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EFFECT OF BIRTH SPACING ON INFANT SURVIVAL IN THAILAND: TWO-STAGE LOGIT ANALYSIS

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EFFECT OF BIRTH SPACING ON INFANT SURVIVAL IN THAILAND: TWO-STAGE LOGIT ANALYSIS

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Abstract. We formulated a two-stage causal model for infant survival and applied it to data drawn from the 1987 Thai Demographic and Health Survey covering the fate of 5,074 index children. The following six variables were considered as the explanatory variables: maternal age, maternal education, birth order, preceding birth interval, survival of the preceding child, and place of residence. The analysis suggests that the birth interval not only directly affected the chance of infant survival but it played the role of the filtering factor through which other variables indirectly operate on infant mortality. The effect of preceding child's death was very strong, the odds ratios for the following infant's death and short birth interval both exceeding three.

INTRODUCTION

As individual data on reproductive history has become widely available through large-scale fertility surveys, such as World Fertility Survey and more recently Demographic and Health Surveys, many researchers have attempted to establish the relationship between birth interval and infant and child mortality, especially in developing areas. Recent reports on the subject include Boerma and Bicego (1992), Lantz *et al* (1992), Koenig *et al* (1990), Retherford *et al* (1989), Park (1986), Hobcraft *et al* (1983), and Fortney and Higgins (1984). The general finding is that a short birth interval, either preceding or subsequent, increases mortality of the infant. The mechanisms through which short birth interval adversely affects a child's health have been speculated to have both biological (*eg*, poor maternal recovery from pregnancy) and behavioral (*eg*, competition for resources) origins.

While the length of birth interval is related to child survival, the former variable is also associated with many biological and socioeconomic variables which are associated with infant mortality. Some of these latter variables may affect the chance of child survival only through birth interval, while others may do so directly and still others may exert both direct and indirect effects. Then a two-tier causal model for infant mortality, akin to that for fertility (Bongaarts, 1978), may be formulated, considering socioeconomic variables as background variables and birth interval as a proximate variable. Unfortunately, infant mortality studies based on this kind of conceptual framework are rare.

Mosley and Chen (1984) have proposed an elaborate analytical framework but its applicability appears to be limited, because to a large extent of poor availability of data for four of the five groups of their proximate determinants which include environmental contamination, nutritional deficiency, and personal illness control. Park (1986) has provided a more modest two-stage logistic recursive model suggesting birth interval as the intermediate variable and others as background variables and applied it to Korean data. More recently workers in Indonesia have followed this approach (Utomo and Poedjastoeti, 1987, Achadi and Costello, 1991). Their findings uniformly indicate that while birth interval directly affects infant mortality, other socioeconomic and demographic variables, such as maternal age, birth order, maternal education, and place of living, do so indirectly through birth interval. Survivorship of the immediately preceding child in infancy appears to exert both direct and indirect effects on child survival, the former being especially strong.

Recently Thailand has been experiencing a fast fertility decline, some even call the situation a "reproductive revolution" (Knodel *et al*, 1987). Although a large portion of the decline appears to be due to termination of childbearing rather than spacing (Chayovan *et al*, 1988), the average birth

interval may have also been lengthened. A recent study (Tsuya *et al.* 1993) reports that previous birth interval, breastfeeding and maternal education are significant factors in infant survival. The main purpose of this paper is to analyze the effects of preceding birth interval and other selected factors on infant mortality in Thailand applying a two stage model developed by Park (1986). Thus in this paper we emphasize the causal ordering with respect to infant survival, evaluating direct and indirect effects of selected determinants.

MATERIALS AND METHODS

This study has used data extracted from the 1987 Thai Demographic and Health Survey (TDHS) a nationally representative sample survey conducted during March-June 1987 by the Chulalongkorn University Institute of Population Studies with the cooperation of the Westinghouse Institute for Resource Development, USA, interviewing 6,775 ever-married women aged 15-49 years. Details of the survey procedure and design and overall findings are described elsewhere (Chayovan *et al.* 1988). The TDHS data are generally believed to be excellent in quality and rich in demographic and socioeconomic information. For each woman interviewed, her pregnancy history was obtained asking the date of each birth and the date of death if the child died.

The index children of this study consisted of 5,074 second- and higher- order births that occurred during a 10-year period between January 1976 and February 1986. As our primary purpose of the study was to evaluate the effect of the preceding birth interval on the survival of the following infant, we excluded the first order births from the index children. For the index children the observed infant mortality rate was 41.4 per 1,000 births. It may be added here that the official figures on infant mortality are much lower, probably owing to under-reporting, a report to the Asian Development Bank shows that in the 1970s the rate was in the twenties and in the early 1980s it was in the level of low teens (Suntrajarn and Sudsok 1986).

As the explanatory variables for infant mortality (X), we selected the following six variables: maternal age at birth of the index child (A), birth order of the index child (B), survival status of the immediately preceding child in infancy (C), length of the preceding birth interval (D), educational attainment of mother (E), and place of residence of the parent (F). For simplicity, all the variables were considered as binary. The categorization of the variables is shown in Table 1.

Maternal age, parity and birth interval have long been thought to affect the chance of a child's survival. It is known that there is a close association in the survival of siblings, since the seminal works of Yerushalmy and his associates (1941-1956). When the preceding child dies in infancy, however, birth interval is also likely to be shortened owing to inevitable cessation of breastfeeding and the "replacement" effect. Maternal education is sometimes considered to represent the general socioeconomic background of the woman (Hobcraft *et al.* 1983). The modernization process, which is closely related to fertility and mortality, may be more rapid in urban living than in rural living. These variables have been used for the causal analysis of Korean infant mortality (Park 1986).

Although we realize breastfeeding and family planning are important factors in both birth interval and infant survival, we could not include them in our analysis, in TDHS both sets of information were asked for in the case of births which occurred after 1982. As all the seven variables are categorical, each having two categories, a 2^7 cross-classified table was created and log-linear analysis was applied. As to the causal ordering, we considered that infant survival was preceded by birth interval which was in turn preceded by the rest of the five variables. Some of these five variables may have direct effects on the child's survival in addition to indirect effects through birth interval. This ordering is consistent with the conceptual framework of birth interval being the proximate variable and others being the background variables. Analytically this is equivalent to two-stage log-linear analysis, first analyzing on a 2^6 cross-classified table collapsing over the variable of infant survival then on the full 2^7 table (Fienberg, 1980).

Once the log-linear analysis is performed for the appropriate model, presentation of the causal relationship in terms of logistic regression is easy (Fienberg, 1980). The "best" fit log-linear model for the data was selected as elaborated later, by the standard stepwise procedure. The initial model was determined by the Brown screening technique (Brown, 1978). We also considered the Akaike Information Criterion (AIC) (Akaike,1973, de Leeuw, 1992) in the selection procedure. The multi-stage

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Table 1

Description of variables

Notation	Variable	Category
Explanatory variables		
A	Maternal age	A_1 <25 years of life A_2 25 years and above
B	Birth order of index child	B_1 Birth order 2 B_2 3 and above
C	Survival status of the preceding child	C_1 Survived through infancy C_2 Died in infancy
D	Preceding birth interval	D_1 <24 months D_2 24 months and above
E	Maternal education	E_1 Elementary or lower E_2 Secondary or higher
F	Place of residence	F_1 Rural area F_2 Urban area
Response variable		
X	Survival of the index child	X_1 Survived through infancy X_2 Died in infancy

logistic analysis thus performed is analogous to the path analysis for qualitative data (Goodman, 1973)

RESULTS

Univariate and bivariate analysis

We first examined the odds ratio of a given factor - difference in the odds of infant death between the two categories of the factor without controlling other factors If the confidence interval of an odds ratio covers unity, there is no evidence that infant mortality is different by category of the variable The larger the deviation from unity in the ratio, the stronger the association between mortality and the factor As shown in Table 2, among the six factors, all but age of mother (A) yielded significant findings The directions of the significant odds ratios were plausible Especially a strong odds ratio was associated with the survival of the previous child (C) if it died rather than survived, there would be 160% increase in the odds of death of the following infant The role of the preceding birth interval was also fairly strong if the interval were long, the odds of death would be decreased by nearly half Education of mother and place of residence produced a relatively weak effect

The odds ratios within a given category of birth interval are shown in Table 3 When the birth interval was short, three variables-birth order, fate of the previous child, and education-presented odds ratios significantly different from unity When the interval was long, only one variable survival status of the previous infant showed significance Thus it appears that many factors are associated with birth interval and their effects on infant mortality largely disappear if the birth interval is long

Selection of the best fit causal model

Among the many possible log-linear models for a multidimensional table (Fienberg, 1980), we need to select the most appropriate causal model in terms of parsimoniousness, goodness-of-fit, and amount of information the model could offer To reach such a model for our data, we sequentially examined a series of nested models as listed in Table 4 The models consist of two or more letters in brackets Each letter indicates the main effect of the variable as denoted in Table 1, omitting the full interaction effect of the explanatory variables,

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Table 2

Infant mortality for birth order 2 and above by selected factors, Thailand.

Factors interval	No of births	No of infants died	Infant mortality (per 1,000)	Odds ratio	95% confidence interval
Total	5,074	210	41 4		
Maternal age (A)					
< 25 yrs (A1)	1,673	69	41 2		
25 yrs + (A2)	3,401	141	41 4	1.00	0 75 - 1.35
Birth order (B)					
Order 2 (B1)	2,083	70	33.6		
Order 3 (B2)	2,991	140	46 8	1.39	1.04 - 1.86
Survival status of previous child (C)					
Survi > 12 m (C1)	4,813	184	38 2		
Died ≤ 12 mo (C2)	261	26	99 6	2 61	1.70 - 4.00
Previous birth interval (D)					
≤ 24 mo (D1)	1,619	99	61 1		
> 24 mo (D2)	3,455	111	32 1	0 52	0.40 - 0.69
Education of mother (E)					
≤ Elemen (E1)	4,308	190	44 1		
Second + (E2)	766	20	26 1	0 59	0 37 - 0 94
Place of residence (F)					
Rural (F1)	3,697	168	45 4		
Urban (F2)	1,377	42	30 5	0 67	0 48 - 0 95

as it must be included anyway by theory Our initial model in the selection process for the best fit model included all the effects but that of place of residence (Model 1), as the latter effect was not significant either by partial or marginal association, while others were The importance of an effect in the model was evaluated by examining the difference in the likelihood ratio chi-square values (G^2) between the two models, one including the effect and the other excluding it If the G^2 under examination is significant, the effect is too large to ignore

Our strategy was to repeat the procedure until we reached the model that no more individual effects could be eliminated As shown in Table 4 we could ignore the effect of B but not others In terms of AIC, however, Model 1, which included the effect of B, presented the smallest value among the models tested and its goodness of fit was excellent Under the circumstances, we decided to accept Model 1 as the best fit model for the first stage of causation, although it is less parsimonious than Model 2 By undergoing a similar procedure for the second stage, we selected the model (B, C, D) Combing these two stages the overall causal interpretation is that maternal age and education are indirectly affecting the survival chance of the subsequent infant through birth interval, but birth order and the fate of the last child exert both direct and indirect effects on infant survival Birth interval is not only directly affecting the chance of infant survival but all the indirect effects of the other variables operate through it

Strength of effects

The logit parameter is useful in evaluating the strength and direction of a determinant As our logit models are derived from the log - linear models, the parameter represents the deviate from the mean logit owing to the case belonging to the first category of the factor Then the odds ratio of a determinant is measured by the exponential of twice its logit parameter (Hosmer and Lemeshow,

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Table 3

Infant mortality by factors within a given birth interval

Factors	No of births	No of infants died	Infant mortality (per 1,000)	Odds ratio	95% confidence interval
Short interval (≤ 24 mo)					
Total	1,619	99	61 1		
Maternal age (A)					
< 25 yrs (A1)	770	47	61 0		
25 yrs + (A2)	849	52	61 2	1.00	0.67 - 1.51
Birth order (B)					
Order 2 (B1)	774	37	47.8		
Order 3 (B2)	838	62	74 0	1.55	1.02 - 2.35
Survival status of previous child (C)					
Survi > 12 m (C1)	1,463	83	56 7		
Died ≤ 12 mo (C2)	156	16	102 6	1.81	1.03 - 3.16
Education of mother (E)					
≤ Elemen (E1)	1,339	91	68 0		
Second + (E2)	280	8	28 6	0.42	0.20 - 0.88
Place of residence (F)					
Rural (F1)	1,173	78	66 5		
Urban (F2)	446	21	47.1	0.71	0.43 - 1.16
Long interval (> 24 mo)					
Total	3,455	111	32 1		
Maternal age (A)					
< 25 yrs (A1)	903	22	24.4		
25 yrs + (A2)	2,552	89	34.9	1.43	0.89 - 2.30
Birth order (B)					
Order 2 (B1)	1,302	33	25.3		
Order 3 (B2)	2,153	78	36 2	1.43	0.94 - 2.16
Survival status of previous child (C)					
Survi > 12 m (C1)	3,350	101	30.1		
Died ≤ 12 mo (C2)	105	10	95 2	3.16	1 60 - 6 22
Education of mother (E)					
≤ Elemen (E1)	2,969	99	33 3		
Second + (E2)	486	12	24 7	0.74	0 40 - 1 36
Place of residence (F)					
Rural (F1)	2,524	90	35 6		
Urban (F2)	931	21	22.6	0 63	0 39 - 1 02

1989) For instance, the odds of infant survival would be decreased by $e^{2(0\ 296)} = 0\ 55$, if birth interval were shorter rather than long, or conversely, the odds ratio of long interval relative to short interval would be $1/0\ 55 = 1\ 81$ These odds ratios are also shown in Table 5

In the first stage of causation, the effect of mortality status of the previous child was very

Table 4

Selection of log-linear models

Model					Effect under test		
No description	df	G^2	p	AIC	effect	df	G^2
First stage of causation							
1 (A, B, C, E)#	27	22 8	0 69	−31.2			
2 (A, C, E)	28	25 0	0 63	−31 0	B	1	2.16
3 (A, C)	29	33 1	0 27	−24 9	E	1	8 11**
4 (C, D)	29	235 4	0 00	177 4	A	1	210 41**
Second stage of causation							
1 (A, B, C, D, E, F)	57	50 0	0 73	−64 1			
2 (A, B, C, D, E)	58	50 0	0 76	−66 0	F	1	0.03
3 (A, B, C, D)	59	50 9	0 76	−67 1	E	1	0.09
4 (B, C, D)#	60	51 0	0 79	−69 0	A	1	0.00
5 (C, D)	61	55 7	0 67	−66.3	B	1	4.72*

df degrees of freedom
G^2 likelihood ratio chi-square
p probability
AIC Akaike Information Criterion
the best fit model
* $p < 0 05$
** $p < 0 01$

Table 5

Estimates of the logit parameters and odds ratios for the effects in the best fit causal models for the Thai infant survival data.

Determinant	Logit parameter	Odds ratio
First stage-effects on birth interval (short rather than long)		
Maternal age (young *vs* old)	0 460	2 51
Birth order (low *vs* high)	0 050	1.10
Prev child (survived *vs* died)	−0.578	0.31
Education (low *vs* high)	−0.120	0 79
Second stage-effects on infant survival (survive rather than die)		
Birth order (low *vs* old)	0 150	1.35
Prev child (survived *vs* died)	0.596	3.29
Birth interval (short *vs* long)	−0.296	0 55

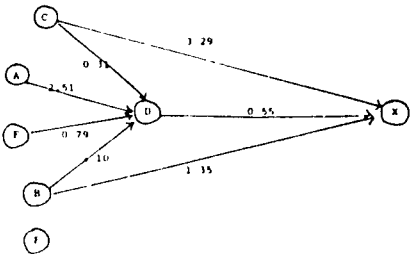
strong If the preceding child survived through infancy, the odds of having the short birth interval rather than the long one would be reduced to less than one-third The effect of maternal age was also strong, the odds ratio exceeding 2 5 The birth order effect on birth interval was relatively meager The direction of the education effect should be noted; if lowly educated, the odds of short birth interval would be decreased by 20% It is reported that the age of first birth is closely and

positively associated with education in Tables 3, 5 (Chayovan *et al*, 1988) If the highly educated also end childbearing earlier than the lowly educated, our finding seems to suggest a short but intense childbearing period among the highly educated The place of residence did not play any role in our causal system

In the second stage of causation, the direct effect of the survival status of the previous child on the following child's survival chance was remarkably strong If the previous infant survived, the odds of survival of the following child would be increased more than three times The birth order effect was moderate, its odds ratio being 1 35 The birth interval effect appears to be fairly strong, short interval would reduce the odds of survival of an index child by nearly half

As there are no significant interaction effects in our models, the combined effect of two or more variables on the response variable may be estimated by the sum of the respective logit parameters For example, the odds of infant survival would be increased, $e^{0.596 + 0.296} = 2.44$ times, if the previous child survived through infancy and birth interval were long If the situation were reversed, *ie*, the previous child died and birth interval were short, the odds of infant survival would be increased, $e^{0.596\ 0.296} = 0.41$ times Then, in this contrast of C and D combination C_1D_2/C_2D_1, the odds ratio was about six (2 44/0 41) (This is a first-order odds ratio, as it is also obtained by the ratio of the two odds ratios pertaining to the two factors shown in Table 5, *ie*, 3 29/0 55 = 6 0) In the same two-factor combination there is another contrast C_1D_1/C_2D_2 which yielded an odds ratio of 1 8 These high order odds ratios are presented in Table 6, listing the contrast that showed the largest ratio for a given combination of factors in the left side and all the other contrasts in the right side

Depending on the contrast, the magnitude of a multifactor odds ratio can be very large In the first stage of causation the combination of maternal age (A) and the previous child's survival (C) could cause large changes in the odds of birth interval The odds ratio of A_1C_2 *vs* A_2C_1 was eight, and if E_2 *vs* E_1 were added to the contrast, the odds ratio exceeded 10 However, when the contrast included A_1C_1, the odds ratios deviated only moderately from unity, their constituent effects canceling each other In the second stage of causation, there was an eight-fold difference in the odds



For variable notations, see Table 1
Numbers by the arrow indicate odds ratios

Fig 1 Path diagram for infant survival births in 1976-81, Thailand

of child survival if all three significant factors B, C, and D took favorable categories

Our two-stage causal model of infant mortality is schematically shown in Fig 1, akin to the path diagram In the figures the arrow shows the causal relationship between the two connected variables, and the numbers by an arrow show the pertaining odds ratio, corresponding to the path coefficient in a path diagram.

DISCUSSION

In this paper we formulated a two-tier causal model for infant survival in Thailand using 1987 TDHS data Among the six explanatory variables selected for the survival of an index child, we considered the preceding birth interval as the proximate variable and the other five variables, maternal age, birth order, survival status of the preceding child in infancy, maternal education, and place of living as the background variables This causal ordering should be reasonable, as the preceding birth interval is temporarily prior to the birth of the subsequent child and the other explanatory variables are prior to birth interval, although in case of the survivorship of the previous child the ordering can be problematic It can be both prior and posterior to birth interval If a young child dies, the following child is likely to be born sooner owing to physiological and behavioral reasons, but it is also possible that if the current birth interval is short, the earlier child may have a higher risk of dying owing to the competition for resources with the following child However, our reference

Table 6

High order odds ratios for combinations of factors.

Contrast of factors	Odds ratio	Contrast of factors	Odds ratio
First stage (short birth interval *vs* long interval)			
A_1B_1/A_2B_2	2 77	A_1B_2/A_2B_1	2.27
A_1C_2/A_2C_1	7 97	A_1C_1/A_2C_2	0.79
A_1E_2/A_2E_1	3 19	A_1E_1/A_2E_2	1 97
B_1C_2/B_2C_1	3 51	B_1C_1/B_2C_2	0 35
C_2E_2/C_1E_1	4 04	C_1E_2/C_2E_1	0.40
$A_1B_1C_2/A_2B_2C_1$	8.81	$A_1B_1C_1/A_2B_2C_2$	0 87
		$A_1B_2C_1/A_2B_1C_2$	0.71
		$A_1B_2C_2/A_2B_1C_1$	7.21
$A_1B_1E_2/A_2B_2E_1$	3 52	$A_1B_1E_1/A_2B_2E_2$	2.18
		$A_1B_2E_1/A_2B_1E_2$	1.79
		$A_1B_2E_2/A_2B_1E_1$	2 89
$A_1C_2E_2/A_2C_1E_1$	10 18	$A_1C_1E_2/A_2C_2E_1$	1.00
		$A_1C_2E_1/A_2C_1E_2$	6.27
		$A_1C_1E_1/A_2C_2E_2$	0.62
$B_1C_2E_2/B_2C_1E_1$	4 46	$B_1C_2E_1/B_2C_1E_2$	2 76
		$B_1C_1E_1/B_2C_2E_2$	0 27
		$B_1C_1E_2/B_2C_2E_1$	0 44
$A_1B_1C_2E_1/A_2B_2C_1E_2$	11 20	$A_1B_1C_2E_1/A_2B_2C_1E_2$	6.93
		$A_1B_1C_1E_1/A_2B_2C_2E_2$	0 69
		$A_1B_1C_1E_2/A_2B_2C_2E_1$	1 11
		$A_1B_2C_1E_1/A_2B_1C_2E_2$	0.56
		$A_1B_2C_1E_2/A_2B_1C_2E_1$	0.91
		$A_1B_2C_2E_1/A_2B_1C_1E_2$	5.67
		$A_1B_2C_2E_2/A_2B_1C_1E_1$	9.17
Second stage (survival *vs* death)			
B_1C_1/B_2C_2	4 44	B_1C_2/B_2C_1	0.41
B_1D_2/B_2C_1	2 44	B_1D_1/B_2D_2	0.75
C_1D_2/C_2D_1	5.95	C_1D_1/C_2D_2	1.82
$B_1C_1D_2/B_2C_2D_1$	8 04	$B_1C_2D_1/B_2C_1D_2$	0.23
		$B_1C_1D_1/B_2C_2D_2$	2 46
		$B_1C_2D_2/B_2C_1D_1$	0 74

For notations of variables, see Table 1

period for survival is limited to 12 months Then it may be reasonable to assume that birth interval is temporarily preceded by survival status of the previous child, as the birth interval is necessarily longer than nine months

This causal formulation is directly taken from Park (1986) which was applied to Korean data Conceptually, it is analogous to the Bongaarts' model (1978) for fertility in that a two-tier causation is considered Although the framework is also conceptually similar with that of Mosley and Chen (1984), ours is not only simple but the ordering of variables is not always consistent with theirs They regard, for instance, age of mother and birth order as proximate variables for infant mortality We considered these as background variables affecting infant mortality through birth interval The result of the present analysis appears to be consistent with our model

The present study and earlier works which used the same analytical model (Park, 1986, Utomo and Poedjastoedi, 1987, Achadi and Costello, 1991) uniformly suggest that (a) the previous birth interval not only directly affects the chance of infant survival but it plays the role of a filtering factor through which many other variables indirectly operate on child survival and (b) mortality of the previous child exerts very strong direct and indirect effects on the survival of the following infant It should be noted that these studies are applied to three countries culturally and geographically widely apart On the other hand, they are all undergoing fast transition of fertility pattern through acceptance of government sponsored family planning services

There are, however, some minor differences in the causal structure among the countries Unlike the situation of early Korea or Indonesia, in this study we found that place of residence was independent of birth interval If urban living affects the level of contraceptive use which in turn affects the length of birth interval this is a reasonable finding With a near 70% contraceptive use nationwide in Thailand (Chayavon *et al*, 1988, Table 4, 6), little difference in the use was found between urban and rural areas Elsewhere we (Park *et al*, 1993) found that all the background variables affected birth interval through breastfeeding and amenorrheic period, while education and place of residence did so weakly through family planning The direct effect of birth order on child survival was not observed in the Korean study However, in the latter the coding of birth order was done in conjunction with maternal age Mosley and Chen (1984) treat birth order as a proximate variable

Survivorship of the previous child was, as in the earlier studies, unique in that both direct and indirect effects on child survival were strongly operating While it is hard to consider that the death of the previous child literally "causes" the death of the following child, the risk factors to the previous child, such as nutrition, sanitary conditions, disease from common agents, and others may remain to act on the index child as well In this sense, the survival of the previous child would represent certain components of proximate variables which Mosley and Chen (1984) have suggested

While the model appears to work well, there are several inherent problems in using multi-stage logistic analysis which deals with categorical variables exclusively (Fienberg, 1980) We dichotomized all the variables but when an explanatory variable has multiple categories, the analysis necessarily leads to multiple logit parameters or odds ratios, unlike the path model that estimates a single coefficient per variable Multiple parameters for a variable are inconvenient for illustrating the causal model in a path diagram, while they allow a nonlinear causal relationship which path analysis does not assume We had to use odds ratios to describe the strength of an effect, as the logistic approach has no calculus of path coefficients As such, the strength of indirect effects cannot be presented If all the variables are continuous, use of regular path analysis should be contemplated But when the dependent variable is a rare event, as in our case, and independent variables are categorical, multistage logistic analysis is the method of choice It must be also pointed out that our model lacks some crucial variables, such as breastfeeding

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