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Consanguinity in the Chaouia population (Morocco): prevalence, trends, determinants, fertility, and spontaneous abortions

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Abstract

Background: One of the aspects that helps to understand the genetic structure of a population throughout its biological history is the description of its matrimonial practices. Thus, the objective of this study is to explore consanguinity, one of these practices, to its full extent by identifying the prevalence, determinants, and trends of a consanguineous marriage, as well as its impact on fertility and spontaneous abortions in the Chaouia population, a region located in the western center of Morocco. Therefore, a survey-based cross-sectional study was conducted between January 2019 and January 2020. The sample was collected by province using a stratified random sampling approach, yielding a sample of 788 people. The association between consanguinity and socioeconomic and demographic characteristics, as well as reproductive health and pregnancy outcomes, was described using chi-square and ANOVA analysis. Multivariate logistic regression analysis was used to determine the predictors of a consanguineous marriage.

Results: Our findings revealed a consanguinity rate of 25.38%. The mean inbreeding coefficient was 0.012214. The most common type of union was between first cousins. This practice was strongly associated with an early age at marriage for both genders and with endogamy and immobility of couples, according to their place of birth. Consanguinity was significantly associated with fertility ($p < 0.001$) and spontaneous abortions ($p = 0.029$). The average number of pregnancies and spontaneous abortions was higher in consanguineous unions ($5.18 \pm 0.20/0.47 \pm 0.08$) compared to non-consanguineous unions ($4.33 \pm 0.10/0.31 \pm 0.03$).

Conclusions: Consanguinity is a deeply rooted social and cultural tradition in this population, providing individuals with a sense of social-economic stability while assuring their attachment to the group. Despite being highly associated with fertility, this practice has a significant influence on pregnancy outcomes, namely spontaneous abortions. Therefore, further studies are needed to examine the impact of consanguinity on various aspects of reproductive health and its association with numerous genetic abnormalities and diseases.

Keywords: Consanguinity, Trends, Determinants, Fertility, Spontaneous abortions, Chaouia, Morocco

Background

Marriages between males and females have traditionally been the primary institution through which procreation occurs, and genes are transmitted through generations [1]. To understand the micro-evolutionary processes affecting the genetic structure of a population during its biological history, it is necessary first to examine the nature of their matrimonial practices. Consanguinity;

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is one of these practices; a marriage or a reproductive relationship between two people who share one or more common ancestors, the proportion of genes shared by two people is determined by their degree of relatedness [2].

This practice is widespread in Arab countries, ranging from around 20–50% of all marriages [3]. These societies share a core set of traditions, cultural values, and beliefs, resulting in a social life and identity centered on the family, community, tribe, or group in general. As a result, endogamous and consanguineous marriages are quite common [4]. Nevertheless, the perpetuation of these behaviors has dreadful consequences on populations. It affects their genetic diversity by increasing the rate of homozygotes and thus raising the incidence of various genetic disorders and abnormalities [5]. It also has a massive impact on reproductive health and pregnancy outcomes [4, 6].

Indeed, consanguinity was addressed in various studies on different Moroccan populations [7–10]. However, fewer studies emphasized the consequences of consanguinity on the health status of populations [11, 12].

Thus, the objective of this study is to explore consanguinity to its full extent by identifying the prevalence, determinants, and trends of consanguineous marriage, for the first time in the Chaouia population; a region located in the western center of Morocco; as well as estimating its effects on reproductive behavior and pregnancy outcomes, namely fertility and spontaneous abortions.

Population and methods

From a historical perspective, Chaouia is a Moroccan region located between the plains of Zair in the Northeast and Dokkala in the West, Rehamna in the Southwest. Plains of Tadla and Beni Meskine in the southeast, and bordered by the Atlantic Ocean in the Northwest [13]. In terms of origins, the Chaouia people were described as an intimate mixture of heterogeneous Berber elements strongly arabized and crossed, with a small proportion of Hilalian Arab blood [14].

The term "Chaouia" is derived from the word "chat," which means "herd owners" or "pastoralists." This designation could be attributed to the fact that the Marinid Sultanate had their herds maintained by various Chaouia tribes at the end of the fourteenth century. Perhaps this tradition contributed to the term "Chaouia" gaining ethnic significance [13]. The Chaouia region was also known for its agricultural activities and is still considered the breadbasket of the country [15].

The administrative structure of this region changed mainly throughout the years. It adopted an independent tribal societal movement in the earlier centuries. During the French conquest, it was part of useful Morocco (a term applied during the French protectorate to certain Moroccan regions with the greatest resources and potential). Later, between 1971 and 1997, after independence, it was a part of the central region [16]. In 1997, it was part of Chaouia-Ourdigha. In 2015, according to the advanced regionalization division, Chaouia is now part of the region Casablanca-Settat [17].

Field survey

A survey-based cross-sectional study was conducted between January 2019 and January 2020.

Our studied population is divided into three provinces: Settat, Berrchid, and Benslimane, representing the current Chaouia territory (Fig. 1). For a more representative sample of the population, the sample collection was by province using a stratified random sampling approach. Individuals were asked directly in their homes, through one-on-one interviews and collective ones, to verify the information obtained and avoid, as far as possible, any omissions.

Following the provision of informed consent, participants were invited to give information about themselves and their partner's social and demographic characteristics, including the geographical origin (place of birth), the location of residence of the couple after marriage, urban/rural origin (birth environment), age at first marriage, literacy level, the field of work of the men, the degree of relatedness of the couple, and the first marriage contraction year. Information about the reproductive behavior of couples was also collected, including the number of pregnancies, live births, and spontaneous abortions.

We interviewed 1000 individuals. However, due to memory errors, some participants failed to provide important information required for our study, resulting in incomplete responses during interviews. Therefore, the final sample size was set at 788 for the current study (Table 1).

The inclusion/exclusion criteria

As the study describes a matrimonial practice, our main target population was ever-married individuals. Participants of both genders were included (530 women and 258 men). They were legally adults (18 years or older) and permanent residents of the study area. Indeed, single individuals who had never married and temporary household visitors were excluded from the study. All participants who provided incomplete answers were also excluded.

Data analysis

The coefficient of inbreeding for a child (individual) of a consanguineous marriage is the probability of inheriting

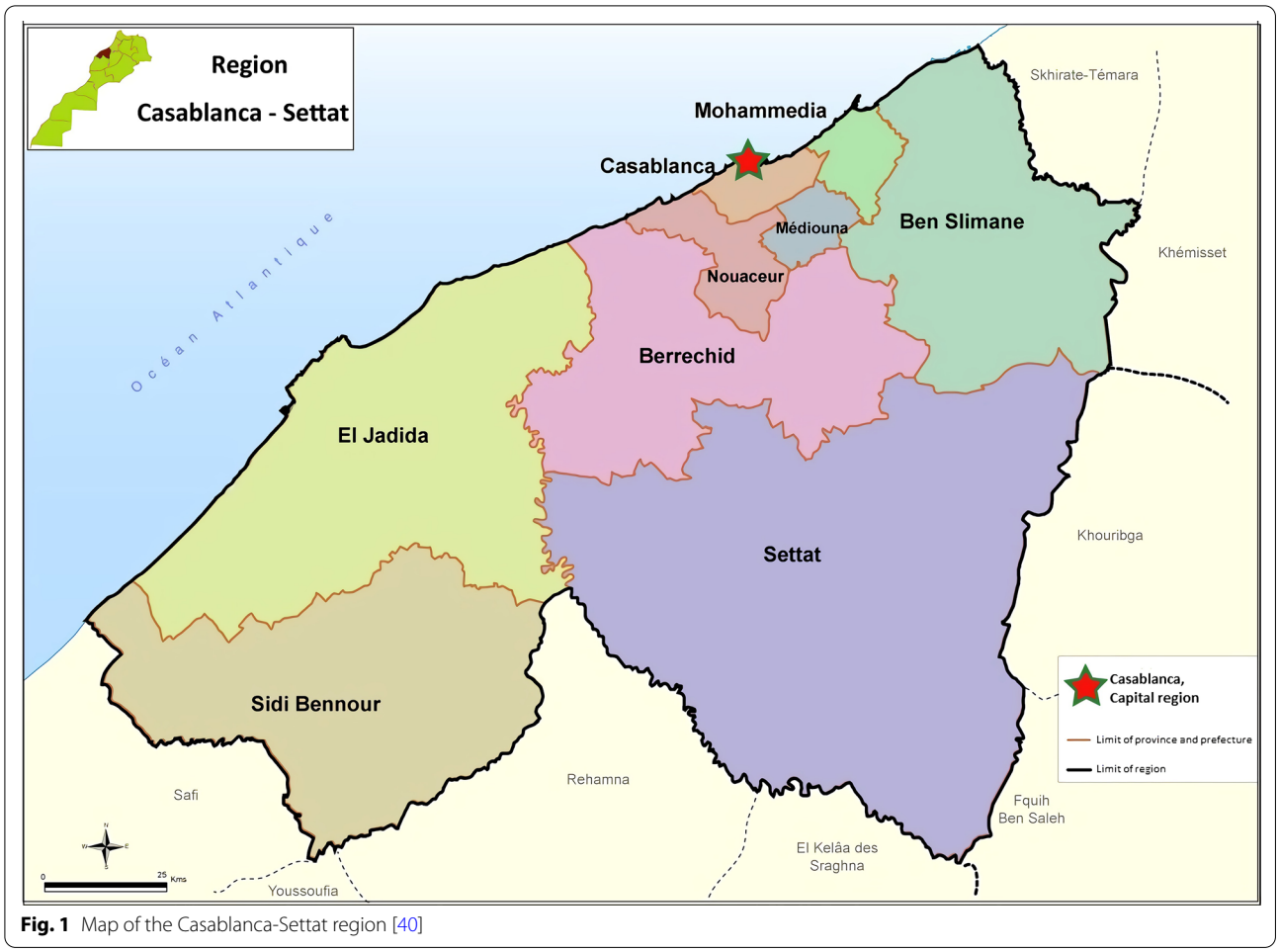

Fig. 1 Map of the Casablanca-Settat region [40]

Table 1 Sample distribution by provinces

Provinces	The population size [18]	The initial sample	The final sample	Excluded interviews
Settat	633,575	470	411	59
Berrrchid	484,019	358	259	99
Benslimane	232,645	172	118	54
Total	1,350,239	1000	788	212

two alleles at a locus from a common ancestor and are thus identical by descent [19].

The coefficient is calculated using the following equation [20]:

$$F_i = \sum_i \left(\frac{1}{2}\right)^{p+m+1} (1 + F_{Ai}) \quad (1)$$

p: Number of generations between the individual I and the common ancestor from the father's side A_i. m: Number of generations between the individual I and the common ancestor from the mother's side A_i. F_{Ai}: The Inbreeding Coefficient of the ancestor A_i.

Various levels of consanguinity were emphasized including: first cousins ($F=0.0625$), double first cousins ($F=0.125$), cousins once removed ($F=0.0313$), second cousins ($F=0.0156$) and distant cousins ($F<0.0156$).

At the population level the average inbreeding coefficient (α) was calculated according to the formula [21]:

$$\alpha = \sum_i f_i F_i$$

where f_i is the relative frequency of individuals with inbreeding coefficient F_i.

In clinical genetics, most marriages are considered consanguineous if the partners are second cousins or closer. The rates of homozygosity in marriages beyond the second cousin ($F<0.0156$) present minor differences from those observed in the general population, which may underestimate the actual level of homozygosity [22].

Thus, distant cousins were excluded from the average inbreeding coefficient.

Couples were divided into marriage cohorts based on the year of their first marriage to describe the evolution of consanguineous marriages over time. These periods were chosen based on some key events that occurred in Morocco's overall territorial development through the years and could have influenced the social behavior of the population.

The association between socioeconomic and demographic characteristics and consanguinity was tested using the chi-square test of independence for categorical data and ANOVA (analysis of variance) for continuous level data. The relationship between consanguinity and the average number of pregnancies, live births, and spontaneous abortions was examined using ANOVA.

Multivariate logistic regression analysis was performed to identify the socioeconomic and demographic characteristics that are predictors or in other words determinants of a consanguineous marriage. The odds ratios were calculated with a 95% confidence interval.

The significance level was set at $p < 0.05$.

Results

The prevalence of consanguinity in the Chaouia population represented 25.38% of all marriages. The most common type of union in our studied population was between first cousins, accounting for 11.55%, a result similar to most studies in Arab countries [6]. The average inbreeding coefficient was 0.012214 (Table 2).

Factors and determinants of consanguineous marriages

Table 3 showcases the socioeconomic and demographic characteristics associated with consanguineous marriages. For women, the age at first marriage was significantly ($p = 0.001$) correlated with consanguinity. Marriages were more prevalent among women married under the age of 15 and between the ages of 15 and 20, accounting for 34% and 27.4% of marriages, respectively. The average age at marriage in consanguineous unions was 17.96 years old, while it was 19.45 years for non-consanguineous marriages ($p < 0.001$) (Table 3). Similarly, in a consanguineous marriage, men tend to marry younger, with 47.9% married between 15 and 20 years old ($p < 0.001$). The average age at first marriage in consanguineous unions was 25.34 years, while it was 26.89 years old ($p < 0.001$) for non-consanguineous unions.

Women born in rural areas had a significantly ($p = 0.005$) higher rate of consanguineous unions (26.7%) than those born in urban areas (11.4%). As for men, the relation between consanguinity and rural or urban birthplace wasn't statistically significant.

The literacy level wasn't statistically associated with consanguinity for either gender. Our population was predominantly illiterate or just contented with basic education. Indeed men tend to have more opportunities in terms of education, but because they work primarily in agriculture, it is more crucial for them to work on their land and preserve it for future generations [23]. For women, education was more likely a qualification that raises the bar when selected for marriage. Men's field of work didn't either have a significant correlation with consanguinity. It attests, however, to the predominance of agricultural activities.

Consanguinity was more prevalent between couples with the same place of birth and residence after marriage (39.2%). It appears that Endogamy and immobility of couples, according to their place of birth, are significantly associated with consanguinity ($p < 0.001$).

The trend of consanguineous marriages in this population was examined through marriage cohorts based on the year of first marriage. According to our findings, the prevalence of consanguinity decreased significantly over time, from 33.08% before 1976 to 17.2% between 2006 and 2020.

Table 2 Distribution of marriages according to the level of consanguinity in the Chaouia population

Level of consanguinity	*N*	%	Inbreeding coefficient of an individual	Average inbreeding coefficient
First cousins	91	11.55	0.0625	0.007218
Double first cousins	18	2.28	0.125	0.002855
Cousins once removed	41	5.20	0.0313	0.001626
Second cousins	26	3.30	0.0156	0.000516
Distant cousins	24	3.05	< 0.0156	–
Consanguineous unions	200	25.38	–	–
Non-Consanguineous unions	588	74.62	0	0
Total	788			0.012214

Table 3 The relationship between consanguinity and socioeconomic and demographic characteristics in both genders

Characteristics	Consanguineous	Non- consanguineous	*N*	*p* value
Women				
Age at first marriage				$p=0.001$
< 15	34.0	66.0	106	
15–20	27.6	72.4	463	
21–26	18.8	81.3	160	
27 +	10.2	89.8	59	
Mean age at first marriage (mean ± standard error)	17.96 ± 0.26	19.45 ± 0.18		$p<0.001$
Urban/rural origin				$p=0.005$
Rural	26.7	73.3	718	
Urban	11.4	88.6	70	
Literacy level				$p=0.103$
Illiterate	27.0	73.0	607	
Primary	17.9	82.1	123	
Secondary+	24.1	75.9	58	
Men				
Age at first marriage				$p<0.001$
< 15	–	–	–	
15–20	47.9	52.1	73	
21–26	24.1	75.9	419	
27 +	21.6	78.4	296	
Mean age at first marriage (mean ± standard error)	25.34 ± 0.32	26.89 ± 0.19		$p<0.001$
Urban/rural origin				$p=0.199$
Rural	25.9	74.1	742	
Urban	17.4	82.6	46	
Literacy level				$p=0.582$
Illiterate	25.6	74.4	542	
Primary	26.9	73.1	156	
Secondary+	21.1	78.9	90	
Field of work				$p=0.216$
Agriculture	24.5	75.5	714	
Services	42.9	57.1	21	
Commerce	28.6	71.4	35	
Industrial	33.3	66.7	18	
Couples with the same place of birth and residence after marriage				$p<0.001$
Yes	39.2	60.8	344	
No	14.6	85.4	444	
Marriage cohort				$p=0.003$
< 1976	33.1	66.9	136	
1976–1990	29.8	70.2	215	
1991–2005	24.3	75.7	222	
2006–2020	17.2	82.8	215	

Table 4 presents the results of the logistic regression analysis used to predict the determinants of a consanguineous marriage. According to our findings, women under the age of 15 (2.740) and between 15 and 20 years old (2.815) had a significantly higher likelihood of being involved in a consanguineous marriage than women married older. Men married between 15 and 20 years old were 2.177 times more likely to meet their spouse within the family. It appears that the age at first marriage is a major determinant of consanguineous marriage for both genders. When the effects of other factors were considered, neither the birth origin, the literacy

Table 4 Determinants of consanguineous marriage for both genders in the Chaouia population based on Multivariate logistic regression analysis

Characteristics	Coefficient B	*p* value	Odds ratio
Women			
Age at first marriage			
< 15	1.008	0.048	2.740
15–20	1.035	0.026	2.815
21–26	0.726	0.139	2.068
27 + (reference)			1.000
Urban/rural origin			
Rural	0.660	0.122	1.936
Urban (reference)			1.000
Literacy level			
Illiterate	-0.579	0.151	0.561
Primary	-0.761	0.071	0.467
Secondary + (reference)			1.000
Men			
Age at first marriage			
15–20	0.778	0.010	2.177
21–26	-0.073	0.712	0.929
27 + (reference)			1.000
Urban/rural origin			
Rural	0.018	0.967	1.018
Urban (reference)			1.000
Literacy level			
Illiterate	0.006	0.986	1.006
Primary	0.261	0.452	1.298
Secondary + (reference)			1.000
Couples with the same place of birth and residence after marriage			
Yes	1.191	0.000	3.291
No (reference)			1.000
Marriage cohort			
< 1976	0.539	0.094	1.714
1976–1990	0.456	0.111	1.577
1991–2005	0.366	0.186	1.442
2006–2020 (reference)			1.000

level, nor marriage cohorts showed a significant association with consanguinity. Couples with the same place of birth and residence after marriage were 3.291 times more likely to be involved in a consanguineous type of union.

Fertility and Spontaneous Abortions

According to our findings, consanguinity and fertility were strongly associated, as the average number of pregnancies was significantly ($p < 0.001$) higher (Table 5). In consanguineous marriages, women in our population tend to marry at a younger age. Thus, their reproductive period extends, as does their family size. The same reasoning could be adopted to explain, the high average number of live births in consanguineous unions ($p = 0.002$). Meanwhile, despite having higher averages of pregnancies and live births in consanguineous marriages, the average number of spontaneous abortions was significantly higher ($p = 0.029$).

Discussion

The evolution of consanguinity revealed a decreasing trend over time. This could be attributed to the overall territorial development of Morocco. Through the years, Morocco's state system underwent numerous changes. Before 1976, Morocco was recovering after its independence in 1956. In an attempt to redress territorial imbalances inherited from the French protectorate, in 1971, the country opted for a regional system of 7 regions to develop the country's economic status [16]. Between 1976 and 1990, the 1971 system proved ineffective when confronted with an increase in the price of petrol between 1973 and 1979, followed by a drought between 1979 and 1986, resulting in a financial deficit [24].

Since 1990 and most notably during the mid-1990, Morocco has experienced various changes [16]. It began by establishing a new regional division in 1997 to achieve financial self-sufficiency for each region accompanied by an acceleration of urbanization across the country. However, this reform was harshly criticized since it showed an unequal distribution of the population in terms of density, development, and resources, which varies significantly from one region to another. In 2011, *"La commission consultative de la régionalisation"* proposed a territorial reform, launching the constitutional establishment of the advanced regionalization, a system officially adopted in 2015 [17].

Table 5 The average number of pregnancies, live births, and spontaneous abortions in consanguineous and non-consanguineous unions

Parameters	Consanguineous	Non-consanguineous	*p* value
Pregnancies (mean ± standard error)	5.18 ± 0.20	4.33 ± 0.10	$p < 0.001$
Live births (mean ± standard error)	4.57 ± 0.17	3.94 ± 0.09	0.002
Spontaneous abortions (mean ± standard error)	0.47 ± 0.08	0.31 ± 0.03	0.029

Indeed, This gradual shift from a centralized state to a decentralized state system resulted in the dismantling of boundaries between regions, rural and urban areas, thus potentially creating attendant changes in social practices and relationships [16, 17]. These transitions could explain the decrease in the prevalence of consanguinity in our population through the years.

In general, the prevalence of consanguineous unions varies both within and among countries. In Morocco, the prevalence of consanguinity ranges between 19.64% and 38.9% (Table 6). The highest rate was recorded in the Tiflet area (38.9%), a region characterized by a rural aspect [8].

The rates were also remarkably high in mountainous regions, including the Population of Fritissa (30.32%) and the population of High Atlas of Morocco (28%). This could be explained by the nature of the environment in these regions since the higher the altitude, the less socialization, thus higher consanguinity rates.

The population of Chaouia and the population of Doukkala had similar rates, at 25.38% and 26.03%, respectively. These two regions are geographically and administratively close to each other, as they are both parts of the Casablanca-Settat region [18]. These regions had lower rates than the Tiflet region, despite their rural aspect. Their proximity to a major urban center (Casablanca) may have influenced their behavior. Meanwhile, consanguinity rates tend to decrease in more urbanized regions, accounting for 24.37% in Northern Morocco, 20% in the Rabat-Salé-Zemmour-Zear region, and 19.64% in the Agadir region.

Compared to other countries, in North Africa, consanguinity rates get even higher, ranging from 17.7% to 59.9% in Egypt [29] and reaching up to 55.06% in Algeria [30]. The prevalence of consanguineous marriages is relatively higher in the Middle East and South Asia, ranging from 45.7% to 61% in Oman [31] and more than 73% in Pakistan [32]. Meanwhile, lower rates could be detected in countries like Turkey [33], ranging from 6.4% to 44.8%, or in Siri Lanka [34] between 3.8% and 22.4%.

Table 6 The prevalence of consanguineous marriages in various regions of Morocco

Regions of Morrocco	Consanguinity (%)	Mean inbreeding coefficient	Source
Doukkala	26.03	0.0166	[7]
Oriental	29.58	0.0138	[25]
Northern Morocco	24.37	0.0080	[10]
Tiflet	38.90	0.0564	[8]
Rabat-Salé-Zemmour-Zear	20.00	–	[26]
Middle Atlas of Morocco (Population of Fritissa)	30.32	0.0399	[9]
Agadir region (Souss massa)	19.64	0.0119	[27]
High Atlas of Morocco (valleys of Anougal and Azgour)	28.00	0.0114	[12]
Gharb-Chrada-Beni Hssen	19.81	0.0075	[28]

In our population, early age at first marriage for both genders appears to be a strong determinant of consanguinity. Consanguineous unions are generally arranged by families, sometimes even before the partners reach puberty. The couple, especially the young woman, had no say in their marriage. Studies in countries such as Jordan [35] revealed a significant relationship between consanguinity, marriage arrangement, and early age at marriage.

Our study attested to a strong association between consanguinity and fertility. However, despite having a high average number of pregnancies, the average number of spontaneous abortions was significantly higher in consanguineous unions. Thus, increased fertility might have compensated for pregnancy loss. This compensation can be a result of women's increased reproductive period due to their young age at marriage or a decision made by the couple to reach the number of children desired [12]. Indeed, numerous studies highlighted that consanguinity was associated with spontaneous abortions [36, 37]. However, other studies [38, 39] did not show a significant relation between spontaneous abortions and consanguineous marriages. They explained that in some cases abortions could occur due to genetic abnormalities and go undetected, especially in the first stages of pregnancies in consanguineous marriages. Eventually, if this possibility exists, it may indicate an underestimation of the impact of consanguinity on spontaneous abortions.

Limitations

The key limitation of this study is that the collection of information relied entirely on the memory of those interviewed; however, the fact that we opted for two types of interviews, individual and collective, compensated for this and facilitated confirming the information collected when possible.

Conclusion

The population of Chaouia revealed a high rate of consanguinity. The most common type of union was between first cousins. This practice was strongly associated with early age at marriage for both genders, as well as endogamy and immobility of couples, according to their place of birth. Fertility was highly associated with consanguineous marriages. This, however, might be a compensation for pregnancy loss, namely spontaneous abortions.

The evolution of consanguinity revealed a significant decreasing trend over time. However, the evolution pattern was not a significant predictor of consanguinity.

This matrimonial practice is a deeply rooted social and cultural tradition in this population, considerably enhanced by their rural background. The transition in Morocco's overall administrative structure and economic status, as well as the acceleration of urbanization across the country, are still recent and will require more time to be projected on our population. Furthermore, Chaouia is currently undergoing significant industrial penetration in its rural areas via the Berrechid-Settat corridor [17]. The emergence of this new activity may lead to a new perspective on selecting a partner in the future.

Indeed, consanguineous marriage provides the individual with a sense of social-economic stability while assuring his attachment to the group. However, we must not overlook the consequences of this practice on the population's genetic diversity and health. Therefore, further studies are needed to examine the impact of consanguinity on the overall genetic equilibrium of the population and its association with various aspects of the population's health, including reproductive health issues and various genetic abnormalities and diseases.

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Author contributions
KC represents the first author, has contributed to the conception and design of the study, fieldwork, data analysis, and interpretation, and has written the manuscript following the journal's guidelines. ND and AE have assisted with the fieldwork. JT, HS, and AE have corrected and approved the final version of the manuscript. AH and EH created the initial concept for this study and guided KC through each step of the process. All authors read and approved the final manuscript.

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Availability of data and materials
The dataset supporting the conclusions of this article is available in on request from the corresponding author.

Declarations

Ethics approval and consent to participate
Ethical clearance for this study was obtained from the Biomedical Research Ethics Committee (CERBC) of Casablanca. The ethics committee is based on the following: Law 28-13, 17/09/2015 on the protection of individuals involved in biomedical research. Minister of Health's Decision N°02/DRC/00, 03/12/2012 concerning biomedical research.

Consent for publication
Not applicable.

Competing interests
The authors have no competing interests to declare.

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