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A Bayesian Binary Logistic Regression Approach in Identifying Factors Associated with Exclusive Breastfeeding Practices at Arba Minch Town, South Ethiopia

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Authors' contributions

This work was carried out in collaboration between two authors. Authors BBA and TTH designed the study, managed the literature searches, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: To assess the prevalence and the factors associated with the exclusive breast feeding practices among women with infants less than six months of age at Arba Minch town in order to fill the existing information gap in the area.
Study Design: Community based cross sectional study design and a single stage simple random sampling technique was used to select a sample.
Methodology: A sample of 330 women was determined among mothers with infants less than six months of age using a formula for estimation of single population proportion. Descriptive analysis was used to estimate the prevalence and potential predictors were selected by bivariate analysis using chi-square test of association between exclusive breast feeding practices and each predictor. Bayesian binary logistic regression analysis was employed to identify the factors affecting exclusive breast feeding.
Results: From a sample of 330 women with infants of less than six months of age, the prevalence of exclusive breastfeeding practice was found to be 53.9 %. From binary logistic regression analysis

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based on the Bayesian 95% credible intervals, age of mothers, mother's educational status, use of antenatal care service during pregnancy, birth orders of the child, exclusive breastfeeding counseling during pregnancy, use of postnatal care, timely initiation of breastfeeding, and attitude towards breast feeding were found to be statistically significant factors affecting exclusive breastfeeding since the credible intervals of posterior mean given by the MCMC method did not include 0.

Conclusions: Use of antenatal care during pregnancy, counseling about the benefits of exclusive breast feeding during pregnancy, awareness about exclusive breast feeding, timely initiation of breastfeeding and attitude towards breast feeding were factors that affected exclusive breast feeding practices among women.

Keywords: Exclusive breast feeding; Bayesian logistic regression; Markov chain Monte Carlo; posterior distribution; odds ratio; credible interval.

ABBREVIATIONS

OR : odds ratio;
ANC : antenatal care;
DHS : Demographic and health survey;
PNC : postnatal care;
EBF : Exclusive breastfeeding;
WHO : World Health Organization;
ETB : Ethiopian Birr;
SPSS : Statistical package for social science.

1. INTRODUCTION

Breast milk is a safe and nutritive diet for the healthy growth and development of infants. The World Health Organization (WHO) recommends that all mothers should breastfeed their children exclusively for the first six months and continued breastfeeding for two years with the introduction of a complementary diet at six months of age [1-3]. Breastfeeding is an important public health strategy to reduce infant, child and maternal morbidity and mortality and helps to control health care costs [4].

According to the research conducted in 29 African countries using 2010-2015 Demographic and Health Survey (DHS) of the countries surveyed, the overall prevalence of exclusive breast feeding was 41.07%. From this study, Ethiopia accounted 53.1% of exclusive breast feeding using 2011 DHS [5]. According to Ethiopia DHS 2016, exclusive breastfeeding of children under 6 months in Ethiopia was 58% [6].

Despite its demonstrated benefits, EBF duration in many countries including Ethiopia are lower than the international recommendation of exclusive breastfeeding for the first six months of life, especially in urban areas [7, 8]. As a country, Ethiopia has also done initiatives to promote, support and protect optimal breastfeeding practices for infants 0–6 months at community and facility level through individual and group counseling that follow international recommendations to infants and child. In 2016, the Ministry of Health (MoH) established the National Nutrition Programme II [9] and Multi-sectoral National Nutrition Program II [10] to Improved Nutritional Status of Infants and Young Children 0-23 Months. Under these strategies mothers were encouraged to breastfeed exclusively until the child is age 6 months without adding any water, other fluids or foods, and to continue breastfeeding until the child turns age 2. Strategies to protect, promote, and support exclusive breastfeeding are needed at the national health center and community levels [11].

Globally, 60% of infant and young child deaths occur due to in appropriate infant feeding practices and infectious disease from which two third of these deaths are attributable to sub optimal breast feeding practices. Inappropriate infant feeding practice could have negative effect on child growth and development, especially in developing countries, where accessibility of basic health serves is not sufficient [12]. Several studies documented that the socio-demographic characteristics including maternal age, educational status, marital status of mothers, employment and household income were identified as factors influencing EBF practice [13–18]. It was also showed that the routine maternal and child health services namely antenatal, delivery, postnatal and infant feeding counselling were positively associated with EBF.

In many literatures classical binary logistic analysis have been employed to identify factors associated with exclusive breast feeding practice. In classical statistics, the analysis of the logistic regression model is based on estimating parameters through Maximum Likelihood Estimation (MLE) and given the asymptotic properties, MLE in small samples encounters

with serious inferential problems. In such a case the Bayesian approach has an advantage that estimation of the model parameters is conducted on the basis of their posterior distribution which is the combination of observed data and information from previous studies or personal experiences that are known as prior distribution [19]. Therefore, the aim of this study was to assess the prevalence and the factors associated with the exclusive breast feeding practices among women with infants less than six months of age using Bayesian binary logistic regression model at Arba Minch town in order to fill the existing information gap in the area.

2. METHODOLOGY

2.1 Study Design and Setting

Study Area and Population: The study was conducted in Arba Minch town which is found in Gamo Gofa zone in southern nation's nationalities and people's regional state (SNNPRS). It is situated at 505 km to south of Addis Ababa. According to Central Statistical Agency in 2007 population and housing census, the population size of Arba Minch town was 74, 879, of whom 39,208 are men and 35,671 women residing in four sub city administrations namely Sikela, Secha, Abaya and Nech Sar [20]. The target populations for this study were all mothers with a child/children aged less than 6 months and who were the usual residents of the Arba Minch town.

Method of Data collection: A Community based cross-sectional study design was used among mothers who had infants of aged less than months. For data collection, training was given to all data collectors on the data collection tool and procedure. Primary data were collected by face-to-face interview using pre-tested open-ended and close ended questionnaires on the exclusive breast feeding practice and socio-economic and demographic variables. The questionnaires were prepared in English and translated to Amharic. Whole data collection process was coordinated and supervised by investigators.

Sampling Techniques and Sample Size Determination: A single stage simple random sampling method was used to select households from study area. Finally, eligible women who had infants of aged between 0 and 6 months in the selected households were asked to participate in the study. When two or more women were in a household, only one of them was selected randomly and asked to participate, to avoid intra-class correlation. A sample size of 314 was determined using the formula for single population proportion [21] based on prevalence of EBF of 71.3% from study conducted in Goba district which is located in south east Ethiopia [18]. Moreover, at 5% margin of error and 95% confidence coefficient with 5% contingency for non-response [16], a total sample size of 330 women were considered.

Variables in the Study: The dependent variable was exclusive breastfeeding practice of mothers for the first six months and coded as '1' for those mothers who had not been practiced EBF while '0' for those mothers who had been practiced EBF for the first six months. The independent variables were socio-economic, demographic and related with maternal health care services. The choice of these variables was guided by literatures on the determinants of exclusive breastfeeding practice of mothers for the first six month. They were: age group of mothers (years), religion of mothers, marital status of the mothers, maternal educational status, maternal occupation, average monthly family income (in ETB), place of delivery, use of antenatal and postnatal care services, birth order of the child, awareness about the health benefits of breastfeeding, number of children, attitude towards EBF, exposure to media about EBF, initiation of breastfeeding within one hour after childbirth, mode of delivery, place of delivery, birth weight of the child and breast feeding counseling at health facility during delivery.

2.2 Method of Data Analysis

Bayesian Binary Logistic Regression Model: The binary logistic regression model is used to explain the probability of a binary response variable as a function of some covariates [22, 23]. In this study, the dependent variable Y_i considered was dichotomous as 1 for those mothers who were non-EBF and 0 for those mothers who had EBF practice, binary logistic regression model with Bayesian approach was adopted to examine the effect of the predictors on the response variable, exclusive breast feeding practice. For binary response variable Y, binary logistic regression model with logit link function has the form (1):

$$\log\left(\frac{P_i}{1-P_i}\right) = \beta_o + \beta_1 X_{i1} + \beta_2 X_{i2} + ... + \beta_p X_{ip} \quad .....(1)$$

where, P_i = the probability that the i^{th} woman to be non-EBF, Y_i = the observed status of exclusive breast feeding practice for the i^{th} woman, $X_1, X_2, ..., X_p$ are set of independent variables and $\beta = (\beta_0, \beta_1, ..., \beta_p)^T$ are vector of unknown binary logistic regression parameters. In classical approach, the analysis of the logistic regression model is based on estimating parameters of the model through Maximum Likelihood Estimation (MLE) and calculating an estimate using expectation maximization algorithm. In such method, it is possible to evaluate local maximum instead of general MLE without calculating the convergence of the model. Furthermore, given the asymptotic properties, MLE in small samples encounters with serious inferential problems. However, in Bayesian method, inference about the model parameters is conducted on the basis of their posterior distribution which is the combination of the likelihood function of observed data and information from previous studies or personal experiences that are known as prior distribution [19]. This approach was applied to a binary logistic regression model taking account of the uncertainty in the parameters to identify the determinants of exclusive breast feeding practice at Arba Minch town. In fitting Bayesian binary logistic regression model, potential predictors were selected by bivariate analysis using chi-square test of association between exclusive breast feeding practice and each of the predictors. Those predictors that showed p-value less than 0.25 were taken to the model to identify the determinants of exclusive breast feeding practice in Bayesian binary logistic regression analysis. A cutoff value of 0.25 is supported by literature [24,25] since more traditional levels such as 0.05 can fail in identifying variables known to be important.

Furthermore, the idea of Bayesian statistics within the context of life data analysis is to integrate prior knowledge, along with a given set of current observations, in order to make statistical inferences. The advantages of Bayesian inference are well known and include elicitation of prior beliefs about past experience, avoidance of asymptotic approximations and practical estimation of functions of parameters [26,27]. Bayesian inference assumes that the data are fixed and consider all unknown parameters as random variables [27]. This method also allows a detailed inference from parameters and can be obtained for any arbitrary sample size. To progress with the Bayesian analysis it is necessary to provide a likelihood function for the data and joint prior distribution over the parameter space. Hence, for data from individual subjects which are assumed to be independent from each other, the likelihood function over a data set of sample of size n subjects, the likelihood function for data $y = (y_1, y_2, \dots, y_n)^T$ is:

$$prob(y \mid \beta) = L(\beta \mid y) = \prod_{i=1}^{n} \left[P_i^{y_i} (1 - P_i)^{(1-y_i)} \right]$$

$$= \prod_{i=1}^{n} \left(\frac{e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}}{1 + e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}} \right)^{y_i} \left(1 - \frac{e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}}{1 + e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}} \right)^{(1-y_i)} \quad (2)$$

Moreover, one of the preconditions in any Bayesian analysis is the choice of a prior and the most common prior choice for logistic regression parameters is normal distribution with mean μ_j and with variance σ^2_j and has the form: $\beta_j \sim N(\mu_j, {\sigma_j}^2)$. Mathematically, prior distribution for logistic regression parameters has the form (3):

$$P(\beta_j) = \frac{1}{\sqrt{2\pi {\sigma_j}^2}} \exp\left\{ \frac{-1}{2} \left(\frac{\beta_j - \mu_j}{{\sigma_j}^2} \right)^2 \right\} \quad (3)$$

The most common choice for prior mean μ_j is 0 for all the coefficients and large enough prior variance σ^2_j. Hence, in this paper, due to due to lack of past information for the prior distribution of regression coefficients, non-informative normal prior distribution with the prior distribution parameters of mean value 0 and variance of 1000 was considered. Then, for the choice of non-informative independent normal priors and likelihood function for the data, posterior distribution of model parameters which is the product of the equation (3) and (2) has the form (4 and 5):

$$P(\beta \mid y) = \prod_{j=0}^{p} \left[P(\beta_j) \right] * \prod_{i=1}^{n} \left[L(\beta \mid y) \right] \quad (4)$$

$$= \prod_{j=0}^{p} \frac{1}{\sqrt{2\pi {\sigma_j}^2}} \exp\left\{ \frac{-1}{2} \left(\frac{\beta_j - \mu_j}{\sigma_j} \right)^2 \right\} . *$$

$$\prod_{i=1}^{n} \left[\left(\frac{e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}}{1 + e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}} \right)^{y_i} \left(1 - \frac{e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}}{1 + e^{\beta_o + \beta_1 x_1 + \dots + \beta_p x_p}} \right)^{(1-y_i)} \right] \dots (5)$$

Clearly the above posterior distribution is a complex function of the parameters and numerical methods are needed in order to obtain the marginal posterior distribution for each of the model parameters. The most popular method is simulating from a general posterior distribution is by using Markov Chain Monte Carlo (MCMC) simulation methods [28]. Hence, in this study a Markov chain Monte Carlo (MCMC) method by Gibbs sampling was used to simulate samples from the posterior distribution and implemented on WinBugs software. The empirical results from a given MCMC analysis are not deemed reliable until the chain has reached its stationary distribution. On account of this, the term convergence of an MCMC algorithm refers to whether the algorithm has reached its target distribution. Hence, monitoring the convergence of the algorithm is essential for producing results from the posterior distribution of interest [29]. Among several ways the most popular and straight forward convergence assessment methods; time series(history) plot, density plot, Monte Carlo standard errors and Gelman-Rubin statistic[30] were used to assess whether the sample has reached its stationary distribution or not. Summary statistics (posterior mean, standard error of posterior mean, odds ratio of posterior mean and credible interval of posterior mean) was computed for each parameter. Finally, the importance of each of the explanatory variables is assessed by carrying out statistical tests of the significance of the regression coefficients (posterior mean) via 95% Bayesian credible interval of the posterior mean [31]. Furthermore, descriptive analysis was also used to estimate the prevalence of exclusive breast feeding practices and to describe variables related with socio-economic, demographic and maternal health care services with respect to EBF practices in the study area.

3. RESULTS AND DISCUSSION

The data were entered, cleaned and explored for outliers, missing values and any inconsistencies and then analyzed using SPSS version 20 and WinBugs software for Bayesian analysis as the results are depicted subsequently.

3.1 Descriptive Analysis

The data used for the study were obtained from a random sample of 330 mothers with a child/children aged less than 6 months in Arba Minch town, Gamo Gofa zone in the southern part of Ethiopia. It was found that from a total of 330 sampled mothers, 178(53.9%) of women were practiced EBF while 152(46.1%) were not practiced EBF for the first 6 months. In the current study, the prevalence of exclusive breast feeding (53.9 %) was higher than that of study done at Bahir Dar city, Ethiopia (50.3%) [13]; however, it was lower than Ethiopian DHS 2016 at country level (58%) [6], study done at Arba Minch Zuria, Ethiopia (55.6%) [16], Jimma Arjo Woreda, Ethiopia (75.4%) [17] and Goba District, Ethiopia (71.3%) [18]; this was attributed to various socio-economic, demographic and maternal health care related factors.

Table 1 shows count and percentage of mothers who practiced EBF by socio- economic, demographic and some related variables with maternal health care services in Arba Minch town. Among 330 sampled mothers, 49(14.8%) and 120(36.4%) of them were in the age group of 15-25 and 26-35 years who were practiced EBF, respectively. Regarding marital status, 42.7% of married and 11.2% of unmarried women were practiced EBF. Concerning the educational level of mothers, 15.5% were uneducated, 14.8% were attended primary school, 6.7% were attended secondary school and 17.3% attended college and above education were practiced EBF. Table 1 also revealed that about 14.8% of mothers had average family monthly income of below 2000 ETB, 14.5% of mothers had 2000-4000 ETB and 18.5% of mothers had above 4000 ETB were practiced EBF.

With respect to ANC, about 45.8% of mothers who used ANC service were practiced EBF and 8.2% of mothers who not used ANC service were practiced EBF. Regarding mothers awareness about EBF, about 40.6% of women who were aware of the benefits of EBF were practiced EBF while 13.3% of women who had no awareness about the benefit of EBF were practiced EBF. Of those who practiced EBF among 330 mothers, 34.2% of them responded that they have positive attitude toward practicing of EBF and 19.7% replied that they have negative attitude toward EBF practiced EBF. Furthermore, 45.8% and 8.2% of mothers who fed their child in the first one hour after birth reported that they had practiced EBF and had not practiced EBF, respectively. Moreover, about 10.6% of women were delivered by SVD, 23.3% by caesarean and 20% delivered by instrument practiced EBF.

3.2 Bayesian Binary Logistic Regression Analysis

During the Bayesian binary logistic regression analysis, independent variables religion of

mother (p-value=0.890), average monthly income of family (p-value=0.925) and number of children in a family (p-value=0.912) were excluded from Bayesian binary logistic regression model since they showed p-value greater than 0.25 in bivariate analysis using chi-square test of association. After identifying the nominee predictor variables of the EBF practice of mothers, Bayesian binary logistic analysis procedure was used to make inference about the parameters of the model. The Gibbs sampler algorithm was implemented with 60000 iterations in two different chains initialized with over dispersed values defined at 0 (chain 1) and classical logistic regression estimates (chain 2) for all parameters. Then, 15000 burn-in terms discarded, so that the 45000 samples generated from the full posterior distribution are used to make inference about the model parameters. Before undertaking any inference from posterior distribution the convergence of generated Markov chains has been verified by density plot (Fig. 1), Gelman-Rubin Statistics (Fig. 2), time series or history plot (Fig. 3) and precision of the estimated model parameters was checked by comparing the Monte Carlo error to its posterior standard errors (Table 2). Fig. 1 shows density plots for only statistically significant regression coefficients in the model and simulated samples from posterior distribution for each regression coefficient is smooth, uni-modal shape of posterior marginal distribution indicating that simulated parameter value indicates convergence to the target distribution. The density plots for the rest of the parameters (not shown here) also tell a similar story.

Fig. 2 shows plots of Brooks Gelman-Rubin convergence diagnosis statistic and for a given parameter this statistic assesses the variability within parallel chains as compared to variability between parallel chains. The model is judged to have converged if the ratio of between variability to within variability is close to 1. The green line represents the between variability, the blue line represent the within variance and the red line represents the ratio. Evidence for convergence comes from the red line being close to 1on the y-axis. In the plots the red line seems to be exactly on 1 for all regression coefficients, providing evidence for convergence. The Brooks Gelman Rubin convergence diagnosis plots for the rest of the parameters (not shown here) also tell a similar story.

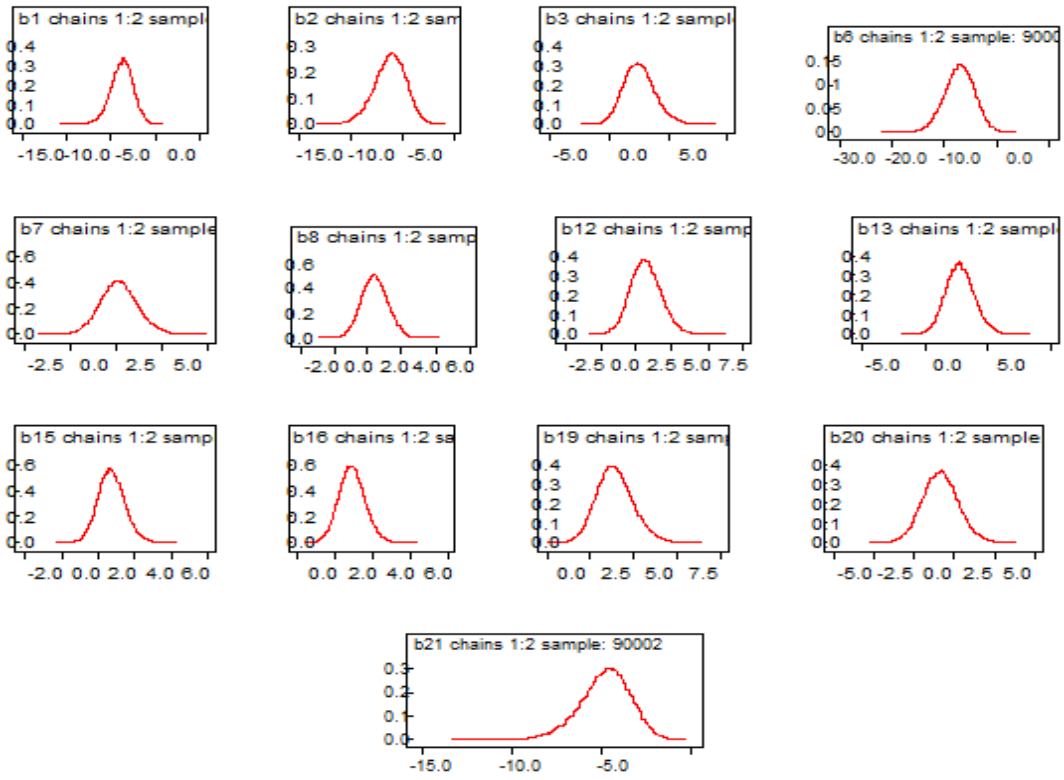

Fig. 1. Density plots for only statistically significant regression coefficients in the model

Table 1. Count and percentage of women who were practiced EBF by independent variables among 330 sampled women (Arba Minch Town, Gamo Gofa Zone, Southern Ethiopia, 2018)

Independent Variables	Categories	Status of EBF Practice		Independent Variables	Categories	Status of EBF Practice	
		Yes	No			Yes	No
		Count (%)	Count (%)			Count (%)	Count (%)
Age Group of Mother	15-25	49(14.8)	34(10.3)	Birth order	First	18(5.5)	55(16.7)
	26-35	120(36.4)	53(16.1)		Second	80(24.2)	47(14.2)
	Above 35	9(2.7)	65(19.7)		Third and above	80(24.2)	50(15.2)
Religion of Mother	Orthodox	40(12.1)	87(26.4)	Use of ANC	Yes	151(45.8)	38(11.5)
	Protestant	25(7.6)	53(16.1)		No	27(8.2)	114(34.5)
	Muslim	20(6.1)	45(13.6)	Media Exposure about EBF	Yes	101(30.6)	34(103)
	Others	22(6.7)	38(11.5)		No	77(23.3)	118(35.8)
Marital Status of Mother	Married	141(42.7)	76(23.0)	Use of PNC	Yes	131(39.7)	75(22.7)
	Unmarried	37(11.2)	76(23.0)		No	47(14.2)	77(23.3)
Educational level of Mother	Uneducated	51(15.5)	59(17.9)	Average monthly income (ETB)	<2000	49(14.8)	50(15.1)
	Primary	48(14.5)	40(12.1)		2000-4000	48(14.5)	53(16.0)
	Secondary	22(6.7)	11(3.3)		Above 4000	61(18.5)	69(20.9)
	College and Above	57(17.3)	42(12.7)	Place of Delivery	Health Institution	134(40.6)	69(20.9)
					Home	44(13.3)	83(25.2)
Occupation of Mother	Housewife	53(16.1)	49(14.8)	Number of Children	Less than 3	75(22.7)	90(27.3)
	Self employed	59(17.9)	62(18.8)		3 and More	76(23.0)	89(27.0)
	Government Employee	66(20.0)	41(12.4)	Awareness about Benefit of EBF	Yes	134(40.6)	49(14.8)
Counseling about EBF	Yes	139(42.1)	52(15.8)		No	44(13.3)	103(31.2)
	No	39911.8)	100(30.3)	Mode of Delivery	SVD	35(10.6)	42(12.7)
Birth Weight (Kg)	Less than 2.5	30(9.1)	110(33.3)		Caesarean	77(23.3)	22(6.7)
	2.5 and above	148(44.8)	42(12.7)		Instrumental	66(20.0)	88(26.4)
Timely initiation	Yes	151(45.8)	68(20.6)	Attitude towards EBF	Positive	113(34.2)	93(28.2)
	No	27(8.2)	84(25.5)		Negative	65(19.7)	59(17.9)

Table 2. Summary statistics (i.e., posterior mean, odds ratio from posterior mean, posterior standard error, Monte Carlo error and 95% credible interval of posterior mean) of the posterior distribution of the model parameters

Predictors	Categories	Posterior mean $(\hat{\beta})$	Odds ratio (i.e., exp($\hat{\beta}$))	Posterior standard error $(\hat{\beta})$	Monte Carlo error	95% Credible interval of posterior mean $(\hat{\beta})$
	Intercept	-5.080		2.731	0.093	
Age group of Women	15-25 (Ref)					
	26-35	-3.810	0.022	1.231	0.020	(-6.371, -1.545)*
	Above 35	-6.168	0.002	1.501	0.029	(-9.337, -3.476)*
Marital Status of women	Unmarried	2.582	13.223	1.298	0.017	(0.236, 5.327)*
	Married (Ref)					
Educational level of mothers	Uneducated (Ref)					
	Primary	1.426	4.162	1.657	0.039	(-1.756, 4.737)
	Secondary	2.026	7.584	1.847	0.056	(-1.494, 5.689)
	College diploma and above	-7.180	0.001	2.796	0.064	(-12.85,-1.933)*
Use of ANC	No	2.647	14.112	0.995	0.015	(0.761, 4.680)*
	Yes (Ref)					
Awareness about EBF	No	2.415	11.190	0.800	0.009	(0.885, 4.026)*
	Yes (Ref)					
Place of Delivery	Health institution	.776	2.173	1.122	0.013	(-1.433, 2.974)
	Home (Ref)					
Occupation of woman	Housewife	-.134	0.874	1.246	0.029	(-2.643, 2.262)
	Government employee	-.275	0.759	1.953	0.054	(-4.150, 3.493)
	Self-employed (Ref)					
Counseling about EBF	No	3.156	23.476	1.059	0.019	(1.194, 3.117)*
	Yes (Ref)					
Birth Order	First	2.815	16.693	1.116	0.010	(0.736, 5.109)*
	Second	.162	1.176	0.733	0.007	(-1.264, 1.620)
	Third and above (Ref)					
Use of PNC	No	2.733	15.379	0.716	0.009	(1.402, 4.205)*
	Yes (Ref)					

Predictors	Categories	Posterior mean $(\widehat{\boldsymbol{\beta}})$	Odds ratio (i.e., exp($\widehat{\boldsymbol{\beta}}$))	Posterior standard error $(\widehat{\boldsymbol{\beta}})$	Monte Carlo error	95% Credible interval of posterior mean $(\widehat{\boldsymbol{\beta}})$
Birth Weight(kg)	Above 2.5(Ref)					
	2.5 and below	2.893	18.047	0.686	0.006	(1.599, 4.288)*
Mode of delivery	SVD(Ref)					
	Caesarean	-.901	0.406	1.294	0.026	(-3.466, 1.636)
	Instrumental	1.043	2.840	1.339	0.023	(-1.565, 3.683)
Timely initiation	No	3.884	48.618	1.034	0.015	(2.017, 6.074)*
	Yes (Ref)					
Media Exposure about EBF	No	1.615	5.028	1.101	0.017	(0.486, 3.836)*
	Yes (Ref)					
Attitude towards EBF	Positive	-4.759	0.009	1.377	0.022	(-7.720, -2.337)*
	Negative (Ref)					

*Note: Values within parenthesis represent 95% Bayesian credible interval for posterior mean, where * represent significant regression coefficient of predictors at 5% in which credible intervals does not include zero and Ref denotes reference category.*

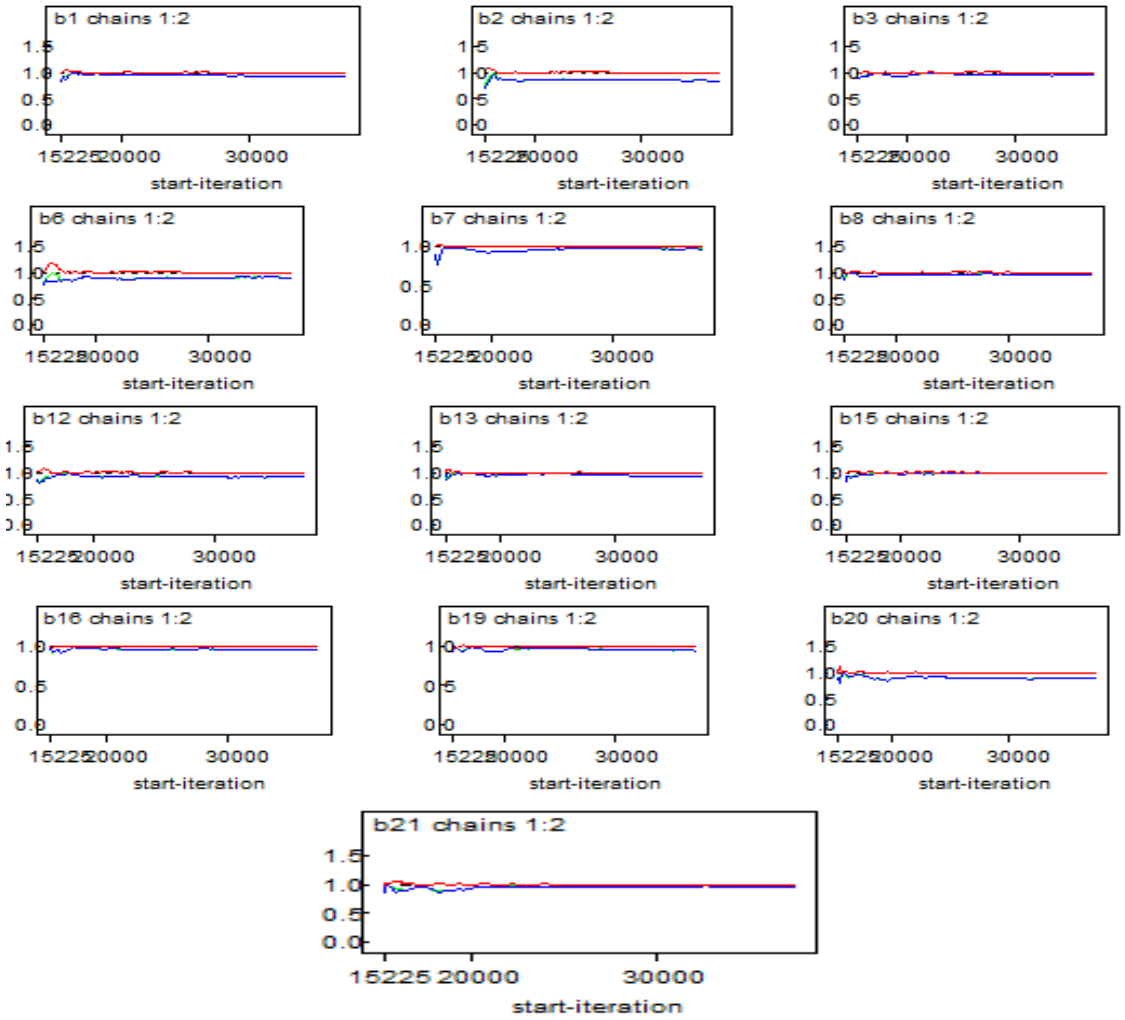

Fig. 2. Brooks Gelman Rubin convergence diagnosis plots for only statistically significant regression coefficients in the model

Fig. 3 shows history plots for only statistically significant regression coefficients in the model and this option produces iteration number on x axis and parameter value on y-axis). The plots looks like a horizontal band, with no long upward or downward trends and the two independently generated chains demonstrated good "chain mixture" indicating that the chains has converged. The Time series (history) plots for the rest of the parameters (not shown here) also tell a similar story.

In addition, the measure of simulation accuracy is Monte Carlo error and the values of Monte Carlo errors for the fitted model are presented in Table 2. Hence, it can be seen that Monte Carlo error for each of regression coefficient of predictor variables is less than 5% of its posterior standard error. This implies convergence and accuracy of posterior estimates for the regression parameters are attained. Table 2 presents the estimates (estimated parameters, odds ratios (OR), Monte Carlo errors and 95% credible intervals for estimated posterior mean) from Bayesian binary logistic regression model of non-exclusive breast feeding practices of mothers for the first six months. Based on the Bayesian 95% credible intervals, the independent variables: age of mothers, mother's educational status, marital status of mother's, use of antenatal care service during pregnancy, birth orders of the child, exclusive breastfeeding counseling during pregnancy, use of postnatal care, awareness of the benefits of exclusive

breastfeeding, birth weight of the child, timely initiation of breastfeeding, media exposure about exclusive breasting feeding and attitude towards breast feeding were found to be statistically significant factors affecting exclusive breastfeeding among infants less than six months of age since the credible intervals of posterior mean given by the MCMC method did not include 0.

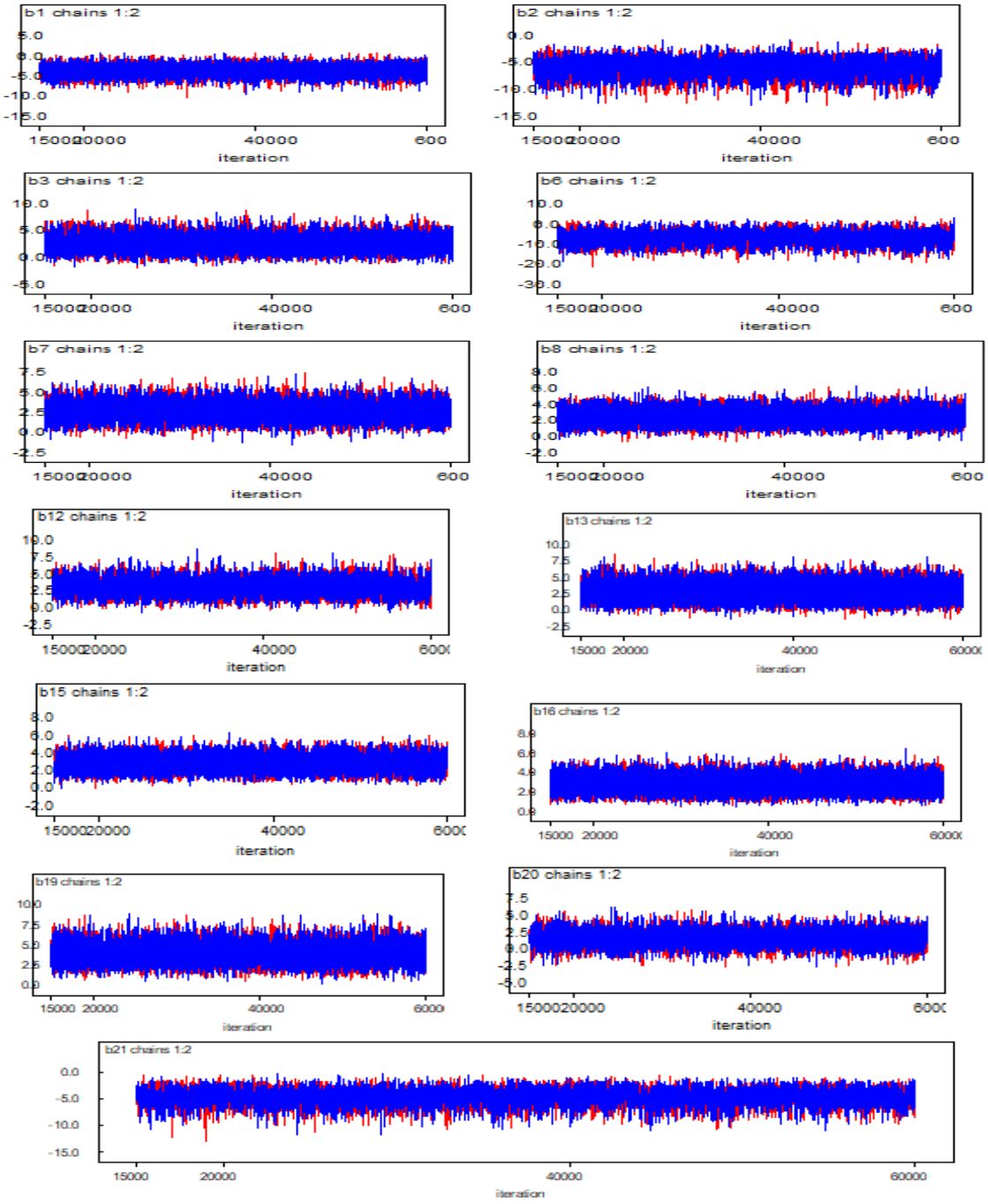

Fig. 3. Time series (history) plots for only statistically significant regression coefficients in the model.

Thus, when all the other independent variables are controlled, the odds of being non-EBF among mothers age 26–35 years and above 35 years was 97.8% (OR 0.022; 95% credible interval: -6.371, -1.545) and 99.8% (OR: 0.002; 95% credible interval: -9.337, -3.476) less likely than their counterpart mother aged less than 25 years. This finding was in agreement with the study in Debre Berhan District, Ethiopia [32]. Regarding maternal marital status, unmarried mothers were 13.223 times more likely than married mothers to be non-EBF (OR; 13.233, 95% credible interval: 0.236, 5.327). Women who completed college diploma and above were 99.9% less likely to be non-EBF compared with women who were uneducated (OR; 0.001, 95% credible interval: -12.85,-1.933). Mothers who were not used antenatal care during pregnancy were almost 14 times more likely to be non-EBF than mothers who were used antenatal care (OR: 14.112, 95% credible interval: 0.761, 4.680). This finding is in agreement with a study done in Arba Minch Zuria, Ethiopia [16]. Mothers who were not counseled regarding to breastfeeding during pregnancy were almost 23 times more likely to be non-EBF than mothers who were not counseled (OR: 23.476, 95% credible interval: 1.194, 3.117). This finding was in in-line with a study from Bahir Dar city, Ethiopia [13]. This might be due to the fact that counseling about the benefits of EBF during pregnancy improves maternal knowledge and facilitates breastfeeding. Regarding awareness of the benefits of breastfeeding, mothers who were not awarded about the benefits of breastfeeding were almost 11 times more likely to be non-EBF than mothers who were awarded (OR: 11.190, 95% credible interval: 0.885, 4.026).

Furthermore, birth order of the child showed a statistically significant effect on the practice of exclusive breast feeding. Hence, for those mothers with first birth order, the odds of being non-EBF were almost 16 (OR:16.693, 95% credible interval: 0.736, 5.109) times higher than women with third and above birth order. However, there was no significant difference in the odds of being non-EBF for women with first birth order compared to those women with second birth order (OR: 1.176, 95% credible interval: -1.264, 1.620). Mothers who were not used postnatal maternal health care service were almost 15 times more likely to be non-EBF than mothers who were used postnatal maternal health care service (OR: 15.379, 95% credible interval: 1.402, 4.205). Regarding birth weight of the child, for those mothers with birth weight of child was less than or equal 2.5Kg, the odds of being non-EBF were almost 18(OR: 18.047, 95% credible interval: 1.599, 4.288) times higher than women with birth weight of child was greater than 2.5Kg. Mothers who had no initiation of breastfeeding within one hour after childbirth (timely initiation) were almost 48 times more likely to be non-EBF than mothers who had the initiation of breastfeeding within one hour after childbirth (OR: 48.618, 95% credible interval: 2.017, 6.074).

Regarding media exposure, for those mothers who had no exposure to media to get information about exclusive breast feeding, the odds of being non-EBF were almost 5(OR: 5.028, 95% credible interval: 0.486, 3.836) times higher than mothers who had exposure to media. This could be due to the fact that nutrition education messages given through the mass media which will rise the knowledge about the benefits of breast feeding. This finding was consistent with study done in Jimma Arjo Woreda, Ethiopia [17]. Mothers with positive attitude towards exclusive breast feeding were 99.1% less likely to be non-EBF than mothers with negative attitude (OR: 0.009, 95% credible interval: -7.720, -2.337).

Unlike other studies, in this study religion of mother's, average monthly income of family, place of delivery, mode of delivery, number of children in a family and maternal occupation was not found to have a statistically significant relationship with practicing EBF.

4. CONCLUSIONS

In this study, the prevalence of exclusive breast feeding practices (53.9%) among women with infants less than six months of age was low as compared to WHO recommendation where by every woman should breastfeed their children exclusively for the first six months. From the empirical result, it can be concluded that the age of women, educational status of women, marital status of mothers, attending antenatal health care during pregnancy, awareness about the benefits of exclusive breast feeding, attending postnatal maternal health care service within the first 42 days after birth, receiving counseling about exclusive breast feeding, birth order of the child, exposure to mass media to get information about exclusive breasting feeding, attitude towards EBF, birth weight of the child and initiation of breastfeeding within one hour after childbirth (timely initiation) were statistically significant factors affecting exclusive breast

feeding practices. Hence, those women with no education, born to a unmarried woman, women who were not attended ANC during pregnancy, women with first birth order, women with child birth weight of less than 2.5 Kg, women who were not received counseling about exclusive breast feeding, women who had no awareness about the benefits of exclusive breast feeding and exposure to mass media, women were not attended PNC within the first 42 days after birth, women who had no initiation of breastfeeding within one hour after childbirth and women who had negative attitude towards EBF were more likely not to practice exclusive breast feeding. Therefore, improving education of women, promoting the use of maternal health care services for those who do not visit the health facility at community level and strengthening continuous exclusive breastfeeding counseling were highly recommended to improve exclusive breast feeding practices in the study area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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