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Modelling Childbearing Desire: Comparison of Logistic Regression and Classification Tree Approaches

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Abstract

Objectives: According to health surveys, population growth and total fertility rate (TFR) are decreasing in Iran. The economic and social factors in addition to the changing values and attitudes in the Iranian society have had a major impact on fertility decisions and the actions of families, especially women towards childbearing. This is an important issue for policymakers and many researchers in demography and public health thus the investigation of factors that affect low TFR is considered as a necessity.

Materials and Methods: The classification and regression trees (CART) algorithm, as one of the most applicable classification trees, along with logistic regression was applied to model the tendency of 4898 women for childbearing in provinces with a TFR lower than the replacement level in Iran. The secondary data were then analysed by SPSS version 24.0.

Results: Based on these two approaches, it was concluded that despite the CART algorithm, logistic regression suffers from some shortcomings including the difficult interpretation of three levels of interactions while not containing a specific method for handling the outliers. In addition, CART results demonstrated that women's children ever born (CEB), age, and opinion had significant impacts on their desire to have a child. The groups encompassing "10-39-year-old women with CEB≤2" and "40-49-year-old women with positive attitudes towards childbearing" desired to have more children while "women with CEB ≥3" showed no tendency for childbearing.

Conclusions: In general, the results revealed that adopting policies for changing women's views on childbearing and creating the necessary resources for preventing the delays in marriage are regarded as important actions toward altering fertility rates. Another important conclusion is applying the CART algorithm as a convenient method for classifying demographical data.

Keywords: Fertility Preferences, Child, Women, Decision Trees, Logistic Regression

Introduction

Most countries in the world are currently in a state of population imbalance and are facing the consequences of this problem. Thus, demographic policies in each country can play an important role in reforming such situations (1). Like the other countries, Iran has encountered the same challenge as well. Over three decades, fertility has astonishingly reduced in Iran and the average number of children in each Iranian family has reached 1.8 (2). Since 2006, the total fertility rate (TFR) has been below the replacement level (3).

To control the fertility decline in Iran and prevent more decreases, the adoption of any action plan in this regard requires the field studies with the aim of awareness and identification of women's desires towards childbearing (4-7). Childbearing desire (CD), which is the desired number of children that families bear considering the number of their children ever born (CEB), has become an interesting issue for many researchers who study the determinants that influence fertility (1,3,5,7). Some of the most important factors that contribute to women's fertility intentions are as follows.

- The sexual composition of children (1, 8);
- Age (4,7-9);
- Marriage age (8,10,11);
- Job status (4,7,8);
- CEB (4,7,8);
- Religion (8,12);
- Residence (7);
- Income (8);
- Educational level (4,7-9);
- The ideal number of children (8);
- Abortion (8);
- Decision-making (4);
- Economic dependency (4);
- Social participation (4,12);

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- Opinion towards childbearing, namely, its benefits against losses (7);
- Sex preference (7);
- Socioeconomic status (9).

Different statistical methods such as logistic regression and multiple regression models were applied to analyse influential factors on fertility (13-17). However, the application of some methods including data mining, which is a computational process of discovering the patterns in large data sets, has recently increased in demographical data (18-22). Logistic regression is used to analyse the relationship between a single or several predictor(s) and an outcome that is dichotomous in nature (23-25). This method has an increasing use in medical and psychological contexts in addition to its many applications for developing the models which predict the events in different scopes of sciences (26). Similar to any statistical technique, several considerations that should be taken into account when employing the logistic regression, including the task of variable selection, the occurrence of complicated interactions, and missing data handling. Among data mining methods, a decision tree has various advantages such as having simple understanding and interpretation, containing little data preparation, handling both numerical and categorical data, having the possibility of validating a model using the statistical tests, being robust, and enabling good performance with large datasets (27).

The main purpose and the novelty of this paper was to study the best model to classify CD through applying the classification tree and comparing it with logistic regression in terms of the results which were obtained from the data. For this purpose, the following section was devoted to a brief introduction of these two methods. Further, the application of both approaches on women's CD in the survey entitled "Childbearing Attitudes and its Social, Economic, and Cultural Factors" (28) was investigated in the result section, followed by presenting discussion and concluding remarks.

Materials and Methods

The classification and regression trees (CART) algorithm (29) is considered as one of the most applicable classification trees that is a non-parametric statistical method and extracts binary splits. This algorithm produces a classification tree if the dependent variable is categorical. On the other hand, it creates a regression tree when such variable is of continuous type. Furthermore, CART algorithm is performed in three phases including constructing a maximum tree, selecting the right tree size, and classifying new data (30).

In this study, logistic regression and CART classification methods were applied for modelling CD based on some selected predictors and then their results were compared by SPSS software, version 24. It is noteworthy that the developmental level of provinces has affected fertility in different studies in Iran, ignoring this difference in fertility analysis prevents the acquisition of accurate results (19). Several studies (19,20,31) considered province divisions as well. These divisions were constructed based on whole-province TFR in Iran, as calculated in a previous study (32) based on the own-children method during 2009-2011 (33). In the current study, the provinces of Iran were divided into TFR ≤2 and TFR ≥2 categories in order to more precisely analyse the data according to the values of TFR and replacement level. Since almost 80% of women in the survey entitled "Childbearing Attitudes and its Social, Economic, and Cultural Factors" (28) lived in provinces with a TFR less than the replacement level, logistic regression and CART algorithm were applied to the data of these provinces.

The CD of 4898 women was assessed by the question "Considering the number of children you have already had, do you desire to have another child?" Multistage stratified sampling technique was used to select the women who referred to public health and treatment centres to vaccinate their children in 31 provinces of Iran during 2014. Different factors may affect women's CD. In the present study, the selected predictors were the most influential factors that caused women to postpone childbearing and could decrease the desire for more children.

Results

Table 1 presents the descriptive statistics of the selected variables for women in provinces with a TFR ≤2. Based on the results, approximately 63.7% of women in these provinces had CD, showing that most women had a tendency to bear children considering their CEB. Almost 14% of women were employed as well. Moreover, more than 70% of women lived in urban areas and were within the age range of 20-39 years old. Similarly, most women (36.0%) had a negative opinion toward childbearing. And the majority of them (90%) married between the ages of 10 and 29 years old. The percentage of women with high school and higher education was 66.1%, and 0.2% of them had no children. Additionally, the CEB of more than 85% of the women was 1-2 children. Finally, almost 13% of women had three or more children.

CD crossed by predicted variables is shown in Table 2. According to the results, more than 60% of women with different job statuses and residences had CD. Approximately 86.7, 74.1, and 55.6% of women, aged 10-19, 20-29, and 30-39, respectively, had a desire for childbearing while 62.2% of women aged 40-49 years old represented no willingness to have another child. Most women with different opinions toward childbearing desired to have another child and more than 60% of women in all marriage groups had a desire for childbearing. Excluding illiterate women (52.6%), the other women with different educational levels desired to have another child. Likewise, more than 60% of women who had two children

Table 1. Frequency Distribution of Model Variables

Variables		TFR≤2	
		No.	%
Childbearing desire (response variable)	Yes	3122	63.7
	No	1776	36.3
Job status	Employed	676	13.8
	Unemployed	4222	86.2
Residence	Urban	3517	71.8
	Rural	1381	28.2
Age	10-19	128	2.6
	20-29	2285	46.7
	30-39	2120	43.3
	40-49	365	7.5
Opinion	Negative	1763	36.0
	Neutral	1557	31.8
	Positive	1578	32.2
Marriage age	10-19	1790	36.5
	20-29	2830	57.8
	30-39	271	5.5
	40-49	7	0.1
Educational level	Illiterate	116	2.4
	Primary and middle school	1542	31.5
	High school/Diploma	1897	38.7
	University	13473	27.4
Children ever born	0	8	0.2
	1-2	4274	87.3
	3-4	584	11.9
	5+	32	0.7
Total		4898	100

or less were eager to have another child. Contrarily, most women with three children or more were not interested in having any other children. Based on the results of Table 2, women's residence, age, opinion, educational level, and CEB were associated with CD whereas their job status and marriage age had no significant correlation with CD.

A binary logistic regression model was fitted to the data based on the type of dependent variable (i.e., CD). The risk of CD in provinces with TFR ≤2 was modelled by logistic regression on women's job status, residence, age, opinion, marriage age, educational level, and CEB. All two- and three-predictor interactions were also included in the model and analysed based on the backward method. The goodness of fit of the model was determined and confirmed by the Hosmer–Lemeshow test (P=0.88) and Nagelkerke's R^2 test (0.153). The results of the fitted model are provided in Table 3. As shown, the remaining variables in the final model had a significant effect on CD except for women's job status and CEB. None of the interactions were significant.

Urban women (i.e., women with a negative opinion), along with primary/middle school and high school/diploma-educated women had a lower tendency to have a child in contrast to rural women (women with a positive opinion) and university-educated women. The odds of having another child in women with negative attitudes towards childbearing was 0.34 less than those with positive attitudes. In addition, the odds of CD decreased by an increase in women's age, but this ratio increased by

Table 2. Childbearing Desire Crossed by Predicted Variables

Variables		Childbearing Desire (Response Variable)			Test Statistic	*P* Value
Name	Value	Yes	No	Total		
Job status	Employed	62.6	37.4	100	0.462*	0.497
	Unemployed	63.9	36.1	100		
Residence	Urban	62.6	37.4	100	6.56*	0.010
	Rural	66.5	33.5	100		
Age	10-19	86.7	13.3	100	301.27**	<0.001
	20-29	74.1	25.9	100		
	30-39	55.6	44.4	100		
	40-49	37.8	62.2	100		
Opinion	Negative	56.0	44.0	100	87.41	<0.001
	Neutral	64.7	35.3	100		
	Positive	71.5	28.5	100		
Marriage age	10-19	62.0	38.0	100	1.98**	0.159
	20-29	65.0	35.0	100		
	30-39	61.3	38.7	100		
	40-49	85.7	14.3	100		
Educational level	Illiterate	47.4	52.6	100	28.12**	<0.001
	Primary and Middle school	59.9	40.1	100		
	High School/diploma	65.2	34.8	100		
	University	67.5	32.5	100		
Children ever born	0	87.5	12.5	100	250.43**	<0.001
	1-2	67.9	32.1	100		
	3-4	34.8	65.2	100		
	5+	31.3	68.8	100		

Note. *Pearson chi-square test; **linear-by-linear association

Table 3. CD Regressed on Predictors

Variables		Exp (B)	*P* Value	95% CI	
Name	Value			Lower	Lower
Job status	Employed	1.024	0.814	0.838	1.252
	Unemployed (ref.)				
Residence	Urban	0.710	0.000**	0.611	0.824
	Rural (ref.)				
Age	10-19	14.216	0.000**	4.121	49.042
	20-29	4.123	0.000**	2.689	6.322
	30-39	1.414	0.096	0.940	2.128
	40-49 (ref.)				
Opinion	Negative	0.340	0.000**	0.198	0.584
	Neutral	0.630	0.105	0.360	1.101
	Positive (ref.)				
Marriage age	10-19	0.074	0.018*	0.009	0.638
	20-29	0.098	0.035*	0.011	0.851
	30-39	0.131	0.066	0.015	1.144
	40-49 (ref.)				
Educational level	Illiterate	0.694	0.093	0.453	1.063
	Primary/Middle school	0.736	0.001**	0.614	0.883
	High school/diploma University	0.814	0.014*	0.691	0.959
Children ever born	0	44.3	0.143	0.562	52.675
	1-2	2.019	0.095	0.885	4.604
	3-4	0.815	0.631	0.355	1.874
	5+				

*Significance at the 0.05 level; **Significance at the 0.01 level.

increasing women's marriage age.

Figure 1 illustrates the classification trees of CD in provinces with TFR ≤2. Based on the data, rules 1-3 were extracted from the intended classification tree as follows.

1. The 10-39-year-old women with 2 children or less had a desire for more children;
2. The 40-49-year-old women with 2 children or less and those with negative and neutral opinions as compared to women a positive opinion toward childbearing were not willing to have more children;
3. Those with three children or more showed no willingness to have more children.

The accuracy of the classification tree of CD in provinces with TFR ≤2 (Figure 1) is 0.68 according to the misclassification matrix. This means that the CD of 68% of women was classified correctly. Based on this value, the misclassification of this model is 32%.

Likewise, Table 4 shows the risks and standard errors of classification trees, which are calculated based on training and learning data. When the risk of these two data groups is close to each other, it confirms the validity of the fitted models (30). Based on the results of Table 4, these values are almost equal, indicating the validity of the classification model which was proposed by the classification tree in Figure 1.

Misclassification matrices were used for logistic regression and CART algorithm in order to compare these approaches. Table 5 represents the above-mentioned matrix in which the shaded cells signify the correct classification or the accuracy of both models. According to this table, the accuracy of these models, which was computed in equations 1 and 2, demonstrated no significant differences.

$$Accuracy\ of\ CART\ model = \frac{2856+489}{4898} = 0.68 \quad (1)$$

$$Accuracy\ of\ Logistic\ regression = \frac{2848+508}{4898} = 0.685 \quad (2)$$

The comparison of the results of both methods on CD revealed that the CART algorithm had specific divisions based on variables like women's CEB, age, and opinion. This indicates the presence of significant interactions among these predictors in logistic regression although none of the interactions were significant in this model. Thus, the CART algorithm had a smaller division in the data set, which could result in significant splits as compared to logistic regression results.

The predictor interactions were not significant in the fitted logistic regression in this study although it is important to mention that the interpretation of these interactions with more than three levels would be difficult even if they were significant. However, this task is one of

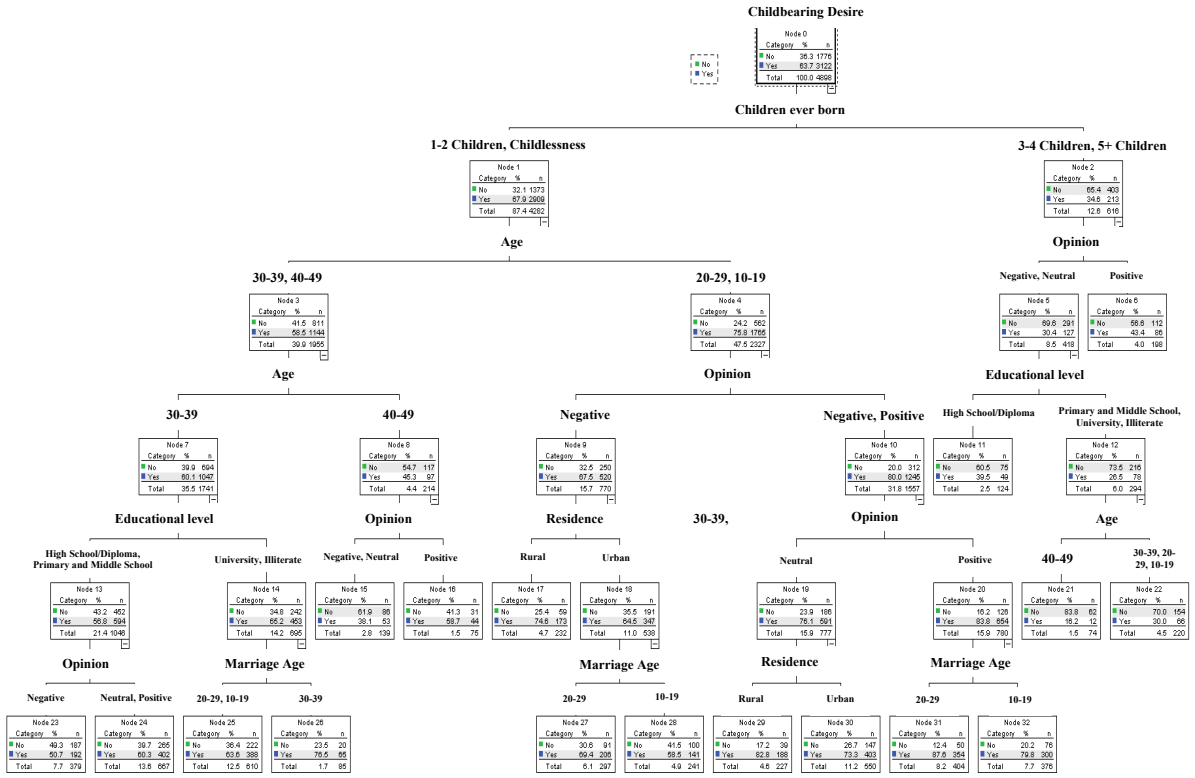

Figure 1. Classification Tree of Childbearing Desire.

the vital benefits of applying the CART algorithm on data sets.

The continuity of low fertility is undesirable for any population. Given the consequences of the continued fertility below the replacement level, adopting programmes to prevent the continuity of fertility reduction while increasing fertility at least to the replacement level is of great necessity. Moreover, any policy for increasing fertility rate or preventing its further reduction requires understanding the factors and conditions that affect fertility (1).

Table 4. Risks and Standard Errors of Classification Trees

	TFR≤2	
	Risk	**Standard error**
Learning set	0.317	0.007
k-fold cross validity of training set	0.325	0.007

Discussion

The present study mainly aimed at applying CART algorithm to classify women's CD and compare the results of the fitted model with those of logistic regression. Since most of the women in the Shahla's survey (28) lived in provinces with a TFR less than the replacement level, these women's CD was considered for further investigation. Based on the results, almost 70% of women with one child or more had CD while the majority of those women with more than two children were not willing to have any other child (Table 2). According to the results of the accuracy (almost 68%), there were no significant differences between logistic regression and CART algorithm regarding analysing these data. By considering predictor

Table 5. Misclassification Matrix for Classification Trees and Logistic Regression

Observed Category		CART			Logistic Regression		
		Predicted Category		Total	Predicted Category		Total
		Yes	No		Yes	No	
Yes	Numbers	2856	266	3122	2848	274	3122
	Total Percentage	58.32	5.42	63.74	58.15	5.59	63.74
No	Numbers	1287	489	1776	1268	508	1776
	Total Percentage	26.28	9.98	36.26	25.89	10.37	36.26
	Total	4143	755	4898	4116	782	4898
	Total Percentage	84.59	15.41	100	84.03	15.97	100

CART: Classification and regression tree.

interactions, CART could divide more precise splits compared to logistic regression for these data. However, none of these interactions were significant in logistic regression. Even if such interactions were significant, they would not be easy to interpret (15-17), especially in three-term interactions such as women's CEB, age, and opinion. The findings of some studies on medical data confirmed the results of this study, which indicate the superiority of the CART algorithm in this regard (22, 26, 34-36).

The results of the CART algorithm (Figure 1) indicated that CEB was the most influential factor on CD. Thus, the tendency towards childbearing decreased by increasing the number of CEB, which is in line with the results of several other studies (1,4,6,7,37).

More importantly, women's age also played a significant role in CD. In this study, most of the women with lower CEB (2 children or less) and older age (40-49 years old) had no tendency toward childbearing. Moreover, most women with higher CEB (three or more children) and older age (30-49 years old) wanted no other child. These results confirm the influential role of women's age in CEB. Other studies obtained similar results about women's age as well (4,7,9). For example, they found that the desire to have more children reduces when women get older. Saadati and Bagheri indicated that younger women will have at least two children if their socio-economic conditions change according to their needs (38). The unwillingness of older women could also be due to the decreasing ability of women to bear children at these ages (38).

Based on the findings of this study, the opinion regarding cultural, economic, and social variables also somewhat affected the decline in women's desires. Women aged 40-49 with 2 children or less and negative and neutral opinions were less likely to have another child as compared to those with positive opinions toward childbearing, which corroborates with the findings of similar results (7,39). Women's negative opinions could cause a decrease in their willingness to have more children, including a reduced sense of happiness with the presence of the child, blame from others when having more children, the high cost of childbearing, and considering children as a barrier to their work and education progress.

Considering that the most influential variables in women's willingness for having a child encompassed the number of CEB, along with their age and opinion toward childbearing, policymakers should help strengthen women's positive opinion in this regard and promote marriage at younger ages in order to provide suitable time for them to reach their ideal number of children.

Further, CART was utilized to produce the classification trees of CD in this study because it is a distribution-free (non-parametric) algorithm which is robust against outliers and collinearities and can employ both categorical and continuous variables. Finally, this model can encounter the missing data and detect the interactions and is considered as an exploratory analysis (22, 29).

Conflict of Interests

Authors have no conflict of interests.

Ethical Issues

Not applicable.

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