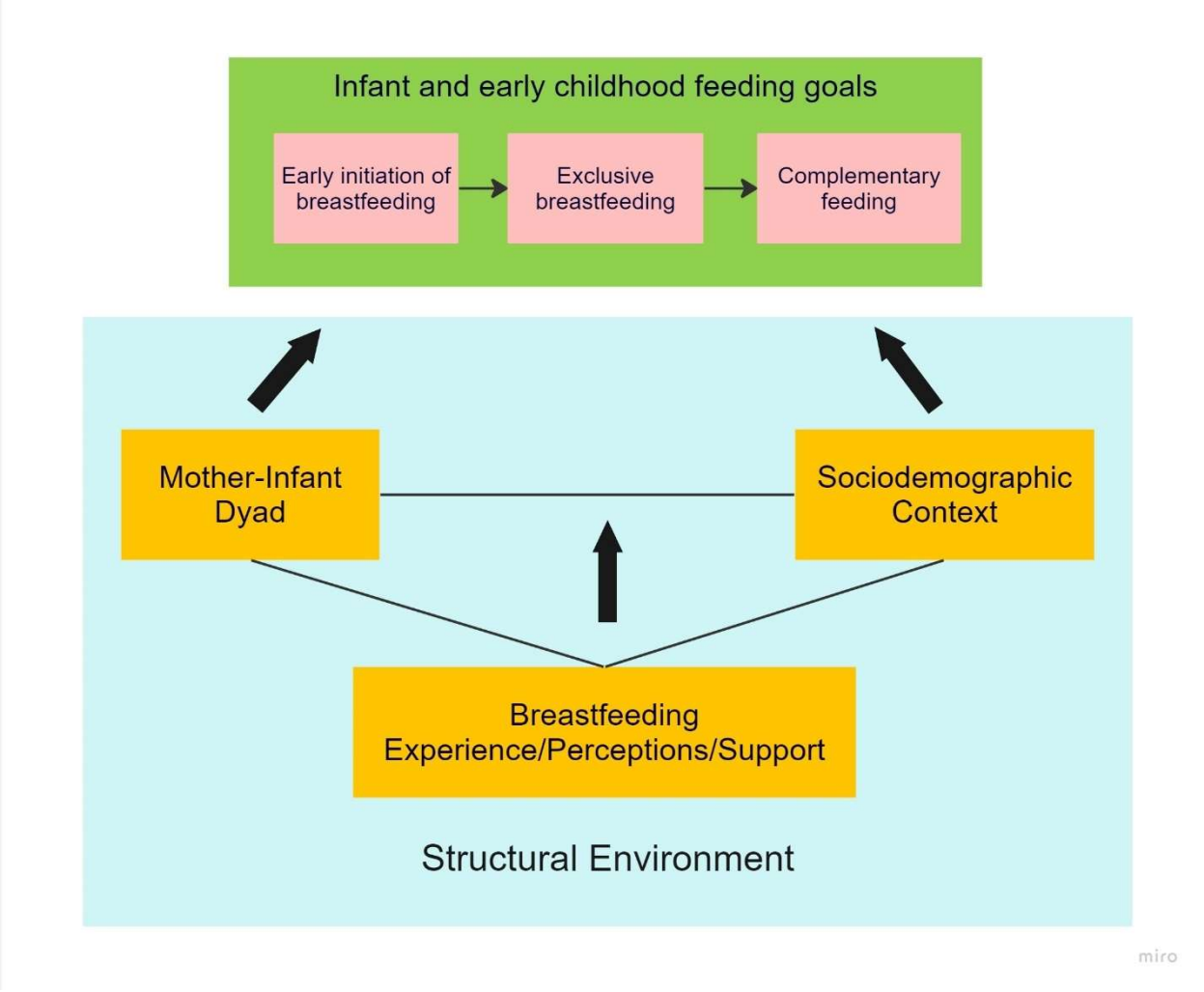

Figure 1: Determinants of exclusive breastfeeding framework

The category of the mother-infant dyad includes characteristics about the mother and the infant, including maternal age, maternal education level, her risk for depression, whether the infant was born at a low weight, the sex of the child, etc. Some of these characteristics have been found to be negatively associated with exclusive breastfeeding, while other mother-infant dyad characteristics were found to be positively associated with exclusive breastfeeding across multiple contexts; including but not limited to maternal age and education level [42], parity of the mother and physical health of the infant [43], and maternal occupation [44].

Sociodemographic context factors are characteristics of the greater household, or

characteristics that are not exclusive to the mother and/or the infant such as religion, poverty status, caste, and family type. While household socio-economic status has previously been associated with infant and young child feeding practices such as EBF [45, 46], further research is needed to clarify the effects of other potential determinants in this category.

Breastfeeding experience/perceptions/support describes the experiences that a mother encounters while breastfeeding. This ranges from the presence of breastfeeding support from medical staff, family, or friends, whether she experiences physical pain while feeding, or low milk volume. Perceived low milk volume as well as low self-efficacy have previously been shown as powerful predictors of exclusive breastfeeding [47-49] and thus are crucial to include in this model.

The structural environment surrounds and affects all of these categories, and includes elements such as current legislation and health system accessibility. While an important piece to this overall picture, this study will not examine these factors.

2.3 Exclusive Breastfeeding in LMICs

The status of a context as a low- or middle-income country (LMIC) adds another dimension to the socioecological environment surrounding the practice of exclusive breastfeeding, and thus calls for extended analysis and consideration. The majority of infant and child deaths worldwide occur in LMICs [50]. In 2016, and estimated 101.1 million children in LMICs were not breastfed according to international standards [10]. Specifically in LMICs, infants who are exclusively breastfed have up to a 13% reduced risk of mortality compared to those who are non-exclusively breastfed [5]. To address the disproportionate child mortality rates, possible facilitators and barriers to exclusive breastfeeding in these contexts must be examined in-depth.

An analysis of the National Demographic Health Survey in Ethiopia has shown that martial status, child age, and economic status are all determinants of EBF [51]. One important factor in the association between economic status and EBF is that economic status is often directly related to whether or not the mother works and where. In Indonesia, various aspects of the mother's work environment were found to be a major determinant of EBF. It was found that the presence of a dedicated breastfeeding facility in the workplace increased EBF practice threefold, and knowledge of the EBF promotion program being implemented increased EBF practice almost six times [52]. The mother's role as a income earner was also found to effect EBF practice in Nigeria. In a mixed-methods study of about 250 participants with positive perceptions about EBF, many mothers named the need to return back to work as a significant barrier to continuing EBF practice for the full recommended 6 month time period [53].

In addition to the influence of economic status and the workplace on the mother engaging in EBF, the mother's health and perceptions are notable determinants. Within the same investigation in Nigeria, mothers often reported that they discontinued EBF out of fear that their baby would become addicted to breast and/or because they felt their child's hunger wasn't satisfied with only breastmilk. Breast pain was also frequently cited as an barrier [53]. Perceptions of insufficient breastmilk as well as pressure from family and friends were determined to be significant inhibitors among Ghanian mothers [54].

2.4 Exclusive Breastfeeding in India

India, the LMIC with the largest population, is an especially complex context. The rates of breastfeeding vary widely across the country, ranging from 36% in Meghalaya up to 77% in Chhattisgarh [55]. In a nationwide study using data from the India National Family Health Survey, it was found that by region, the highest rates of EBF were in southern India while the

lowest were in the northeast [56]. In cohort of 1200 mothers in the south, key determinants of EBF were found to be maternal age and education, and the mother's perception that they weren't producing enough breastmilk [57]. A questionnaire-based analysis in the central rural region of Gujarat found similarly that common barriers to EBF were early marriage, low levels of parent education, a working mother, and poor counseling services [58].

The northern state of Haryana is one of India's leading states in terms of industrial and agrarian production. The second-largest contributor of food grains to India's supply, it's Gross State Domestic Product (GSDP) continually grows at a pace faster than the GDP of the country as a whole [59]. Despite Haryana's decline in poverty, only 54.9% of children under 6 months of age were exclusively breastfed and the rate of early initiation of breastfeeding in the state is 42.3% [60]. In the rural block of District Jhajjar in Haryana, some determinants of these rates were found to be working mothers, type of family structure, number of children, and early initiation of breastfeeding [60]. While this is an informative insight in the context of this specific region, additional analysis of other populations within Haryana still needed to ensure conclusions are well supported and to address EBF and early initiation of breastfeeding rates. A recent study used Haryana's results from the National Family Health Survey-4 to examine factors associated with no early initiation of breastfeeding, no EBF, and no continued breastfeeding. Delayed initiation was found to be associated with poorer economic status, home births, and high maternal BMI [22]. Additionally, increased risk of non-EBF was associated with no postnatal check-ups and maternal BMIs greater than 25 kg/m^2 [22]. While these findings are informative and provide a meaningful start to addressing infant and young child feeding practices in Haryana, an analysis of more in-depth and primary data is still needed.

This need has been partially met by a qualitative analysis of in-depth interviews completed with 30 lactating mothers in Haryana [61]. Using the COM-B framework to structure a thematic analysis, key barriers and facilitators emerged, such as prior breastfeeding experience, perceived insufficient milk, and misperceptions of water. Maternal work and family support also influenced the woman's opportunity to breastfeed, while maternal mental health, negative impact on body image, and lactation pain significantly influenced maternal motivation. This leaves a need to quantify these illuminating results and examine if there are any additional associations between the sociodemographic characteristics of the mothers, infants, and their household with infant and young child feeding practices. This more complete and well-rounded assessment containing both qualitative and quantitative insights could be used to inform current programming or future public health interventions in Haryana and subsequently improve rates of early initiation of breastfeeding and exclusive breastfeeding.

Chapter 3: Project Content

3.1 Methods

3.1.1 Subjects

Mother-infant dyads were recruited from a previously established pregnancy surveillance database from three primary health centers in peri-urban and urban regions of Faridabad district, Haryana, India. Participants were eligible if they included a lactating mother 18-45 years of age, an infant 2-4 months of age, and were likely to remain in the area for two weeks post enrollment. Mothers who consumed guttka (beetel nut) or smoked tobacco at the time of the study were excluded. Written informed consent was obtained from at least one parent by trained data collectors who visited the household.

3.1.2 Data Collection

These trained data collectors also administered questionnaires that assessed sociodemographic information, infant feeding behaviors, as well as indicators of maternal health and well-being.

To assess total human milk intake and subsequently determine whether the child had been exclusively breastfed, the deuterium oxide 'dose-to-mother' (DTM) technique was used, as specified by the International Atomic Energy Agency [62]. A 30 g dose of deuterium oxide (Product number: Q39316, Sercon, Cheshire, United Kingdom) was weighed via a calibrated analytical balance (Quintix 224-10IN, Sartorius, Goettingen, Germany) in the laboratory. Prepared doses were sealed with parafilm to prevent loss through evaporation and wrapped in an aluminium foil to conceal from light. Doses were stored at 4-8 degrees centigrade (°C) until they were carried to the field in a labelled plastic chiller with temperature maintained at 4-8 °C.

Lactating mothers consumed a single, deuterium oxide dose on day 0, immediately followed by 15 mL of filtered/distilled water [62]. Saliva samples were collected from both mother and infant on day 0, prior to administration of the deuterium oxide, and then on days 1, 2, 3, 4, 13 and 14. Approximately 0.5 mL of saliva was collected at each time. A 30-minute fast was maintained before collection of all saliva samples to ensure no residual food particles were present in the collected sample. Samples were stored in 2 mL acid washed cryogenic vials and sealed with parafilm strips to prevent loss of deuterium oxide through evaporation. Saliva samples were transported using a plastic chiller maintained with a temperature of 4-8 °C, then stored at -20 °C.

Deuterium enrichments of timed saliva samples from the mother and infant were measured by Fourier transform infrared spectroscopy (4500t FTIR, Agilent Technologies, Santa Clara, United States), and then used to estimate infants' total human milk intake and non-milk water intake.

3.1.3 Data Analyses

Key Outcome Variables

This analysis was conducted using three primary outcomes variables. First was exclusive breastfeeding as determined by the DTM technique. It was determined that the mother was practicing exclusive breastfeeding over the two week data collection period if a non-milk water intake of the infant was less than 86.6/day [63].

The second primary outcome variable was exclusive breastfeeding as determined by the mothers recall during the survey administration, using the specifications of the World Health Organization indicator [64]. The mother was asked "Has the infant been given anything other

than breastmilk to eat, drink, or lick in the past 24 hours?". An answer of yes signified that exclusive breastfeeding was not being practiced, while an answer of no was recorded as affirmation that she is exclusively breastfeeding.

Lastly, early initiation of breastfeeding was determined similarly, via maternal recall during survey administration. The mothers were asked if they had put the infant to their breast within one hour of birth, per the WHO indicator definition [64].

Key Predictor Variables

As shown in **Table 1**, the predictor variables used in this analysis can be separated into the three categories of the Determinants of Exclusive Breastfeeding Framework. Within the Sociodemographic Context category, we included: 'family income level', 'family type', and 'below the poverty line card' (BPL card). Family income was separated into levels determined by the tertiles of the range of incomes collected. A 'Low' family income was less than 120,000 INR earned per year, a 'Middle' family income was between 120,000 and 330,000 INR earned per year, and a 'High' family income was greater than 330,000 INR earned per year. Concerning the predictor 'Family Type', a joint family was defined as an extended family, typically consisting of three or more generations and their spouses, living together as a single household. A nuclear family was defined as only a couple and their dependent children living in the household. Lastly, a BPL card is issued to households that meet the state of Haryana's definition of poverty and indicates economic disadvantage.

Within the category of the Mother-Infant Dyad, the predictors 'Young at first birth' and 'Young at first marriage' are binary variables, indicating whether the mother was 18 years old or younger when she gave birth to her first child or got married, respectively. 'At-risk for depression' was defined using the Center for Epidemiological Studies Depressions (CES-D)

Scale [65]. As a part of the administered survey, 20 questions asked the women to rate how often over the past week they experienced various symptoms associated with depression. Responses are then coded from values of 0-3 and summed, a crude score of greater than 16 loosely indicates that an individual could be at-risk for depression. The infant characteristic of 'Low birth weight' is defined as the infant weighing less than 2500g at birth, per the standard cutoff [66].

In the category of Breastfeeding Experience/Perceptions/Support, 'Prelacteal fed' is a binary variable. Women were asked on the survey "In the first 3 days after delivery, was your baby given anything to drink/ lick other than breast milk?", and if they responded yes this was marked as a yes for 'Prelacteal fed'. 'Breastfeeding difficulty currently' and 'Breastfeeding difficulty ever' were marked as 'yes' if the woman reported experiencing one or more of the following symptoms when breastfeeding currently, or ever respectively: breast soreness, breast redness, breast hardness, pain, or pain accompanied with fever.

Analyses

Continuous variables were assessed for normality based on inspection of histograms and measures of skewness. Categorical variables were only included in analyses if each category included 5% of the subject pool or higher.

Simple linear regression models were used to examine the bivariate relationship between each potential predictor and the three key outcome variables; exclusive breastfeeding determined by the DTM technique, exclusive breastfeeding reported via maternal recall, and early initiation of breastfeeding. These results were reported as the unadjusted models. Multiple linear regression models were then used to further assess these relationships, producing adjusted models for each of the three key outcomes. Each model is adjusted for maternal age, religion, maternal education, the sex of the child, socioeconomic status (whether or not the family holds a

below the poverty line card), and breastfeeding difficulty. These standard co-variates were selected a priori based on theoretical evidence on important confounders of the relationship between breastfeeding practices and their common determinants. Various additional covariates were introduced to each model if a significant bivariate relationship was demonstrated in the unadjusted model.

The sample size of 232 mother-infant dyads was 80% powered to detect a 0.2 correlation between exposure and outcome (alpha < 0.05), and assuming a 10% loss to follow-up over the course of data collection. No imputations were made for missing data (< 10% missing in dataset). All analyses were completed in SAS 8.2.5 (SAS Institute, Cary, NC, USA).

3.1.4 Ethics

Ethical approval for this study was obtained by the ethics committee of the Society of Applied Studies and by the Emory University Institutional Review Board. Approval was also obtained from the State government and Health Ministry's Screening Committee of the Indian Council of Medical Research. This observational study is registered with Clinical Trials Registry - India, CTRI/2017/01/007636.

3.2 Results

In total, 232 mother-infant dyads were included as a part of this study. A summary of their demographic characteristics are provided in **Table 1.** The majority of households were Hindu (70.7%), food secure (77.4 %) and joint families (68.1%). The mean age of mothers was 24.7 ± 3.9 years old, and their average parity was 2.3 ± 1.2 children. 82.8% of the mothers completed at least 1 year of formal schooling. The average age of the infants was 2.5 ± 0.5 months, and 14.2% of the infants were born low birth weight. According to maternal recall

reporting, 56.8% of the infants were exclusively breastfed. The dose-to-mother technique reported that 67.8% of infants were exclusively breastfed. Approximately 5.2% of the mothers have experienced breastfeeding difficulty previously, and only 1.7% were currently experiencing breastfeeding difficulty at the time of this study. Slightly more than half of the mothers (57.8%) reported that they had breastfeeding support.

Bivariate relationships between potential predictors and the three primary outcome variables (exclusive breastfeeding reported via the DTM technique, exclusive breastfeeding reported via maternal recall, and early initiation of breastfeeding) are shown in **Tables 2, 3**, and **4** respectively.

Upon examining the associations between DTM exclusive breastfeeding and sociodemographic context predictors, one relationship was found between family type (comparing nuclear families to joint families) and DTM EBF (OR 1.89, CI 1.06, 3.40). There were no associations found between mother-infant dyad predictors and DTM EBF. Among breastfeeding experiences/perceptions/support predictors, it was found that women who had experienced breastfeeding difficulty at any point (OR 0.22, CI 0.06, 0.75), women who reported perceived low milk volume (OR 0.17, CI 0.08, 0.37), and women who had ever perceived themselves with low milk volume (OR 0.16, CI 0.07, 0.36) all had negative associations with DTM EBF.

After including these predictors in an adjusted multivariate logistic regression model, significant relationships were found between DTM EBF and at least one variable in three of the framework categories: sociodemographic context, mother-infant dyad, and breastfeeding experience/perceptions/support. Negative associations were found between DTM EBF and maternal perceived low milk ever (OR 0.17, CI 0.07, 0.41), breastfeeding support from family

and/or friends compared to no support (OR 0.32, CI 0.13, 0.74) as well as having ever experienced breastfeeding difficulty (OR 0.24, CI 0.06, 0.95). Additionally, maternal age was slightly negatively associated with DTM EBF (OR 0.90, CI 0.83, 0.99). A significant relationship was also found between family type and DTM EBF, with dyads living in joint family types showing a positive association with exclusive breastfeeding compared to dyads living in nuclear family types (OR 2.14, CI 1.05, 4.38).

Secondly, slightly different bivariate associations were discovered when exclusive breastfeeding as determined by maternal recall is used as the outcome. While no sociodemographic context predictors were found to be significant, both maternal age at first marriage (OR 1.10, CI 1.00, 1.21) and maternal young marriage (<18 years old) (OR 0.47, CI 0.26, 0.87) were found to be associated with recall EBF. Similar to associations found with DTM EBF, current maternal perceived low milk (OR 0.28, CI 0.12, 0.61) and maternal perceived low milk ever (OR 0.34, CI 0.16, 0.72) were both negatively associated with recall EBF.

Only two significant associations were found in the multivariate model where recall EBF was the primary outcome. Negative relationships were found between mothers who were married at a young age (less than 18 years old) and recalled EBF (OR 0.43, CI 0.22, 0.83), as well as between mothers who have ever perceived themselves with low milk volume and recalled EBF (OR 0.35, CI 0.15, 0.78).

Thirdly, significant relationships were found in the multivariate model between mother-infant dyad predictors and early initiation of breastfeeding, and between a breastfeeding experience/perceptions/support predictor and early initiation of breastfeeding. A weak positive association was shown between maternal age and early initiation (OR 1.09, CI 0.99, 1.21). Additionally, a slight negative association was found between the difference in years of

education between the mother and the head of her household and early initiation of breastfeeding (OR 0.92, CI 0.85, 0.99). The strongest negative relationship was found between dyads where the child had been given a prelacteal feeding and early initiation of breastfeeding (OR 0.24, CI 0.13, 0.37).

Appendices

Table 1: Descriptive characteristics of lactating females and infants 2 to 4 months postpartum in Haryana, India (n=232)

Sociodemographic Context	
Family Income, level % (n)	
Low	17.7 (41)
Middle	57.3 (133)
High	25.0 (58)
Family type, %(n)	
Nuclear	31.9 (74)
Joint	68.1 (158)
Caste, % (n)	
Scheduled Caste/Tribe	23.2 (54)
Other Backward Caste (OBC)	49.1 (168)
Other	27.6 (64)
Religion, % (n)	
Hindu	70.7 (164)
Muslim	28.0 (65)
Other	1.3 (3)
Below poverty line card, % (n)	22.8 (53)
Mother-Infant Dyad	
Maternal characteristics, %(n)	
Maternal age, years, mean ± SD	24.7 ± 3.9
Maternal age at first birth, years	20.9 ± 2.8
Young first birth (≤ 18 years old)	4.3 (10)
Age difference with husband, years	3.3 ± 3.2
First-time mother	35.7 (82)
Parity, mean ± SD	2.3 ± 1.2
Maternal age at first marriage, years, mean ± SD	18.9 ± 2.9
Young first marriage (≤ 18 years old)	24.6 (57)
Maternal occupation, housewife	97.0 (225)
Maternal education (≥1 year of schooling)	82.8 (192)
Education difference with husband, years	1.9 ± 4.5
At-risk for Depression	5.2 (12)

Table 1: Descriptive characteristics of lactating females and infants 2 to 4 months postpartum in Haryana, India (n=232), Continued

Child characteristics, %(n)	
Sex, F	47.4 (110)
Age, months	2.5 ± 0.5
Birth weight, kg	2.8 ± 0.5
Low birth weight	14.2 (33)
Breastfeeding Experience/Perceptions/Support, %(n)	
Prelacteal fed	45.9 (105)
Colostrum fed	91.2 (209)
Exclusively breastfed (maternal recall)	56.8 (130)
Exclusively breastfed (dose-to-mother)	67.8 (156)
Breastfeeding Difficulty	
Currently	1.7 (4)
Ever	5.2 (12)
Breastfeeding support present	58.9 (135)
Health system support (ANM, ASHA or, Medical Staff	19.2 (44)
Family and/or Friends	25.3 (58)
Other	14.4 (33)
None	41.1 (94)

Table 2: Bivariate and multivariate relationships between three categories of predictors and exclusive breastfeeding (EBF) as determined by dose to mother (DTM) technique from 232 women in Haryana, India

EBF DTM	Crude OR	95% CI	P value[1]	Adjusted OR	95% CI	P value[1]
Sociodemographic Context						
Caste						
Sch. C/T v. OBC	0.93	(0.46, 1.88)	0.83			
Sch. C/T v. Other	0.83	(0.38, 1.80)	0.63			
Religion (Hindu compared to Muslim)	1.31	(0.71, 2.40)	0.39	1.43	(0.67, 3.06)	0.36
BPL Card	1.01	(0.52, 1.94)	0.98	0.99	(0.46, 2.17)	0.99
Family Type (Nuclear to joint)	1.895	(1.06, 3.40)	0.03**	2.14	(1.05, 4.38)	0.04**
Mother-Infant Dyad						
Maternal Characteristics						
Maternal age	0.94	(0.88, 1.01)	0.08*	0.90	(0.83, 0.99)	0.03**
Age Difference w/ Hoh[2]	0.97	(0.91, 1.08)	0.78			
Young marriage (categorical)	1.12	(0.58, 2.15)	0.74			
Age at first marriage	1.00	(0.91, 1.10)	0.94			
Young first birth (categorical)	0.70	(0.12, 2.56)	0.59			
Age at first birth	1.02	(0.92, 1.13)	0.68			
Parity	0.84	(0.67, 1.05)	0.12			
Maternal Education						
Any v. None	0.89	(0.42, 1.86)	0.75	0.56	(0.22, 1.44)	0.23
Maternal Education						
Low v. None	0.74	(0.33, 1.63)	0.45			
High v. None	1.08	(0.48, 2.43)	0.85			
Education Difference w/ Hoh	0.98	(0.92, 1.04)	0.54			
Maternal Occupation, Housewife	0.34	(0.04, 2.89)	0.33			
Maternal risk of depression	1.28	(0.33, 4.97)	0.72			
Child Characteristics						
Child sex (F)	0.81	(0.47, 1.41)	0.46	0.98	(0.51, 1.87)	0.95
Child age	0.95	(0.56, 1.62)	0.85			
Low birth weight	1.27	(0.55, 2.90)	0.57			
Breastfeeding Experience/Perceptions/Support						
Colostrum	0.69	(0.24, 1.97)	0.48			
Prelacteal Fed	0.60	(0.34, 1.04)	0.07*	0.82	(0.42, 1.59)	0.55
Early Initiation	1.07	(0.61, 1.86)	0.82			
BF Support						
Any v. None	0.82	(0.46, 1.44)	0.49			
Medical Staff v. None	1.17	(0.52, 2.66)	0.70			
Family/Friends v. None	0.53	(0.27, 1.06)	0.07*	0.32	(0.13, 0.74)	0.008**
Other v. None	0.93	(0.39, 2.21)	0.86			
Breastfeeding Difficulty Ever	0.22	(0.06, 0.75)	0.02**	0.24	(0.06, 0.95)	0.04**
Perceived Low Milk Ever	0.17	(0.08, 0.37)	<0.0001***	0.19	(0.08, 0.47)	0.0003**
Perceived Low Milk Currently	0.16	(0.07, 0.36)	<0.0001***			

[1] (P-value from chi-squared)

[2]Defined as the age of the head of the household minus the age of the mother

Table 3: Bivariate and multivariate relationships between three categories of predictors and exclusive breastfeeding as determined by maternal recall from 232 women in Haryana, India

EBF Recall	Crude OR	95% CI	P value[1]	Adjusted OR	95% CI	P value[1]
Sociodemographic Context						
Caste						
Sch. C/T v. OBC	0.96	(0.50, 1.86)	0.91			
Sch. C/T v. Other	0.83	(0.40, 1.74)	0.63			
Religion (Hindu compared to Muslim)	1.66	(0.93, 2.97)	0.09*	1.14	(0.58, 2.25)	0.71
BPL Card	1.49	(0.79, 2.81)	0.22	1.58	(0.79, 3.15)	0.20
Family Type (Nuclear to joint)	1.38	(0.78, 2.41)	0.27			
Mother-Infant Dyad						
Maternal Characteristics						
Maternal Age	0.97	(0.91, 1.04)	0.42	0.97	(0.90, 1.05)	0.44
Age Difference w/ Hoh[2]	1.07	(0.98, 1.17)	0.12			
Young marriage (categorical)	0.47	(0.26, 0.87)	0.02**	0.43	(0.22, 0.83)	0.01**
Age at first marriage	1.10	(1.00, 1.21) (weak)	0.04**			
Young first birth (categorical)	0.49	(0.14, 1.80)	0.29			
Age at first birth	0.99	(0.91, 1.10)	0.93			
Parity	0.88	(0.71, 1.09)	0.25			
Maternal Education						
Any v. None	1.78	(0.89, 3.53)	0.10*			
Maternal Education						
Low v. None	1.51	(0.72, 3.16)	0.28	1.45	(0.65, 3.23)	0.36
High v. None	2.21	(0.99, 4.50)	0.05**	1.75	(0.75, 4.09)	0.19
Education Difference w/ Hoh	0.95	(0.91, 1.02)	0.20			
First-time mother	0.77	(0.44, 1.32)	0.34			
Maternal Occupation, Housewife	1.78	(0.39, 8.15)	0.46			
Maternal risk of depression	0.75	(0.23, 2.40)	0.63			
Child Characteristics						
Child sex (F)	1.08	(0.64, 1.83)	0.76	1.34	(0.75, 2.40)	0.32
Child age	1.00	(0.60, 1.66)	0.99			
Low birth weight	1.18	(0,55, 2.53)	0.67			
Breastfeeding Experience/Perceptions/Support						
Colostrum	1.08	(0.43, 2.72)	0.87			
Prelacteal Fed	0.67	(0.40, 1.13)	0.13			
Early Initiation	1.11	(0.66, 1.87)	0.69			
BF Support						
Medical Staff v. None	0.78	(0.42, 1.43)	0.42			
Family/Friends v. None	0.75	(0.39, 1.44)	0.38			
Other v. None	0.96	(0.48, 1.90)	0.90			
Breastfeeding Difficulty Ever	1.07	(0.33, 3.48)	0.91	1.17	(0.32, 4.24)	0.81
Perceived Low Milk Ever	0.34	(0.16, 0.72)	0.005**	0.35	(0.15, 0.78)	0.01**
Perceived Low Milk Currently	0.28	(0.12, 0.61)	0.002**			

[1] (P-value from chi-squared)

[2]Defined as the age of the head of the household minus the age of the mother

Table 4: Bivariate and multivariate relationships between three categories of predictors and early initiation of breastfeeding from 232 women in Haryana, India

Early Initiation	Crude OR	95% CI	P value[1]	Adjusted OR	95% CI	P value[1]
Sociodemographic Context						
Caste						
Sch. C/T v. OBC	1.02	(0.53, 1.95)	0.96			
Sch. C/T v. Other	1.13	(0.54, 2.35)	0.75			
Religion (Hindu compared to Muslim)	1.44	(0.81, 2.57)	0.21	1.10	(0.53, 2.23)	0.81
BPL Card	0.95	(0.51, 1.75)	0.87	1.13	(0.56, 2.29)	0.74
Family Type (Nuclear to joint)	0.63	(0.36, 1.11)	0.11			
Mother-Infant Dyad						
Maternal Characteristics						
Maternal Age	1.09	(1.01, 1.16)	0.02**	1.09	(0.99, 1.21)	0.09*
Age Difference w/ Hoh[2]	1.08	(0.99, 1.18)	0.07*			
Young marriage (categorical)	0.82	(0.45, 1.50)	0.52			
Age at first marriage	1.10	(0.96, 1.15)	0.29			
Young first birth (categorical)	0.60	(0.17, 2.20)	0.44			
Age at first birth	1.04	(0.94, 1.14)	0.47			
Parity	1.24	(1.00, 1.55)	0.05**	1.02	(0.73, 1.42)	0.93
Maternal Education						
Any v. None	0.97	(0.49, 1.93)	0.94	0.64	(0.25, 1.69)	0.37
Maternal Education						
Low v. None	0.98	(0.47, 2.06)	0.97			
High v. None	0.97	(0.46, 2.03)	0.93			
Education Difference w/ Hoh	0.94	(0.89, 0.99)	0.03**	0.92	(0.85, 0.99)	0.03**
First-time mother	0.60	(0.35, 1.04)	0.07*			
Maternal Occupation, Housewife	2.78	(0.53, 14.70)	0.23			
Maternal risk of depression	0.92	(0.29, 2.94)	0.89			
Child Characteristics						
Child sex (F)	1.10	(0.65, 1.85)	0.72	1.25	(0.70, 2.27)	0.45
Child age	0.80	(0.49, 1.33)	0.40			
Low birth weight	1.04	(0.49, 2.21)	0.92			
Breastfeeding Experience/Perceptions/Support						
Colostrum	1.36	(0.54, 3.41)	0.52			
Prelacteal Fed	0.22	(0.13, 0.38)	<0.0001***	0.24	(0.13, 0.37)	<0.0001***
BF Support						
Medical Staff v. None	0.55	(0.39, 1.00)	0.05**	0.70	(0.30, 1.62)	0.40
Family/Friends v. None	0.47	(0.24, 0.92)	0.02**	0.74	(0.33, 1.67)	0.46
Other v. None	0.86	(0.44, 1.71)	0.67			
Breastfeeding Difficulty Ever	1.31	(0.40, 4.26)	0.65	1.35	(0.37, 4.93)	0.65
Perceived Low Milk Ever	0.85	(0.41, 1.80)	0.66			
Perceived Low Milk Currently	0.64	(0.30, 1.35)	0.24			

[1] *(P-value from chi-squared)*

[2]*Defined as the age of the head of the household minus the age of the mother*

Chapter 4: Discussion, Conclusion and Recommendations

4.1 Discussion

We find that factors from all levels of the exclusive breastfeeding determinant framework influence whether essential infant feeding practices, such as exclusive breastfeeding and early initiation of breastfeeding, are implemented among the women of Haryana included in this sample. Breastfeeding experience/perceptions/support was consistently and strongly negatively associated with each of the primary outcome variables, namely perceived low milk volume, prelacteal feeding, and breastfeeding support. Child characteristics within the mother-infant dyad group of predictors showed no significance in any of the models, while some maternal characteristics such as age, education difference with the head of the household, and married at a young age show negative associations in some models. Few sociodemographic factors, such as family type, were found to have significant relationships with the infant feeding practice outcomes.

At the level of the mother-infant dyad, in the DTM model we see an inverse relationship between maternal age and EBF. With each additional year of age, the odds of EBF are 10% less. This is contradictory to the conclusions of a similar study in southern India, which stated that increasing maternal age positive facilitator of EBF [57]. This result also contradicts a second finding at the mother-infant dyad level, where, according to the recall EBF model, the odds of practicing EBF are 57% less among women who married young compared to women who were 18 years old or older when they married. This is consistent to the findings in Bhanderi et al., where early marriage was also found to be a significant barrier to exclusive breastfeeding practice [58]. Contrary to findings in previous literature [58, 60], the mother's working location (housewife v. working outside the house) was not shown to be a determinant of EBF. However, additional confirmation is needed as only 3% of the women in this sample worked outside the

home, rendering this analysis underpowered. The negative association between maternal age and DTM EBF also merits further examination to examine if there are any underlying confounding factors, or possible causal factors such as increased household responsibilities with age and thus less opportunity or motivation to exclusively breastfeed.

Some of the strongest and most consistent determinants of EBF across both DTM and recall models involve the mother's perception of herself and her capacities. In the DTM model, if the mother had ever experienced breastfeeding difficulty the odds of her engaging in EBF are 76% less than the odds of a mother who has never experienced breastfeeding difficulty. Additionally, if the mother has ever perceived that she has a low volume of milk the odds of her exclusively breastfeeding are 81% less than the odds who have never perceived themselves as producing low milk volume. The conclusions of Nishimura et al. also support this finding about perceived low milk volume [57]. These findings are also consistent with the results of the qualitative arm of this study, where perceived low milk volume and lactation pain (a breastfeeding difficulty) were found to be significant barriers to EBF [61].

As for the sociodemographic context determinants of EBF, the odds of women in joint families exclusively breastfeeding were 2.14 times the odds of EBF among women in nuclear families in the DTM model. This is in accordance with additional findings in Haryana which also cite family structure type as a determinant of exclusively breastfeeding [60]. Interestingly, compared to having no breastfeeding support, the odds of women who received or currently received breastfeeding support from family and/or friends breastfeeding are 48% less. This could suggest that the facilitating element of a joint family structure is not in-house presence of family support, as family support appears to be a barrier to exclusive breastfeeding. Another potential explanation for this finding could be that only women experiencing difficulties reach out to

friends and family for support, and thus confounding is present. Further research is needed to examine which element of a joint family structure encourages EBF practice by the mother if it is not this additional familial support. One possibility is that family and friends are giving these mothers advice contrary to the practice of EBF and this creates the barrier presented here. If this is the case, it will be critical that interventions to promote exclusive breastfeeding target not only mothers, but also the community around them. Again, further research is needed to verify this claim. Neither poverty, religion, nor caste have a significant relationship with either of the EBF models. This is in concordance with similar studies examining infant feeding practices in India, who also found no association between exclusive breastfeeding and income, religion, or caste [57, 67].

One interesting aspect of this analysis is the similarities and differences observed between the model where EBF was determined by the dose-to-mother technique, and the model where EBF was determined via maternal recall. While perceived milk volume remains a key barrier across both models, the maternal characteristics that present relationships to EBF vary by model. This variation could be present due to possible reporting biases. Social desirability bias in reporting could be present for women who feel like they are "supposed to" exclusively breastfeed and thus report that they are exclusively breastfeeding when that is not the case. Variation could also have been introduced by the time period differences in the data collection methods. The DTM technique was able to assess the infant's water intake, and thus practice of exclusive breastfeeding, over a two-week period. The question asked of mothers in the survey however, only asked if in the past 24 hours they had exclusively breastfed their baby. This difference in time period could account for any differences observed.

The examination of early initiation of breastfeeding adds another dimension to this analysis. The perceived low milk volume and breastfeeding difficulty are not key determinants in this model, as the initiation of breastfeeding would happen before extended breastfeeding practice. Breastfeeding difficulties and low milk volume while breastfeeding would occur after breastfeeding has already been initiated and thus can't influence an event that has already passed. In this model, the difference between years of education between the mother and the head of household becomes a significant predictor. For each increasing year of education difference between the mother and head of household, the odds of early initiation of breastfeeding decrease by 8%. While this metric hints at the conclusion found by others that lower maternal education is a barrier to breastfeeding practices [22, 57], it is important to note that no association was found between maternal education level and early initiation of breastfeeding. This suggests that this determinant is instead showing the potential influence of women empowerment on breastfeeding practices, as differences in age and education level between a woman and her head of household are crude measures for female empowerment. The findings here suggest that increased empowerment could be a facilitator to breastfeeding practices. While it has been shown that women feeling and experiencing empowerment *in* breastfeeding is a strong facilitator of infant feeding practices [68, 69], there is limited evidence examining the influence of women's empowerment in relation to the social structures around her and feeding practices such as breastfeeding. Low women empowerment as defined by autonomy to make decisions and confirmation to traditional gender roles was found to be a significant predictor of suboptimal infant feeding practices [70], but more research is needed to confirm this conclusion as well as the association found in our study.

Additionally, prelacteal feeding is a significant determinant of early initiation of breastfeeding. If the infant was given anything to drink, eat, or lick in the first three days after delivery, it's 76% less likely that early initiation of breastfeeding occurred.

There are various key limitations of this study. Firstly, the cross-sectional design of this study doesn't allow for conclusions about causality to be drawn. Reverse causality in the associations described also can't be completely ruled out. Additionally, since this data was collected via a survey tool, there is always a possibility of discrepancies and bias in reporting. Ideally, these limitations could be improved upon by having access to a milk volume indicator other than recall and/or the number of times that each type of support was accessed.

A primary strength of this study, however, is the utilization of multiple techniques to determine whether exclusive breastfeeding is being practiced. This helps to cover the weaknesses of each individual data collection technique while providing a more holistic analysis. Additionally, the combination of this quantitative analysis with the qualitative arm of the same study allows for deeper analysis.

4.2 Conclusions and Recommendations

Currently, there are some existing approaches to address and improve infant and early childhood feeding practices in Haryana. In late 2016, a nationwide program named MAA (Mothers' Absolute Affection) was implemented across all Indian states with the objective of improving rates of breastfeeding and overall child feeding practices [71]. Some of their primary components are capacity building for healthcare providers, as well as improving interpersonal communication within and between community groups. Accredited Social Health Activists (ASHAs) are community health workers who are employed by the Ministry of Health and

Family Welfare. Primarily women between the ages of 25-45, they "create awareness on health and its social determinants and mobilize the community towards increased utilization of the existing health services" [72]. In addition to the rural village based ASHAs, additional government workers supporting breastfeeding mothers include Anganwadi Workers (AWW) and Auxiliary Nurse Midwives (ANM).

When designing public health interventions, it is often most efficient and cost-effective to build onto existing systems or programs. Taking into consideration this body of evidence, it's clear that some of the primary barriers to exclusive breastfeeding and optimal IYCF practices in Haryana include maternal perceptions and knowledge as well as the knowledge base of their surrounding community (the maternal and paternal grandmothers of the infant, other family, friends). To address this, increased training of community health workers as well as social and behavioral change communication interventions can be effective. At the local level, monthly meetings are held at state-owned health care facilities called Primary Health Centers for the ASHA workers, AWWs, and ANMs along with regional staff from the Health Department Haryana. This is an excellent opportunity for additional IYCF training to be implemented. Specifically, this training program would focus on identifying mothers who are experiencing breastfeeding difficulties, listening to and recording their perceptions and physical symptoms, and addressing these concerns appropriately to promote early initiation of breastfeeding and EBF.

In conclusion, maternal perceptions such as low milk volume in addition to breastfeeding difficulties are some of the most significant barriers to practicing exclusive breastfeeding. It will be essential that these future interventions target mothers as well as the community of family and friends surrounding the mother. So, implementing regular training regarding these subjects at a

regional level for community health workers as well as integrating it into the pre-existing materials of the MAA is a possible solution to improve less than ideal rates of recommended infant and young child feeding practices. Additionally, further research is needed to explore the cause of these breastfeeding perceptions, the extent to which milk volume is reduced from the expected amount, and what interventions most effectively address this determinant.

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