

REVIEW

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Study of the impact of consanguinity on abortion and mortality in the population of Beni Abbes (southwestern Algeria)

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Abstract

Background: Despite the numerous studies confirming the involvement of consanguinity in health problems, some populations around the world continue to practice this marital behavior. Algeria, like many Arab-Muslim countries, has very high consanguinity rates that require studies to measure the effects on public health. This study aims to estimate the frequency of consanguinity and to analyze its effects on two health indicators, namely abortion, neonatal, and postnatal mortality, and it focused on the population of Beni Abbes in southwestern Algeria previously known to be a genetic isolate.

Results: The results of the study revealed a high consanguinity rate of 55.06% with a clear preference of first cousin marriages. A highly significant correlation was highlighted between inbreeding and the incidence of abortion as well as post and neonatal mortality.

Conclusion: These results are an encouraging indicator for further future genetic studies on this population, especially since this locality is likely to remain a genetic isolate. In order to reduce the adverse health effects of consanguinity, it is essential to establish genetic counseling services in health facilities and to promote the dissemination of information on risks arising from consanguineous marriages through health education for populations.

Keywords: Abortion, Beni Abbes (Algeria), Consanguineous marriage, Mortality, Population

Background

Marriage is the basic institution that decides most gene redistributions among individuals over generations, so we can closely monitor the fate of the population's genetic heritage [1].

Inbreeding is a special case of matrimonial relationships between spouses, defined as the phenomenon that results from the union between blood-related individuals, having at least one common ancestor.

Geneticists classify consanguineous marriage according to the coefficient of consanguinity, defined by the probability that a consanguineous individual has at a given locus, two identical alleles [2].

Inbreeding marriages have been practiced since the existence of man. The frequency of consanguineous unions depends on the size of the population, its degree of isolation, and it is influenced by socio-economic and cultural practices [3]. Currently, about 20% of the world's populations live in consanguineous communities [4].

In Algeria, consanguineous marriages have been celebrated since ancient times in all regions and all social strata; they appear as a current, preferential, and normative social practice where the marriage between first cousins is the most frequent type [5].

One of the major consequences of such practices is the considerable reduction of inter- and intra-population genetic variability. As a result of inbreeding, the degree of homozygosity increases both at the level of individuals and at the level of populations, a fact that will have an impact on an increase in the rate of abnormalities by fixation of deleterious genes [6].

The consequences of consanguineous marriage, particularly on fertility, mortality, and morbidity, have since a

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long time been of a great interest to doctors and geneticists. That has led to an abundance of publications since the end of the 20th century [4, 7–13].

Similarly, studies conducted to investigate the effects of consanguinity on Algerian populations' public health [14–17] have also emphasized the importance of consanguinity, which remains a social phenomenon and a privileged marriage practice justified by financial and emotional security.

The present study is a continuation of studies conducted in Algeria where consanguineous marriages are a common practice. It is devoted to the population of Beni Abbes in southwestern Algeria (Fig. 1)

We aim to describe at best the perception of consanguineous marriages, to determine the frequency of consanguinity and to estimate its effects on health through two indicators (abortion, neonatal, and postnatal mortality).

Methods

For the realization of our investigation, we conducted for a period of about 2 years (09 spaced stays) a prospective survey in a hospital (Beni Abbes PHEP) which

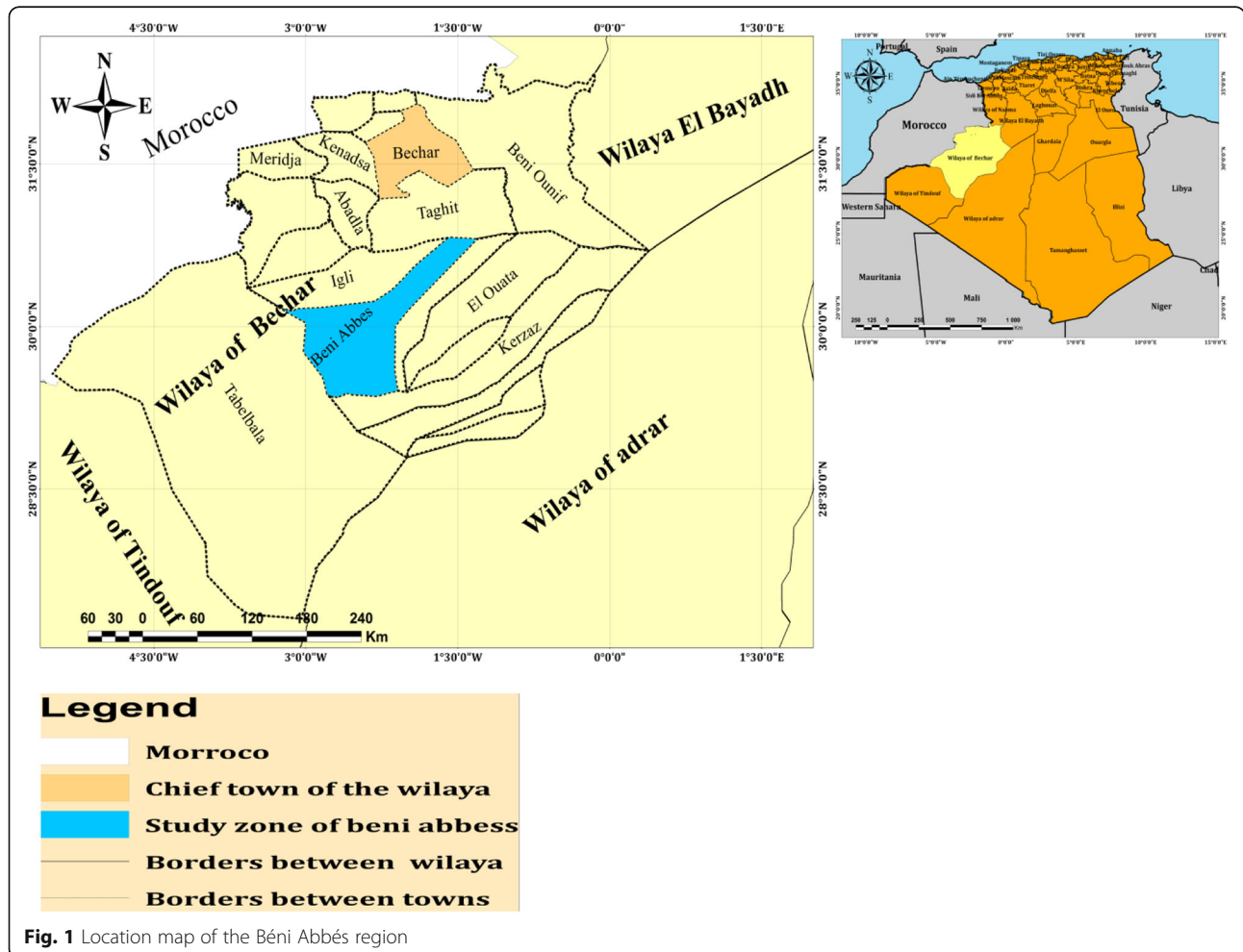
involved 267 people living in couples that originated from the region for at least three generations.

The interviewees were randomly selected (we did not know if they had a consanguineous relationship or not) among the women hospitalized in the department of maternity and failing that, we interviewed their husband. They were invited to fill out a questionnaire preestablished by our environment and health team of the laboratory for the promotion of human action for the protection of the environment and its application in public health at Abu Baker Belkaid University of Tlemcen, from which a number of health, socio-demographic, and cultural data were collected.

Everyone included in this study is informed and has given us written consent in accordance with Executive Decree No. 92-276 of 6 July 1992 on the Algerian Code of Medical Ethics [18].

Data processing

To analyze the fertility of couples and the mortality of their offspring in our population, we calculated abortion and mortality rates. In addition, we estimated for these



parameters the relative risk and attributable risk (Epidemiology: Principles and Quantitative Methods) [19].

Relative risk

Relative risk (RR) is determined by the ratio of the probability of death among children from consanguineous marriages (Rc) and the probability of death among children from non-consanguineous marriages (Rnc): $RR = Rc/Rnc$.

A relative risk greater than 1 means that the risk of mortality among children from consanguineous marriages is higher compared to that of children from non-consanguineous marriages. If the RR is 1, the offspring of consanguineous marriages is not considered to be more risky than that of non-consanguineous marriages. However, if the RR is included between 0 and 1, the risk of mortality among children from consanguineous marriages is lower than that of children from non-consanguineous marriages.

Attributable risk

Attributable risk (AR) is the portion of the risk that can be directly related to the factor under study. In our case, this is indeed the “consanguinity” factor. Proportional attributable risk of the population (RAPP) is a risk that takes into account the frequency of inbreeding (Pc) in the population and is calculated according to the formula: $RAPP = Pc (RR - 1) / 1 + Pc (RR - 1)$.

A high mortality rate associated with consanguinity can be expressed as the attributable risk for the population as a whole or for a particular category of consanguineous marriages.

To process our data, we also used the chi-two test χ^2 independence realized by the software SPSS: Statistic base, version 22.0.

Result

Frequency of consanguinity among the population of Beni Abbes

The analysis of the questionnaires completed by the 267 people interviewed revealed a 55.06% incidence of consanguineous marriages (Table 1). It represents more than half (1/2) of the unions among our population.

Table 1 Distribution of consanguinity in the population of Beni Abbes

Couples		Numbers and percentages
Consanguineous couples	1st cousin	99 (67.35%)
	2nd cousin	147 (55.06%)
Non-consanguineous couples		48 (32.68%)
		120 (44.94%)
Total couples		267 (100%)

Intergenerational variation of consanguineous marriages among the population of Beni Abbes

In order to verify the evolution in the matrimonial behavior from one generation to the next (grandparents, parents, and children), intergenerational comparisons of inbreeding among the population of Beni Abbes were established based on the data collected from the questionnaires informed by the 267 individuals interviewed in this survey. Table 2 presents the frequency distribution of inbreeding (first-degree consanguine and second-degree consanguine) over the three generations. A high frequency of 55.06% was recorded in the generation of couples studied against 53.93% in the generation of parents and 39.33% in the generation of grandparents (Table 2).

Inter-local variability in the frequency of consanguineous unions of the population of Beni Abbes compared to those of populations in geographically neighboring regions

The analysis of the spatial variation of consanguineous marriages in the region of Béchar shows that the consanguinity rates in the populations of Beni ounif, Beni Abbés, and Igli are very high 65.65%, 55.06%, and 49.28%. % respectively (Fig. 2).

Comparison of the frequency of consanguineous marriages of the population of Beni Abbés to those of the Arab-Muslim world

The inter-population comparison shows that the population of Beni Abbés has one of the highest frequencies of consanguinity in Arab-Muslim countries. It is lower than that of Kuwait 64.30% [22] and Jordan 63.7% [23], is equal to that of Oman 56.3% [24], is almost double that of Palestine 27.70% [25], and is three times that of Morocco 19.90% [26].

Biological effects of consanguineous unions on abortion and mortality

In order to evaluate the biological effects of consanguineous marriages on the offspring of the inbred population of Beni Abbés, we used direct health

Table 2 Frequency distribution of consanguinity over three generations

Generation	Type of wedding		Total	Non-consanguineous
	Consanguineous			
	1st cousin	2nd cousin		
Couples	67.35%	32.65%	55.06%	44.94%
Parents	52.08%	47.92%	53.93%	46.07%
Grandparents	62.85%	37.15%	39.33%	60.67%

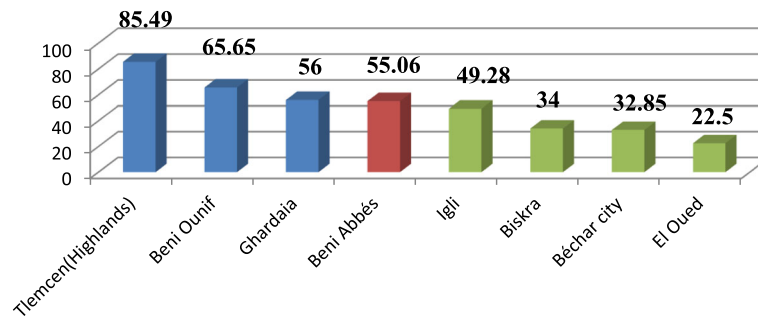


Fig. 2 Frequency of consanguinity in the population of Beni Abbès compared to those of other populations in Algeria. Green indicates rates lower than our value, red indicates our value, and blue indicates rates higher than our value

indicators that are related to obstetrics (fertility of women, abortion, and mortality).

Effects of consanguinity on abortion

The analysis of the results in Table 3 clearly shows the harmful effect of consanguinity on abortion in Ben Abbès’ population. The abortion rate is significantly higher among consanguineous couples compared to non-consanguineous couples, accounting for almost 2/3 of the entire number of registered abortions. First cousin marriages had more cases of abortions than second cousin marriages ones, both for the early and late types. Moreover, the repeatability of abortions (more than one case of abortion in the same couple) was recorded exclusively in consanguineous couples with a clear predominance in the first cousin marriages.

Influence of consanguinity on mortality

In our population, the relative risk and the attributable risk that takes into account the consanguinity rate are respectively 1.55 and 0.23. The analysis of the results in Table 4 shows a clear correlation between inbreeding and the mortality rate of the offspring in our population. This correlation is even more significant among first cousin marriages.

Discussion

Frequency of consanguinity among the population of Beni Abbès

The high level of consanguinity detected (55.06%) could be explained by the fact that individuals opt for consanguineous marriage as a tradition. The social structure of the Beni Abbès region ensures that families are in many cases very united by socio-economic factors that force members of these families to live in close proximity.

This frequency is significantly higher than the Algerian average of 38.8% [16]. With regard to the distribution by type of kinship in the population (first cousins marriages and second cousins marriages), a clear preference for 1st cousin marriages (37.08%) is found among the studied couples. This result is in perfect agreement with those recorded in the populations of Tlemcen Mountains and Highlands [15]. However, it does not agree with the results recorded in the populations of Sabra, where there has been a clear preference for 2nd cousin marriages [17].

In his study on consanguineous marriages in Beirut in 1986, Khalt M indicates that the type of first cousin marriages is most prevalent among Arab-Muslim populations and is a characteristic feature of this group [20].

Table 3 Effect of consanguinity on abortions

Marriage status	Consanguineous				Non-consanguineous	
Number of births/178	CC1, 102		CC2, 76		149	
Number of abortions (N and %)/23 (62.16)	CC1, 14 (37.84)		CC2, 9 (24.32)		14 (37.84)	
	Early	Late	Early	Late	Early	Late
	5 (13.51)	9 (24.32)	3 (08.11)	6 (16.22)	6 (16.22)	8 (21.62)
χ^2	0.24				0.24	
P	0.00				0.23	

Observed value = 3841

CC1 first-cousin marriage couples, CC2 second-cousin marriage couples, (N and %) number and percent

Table 4 Effect of consanguinity on mortality

Marriage status	Consanguineous		Non-consanguineous
	CC1, 102	CC2, 76	
Number of births/178			149
Number of deaths (N and %)/14(60.87)	9 (39.13)	5 (39.13)	9 (39.13)
χ^2	0.36		0.36
P	0.55		0.55

Observed value = 3841

Intergenerational variation of consanguineous marriages among the population of Beni Abbes

These results obtained testify the existence of continuity in the practice of marriages between relatives. The tendency to marry a first cousin is preferable both in the generation of the studied couples 67.35% than in the parents 52.08% and in grandparents 62.85%. The high rate of consanguinity across the three generations can be explained by the fact that Beni Abbés has always been a genetic isolate [21] and is likely to continue to be so.

Inter-local variability in the frequency of consanguineous unions of the population of Beni Abbes compared to those of populations in geographically neighboring regions

High consanguinity rates in the three populations of Beni ounif, Beni Abbés, and Igli which respectively 65.65%, 55.06%, and 49.28% can be explained by the fact that these three populations were already genetic isolates according to the 1989 study by Bachir and Abdulkader on the distribution of frequencies of blood groups and their genes on populations in southwestern Algeria [21].

The comparison of the inbreeding rate of the population of Beni Abbés with some populations of geographically neighboring regions (Fig. 2) shows that it is lower than the frequencies recorded in the highlands of the wilaya of Tlemcen [15], relatively close to those recorded in Ghardaïa [16], and it is well below the frequencies recorded in Biskra and El Oued [16].

Comparison of the frequency of consanguineous marriages of the population of Beni Abbés to those of the Arab-Muslim world

The high consanguinity rate recorded at the end of the study carried out on the population of Beni Abbés (56.06%) is one of the highest rates in the Arab Muslim world; it reinforces the results obtained by the survey conducted in 2007 in 11 wilayas (from different regions) by the National Foundation for Medical Research (FOREM) that consanguineous marriage is a widespread practice in Algeria and enriched the scientific literature in this field.

Biological effects of consanguineous unions on abortion and mortality

Effects of consanguinity on abortion

The correlation established between consanguinity and abortion in our population is consistent with those in Iraq [27] and Turkey [28], who reported twice as many abortions among first cousin consanguineous couples as in non-consanguineous couples.

On the other hand, our results do not agree with the results of studies realized in Pakistan that has shown lower rates of abortions in families where consanguinity is customary across successive generations, presumably because of the increasing effect homozygosity on fetal development [29].

Influence of consanguinity on mortality

The values of relative risk (1.55) and attributable risk (0.23) mean that the risk of mortality of children from consanguineous marriages is high compared to that of children from non-consanguineous marriages.

Our results are consistent with those Abbad et al. [13] and Moussouni et al. [17] which unambiguously confirm that prenatal and postnatal mortality rates and infant morbidity increase when couples are in consanguineous unions.

These results reinforce those achieved since 1984 [14], 2007 [16], and 2017 [17], particularly with regard to the negative effects of consanguinity on public health in Algeria, and alert the public authorities to the need to install genetic counseling in services to level of all health structures to reduce these effects.

Despite the results recorded, difficulties in particular social (it was very difficult to convince the subjects to join the survey) which explains the size of the sample compared to the relatively long time to realize the study.

Conclusion

Through the analysis of consanguinity and two health indicators namely abortion and mortality in the population of Beni Abbes (southwest Algeria), we were able to define the main characteristics explaining its socio-cultural and biological profiles. Thus, consanguineous marriages have been for several generations and continue to be so far, a common social preference in our population and despite the fact that the impact of such unions is

not very clear. They seem to offer couples and their families, and even society a lot of advantages in terms of the emotional and material security of spouses, more assurance on the stability of marriage, acceptance of parents in their beings and their assets, solidarity, and social cohesion.

The inbreeding rate of 56.06% revealed by the study conducted on this population remains one of the highest among the Arab-Muslim countries, including the national average of Algeria; nevertheless, it remains below some Arab frequencies and other excessively high frequencies within populations of geographically neighboring regions in Algeria.

These results also reveal the continuity in the practice of consanguineous marriages from one generation to the next, with always a preference of unions between cousins of the first degree.

A harmful impact of consanguinity on abortion and mortality among the population of Beni Abbes was highlighted through this study. This result is in perfect agreement with many studies in this field that confirm a highly significant relationship between consanguinity and some fitness parameters by promoting the expression of deleterious recessive genes under the effect of increasing homozygosity through successive consanguineous generations.

Despite these results, which clearly show, from a genetic point of view, the impact of consanguinity on abortion and mortality, other socio-economic, cultural, and environmental factors, particularly in development, could intervene in the determinism of these two phenomena.

These results are an encouraging indicator for further future genetic studies on this population, especially since this locality is likely to remain a genetic isolate.

In order to reduce the adverse health effects of consanguinity, it is essential to establish genetic counseling services in health facilities and to promote the dissemination of information on risks arising from consanguineous marriages through health education for populations.

Abbreviations

AR: Attributable risk; CC: Consanguineous couples; CC1: First-degree consanguineous couples; CC2: Second-degree consanguineous couples; Cousin1: Cousin of first-degree; Cousin2: Cousin of second-degree; FOREM: Foundation for Medical Research; NCC: Non-consanguineous couples; Pc: Proportion of Consanguinity; PHEP: Public Health Establishment of Proximity; Rc: Probability of death among children from consanguineous marriages; Rnc: Probability of death among children from non-consanguineous marriages; RPP: Proportional attributable risk of the population; RR: Relative risk; SPSS: Statistical Package for the Social Sciences; χ^2 : Chi-square test

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Authors' contributions

AA has a substantial contribution to the conception and design of the work and substantively revised manuscript, have approved the submitted version and all modified versions (to comply with the journal standards). BS has contributed to the conception and design of the work, acquisition, analysis, and interpretation of data; have drafted the manuscript; and have finalized the submitted version and all modified versions (to comply with the journal standards). Both authors read and approved the final manuscript.

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Availability of data and materials

The data collected during the survey through the questionnaire have been tabulated and are included in the manuscript. However, all the questionnaires containing all the individual information of the subjects interviewed are kept at the level of the laboratory indicated in the manuscript.

Ethics approval and consent to participate

Everyone included in this study is informed and has given us written consent in accordance with Executive Decree No. 92-276 of 06 July 1992 on the Algerian Code of Medical Ethics.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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