Introduction

Consanguinity, defined as the marriage or unions between individuals of the same blood, is widely practiced in countries of Asia and Africa especially in societies where Islam prevails but its prevalence is low in Western countries. High rates of these marriages are reported in most of the Arab countries. For example, in Sudan 65% of women are married to a relative (Federal Ministry of Health 1995), Saudi Arabia 57.7% (El Hamzi et al. 1995), Jordan 51.3% (Khoury and Massad 1992), United Arab Emirates 50.5% (Al-Gazali et al. 1997), Tunisia 49% (Ministry of Public Health 1996), Egypt 40% (National Population Council 1996), Yemen 40% (Jurdi and Saxena 2003) and in Kuwait 36% (Ministry of Health 1996).

The practice of consanguinity is very old; it was common between the ancient Egyptians of the reigning dynasty to keep the "royal blood" (Stern 1949). It is known that their offspring have an increased risk of morbidity and mortality. This is because, genetically, they might inherit autosomal recessive conditions or congenital malformations that appear at time of birth or later in childhood. In fact, single gene disorders is common in Eastern Mediterranean families due to the practice of consanguinity that tends to retain rare mutations within affected families, who may contain a high frequency of mutation carriers. Genetic disorders and congenital abnormalities occur in about 2%-5% of all live births, account for up to 30% of pediatric hospital admissions and cause about 50% of childhood deaths in industrialized countries (Emery and Rimoin 1990). They are the leading cause of infant mortality in United Arab Emirates (Ministry of health 1992) and the second leading cause in Bahrain, Kuwait, Oman and Qatar (Ministry of Health of Bahrain 1991; WHO 1993; Ministry of Public Health of Qatar 1993). In Saudi Arabia, 25%-35% of perinatal deaths in two hospitals were attributed to congenital malformations (Agwiser 1990; Haque and Bashi 1988). Thus, congenital and genetically determined disorders are very common in the Eastern Mediterranean region. The prevailing high rate of consanguineous marriages is believed to be the root cause of these problems. In a study of 3000 consecutive neonates delivered in a maternity hospital in Giza, Egypt, who were subjected to full clinical and genetic evaluation, parental consanguinity was found in 31.8% of all cases and in 55% of malformed cases, thus illustrating the effects of consanguinity (Temtamy et al. 1998).

Consanguinity has been reported as the most important cause of genetically associated mortality in developing countries (Guo 1993). Couples who are related by blood are more likely to experience the death of an offspring than those not related by blood (Bittles 1994). A study in Pakistan, found that first cousin marriages are 1.18 times more likely to experience a child's death by its fifth birthday than couples not related by blood (Shah et al. 1998). Another study demonstrated a 3-fold increase of post-neonatal mortality and childhood morbidity in the off-springs of couples having consanguineous marriages. It was estimated that 60% of the mortality and morbidity of children, in Pakistan, could be eliminated if these marriages are stopped (Bundey and Alam 1993). Of late, Banerjee and Roy (2002) found a linkage between consanguinity and offspring

mortality among close consanguineous marriages in India after controlling for the socio-economic determinants. However, the relationship between consanguinity and offspring mortality is still complex and unclear due to the difficulty in classifying death as genetic or non-genetic. In fact, the role of the latter factors has always been an impediment to the understanding of the possible linkage between parental consanguinity and offspring mortality. Among non-genetic factors, socio-demographic characteristics of birth, housing conditions, under-utilization of Maternal and Child Health (MCH) services and quality of sanitation are closely associated with offspring mortality (Banerjee and Roy 2002; Bittles 1994; Cabigon 2002; Dashtseren 2002; Grant and Bittles 1997). Hence, understanding of these interrelationships remains a major and special goal for researchers from various disciplines.

The 1990's have seen a remarkable decrease in mortality among infants and children inmost of the less developed countries. The Demographic and Health Survey (DHS) has identified five factors, one of which is the decline in fertility. Fertility has been observed to be greater among consanguineous couples. This could be due to social factors such as illiteracy, low age at marriage and first birth. Studies have revealed the impact of child mortality on fertility regulation behavior (Doepke 2002) in terms of social security. High fertility is a behavioral response to increased infant and childhood mortality in an attempt to achieve their desired family size (Rahman 1998). Also, fertility control measures are low among parents who have lost a child.

There is, however, little evidence in support that consanguinity leads to genetic ill-health and hence higher mortality among children. More established determinants of the latter include, poverty, lack of education of mothers and under-utilization of MCH services. Nevertheless, it is important to understand whether or not offspring of consanguineous couples have a higher risk of dying during infancy and childhood compared to non-consanguineous couples. And whether such a linkage remains valid even after controlling for other risk factors of infant and child mortality. Keeping this in mind, the present study aims to examine causal linkages between parental consanguinity after exercising statistical control on other known risk factors of infant & child mortality and fertility in Egypt – the country where consanguinity is widely practiced and little is known about the its linkages with the dependable variables of interest..

Methods

This study is a secondary analysis of the data of 2000 Egypt Demographic Health Survey – a nationally representative sample of 16957 households from six administrative divisions of Egypt, namely, Frontier Governorate, Upper Egypt – Rural, Upper Egypt – Urban, Lower Egypt – Rural, Lower Egypt – Urban, and Urban Governorates. The sample from these six regions included 15573 ever-married women aged 15-49. The prevalence and pattern of consanguinity have been estimated from the answers to the two questions asked of all ever-married

women in the Survey: " Prior to marriage, was your husband related to you in any way?" and if the answer to the first question was 'yes', "What type of relationship was it?" In order to assess the impact of consanguinity on offspring mortality the consanguineous group of women has been further divided into two separate categories of women, namely 'close consanguineous' and 'remote consanguineous' on the basis of the answers to the second question. Only first-degree relations have been included in the 'close' category; whereas second degree and other relations have been incorporated in the 'remote consanguineous' group of women.

Two files were used: the file of women and the file of children <5 years of age. The survey provided detailed information on fertility, family planning, infant and child mortality, and maternal and child health care and nutrition. A composite index of 'living standards' of the respondents has been computed from the information collected on the quality of housing, availability of electricity, sources of drinking water, nature of toilet facilities, fuel for cooking, ownership of goods etc. The index has been divided into 3 categories based on the fact that the scores were normally distributed and thus one third of population is taken in each category as: low (0-15), medium (16-22), and high (23 and above). Bivariate analysis revealed the effect of some background variables on mortality and consanguinity, such as education of the mother, birth interval, birth order, standard of living etc. Multivariate logistic regression models have been used considering infant mortality and child mortality, as dependent variable. The effect of the selected predictors on the dependent variable has been ascertained after controlling for other non-genetic variables. Infant mortality has been calculated as proportion died within 0-11 months to births aged 12-59 months as denominator. Child mortality has been calculated as proportion died 12-59 months to births aged 5 years or above as denominator during the last 20 years prior to the survey. Finally, analysis has been carried by using Generalized Linear Model (GLIM) to compare the mean number of children ever-born to consanguineous and non consanguineous women after controlling for women's education, their working status and age at marriage. The Statistical Package for the Social Sciences (SPSS 1988) is used for the analysis.

Results

Prevalence and Pattern of Consanguinity

Consanguineous marriages are still high in Egypt (38.9%). The prevalence of these marriages, however, varies by region. It ranges from 25.4% in Lower Egypt Urban to 55.2 % in Upper Egypt Rural (Table 1). The most common type of consanguineous marriages, in most regions, is that occurring between first cousins. Close consanguinity accounts for 22.2% of the total marriages; it is higher in rural areas and is found highest in Upper Egypt-Rural.

[Table 1 about here]

Consanguinity and Offspring Mortality

Infant and Child Mortality are positively related to the degree of consanguinity. Infant and child mortality rates among consanguineous couples have shown elevated mortality rates among the off-springs of close consanguineous marriages, where child and infant mortality are doubled among close consanguineous parents compared to parents having no relation (Figure 1).

[Figure 1 about here]

Non-genetic Factors Affecting Offspring Mortality

The Bivariate analysis revealed that irrespective of the degree of consanguinity the non-genetic determinants, namely, standard of living, education of the mother, region/residence, birth order, birth interval, age of the mother at birth, size and sex of the child, medical assistance during delivery and antenatal care all have significant effect on offspring mortality (Table 2). The environmental factor that affects offspring's' mortality is standard of living. An inverse relationship has been documented between the two. However, in the population having low standard of living, child mortality among close consanguineous marriages is observed higher by 40% than non-consanguineous marriages and 6% than remote consanguineous marriages. In addition, off springs mortality varies by region/residence. It is very much true in case of Egypt where it is found significantly higher in Upper Egypt – Rural and low in urban areas, and these rates are higher among close consanguineous marriages.

Among other characteristics, mother's education has been regarded as the best predictor of offspring mortality. An inverse relationship has been found between the two: offspring's' mortality has been observed highest among illiterate mothers (Table 2). Irrespective of education, close consanguineous marriages had the highest mortality rates.

Another strong non-genetic determinants of infant and child mortality are the age of the mother at the time of birth, birth-interval, birth order and size of the child at birth. Mothers delivering babies at the ages below 20 years carry greater risk of mortality in infancy and childhood of their newly born. For example, in the present sample, among close consanguineous marriages infant mortality is doubled for very young mothers as compared to mothers aged 20-29 years at the time of delivery. Among very young mothers, infant mortality rates were higher in close consanguineous marriages by 70%; were up by 27% in case of remote consanguineous marriages as compared to non-consanguineous unions. Similar observations were made in child mortality where rates were higher in close consanguineous marriages and remote consanguineous marriages by 59% and 28% than non-consanguineous couples, respectively. Further, children were at elevated risk of mortality if the interval between births was less than 24 months and it was higher for consanguineous marriages. Among the characteristics related to the child, children of birth order four and above had higher risk of

offspring's' mortality. Also, the risk was higher in case of consanguineous marriages. Child mortality too was significantly higher in case of female children as compared to male children in close consanguineous marriages. Moreover, size of the child at birth had an inverse relationship with infant mortality. The smaller the child at birth the higher was the risk of mortality being approximately 5 times more among very small children as compared to having normal size babies. Again, among normal size children at birth, infant mortality rates were higher in close consanguineous marriages and remote consanguineous marriages by 63% and 6% as compared to non-consanguineous unions, respectively. The lack of antenatal care had an impact on infant mortality. Even if mothers had received antenatal care, infant mortality was 118% higher among close consanguineous marriages than that of parents with no relation (Table 2). `

[Table 2 about here]

Multivariate Analyses

Multivariate analyses have been carried out to find the effect of consanguinity on infant and child mortality after controlling the effects of selected non-genetic determinants. Two logistic models have been used with two different indices of offspring mortality as dependent variables. Models I & II take infant mortality and child mortality as dependant variable, respectively. The results are presented in Table 3. As can be seen from the table, the risk of infant mortality was higher in case of consanguineous couples even after controlling for selected non-genetic predictors of infant mortality. The risk of mortality was 30% (odds ratio=1.30) higher and was statistically significant in case of close consanguineous couples; it was higher by 19% (odds ratio=1.19) among remote consanguineous couples but was not found significant. The results also show the impact of consanguinity on child mortality after controlling for other non-genetic factors. The risk of child mortality was higher among the close consanguineous couples by 52 % (odds ratio=1.52) and among remote consanguinity by 27% (odds ratio=1.27) as compared to no relation couples. The effects were found statistically significant.

[Table 3 about here]

The Generalized Linear Model (GLIM) analysis revealed a higher mean number of children ever-born among close consanguineous marriages (3.7), compared to no relation (3.2) and remote consanguineous marriages (3.6), after controlling for the effect of women's education, work status and age at marriage. This model is significant with a p-value less than 0.01 (Table 4).

[Table 4 about here]

Discussion

Egypt has the largest population among 22 members of the League of Arab States. The prevalence of consanguinity varies between 20-50% in the region (Hamamy 2003). It is widely practiced in Egypt (39%). However, the rate of

consanguineous marriages in the country is lower than several other Arab countries. First cousin marriages constitute almost one third of all marriages in many Arab countries. The rates of these marriages differ between, as well as within, countries. In Egypt also, a wide variation in the prevalence of consanguineous marriages is observed in its six administrative divisions. Marriages between close relatives are found highest in Upper Egypt - Rural (30.8%); whereas they were lowest for Lower Egypt - Urban (14.5 %). The regional differentials in Infant and child mortality consistently revealed its pattern in close agreement with that of the prevalence of consanguinity in the six administrative divisions of Egypt. The results strongly support the close association of consanguinity with offspring's' mortality.

The influence of most of the non-genetic determinants of mortality is in the expected direction. Housing conditions and quality of sanitation are found significantly related with offspring's mortality. Socio-economically weaker households were likely to experience higher infant and child mortality in the first five years of life and also fertility as compared to the affluent households. Furthermore, while studying the relationship between Infant and child mortality and subsequent fertility in Indonesia, Frankenberg (1998) showed that for certain groups of women, a child's death changes the fertility pattern of subsequent interval lengths relative to that pattern when a child survives. Also, several studies revealed that both infant mortality and child mortality are conditioned by the circumstances of childbirth and environmental factors to which mothers were exposed prior to giving birth (Dashtseren 2002). In addition, the inverse association between maternal education and offspring mortality found here is in agreement with the findings of many other studies, which show that maternal education decreases the risk of offspring mortality significantly (Hussein 1998; Banerjee and Roy 2002). This strong association between the two may be due to better personal hygiene, greater use of available health services and better child-care practices. Data from the Demographic and Health surveys indicated that in most of the Middle Eastern countries, infant and child mortality was higher for girls than that of boys. However, in case of the predictor 'utilization of health services', girls' mortality was lower as compared to boys (Hill 1995). Contrary to general belief, the effect of 'medical assistance' during delivery is found inversely associated with the infant mortality. In the present study, higher infant mortality was observed where mothers received medical assistance as compared to those who did not at the time of delivery. This is in agreement with the findings of the study of Banerjee and Roy (2002) in India where it was found that births occurring in a hospital or clinic had higher risk of mortality compared with those delivered at home and without the help of any health professional. The authors argue that medical care is sought only in case of complications and unfortunately doctors were not always successful in saving lives of newborn (Banerjee and Roy 2002).

Findings of the logistic regression analysis are in agreement with many other previous studies that show an increased risk of mortality in the offspring of

consanguineous and inbred women, despite simultaneous control for other factors that could potentially confound such an association. The global picture is that the highest rates of consanguineous marriage are among poor, rural, and largely illiterate communities. This over-representation of poorer and less educated families among consanguineous couples creates problems in assessing the effects of consanguinity on morbidity and mortality. However, even when control is exercised on other risk variables, consanguinity remained a significant factor in determining mortality during very early ages.

There are, however, three major limitations of the present study: First, the information on congenital malformations, which are one of the leading causes of infant mortality particularly in the Arab region, was not available. This was a major impediment in assessing the effect in depth of consanguinity on the mortality of offspring. Second, the higher probability of clustering of deaths in the same family might have resulted in overestimation of infant and child mortality. Third, there are limitations in the use of Demographic and Health Survey (DHS) data on consanguinity due to misreporting of levels of consanguinity. Also, the data collected over one generation can be misleading in terms of true level of offspring homozygosity. Further, unless a full genealogical assessment is done, it is difficult to say whether in genetic terms the coefficient of inbreeding is similar or different in offspring of first cousin and more remote relationships. Obviously, such information is not within the scope of DHS.

Conclusion

Reduction of infant and child mortality, and fertility is a key development goal. The findings of this study show the double impact of consanguinity on infant and child mortality in Egypt, after controlling for their selected non-genetic determinants, leading indirectly to an increased fertility. Close consanguineous marriages, a cultural practice governed by consanguinity values and norms, increase a couple's risk of enduring the death of one or more of their children. This may lead to higher fertility to compensate for the child loss in order to achieve couple's desired family size. Genetic disorders predictably will account for an increasing proportion of morbidity and mortality worldwide, and it is evident that this burden will fall disproportionately on countries and communities in which consanguinity is prevalent. Thus, an emphasis on the effect of consanguinity on mortality of offspring, should be a part of intervention strategies that addresses the personal, emotional, and economic loss that families may face with the death of a child. A culturally appropriate approach for counseling about the ill effects of consanguineous marriage is required. Some Governments have put laws for premarital tests and counseling. The success of such counseling in Lebanon (Khlat et al. 1986) could be taken as an example. Public educational campaigns based on scientific evidence could help the purpose. In Egypt, where consanguinity is largely practiced, a proportion of offspring mortality may be prevented if society understands the importance of the issue and voluntarily decides to avoid marriage among biological relatives. A national program may devise strategies that have enough strength to dilute the cultural taboos linked with these social practices.

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Table 1: Distribution of Ever-married Women, Aged 15-49 Years, by Marriage Pattern, Egypt and its Governorates, 2000.

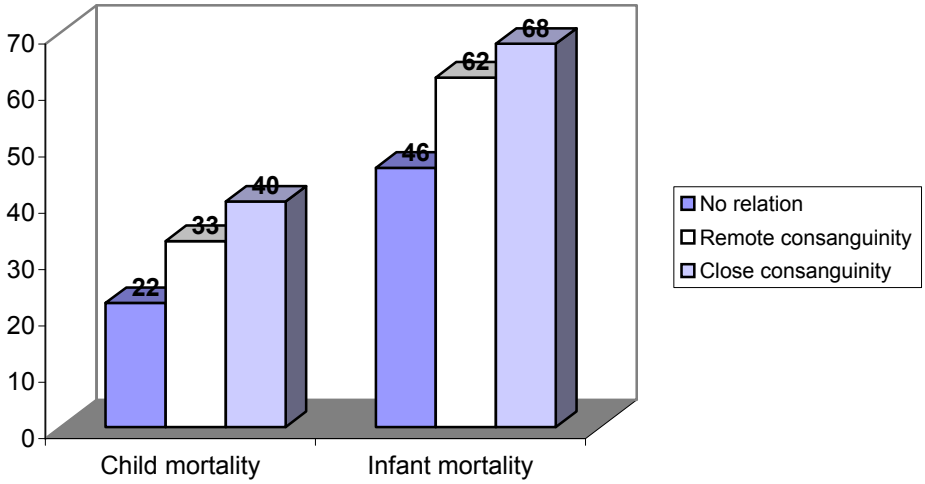
Region of Egypt	**Type of Relationship With the Husband**						**Total No. of Ever-married Women**	
	No relation		Close Consanguinity[1]		Remote Consanguinity[2]			
	N	%	N	%	N	%	N	%
Urban Governorates	2212	71.3	519	16.7	371	12.0	3102	100
Lower Egypt - Urban	1367	74.7	265	14.5	199	10.9	1831	100
Lower Egypt - Rural	2706	633.3	989	23.1	582	13.6	4277	100
Upper Egypt - Urban	1040	62.3	316	18.9	314	18.8	1670	100
Upper Egypt - Rural	1678	44.8	1151	30.8	914	24.4	3743	100
Frontier Governorates	509	53.6	212	22.3	228	24.0	949	100
Total	9512	61.1	3452	22.2	2608	16.7	15572	100

Note: Egypt is divided into 26 governorates. Four Urban (Cairo, Alexandria, Port Said, and Suez) with no rural population, while the other 22 have both urban and rural. 9 of the mixed governorates are in the Nile Delta(Lower Egypt), and 8 in the Nile Valley (Upper Egypt), while the remaining 5 Frontier governorates are on the eastern and western boundaries of Egypt.

1 Includes marriage among first degree relations.

2 Comprises marriage among second degree and other relations.

Figure 1: Infant and Child Mortality Rates by Degree of Consanguinity, Egypt, 2000.



Note: Infant mortality was calculated as proportion died within 0-11 months to births aged 12-59 months as denominator during 4 years prior to the survey, using the file of children < 5. Child mortality was calculated as proportion died 12-59 months to births aged 5 years or above as denominator during the last 20 years prior to the survey, using birth history from the women's file. Both rates were per 1000 live births.

Table 2: Infant and Child Mortality Rates by Selected Determinants, Egypt, 2000.

	Infant mortality			Child mortality		
Variable	**No**	**Close**	**Remote**	**No**	**Close**	**Remote**
Standard of living						
Low	56	63	73	35	49	46
Medium	53	78	58	25	42	28
High	28	65	49	5	20	19
Region						
Urban Governorates	34	73	39	12	24	9
Lower Egypt Urban	37	63	32	17	39	16
Lower Egypt Rural	38	63	52	20	37	32
Upper Egypt Urban	56	88	34	18	23	46
Upper Egypt Rural	71	68	88	39	54	41
Frontier Governorates	27	59	33	10	22	24
Maternal education						
Illiterate	52	70	84	32	47	42
Primary	64	63	72	19	39	34
Secondary & Higher	37	68	32	6	14	6
Age of mother at birth						
<20	69	117	92	29	46	36
20-29	41	58	43	20	36	32
30-49	51	72	90	24	48	31
Birth Interval						

<24	73	90	111	39	71	55
24-47	44	65	52	15	31	25
48+	26	38	47	12	12	14
Birth Order						
1	41	78	43	17	26	17
2-3	41	51	57	16	38	32
4+	60	80	80	33	49	41
Sex of the child						
Male	50	67	65	21	38	26
Female	42	69	58	23	43	40
Size of the child						
Normal	32	52	49	---	---	---
Small	106	99	113	---	---	---
Very small	194	285	263	---	---	---
Assistance during delivery						
Some assistance	45	66	61	---	---	---
No one	29	97	59	---	---	---
Antenatal care						
Yes	33	72	46	---	---	---
No	60	62	75	---	---	---

Note: Infant and child mortality rates were calculated per 1000 live births.
--- Information on Antenatal care, Assistance during delivery and size of the child was collected for children born during the four years prior to the survey.

Table 3: Logistic Regression Coefficients Giving Extent of the Effects of Selected Determinants of Infant and Child Mortality, Egypt, 2000.

	Infant mortality (N=8978)		**Child mortality (N= 30754)**	
Variable	**OR**	**95% CI**	**OR**	**95% CI**
Consanguinity				
No relation	1		1	
Close	1.295 †	1.028-1.632	1.516 *	1.294-1.776
Remote	1.188	0.911-1.550	1.269 †	1.051-1.533
Standard of living				
Low	1		1	
Medium	1.112	0.883-1.400	0.925	0.791-1.081
High	0.811	0.589-1.118	0.486 *	0.368-0.642
Region				
Urban Governorates	1		1	
Lower Egypt Urban	0.965	0.618-1.506	1.361	0.966-1.918
Lower Egypt Rural	0.904	0.634-1.289	1.054	0.794-1.398
Upper Egypt Urban	1.239	0.831-1.847	1.352	0.971-1.883
Upper Egypt Rural	1.226	0.861-1.747	1.506 *	1.139-1.992
Frontier Governorates	0.748	0.296-1.893	0.783	0.358-1.714
Maternal education				
Illiterate	1		1	
Primary	1.023	0.777-1.347	0.834 †	0.696-1.000
Secondary & Higher	0.993	0.761-1.297	0.376 *	0.273-0.516
Age of mother at birth				

<20	1.701 *	1.213-2.351	1.279 †	1.020-1.604
20-29	1		1	
30-49	1.243	0.964-1.603	1.116	0.936-1.331
Birth Interval				
<24	1		1	
24-47	0.617 *	0.485-0.785	0.435 *	0.374-0.506
48+	0.351 *	0.245-0.502	0.289 *	0.225-0.371
Birth Order				
1	0.670 *	0.498-0.901	1.034	0.823-1.299
2-3	1		1	
4+	1.328 †	1.014-1.740	1.409 *	1.181-1.680
Sex of the child				
Male	1		1	
Female	0.880	0.724-1.069	1.233 *	1.073-1.416
Size of the child				
Normal	1		---	---
Small	2.434 *	1.900-3.119	---	---
Very small	5.031 *	3.640-6.954	---	---
Assistance during delivery				
Some assistance	1		---	---
No one	0.752	0.298-1.903	---	---
Antenatal care				
Yes	1		---	---
No	1.276 †	1.027-1.584	---	---

Note: --- refers to variables that were not included in the model.

* p-value < 0.01. † p-value < 0.05.

Table 4: General Linear Model Analysis of the Mean Number of Children Ever-born by Degree of Consanguinity after Controlling for other Determinant,Egypt, 2000.

Source of variation	Mean	SD	N	P-value
Consanguinity				
No relation	3.2	2.1	8555	
Close	3.7	2.2	2985	< 0.01
Remote	3.6	2.3	2225	
Covariates [1]				
Women's education				< 0.01
Working status				< 0.01
Age at marriage				< 0.01

Note: the women's file is used in the analysis taking women as the unit of analysis.
[1] Women's education is categorical (Illiterate, Primary, Secondary and Higher), Working status (working and not working), Age at marriage is continuous.