

Research Article

Comparison of Bayesian and Classical Methods for Exploring the Important Factors regarding Maternal and Child Health Care

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The literature contains a number of studies to analyze the important factors relating to maternal and child health care (MCH). However, the earlier contributions have employed classical models for the analysis. We have proposed Bayesian models for exploring the factors regarding MCH in Pakistan. The latest data, from Pakistan Demographic and Health Survey (PDHS) conducted in 2017-18, have been used for analysis. The performance of Bayesian methods have been compared with classical methods based on various goodness-of-fit criteria. The performance of Bayesian methods was observed to be better than the classical methods. The results advocated that 86.20% of mothers received antenatal care (ANC), while only 51.40% of the mothers received it at least for ANC visits during the whole pregnancy period. Further, 68.90% of the mothers were protected against neonatal tetanus. More than 30% of women neither delivered in the health facility place nor they were in receipt of postnatal checkups. Additionally, only three out of five newborns were availed with postnatal checkup (PNC) within two days of their births. About 66.89% of women reported problems in accessing the MCH in the country. The study also suggested the presence of severe disparities among different socio-economic groups in availing MCH. There is immediate need to reduce these disparities among various socio-economic groups in the country.

1. Introduction

The access to the ANC and PNC is fundamental. At present, Pakistan is far behind the Millennium Development Goal (MDG) number 5 to diminish maternal mortality ratio (MMR) by three quarters [1, 2]. The MMR for Pakistan in 2015 was 178 per 100,000 live births, that is substantially more than the MDG target of less than 140 per 100,000 MMR. The reduction in the maternal mortality rate is a part of Sustainable Development Goal (SDG) number 3, and it is a real challenge for Pakistan [3]. The rise in the maternal deaths has been reported in the country [4]. The adequate access to ANC and PNC is fundamental in reduction of MMR [5, 6]. Unfortunately, there is a lack of accessibility to the MCH services among pregnant women in Pakistan [7].

The literature contains numerous studies for determination of important factors regarding access to MCH in the country. The health care by skilled professionals before, during, and after child birth can save the lives of women and their babies [8]. However, the majority of women in the country do not have access to MCH [9]. Poverty has been considered to be a major barrier in access to maternal healthcare services in Pakistan [10, 11]. Unfortunately, the women with lower education levels are also less likely to get ANC in the country [11–14]. The lack of knowledge about ANC, high transport costs, and traditional attendants were also the common causes for insufficient utilization of maternal healthcare services in the country [15, 16]. Comparatively lower levels of MCH utilization were identified in women with less education, lower income levels, and higher

birth order in the country [17]. An inflexibly controlled caste ladder also restricts the females from the well-deserved MCH services [18]. The communities' attitude and the health system in rural areas are also important in order to access the maternal health care in the country [19]. The knowledge of women regarding health played an important role in their use of maternal health care [13]. Improving education, nutrition, and the standardized implementation of protocols of obstetric care are required in Pakistan for better maternal and neonatal health [14].

The socio-economic factors are closely related to the delivery of maternal health services in the country [17]. The exploration of such socio-economic factors is important for policy making. Although literature contains a number of earlier contributions, some of them used old data [12, 13, 20] and [17] some others contain limited number of respondents and areas [20, 21]. The contribution by Ref. [17] has considered the detailed investigation regarding factors of the MCH services in Pakistan, using nationally representative data. But the said contribution contained only three dependent variables, namely, number of visits for ANC, delivery in the healthcare facility, and delivery assistance by skilled health provider. The said contribution used the data from Pakistan Demographic and Health Survey (PDHS) 2012-13, which have been updated in PDHS 2017-18. In addition, the PNC is a very important component of the maternal health care, which was not discussed in the said contribution. The identification of specific problems in receipt of MCH is also important. On the other hand, the detailed studies regarding child health care in connection with maternal health care are also very important for the country. We have considered a more detailed study including twelve output variables that explore vital factors of ANC and PNC in the country. The detailed investigation of the child health care has also been considered. The earlier studies have employed classical models, such as logistic regression and chi-square tests, for the analysis of MCH facilities in Pakistan. It is worth mentioning here that the Bayesian methods often produce better results as compared to classical estimation methods [22–24]. Though corresponding estimates can be biased, they are associated with smaller amounts of mean square errors as compared to their classical counterparts. They include additional information (prior) about the model parameters [25] and are applicable even in case of correlated parametric estimates [26, 27]. Despite these features, the Bayesian models have not yet replaced the conventional models in their application in different fields [28]. For modeling the binary response data, the Bayesian methods have shown better results than the classical methods [29, 30]. An improvement in the Bayesian methods for modeling binary response data was also proposed [31]. Further, Workie and Belay [32] also employed the Bayesian methods to analyze the categorical data regarding study of dental caries.

Though the literature contains a number of studies to explore MCH in the country, some of them have used old data and some others contain a limited number of respondents and areas. Most of the earlier studies have considered the exploration of important determinants of

antenatal care; however, the investigation of PNC in the country is equally important. Further, all of the previous studies have employed classical methods for identifying the factors related to MCH in the country. We have proposed improved models for identification of important factors regarding maternal and child health care in the country, using latest nationally representative data. We have considered a more detailed study including twelve output variables to explore vital factors regarding ANC and PNC. The study has explored that there are high inequalities in access to MCH across different socio-economic and demographic sectors of the society. The results from the study will be helpful for the policy makers in order to devise strategies for improving the MCH in the country by reducing the observed inequalities among various socio-economic groups in society.

2. Methodology

The secondary datasets regarding MCH facilities in Pakistan have been used for the analysis. These datasets have been obtained from the published reports of PDHS, conducted in 2017-18. The data were collected by National Institute of Population Studies (NIPS) [Pakistan] and ICF [33]. The main survey was conducted for 14,161 respondents. However, the information regarding different factors relating to MCH was collected from 6710 mothers aged 15–49 years. The responses regarding live births in five years preceding to the survey, containing data regarding 1,04,494 births. On the other hand, the responses regarding postnatal checkup of mothers and newborns are based on live births in two years preceding to this survey. These data contain 3936 responses. The data regarding problems in access to MCH were obtained from ever-married women aged 15–49. The said information was collected from 12,365 eligible women.

The Bayesian logistic regression has been used to identify the vital factors for MCH facilities in Pakistan. The prior distribution for modeling the said response has been assumed to be normally distributed. The comparison between Bayesian and classical methods has also been reported. The Akaike information criteria (AIC) and Bayesian information criteria (BIC) has been used for the said comparison.

Let " L " denote the log-likelihood function for a model $f(x)$ and " k " be the number of parameters involved in $f(x)$, then AIC and BIC can be defined as

$AIC = -2L + 2k$ and $BIC = -2L + k * Ln(n)$, where Ln denotes the natural logarithmic value and " n " is the sample size.

The following response variables were considered in the study: (i) ANC from a skilled provider, (ii) medical drugs during pregnancy, (iii) protection against neonatal tetanus, (iv) counseling during the pregnancy, (v) delivery in health facility place, (vi) delivery by a skilled provider, (vii) checkup during the first two days of delivery, (viii) skilled postnatal checkup during the first two days of delivery, (ix) checkup of newborn baby during the first two days of birth, (x) the first skilled postnatal checkup for newborn babies, (xi) at least one signal (cord examination, temperature measurement, counseling on danger signs, counseling on breast feeding,

observation of breast feeding, and weight) performed within two days of birth, and (xii) at least one problem, in accessing the maternal and child health care, faced by the mothers. On the other hand, age of mother at birth (MAB), order of birth (BO), residence (RES), level of education (EDU), wealth status (WQ), and region (REG) of the respondents has been considered as exploratory variables in the study. All the results have been obtained using R software. In case of Bayesian methods, the normal prior has been used for the posterior estimation. The *rstanarm* package in R software has been used for numerical computations. The advantage of using this package as compared to other packages such as *lme4* is that (i) it provides better estimates for the uncertainty and (ii) it allows users to incorporate prior information.

3. Results

The reduction in the maternal mortality is the Millennium Development Goal (MDG) 5. Pakistan is also signatory of Sustainable Development Goals (SDGs) 2015-30. The MCH is a major feature of SDG 3. The compliance of SDGs needs even more efforts than those for MDGs. Being a responsible country, Pakistan has already started efforts to come close to MDG 5 and SDG 3. The country has already installed the National Maternal Neonatal and Child Health (MNCH) program in 2007 to speed up the progress on MDG 5 and SDG 3. The country has also determined a National Health Vision (NHV) 2016–2025. A monitoring and evaluation mechanism has also been established for the NHV. The current situation of MCH services in the country has been investigated using data from PDHS 2017-18. The survey included the women aged 15–49 years having a live birth in five years preceding the said survey. The results reported in PDHS 2017-18 revealed that 86.20% of mothers accessed antenatal care (ANC) from the skilled provider. The major contributors for the skilled ANC were doctors (82%). Only 51.40% of the mothers received at least four ANC visits during the whole pregnancy period, while 6 out of 10 (60.32%) of the mothers used medical drugs during the most recent pregnancy. About one-third (30%) of the mothers did not even receive any counseling during the whole period of pregnancy. The major cause of neonatal deaths in developing countries is neonatal tetanus. However, in Pakistan, approximately seven out of ten (68.90%) were protected against neonatal tetanus. The delivery by skilled attendant in a clean and safe environment is fundamental in reducing the complications for mothers and newborn babies. In Pakistan, 66.16% of the mothers delivered in a health facility place, and 69.34% received assistance from a doctor, nurse, midwife, or lady health worker during the delivery. The postnatal period is often considered very risky for the mothers. In order to reduce the chances of complications during this period, the mothers should receive recommended postnatal care visits. However, only three out of five (61.61%) women who gave birth in last two years got the PNC facility within two days after the delivery. PNC for the newborn is also very important to minimize the neonatal complications and mortalities. The percentage of newborn babies with PNC within

the first two days of birth is 63.91% in the country. Additionally, 56.86% of the mothers availed the skilled PNC during the first two days after birth, while 59.35% of the newborn babies were in receipt of PNC within two days after birth. At least one signal (cord examination, temperature measurement, counseling on danger signs, counseling on breast feeding, observation of breast feeding, and weight) was performed for newborns within two days of birth in 58% of the cases. A high number (66.89%) of the mothers faced problem in accessing the MCH in the country. In addition, there are high disparities in access to MCH across different socio-economic sectors of the society.

The comparison between proposed Bayesian logistic models and classical logistic models has been made using the values of AIC and BIC. The smaller values of AIC and BIC indicate a better model. This comparison is shown in Table 1. From these results, it can be seen that amounts of AIC and BIC are relatively smaller in case of Bayesian logistic regression models, as compared to classical logistic regression models. Similarly, the comparison between Bayesian and classical methods based on widths of 95% CI for ORs is shown in Table 2. The results, presented in Table 2, also advocate the improved performance of Bayesian methods. This is owing to the fact that a width of 95% CI for ORs using Bayesian methods is smaller than those under classical methods.

Since the results under Bayesian logistic regression models are superior to those under classical logistic regression models, we have reported the ORs and associated 95% CIs for Bayesian logistic regression models only. These results are shown in Tables 3 and 4. The ORs and respective 95% CIs for the delivery of ANC is shown in Table 3. For each explanatory variable, the reference group has been represented by letter "R.". The results from this table suggest that for mothers with less than six births, the OR for skilled ANC is 2.0607 [1.7623, 1.4054] and the same OR for the first birth is 5.6839 [4.6140, 7.1165], which means that the mothers at first birth receive almost more than double skilled ANC as compared to those having the fifth birth. Similarly, in case of rural residence, the said OR is 0.2771 [0.2340, 0.3251], indicating seriously low-skilled ANC in rural areas of the country. On the other hand, the said OR for delivery of the skilled ANC to the mothers having secondary education is 0.1456 [0.0620, 0.2976], while the said OR in case of illiterate mothers is 0.0179 [0.0083, 0.0342]. Hence, the provision of skilled ANC is highly dependent on the education of the mothers. Further, for the lowest wealth quintile, the said OR is 0.0375 [0.0255, 0.0520], suggesting the vulnerability of the poor families in access to the skilled ANC in comparison to access to skilled ANC in different regions of the country, and Punjab takes the lead with OR 0.7048 [0.1707, 1.9316]. However, the utilization of ANC services in Punjab is still much lower as compared to the capital city Islamabad. The likelihood of these services in other parts of the country is even lower. Hence, there is a serious disparity in receipt of the skilled ANC across different provinces of the country.

Table 3 also suggests that the odds for using medical drugs (iron tablets or syrup and intestinal parasite drugs) during pregnancy period at the time of first birth are 2.1156

TABLE 1: Comparison of classical and Bayesian logistic regression models using AIC and BIC.

Factors	Classical		Bayesian		Classical		Bayesian	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
	Skilled ANC				Medical during pregnancy			
MAB	17.21	14.24	15.89	13.42	17.74	15.31	16.44	14.04
BO	18.04	15.46	17.16	14.24	18.96	16.50	17.59	14.53
RES	19.58	16.31	18.29	15.77	20.79	17.94	19.71	17.11
EDU	15.80	13.80	14.91	12.23	18.83	16.37	18.04	14.51
WQ	17.03	14.51	16.04	13.42	18.84	15.10	17.52	15.04
REG	12.71	11.08	12.16	10.53	13.79	11.25	12.83	10.91
	Protection against neonatal tetanus				Counseling during pregnancy			
MAB	17.73	14.28	16.76	14.33	18.18	14.92	16.78	14.57
BO	18.91	15.53	17.88	14.41	19.32	16.46	18.10	14.88
RES	20.54	17.62	19.01	15.80	21.02	17.00	20.08	16.94
EDU	18.39	14.98	17.56	14.81	18.80	15.10	17.54	15.24
WQ	18.39	16.08	17.64	14.63	18.88	15.98	18.07	14.60
REG	13.79	11.80	13.15	11.06	13.97	11.92	13.31	11.69
	Delivery in a health facility place				Delivery by a skilled provider			
MAB	18.65	15.26	17.90	14.95	18.62	14.92	17.37	14.72
BO	19.71	17.01	18.82	16.35	19.67	16.02	18.78	15.61
RES	21.34	18.15	19.96	16.36	21.24	17.91	19.56	16.78
EDU	18.90	15.98	17.74	14.60	18.77	16.05	17.82	14.36
WQ	19.01	16.55	18.09	15.87	18.91	16.53	17.65	15.36
REG	14.30	11.89	13.60	11.91	14.15	11.35	13.02	11.32
	Checkup during the first two days of delivery				First skilled postnatal checkup			
MAB	16.82	14.05	15.80	12.92	16.83	14.00	15.56	13.29
BO	17.83	14.84	16.49	14.50	17.79	14.34	16.61	13.77
RES	19.56	17.13	18.52	15.10	19.61	16.97	18.35	14.93
EDU	17.75	15.13	16.55	13.36	17.72	14.38	16.32	13.81
WQ	17.55	15.26	16.42	13.72	17.53	15.32	16.83	14.76
REG	12.81	10.73	12.06	10.05	12.90	11.07	12.16	10.44
	Postnatal checkup of newborns				Skilled postnatal checkup of newborns			
MAB	17.74	14.72	16.52	13.80	17.73	14.78	16.88	13.66
BO	18.77	15.73	17.35	14.32	18.73	15.86	17.91	14.97
RES	20.45	17.38	18.89	16.29	20.42	16.72	18.85	15.27
EDU	18.32	15.22	17.48	14.94	18.24	14.68	17.11	14.02
WQ	18.28	15.24	16.96	13.95	18.22	15.79	16.97	14.91
REG	13.55	11.44	12.50	10.20	13.52	11.06	12.64	10.98
	At least one signal is performed				At least one problem is faced			
MAB	17.93	14.39	16.68	14.53	17.96	15.79	16.54	14.34
BO	18.88	16.16	17.43	14.96	19.12	15.40	18.03	15.26
RES	20.46	17.80	19.63	16.50	20.78	17.51	19.44	16.53
EDU	17.35	15.20	16.34	13.62	18.60	16.26	17.77	14.49
WQ	18.02	14.56	17.05	14.49	18.63	15.75	17.15	14.00
REG	13.51	11.29	12.43	10.70	13.88	11.24	12.96	11.05

[1.8322, 2.4384], which decreased to 1.3052 [1.1499, 1.4876] at the time of fifth birth. Similarly, the use of medical drugs during pregnancy is much lower in rural areas, with OR 0.6008 [0.5499, 0.6562], as compared to urban areas. Likewise, the utilization of the medical drugs during pregnancy is much lower among those with lower education levels. To be more specific, the OR for utilization of medical drugs during pregnancy for illiterate mothers is 0.1847

TABLE 2: Comparison of widths regarding 95% CI for ORs under classical and Bayesian logistic regression models for ANC and medical drugs.

Factor	ANC		Medical drugs	
	Classical	Bayesian	Classical	Bayesian
Mother's age at birth				
<20	0.417	0.341	0.965	0.788
20–34	0.305	0.259	0.750	0.603
35–49 (R)	1	1	1	1
Birth order				
1	0.704	0.606	2.970	2.502
2–3	0.483	0.401	1.207	1.043
4–5	0.402	0.338	0.777	0.643
6+ (R)			1	1
Residence	1	1		
Urban (R)			1	1
Rural	0.128	0.106	0.108	0.091
Mother's education	0.000	0.000		
No education	0.070	0.060	0.031	0.026
Primary	0.131	0.112	0.134	0.113
Middle	0.179	0.148	0.237	0.227
Secondary	0.255	0.214	0.287	0.236
Higher (R)	1	1	1	1
Wealth quintile				
Lowest	0.064	0.054	0.033	0.027
Second	0.086	0.070	0.064	0.054
Middle	0.110	0.094	0.185	0.156
Fourth	0.201	0.170	0.409	0.331
Highest (R)	1	1	1	1
Province				
Punjab (R)	1	1	1	1
Sindh	0.242	0.208	0.750	0.165
KPK	0.217	0.191	0.131	0.113
Balochistan	0.320	0.268	0.050	0.043

[0.1567, 0.2166], which is much smaller as compared to those for educated mothers. Similarly, the facility of medical drugs during pregnancy is significantly more available to the mothers from wealthy families than those from the poor families. For example, the said OR in case of mothers from lowest wealth quintiles is 0.1822 [0.1568, 0.2103] as compared to that for mothers from the families falling in highest wealth quintiles. The utilization of the medical drugs during pregnancy period is very low in all parts of the country, as compared to Islamabad. Similar patterns for the ORs have been observed for other response variables. The numerical results for all other variables are shown in Table 4. For brevity, the results regarding ORs are shown in Table 4.

The graphical results for all twelve response variables are shown in Figure 1. Figure 1(a) represents the magnitudes of the ORs for age groups (at the time of birth) regarding all twelve variables. This figure shows that access to MCH is significantly higher for the mothers within the age group 20–34 as compared to those in the age group 35–49 throughout. However, OR for the problem faced by mothers (represented by variable 12) are lower for the mothers within the age group 20–34. The ORs for the availability of MCH services, with respect to birth order is shown in Figure 1(b).

TABLE 3: Odds ratios regarding access to ANC and medical drugs using Bayesian logistic regression models.

Factors	Access to ANC		Utilization of medical drugs		ORs with CI
	Utilized	Total	Utilized	Total	
MAB					
<20	416 (85%)	491	284 (58%)	491	0.817 {0.760, 1.101} ^a
20–34	4709 (88%)	5370	3254 (61%)	5370	1.098 {0.908, 1.167} ^a
35–49 (R)	658 (78%)	849	509 (60%)	849	1 {reference}
BO					
1	1265 (94%)	1351	919 (68%)	1351	2.115 {1.832, 2.438} ^d
3-Feb	2311 (89%)	2585	1621 (63%)	2585	1.668 {1.473, 1.874} ^d
5-Apr	1447 (84%)	1718	976 (57%)	1718	1.305 {1.149, 1.487} ^d
6+ (R)	762 (72%)	1057	531 (50%)	1057	1 {reference}
Residence					
Urban (R)	2120 (94%)	2248	1533 (68%)	2248	1 {reference}
Rural	3664 (82%)	4463	2513 (56%)	4463	0.601 {0.549, 0.656} ^d
Education					
No education	2431 (76%)	3212	1567 (49%)	3212	0.184 {0.156, 0.216} ^d
Primary	1018 (93%)	1097	670 (61%)	1097	0.305 {0.253, 0.365} ^d
Middle	633 (95%)	663	436 (66%)	663	0.376 {0.308, 0.456} ^d
Secondary	797 (96%)	828	609 (74%)	828	0.541 {0.445, 0.659} ^d
Higher (R)	906 (99%)	911	763 (84%)	911	1 {reference}
WQ					
Lowest	973 (67%)	1444	637 (44%)	1444	0.182 {0.156, 0.210} ^d
Second	1038 (80%)	1299	661 (51%)	1299	0.237 {0.205, 0.276} ^d
Middle	1256 (92%)	1371	786 (57%)	1371	0.311 {0.266, 0.359} ^d
Fourth	1291 (96%)	1349	948 (70%)	1349	0.543 {0.466, 0.635} ^d
Highest (R)	1226 (98%)	1248	1015 (81%)	1248	1 {reference}
Region					
Punjab	3187 (92%)	3453	2137 (62%)	3453	0.409 {0.227, 0.697} ^d

TABLE 3: Continued.

Factors	Access to ANC		Utilization of medical drugs		ORs with CI
	Utilized	Total	Utilized	Total	
Sindh	1346 (86%)	1571	966 (62%)	1571	0.412 {0.234, 0.693} ^d
KPK	882 (80%)	1101	618 (56%)	1101	0.331 {0.183, 0.551} ^d
Balochistan	209 (56%)	377	206 (55%)	377	0.309 {0.169, 0.543} ^d
FATA	111 (71%)	156	76 (49%)	156	0.249 {0.132, 0.442} ^d
AJK	812 (90%)	906	608 (67%)	906	0.520 {0.291, 0.891} ^d
Gilgit Baltistan	532 (80%)	668	390 (58%)	668	0.366 {0.198, 0.627} ^d
Islamabad (R)	51 (94%)	54	43 (80%)	54	1 {reference}

a: $p > 0.05$; b: $p < 0.05$; c: $p < 0.01$; d: $p < 0.001$.

TABLE 4: ORs for different output variables under Bayesian logistic regression models.

Factors	Protection against neonatal tetanus	Counseling during the pregnancy	Delivery in the health facility	Delivery by a skilled provider	Postnatal checkup	Skilled postnatal checkup	Postnatal checkup of newborns	Skilled postnatal checkup of newborns	At least one signal performed for newborns	At least one problem
MAB										
<20	1.126	0.963	1.365	1.325	1.043	1.188	1.065	1.120	1.079	0.464
20–34	1.820	1.100	1.437	1.468	1.474	1.538	1.442	1.568	1.372	0.680
35–49 (R)	1	1	1	1	1	1	1	1	1	1
BO										
1	2.266	1.476	3.707	3.671	2.753	3.261	2.397	2.889	2.276	0.668
2–3	2.364	1.750	2.283	2.279	2.412	2.724	1.917	2.179	2.038	0.764
4–5	1.888	1.450	1.306	1.311	1.727	1.897	1.440	1.527	1.524	0.791
5 and above (R)	1	1	1	1	1	1	1	1	1	1
RES										
Urban (R)	1	1	1	1	1	1	1	1	1	1
Rural	0.432	0.514	0.338	0.389	0.378	0.357	0.395	0.370	0.408	2.636
Education										
No education	0.113	0.200	0.081	0.079	0.161	0.121	0.168	0.135	0.214	3.344
Primary	0.357	0.368	0.155	0.152	0.288	0.264	0.313	0.264	0.341	2.305
Middle	0.560	0.671	0.267	0.254	0.387	0.367	0.457	0.391	0.478	1.613
Secondary	0.688	0.783	0.468	0.494	0.740	0.698	0.834	0.768	0.893	1.702
Higher (R)	1	1	1	1	1	1	1	1	1	1
WQ										
Lowest	0.090	0.162	0.064	0.062	0.118	0.097	0.121	0.101	0.197	4.192
Second	0.180	0.210	0.101	0.099	0.132	0.116	0.143	0.130	0.150	4.065
Middle	0.280	0.417	0.189	0.190	0.212	0.200	0.235	0.229	0.244	2.690
Fourth	0.525	0.578	0.380	0.391	0.410	0.431	0.442	0.425	0.461	1.474
Highest (R)	1	1	1	1	1	1	1	1	1	1
Region										
Punjab	0.807	0.783	0.409	0.371	0.553	0.555	0.623	0.622	0.706	1.428
Sindh	0.415	0.344	0.470	0.443	0.684	0.602	0.846	0.737	0.749	1.356
KPK	0.366	0.257	0.299	0.309	0.211	0.211	0.214	0.211	0.164	2.432
Balochistan	0.094	0.237	0.098	0.093	0.172	0.136	0.148	0.136	0.123	4.229
FATA	0.160	0.107	0.179	0.162	0.133	0.151	0.178	0.193	0.127	5.581
AJK	0.825	0.821	0.305	0.267	0.381	0.371	0.417	0.379	0.497	2.225
Gilgit Baltistan	0.459	0.335	0.306	0.270	0.183	0.211	0.177	0.206	0.213	2.596
Islamabad (R)	1	1	1	1	1	1	1	1	1	1

This figure elucidates that likelihood for the access to the MCH is more than double at the first birth as compared to that for the sixth (and above) birth. The access to the said services tends to decrease with the increase in the birth order, with few exceptions. On the other hand, the ORs for the problems faced in receipt of the said services are lower for lower birth orders. Similarly, the ORs for availability of MCH services are almost half in rural areas as compared to urban areas of the country (Figure 1(c)). Figures 1(d) and 1(e) show that access to MCH is highly skewed towards the mothers with high levels of education and incomes. Likewise, the ORs for problems faced in access to these facilities are much lower for women with more education and higher wealth.

Figure 1(f) shows the likelihood of MCH services across different regions of the country. From this figure, it can be

assessed that the utilization of said services is considerably low in different regions of the country as compared to the capital city Islamabad. The availability of the said services is the least in KPK, Balochistan, and Gilgit Baltistan. Additionally, the hurdles in access to MCH are the highest in KPK, Balochistan, and Gilgit Baltistan.

4. Discussions

The results from the analysis revealed that the odds of MCH facilities in the country are in favor of mothers with lower ages, lower birth orders, urban residences, higher education, higher wealth quintiles, and the residents of capital city Islamabad. The utilization of the said services is drastically different among different socio-economic sectors of the society. Hence, the future policies regarding delivery of the

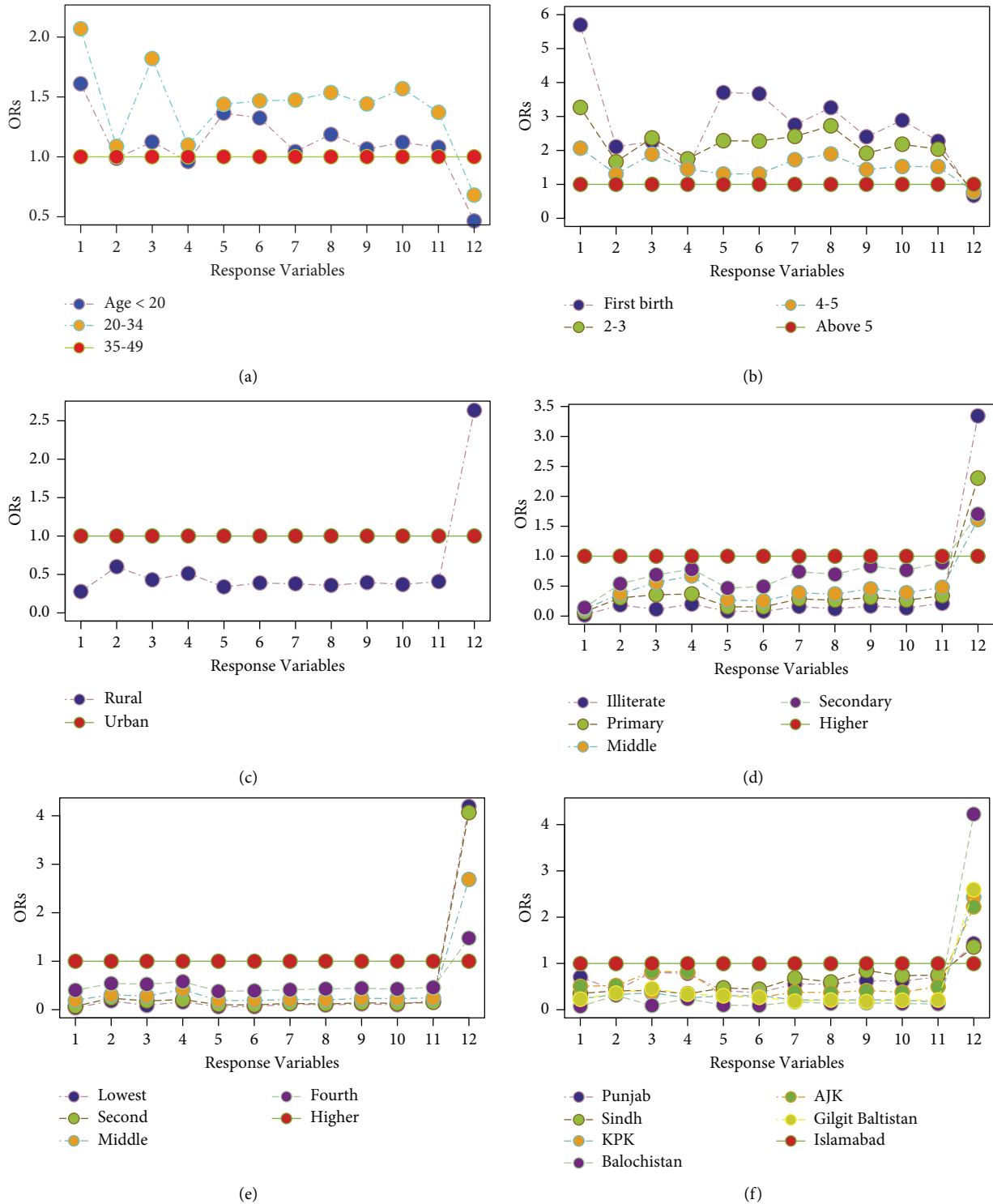


FIGURE 1: Graphs of ORs for age at birth, birth order, residence, education levels, wealth quintiles, and provinces. The response variables have been placed along x -axis with the following codes: the availability of ANC (1), the use of medical drugs during pregnancy (2), protection against tetanus (3), counseling during the pregnancy (4), delivery at the health facility place (5), delivery by the skilled attendant (6), postnatal checkup of mother during the first two days after delivery (7), skilled postnatal checkup of mother during the first two days after delivery (8), postnatal checkup of newborns during the first two days of birth (9), skilled postnatal checkup of newborns during the first two days of birth (10), at least one performed for newborn within two days of birth (11), and at least one problem faced by the mothers in access to maternal health services (12). (a) Age groups. (b) Birth orders. (c) Residence. (d) Education levels. (e) Wealth quintiles. (f) Regions.

MCH services in the country should target the deprived sectors of the society to come closer to MDG 5 and SDG 3. Following studies reported similar kinds of results for different countries. Agha and Carton [34] analyzed the determinants of skilled delivery in Pakistan. Amano et al. [35] explored the determinants of institutional delivery in Ethiopia. Chakraborty et al. [36] considered a similar study in Bangladesh. Celik and Hotchkiss [37] identified the fundamental factors relating to MCH in Turkey. The obstacles in delivery of MCH in Mali were identified by Gage [38]. Iqbal et al. [39] used nationally representative data to analyze the change in access to MCH in Pakistan. The economic aspects of the MCH in India were discussed by Kesterton et al. [40]. Matsumura and Gubhaju [41] explored the household structure and women's status as important determinants of MCH. Muchabaiwa et al. [42] discussed the status of MCH for Zimbabwe. Onah et al. [43] reported the factors relating to MCH in Nigeria. Singh et al. [44] presented the factors and status of MCH in some targeted states of India. Again, Singh et al. [45] reported the determinants for MCH among married youngsters in India. Yunus et al. [46] discussed important factors relating to MCH using data from PDHS 2006-07 for Pakistan. In addition, Al-Alwan et al. [29] reported the improved performance of Bayesian models as compared to classical models in modeling trends of awareness about Hepatitis in Pakistan. In the similar way, Feroze et al. [30] advocated the better performance of Bayesian models as compared to classical models for analyzing the binary responses.

5. Conclusions

The improvement in the MCH is still receiving central importance in the global health initiatives. Unfortunately, Pakistan remains behind many developing countries to provide adequate maternal and child health services. Given the importance of these services, there has been number of contributions dealing with exploration of important factors related to the utilization of the said services in the country. However, the earlier contributions have employed classical models for the analysis. We have employed the Bayesian logistic regression models for exploration of the important factors regarding access to MCH services. The performance of Bayesian logistic regression models has been compared with the most frequently used classical logistic regression models. The detailed analysis has been carried out using twelve response variables.

The results under the proposed Bayesian logistic regression models were superior to those under classical logistic regression models. This argument was supported by large number of AICs and BICs. The results from the study elucidate that access to maternal and child health care, in the country, is still far behind the desired levels. The finding of the study advocated that there are high disparities in access to MCH across different socio-economic sectors of the society. Any healthcare initiative in the country should target the reduction of these disparities. The results from the study will be helpful for the policy makers in order to plan and implement various strategies to improve the MCH in the country by reducing the observed inequalities for various socio-economic groups in society.

6. Strengths and Limitations of the Study

The proposed Bayesian models for exploring the important determinants of the maternal and healthcare services in the country used latest nationally representative data. The proposed models provided improved results as compared to the most frequently used classical logistic models. However, the study has some limitations as well. Since self-reporting mothers were the main source of information regarding MCH services, the obtained information may include social desirability biases. The current information is based on the MCH utilization for the most recent birth; hence, the previous patterns regarding access to the said services remained unknown.

Data Availability

All data used in this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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