ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/biostatic.2019-66764

Rural-Urban Differentials in Birth-to-Conception Intervals in Ethiopia: A Parametric Survival Analysis Approach

Etiyopya'da Gebe Kalma Aralıklarında Kırsal-Kentsel Farklılıklar: Parametrik Sağkalım Analizi Yaklaşımı

Samba Siva Rao PASUPULETI[a],
Yohannes Tadesse ASNAKEW[b]

[a]Department of Research,
Institute of Liver and Biliary Sciences,
New Delhi,
INDIA/HİNDİSTAN
[b]Department of Statistics,
University of Gondar,
College of Natural and Computational Science, Gondar,
ETHIOPIA/ETOPYA

Received: 05.05.2019
Received in revised form: 02.10.2019
Accepted: 09.10.2019
Available Online: 20.12.2019

Correspondence:
Yohannes Tadesse ASNAKEW
University of Gondar,
College of Natural and
Computational Science,
Department of Statistics, Gondar,
ETHIOPIA/ETOPYA
yohannes.tadesse@uog.edu.et

ABSTRACT Objective: Huge fertility and mortality differentials exist between rural and urban women in Ethiopia. But very little is known about their differential in birth intervals. This study fills knowledge gap by exploring latest birth-to-conception interval patterns by place of residence in Ethiopia and by exploring the role of various socioeconomic and demographic factors in the rural urban differential in birth-to-conception interval. The study also identifies the best fitted parametric survival regression models to estimate rural-urban differentials in birth-to-conception intervals in Ethiopia. **Methods:** This study makes use of data from the latest (fourth) Ethiopian Demographic Health Survey, and uses Kaplan-Meier and parametric survival models to better address the study objectives. **Results:** The study findings showed median time to subsequent conception following a baby birth is 2 year 2 months (26 months) for rural women and 3 year 11 months (47 months) for urban women in Ethiopia. Similarly, average birth-to-conception interval is 3 years for rural women and 5 years 1 month for urban women. Place of residence remained as a significant predictor of birth-to-conception interval even after controlling for possible confounders in their relationship. Around 17% of the gap in the ratio of mean of birth-to-conception interval for urban women to that of rural women is found to be explained by the considered socio-economic and demographic mediators. Conclusions: Differences in the usage of modern contraceptive methods for spacing purposes accounts for less than 1% of the gap in the ratio of mean of birth-to-conception interval for urban women to that of rural women. Finally, based on the results of the study, we can conclude that the Weibull regression model was the best fitted parametric model for rural-urban differentials in birth-to-conception intervals in Ethiopia. **Recommendation:** We recommend that it is better to see rural-urban differentials in birth-to-conception intervals in Ethiopia by including other covariates and statistical analysis systems. This study also recommends public health intervention strategies in Ethiopia should consider to improve the awareness of people about the benefits of optimal birth spacing of 3 to 5 years, and encourage and facilitate people to use contraceptive methods for spacing purposes. This is expected to result in improved maternal and child health outcomes.

Keywords: birth-to-conception interval; birth interval; Ethiopia; parametric survival models; Weibull distribution; and right censored

ÖZET Amaç: Etiyopya'da kırsal ve kentsel kadınlar arasında büyük doğurganlık ve ölüm farklılıkları bulunmaktadır. Ancak doğum aralıklarındaki farklar hakkında çok az şey bilinmektedir. Bu çalışma kırsal ve kentteki gebe kalma aralıklarında çeşitli sosyoekonomik ve demografik faktörleri araştırarak Etiyopya'da ikamet yerine göre en yeni gebe kalma aralıkları yapısını araştırarak bilgi boşluğunu doldurmaktadır. Ayrıca bu çalışma Etiyopya'da gebe kalma aralıklarında kırsal ve kentsel farklılıkları tahmin etmede en iyi parametrik sağkalım regresyon modellerini tanımlamaktadır. **Gereç ve Yöntemler:** Bu çalışma, en son (dördüncü) Etiyopya Demografik Sağlık Araştırması verilerinden faydalanmakta ve çalışma hedeflerini daha iyi ele almak için Kaplan-Meier ve parametrik sağkalım modellerini kullanmaktadır. **Bulgular:** Çalışma bulguları Etiyopya'da bebek doğumunu izleyen gebe kalma medyan süresinin kırsal kesimde yaşayan kadınlarda iki yıl iki ay (26 ay) kentte yaşayan kadınlarda ise üç yıl on bir ay (47 ay) olduğunu göstermiştir. Benzer olarak, gebe kalma aralıkları ortalaması kırsal kesimde yaşayan kadınlarda üç yıl, kentte yaşayan kadınlarda ise beş yıl bir aydır. İkamet yeri olası karıştırıcı faktör olarak kontrol altına alındıktan sonra bile gebe kalma aralığının anlamlı tahmin edicisi olarak bulunmuştur. Kentte ve kırsalda yaşayan kadınların gebe kalma aralıkları arasındaki ortalama %17'lik farkın sosyoekonomik ve demografik aracılarla açıklandığı bulunmuştur. **Sonuç:** Kentte ve kırsalda yaşayan kadınların gebe kalma aralıkları arasındaki ortalama farkın %1'i modern doğum kontrol yöntemlerini kullanım farklılıklarından kaynaklanmaktadır. Sonuç olarak çalışma sonuçlarına dayanarak Etiyopya'da kentte ve kırsalda yaşayan kadınların gebe kalma aralıkları için tahmin edilen en iyi parametrik modelin Weibull regresyon modeli olduğu sonucuna varılabilir. **Öneriler:** Etiyopya'da kentte ve kırsalda yaşayan kadınların gebe kalma aralıklarındaki farkı daha iyi görebilmek için diğer değişkenler ve istatistiksel analiz sistemleri çalışmaya dahil edilmelidir. Bu çalışma aynı zamanda Etiyopya'da halk sağlığına müdahale stratejilerinin, insanların 3-5 yıl arasındaki optimal doğum aralığının yararları hakkındaki farkındalığını arttırmayı göz önünde bulundurmasını ve insanları doğum kontrol yöntemleri kullanmaya teşvik dilmesini önermektedir. Bu yaklaşımların anne ve çocuk sağlığı sonuçlarında iyileşme ile sonuçlanması beklenmektedir.

Anahtar kelimeler: Gebe kalma aralığı; doğum aralığı; Etiyopya; parametrik sağkalım modelleri; Weibull dağılımı; sağdan sansürlü

Birth interval, defined as the duration between two successive live births, is one of the significant predictor of maternal and child health outcomes, and the overall timing of fertility.[1-3] For instance, short birth intervals are associated with low birth weight, preterm birth, perinatal death, infant and child mortality rates.[4,5] The research conducted in Ethiopia also showed birth interval is a significant predictor of child health outcomes.[6-10] So, it is anticipated that if birth intervals vary between rural and urban women, and as birth intervals can influence maternal and child health outcomes, which in turn can influence fertility, a part of the differences in fertility, maternal and child health outcomes between rural and urban women can be attributable to differences in birth intervals between rural and urban women.[11] However, in the context of Ethiopia very little is known about birth interval patterns by place of residence, and the factors that are responsible for rural urban differences in birth intervals. Almost all existing studies on this topic were regional, making it hard to generalize these study findings to the national level, due to wide ethnic variation across the regions in Ethiopia.[12-14] While EDHS reports provide median and few other quantiles of birth intervals by place of residence, and by few other important characteristics of women, both at national level and regional level, but they do so only for closed birth intervals.[15] And these reports do not provide any multivariate analysis results on the topic.

Almost all studies that assessed the effect of place of residence on birth internals in Ethiopia, in their effort to study factors affecting birth-intervals in Ethiopia or in its regions, have used either logistic regression analyses or Cox Proportional hazards regression analyses and found odds of a short birth interval or the instantaneous risk of subsequent conception is higher for rural women than for urban women, even after controlling for other influencing factors.[12-14] However, it must be noticed here that such analyses cannot directly throw light on actual levels of birth intervals among rural and urban women. For instance, using Cox proportional hazards model will only give effect of various individual factors on instantaneous risk of subsequent conception but not on the direct effect of various factors on birth intervals itself. Similarly, using logistic regression cannot help to get the actual picture of effect of various factors on birth intervals. In addition to these, none of the existing studies have taken into account the possible mediating and confounding roles of various factors in the relation between place of residence and birth intervals.[12,14,13] It is well known that controlling for mediators or path variables in the relation between exposure and outcome while finding the actual effect of exposure on outcome is called over controlling and it will generally result in underestimation of the actual effect of exposure on outcome.[16,17] While confounders in the relation between place of residence and birth intervals need to be controlled while finding the actual effect of place of residence on birth intervals, but mediators need to be controlled only while assessing their mediating role in the actual effect of place of residence on birth interval.

In brief, the major drawbacks in the existing literature on birth intervals by place of residence in Ethiopia include: 1) no clear knowledge about actual levels of birth intervals in Ethiopia at national level (indeed not even a single study reported the distribution of birth intervals by place of residence in Ethiopia, and few other characteristics like mean and various quantiles of birth interval distribution), 2) very limited sample size, 3) not including many important variables in their analysis (so earlier studies heavily suffered from omitted variable bias), and 4) ignoring the possible mediating and confounding roles of various factors in the analysis. So, earlier studies in Ethiopia that have provided the effect of place of residence (i.e. being rural/being urban) on birth intervals might have actually produced biased results. The present study overcomes all these limitations in examining the association between place of residence and birth-to-conception intervals in Ethiopia, and explores the role of various socio-economic and demographic characteristics of women in this relationship.

CONCEPTUAL FRAMEWORK

Empirical research conducted around the world and in Ethiopia showed place of residence and maternal characteristics, such as age, age at marriage, socioeconomic and cultural characteristics of women, have been associated with length of birth intervals.[18-20] Rural and urban populations in Ethiopia differ in terms of their educational status, income per capital, exposure to media, autonomy levels, and in many other socio-cultural and demographic characteristics, that have bearing on their birth-to-conception intervals.[15] This study conjectures place of residence can directly and/or indirectly influence birth-to-conception interval through various pathways or mechanisms. Place of residence acts on birth-to-conception interval are called mediators or path variables in the relation between place of residence and birth-to-concepti-on interval. Figure 1 outlines the conceptual framework considered in this study and the role of various socio-economic and demographic factors in the relation between place of residence (being rural/ being urban) and birth-to-conception interval.

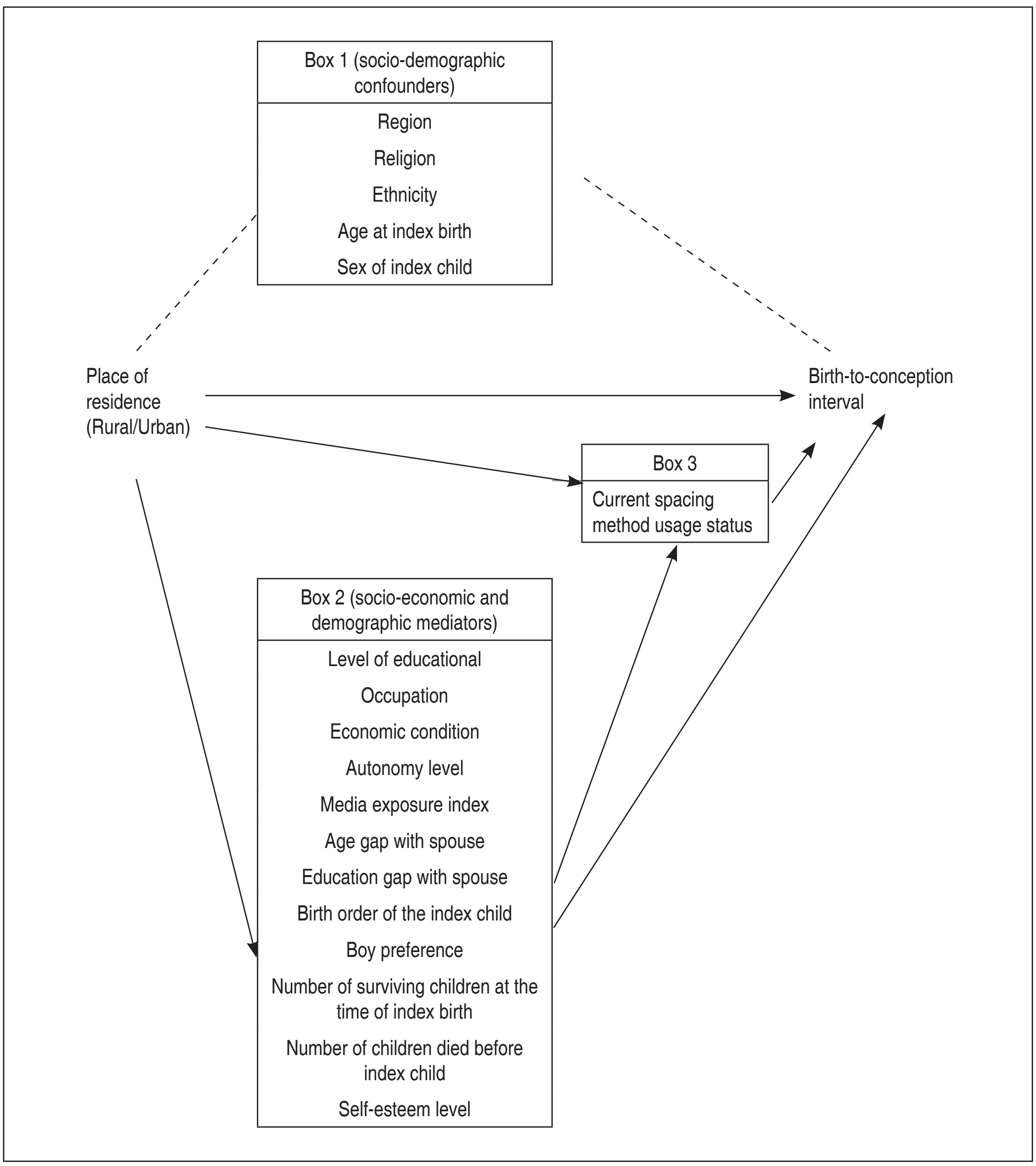

FIGURE 1: Conceptual framework.

Causally, place of residence of a woman may have no influence on her region of residence, religion, ethnicity, age at index birth and sex of index birth. Nonetheless, these factors may have association with both place of residence and birth-to-conception interval. For instance, the distribution of Muslims and Christians may vary by place of residence due to historical reasons. Similarly, across the regions of Ethiopia the composition of rural and urban proportions may vary. In the same way, ethnic composition may vary from rural to urban areas. If birth-to-conception intervals vary by region of residence, religion, ethnicity, age at index birth and sex of index birth, for reasons specific to them, then not controlling for these confounders would inflate or deplete the effect of place of residence on birth-to-conception interval, as the effect of these factors would be confounded in the effect of place of residence. Hence, the factors shown in box 1 of Figure 1 may play the role of confounders in the relation between place of residence and birth-to-conception interval, and hence from now onwards these factors are referred to as 'socio-demographic confounders' in this study. Place of residence, on the other hand, may causally influence level of education of woman, autonomy level, economic condition, and exposure to media directly or indirectly, due to differences gender roles and attitudes between rural and urban, and due to having differences in infrastructure, employment opportunities and modern western values between rural and urban areas. In turn, these factors may influence boy preference, age and educational differences with spouse, and the number of child deaths experienced, which in turn may influence birth-to-conception interval. Place of residence may even directly influence some of the above mentioned factors including son preference and number of child deaths experienced (all these complex relations were shown partially in Figure 1). These factors in turn can influence contraceptive usage for spacing purposes. Place of residence of a woman can also directly influence usage of contraceptive methods for spacing purposes. Hence, place of residence may directly or indirectly influence various socio-economic and demographic characteristics of women, and the woman's usage of contraceptive methods for spacing purposes, as shown in boxes 2 and 3 in Figure 1. These factors in boxes 2 and 3 in turn may influence birth-to-conception interval. Therefore, these socio-economic and demographic factors shown in box 2 and contraceptive usage shown in box 3 can act as the potential mediators in the relation between place of residence and birth-to-conception interval. And hence variables shown in box 2 are referred to as 'socio-economic and demographic mediators.

METHODOLOGY

DATA SOURCE

This study makes use selected portions of data from the fourth Ethiopian Demographic Health Survey, popularly known as EDHS-4. EDHS-4 is a cross-sectional multipurpose health survey conducted in Ethiopia during January 18, 2016 to June 27, 2016. The survey covers a nationally representative sample of 15,683 women in the age group 15-49 years, from 16,650 households. The main purpose of the EDHS-4 is to provide up-to-date estimates of key demographic and health indicators.

The sampling frame used for EDHS-4 is Population Housing Census, conducted in 2007. The 2007 census frame consists a total of 84,915 enumeration areas (EA), with an average of 181 households in each EA. Data was collected using a two stage stratified systematic random sampling approach. Ethiopia consists of nine geographical regions (states) and two administrative cities. Each state was stratified into urban and rural areas. A total of 21 stratums were made out of the 9 regions and 2 administrative cities. In the first stage, enumeration areas were selected from each stratum based on probability proportional size sampling and in the second stage households were selected based on systematic random sampling, from each EA. Further details about the methodology of collecting data in EDHS-4 can be found elsewhere.[15]

METHODS

Initially, basic descriptive analysis was carried out using cross tabulations and summary measures such as quartiles to describe length of birth-to-conception intervals. Following it Kaplan-Meier (K-M) survival estimation procedure was used to estimate the proportion of women who have not conceived in a length of time‘t’, following the index birth. Log-rank test was employed to examine whether the pattern of subsequent conception, following index birth, vary significantly by place of residence or not. In the next step, from the commonly used parametric survival distributions namely Lognormal, Gamma (three parameter), Exponential, Weibull, Pareto, Generalized pareto, and Inverse Gaussian distributions, the best fitted distribution to the length of birth-to-conception interval was identified.

Parametric survival regression models, with the distribution of the dependent variable that has been identified in the previous step, have been used step by step to examine the association between place of residence and duration of birth-to-conception interval, taking into account the confounding and mediating roles of various factors in their relationship as discussed in the conceptual framework.

The form of the parametric survival regression model used in this study is:

$$\log(T_i)=\beta X_i+\sigma\varepsilon_i$$

where T_i is the length of birth-to-conception interval for i^{th} individual, X_i is the vector of values of the considered explanatory variables for i^{th} individual, β is the vector of corresponding coefficients, σ is the shape parameter, and ε_i is the random disturbance term for i^{th} individual. Here it is to be noted that the distribution of the dependent variable T depends upon the distribution of the random disturbance ε.

RESULTS

Of the 4720 respondent women in this study, 3914 (82.9%) were from rural areas and the remaining 806 (17.1%) were from urban areas. Majority of the respondents (63.0%) were from South Ethiopia. Nearly half of the respondents (49.5%) were Christians, and the remaining were mostly (48.8%) Muslims. Around 25% of the respondents have reported Oromio as their ethnicity and 15% reported Amahara as their ethnicity. Roughly 47.0% of respondents had their index birth before the age of 25 years, 41.4% between the ages 25 to 34 years, and only 11.6% had their index birth on or after the age of 35 years. Around 52% of the index births were boy children. About 68.9% of respondents had no formal education, and about 57.7% are not working. Around 52.7% of respondent women had poor economic condition (Table 1).

As we can see from the table that out of 3,914 rural women in this study. i.e., rural women in EDHS-4 who had at least one birth (index birth) during 2010-2012 – 3,168 (80.94%) women had conceived on or before their survey date. On the other hand, of the 806 urban respondent women in this study, only 476 (59.06%) women had conceived on or before their survey date. At national level, out of 4,720 respondent women 3,644 (77.20%) women had conceived on or before their survey date. Percent of present study women for whom complete information on their actual time to next conception is unknown but is known that they

TABLE 1: Number of subsequent conceptions following index birth, by place of residence.

Place of residence	Total number of respondents	Number conceived during study period	Number did not conceived during study period (censored)	Percent Censored
Rural	3914	3168	746	19.06
Urban	806	476	330	40.94
Total	***4720***	***3644***	***1076***	***22.80***

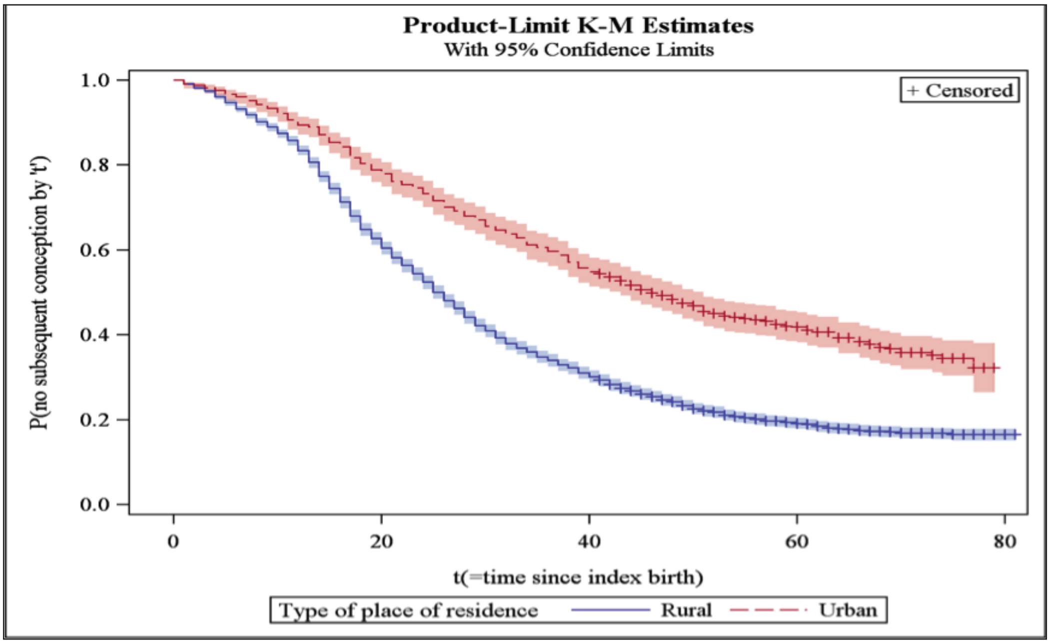

FIGURE 2: Probability of no subsequent conception and its 95% confidence interval, by various durations since the index birth, and by place of residence, as estimated by using product-limit Kaplan-Meier (K-M) survival estimation procedure.

were not yet conceived on or before their survey date (censored observations) is 22.8% at national level, 19.06% in case of rural women and 40.94% in case of urban women.

Figure 2 shows the pattern of subsequent conception for rural and urban women, following their index birth during 2010-2012. In particular, this figure shows the estimated probabilities for a woman (or proportion of women) who had her index birth during 2010-2012, not to have her subsequent conception by various durations since then. It is very clear from this figure that probability of no subsequent conception by various durations since the index birth is high for urban women than for the rural women. This indicates birth-to-conception interval is longer for urban women than for the rural women. Log-rank test was conducted to assess whether the pattern of subsequent conception varies statistically significantly between rural and urban women. And this test revealed that the pattern of subsequent conception significantly vary between rural and urban women ($p<0.001$) (Table 2).

Around 48% of rural women and 27% of urban women have conceived within the first two years (on or before 24 months) following their index birth during 2010-2012. At the national level, the same is 44%.

TABLE 2: Probability of no subsequent conception by various years since the index birth, by place of residence.

Time since index birth (in months) (t)	Place of residence					
	Rural		Urban		Total	
	P(no subsequent conception by time 't')	P(subsequent conception by time 't')	P(no subsequent Conception by time 't')	P(subsequent conception by time 't')	P(no subsequent conception by time 't')	P(subsequent conception by time 't')
12	0.8344	0.1656	0.8945	0.1055	0.8447	0.1553
24	0.5235	0.4765	0.7333	0.2667	0.5593	0.4407
36	0.3403	0.6597	0.5968	0.4032	0.3841	0.6159
48	0.2412	0.7588	0.4837	0.5163	0.2825	0.7175
60	0.1907	0.8093	0.4182	0.5818	0.2292	0.7708
72	0.1682	0.8318	0.3580	0.6420	0.2004	0.7996

TABLE 3: Quartiles of time to next conception since the index birth, by place of residence.

Characteristics	Quartiles					
	1st quartile (25th percentile)		2nd quartile (50th percentile)		3rd quartile (75th percentile)	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Rural	15	(15, 16)	26	(25, 26)	47	(45, 49)
Urban	23	(20, 25)	46	(43, 51)	.	.
Total	**16**		**28**	**(27,28)**	**54**	**(51, 57)**

Slightly above three fourth of rural women (75.9%) and around 52% of urban women had conceived within the first four years following their index birth. Around one in six rural women and one in three urban women have not conceived within the first six years following their index birth during 2010 to 2012 (Table 3).

Following their index birth during 2010-2012, one fourth of the rural women had their subsequent conception within the first 1 year 3 months (15 months), half of women within the first 2 year 2 months (26 months), and three fourth of women within the first 3 year and 11 months (47 months). In case of urban women, one fourth women had subsequent conception within the first 1 year 11 months (23 months), and 50% of women within the first 3 year and 10 months (46 months). At the country level, one fourth of the women had subsequent conception within the first 1 year 4 months (16 months), half within the first 2 year 4 months (28 months), and three fourth within the first 4 and half years (54 months).

IDENTIFYING APPROPRIATE DISTRIBUTION FOR THE LENGTH OF BIRTH-TO-CONCEPTION INTERVAL

Various commonly used parametric probability distributions namely exponential distribution, gamma distribution (three parameter gamma distribution), weibull distribution, lognormal distribution, pareto distribution, generalised pareto distribution, and inverse-gaussian distributions were fitted to the length of birth-to-conception interval, in order to check which of the these probability distributions can fit well to the data.

Figure 3 bellow shows quantile-quantile (Q-Q) plots of the above mentioned distributions to the length of birth-to-conception interval data, at the national level. Table 4, on the other hand, presents the fit of various models to the length of birth-to-conception interval data in terms of Cramer-VonMises and Anderson-Darling test statistics. It is known that both these measures were based on difference between sample and population quantiles, and the lower is the value of these test statistics the better the fit is.[21] Another point need to be remembered here is if a considered model perfectly fits the given data then we expect Q-Q plot of that model looks like a perfect straight line passing through origin, at 45^0 angle. With these two criteria, it could be observed from Figure 3 and Table 4 that Weibull distribution provides relatively best fit among all the considered models in this study. Nonetheless, it could be clearly observable from Figure 3(D) that Weibull distribution fit is not satisfactory at the extreme right tail part of length of birth-to-conception interval data. In particular, the model over estimates the actual quantiles of length of birth-to-conception interval. So, little caution need to be taken while interpreting higher percentiles and quantiles (Table 4).

Table 4 shows the fit of seven commonly used parametric models in terms of log likelihood, Akaike information criteria (AIC) and Bayesian information criteria (BIC) values. The purpose of this table is to identify the best-fitted model. Both AIC and BIC criteria showed that the Weibull model have the lowest AIC and BIC value and hence it is considered as the best fitted model for predicting women on the length of rural-urban differentials in birth-to-conception interval Ethiopia.

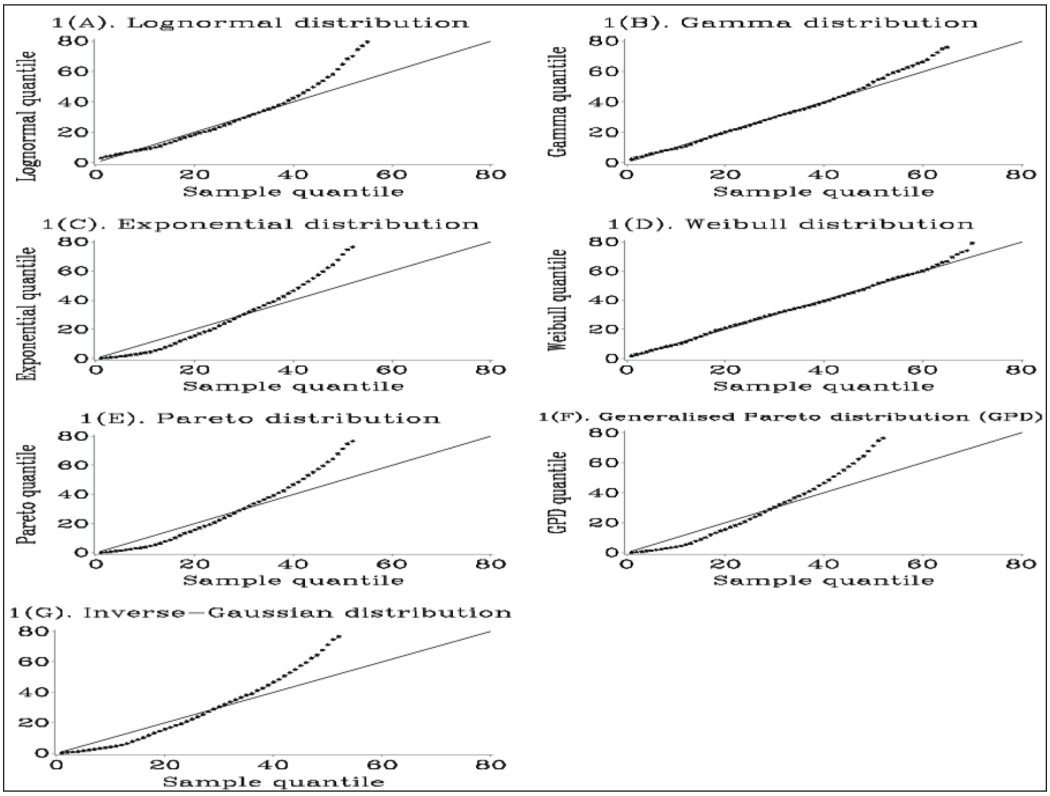

FIGURE 3: Fit of various models to the birth-to-conception interval since the index birth.

TABLE 4: Fit of various models to the length of birth-to-conception intervals.

S No	Model	Log-likelihood	AIC	BIC
1.	Exponential	-196.333	430.6659	509.2827
2.	**Weibull**	**-190.8893**	**421.7785**	**504.5331**
3.	Gamma	-191.2935	422.5871	505.3416
4.	Pareto	-191.8103	423.6431	506.3472
5.	Lognormal	-197.1601	434.3201	517.0747
6.	Generalized pareto	-191.7106	423.4211	506.1757
7.	Inverse Gaussian	-406.423	848.8461	923.3251

Table 4 shows the fit of seven commonly used parametric models in terms of log likelihood, Akaike information criteria (AIC) and Bayesian information criteria (BIC) values. The purpose of this table is to identify the best-fitted model. Both AIC and BIC criteria showed that the Weibull model have the lowest AIC and BIC value and hence it is considered as the best fitted model for predicting women on the length of rural-urban differentials in birth-to-conception interval Ethiopia.

DISTRIBUTION OF LENGTH OF BIRTH-TO-CONCEPTION INTERVAL IN RURAL AND URBAN AREAS IN ETHIOPIA

The following Figure 4 shows the probability distribution of length of birth-to-conception interval for rural and urban women in Ethiopia. Average time to next conception, following index birth, is 3 years (36 months) for rural women and 5 years 1 month (61 months) for urban women. Various percentiles of len-

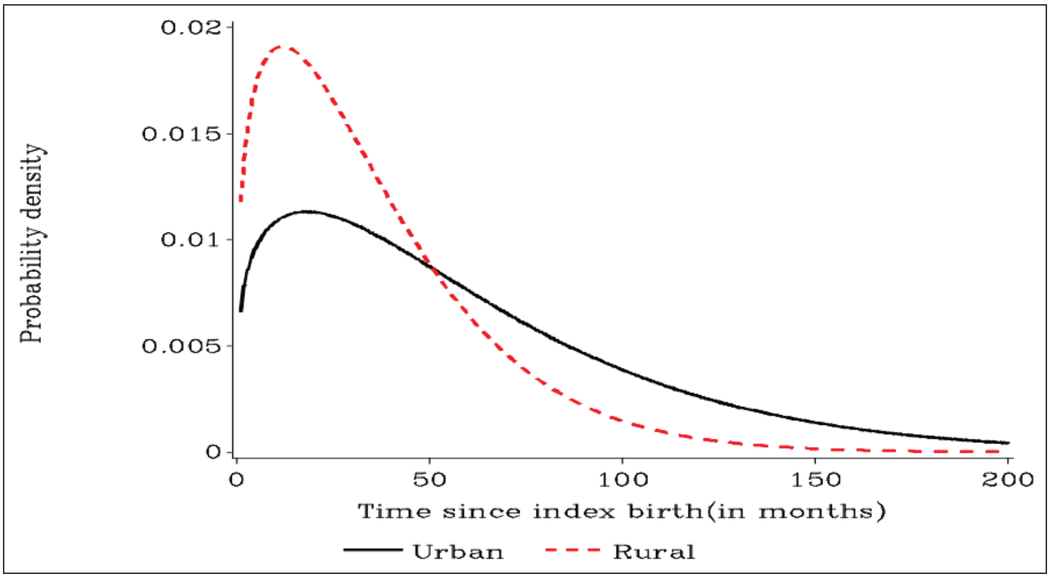

FIGURE 4: Probability distribution of time to next conception since the index birth, for rural and urban women.

gth of birth-to-conception interval, estimated by fitting Weibull distribution, for rural and urban women were shown in Table 5.

Estimated median time to subsequent conception is 2 year 5 months (29 months) for rural women and about 4 years 1 month (48.82 months) for urban women. These estimated median times are about three months higher than the ones estimated by using K-M method, both for rural and urban women. Around 90% of subsequent conceptions are expected to take place within 6 year 2 months (73.97 months) for rural women and within 10 year and 7 months (127.4 months) for urban women. It need to be remembered here that the Weibull distribution fit is poor at the extreme right tail part of birth-to-conception intervals distribution, and indeed Wibull distribution over estimates the higher quantiles of length of birth-to-conception interval (Figure 3). So, roughly it can be considered that almost all subsequent conceptions following index birth will take place within the first six and half years for rural women and within the first 11 years for urban women in Ethiopia.

WEIBULL REGRESSION RESULTS

Weibull regression model is one of the most popular forms of parametric regression model that it provides estimate of baseline hazard function, as well as coefficients for covariates. Results of Weibull regression analysis in table 5 suggest that the probability of Conception per unit time for urban women is 0.69 times that of rural women in Ethiopia (95% confidence interval (CI) is 0.61 to 0.79) ($p<0.001$). On the other hand the probability of conception of women with age at indexed birth less than 25 is 0.88, 95% CI (0.80, 0.96) times that of women aged at indexed >=35 ($p=0.001$).

TABLE 5: Results of Weibull regression analysis.

Covariate	Haz. Ratio	P-Value	[95% Conf. Interval]
Place of residence			
Urban	0.69**	0.001	(0.61, 0.79)
Rural(R)			
Religion			
Christian(R)			
Muslim	1.19**	0.004	(1.07, 1.33)
Others	1.11	0.650	(0.98, 1.26)
Ethnicity			
Amhara(R)			
Oromia	1.80**	0.001	(1.55, 2.09)
Tigray	1.46**	0.001	(1.26, 1.68)
Somali	1.98**	0.001	(1.64, 2.40)
Afar	1.38**	0.002	(1.17, 1.63)
Others	1.45**	0.006	(1.26, 1.67)
Age at index birth			
<25	0.88**	0.001	(0.80, 0.96)
25-34	0.41**	0.001	(0.35, 0.48)
>=35(R)			
Level of Education			
No education(R)			
Primary	0.84**	0.001	(0.76, 0.93)
Secondary	0.69**	0.001	(0.53, 0.91)
Higher	0.63*	0.031	(0.43, 0.93)
Economic Condition			
Poor(R)			
Medium	1.08*	0.003	(1.00, 1.16)
Rich	1.17**	0.001	(1.09, 1.25)
Birth Order			
1 to 2	0.85**	0.001	(0.73, 0.87)
3 to 4	0.80**	0.001	(0.79, 0.92)
>=5(R)			
Contraceptive Use			
Yes	1.88**	0.001	(1.70, 2.08)
No (R)			

DISCUSSION

Using data from Ethiopian demographic and health survey 4, non-parametric and parametric survival models have been used for the analysis. Of the various parametric survival distributions considered in this study Weibull model provided the best fit to the distribution of length of birth-to-conception intervals in Ethiopia, and this model has been used further in addressing the study objectives.

This study found that the median time to subsequent conception following a child birth is 2 year 2 months (26 months) for rural women and around 3 year 11 months (47 months) for urban women. Similarly, average length of birth-to-conception interval is 3 years (36 months) for rural women and 5 years 1 month (61 months) for urban women. It is to be noted here that World Health Organization (WHO) have recommended a birth-to-conception interval of at least 24 months to reduce the risk of adverse maternal and child health outcomes.[22] But present study found percept conceived within the first 24 months following a baby birth is 48% for rural women and 27% for urban women. This indicates there is a clear opportunity to reduce infant and under-five mortality rates in Ethiopia, by increasing awareness about the disadvantages associated with shorter birth-to-conception intervals and by taking those actions that will reduce percept becoming pregnant within the first two years following a baby birth. At the moment, infant and under-five mortality rates in Ethiopia are 48 and 67 respectively. The same are 62 and 83 for rural women, 54 and 63 for urban women in the country. A recently conducted meta-analysis in Ethiopia showed birth interval of less than 24 months (and hence a birth-to-conception interval of less than 15 months, assuming average gestation period of 9 months) enhances the risk of infant death by about 50%. Present study found one in four women in rural area and 1 in 7 women in urban area are getting pregnant within the first 15 months following their index birth. This may suggest a considerable portion of rural disadvantage in terms of infant and child mortality rates can be attributable to relatively shorter birth-to-conception intervals in rural areas. Future studies on this issue should assess what extent of the rural disadvantage in terms of infant and fewer than five mortality rates can be attributable to shorter birth-to-conception intervals for rural women.

This study explored what extent of the urban advantage in terms of birth-to-conception can be further attributable to differences in the usage of contraceptive method for spacing purposes between rural and urban women, and found that the usage of contraceptives for spacing purposes account for less than 1% of the variation in birth-to-conception interval between urban and rural women. This may not essentially indicate almost no further role of contraceptive methods for spacing purposes in the rural urban differential in birth-to-conception intervals, after controlling for the considered socio-economic and demographic mediators. Rather it may indicate the need for a better measure that can be used to better measure the effect of using contraception for spacing purposes. For instance, a measure like how many months were protected from getting a pregnancy as a result of using temporary contraceptive methods is more appropriate to use in place of 'whether a woman is currently using any conceptive method for spacing purposes or not'. Unfortunately such a measure is neither available with demographic health survey data nor could be calculated based on available data. One of the other interesting point that has been noticed from the results of this study, though it is not the main focus in this study, is: women with secondary or higher education are not statistically significantly different from the women with no education, in terms of their birth-to-conception intervals, after controlling for various socio-economic and demographic variables considered in this study. This may perhaps indicate the effect of having higher or secondary education on birth-to-conception interval is completely explained or accounted for by the considered socio-demographic confounders or socio-economic and demographic mediators considered in this study, in the context of Ethiopia.

Existing literature also suggests birth intervals can influence the overall timing of birth of children and period fertility, which in turn can influence population growth.[2] And, indeed, there was one popular Chinese strategy called "later, longer and fewer" to control population growth. This strategy suggests births should be fewer, they should be reasonably spaced, and they should in the later ages of reproductive period instead of at the very earlier ages of reproductive period, to slow down or control population growth.[23,24] Ethiopia is one those 37% of the world countries that have reported that their population size and fertility levels are too high.[25] The country has adopted multi-sectoral national population policy in the year 1993 itself, to control its population growth and expedite socio-economic development in the country.[26] Given the high level of fertility and population problem faced by Ethiopia, increase in birth intervals may directly and indirectly will help to slow down population growth in the country.

It need to be noted here that present study findings cannot be directly comparable with the findings of previous studies on birth intervals in Ethiopia, mainly because of the following three important reasons. First, this study used birth-to-conception intervals as the main outcome variable while most of the existing studies have used birth to birth interval as the main outcome variable in their studies. Second, the measure of birth spacing considered in this study consists both open and closed birth-to-conception intervals. Third, this study regressed log of birth-to-conception interval on various explanatory variables considered in this study, instead of regressing hazards of subsequent conception on various explanatory variables, which is the case with most of the existing studies in Ethiopia.

CONCLUSION

Around half of rural women and slightly above one fourth of urban women in Ethiopia have shorter birth-to-conception intervals than the WHO recommended birth-to-conception interval. Maintaining the optimal birth interval of 3 to 5 years or optimum birth-to-conception interval of 27 months to 53 months is one of the cost effective mechanism that would benefit both mothers and children, in terms of their health outcomes. We can conclude that the Weibull regression model was the best fitted parametric model for rural-urban differentials in birth-to-conception intervals in Ethiopia.

It may also directly or indirectly help to control fertility level and slow down population growth in the country. So, population and public health intervention strategies in Ethiopia should take those steps that will increase birth-to-conception intervals in the country. Finally, we recommended that it is better to see birth-to-conception interval in Ethiopia by including other covariates and other statistical analysis systems.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Yohannes Tadesse Asnakew;* ***Design:*** *Samba Siva Rao Pasupuleti;* ***Control/Supervision:*** *Yohannes Tadesse Asnakew;* ***Data Collection and/or Processing:*** *Yohannes Tadesse Asnakew;* ***Analysis and/or Interpretation:*** *Samba Siva Rao Pasupuleti;* ***Literature Review:*** *Yohannes Tadesse Asnakew;* ***Writing The Article:*** *Yohannes Tadesse Asnakew;* ***Critical Review:*** *Samba Siva Rao Pasupuleti;* ***References and Fundings:*** *Samba Siva Rao Pasupuleti;* ***Materials:*** *Yohannes Tadesse Asnakew.*

REFERENCES

1. King JC. The risk of maternal nutritional depletion and poor outcomes increases in early or closely spaced pregnancies. J Nutr. 2003;133(5):1732S-6S. PMID: 12730491. [Crossref] [PubMed]
2. Rajaretnam T. How delaying marriage and spacing births contributes to population control: an explanation with illustrations. J Fam Welfare. 1990;34:3-13.
3. Rousso D, Panidis D, Gkoutzioulis F, Kourtis A, Mavromatidis G, Kalahanis I. Effect of the interval between pregnancies on the health of mother and child. Eur J Obstet Gynecol Reprod Biol. 2002;105(1):4-6. PMID: 12270555. [Crossref]
4. Conde-Agudelo A, Rosas-Bermúdez A, Kafury-Goeta AC. Birth spacing and risk of adverse perinatal outcomes: a meta-analysis. JAMA. 2006;295(15):1809-23. PMID: 16622143. [Crossref] [PubMed]
5. Conde-Agudelo A, Rosas-Bermudez A, Castaño F, Norton MH. Effects of birth spacing on maternal, perinatal, infant, and child health: a systematic review of causal mechanisms. Stud Fam Plann. 2012;43(2):93-114. PMID: 23175949. [Crossref] [PubMed]
6. Andargie G, Berhane Y, Worku A, Kebede Y. Predictors of perinatal mortality in rural population of Northwest Ethiopia: a prospective longitudinal study. BMC Public Health. 2013;13:168. PMID: 23433304. [Crossref] [PubMed] [PMC]
7. Dube L, Taha M, Asefa H. Determinants of infant mortality in community of Gilgel Gibe Field Research Center, Southwest Ethiopia: a matched case control study. BMC Public Health. 2013;13:401. PMID: 23621915. [Crossref] [PubMed] [PMC]
8. Lindstrom DP, Berhanu B. The effects of breastfeeding and birth spacing on infant and early childhood mortality in Ethiopia. Soc Biol. 2000;47(1-2):1-17. PMID: 11521450. [Crossref] [PubMed]
9. Mekonnen Y, Tensou B, Telake DS, Degefie T, Bekele A. Neonatal mortality in Ethiopia: trends and determinants. BMC Public Health. 2013;13:483. PMID: 23683315. [Crossref] [PubMed] [PMC]
10. Yigzaw M, Enquselassie F. Birth spacing and risk of child mortality at Kalu district South Wollo Zone of Amhara region, Ethiopia. Ethiop Med J. 2010;48(2):105-15. PMID: 20608014.
11. National Research Council Committee on Population. From Death to Birth: Mortality Decline and Reproductive Change. Washington: National Academies Press; 1998. p.440.
12. Begna Z, Assegid S, Kassahun W, Gerbaba M. Determinants of inter birth interval among married women living in rural pastoral communities of southern Ethiopia: a case control study. BMC Pregnancy Childbirth. 2013;13:116. PMID: 23688144. [Crossref] [PubMed] [PMC]
13. Yohannes S, Wondafrash M, Abera M, Girma E. Duration and determinants of birth interval among women of child bearing age in Southern Ethiopia. BMC Pregnancy Childbirth. 2011;11:38. PMID: 21599927. [Crossref] [PubMed] [PMC]
14. Tessema GA, Zeleke BM, Ayele TA. Birth interval and its predictors among married women in Dabat District, Northwest Ethiopia: a retrospective follow up study. Afr J Reprod Health. 2013;17(2):39-45. PMID: 24069750.
15. Central Statistical Agency-CSA/Ethiopia, & ICF. Ethiopia Demographic and Health Sruvey 2016. Addis Ababa, Ethiopia: CSA and ICF; 2017. p.373.
16. Rothman KJ, Greenland S, Lash TL. Modern Epidemiology. 1st ed. Philadelphia: Lippincott Williams & Wilkins; 2008. p.758.
17. Weisberg HI. Bias and Causation: Models and Judgment for Valid Comparisons. Vol. 885. 1st ed. Hoboken, N.J: John Wiley & Sons; 2011. p.348. [Crossref]
18. Exavery A, Mrema S, Shamte A, Bietsch K, Mosha D, Mbaruku G, et al. Levels and correlates of non-adherence to WHO recommended inter-birth intervals in Rufiji, Tanzania. BMC Pregnancy Childbirth. 2012;12:152. PMID: 23237623. [Crossref] [PubMed] [PMC]
19. Fallahzadeh H, Farajpour Z, Emam Z. Duration and determinants of birth interval in Yazd, Iran: a population study. Iran J Reprod Med. 2013;11(5):379-84. PMID: 24639769.
20. McGuire C, Stephenson R. Community factors influencing birth spacing among married women in Uganda and Zimbabwe. Afr J Reprod Health. 2015;19(1):14-24. PMID: 26103691.
21. Stephens MA. Tests of fit based on the empirical distribution function. In: Lovric M, ed. International Encyclopedia of Statistical Science. 1st ed. Berlin, New York: Springer; 2011. p.1597-8. [Crossref]
22. World Health Organization (WHO). Report of a WHO Technical Consultation on Birth Spacing. Geneva, Switzerland: WHO; 2006. p.44.
23. Basten S, Jiang Q. Fertility in China: an uncertain future. Popul Stud (Camb). 2015;69 Supp 1:S97-105. PMID: 25912921. [Crossref] [PubMed] [PMC]
24. Yang Z. China Historical Population Data and the Relevant Studies. Beijing: Reform Publisher (in Chinese); 1996.
25. United Nations. World Population Prospects 2013. New York: United Nations, Department of Economic and Social Affairs, Population Division; 2013. p.49.
26. Hailemariam A. Implementation of the Population Policy of Ethiopia. Vol 12. Achievements and Challenges. 2016;13(1). [Crossref]