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Birth Distance Influential Factors: A Multilevel Recurrent Events Approach

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ABSTRACT

Background: The study was developed in order to find a subset of potential factors, which affect birth distance pattern, regarding consideration on correlation of events of birth in a family and correlation within clusters/centers which other studies omit these correlations.

Methods: Referring to documents that were registered for family in the health care centers on socio-economical zone, we consider the families with at least one successful birth. Data were drawn from four health care centers, which selected via 27-health center in Hamedan City, western Iran, each from a socio-economic zone. It was expected, same socio-economic status family have same specific birth distance and a family follows a specific pattern. The multilevel recurrent approach was conducted to analyze the sample. The sample was 480 families and 1115 birth events occurred in these families.

Results: The final step model shows that significant factors on the birth distance time were mothers job (P=0.018). The random effect of second level (clusters/centers) was significant (P=0.038). In other words, the socio-economic of family affects on the birth distance patterns. Other potential variables were not significantly affected birth distances and were deleted from the final model.

Conclusions: There are many potential factors, which may affect to birth distance, but multilevel recurrent event model has a better fit to data because of frailty and center effects. Application of other model such as Cox and frailty models may result in misleading reports.

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Introduction

Health Education programs and their implications are one of the most important discussion in developing countries. In fact, a good performable program can be only resulted by a powerful and reliable analysis of target society¹. Birth distance is a very important parameter for describing mother and family health². This article is going to find the most effective factors on birth distances regarding health education passages ^{1, 2}. It has been revealed that mothers age, fathers age, mother education, fathers education, mothers job, fathers job, socio-economical zone are potential factors which may affect the birth distance. The higher educated parents are more informed about families' health ². A similar study was reported by Iran Social Study Journal, but it was based on Cox regression model, which ignored correlation between the birth distances. There find many significant factors like mothers education and prevention tools ³. Another study was conducted on Zahedan City, which has not a survival approach, and the families were divided in to category distance over 24 months and less than 24 months. In addition, demographic factors were taken into account and described by a Logit model ⁴.

Additionally a study of birth distance had been done on Bangladesh on 1993, which used Cox model with time dependent variables, although they did not enter demographic factors in the model, and it hardly report a non-significant factor ⁵. In addition, another work had been done on birth distance in India and Pakistan like Zahedan work, used the logistic regression model. They found race (tribal race) and number of male child as significant factors ⁶.

Multilevel survival model were used by Yau and Lee in describing recurrent of urinary tract infection ⁷, and another use of this model can be seen in ^{8, 9}. Multilevel models were also applied for evaluation of hospitalizations for recurrent diarrhoeal disease ¹⁰.

Moreover analyzing survival data with random effect factors in different health and biomedicine field had been done via survival frailty models. This approach is done by assuming gamma, normal and lognormal distributions for the random effects ¹¹⁻¹³. Alternatively, random effects Cox models can be defined by specifying the first and second moments of the frailty distribution ¹⁴. The advantage of applying lognormal frailty model is its flexibility on the correlation structure for the failure time data, while keeping the interpretation of regression coefficients meaningful. For example, in order to handle time dependent correlated frailties, Yau and McGilchrist¹⁰ proposed a lognormal frailty incorporating model an autoregressive correlation structure for the frailty term. In This study, we used multilevel recurrent event model with correlation of birth distance in the family level and socio-economic zone effect in the center/cluster level.

Materials and Methods

Sample

This historical cohort study was conducted to obtain the information concerning factors that affected the birth distance. The target population was families, which were registered in the Hamedan City Health Care Centers. As it was expected that same socio-economic status family had same specific birth distance and a family followed a specific pattern, four centers were randomly selected from each socioeconomic zone. The sample was taken via referring to the family's documents randomly in each center. Regarding to registration of the families on health care centers in Hamedan City, the families in the sample at least had one successful birth. The sample was 480 (120 in each center) documents of families which were registered on health centers. Totally, 1115 birth dates were recorded in sample.

Protocol and measures

According to survival analysis rules ^{15, 16}, a cohort study was designed via Lexist method. The cohort started on the maximum age of the observations (one who born in middle of 1991), and the end of study was on middle of 2009. The response time to event was measured in month. Other researches considered date of marriage of parents ¹⁶. As date of marriage in Iran is a conceptual date and a birth date is a real date, this study focused on the birth date of older child of family as the start time of the cohort study. This means that every family enters the study with first birth date. The cohort virtual time is 216 month and this is the time for the subjects that are censored (Families with one and just one birth). The covariates included in the model were: Fathers' jobs were divided into five categories: blue collar (worker), farmer, white collar (employee), teacher and businessman, mothers' jobs (2 categories: household=0 and outside of house engagements=1), education of both parents (4 categories: ability to read and write=0, under diploma=1, diploma to technician=2, higher educated=3), prevention status of a family (5 classes: withdrawal, IUD, condoms, tablets, and using multiple tools for prevention), Unwanted pregnancy history (2 class: had

unwanted 1, had not unwanted pregnancy 0). Also the macro level variable was socioeconomic zone with 4 categories: (High: southern of city, Middle: center of city, Moderate: northern of city, low: northern countryside).

Statistical Analysis

The modeling procedure deals with hazard function. According to social and economical subject norms², it was expected that families living in the same socio-economical zone followed same birth pattern, so the macro-level cluster were socio-economic zones. It was also expected that the family followed a pattern for all its births. (On the other hand, birth distances of the same family were assumed auto correlated.) The proportional hazard function can be written as:

$$h(t_{i,j,k}) = \lambda(t) \cdot exp(\eta_{ijk}); \eta_{ijk} = x'_{ijk} \beta + u_i + v_{ijk}$$

Where $\lambda(t)$ is the underlying baseline hazard, x'_{ijk} is a covariate vector corresponding to t_{ijk}, and β is the associated vector of regression coefficients. In addition, a Cox regression model was developed and the results were compared with the multilevel recurrent model. The proportional hazard function of the Cox model is:

$$h(t;k) = h_0(t) . exp(x'_k \beta); k = 1, 2, ..., k$$

X and β are the same as above and h_0 is a baseline hazard. For Cox proportional model every event was set to a separate observation that is why the k is ranged 1 to 1115, on the other hand k was events index. A parametric survival frailty model was also been fitted to data set. The fitted multilevel model was a semi-parametric one and it seems vital to asses a parametric frailty model jointly with these semi-parametric models. Without loss of generality, u assumed to be normally distributed with mean zero and variance of $\sigma^2 I_b$ and independent of v. More extended theory can be found in reference 7 . It is assumed that the random effect of clusters/centers follows a Gaussian distribution.

Parameter estimation was done via using a developed R program. The developed code was referred to Yau's code in some procedure, but the overall structure of code was developed by

the first author. Iterative algorithms were used inside the codes.

Results

There were N = 1115 observation in total from M = 480 families nested in b= 4 randomly selected health care centers from Hamadan City. Table 1 shows the recurrent of birth (family dimension) percentage in the sample.

Table 1: Distribution of recurrent of birth in480 families

No. of Children	Frequency	Percent
1(non recurrent)	128	26.7
2	141	29.3
3	146	30.4
≥4	65	13.6
Total	480	100.0

As it has been noted earlier as the sample space was the families with at least one child, the no recurrent is refer to families with one child.

Twenty six percent (125) of mothers in families have worked outside of home and 18.8% (90) of them have an unwanted pregnancy. Also 20.6% of families used natural method (withdrawal) for prevention of pregnancy. Only 22.7% of families used only condoms and 16% of them used multiple methods for prevention.

The estimated parameters of three final models that represented can be seen in Table 2. Regarding to the model I (Cox Regression model), the influential factors are mothers job (P=0.031) and number of children (P=0.023). As adjusted hazards ratio for number of children is 1.952, it seems irrational that a family with one more child is more likely to reduce the next birth distance. This means that the more children in the family resulted in less distance between the births. In addition, it reveals that a family with mother who has a job outside of house is more likely to increase next birth distance. The estimated value for the adjusted hazards ratio is 0.754 which is less than 1 and it reveals that the hazards of birth for a family with mother who has a job in the outside of house is about 0.754 of hazard of birth in a family with a housewife mother.

Regarding to model II (Frailty survival model): influential factors are mothers job (P=0.048), unwanted pregnancy (P=0.016) and number of children (P=0.000). As this model structure is for survival function and adjusted hazards ratio for number of children has been estimated less than one, regarding to this estimation, family with one more child is less likely to increase next birth distance. This result is same as model I and both are irrational. Also adjusted hazards ratio of unwanted pregnancy for model II has been estimated 1.189 and it reveals that family with an unwanted pregnancy history is more likely to increase next birth distance. By the way, mothers' job adjusted hazards ratio had been estimated 1.232. It represent that family with mother who has a job outside of house is more likely to increase next birth distance than family with a housewife mother. According to model III (multilevel model with recurrent), the only significant factor in the model is mothers job (P=0.018) and other factors are not significant. As adjusted hazards ratio had been

estimated 0.671 it reveals that hazards of next birth for a family with mother who has a job outside of house is 0.671 of hazards of birth for a family with a housewife mother. In addition, the correlation of events (birth) in the subjects (families) is 0.607 as its positive one can conclude that births after the first child are positively correlated on the other hand if distance between first and second birth become larger the distance between second and third birth will become larger too. Additionally, the models can be compared by their results. It is more logic that both birthrate and mothers' job in Hamadan City are affected by a third potential factor like Social Subject Norms. However, having an unwanted pregnancy cannot make subject norm to change, although it may cause a family to decide to change its health programs and using more effective prevention tools. Another misleading of the first model is the estimated HR for number of children. It shows number of children is significant but in a wrong direction; families with more children are more likely to reduce the distance of their next birth.

Table 2 : Birth distance models param	neters estimates
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Variables	I: Cox Regression model	II: Frailty Survival model	III: Multilevel Recurrent model
	Adjusted HR ^a	Adjusted HR ^a	Adjusted HR ^a
Mothers Job (95% CI)	0.754 (0.573,0.991)	1.232 (1.074,1.414)	0.671 (0.460,0.978)
Unwanted Pregnancy (95% CI)	Not Significant	1.189 (1.008,1.402)	Not Significant
No. of Children	1.952 (1.760,2.166)	0.654 (0.616,0.695)	Not Significant
σ^2 Family (SE)	-	1.173 (0.241)	0.887 (0.283)
σ^2 Centers (SE)	-	-	0.574 (0.318)
ρ	-	0.538	0.607
-2 log likelihood	3174.358	1990.000	824.839
All	3178.358	1998.000	830.839

^a Hazard Ratio

Discussion

A multilevel survival model was constructed for analyzing clustered recurrent time. A Restricted Maximum Likelihood approach was adopted to estimate the parameters of the fixed and random components. A program was developed due to estimation of parameters Newton-Raphson using algorithm. An application to the recurrent of birth study demonstrates the usefulness of the method in analyzing hierarchical survival data. In particular, omitting the correlation causes an additional risk factor for recurrent birth distance to be identified, which may have not important effect on birth distance and cause cost inflation for managing and planning health education and health promotion for Hamadan City. The factors remain in the last step of the model was mothers' job (P = 0.018) also the clusters/centers was significant (P=0.038). Other potential risk factors were not significant (P > 0.05) and were deleted from the model. The estimated within class correlation was 0.607. In addition, the mother education was independent from mother's job this may be so important which some other motivators and factor may be latent or hidden in this study which affect both of mother job and birth distance. A potential factor may be social subject norms and utilization of a health education model like Theory Planned Behavior is suggested for further study on birth distance in Hamedan City. Comparing model via Akaike information Criterion represented that when correlation take into account in model II the AIC decrease and when hierarchical structure take into account in model III AIC decrease and meet 830. Therefore, the better model with minimum AIC is model III, as it expected when model concerns about cluster and subject correlation it would lead to better results. Ahvaz City study presents many potential factor were significant in the model; mothers' education and prevention tools and child gender. Due to ignoring intra subject/family correlation. Cox regression model is more likely to report more significant factors, as in this study entered unwanted pregnancy history as a significant factor in the model. In addition, frailty parametric model. which omit subject/family correlations, represent that

number of children in the family is a significant factor. Other result of another study on Zahedan City cannot be compared because the basic difference of studies. However, by its Logit model they have found mothers education and Race (tribal race) and number of male child in the family are significant factors in the model⁴. The estimated effect for centers and socio-economical zones regarding to choose one center per zone is contaminated, for further study it is recommended that sample to be taken from at least two centers from each zone. Due to model, it can be concluded that socio economic zones has an important role for family's birth pattern. In addition, the father's job had not a significant correlation with socioeconomic zones. It seems that some covariates, which were not concluded in the model, may affect both birth distance and mother's job. A further study is recommended to measure the social subject norms and other health education models elements.

Conclusion

A multilevel survival model was constructed for analyzing clustered recurrent time when there was correlation with subjects' events. This study shows that the multilevel recurrent model describe birth pattern better than other models which developed recently as it take correlation of distances into account.

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Conflict of interest statement

The authors declare that they have no conflicts of interest.

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