Parental Consanguinity and Offspring Mortality: The Search for Possible Linkage in the Indian Context

Great care must be taken to be sure that society understands the issue and voluntarily agrees to avoid any marriage among biological relatives

By Sushanta K. Banerjee and T.K. Roy*

The main reason for reinvestigating the possible linkage between consanguinity and offspring mortality emerged as a result of the gross disagreement among researchers on this subject. For the purpose of this study,

---

* Sushanta K. Banerjee, Research Manager, Taylor Nelson Sofres MODE, 1796-A Kotla Mubarakpur, Delhi 100 003, and T.K. Roy, Director, International Institute for Population Sciences, Deonar, Mumbai 400 088, India.

consanguinity is defmed as marriage between relatives who share at least one common and detectable[1] ancestor. There is no common consensus in the field of human genetics or demographic research regarding the biological impact of parental consanguinity on the health of their offspring. However, in this regard it is possible to recognize three broad schools of thought. Adherents of the first school consider that there is an overwhelming possibility of consanguineous parents having an unhealthy child. According to this school of thought, marriage between close relatives is genetically critical, because closely related individuals have a higher probability of carrying the same alleles[2] than less closely related individuals. Consequently, an inbred child (the progeny of a consanguineous couple) will more frequently be homozygous[3] for various alleles than the offspring of unrelated persons (Whittinghill, 1965). To the extent that homozygosity for genes is deleterious, consanguineous marriage is deleterious (Sutton, 1965). In this respect, the genetic load of deleterious recessive genes, usually known as the lethal equivalent, would cause death if present in homozygous combination (Cavalli-Sforza and Bodmer, 1971). A number of studies on this subject have focused on an increased level of morbidity (Bemiss, 1858; Rao and others, 1977; Ansari and Sinha, 1978) and mortality (Farah and Preston, 1982; Bundey and Alam, 1993; Bittles, 1994) among the offspring of consanguineous parents. Survey results from a few other sources have also identified a linkage between consanguinity and spontaneous abortion (Neel and Schul, 1962; Al-Awadi and others, 1986) and intrauterine loss (Saheb and others, 1981).

Perhaps these observations on genetic complications have encouraged certain states and religious institutions to initiate special marriage laws regarding the permissibility of marriage between biological relatives. For example, in India, according to the Hindu Marriage Act of 1955, marriage between two persons related within five generations on the father's side and three generations on the mother's side is void unless permitted by local custom (Kapadia, 1958). Under the civil statutes of the United States of America, marriage between first cousins has been declared a criminal offence (Ottenheimer, 1990). In many other states, marriage among biological relatives also falls under a ban.

Such prohibitions, according to the view of the second school, however, are based on either biological misconceptions or non-biological grounds. From the genetic point of view, these are meaningless (Stern, 1949; Arora and Sandhu, 1989). In the words of Arora and Sandhu (1989:409):

> "Sometimes it is falsely believed that as a result of inbreeding harmful characters appear. No doubt, some harmful characters do

> appear during inbreeding, but this will not be in case of heterozygous individuals due to the presence of recessive genes and they will appear only when the individual is homozygous recessive. If the race is free of such recessive genes, there will be no harmful characters".

The same line of argument has also been raised by Bittles (1994) but for a different reason; he states that, even in the absence of consanguinity, the frequency of alleles can increase owing to the founder effect[4] and genetic drift.[5] On the other hand, the complex role of non-genetic determinants of child mortality throws into doubt the validity of the widely accepted positive relationship between consanguinity and offspring mortality. In most cases, it is either very difficult or impossible to classify a death as genetic or non-genetic. Many of the deaths among inbred children may occur because of environmental as well as genetic causes, or interactions between genotypes as well as environmental factors (Cavalli-Sforza and Bodmer, 1971; Bittles, 1994). Another group of studies from different parts of the world have failed to demonstrate as such any positive association between consanguinity and offspring mortality in Brazil (Azevedo and others, 1980), India (Ramkumar and Sood, 1961) and Ireland (Stevenson and Warnock, 1959).

The complex linkage between consanguinity and offspring mortality thus remains at best unclear. A careful tracing back of the histories of different regions and religions may offer enough evidence regarding this ambiguity. For example, the ancient Egyptians and Incas favoured unions between brothers and sisters of the reigning dynasty, because "royal blood" was considered worthy of mixing only with other royal blood (Stern, 1949). By contrast, the Bible forbids marriage between certain classes of relatives. However, in Hindu as well as Islamic religious culture, there is ample evidence of marriage among biological relatives (Kapadia, 1958; Armstrong, 1991). Even in Western societies, some notable personalities, from Charles Darwin to Emma Wedgewood, were married to close relatives (Bittles, 1994). Surprisingly and contrary to the expectation of the first school of thought, no harmful effects were recorded vis-a-vis the offspring from such marriages (Arora and Sandhu, 1989).

According to the third school, however, it is believed that the continued practice of consanguineous marriage over several generations may lead to a narrowing of the differentials in offspring mortality (Bhasin and Nag, 1994; Rao and Inbaraj, 1977). Relatively closed populations that have followed a pattern of close consanguineous marriage for many generations can tolerate quite intensive inbreeding because of the elimination over time of an

X-mutation from that community's gene pool (Bittles and Neel, 1994). It is thus difficult to establish any unique genetic theory on the "inbreeding effect", which really is universal. The role of non-genetic factors has always complicated the endeavour to understand the possible linkage between parental consanguinity and offspring mortality.

Keeping these views in mind this article aims to shed light on two questions: What are the genetic consequences of parental consanguinity, and how is consanguinity likely to affect the scenario of child mortality in India? This study attempts to provide some suitable answers to these questions by exploring the extent of stillbirths, and the neonatal, post-neonatal and child mortality rates among the offspring of consanguineous vis-a-vis non-consanguineous parents, by controlling other important non-genetic proximate determinants of child mortality.

Data and methods

The 1992/93 National Family Health Survey provides an excellent opportunity to undertake this study, because it is a nationally representative probability sample of 88,562 households from 25 states of India that includes 89,777 eligible ever-married women aged 13-49 within these households. Two common questions were asked of all ever-married women in the Survey: "Before you got married, 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"? The prevalence and pattern of consanguinity have been estimated from the answers to these two questions. In order to understand more clearly the impact of consanguinity on offspring mortality, the whole consanguineous group has been further divided into two separate categories, close consanguinity and remote consanguinity, according to the relative distance between husband and wife ties. In this regard, only cousin and uncle-niece marriages have been included in the close consanguinity section, because the genetic impact of these marriages is reportedly much more serious than that of remote consanguineous marriage[6] (Sutton, 1965; Whittinghill, 1965; Bittles, 1994). On the other hand, all eligible women were asked to provide a complete birth history, comprising date of birth, survival status and age of child at death, if applicable. Information on the utilization of antenatal care during pregnancy and delivery assistance from trained professionals was also collected for each child born during the four years prior to the day of the Survey. In this respect, each mother who had a live birth during the previous four years was asked whether she received ferrous tablets or tetanus toxoid injections during her pregnancy (these interventions are usually given during antenatal check-ups). If a woman had more than one live birth during this four-year period, information was collected for the three most recent live births (IIPS, 1995).

Finally, for a better appraisal of the impact of consanguinity on offspring mortality, multivariate logistic regression models have been ‘applied that consider four different indices of mortality, namely, stillbirth[7], neonatal mortality[8], post-neonatal mortality[9] and child mortality[10], as the dependent variables. Except for stillbirth, the three other indices of offspring mortality have been calculated by the conventional method of using live births as the denominator. However, in the case of stillbirths, this study calculated the rate by using eligible women as the denominator. This is appropriate, because at the aggregate level, it represents the proportion of women who had a stillbirth because of consanguinity. At the individual level (for the multivariate analysis), it is a dichotomous variable indicating whether or not a woman had a stillbirth. In the Survey, in addition to birth histories, information on stillbirths was collected from each eligible woman in terms of whether she had a stillbirth, and, if so, the number of such events.

Prevalence of consanguinity

Global context

In spite of the widespread detrimental impressions about inbreeding, marriage among relatives is still quite common in various parts of the world, especially in Asia and Africa. Besides India, in the ESCAP region, the prevalence of marriage among biological relatives is still high in Pakistan (Maian and Mushtaq, 1994; Bittles, 1994), Uzbekistan (Ginter and others, 1980) and the Islamic Republic of Iran (Naderi,1979). If the African countries, where the practice is cornmon, are included, it can be seen that a wide spectrum of Muslim countries show a strong preference for consanguineous marriage. Parallel fast-cousin marriage (for example, between the son of a woman’s brother and her daughter) is the most common type of union in this regard (Bittles, 1994).

Indian context

The Indian subcontinent is a panorama of diversity in terms of culture, caste, religion, beliefs and attitudes towards customary social practices. A reflection of this diversity can be seen in the preference for consanguineous marriage. **Table 1** shows the regional variations in the prevalence of consanguinity in India. According to this table, one out of every six (16 per cent) marriages in India is among biological relatives. The prevalence of such

Table 1. Percentage distribution of ever-married women, aged 13-49 years, by region, according to their marriage pattern, India, 1992-1993

Regions of India	Close consanguineous marriage[f]	Remote consanguineous marriage[g]	Non-consanguineous marriage	Total number of ever-married women
East and North-East[a]	4.7	3.0	92.3	23,275
North[b]	1.7	3.9	94.4	10,630
Central[c]	6.4	2.7	90.9	22,010
West[d]	15.5	5.3	79.2	12,985
South[e]	29.2	6.9	63.9	20,877
All India	12.0	4.3	83.7	89,777

a East and North-East comprises West Bengal, Bihar, Orissa, Assam, Tripura, Arunachal Pradesh, Manipur, Nagaland and Mizoram, and Maghalaya.

b North comprises Himachal Pradesh, Jammu and Kashmir, Delhi, Rajasthan, Punjab and Haryana.

c Central comprises Uttar Pradesh and Madhya Pradesh.

d West comprises Maharashtra, Gujarat and Goa.

e South comprises Tamil Nadu, Andhra Pradesh, Karnataka and Kerala.

f Close consanguineous marriage includes marriage among cousins, and among uncles and nieces.

g Remote consanguineous marriage includes marriage with brother-in-law and other relatives.

marriages, however, is not uniformly distributed, varying from a very low level of 6 per cent in the northern region of the country to 36 per cent in the southern region; the level is 19 per cent in the western region and 9 per cent in the central region. Even in the southern region, wide variations can be seen among the States of Kerala, Tamil Nadu, Andhra Pradesh and Kamataka. The frequency of consanguinity varies from 52 per cent in Tamil Nadu and approximately 37 per cent in Andhra Pradesh and Kamataka to only 11 per cent in Kerala (Banerjee and Roy, 1996). The relatively high level of consanguinity in the southern region has often been interpreted as a practice of Dravidian people (Bittles and others, 1985). In the southern region, Hindus have a stronger affinity for consanguineous marriage than Muslims (Banerjee and Roy, 1996; Bittles and others, 1987).

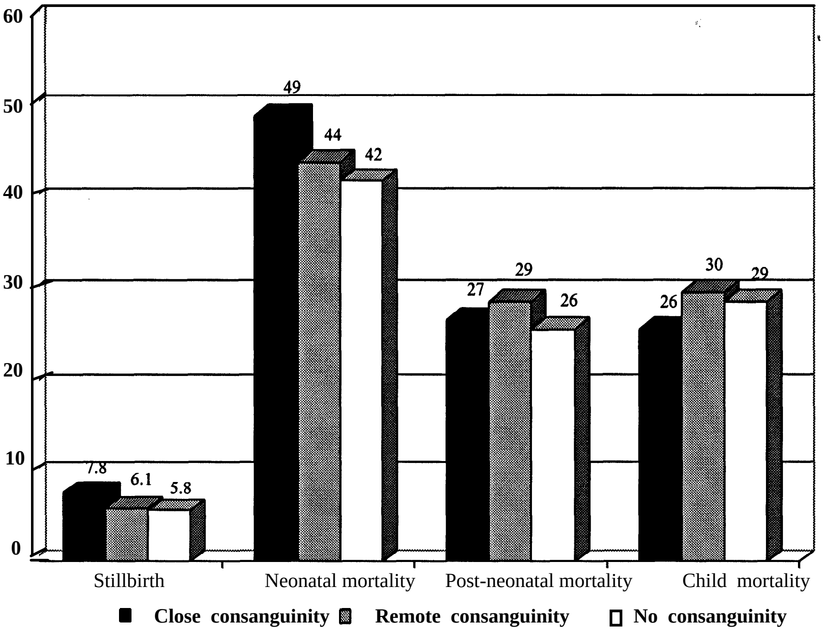
In the western region, marriage among biological relatives has been found to be fairly common in Maharashtra (20 per cent) followed by Goa (15 per cent) and Gujarat (7 per cent). Although consanguineous marriage in this region of the country is fairly common among all religious communities, namely Muslims, Hindus, Parses and Christians (Bhasin and Nag, 1994), the strongest preference for consanguinity is seen among Muslims (Banerjee and Roy, 1996). The prevalence rates for the remaining regions, namely the northern, central, eastern and northeastern parts of the country, are low and basically found among Muslims and some minority communities.

With regard to the type of consanguinity, close consanguinity is quite frequent in all regions as compared with remote consanguinity. For example, 29 per cent of all marriages in South India have been recorded as close consanguineous marriages compared with only 7 per cent being remote consanguineous marriages. In this respect, marriage between first cousins (mostly between cross cousins and occasionally between parallel cousins) is much more common than uncle-niece and second cousin marriages. However, in earlier times, the preferred consanguineous marriage for a man was his sister's daughter (Dronamrayu and Khan, 1960). But in recent times, the incidence of uncle-niece marriage has declined, mainly because of the shortage of suitable nieces of marriageable age for an uncle to choose from. When fertility was high and the age at marriage low, each woman had many children, and it was considered appropriate for a woman's eldest daughter's daughter to marry her mother's younger brother (Richard and Rao, 1994). As a result of this situation, even though it is allowed by custom, all other remaining states, except for Tamil Nadu, have a very low frequency of uncle-niece marriage.

Consanguinity and offspring mortality

Until the recent past, there has been no consensus in the literature regarding the genetic impact of inbreeding on offspring mortality. The overwhelming majority of research in the fields of human genetics, medical biology and demography has consistently shown elevated mortality rates among the offspring of consanguineous parents from different parts of world: from Brazil (Azevedo and others, 1980), Egypt (Hussein, 1971), France (United Nations, 1962), India (Centerwall and Centerwall, 1966; Padmadas and Nair, 2001), Japan (United Nations, 1962), Pakistan (Bittles, 1994) Sudan (Ahmed, 1979; Farah and Preston, 1982), Sweden (Book, 1957), United Kingdom of Great Britain and Northern Ireland (Bundey and Alam, 1993) and United States (Bemiss, 1858; United Nations, 1962). None of these studies is, however, comparable. They vary in their methodological rigour; different researchers have utilized different types of data (hospital-based data, localized data, large-scale sample survey data or census data) as well as different statistical techniques (with or without controls). Although they have come to more or less same conclusion, the crucial questions of validity and reliability need to be examined carefully.

Figure 1. Consanguinity and offspring mortality, India



Note: The neonatal, post-neonatal and child mortality rates have been calculated per thousand live births, whereas stillbirth has been estimated per thousand eligible women.

Figure 1 exhibits the survival status of births to consanguineous couples in India by four indices, namely, stillbirths, neonatal mortality, post-neonatal mortality and child mortality, according to the degree of consanguinity. Differentials in terms of stillbirths as well as neonatal mortality show a clear association between mortality and the degree of consanguinity.

As expected, stillbirths are highest among mothers in close consanguineous marriages (7.8 per thousand women) followed by mothers in remote consanguineous marriages (6.1 per thousand women) and mothers in non-consanguineousmarriages (5.8 per thousand women). The same differentials can also be seen in the case of neonatal mortality. The mortality rate increased from 42 per thousand live births among the offspring of non-consanguineous parents to 44 per thousand among the offspring of remote consanguineous parents and 49 per thousand among the progeny of close consanguineous parents. However, the same differences are not observed with regard to post-neonatal and child mortality; the offspring of remote consanguineous parents have slightly higher mortality rates than the offspring of close and non-consanguineous parents.

Do these factors really imply that the genetic impact of inbreeding is more deleterious during the prenatal phase or in the early postnatal period (first 30 days of life)? It is really very difficult to provide a suitable answer to this question with confidence, based on the crude results shown in **figure 1**, particularly in the case of developing countries such as India where a huge number of newborn babies die because of environmental conditions, disease, malnutrition and especially poorly managed pregnancies, deliveries and postnatal care (Banerjee and Roy, 1997). A large proportion of deliveries among illiterate mothers, mostly from rural areas, are still being performed in an unhygienic room with the help of a traditional birth attendant who customarily uses a non-sterilized razor blade or a sharp piece of bamboo in order to cut the umbilical cord. As a consequence, a large number of newborns have been observed to die from infectious diseases (CBHI, 1991; Banerjee and Roy, 1997). For example, over 55 per cent of the total number of infant deaths in India have been reported as due to prematurity, birth injury and cord infections (CBHI, 199 1). Under circumstances where a set of complex non-genetic factors also play a crucial role in influencing the survival status of the offspring, it is very difficult to classify a death as genetic or non-genetic without proper control of all possible non-genetic proximate determinants of child mortality. This would be clear from a study in Sudan where the investigators found 20 per cent higher rates of child mortality among consanguineous parents:

> "There may, of course, be genetic reasons for higher mortality among offspring of close kin . . . . The effect is by no means inconsequential, ... it requires about six additional years of education for a woman (or ten for a man) to offset the child-survival consequences of marring a cousin" (Farah and Preston, 1982:378).

An important problem in the study of consanguinity is, therefore, the choice of non-genetic controls. Keeping this issue in mind, this article includes a set of social, economic and biological determinants of child mortality (as control variables), which necessarily operate through a common set of proximate determinants to exert an impact on child mortality (Mosley and Chen, 1984).

Non-genetic determinants of offspring mortality

Mother's education

Maternal education has always been regarded as the best "immunization" against child mortality, because it is associated with better personal hygiene, greater use of available health services and better child-care practices. The present study provides sufficient evidence in favour of this hypothesis (table 2). Irrespective of the degree of parental consanguinity, education infers a clear negative association with offspring mortality. For example, even among consanguineous parents, the rate of neonatal mortality in the case of illiterate mothers is 61 per cent higher than among mothers who are highly educated (those who have completed 10 years of schooling). The same trend in mortality differentials can also be observed in the case of remote consanguineous and non-consanguineous mothers. Although this may be true for any indices of offspring mortality, the most interesting point is that, if we control the level of maternal education, the degree of parental consanguinity will infer a positive association with offspring mortality. In this regard, mortality differentials are more pronounced among educated mothers. In the case of highly educated mothers, neonatal mortality among the close consanguineous group is 57 per cent and 43 per cent higher than among remote and non-consanguineous groups respectively. In the case of illiterate mothers, although the general level of mortality is quite high, the close consanguineous group had only an 8 per cent higher rate of mortality than the non-consanguineous group with regard to stillbirths. The close consanguineous group had higher rates of foetal loss compared with the remote and non-consanguineous groups. As for post-neonatal mortality, the remote consanguineous group experienced higher rates of mortality when the mothers were either illiterate or literate up to the middle standard, whereas the close consanguineous group had substantially higher mortality when the mothers were highly educated. However, the role of parental consanguinity with respect to mother's education is quite inconclusive in terms of child mortality.

Standard of living

Living standards, especially the physical environment at home, water supply, sanitation facilities and cooking arrangements comprise the single most important factor influencing child survival. In one way, living standards directly influence the child's risk of exposure to infectious diseases (Behm, 1991) through contamination of the household environment. In another, they indirectly influence nutritional intake and personal hygiene, and especially the

Table 2. Stillbirths, neonatal, post-neonatal and child mortality in India, by marriage type and selected background characteristics

Background characteristics	Stillbirth[a]			Neonatal mortality			Post-neonatal mortality			Child mortality[a]		
	CC[b]	RC[c]	NC[d]	CC[b]	RC[c]	NC[d]	CC[b]	RC[c]	NC[d]	CC[b]	RC[c]	NC[d]
Education												
Illiterate	8.6	7.5	6.9	53	55	49	31	37	32	31	40	38
Literate up to middle school	6.4	4.8	4.6	44	30	32	20	22	19	18	17	15
Educated (l0+ years)	4.6	2.4	2.7	33	21	23	16	6	9	5	6	5
Standard of living												
Low	8.6	6.8	6.6	56	56	51	35	41	33	33	42	42
Medium	7.3	5.9	5.7	42	40	37	18	27	22	22	27	21
High	5.0	4.8	3.6	37	22	23	19	10	11	4	6	7
Birth spacing (months)												
24 or more	--	--	--	39	38	35	21	19	20	26	30	27
< 24	--	--	--	88	68	67	50	68	47	28	31	36
Mother's age (years)												
< 20	--	--	--	62	70	63	33	29	32	26	29	32
20-29	--	--	--	41	38	36	25	27	24	27	32	28
30 or more	--	--	--	84	50	40	31	56	35	19	16	34
Antenatal care												
Received	--	--	--	38	27	27	19	13	16	--	--	--
Not received	--	--	--	62	61	53	37	45	34	--	--	--
Delivery care												
Home delivery without trained health professional (including doctor and nurse)	--	--	--	50	47	44	29	34	31	--	--	--
Home delivery with trained health professional (including doctor and nurse)	--	--	--	53	38	29	32	17	20	--	--	--
Institutional delivery	--	--	--	46	40	40	23	23	16	--	--	--

Note: The neonatal, post-neonatal and child mortality rates have been calculated per thousand live births, whereas stillbirths have been estimated per thousand eligible women.

a Data were not included in the cells with a dash.

b Close consanguineous marriage.

c Remote consanguineous marriage.

d Non-consanguineous marriage.

household's capacity to purchase health services (Banerjee and Roy, 1997). In this context, household living standards are estimated here by stratifying all households into three categories (high, medium and low) on the basis of quality of housing, availability of electricity, sources of drinking water, nature of toilet facilities and possession of consumer durable goods.[11] Thus, a high living standard implies not only a higher economic status but also a favourable disposition towards a better quality of life (Roy and others, 1999). **Table 2** exhibits the expected negative association between living standards and mortality among offspring. Cross analysis of mortality indices by living standard reflects a clear positive association with the degree of consanguinity, that is, the closer the degree of parental consanguinity, the higher is the incidence of offspring mortality. For example, in the case of mothers who have a high standard of living, the rates of neonatal mortality among those in the close consanguineous group are higher by 68 per cent and 61 per cent respectively than in the remote consanguineous and non-consanguineous groups. The same trend in mortality differentials, although to a lesser extent, can be seen among mothers who have a low standard of living. Parental consanguinity plays no role in influencing child mortality.

Biological risk factors

In terms of child survival, the biological risk faced by a mother has always been determined according to her age at the time she gives birth, the interval between two successive births and the order of birth. A very young age at the time she gives birth reflects maternal immaturity, whereas giving birth at an older age increases the likelihood of birth defects (DaVanzo, 1984). In this respect, mothers who have given birth either before the age of 18 years or at 30 years or more are identified as biologically risky mothers. Further, a short interval between two successive births would affect the survival prospects of the newborns either because of nutritional depletion and lack of gestational maturity on the part of the mother which results in low birth weight babies, or because of competition among children for the mother's attention (DaVanzo, 1984). Available research in this direction has also shown that children are at an increased risk of mortality if the interval between births is less than 24 months (Hobcrafi and others, 1983). Considering this point, all births have been stratified here into two categories on the basis of the interval between two births: a short birth interval being an interval of fewer than 24 months and a lengthy birth interval being an interval of 24 or more months. The impact of these risk factors is also covered in the present study. **Table 2** shows elevated rates of mortality with respect to birth intervals and mother's age at the time she gives birth. For example, in the case of consanguineous mothers, the post-neonatal mortality rate among babies characterized by a short birth interval is 138 per cent higher than among births separated by 24 or more months. However, irrespective of the birth interval (with or without risk), neonatal and post-neonatal mortality is highest in the close consanguineous group. As for long birth intervals, the rate of neonatal mortality in the close consanguineous group is 11 per cent higher than among the non-consanguineous groups, whereas in case of a short birth interval, the gap further increases to 31 per cent. Although the rate of neonatal mortality by mother's age at the time she gives birth exhibits no difference between the close consanguineous and remote consanguineous groups in the case of very young mothers (under 20 years of age), the difference is very high in the case of mothers who have given birth at 30 years of age or older.

Prenatal care

The lack of scientific care for foetuses and unborn babies has the greatest influence on the health of the newborn. It can be observed from the present study that the care of the mother during pregnancy (antenatal care) and delivery (assistance from a trained health professional) has a substantial impact on pregnancy outcome **(table 2)**. Irrespective of parental consanguinity, the rates of neonatal mortality are quite high among mothers who did not receive any antenatal care. However, it is interesting to note that, even if mothers have received antenatal care, the neonatal mortality rate among those in the close consanguineous group is approximately 41 per cent higher than among the remote and non-consanguineous groups; the same is also true in terms of delivery assistance.

Thus, a bivariate control of any proximate determinant of offspring mortality infers an elevated risk of mortality (particularly in the very early phase of infancy) among the offspring of consanguineous parents. The extent of risk, however, varies in degree from a close consanguineous mother at one end of the spectrum to a remote and non-consanguineous mother at the other end; likewise, it varies from an educated mother who most likely has received antenatal care to an illiterate mother who has not received any antenatal care. However, the failure to control simultaneously for all selected proximate determinants may be the root of a superfluous variation in searching the possible linkages between parental consanguinity and offspring mortality. Keeping this view in mind, multivariate analyses have been undertaken in order to assess the impact of parental consanguinity on mortality after controlling the role of all other selected proximate determinants of offspring mortality.

Multivariate analyses for offspring mortality

Four different logistic regression models have been used with respect to the four different indices of offspring mortality as dependent variables. Model I considers stillbirths, whereas models II, III and IV are assigned to neonatal mortality, post-neonatal mortality and child mortality respectively.[12] The regression coefficients of the selected variables represent the amount by which the odds of mortality for a specific category vary from that of the reference category, once the effects of all other variables in the model have been controlled. For each model, two separate regression equations have been estimated. In the first step, only parental consanguinity has been included as an explanatory variable in each model; in the second step, with consanguinity following selected proximate determinants of offspring mortality, place of residence, religion, caste, maternal education, living standard, region, birth order, birth interval, utilization of antenatal care services, assistance during delivery and mother's age at the time she gave birth have been added. The logic behind this is to see how the impact of consanguinity on offspring mortality changes once other variables, which are expected to have an impact on different indices of mortality, are controlled statistically.

Findings of the regression analyses **(table 3)** disclose that in regressions limited to the consanguinity variable only, close consanguinity has a significant positive effect on stillbirths (model I) and neonatal mortality (model II), while remote consanguinity as such has no significant effect on any of the indices of offspring mortality. However, in contrast to the bivariate analysis, close consanguinity has a negative (although insignificant) effect on post-neonatal mortality (model III). Concerning model IV, close consanguinity again reveals a strong and significant negative effect on child mortality, which implies a considerably lower risk of child mortality among the consanguineous group with respect to the reference category, that is, the non-consanguineous group. Some interesting changes in the relationship between consanguinity and offspring mortality can be observed in two regression equations (with and without controls) in models II to IV. In model II, once all the proximate determinants are included in the regression, the relationship between close consanguinity and neonatal mortality becomes even stronger. For post-neonatal mortality (model III), the change is more conspicuous; the regression coefficient of close consanguinity changes from negative and insignificant to positive and significant. For example, the odds of post-neonatal mortality (the ratio of children dying during the post-neonatal period to those who survive) after control is 27 per cent higher among the close consanguineous couples than non-consanguineous couples. Because the utilization of antenatal care, which is found to have a strong influence on lowering the mortality levels, is much higher among close consanguineous mothers compared with non-consanguineous mothers [13], the effect of consanguinity changes after control. In model IV, close consanguinity has lost its strong and significant negative effect on child mortality, once the effects of all other variables are controlled. It is unlikely that other mortality indices of consanguinity have any influence as such on child mortality.

Table 3 also shows few interactions having a significant influence on mortality. Although the effects of many more interactions have been investigated, since they did not show any significant influence, they were excluded from the models. It is worth mentioning that there is no significant interaction between consanguinity and region or religion on offspring mortality. In other words, the higher incidence of offspring mortality (both neonatal and post-neonatal) among close consanguineous couples was uniformly evident in all regions and among all religious groups. The influence of all other proximate determinants on the mortality levels was found to be in the expected direction. The only exception is the effect of delivery care. It may appear surprising to find that births occurring in an institution such as a hospital or clinic had higher odds of mortality compared with those delivered at home and without the help of any health professional. Does this really imply a higher risk of mortality in institutional delivery? Certainly not, particularly in a country such as India, where only 16 per cent of total deliveries in rural areas are performed in an institutional setting. In this regard, mothers from the rural areas have been observed as seeking institutional delivery if and only if they face a complication at the time of delivery. Naturally, in helpless situations, doctors are not always successful in saving the life of a newborn baby (Banerjee and Roy, 1997). That is why the incidence of mortality in cases of institutional delivery is higher than the reference category.

Conclusions

There is still some preference for marriage among biological relatives in India, particularly in the southern and western parts of the country. Close consanguineous marriage occurs quite frequently and it has a crucial genetic effect on offspring mortality. It is quite clear from the bivariate as well as multivariate analyses, however, that the genetic effect of consanguinity on offspring mortality is detrimental only among close consanguineous couples and exclusively during the period of development of the foetus (stillbirths) and

Table 3. Results of logistic regression analysis for stillbirth, neonatal, post-neonatal and child mortality, India

Variables	Reference category	Model I - stillbirth (Na= 89,777)				Model II - neonatal mortality (N=48,412)				Model III - post-neonatal mortaliy (N=36,318)				Model IV - child mortality (N=79,362)			
		β	EXP (β)	β	EXP (β)	β	EXP (β)	β	EXP (β)	β	EXP (β)	β	EXP (β)	β	EXP (β)	β	EXP (β)
Consanguinity																	
Close consanguinity	Non-consanguinity	.306[b]	1.4	.345[b]	1.4	0.131[c]	1.14	0.219[b]	1.3	-.017	0.98	0.240[c]	1.27	-199[b]	0.82	-.015	0.98
Remote consanguinity		.056	1.1	.103	1.1	0.153	1.17	0.148	1.2	0.083	1.08	0.274	1.32	-.123	0.88	0.038	1.03
Place of residence																	
Urban	Rural			.015	1.0			-.223[b]	0.80			-0.063	0.94			-.102	0.90
Religion																	
Muslim	Hindu			.147[b]	1.2			-.140[c]	0.87			-.101	0.90			-095	0.91
Other				0.91	1.1			-.213	0.81			0.437[c]	0.64			-.140	0.87
Caste																	
other caste	Scheduled caste and scheduled tribe			-025	0.98			-.051	0.95			-.056	0.95			0.196[b]	0.82
Education																	
Literate up to middle School	Illiterate			.329[b]	0.72			-.130	0.88			-.122	0.89			-.406[b]	0.67
Highly educated				-.783[b]	0.45			-.007	0.99			0.125	1.13			-1 .03[b]	0.36
Standard of living																	
Medium	Low standard of living			-.056	0.95			-.209[b]	0.63			-.308[b]	0.73			-.456[b]	0.63
High				-.116[b]	0.88			-461[b]	0.81			-.616[b]	0.54			-1.167[b]	0.31
Region																	
East	South			.185[b]	1.2			0.090	1.09			0.273[c]	1.31			0.335[b]	1.39
North				.287[b]	1.3			-.215[c]	0.80			0.426[b]	1.53			0.252[b]	1.28
Central				.037	1.0			0.154	1.16			0.332[b]	1.39			0.655[b]	1.93
West				-.242[b]	0.78			-.103	0.90			0.314[c]	0.73			0.101	1.10
Birth order																	
Older 1	Birth order and 3			d	d			1.001[b]	2.72			0.788[b]	2.19			-.281[b]	0.75
Order 4 and above				d	d			0.076	1.07			0.177[c]	1.19			0.098[c]	1.10

Birth interval													
<24 months	24 months and above		d	d		1.151[b]	3.16		1.150[b]	3.16		d	d
Antenatal care													
Received antenatal care	No antenatal care		d	d		-.497[b]	0.61		0.402[b]	0.67		d	d
Delivery care													
At home with health professional	At home with no health professional		d	d		-.423[b]	0.65		-.521[b]	0.59		d	d
Institutional			d	d		0.831[b]	2.29		0.441[b]	1.56		d	d
Mother's age (years)													
<20	20-29		d	d		0.204[b]	1.23		0.067	1.07		0.188[b]	1.21
>30			d	d		0.236[c]	1.27		0.483[b]	1.62		-.150	0.86
Interaction													
Antenatal care - institutional delivery			----	----		-.365[b]	0.69		-.376[c]	0.68		-----	----
Birth order 1 -institutional delivery			----	----		-.283[b]	0.75		-.539[b]	0.58		-----	----
Antenatal care - home delivery but assisted by a health professional			----	----		0.598[b]	1.82		0.406	1.50		-----	----
Literate up to middle school - institutional delivery			----	----		-.36g[b]	0.69		-.024	0.98		-----	----
Highly educated 10-yeam - institutional delivery			----	----		-.710[b]	0.49		-.893[c]	0.41		-----	----
Central zone - institutional delivery			----	----		0.346[b]	1.41		0.060	1.06		-----	----
Northem Zone - institutional delivery			----	----		0.445[b]	1.56		0.428	1.53		-----	----
Constant		-2.79	-2.65		-3.04	-3.44		-3.690	-4.074		-3.415	-3.358	

a Total number of samples
b p< .0l
c p< .05
d not included in the model

the early phase of infancy (neonatal and postnatal periods). Thus, unless genetic impacts are operative in the very early phase of conception, consanguinity seems to have as such no adverse effect on offspring mortality.

Hence, the findings of this study are likely to attract serious attention from policy makers in Government, and social and religious institutes. The question that arises in the current scenario is how to deal with the long-standing cultural practices of consanguinity, which may have detrimental impacts on the health of children. Banning of marriage among biological relatives by law is not the ultimate solution. Before enacting a ban, great care must be taken to be sure that society understands the issue and voluntarily agrees to avoid any marriage among biological relatives. To ensure this, a comprehensive and mutually consistent IEC (information, education and communication) programme is needed on these matters along with other important issues associated with reproductive health and sexually transmitted infections. Such a programme certainly should have enough strength to dilute the cultural taboos linked with these social practices.

Endnotes

1. Human beings are all remotely related. The population of the world is not large enough to provide ancestors for each of our 2^n bearers of chromosomes, where "n" is the number of generations. Thus, some persons served as ancestors through more than one line of decent. Such remote consanguinity is of little genetic interest.

2. An allele is one of two genes, found on a chromosome, that causes specific characteristics, such as eye colour.

3. Individuals who carry two genes of the same type, such as AA or A'A' are said to be homozygotes, meaning that as zygotes they were formed by the union of "same" gametes. Otherwise, individuals who carry a pair of different genes such a AA' are called heterozygotes.

4. Gene frequency in a population which can be traced back to one of the founders is regarded as the "founder effect"

5. Genetic drift is the random fluctuation of gene frequencies in a population of finite size.

6. For any given gene frequency, marriage among close relatives produces a specific additional chance of having offspring homozygous for a rare recessive allele in comparison to random matings. For example, at gene frequency q= 0.01 cousin marriage contributes recessive genes at a frequency over seven times higher than that of a random marriage. The lower the value of "q", the higher is the risk from consanguinity (see Whittinghill, 1965: 125).

7. Birth of a dead child, who did not show any signs of life by crying, breathing or moving, is considered a stillbirth. The relevant index was calculated as the proportion of eligible women ever having a stillbirth.

8. The neonatal index is the proportion of babies who died in the first month of life; it was calculated from the records of birth history (for the four-year period preceding the Survey) considering all births aged 30 days and above as the denominator.

9. The post-neonatal index is the proportion of babies who died within l-11 months of life; it was calculated from the records of birth history (for the four-year period preceding the Survey) considering all births aged 12 months and above as the denominator.

10. The child mortality index is the proportion of babies who died between their first and fifth birthday; it was calculated from the records of birth history, considering all births aged five years and above as the denominator.

11. In order to understand the socio-economic status of the household, a standard of living index was estimated on the basis of possession of the following variables: (a) separate room for cooking, (b) type of house, (c) source of lighting, (d) fuel for cooking, (e) source of drinking water, (f) type of toilet facility, (g) ownership of livestock, (h) ownership of goods such as sewing machine, sofa, fan, radio, bicycle, clock, watch, refrigerator, television, video tape recorder, mortor cycle and car.

12. In model I, the dependent variable is whether or not a woman had a stillbirth at any time in her reproductive life. The analysis is based on each individual woman's file. The unit of analysis in the remaining three models are births occurring to women in different periods prior to the Survey. The dependent variables in these models are whether a child who had been born died during the neonatal, post-neonatal and childhood (l-4 years) periods respectively. For model II, all births occurring during 1 to 47 months are considered. Model III considers all births occurring during 12-47 months prior to the Survey and the last model takes into account births occurring beyond five years prior to the Survey. The information on antenatal and natal care services are available only for births during the previous four years. Because they are important determinants of neonatal and post-neonatal mortality, the analyses of model II and III are restricted to births during the period four years before the Survey.

13. Around 55 per cent of close consanguineous mothers are estimated tohave received antenatal care services compared with 44 per cent in the case of non-consanguineous mothers.

References

Ahmed, A.H. (1979). "Consanguinity schizophrenia in Sudan", ***British Journal of Psychiatry.*** 134:635-636.

Al-Awadi, S.A., K.K. Naguib, M.A. Moussa, T.I. Farag, AS. Teebi and M.Y. FI-Khalifa (1986). "The effect of consanguineous marriages on reproductive wastage", ***Clinical Genetics,*** 29:384-388.

Ansari, N.A. and S.P. Sinha (1978). "Survey on the effects of inbreeding in two populations of Bihar", ***Indian Journal of Medical Research***, *68:295-299.*

Armstrong, *K.* (1991). ***Muhammad: A Western Attempt to Understand Islam*** (London, Gollancz).

Arora, M.P. and G.S. Sandhu (1989). *Genetics,* (Bombay, Himalaya Publishing House), pp 408-419.

Azevedo, E.S., N. Freire-maia, C.C. Azevedo Maria, T.A.Weimer and M.M. Souza Monica (1980). "Inbreeding in a Brazilian general hospital", ***Annals of Human Genetics***, *43:255-264.*

Banerjee, Sushanta K. and T.K. Roy (1996). "Incidence of consanguineous marriage in India and its impact on child health and reproductive complication", paper presented at 19th Congress of the Indian Association for the Study of Population, Baroda, India, 25-27 February.

__________ (1997). "Newborn care for the Indian mother: evidences from National Family Health Survey", ***The Newborn,*** *3:9-14.*

Behm, H. (1991). "An analytical framework", in ***Child Mortality in Developing Countries: Socio-economic Differentials, Trends and Implications*** (New York, United Nations Department of International Economic and Social Affairs).

Bemiss, S.M. (1858). "Report on influence of marriages of consanguinity upon offspring", ***Transition of the American Association,*** 11:319-425.

Bhasin, M.K. and S. Nag (1994). "Incidence of consanguinity and its effects on fertility", in Venna Bhasin (ed.), ***People, Health and Disease: The Indian Scenario,*** (Delhi, Kamla-Raj Enterprises).

Bittles, A.H. (1994). "The role and significance of consanguinity as a demographic variable", ***Population and Development Review,*** *20 (3):* 561 -584.

__________ A.R.R. Devi, H.S. Savithri, S. Rajeshwari and N.A. Rao (1985). "Inbreeding and postnatal mortality in South India: effects on the gene pool", ***Journal of Genetics***,64:135-142.

Bittles, A.H., A.R.R. Devi, H.S. Savithri, R. Sridhar and N.A. Rao (1987). "Consanguineous marriage and postnatal mortality in Kamataka, South India", *Man, 221736-745.*

Bittles, A.H. and J.V. Neel (1994). "The costs of human inbreeding and their implications for variations at the DNA level", ***Nature Genetics***, *8: 118.*

Book, J.A. (1957). "Genetic investigations in a north Swedish population : the offspring of first-cousin marriages", ***Annals of Human Genetics***, 21:191-223.

Bundey, S. and H. Alam (1993). "A five-year prospective study of the health of children in different ethnic groups, with particular reference to the effect of inbreeding", ***European Journal of Human Genetics,*** *11206-2 19.*

Cavall i-Sforza, L.L. and W.F. Bodmer (1971). The ***Genetics of Human Populations*** (San Francisco, California, W.H. Freedman and Company).

Centerwall, W.R. and S.A. Centerwall (1966). "Consanguinity and congenital anomalies in South India: a pilot study", ***Indian Journal of Medical Research***, *54:* 1160-l 167.

Centerwall, W.R., G. Savarinathan, L.R. Mohan, V. Booshanam and M. Zachariah (1969). "Inbreeding pattern in rural South India", *Social Biology,* 16:8 1-91.

CBHI (Central Bureau of Health Intelligence) (1991). ***Health Information of India-1991***, *(New* Delhi, Ministry of Health and Family Welfare).

DaVanzo, J. (1984). "A household survey of child mortality determinants in Malaysia", ***Population and Development Review*** , 10 (supplement):307-322.

Dronamarju, K.R. and M.P. Khan (1960). "Inbreeding in Andhra Pradesh", ***Journal of Heredity***, 51:239-242.

Farah, A.A. and S.H. Preston (1982). “Child mortality differentials in Sudan”, ***Population and Development Review*** *, 8:365-383.*

Ginter, E.K., R.F. Garkavtzeva and A.A. Revazov (1980). “Population structure and hereditary diseases in Uzbekistan”, in A.W. Eriksson, A.R. Forsius, H.R. Nevalinna, P.L. Workman and R.K. Norio (eds.), ***Population Structure and Genetics Disorders*** *(New* York, Academic Press).

Hobcraft, J . , J. McDonald and S. Rutstein (1983). “Child-spacing effects on infant and early child mortality*“,* ***Population Index*** *, 49(4):585-618*

Hussein, F.H. (1971). “Endogamy in Egyptian Nubia”, ***Journal of Biosocial Science,*** *3:25 l-257.*

IIPS (International Institute for Population Sciences) (1995). ***National Family Health Survey (MCH and Family Planning), India,*** *1992-93,* (Bombay, IIPS).

Kapadia, KM. *(1958).* ***Marriage and Family in India*** (Calcutta, Oxford University Press).

Maian, A. and R. Mushtaq (1994). “Consanguinity in population of Quetta (Pakistan): a preliminary study”, ***Journal of Human Ecology*** *5*:49-53.

Mosley, W.H. and L.C. Chen (1984). “An analytical framework for the study of child survival in developing countries”, ***Population and Development Review*** , 10 (supplement):25-45.

Neel, J.V. and W.J. Schull (1962). “The effect of inbreeding on mortality and morbidity in two Japanese cities”, ***American Journal of Human Genetics*** *, 481573-582.*

Naderi, S. (1979). “Congenital abnormalities in newborns of consanguineous and non-consanguineous parents”, ***Obstetric Gynaecology*** *, 53: 195-I 99.*

Ottenheimer, M. (1990). “Lewis Henry Morgan and the prohibition of cousin marriage in the United *States”,* ***Journal of Family History****, 15:325-334.*

Padmadas, S. S. P. and Sadasivan Nair (2001). “Consanguineous union and its effect on foetal and infant loss in India”, ***Genus*** , 83-105.

Ramkumar, L. and S.C. Sood (1961). “TaySachs disease”, ***Indian Journal of Child Health*** *,* 10:303.

Rao, P.S.S. and S.G. Inbaraj (1977). “Inbreeding in Tamil Nadu, South India”, ***Social Biology,*** 24:28 l-288.

Richard, J. and P.S.S. Sundar Rao (1994). “Changes in consanguinity and age at marriage”, ***Demography India*** *, 23115-28.*

Roy, T.K., V. Jayachandran and Sushanta K. Banerjee (1999) “Economic condition and fertility: is there a relationship" *?,* ***Economic and Political Weekly*** *, 34(42-43).*

Saheb, S.Y., S.M. Sirajuddin, C.M. Raju, D.B. Sastri and R.K. Gulati (1981). “Consanguinity and its effect on fertility and mortality in Kodava populations of Kodagu district: Kamataka”, ***Indian Anthropologist*** , 11:101 123.

Stern, c. (1949). ***Principles of Human Genetics*** (San Francisco, California, W.H. Freedman and Company).

Stevenson, A.C. and H.A. Wamock, (1959). "Observations on the results of pregnancies in women resident in Belfast: data relating to all pregnancies ending in 1957", ***Annals of Human Genetics****, 23 :382-394.*

Sutton, H.E. (1965). ***An Introduction to Human Genetics*** (New York, Holt, Rinehart and Winston).

United Nations (1962). ***Report of the United Nations Scientific Committee on the Effects of Atomic Radiation,*** *(17th* session, supplement No. 16) (New York, United Nations).

Whittinghill, M. (1965). ***Human Genetics and its Foundations*** ,(Calcutta, Oxford & IBH Publishing Co.).