Murray *et al.*
International Breastfeeding Journal (2024) 19:54
https://doi.org/10.1186/s13006-024-00660-x

International Breastfeeding Journal

RESEARCH

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Prenatal intention to human milk feed in the native Hawaiian population: predictors of any human milk feeding from birth to six months postpartum

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Abstract

Background Rates of non-communicable diseases are disproportionately high among Native Hawaiian (NH) people, and the proportion of NH infants being fed human milk (HM) is the lowest among all ethnicities within the state of Hawai'i. The aim of this study was to explore biological, socio-economic, and psychosocial determinants of the initiation and duration of human milk feeding (HMF) among a study of NH mothers and infants.

Methods A sample of 85 NH mother-infant dyads who were participating in a larger prospective study were involved in this research. Recruitment for the parent was delayed due to the COVID-19 pandemic. Recruitment started in November 2020 and continued until April 2022. Questionnaires were distributed at birth, two-months, four-months, and six-months postpartum. Questionnaires addressed topics relating to maternal and infant characteristics and infant feeding practices. Descriptive statistics, comparative analysis, and multivariate logistic regression tests were conducted.

Results The majority of participating mothers were aged between 31 and 35 years, had some college education or more, were employed, and multiparous. The majority of infants were receiving HM at each timepoint (94% at birth, 78% at two-months postpartum, and 76% at four and six-months postpartum). Factors found to be significantly associated with HMF initiation and duration were prenatal intention to HMF, maternal educational attainment, Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation, and Supplemental Nutrition Assistance Program (SNAP) recipiency. A prenatal intention to HMF was found to be a strong predictor of HMF at birth (aOR = 64.18, 95% CI 2.94, 1400.28) and at two-months postpartum (aOR = 231.55, 95% CI 2.18, 2418.3). Participants not involved with WIC were more likely to be HMF at four-months postpartum (aOR = 6.83, 95% CI 1.01, 46.23).

Conclusion This research supports existing evidence that prenatal intention to HMF and higher maternal educational attainment are positive predictors of HMF. WIC participation and being a SNAP recipient were found to be negatively associated with HMF which suggests a need for more culturally tailored support. Further research is required to reduce the gap in knowledge related to the determinants of HMF in NH.

Keywords Human milk, Breastfeeding, Native Hawaiian, Infants

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Background

The provision of human milk (HM) to infants, commonly referred to as breastfeeding, is associated with positive health outcomes and is known to impart short-term and long-term benefits to both infants and their mothers [1]. The term 'breastfeeding' no longer encapsulates each of the different methods of providing human milk (HM) to an infant yet is still very prominently used in literature, despite the evolution of infant feeding practices [2]. Therefore, the term human milk feeding (HMF) will be used instead of breastfeeding in this publication. Optimal HMF practices are associated with a significantly reduced risk of sudden infant death syndrome, infant hospitalization due to respiratory infection or diarrhea, childhood overweight or obesity, and the development of non-communicable diseases as an adult [3–5]. Mothers who have fed their infants HM may be less at risk of developing type 2 diabetes, breast or ovarian cancer [3]. Some of the benefits of HM provision on mother-infant dyads is suggested to be dose-dependent, hence the emphasis on prolonged duration by international health organizations [6]. The World Health Organization (WHO) and American Academy of Pediatrics (AAP) recommend that infants are exclusively fed HM for their first six months of life, and then given HM along with complementary foods for up to two years and beyond [6, 7].

Infant formula (IF) is an alternative source of infant nutrition to HM. IF lacks the inherent benefits of HM, as the complex composition and biologically active agents in HM are not yet equally replicable [8]. Previous research has established that formula fed (FF) infants are more likely to develop non-communicable diseases such as obesity, type 2 diabetes, and cardiovascular disease [9]. Furthermore, IF does not provide the health benefits associated with HM feeding to mothers [10].

The Native Hawaiian (NH) population are underrepresented in research. Data resources often fail to disaggregate NH populations from other Pacific Islanders or Asian populations. This can result in a failure to notice disparities in health that specifically affect NH [11]. When data is disaggregated, the disproportionally high prevalence of non-communicable diseases, such as obesity, diabetes, and cardiovascular disease in NH populations is evident [12]. The cause of disproportionately high rates of these conditions among NH is multifactorial, and includes socio-economic inequalities, health inequity, and genetic predisposition [13, 14]. In previous research NH participants have reported that traditional practice and cultural knowledge are important aspects in health and wellbeing [13]. The Pregnancy Risk Assessment Monitoring System (PRAMS) data reveals that NH have the lowest initiation rates (94.9%) and lowest rates of any HMF feeding at two months postpartum (77.6%) in comparison to other ethnic groups in the state of Hawai'i [15, 16].

Determinants of HMF initiation and duration are multifaceted and include biological, socio-economic, and psychosocial factors. Older mothers are more likely to initiate HMF and feed for a longer duration than younger mothers [17]. Nomura et al. established associations between non-initiation and earlier cessation of HMF and mothers with a BMI categorized as overweight/obese [18]. Infants delivered via vaginal delivery are more likely to be fed HM than to those who were delivered via cesarean section [19, 20]. Mothers without a high school degree are associated with having lower HMF rates [20, 21]. This association may be influenced by the relationship between higher maternal age and increased HMF duration, as older mothers are more likely to have a higher educational attainment [22]. Married women are more likely to be HMF for a longer duration than single women or women that cohabit with a partner [23]. Multiparity is also associated with a longer HMF duration [23]. Mothers who have a low-income are deemed to be more at risk of early HMF cessation [24] as lower-income jobs do not provide supportive environments that are appropriate for HM pumping [25]. In addition, mothers in the US who have 12 or more weeks of paid maternity leave are more likely to initiate and continue HMF up to 6 months than mothers with unpaid leave [26]. Infants who were born at a Baby Friendly Hospital Initiative (BFHI) designated center have a higher likelihood of a longer duration of HMF [27]. Of the twelve maternity hospitals in the state of Hawai'i, only two are BFHI-designated, one of which is located on O'ahu, the island with the greatest number of NH [28]. A 2007 study found that NH people who participated in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program were less likely to feed their infants HM [29]. Finally, mothers who have the prenatal intention of HMF are more likely to initiate feeding when compared to those who are undecided on their plans [30].

The relationship between cultural affiliation and HMF is not well researched, especially in indigenous populations. Family (known as 'ohana for NH) and community ties are highly valued within the NH and Pacific Islander culture [25]. A qualitative study on NH and Pacific Islander HMF patterns described how family and community support are integral in encouraging and normalizing HMF. A lack of support from family and friends was cited by some participants as a significant influence on their decision to not HMF [25]. In NH culture it is not uncommon for multiple generations of one family to live in the same house, and grandparents often play an influential role in raising infants which has been found to be either supportive or disruptive to HMF [13, 25, 34]. Research into the determinants of HMF for

wāhine Māori, (Maori women), who share a Polynesian ancestry with NH, found that mothers who considered cultural practices and traditions as very important were more likely to exclusively HMF their infant for at least six months than those who did not [31].

At present, there are few studies that examine the determinants of HMF among NH populations. NH are usually aggregated with other ethnic groups, and as a result, important factors affecting feeding rates in this group may go unnoticed. The intention of this study was to determine the most important factors associated with HMF in NH at different postpartum stages up to six months, and to examine the predictors of a longer duration of HMF.

Methods

Study design and setting

This study used data extracted from the prospective cohort study "Exploring Diet Diversity of Native Hawaiian Infants". This study was conducted by a team of researchers from the University of Hawai'i at Mānoa and Purdue University. The study involves a cohort of NH mother-infant dyads from Hawai'i. Institutional Review Board (IRB) approval from the WCG (Reference number: 2019–088) then the University of Hawai'i was obtained prior to data collection (Reference number: 2021–00437). This study involved a secondary analysis of quantitative data collected at enrollment, birth, two-months, four-months, and six-months postpartum.

Study population and recruitment

The sample population for the prospective study were 101 NH mother-infant dyads who completed the enrollment questionnaire. In this study, the total sample used was $n = 85$, the number of participants who responded to the birth questionnaire. At each subsequent time point, participants included in analysis were those who completed infant feeding relevant questions. Fig. 1 displays the number of participants included in analysis at each time point. Recruitment was delayed due to the COVID-19 pandemic, commencing in November 2020, and finishing in April 2021. The study protocol was modified in response to the COVID-19 pandemic. Face-to-face contact with participants was minimized, and collection of data in-person by study staff was eliminated. Participants were recruited via convenience sampling among patients presenting for pregnancy care, who come from across the state of Hawai'i, at the Obstetrics and Gynecology faculty practice at the John A. Burns School of Medicine, located in Honolulu, O'ahu. Supplemental recruitment was carried out via community events and organizations (e.g., Baby Expo), and social media. All participants signed a consent form prior to data collection. Eligibility criteria included participants who identified as NH, were over 18 years of age, in their third trimester of pregnancy or up to 4 weeks postpartum, living in Hawai'i, and had access to a smartphone. Participants received compensation at each time point of the study: a gift card at enrollment, and then infant-related supplies (e.g., diapers, baby wipes) at each subsequent time point.

Data collection

Questionnaires were administered via a HIPAA-compliant secure platform, REDCap tool hosted at the University Health Partners of Hawai'i [32, 33]. The mothers were asked to complete these questionnaires at enrollment, birth, two-months postpartum, four-months postpartum, and six-months postpartum. The selected questions were informed by previous research on NH populations, NH culture, health and diet quality. These questions addressed topics including age, educational achievement, marital status, employment status, and cultural affiliation [34–36]. Other topics included demographic characteristics of the infants, birth information, mothers' prenatal intention of early infant feeding, and other indicators of early infant feeding such as HMF and FF [37–39]. Mothers self-reported their height and weight measurements.

Data analysis

Data analysis was conducted using IBM SPSS Statistics Version 28.0 (SPSS Inc: Chicago, IL, USA). Identification numbers were used to describe involved participants. In this analysis, results were considered statistically significant if $p < 0.05$. For this study the variable of 'initiation of HMF' describes all mothers who fed their infant any HM at least once in the hospital post-birth and is used in the analysis of HMF at birth. 'Any HMF' includes mothers who fed their infants any HM, regardless of exclusivity. This definition is used in the analysis of the two-, four-, and six-month postpartum time points. Exclusivity was not included in this analysis due to the small number of participants who exclusively provided HM. NH and US cultural identity scores were calculated using a set of cultural affiliation questions. The US cultural identity score was used to reflect affiliation with the dominant or Westernized US culture. Two subscales were created using these questions, informed by previous research [35, 36]. These scales traditionally have eight questions related to participant's knowledge of, involvement in, feelings towards, and association with each culture. One question was unintentionally omitted from the NH cultural identity subscale, so a 3-item NH cultural identity subscale, and a 4-item US cultural identity subscale were used. The median score for each subscale (median score = 8 for NH identity score and median score = 11.5 for US

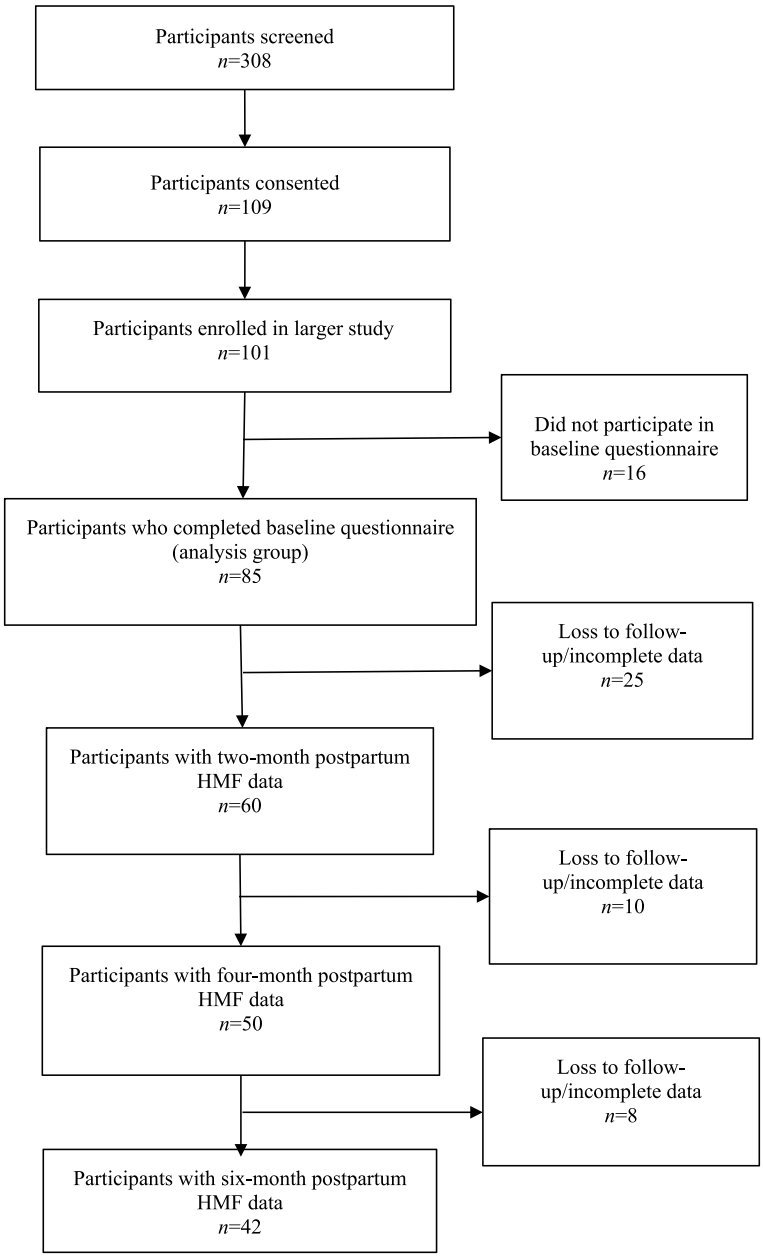


Fig. 1 Flowchart depicting the number of participants analyzed and lost to follow-up in this study on human milk feeding (HMF) in Native Hawaiians

identity score) were used to group participants based on affiliation [36]. Scores lower than the median indicate a higher affiliation with that respective culture. Cronbach's alpha was > 0.7 for each subscale, suggesting acceptable reliability [40]. Descriptive analysis (percentages) of the participants' demographic data was completed. All variables used in this analysis were categorical in nature. Comparative analysis tests (chi-square and Fisher's exact) were conducted to assess relationships between possible predictor variables and any HMF at birth, two, four, and six months postpartum. Univariate and multivariate logistic regression was conducted cross-sectionally to examine predictors of any HMF at birth, two-, and four-months. Only variables found to be significant in the comparative analysis were included in the univariate and multivariate models. No variables were found to be significant in the comparative analysis at six-months postpartum. The Hosmer–Lemeshow test was > 0.05 for

all multivariate models, indicating that the models are a good fit [41]. Due to the small sample size, the following ordinal variables were merged to create dichotomous variables for the logistic regression analysis: maternal age, pre-pregnancy BMI, education status, employment status, and prenatal intention to HMF. Maternal age, pre-pregnancy BMI, marital status, education status and employment status were included as potential confounding variables in the multivariate analysis given that they have previously been identified as being associated with HMF initiation and duration in research [18, 24]. Crude and adjusted odds ratios (OR), *p*-values, and 95% confidence intervals were calculated.

Results

Participant characteristics

Table 1 displays the characteristics of the participants. Participants were grouped based on responses to the questionnaires at birth, two-, four-, and six-months postpartum. From the birth to the six-month questionnaire, half of the participants were lost to follow-up. Across all time points participants were most commonly within the age range of 31–35, had a BMI > 30, were married, had some college education or more, were employed, and were multiparous. The majority of mothers had a strong affiliation with the NH culture, while approximately half had strong affiliations with the dominant or Westernized US culture. Most of the infants were delivered via vaginal delivery at a non-designated BFHI center. The majority of mothers were providing any HM at each time point. More than half of the infants had received IF at least once by six-months postpartum.

As shown in Table 2, prenatal intention was associated with any HMF at birth and two-months postpartum. A higher level of educational attainment and WIC participation were found to be associated with any HMF at two-months and four-months postpartum. SNAP recipiency was also associated with any HMF at two-months postpartum. No significant associations were found between any of the characteristics and any HMF at six-months postpartum.

Predictors of any HMF at birth, 2-months, 4-months, and 6-months postpartum

Tables 3, 4 and 5 display results from multivariate logistic regression with accompanying forest plots. The multivariate model in Table 3 revealed that mothers with a prenatal intention of HMF had 64 times the odds of initiation compared to those without intention or who were unsure of their intention to HMF. The crude analysis (data not shown in tables) reveals that in correlation with the comparative analysis, maternal education level, WIC participation, SNAP recipiency, and prenatal intention to HMF are significant predictors of any HMF at two months. When adjusted for potential confounders, however, only prenatal intention remains a significant predictor. The multivariate model predicts that mothers with a prenatal intention of HMF are 231 times more likely to be feeding their infant any HM at two-months postpartum when compared to mothers who did not have a prenatal intention to HMF or were undecided on their feeding plans.

In the univariate analysis of predictors of any HMF at four-months postpartum maternal education level and WIC participation were found to be significant predictors. When adjusted for potential confounders, only WIC participation remained a significant predictor. Mothers who were not participating in WIC were over six times more likely to be feeding their infant any HM at four-months postpartum than mothers who were WIC participants.

Discussion

This study has provided insight into factors associated with the likelihood of any HMF at birth, two-months, four-months, and six-months postpartum. The number of participants who initiated HMF was 94%, similar to the PRAMS initiation rate of 94.9% [15]. The rate of any HMF at two months, 78%, also is similar to the data reported by PRAMS [16]. There is no disaggregated state data reporting HMF rates among NH in Hawai‘i at four or six-months postpartum. This complicates the interpretation of HMF rates within this cohort. However, the present study was not sampled to be representative of the whole NH population and in combination with high loss to follow-up, nevertheless these results should be interpreted with care.

A prenatal intention of HMF, and a higher maternal educational attainment were found to be significant positive predictors of HMF. WIC participation and SNAP recipiency were found to be negative predictors of HMF. Contrary to other research, factors such as maternal age, maternal BMI, employment, maternity leave, mode of delivery, place of delivery, and parity were not found to be significantly associated with HMF initiation and duration [17–20, 23, 25, 26]. There are a number of possible contributors to this. The study was not powered to detect significant differences in the factors listed previously. Additionally, smaller sample sizes are less likely to produce low *p*-values [42]. Further, this study focused on a single ethnic group, and while this group is underrepresented in research [13, 14], the cultural differences and environmental factors unique to NH populations may have influenced these results.

Prenatal intention to HMF was found to be a significant predictor of the initiation and continuation

Table 1 Characteristics of the Native Hawaiian mother-infant dyads who participated at the birth, two-month postpartum, four-month postpartum, and six-month postpartum data collection events

Maternal and Infant Characteristics	Total at birth ($n=85$)	Total at 2 months ($n=60$)[a]	Total at 4 months ($n=50$)[a]	Total at 6 months ($n=42$)[a]
Mother's age in years, *n*(%)				
≤ 20	7(9)	3(5)	3(6)	1(2)
21–25	17(21)	14(25)	8(17)	9(23)
26–30	20(25)	13(23)	12(26)	10(26)
31–35	26(33)	20(35)	16(34)	12(31)
> 35	10(12)	7(12)	8(17)	7(18)
Mother's pre-pregnancy BMI[b], *n*(%)				
Healthy weight (18.5 ≤ BMI < 25)	20(25)	13(23)	11(23)	8(20)
Overweight (25 ≤ BMI < 30)	28(36)	18(32)	16(34)	15(38)
Obese (BMI > 30)	31(39)	25(45)	20(43)	17(42)
Mother's marital status, *n*(%)				
Married	35(41)	29(48)	27(54)	21(50)
Single, cohabiting with a partner	36(42)	20(33)	17(34)	17(40)
Single, not cohabiting with a partner	11(13)	9(15)	4(8)	2(5)
Divorced/Separated	2(2)	2(3)	2(4)	2(5)
Other[c]	1(1)	0(0)	0(0)	0(0)
Mother's highest level of education *n*(%)				
High school graduate or less	30(35)	16(27)	10(20)	6(14)
Some third-level education	24(28)	20(33)	17(34)	16(38)
Third level degree	31(37)	24(40)	23(46)	20(48)
Mother's employment status, *n*(%)				
Employed	47(55)	36(60)	31(62)	28(67)
Unemployed	26(31)	15(25)	10(20)	7(17)
Homemaker	10(12)	7(12)	7(14)	6(14)
Student	2(2)	2(3)	2(4)	1(2)
WIC[d] participant, *n*(%)				
Yes	23(38)	23(38)	16(34)	11(29)
No	37(62)	37(62)	31(66)	27(71)
SNAP[e] recipient, *n*(%)				
Yes	26(43)	26(43)	17(34)	12(32)
No	34(57)	34(57)	30(60)	26(68)
Primiparous, *n*(%)				
Yes	6(7)	5(8)	5(10)	5(12)
No	79(93)	55(92)	45(90)	37(88)
NH[f] cultural identity score, *n*(%)				
< 9	68(80)	47(78)	38(76)	31(74)
≥ 9	17(20)	13(22)	12(24)	11(26)
US[g] mainland identity score, *n*(%)				
< 12	45(53)	34(57)	29(58)	23(55)
≥ 12	40(47)	26(43)	21(42)	19(45)
Prenatal intention to HMF[h], *n*(%)				
Yes	72(85)	51(85)	44(88)	36(86)
Maybe/Uncertain	9(10)	7(12)	5(10)	5(12)
No	4(5)	2(3)	1(2)	1(2)
Infant's sex, *n*(%)				
Male	45(53)	31(52)	28(56)	21(50)
Female	40(47)	29(48)	22(44)	21(50)

Table 1 (continued)

Maternal and Infant Characteristics	Total at birth (*n* = 85)	Total at 2 months (*n* = 60)[a]	Total at 4 months (*n* = 50)[a]	Total at 6 months (*n* = 42)[a]
Mode of infant delivery, *n*(%)				
Vaginal delivery	64(75)	44(73)	34(68)	28(67)
Cesarean section	21(25)	16(27)	16(32)	14(33)
Delivery at BFHI[i] designated center, *n*(%)				
Yes	2(2)	2(3)	2(4)	1(2)
No	83(98)	58(97)	48(96)	41(98)
Infant fed any HM[j], *n*(%)				
Yes	80(94)	47(78)	38(76)	32(76)
No	5(6)	13(22)	12(24)	10(24)
Infant FF[k], *n*(%)				
Yes	39(46)	39(65)	28(56)	26(62)
No	46(54)	21(35)	22(44)	16(38)
Maternity leave, *n*(%)				
Yes	43(50)	34(57)	28(56)	26(62)
No	16(19)	8(13)	6(12)	5(12)
N/A[l]	26(31)	18(30)	16(32)	11(26)

[a] The *n* changes across the variables due to loss to follow-up between time points

[b] BMI = Body Mass Index

[c] Other = Participant answered that they had a partner, no indication of whether they were cohabiting or not

[d] WIC = The Special Supplemental Nutrition Program for Women, Infants, and Children

[e] SNAP = Supplemental Nutrition Assistance Program

[f] NH = Native Hawaiian

[g] US = United States

[h] HMF = Human milk feeding

[i] BFHI = Baby-Friendly Hospital Initiative

[j] HM = Human milk

[k] FF = Formula fed

[l] N/A = Non-applicable

of HMF until two months postpartum. Research has established that an older maternal age and adequate prenatal HMF education predict a higher likelihood of having a prenatal intention to HMF [43]. This suggests that mothers who are educated about HMF prenatally are more likely to intend on HMF, subsequently increasing the likelihood of HMF. However, prenatal education on HMF in the state of Hawai'i has been found to be inadequate [44]. In another study, a cohort of NH mothers previously identified that prenatal preparation for HMF by healthcare professionals was imperative in creating a supportive HMF environment within the community [45]. Staff shortages, high costs of private lactation consultations, and insufficient availability of appointments have been identified as barriers to prenatal care in Hawai'i [44]. Increasing the availability of these resources and reducing the associated costs may enable more NH mothers to gain access to prenatal care and HMF education. The costs affiliated with improving prenatal care in Hawai'i could be offset with the reduction in costs associated with not HMF, and ultimately contribute to a reduction in the high rates of non-communicable disease among people who identify as NH [1, 13, 46].

The finding that higher maternal education achievement is a significant predictor of any HMF at two-months and four-months postpartum aligns with the literature [20]. However when adjusted for confounders in this study it was no longer significant, suggesting moderation between the independent variables. This is likely due to the strong association between education status and other variables, such as maternal age [22]. Maternal educational attainment is a more difficult factor to target when creating health interventions, as it not easily modified by general interventions. Targeting supports of HMF and prenatal education especially among mothers who did not progress beyond a high school education may be beneficial in increasing HMF rates among this group.

The relationship between WIC participation and HMF outcomes is complex, and results from research remain

Table 2 Comparative analysis[a] of any HMF initiation and any HMF at two-months, four-months, and six-months postpartum, and characteristics of the mother infant-dyads ($n = 85$)

Maternal and Infant Characteristics	Initiation of any HMF	Any HMF at two months postpartum	Any HMF at four months postpartum	Any HMF at six months postpartum
Mother's age in years	0.463[b]	0.888[b]	0.299[b]	0.272[b]
Mother's pre-pregnancy BMI[d]	0.844[b]	0.065[b]	0.662[b]	0.180[b]
Mother's marital status	0.088[b]	0.276[b]	0.820[b]	0.314[b]
Mother's highest level of education	0.126[b]	**0.007****[b]	**0.024***[b]	0.198[b]
Mother's employment status	0.237[b]	0.471[b]	0.500[b]	1.00[b]
WIC[e] participation	0.595[b]	**0.021***[b]	**0.045***[b]	0.102[b]
SNAP[f] recipiency	0.609[b]	**0.006****[c]	0.563[b]	0.862[b]
Primiparous	0.313[b]	0.575[b]	1.00[b]	0.577[b]
NH[g] cultural identity score	0.578[b]	0.713[b]	0.248[b]	1.00[b]
US[h] mainland identity score	0.364[b]	0.387[c]	0.520[c]	1.00[b]
Prenatal intention to HFM[i]	**< 0.001*****[b]	**0.001****[b]	0.141[b]	0.135[b]
Infant's sex	0.364[b]	0.859[c]	0.128[c]	1.00[c]
Mode of infant delivery	1.00[b]	0.481[b]	0.728[b]	0.259[b]
Delivery at BFHI[j] designated center	1.00[b]	1.00[b]	1.00[b]	0.594[b]
Maternity leave	0.263[b]	1.00[b]	0.807[b]	0.748[b]

[a] Results are given as *p*-values

[b] Comparative analysis conducted using Fisher's Exact tests

[c] Comparative analysis conducted using Chi-square tests

[d] BMI = Body Mass Index

[e] WIC = The Special Supplemental Nutrition Program for Women, Infants, and Children

[f] SNAP = Supplemental Nutrition Assistance Program

[g] NH = Native Hawaiian

[h] US = United States

[i] HMF = Human milk feeding

[j] BFHI = Baby-Friendly Hospital Initiative

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

inconsistent. Those not participating in WIC were more likely to be HMF at two-months and four-months postpartum, and these results are consistent with other research [29]. Some studies argue that WIC participation does not influence HMF, or that it positively affects HMF outcomes [47, 48]. The reasons for conflicting evidence is unclear. The negative association between HMF duration and WIC participation, as found in this research, may be influenced by a number of factors [49, 50]. As a low-income population, WIC participants are less likely to work in roles that entitle employees to paid maternity leave, and are less likely to have the resources to take unpaid maternity leave. Upon return to work, WIC participants are less likely to have the time and appropriate space to pump HM. The inability to pump while working decreases the likelihood of HMF [51, 52]. Research has suggested that HMF interventions aimed at WIC participants should be tailored to the mothers' ethnicity. Reasons for HMF cessation varied between ethnicities in a sample of WIC participants [53]. A re-evaluationof the WIC program in Hawai'i is needed to determine what type of lactation support is needed, with a focus of introducing culturally appropriate and tailored interventions to encourage a longer HMF duration may be of benefit.

Participants who were not receiving SNAP benefits were found to have a significantly higher likelihood of any HMF at two-months postpartum in the crude analysis. This finding has not been reported in other studies examining the determinants of HMF initiation and duration. The negative association between HMF and SNAP recipiency may have occurred for a number of reasons. For example, food insecurity has been associated with a shorter HMF duration [54]. Similarly to WIC participants, SNAP recipients are low-income [47], and parents who are in receipt of SNAP benefits are less likely to have a higher educational attainment [55].

This study's results support the belief that determinants of HMF among NH mother-infant dyads are complex and closely related. Given that some predictors were no longer significant post-adjustment, the results suggest

Table 3 Multivariate analysis with accompanying forest plot examining predictors of human milk feeding (HMF) initiation at baseline ($n = 85$)

	Forest Plot	Adjusted Analysis [a]	
		OR	95% CI
Prenatal intention to HMF	Decreased Odds of Initiation / Increased Odds of Initiation		
No/uncertain (Ref)[b]		1.00	-
Yes		**64.18****	2.94, 400.28
Mother's employment status			
Employed (Ref)[b]		1.00	-
Unemployed/Homemaker/student		0.26	0.014, 4.60
Mother's highest level of education			
High school graduate or less (Ref)[b]		1.00	-
Some college education or more		0.59	0.04, 8.74
Mother's marital status			
Married/Cohabiting with a partner (Ref)[b]		1.00	-
Not married/not cohabiting		0.39	0.018, 8.32
Mother's pre-pregnancy BMI [c]			
Healthy weight (18.5≤ BMI <25) (Ref)[b]		1.00	-
Overweight or obese (25≤ BMI)		0.34	0.014, 8.28
Mother's age in years	-1 0 1 2 3 4 5 6 7 8 9 10		
≤30 (Ref)[b]		1.00	-
>30		0.19	0.1, 3.50

[a] Adjusted odds ratio was based on multivariate logistic regression adjusting for age, pre-pregnancy BMI, marital status, education level, employment status and prenatal intention to HMF.
[b] Ref.= Reference group
[c] BMI= Body Mass Index
** $p<0.01$

[a] Adjusted odds ratio was based on multivariate logistic regression adjusting for age, pre-pregnancy BMI, marital status, education level, employment status and prenatal intention to HMF
[b] Ref. = Reference group
[c] BMI = Body Mass Index
** $p<0.01$

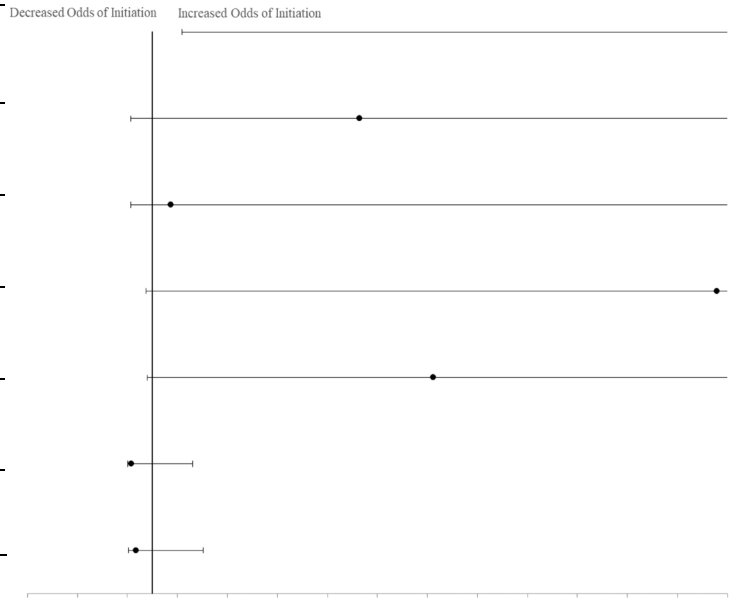
moderation between the independent factors [56]. While a direct measure of income was not used in this study, some indicators of income (e.g. SNAP recipiency) were found to be associated with HMF outcomes [47, 57, 58]. This suggests that there may be a correlation between income and HMF duration within this cohort.

A strength of this study is that it investigates a group that is underrepresented in research given the lack of disaggregated national and state data. Disaggregation of data by race and ethnicity should be the standard of practice for research going forward [59]. Furthermore, this study investigated HMF rates at four and six months postpartum, unlike PRAMS. Therefore this research will add to the current body of knowledge involving NH populations.

The statistical power of this analysis may have been limited due to the small sample size. Factors often found to be associated with HMF in research were not found to be associated with HMF in this study. When conducting regression analysis, predictor groups had to be merged into dichotomous variables to provide sufficient quantity for analysis, at the cost of loss of participant distinctiveness. Wide confidence intervals were calculated in logistic regression, which suggests a large margin of error. As a result, while some significant associations were found, definitive conclusions cannot be determined. While the small sample size proves to be a limitation, this study contributes to the current literature as there is data lacking for the NH population in relation to HMF. More research is required to further discover potential determinants of HMF among

Table 4 Multivariate analysis with accompanying forest plot examining predictors of any human milk feeding (HMF) at two months postpartum ($n = 60$)

	Forest Plot	Adjusted Analysis [a]	
		OR	95% CI
Prenatal intention to HMF			
No/uncertain (Ref)[b]		1.00	-
Yes		**231.55***	2.18, 24618.3
SNAP [c] recipient			
Yes (Ref)[b]		1.00	-
No		9.29	0.123, 702.43
WIC [d] participant			
Yes (Ref)[b]		1.00	-
No		1.73	0.032, 92.92
Mother's employment status			
Employed (Ref)[b]		1.00	-
Unemployed/Homemaker/student		23.59	0.751, 741.4
Mother's highest level of education			
High school graduate or less (Ref)[b]		1.00	-
Some college education or more		12.23	0.79, 189.33
Mother's marital status			
Married/Cohabiting with partner (Ref)[b]		1.00	-
Not married/not cohabiting		0.16	0.01, 2.61
Mother's age in years			
≤30 (Ref)[b]		1.00	-
>30		0.34	0.04, 3.03



[a] Adjusted odds ratio was based on multivariate logistic regression adjusting for age, pre-pregnancy BMI, marital status, education level, employment status, WIC participation, SNAP recipiency, and prenatal intention to HMF.
[b] Ref.= Reference group
[c] SNAP= Supplemental Nutrition Assistance Program
[d] WIC= The Special Supplemental Nutrition Program for Women, Infants, and Children
* $p < 0.05$

[a] Adjusted odds ratio was based on multivariate logistic regression adjusting for age, pre-pregnancy BMI, marital status, education level, employment status, WIC participation, SNAP recipiency, and prenatal intention to HMF
[b] Ref. = Reference group
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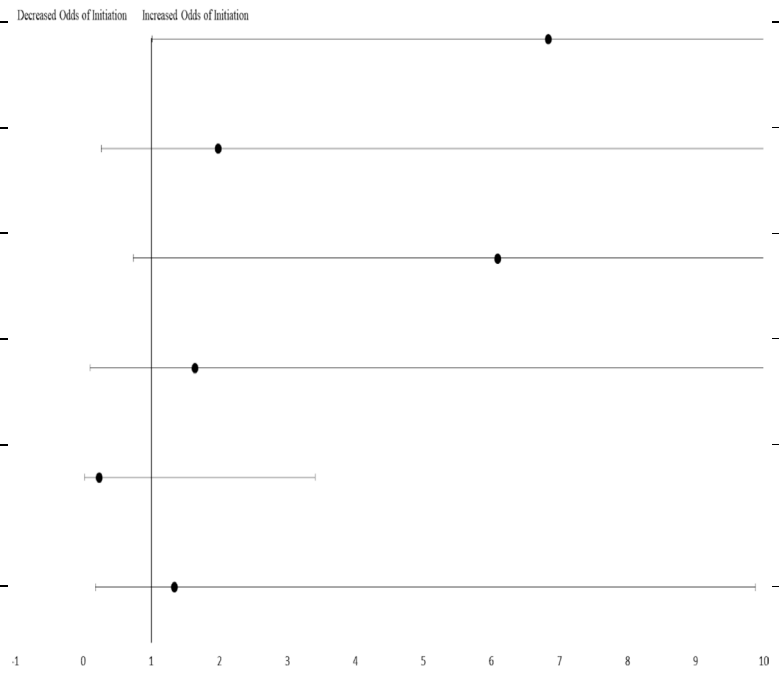
* $p < 0.05$

marginalized populations, such as the NH population [60]. This research may benefit further from additional qualitative study that may enable a deeper examination of the perceptions of NH of various socio-economic backgrounds on HMF, and if these perceptions influence the likelihood of HMF.

This study exhibited a high loss to follow-up. Between the birth and six-month questionnaires, half of the participants were lost to follow up. The COVID-19 pandemic may have contributed to this considerable loss to follow-up [61]. This study was designed prior to the COVID-19 pandemic, and changes to study design had to occur in response. High loss to follow-up can result in attrition bias- a systematic bias that occurs when the characteristics of those who remain in a study differ from those who drop out [62]. Future research in this population should incorporate additional contingency planning that is informed by the population of interest to prevent high numbers of loss to follow-up. Across all time-points, the majority of participants in the present study were older and highly educated. This aligns with the literature that suggests older, highly educated participants tend to enroll in and remain in studies [63, 64]. The characteristics of those who are more likely to remain in longitudinal studies are consistent with the characteristics of those who tend to HMF for a longer duration [17, 20, 21], which may have influenced the HMF rates across time points. A similar longitudinal study involving pregnant women in Australia identified that participants who identified as Aboriginal/Islander had a higher likelihood of being lost to follow-up [65]. As ethnic minorities, Aboriginal and NH people are underrepresented in research and are more likely to face health inequalities [65]. Sampling bias is another possible limitation. Eligibility criteria included access to a smartphone which may have excluded those living in

Table 5 Multivariate analysis with accompanying forest plot examining predictors of any HMF at four months postpartum ($n = 50$)

	Forest Plot	Adjusted Analysis [a]	
		OR	95% CI
WIC [c] participant			
Yes (Ref)[cb]		1.00	-
No		**6.83***	1.01, 46.23
Mother's employment status			
Employed (Ref)[b]		1.00	-
Unemployed/Homemaker/student		1.98	0.27, 14.80
Mother's highest level of education			
High school graduate or less (Ref)[b]		1.00	-
Some college education or more		6.09	0.74, 49.92
Mother's marital status			
Married/Cohabiting with a partner (Ref)[b]		1.00	-
Not married/not cohabiting		1.64	0.10, 25.83
Mother's pre-pregnancy BMI [d]			
Healthy weight (18.5≤ BMI <25) (Ref)[b]		1.00	-
Overweight or obese (25≤ BMI)		0.23	0.02, 3.41
Mother's age in years			
≤30 (Ref)[b]		1.00	-
>30		1.34	0.18, 9.88



[a] Adjusted odds ratio was based on multivariate logistic regression adjusting for age, pre-pregnancy BMI, marital status, education level, employment status and WIC participation.

[b] Ref.= Reference group

[c] WIC= The Special Supplemental Nutrition Program for Women, Infants, and Children

[d] BMI= Body Mass Index

* $p < 0.05$

[a] Adjusted odds ratio was based on multivariate logistic regression adjusting for age, pre-pregnancy BMI, marital status, education level, employment status and WIC participation

[b] Ref. = Reference group

[c] WIC = The Special Supplemental Nutrition Program for Women, Infants, and Children

[d] BMI = Body Mass Index

* $p < 0.05$

more rural areas of Hawai'i, or lower income participants who cannot access such devices. However, with over 83% of households in the state of Hawai'i having access to a smartphone, tablet, or other portable wireless computer or other computer in 2016 we expect this bias may be minimal [66]. In addition, gestational age was not analyzed as a predictor of the initiation or duration of HMF. Gestational age may be beneficial to include in future analysis as gestational age can act as an influence on the likelihood of HMF [19].

Conclusions

These findings contribute valuable information that can be used to guide future policymaking and interventions to optimize health outcomes in NH mothers and infants. Encouraging a longer duration of HMF among NH may contribute towards reducing rates of non-communicable disease in both mothers and infants. Further research into determinants of HMF among NH populations would be of benefit to fully establish why there are consistently lower rates of HMF within this group. While limited by a small sample size and high loss to follow-up, this study has established potential determinants of HMF initiation and duration in NH mother-infant dyads. Future studies should consider recruiting a larger sample size, develop contingencies to minimize loss to follow-up, and incorporate mixed methods. A larger sample size may also enable future researchers to examine determinants of exclusive HMF.

Abbreviations

AAP	American Academy of Pediatrics
BF	Breastfeeding
BFHI	Baby-Friendly Hospital Initiative
BMI	Body mass index
CDC	Centers for Disease Control and Prevention
FF	Formula fed
HM	Human milk
HMF	Human milk feeding
IF	Infant formula
IRB	Institutional Review Board
NH	Native Hawaiian
PRAMS	Pregnancy Risk Assessment Monitoring System
SNAP	Supplemental Nutrition Assistance Program
US	United States
WHO	World Health Organization
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children

Acknowledgements
The authors would like to thank the study participants and community partners for their contributions to this study. The authors would also like to thank retired University of Hawai'i Cancer Center faculty member Dr. Carol J. Boushey for her advisement during the study.

Authors' contributions
Conceptualization, M.K.F and M.M.; methodology, M.M., J.K, and M.K.F; formal analysis, M.M, M.K.F, and M.R.; investigation, M.M and M.K.F.; resources, M.K.F, J.K, L.K., B.K. and A.D; funding acquisition, M.K.F; writing—original draft preparation, M.M.; writing—review and editing, M.M, J.K, A.D, L.K, M.R, J.K, B.K, E.O'B, F.Z. and M.K.F; supervision, M.K.F, J.K, and E.O'B; All authors have read and agreed to the published version of the manuscript.

Funding
This project was supported by grant number U54MD007601 from the National Institute on Minority Health and Health Disparities (NIMHD), USDA Multi-State Hatch Formula Grant project 2067R, and the NCI, National Cancer Institute, grant number P30CA071789.

Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Informed consent was obtained from all participants involved in the study. The study was conducted in accordance with the Declaration of Helsinki, and approved initially by the Institutional Review Board of WCG (protocol number 2019–088, date of approval November 20, 2019) then transferred to the University of Hawai'i at Mānoa (protocol number 2021–00437, date of approval July 16, 2021).

Competing interests
The authors declare no competing interests.

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Received: 2 February 2024 Accepted: 20 July 2024
Published online: 03 August 2024

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