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DETERMINANTS OF WAITING TIME TO THIRD PREGNANCY USING CENSORED LINEAR REGRESSION

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Summary. The intervals between pregnancies have important effects on fertility and maternal and infant health outcomes. This study uses linear regression with censored observation to assess the determinants of the waiting time to third pregnancy. The analysis is applied to data from the Second Malaysian Family Life Survey consisting of 1172 women who had their second delivery ending in a live birth. Contraceptive use, age of the woman, duration of breast-feeding, length of previous pregnancy interval and education of the woman all affect the waiting time to third pregnancy significantly.

Introduction

The number of pregnancies, and the intervals between them, are two factors affecting fertility. Differences in pregnancy-interval length can be accounted for by differences in contraceptive practice, breast-feeding behaviour, natural fecundity and coital behaviour. Research has shown a relationship between birth spacing and child survival. Children born within 2 years of a previous birth have a substantially higher mortality risk than children born after longer intervals (Pebley & Millman, 1986; Hobcraft, 1987; Miller *et al.*, 1992; Curtis, Diamond & McDonald, 1993). On the other hand, it is also found that infant mortality is associated with shorter subsequent birth intervals (Ilinigumugabo, 1992). Close birth spacing is also associated negatively with women's health (Winikoff, 1983; Costello, 1986; Winikoff & Castel, 1987; Merchant & Martorell, 1988), as well as the child's nutrition and maternal care (Greenspan, 1993). The benefit of family planning thus extends beyond fertility reduction to reducing infant mortality risk and improving quality of life. Family planning practices for spacing or stopping purposes limit births of very high order and lengthen the time between births, thus enhancing child survival. A deeper understanding of this lengthening effect on the time to pregnancy with respect to contraceptive methods practised will therefore provide useful information to policy-makers.

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Several approaches can be considered in the analysis of the waiting time to pregnancy. The life-table approach has long been recognized as a method for analysing birth intervals (Suchindran & Lingner, 1977; Rodriguez & Hobcraft, 1980; Ilinigumugabo, 1992). Hazards model analyses have become increasingly popular, as evidenced by the substantial literature (Rindfuss *et al.*, 1984; Rodriguez *et al.*, 1984; Lehrer, 1984; Trussell *et al.*, 1985; Trussell, Vaughn & Farid, 1988; Khalifa, 1989; Miller *et al.*, 1992; Cho & Ahn, 1993). Other methods that have been used include multistate models (Mostafavi, 1991; Heckman & Walker, 1992), logistic regression (DaVanzo & Starbird, 1991; Egger, 1992; Curtis *et al.*, 1993) and a formal search model (Bollinger, 1994). This paper applies a simple linear regression with possible censored observations to analyse the determinants of waiting time to third pregnancy using Malaysian data.

Methods

Sample

The present study uses retrospective data from the Second Malaysian Family Life Survey, which was carried out in Peninsular Malaysia in 1989 jointly by RAND Corporation of the United States and National Population and Family Development Board of Malaysia. The sample, which consisted of 1846 ever-married women aged 49 years or younger, is representative of the entire household population of ever-married women aged 49 years or younger in Peninsular Malaysia. A further refinement of the sample is made to select only 1172 women who had experienced their second pregnancy ending in a live birth.

For each woman, the questionnaire on female history contains detailed information on a woman's marriages, pregnancies and related events, contraceptive practice, breast-feeding, as well as on her and her husband's socioeconomic and demographic status. The interval of interest is the waiting time from the end of amenorrhoea following a woman's second live birth to conception of her third pregnancy ending in another live birth. The waiting time T, in months, is obtained as follows: assuming that a particular woman had experienced a third pregnancy ending in a live birth, then:

X_1 = third birth date − second birth date;
$X_2 = X_1$ − gestational period of third pregnancy;
$T = X_2$ − duration of postpartum amenorrhoea following second birth.

In this sample there are 915 cases with complete waiting times and 257 censored observations. The censored cases are women who have not yet experienced a third pregnancy at the time of the interview. Women for whom either they or their husbands have been sterilized, and those who had reached menopause, are excluded from the study since they are no longer at risk of becoming pregnant.

Statistical method

The linear regression is applied to the data containing censored observations or its transformed form and assumed to have an underlying normal distribution. Let the

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waiting time to the third pregnancy for an individual i be t_i, possibly censored, and let $y = g(t)$ be a specified transformation of the waiting time t. The linear model takes the form:

$$y_i = b_0 + \Sigma b_j z_{ij} + e_i,$$

where $z_{ij} (j = 1 \ldots k)$ are explanatory variables. The error terms e_i are assumed to be independent and normally distributed with mean 0 and common variance σ^2. A positive regression coefficient implies that a unit increase in z_j increases the waiting time to third pregnancy by b_j. The desired parameter estimates are obtained by the iterative maximum likelihood method (Aitkin, 1981).

For this data set, a censored linear regression model is fitted to the waiting times using the following logarithmic transformation:

$$Y = \log_2(2 + \text{waiting time}).$$

This gives the closest approximation to a symmetric distribution except for very small values of Y. The very short intervals have inaccuracies in the dates of birth for women who did not report their exact delivery dates, and the addition of two months to the actual survival time accommodates this discrepancy to some extent. Taking logarithms to base 2 allows a simpler interpretation of the results because a 1 unit increase on the log scale then corresponds to a doubling of the survival duration (Cleveland, 1994). This transformation not only largely removes the skewness from the distributions of the intervals but, more important, improves the fit of the model and normality assumption of the errors. The censored linear regression provides an alternative approach to the Cox regression model when the proportionality assumption of the hazards is violated.

Variables

The aim of the analysis is to assess the determinants of the waiting time to the third pregnancy. Of particular interest is the extent to which the different contraceptive methods affect these interval lengths after controlling for the demographic and socioeconomic factors. The variables chosen as possible predictors of the waiting time are defined below and their proportions are presented in Table 1, with marked categories referring to the reference group used in fitting the censored linear model.

Contraceptive practice. Contraceptive practice is grouped according to specific method used and the initiation of its use: that is, when the woman began using contraception following her second delivery. The category 'other modern method' refers to IUDs, condoms and injections. Initiation of use is not considered for women who practise rhythm, withdrawal or a traditional method because almost all of the women initiated use of these methods within 3 months of their second birth.

Duration of breast-feeding. It is of interest to see if there is any independent effect of breast-feeding duration on the waiting time to the third pregnancy, even though the

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Table 1. Percentages of explanatory variables for the third pregnancy interval

Variable	Percentage	Frequency
Contraceptive practice		
Start pill (months)		
≤3	0·167	196
3–≤6	0·032	38
>6	0·026	31
Start other modern method (months)		
≤3	0·048	56
>3	0·021	25
Rhythm	0·064	75
Withdrawal	0·049	57
Herbal/traditional	0·067	79
No contraception†	0·297	348
Unknown	0·228	267
Breast-feeding duration (months)		
None†	0·173	203
<3	0·363	425
3–<6	0·096	112
6–<12	0·150	176
12–<18	0·057	67
18+	0·129	151
Currently breast-feeding	0·032	38
Education of woman		
None†	0·120	141
Primary (6 years)	0·494	579
Secondary+	0·386	452
Sex of previous child		
Male†	0·514	602
Female	0·486	570
Age of woman at second birth (years)		
<20+	0·160	188
20–24	0·467	547
25–29	0·300	351
30+	0·073	86
Woman's employment		
Not working†	0·142	166
Paid employee	0·592	694
Self-employed/employer	0·073	86
Unpaid family worker	0·193	226
Year of previous birth		
1955–69†	0·172	202
1970–79	0·365	428
1980–88	0·462	542

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Table 1. *Continued*

Variable	Percentage	Frequency
Ethnicity		
Malay†	0·544	638
Chinese	0·241	282
Indian/other	0·215	252
Place of residence		
Urban	0·346	406
Rural†	0·654	766
Husband's education		
Primary/none†	0·584	685
Secondary (7–11 years)	0·371	435
Post-secondary (12+ years)	0·044	52
Husband's employment		
Professional	0·271	318
Agricultural†	0·494	579
Manual	0·235	275
Length of previous interval (months)		
<6†	0·397	465
6–<12	0·194	227
12–<24	0·207	243
24+	0·177	207
Unknown	0·026	30

†Categories used as reference.

effect of breast-feeding has been largely accounted for through the length of postpartum amenorrhoea. The category 'currently breast-feeding' refers to those women who were still breast-feeding at the time of the interview.

Age of woman at second birth. The age of the woman is used to account for the cohort effect.

Education of woman. The highest education completed by a woman should reflect her awareness of and exposure to modern contraceptives.

Work status of the woman. A woman's employment status may have some influence on her breast-feeding behaviour and contraceptive method choice.

Sex of previous child. This refers to the sex of a woman's second child.

Ethnicity. Peninsular Malaysia comprises three major ethnic groups: Malays, Chinese and Indians. Malays made up around 57% of the population in 1991, while

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the Chinese and Indians were about 29% and 10% of the population, respectively (Department of Statistics, 1995).

Year of birth of previous child. This variable is included to account for possible period effects. This study covers a 34-year period from 1955 to 1988. The year is grouped into three periods: 1955–1969, 1970–1979 and 1980–1988.

Length of previous interval (LPI). This refers to the interval between a woman's first birth to conception of her second pregnancy. It is included to capture unmeasured individual variation and couple-specific behaviour that persists over time.

Place of residence. Place of residence is classified as either urban or rural based on the categorization used by the Malaysian Department of Statistics.

Education of husband. Husband's education is included to see if there is any effect on the waiting time to pregnancy through its influence on the woman with regard to decision-making issues, such as use of contraception and choices of contraceptive method.

Occupation of husband. Husband's occupation is one of the proxies for socioeconomic status and is divided into three broad categories: professional and managerial, agricultural and manual.

The modelling strategy

Three models are fitted and compared in terms of their deviance. The first is the *biological model*, which includes as covariates those physiological variables known to affect the waiting time to pregnancy. The variables included in this model are contraceptive use, age, breast-feeding duration and length of the previous interval. The length of the previous interval is included in the biological model, even though its effect may largely be due to behavioural, rather than biological, differences. The second model is a *full model* in which all the explanatory variables in Table 1 are incorporated. A *final model* is selected to include only those variables that are found to be significant in the full model, and the coefficients re-estimated.

Results

Exploratory data analysis shows that many of the explanatory variables are inter-correlated. Chi-squared statistics show that contraceptive use and duration of breast-feeding are significantly associated with each of the variables included in the model. These data also show that independent variables, including education of woman and ethnicity, affect breast-feeding duration and contraceptive practice in opposite directions. For example, Chinese women are more likely to use modern contraceptives than Malays, while the Malay women are more likely to breast-feed for longer durations than their Chinese counterparts. Thus it is of interest to assess the

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direct effects of these independent variables on the waiting time to third pregnancy after controlling for the effects of the biological factors.

The estimated coefficients and standard errors for the biological model are shown in the first two columns of Table 2. All the biological factors are found to be statistically significant. Using contraception of any method, being in an older age group, a longer duration of breast-feeding, currently breast-feeding and a length of previous interval (LPI) greater than 24 months significantly lengthens the waiting time to third pregnancy. An unknown LPI is also found to be statistically significant in lengthening a woman's waiting time to third pregnancy, suggesting that her LPI is at least one year. Being aged 25 years and older is significantly associated with longer waiting times compared with being aged 20 years or younger.

All the contraceptive groupings show a statistically significant lengthening effect on the waiting time compared with non-use. As expected, use of modern methods registers higher coefficients compared with use of herbals and 'unknown' contraceptives. A somewhat surprising result is that women who use an IUD 3 months after the birth of their second child have a longer waiting time to their third pregnancy than those who use it earlier. A similar effect is observed for women who go on the pill, with those using it earlier having shorter waiting times. This suggests that women who initiate the use of the IUD or oral contraceptives later may have been breast-feeding and at the same time using some form of pregnancy control such as abstinence, withdrawal or herbals before initiating use of the IUD or pill, but only reported the latter. The significance of the 'unknown' group relative to non-users could imply that women who did not respond to this question probably used some form of contraceptive. As expected, the lengthening effect of breast-feeding on the waiting time is found to be significant for breast-feeding durations of at least 18 months, and for those who were currently breast-feeding at the time of the survey.

The third and fourth columns of Table 2 show the results of fitting the full model, in which all the explanatory variables are included. The effects of contraceptive use, breast-feeding, age and length of previous interval remain much the same as for the biological model. Among the additional variables, maternal education is the only factor found to be statistically significant, where having a secondary education is positively associated with longer waiting times to pregnancy compared with no schooling. The sex of the previous child, place of residence, the ethnic group of the woman, and her work status, all have no statistically significant influence on the waiting time.

The last two columns of Table 2 give the estimates of the coefficients and standard errors for the final model. These are obtained by dropping out the non-significant covariates in the full model and re-estimating the remaining coefficients. The difference in deviance between the full and final models is 12·54 (with 13 degrees of freedom). The small increase in deviance, compared with the large reduction in the number of covariates included in the final model, indicates that this model provides an equally good fit in assessing the determinants of the pregnancy-interval length.

With the exception of the unknown group and the herbal users, the coefficients associated with the various contraceptive methods exceed 1, indicating that their effects on lengthening the waiting time to pregnancy are at least double those of the non-users of contraception. This follows from the fact that the waiting times are

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Table 2. Factors associated with waiting time to third pregnancy: censored linear regression analysis

Variable	Biological		Full		Final	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Contraceptive practice						
Start pill (months)						
≤3	1·385	0·143**	1·321	0·148**	1·343	0·144**
<3–≤6	1·342	0·278**	1·252	0·282**	1·282	0·279**
>6	1·864	0·306**	1·812	0·310**	1·850	0·307**
Start other modern method (months)						
≤3	1·482	0·241**	1·304	0·250**	1·394	0·244**
>3	1·892	0·352**	1·801	0·359**	1·818	0·353**
Rhythm	1·477	0·210**	1·293	0·223**	1·426	0·212**
Withdrawal	1·496	0·245**	1·449	0·250**	1·433	0·246**
Herbal/traditional	0·495	0·197*	0·515	0·203*	0·443	0·198*
Unknown	0·536	0·129**	0·585	0·134**	0·548	0·132**
Breast-feeding duration (months)						
<3	0·002	0·138	0·093	0·149	−0·014	0·138
3–<6	−0·309	0·189	−0·201	0·201	−0·336	0·190
6–<12	−0·151	0·165	0·025	0·186	−0·160	0·165
12–<18	−0·061	0·224	0·114	0·244	−0·084	0·224
18+	0·499	0·175**	0·743	0·205**	0·509	0·175**
Currently breast-feeding	1·748	0·548**	1·983	0·561**	1·709	0·551**
Education of woman						
Primary			0·125	0·151	0·115	0·148
Secondary+			0·351	0·178*	0·359	0·160*
Age of woman at second birth (years)						
20–24	0·229	0·132	0·151	0·135	0·192	0·133
25–29	0·463	0·151**	0·326	0·160*	0·392	0·154*
30+	1·125	0·227**	1·024	0·236**	1·073	0·229**
Previous child female			0·063	0·094		
Ethnicity						
Chinese			0·297	0·154		
Indian/other			0·156	0·134		
Year of previous birth						
1970–79			0·089	0·143		
1980–88			−0·043	0·159		
Woman's employment						
Fully paid			0·052	0·142		
Self-employed			0·257	0·212		
Unpaid family worker			0·076	0·171		
Urban residence			0·078	0·106		

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Table 2. *Continued*

Variable	Biological		Full		Final	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Husband's education						
Secondary			0·090	0·128		
Post-secondary			0·152	0·271		
Husband's employment						
Professional			0·142	0·140		
Manual			0·112	0·131		
Length of previous interval (months)						
6–<12	0·218	0·129	0·211	0·129	0·213	0·129
12–<24	0·214	0·127	0·230	0·127	0·234	0·127
24+	1·035	0·145**	1·059	0·147**	1·027	0·145**
Unknown	0·915	0·292**	1·022	0·295**	0·973	0·293**
− 2 log likelihood (df)	3633·51 (1149)		3613·98 (1134)		3626·52 (1147)	

*Significant at 5%; **significant at 1%.

transformed using logarithms to base 2. It is also not surprising to see that the net effect of breast-feeding on lengthening the waiting time to conception is statistically significant only for current breast-feeding and for breast-feeding durations of at least 18 months. This could be due to the positive association between duration of breast-feeding and intensity of breast-feeding resulting in a net contraceptive effect, thus lengthening the waiting time to pregnancy. It is also reasonable to suggest that women in the current breast-feeding group may have been breast-feeding for some time.

The length of the previous interval (LPI) included in the analysis shows a significant contribution to the waiting time to a woman's third pregnancy. The coefficients associated with LPI suggest that their effects on lengthening the waiting time increase with increasing LPI. The significance of the unknown LPI might also suggest that the woman's previous birth interval could have been a long one.

Not surprisingly, the biological factors are the most direct determinants of the waiting time to third pregnancy. Use of contraception, longer durations of breast-feeding, being in older age groups, and longer LPIs all have a positive effect on the waiting time. Maternal educational level is the only socioeconomic factor showing a significant positive contribution to the waiting time.

Discussion

This study shows that the waiting time to pregnancy can be analysed using a simple linear model. The importance of contraception, breast-feeding and maternal age

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confirms the findings of Janowitz & Smith (1984), Trussel *et al.* (1985, 1988), Mostafavi (1991), DaVanzo & Starbird (1991), Majinge & Lema (1993) and Bollinger (1994). As suggested earlier, the effect of breast-feeding on lengthening the waiting time that arises only from the long duration of breast-feeding may be explained by the relationship between intensity of breast-feeding and breast-feeding duration. Although intensity of breast-feeding and whether breast-feeding is exclusive or supplemented were not included in the analysis, it is very likely that women who breast-feed for a long duration do so with greater intensity compared with those who breast-feed for a shorter duration.

The length of the second waiting time (LPI) has been shown to be a strong determinant of the waiting time to the third pregnancy, even after controlling for the initiation of contraceptive use and durations of breast-feeding. The result confirms the findings of Rodriguez *et al.* (1984), Trussell *et al.* (1985, 1988) and Murphy (1992). The significance of the effect of education on the waiting time is again in agreement with Rodriguez *et al.* (1984) but contradicts the findings of Rindfuss *et al.* (1984), Trussell *et al.* (1985) and DaVanzo & Starbird (1991). In the present study, ethnicity is found to be a strong determinant of the duration of postpartum amenorrhoea, duration of breast-feeding and contraceptive method choice, leaving no significant influence on the waiting time to the third pregnancy after controlling for biological and other socioeconomic variables. It can be said then that any effect of ethnicity on the waiting time may have been absorbed by these factors. For example, Malay women are more likely to breast-feed and are more likely to do so for a longer duration than Chinese and Indian women, but are less likely to practise modern contraception. This results in a non-significant net effect on the waiting time to pregnancy.

The contraceptive methods practised by women in this study may be classified into three main groups: modern contraceptives, including pills, IUDs, condoms and injections; natural methods that include rhythm and withdrawal; and the traditional or folk practice of using herbals. The choice not only depends on the purpose of using contraception but also the exposure, availability and affordability of such contraceptive methods. In Malaysia the majority of women use contraception for spacing purposes, indicated by the fact that more than half of the users cited desire to become pregnant as a reason for discontinuing contraception (Awang, 1997). Women who chose sterilization to avoid further pregnancies were already excluded from the analysis, although there would be those using IUDs for stopping purpose. As expected, modern contraceptives have the greatest impact on lengthening the waiting time to pregnancy. The study also shows that the proportion of women practising traditional methods and those not using any form of contraception is relatively high (36%). Thus any effort to widen inter-pregnancy intervals or limit future pregnancies will have to come not only from educating women on the use of contraception, but also from the promotion of modern and more effective contraceptives, and educating women in their effective use.

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