


## Consanguinity and Inbreeding Coefficient F in Aligarh City, India: A Cross Sectional Study

Saima Yunus Khan<sup>1</sup>

<sup>1</sup>Department of Paediatrics and Preventive Dentistry, Dr. Z. A. Dental College, Aligarh Muslim University, Aligarh, India.

 0000-0001-7994-8838

Author to whom correspondence should be addressed: Saima Yunus Khan, 4/1376 Sir Syed Nagar, Aligarh 202002, Uttar Pradesh, India. Phone: +91 9236642220. E-mail: [dr.saima.y.khan@gmail.com](mailto:dr.saima.y.khan@gmail.com).

Academic Editors: Alessandro Leite Cavalcanti and Wilton Wilney Nascimento Padilha

Received: 25 September 2018 / Accepted: 18 January 2019 / Published: 04 February 2019

### Abstract

**Objective:** To determine the coefficient of inbreeding of consanguinity (F) and its correlates in Aligarh city, India. **Material and Methods:** Cross sectional household survey with a sample size of 2000 (1600 non-consanguineous and 400 consanguineous couples) using systematic random sampling. Researcher conducted the study by visiting every tenth household of every tenth ward of Aligarh city. Information was recorded on a pre-tested questionnaire, which had questions pertaining to religion, details regarding relationship between couples (consanguineous / non consanguineous marriage), type of consanguinity (first cousin/second cousin/third cousin), level of education and occupation (a proxy for socioeconomic status). Descriptive statistics, Chi-square, and multivariate logistic regression were used. **Results:** Multivariate logistic regression analysis showed that Islam ( $p < 0.001$ ) and Christianity ( $p < 0.001$ ) were significantly associated with consanguinity. Private employment with (-) B value ( $p < 0.001$ ) showed a significant association of the variable with non-consanguineous group. Coefficient of inbreeding for the present study was 0.0538, highest reported from any part of India. **Conclusion:** Consanguinity is a prevailing problem in Aligarh city, India. Evidence based guidelines needed. Information – education – communication and pre-marital counseling suggested to make population aware of the consequences of consanguinity and to help couples make a decision.

**Keywords:** Genetic Phenomena; Consanguinity; Cross-Sectional Studies.

## Introduction

Consanguinity is defined as a union contracted between biologically related individuals [1]. It is estimated that 10.4 % of children have consanguineous parents and 20 % of the world population favours marriages between relatives [2]. The documented reasons for this age old social practice are [1,3,4]: religion, culture, socioeconomic status, migration, population density, degree of ruralisation, demographic factors, illiteracy, better relationship with in laws, strengthening of family ties, better adjustment after marriage and social stability. If we look at all these factors closely, it conclusively means that such unions between relatives have little gene exchange with other population [5].

Looking at the prevalence worldwide, consanguineous marriages reach 59.3% in Afghanistan [6], 56.3% in Sultanate of Oman [7], 52% in Saudi Arabia [8], 51.5% in Jordan [9], respectively. A National Family Health Survey conducted in different states in India in 1960 and 1992-93 respectively, reported a slight change in the prevalence of consanguineous union at National level from 12.9% in 1960 to 11.9% in 1992-93 [10]. State wise, some authors showed the highest prevalence of 38.2% in 1992-93, Uttar Pradesh was at 7.5% in 1992-93 from 3.3% in 1960 [10], with a mean coefficient of inbreeding as 0.0044. Coefficient of inbreeding (F) represents a measure of the proportion of loci at which the offspring of a consanguineous union is expected to inherit gene copies from both the parents [3].

The objective of the present study was to determine the coefficient of inbreeding of consanguinity and its associated factors in Aligarh city (Municipal Corporation), India.

## Material and Methods

### Study Design

The present study was conducted in Aligarh city (Municipal Corporation), situated in Western Uttar Pradesh, India at a latitude of 27 degree 54 min North and longitude of 78 degree 5 min East. The population of Aligarh city is 8.74,408 persons spread over 70 wards living in 147363 number of households. The sex ratio is 882 females per 1000 males. The population density is 536.4 persons per square kilometer and average literacy rate is 67.8% [11].

A household survey using a cross sectional study design was planned. Multi layered sampling method (Stratified random sampling) was used. In the first layer it was assumed that the prevalence of consanguinity itself is around 20% in the study population. At 95 % confidence interval and 80% power and adding for contingency we went with a sample of 2000 (1600 non-consanguineous and 400 consanguineous).

In order to obtain the above calculated sample size in Aligarh city, which has 70 wards and to ensure that each ward in the sampling frame has the chance of being selected, the wards were numbered; then a number was selected at random between 1-10. For this sampling; four was picked up and then every tenth ward was selected like 4,14, 24, 34, 44, 54, 64 – which ended as 7 wards in total by systematic random sampling. The same procedure was adopted for the selection of

households by systematic random sampling. The selected ward no. 4, had 1505 number of households, out of which every tenth household was picked up which came out to be 150 households in ward no.4. The same procedure was adopted in the selection of households in the remaining selected six wards (156+481+143+247+306+114), which came out to a total of 1597 number of households in 7 wards. So, we had a sample size of 2000 (1600 non consanguineous and 400 consanguineous couples) living in 1597 households in 7 wards of Aligarh city, India (Figure 1).

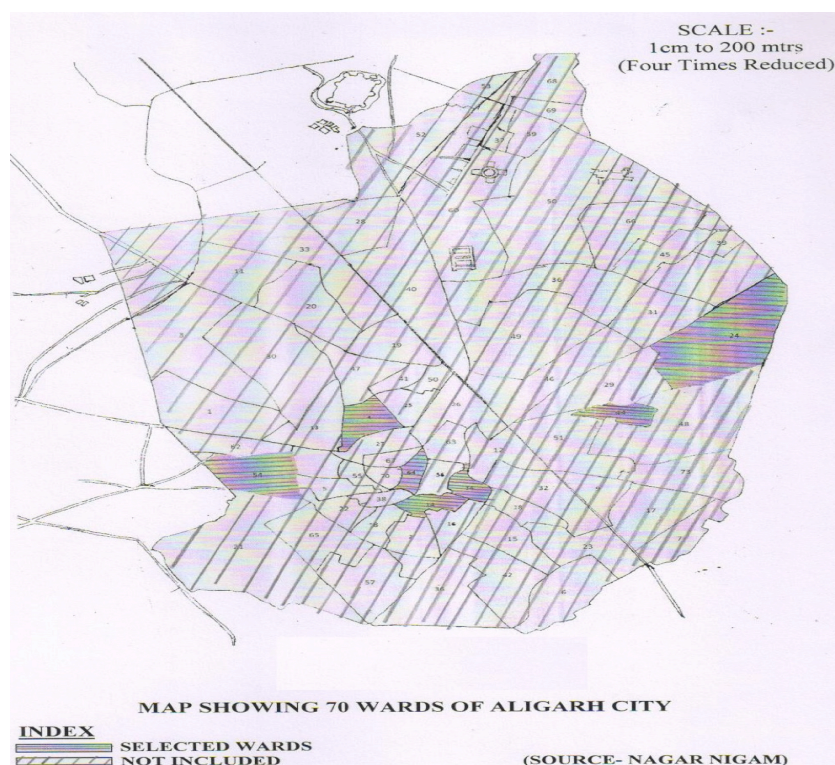


Figure 1. Map showing 70 wards of Aligarh City.

#### Data Collection

To conduct a pilot study and to remove intra-observer bias, the information was recorded on a pre-designed questionnaire, which was administered to 20 couples. These 20 couples were not included in the study sample.

The study was conducted by a single examiner. Standardization and validity of the observer was done before the conduct of the study. The mean Kappa value was found to be 0.86. The overall internal reliability of the questionnaire was 0.74 according to Cronbach's alpha. After testing and making the necessary corrections in the questionnaire used in the pilot study; the couples were interviewed and responses recorded on a self prepared and now a pre tested questionnaire. The questionnaire dealt with particulars like – religion, details regarding relationship between couples (consanguineous /non consanguineous marriage), type of consanguinity (first cousin/second cousin/third cousin), level of education and occupation (a proxy for socioeconomic status).

#### Data Analysis

Data were analyzed using IBM SPSS Statistics for Windows Software, version 16 (IBM Corp., Armonk, NY, USA). Descriptive statistics, Chi-square, and multivariate logistic regression were used, with a significance level set at 5%.

### Ethical Aspects

Permission to carry out the study was obtained from Institutional Ethics and Research Advisory Committee, Faculty of Medicine, Aligarh Muslim University, Aligarh. Informed consent was obtained from all the couples.

### Results

Table 1 shows that, by religion majority in non-consanguineous group were Hindus 1152 (72%) whereas 386 (96.5%) were Muslims in consanguineous group. The difference was statistically significant ( $p < 0.001$ ). For paternal education, maximum number of males in non-consanguineous group was educated up to high school level (32%) against middle school education of males in consanguineous group (30.5%). As for maternal education, illiteracy was prevalent in 658 (41.1%) of females in non-consanguineous group. Males ( $p < 0.001$ ) and females ( $p < 0.001$ ) were significantly more educated and lesser illiterate in consanguineous group than the non-consanguineous group. Self-employment was significantly higher in consanguineous group as compared to non-consanguineous group ( $p < 0.001$ ).

**Table 1. Frequency distribution of variables between consanguineous and non-consanguineous group.**

Variables	Non-Consanguineous		Consanguineous		p-value
	N	%	N	%	
<b>Religion</b>					
Hindu	1152	72	0	0.0	0.000*
Islam	420	26.20	386	96.50	
Christian	16	1	6	1.50	
Buddhist	6	0.40	8	2.0	
Sikh	6	0.40	0	0.0	
<b>Paternal Education</b>					
Illiterate	240	15.0	56	14.0	0.000*
Just Literate	46	2.9	10	2.5	
Primary School	146	9.1	84	21.0	
Middle School	394	24.6	122	30.5	
High School	512	32.0	82	20.5	
Intermediate	204	12.8	10	2.5	
Graduate	38	2.4	30	7.5	
Post Graduate	20	1.2	6	1.5	
<b>Maternal Education</b>					
Illiterate	658	41.1	136	34.0	0.000*
Just Literate	52	3.3	22	5.5	
Primary School	100	6.3	44	11.0	
Middle School	212	13.2	82	20.5	
High School	302	18.9	74	18.5	

Intermediate	216	13.5	18	4.5	
Graduate	56	3.5	16	4.0	
Post Graduate	4	0.2	8	2.0	
<b>Parental Occupation</b>					
Govt. Employed	102	6.3	32	8.0	0.000*
Private	572	35.8	100	25.0	
Self-Employed	768	48.0	232	58.0	
Unemployed	158	9.9	36	9.0	

\*Statistically Significant.

Figure 2 shows the pie chart distribution of types of consanguineous marriages. Out of 400, 340 (85%) marriages were performed between first cousins, 34 (8.5%) between third cousins and 26 (6.5%) between second cousins respectively.

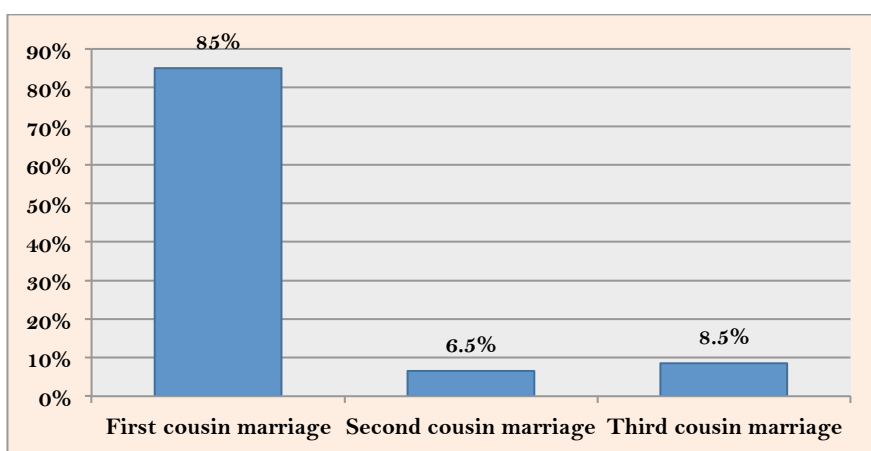


Figure 2. Distribution of types of consanguineous marriages.

Table 2 shows that the coefficient of inbreeding for the present study was 0.0538.

Table 2. Distribution of coefficient of inbreeding according to type of consanguinity.

Type of Consanguinity	Coefficient of Inbreeding (F)	No of Subjects
Non-Consanguineous (NC)	0.0000	1600
Consanguineous (C)	0.0538	400
First Cousin (FC)	0.0625	340
Second Cousin (SC)	0.0156	26
Third Cousin (TC)	0.0039	34

Multivariate logistic regression measures the association of consanguinity with the different variables under study (Table 3).

For multivariate logistic regression analysis, Table 4 showed that Islam ( $p < 0.001$ ) (OR =  $6.642 \times 10^8$ ) (CI  $1.670 \times 10^8 - 2.641 \times 10^9$ ) and Christians ( $p < 0.001$ ) (OR =  $1.829 \times 10^7$ ) (CI =  $1734127.067 - 1.930 \times 10^8$ ) were significantly associated with consanguinity. Private employment with a (-) negative B value ( $p < 0.001$ ) (OR = 0.246; CI = 0.110 - 0.549), showed a significant association of the variable with non-consanguineous group.

**Table 3. Multivariate logistic Regression – Likelihood ratio test.**

Effect	Likelihood Ratio Tests			
	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Chi-Square	Likelihood Ratio Tests d.f	Sig.
Intercept	6.407E2 <sup>a</sup>	0.000	0	
Religion	1.279E3	637.983	4	0.000 <sup>¥</sup>
Paternal education	7.199E2 <sup>b</sup>	79.234	7	0.000 <sup>¥</sup>
Maternal education	6.973E2 <sup>b</sup>	56.556	7	0.000 <sup>¥</sup>
Parental occupation	6.786E2 <sup>b</sup>	37.879	3	0.000 <sup>¥</sup>

The Chi-square statistic is the difference in -2 log – likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are zero. a) This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom; b) Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged. All variables with an ¥ were found to be significantly associated with Consanguinity

**Table 4. Multivariate Logistic Regression: Parameter Estimates.**

Variables	Parameter Estimates							
	B	Std. Error	Wald	df	Sig.	Exp (B)	95% Confidence interval for Exp (B)	
							Lower Bound	Upper Bound
Intercept	-1.791	637.555	0.000	1	0.998			
Religion								
Hindu	-31.214	739.925	0.002	1	0.966	2.780E-14	0.000	b
Islam	20.314	0.704	831.912	1	0.000	6.642E8	1.670E8	2.641E9
Christian	16.722	1.202	193.507	1	0.000	1.829E7	1734127.067	1.930E8
Buddhist	19.615	0.000	.	1	.	3.301E8	3.301E8	3.301E8
Sikh	0 <sup>c</sup>	.	.	0	.	.	.	.
Paternal Education								
Illiterate	-25.660	515.296	0.002	1	0.960	7.175E-12	0.000	b
Just Literate	-24.076	515.296	0.002	1	0.963	3.500E-11	0.000	b
Primary School	-26.549	515.296	0.003	1	0.959	2.952E-12	0.000	b
Middle School	-25.750	515.296	0.002	1	0.960	6.558E-12	0.000	b
High School	-26.260	515.296	0.003	1	0.959	3.939E-12	0.000	b
Intermediate	-26.937	515.295	0.003	1	0.958	2.002E-12	0.000	b
Graduate	4.676	1682.662	0.000	1	0.998	107.335	0.000	b
Post Graduate	0 <sup>c</sup>			0				
Maternal Education								
Illiterate	-13.030	375.845	0.001	1	0.972	2.193E-6	0.000	b
Just Literate	-10.621	375.846	0.001	1	0.977	2.440E-5	0.000	b
Primary School	-11.848	375.845	0.001	1	0.975	7.150E-6	0.000	b
Middle School	-10.563	375.845	0.001	1	0.978	2.586E-5	0.000	b
High School	-12.659	375.845	0.001	1	0.973	3.179E-6	0.000	b
Intermediate	-12.598	375.845	0.001	1	0.973	3.379E-6	0.000	b
Graduate	-25.180	524.836	0.002	1	0.962	1.160E-11	0.000	b
Post Graduate	0 <sup>c</sup>			0				
Parental Occupation								
Govt. Employed	-.561	0.602	0.869	1	0.351	0.571	0.176	1.856
Private	-1.401	0.409	11.712	1	0.001*	0.246	0.110	0.549
Self-Employed	0.121	0.363	0.111	1	0.739	1.129	0.554	2.300
Unemployed	0 <sup>c</sup>			0				

<sup>a</sup>The reference category is: Non-Consanguineous; <sup>b</sup>This parameter is set to zero because it is redundant; <sup>c</sup>Floating point overflow occurred while computing this statistics. Its value is therefore set to system missing; All those entries in bold depict significant association of the variable with Consanguinity; All those entries with\* depict significant association of the variable with Non-consanguineous group.

**Discussion**

The main reported consequence of relation or consanguineous marriage is the higher risk of transfer of autosomal recessive disorders from one generation to the next, as it is difficult to find a partner who carries the same disorder unless they are related [12,13], but the irony is that, still these unions are quite prevalent. Although, at one point of time, consanguinity was inevitable; at the time of Adams and Eve – our common progenitors; when human species was evolving with a small population of approximately  $\approx 700$  to  $\approx 1000$ , a basic level of inbreeding at that time was in fact necessary for the survival of human race.

The present study showed that Muslims had a higher frequency of consanguinity. This finding is in agreement with other studies conducted in Lebanon [2] and Pondicherry, India [14]. A National family health survey, conducted in the year 1992-93 in India showed that Muslims had the highest preference to consanguineous marriages at 23.3% followed by Buddhist at 17.1% and Christians at 10.3% [10]. As for the Hindus of India, region plays an important role. In northern part of India, consanguinity is prohibited under the Aryan Hindu tradition. Before commencing a marriage, seven generations for the males and five generations for the females are consulted. Whereas, in South India there has been a long tradition of uncle-niece and first-cousin marriage [15]. As a result, consanguineous unions show a higher predilection to South India states like Andhra Pradesh, Karnataka, Tamil Nadu as compared to Northern, Eastern and North Eastern states of India [10].

The present study showed that males and females were significantly more educated in the consanguineous group. Males more educated in consanguineous group were in conformity with previous studies [16,17]. The plausible explanation is that more educated males become a valuable asset for the family; hence marrying their cousins in a way preserves the family property. Contrary to the above studies, some author showed that males who were educated had the lowest prevalence of consanguineous marriage, which actually is quite relevant [18,19].

An inverse relation between consanguinity and women's education status has been reported [17,18], though the present study showed that more educated women were associated with consanguineous group, reason being that, Aligarh city is fortunate enough to have a world renowned Aligarh Muslim University and also a female is allowed to continue her education, while search goes on for suitable partner, hence tends to be more educated. Blue-collar occupation (self employed) was significantly higher in the study in consanguineous group; similar results were reported in Yemen [16] and Tunisia and Croatia [19].

In our study, marriages between the first cousins (85%), was the most preferred marriage. Similar observations have been reported [1,2,8,9]. Of the various types of consanguineous unions, marriages between first cousins and second cousins are the two most common types of consanguineous marriages in the world [14]. However; for a particular race, tribe or say a place too, the specific pattern of consanguineous union differs, for example first cousin union between a man and his father's brother's daughter (FBD) is preferred in Arab communities. Uncle-niece and union between a man and his mother's brother's daughter (MBD) are favored in Southern part of India [3].

The coefficient of inbreeding (F) represents a measure of the proportion of loci at which the offspring of a consanguineous union is expected to inherit gene copies from both the parents [3]. The inbreeding of coefficient for the present study was 0.0538; quite high and showed an increase from the previous value reported by a study conducted in Aligarh, which found (F) to be 0.0477 [20]; the highest reported from any part of India. In western countries, the inbreeding coefficient is low, for example in Canada (F= 0.00004-0.0007), USA (F = 0-0.0008), Southern Europe (F = 0.001-0.002). Having such a high coefficient of inbreeding can be one of the reasons that congenital malformations are so prevalent in Aligarh city [20]. It is documented in the literature that, consanguinity in a way is responsible for alteration of genotypic frequencies [21].

### Conclusion

Keeping in view the findings of the present study with such a high coefficient of inbreeding, measures have to be taken. Individual, family and community have to be educated and made aware through IEC (Information – Education – Communication) programmes, with the consequences of consanguinity. Pre-marital and pre-conceptual counseling is another way of allowing the couples to make decisions before planning for a family.

**Financial Support:** None.

**Conflict of Interest:** The authors declare no conflicts of interest.

### References

- [1] Tadmouri GO, Nair P, Obeid T, Al Ali MT, Khaja NA, Hamamy HA. Consanguinity and reproductive health among Arabs. *Reprod Health* 2009; 6:17. <https://doi.org/10.1186/1742-4755-6-17>
- [2] Bittles AH, Black ML. Consanguinity, human evolution, and complex diseases. *PNAS* 2010; 107(Suppl 1):1779-86. <https://doi.org/10.1073/pnas.0906079106>
- [3] Bittles AA. Consanguinity and its relevance to clinical genetics. *Clin Genet* 2001; 60(2):89-98. <https://doi.org/10.1034/j.1399-0004.2001.600201.x>
- [4] Akrami SM, Osati Z. Is consanguineous marriage religiously encouraged? Islamic and Iranian considerations. *J Biosoc Sci* 2007; 39(2):313-6. <https://doi.org/10.1017/S0021932006001684>
- [5] Saadat M. Consanguineous marriages in Iranian folktales. *Community Genet* 2007; 10(1):38-40. <https://doi.org/10.1159/000096280>
- [6] Saadat M, Taj Baksh R. Prevalence of consanguineous marriages in west and south of Afghanistan. *J Biosoc Sci* 2013; 45(6):799-805. <https://doi.org/10.1017/S0021932012000661>
- [7] Rajab A, Patton MA. A study of consanguinity in the Sultanate of Oman. *Ann Hum Biol* 2000; 27(3):321-6.
- [8] al-Abdulkareem AA, Ballal SG. Consanguineous marriage in an urban area of Saudi Arabia: Rates and adverse health effects on the offspring. *J Community Health* 1998; 23(1):75-83.
- [9] Khoury SA, Massad D. Consanguineous marriages in Jordan. *Am J Med Genet* 1992; 43(5):769-75.
- [10] Bittles AH. The impact of consanguinity on the Indian Population. *Indian J Human Gen* 2002; 8(2):45-51.
- [11] Office of the Registrar General & Census Commissioner. Ministry of Home Affairs. Government of India. Available at: [http://www.censusindia.gov.in/Census\\_Data\\_2011](http://www.censusindia.gov.in/Census_Data_2011). [Accessed on October 01, 2017].
- [12] Freire-Maia N. *Genética de Populações Humanas*. Sao Paulo: Hucitec, 1974. 215p. [In Portuguese]



- [13] Rafiee L, Saadat R. Prevalence of consanguineous marriages among Iranian Georgians. *J Biosoc Sci* 2011; 43(1):47-50. <https://doi.org/10.1017/S0021932010000295>
- [14] Villanueva P, Fernandez MA, Barbieri ZD, Palomino H. Consanguinity on Robinson Crusoe Island, an Isolated Chilean Population. *J Biosoc Sci* 2014; 46(4):546-55. <https://doi.org/10.1017/S0021932013000436>
- [15] Sastri KAN. *A History of South India: From Prehistoric Times to the Fall of Vijayanagar*. 4<sup>th</sup>. ed. Oxford University Press; 1976. 534p.
- [16] Jurdi R, Saxena PC. The prevalence and correlates of consanguineous marriages in Yemen: Similarities and contrast with other Arab countries. *J Biosoc Sci* 2003; 35(1):1-13.
- [17] Hussain R, Bittles AH. Sociodemographic correlates of consanguineous marriage in the Muslim population of India. *J Biosoc Sci* 2000; 32(4):433-42.
- [18] Barbour B, Salameh P. Consanguinity in Lebanon: Prevalence, distribution and determinants. *J Biosoc Sci* 2009; 41(4):505-17. <https://doi.org/10.1017/S0021932009003290>
- [19] Kerkeni E, Monastiri K, Saket B, Rudan D, Zgaga L, Ben Cheikh H. Association among education level, occupation status and consanguinity in Tunisia and Croatia. *Croat Med J* 2006; 47(4):656-61.
- [20] Badaruddoza, Afzal M, Ali M. Inbreeding effects on the incidence of congenital disorders and fetal growth and development at birth in north India. *Indian Pediatr* 1998; 35(11):1110-3.
- [21] Bittles AH. The role and significance of consanguinity as a demographic variable. *Pop Dev Rev* 1994; 20(3):561-84.