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THE GENETIC DIVERSITY AND ANCESTRY OF A SMALL SAMPLE FROM GREATER KURDISTAN: INSIGHTS FROM DNA SEQUENCING RESULTS

SIRWAN **A**ZIZ. **A**KBAR
Dept. of Pharmacy, Sulaimani Technical Institute, Sulaimani Polytechnic University, Kurdistan Region–Iraq

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ABSTRACT

In this research, the DNA sequencing method is used to analyse the genetic diversity and ancestry of a small group of people from greater Kurdistan. The ancestry report data indicates the anthropological roots of the individual. It's interesting to note the distribution of the DNA sequencing results of the Kurdish specimens. The results showed that the Kurdish-origin volunteers from Greater Kurdistan had a high degree of genetic similarity, indicating a common genetic ancestry. The sequencing showed that all Kurds from Greater Kurdistan share approximately similar origins. All regions and countries with ancestry in these results were either Kurdish lands or settled by Kurds. In addition, the data revealed that volunteers from other countries, compared to Kurds, displayed a lower level of genetic similarity, indicating a more diverse genetic ancestry. i.e., the significance of the distinctions between Kurds from all regions of Greater Kurdistan and other ethnicities from Turkey, Iraq, Iran, and Israel, as well as ethnicities from the remaining countries (the United Kingdom and Spain), confirms the accuracy of the findings. The results of this study are important for understanding the genetic diversity and ancestry of the Kurdish population. It provides a detailed picture of the genetic makeup of the Kurds, which can be used to understand better the history and culture of the Kurdish people. However, it is important to emphasise that these estimates are based on the individuals who were sampled for the study and may not represent the genetic diversity of the entire population of Greater Kurdistan. It's also important to note that various factors such as migration, historical events, and genetic drift can influence genetic ancestry, which is a complex topic. The fact that the specimen's DNA is predominantly linked to Iraq, Iran, Turkey, Syria, Armenia, Pakistan, and Lebanon suggests that the region may have played a vital role in the ancestry of the individual to which the specimen belonged, or historical genetic ties between the Kurd regions and their countries that are related; or Kurds have with time become multiethnic due to admixture with other groups, and this is due to more recent migrations or genetic exchanges (intermarriages) between those regions and Kurds. Additionally, ten major haplogroups (Hg) of the Y-chromosome Kurdish gene pool were determined, which indicates a diverse genetic background. Among these haplogroups, J, R (R1b), G, and E were considered the most common. However, the results of the present study are not totally significant and do not totally represent all Kurds; because of the limited sample size, they are considered a beginning for further research.

KEYWORDS: Genetic Diversity, Ancestry, Greater Kurdistan, DNA Sequencing Results, Insights.

1. INTRODUCTION

An ethnic group called Kurds are people who live in the mountainous region of Western Asia, which is also called Greater Kurdistan. The term "Greater Kurdistan" means the region of Kurds or refers to the areas that are geographically and historically where Kurdish people live and form a majority of the population (Bozarslan, 2004). The areas of greater Kurdistan extend into south-eastern Turkey (Northern Kurdistan), northern Iraq (Southern Kurdistan), north-western Iran (Eastern Kurdistan), and northern Syria (Rojava or Western Kurdistan) (Bengio, 2014, Izady, 1992). In another study, Bozarslan, (2004), indicated that the north-western Zagros and the eastern Taurus mountain ranges in central Anatolia and Khorasan are part of Kurdistan. There are also Kurdish exclaves, and there are large communities of Kurdish immigrants in the cities of western Turkey, especially Istanbul, and in Western Europe (Bozarslan, 2004). Kurds are an ethnolinguistic group. After the collapse of the Ottoman Empire in World War I, Kurds have been divided among four countries: Turkey,

Iraq, Syria, and Iran. The Kurds also exist in smaller numbers in Lebanon and Russia (Ghafour, 2011). Currently, the term Kurdistan refers to the Kurdistan of Iraq after an agreement with the Iraqi government in 1970 to become autonomous, which then re-established itself as an autonomous area inside the Iraqi federal republic in 2005 (Gürbey *et al*., 2017). Kurdistan is also a province of Iran; however, it is not autonomous and is ruled by Tehran. During the Syrian Civil War, Kurdish troops were able to seize control of a large part of northern Syria and establish their Rojava government. They demanded autonomy in a federal Syria following the war (Radpey, 2015, Radpey & Rose 2017). Additionally, Khorasan and central Anatolia have Kurdish exclaves. There are also considerable Kurdish diaspora groups in the cities of western Turkey, particularly Istanbul. The Kurdish diaspora has also formed throughout Western Europe, particularly Germany. The estimated population of Kurds is between 30 and 45 million (Bozarslan, 2004, Gunter, 2004, Asatrian, 2009, Aziz, 2020).

The word Kurds originally was unclear, and the suffix -stan (Persian: stân) is Persian for land, which means "Land of Kurds". Numerous theories exist regarding the name Kurd's etymology (Gunter, 2004, Paraskiewicz, 2008, Asatrian, 2009). One of these theories indicated that the word Kurd comes from (Kart, Kurt) (Coban, 2013). According to another source, Corduene is one of the ancient names for Kurdistan (Torelli, 2017).

The largest nation that is now without a state is the Kurds. More than thirty million Kurds reside in Kurdistan under the national authority of Turkey, Iran, Iraq, and Syria, four sovereign states that oppress the political and cultural expressions of the Kurdish people in various ways (Vali, 1998). In the past, the myth perpetuated indicated that the Kurds were errant Turks who should reclaim their Turkishness, either through assimilation or if necessary by force (Heper, 2007). According to a US State Department report, Turkey has long denied the Kurdish population basic political, cultural, and linguistic rights, as well as instances of intolerance (Loizides, 2010).

In Iraq, Qawmiyyah nationalists propagated myths that denied the Kurdish ethnicity, particularly under Ba'athist ideology, which considered the Kurds to be of Arab origin. They even claimed that Saladin Ayubi, the famous Kurdish warrior, was of Arab descent (Natali, 2005).

The relatedness and ancestry of Kurds have been studied in the past using a variety of genetic markers, including mtDNA, Y-DNA, HeLa cells, etc. Nebel *et al.* (2001) examined 13 binary polymorphisms and six microsatellite sites on the Y chromosomes of six Middle Eastern groups, including Kurdish Jews and Muslim Kurds. No genetic differences were found between Kurdish and Sephardic Jews; however, there were modest variations among Ashkenazi Jews, presumably as a result of restricted gene flow and genetic drift. A minimal genetic exchange was observed between Kurdish Jews and their former Muslim hosts in Kurdistan. Jews displayed a closer genetic affinity with Kurds, Turks, and Armenian groups in the northern Fertile Crescent (Nebel *et al.*, 2001). In another study in the Kurdistan region of Iraq, Ehsaan and Fattah (2022) examined genetic relationships between Arabs, Sorani, and Behdinan residents using Y chromosomal STR variation. The study found that the Sorani residents showed a closer genetic affinity to the Behdinan residents (Ehsaan and Fattah 2022). Further research investigated the origins and affiliations of Kurdish-speaking groups by analysing mtDNA HV1 sequences, eleven Y chromosome biallelic markers, and nine Y-STR loci among three Kurdish groups: Zazaki and Kurmanji speakers from Turkey, and Kurmanji speakers from Georgia. The findings revealed that Kurdish groups are genetically similar to other West Asian groups, and most distant from Central Asian groups (Nasidze *et al*., 2005). Fadhl *et al*. (2021) analysed the genetic composition of 36 Sulaimaniah residents. The findings revealed a predominance of Western Eurasian haplogroups (Hg), particularly H, indicating a stronger genetic connection between the city's residents and the European lineage.

According to our Knowledge, to date, there has been a notable absence of comprehensive studies investigating the genetic ancestry of Kurds across all regions comprising the greater Kurdistan area. Moreover, comparative analyses between Kurds and neighbouring populations using a novel and highly accurate technique involving the examination of approximately 700,000 genetic markers are currently lacking. Additionally, an examination of Kurds' Hg distribution is warranted. The outcomes of such research endeavours are anticipated to provide substantial support for the distinctiveness of

Kurdish ethnicity in relation to Arab, Turkish, and Persian ethnicities. Despite some shared cultural and historical affinities, these groups exhibit distinct languages, cultural practises, and identities. Furthermore, investigating the genetic diversity and ancestry of the Kurdish population is of great significance. Exploring Kurds' genetic variety and ancestry as an entirety can provide important insights into their history, culture, and evolutionary trajectory. Moreover, this knowledge holds potential benefits for medical research applications.

2. MATERIALS AND METHODS

In this study, to achieve a great level of detail, all data represents statistical approximations featuring 700,000 genetic markers. Ten unrelated male individuals from different geographical areas were selected as volunteers to collect specimens and perform DNA ancestry tests (Fig. 9). Kurdish-origin volunteers from the Garmian region in northern Iraq (southern Greater Kurdistan), Kermanshah in northwestern Iran (eastern Greater Kurdistan), Hasaka in northern Syria (western Greater Kurdistan), and Van Province in eastern Turkey (northern Greater Kurdistan) all provided four samples each. Volunteers from Baghdad-Iraq (Iraqi Arab), Konya-Turkey (Turkish Turk), Yazd-Iran (Iranian Persian), and the Israel Jewish residence in the United Kingdom also supplied four specimens. Another two specimens were collected from volunteers from other countries (Spanish and English ethnic) that were used as controls. According to the instructions, specimens were collected from volunteers who washed their mouths thoroughly with water and did not eat, drink, smoke, brush their teeth, chew gum, or do anything else for at least 1-2 hours before sample collection. After wearing gloves, a swab was used to rub firmly and hard against the inner side of the cheeks (both sides of the inner cheeks) for at least one minute at each side of the mouth without touching anything else with it. The end of the swab was then breached and inserted into the test tube, to which a stabilising capsule was added very carefully (without touching the capsule) before it was sealed. Finally, the test tube sent to Spain and sequenced by 24 Genetics. Autosomal DNA was focused on and analysed to perform this test, which provides genealogical information inherited from parents and previous generations that dates back hundreds or even thousands of years. The test compares the individual genetic map with a massive DNA marker database from countless geographical areas and countries around the world to show where the ancestors came from. Additionally, to determine Hg profile distribution, a total of 700,000 base pairs of the Y DNA were also analysed for each individual. Using the software at https://mytrueancestry.com (MyTrueAncestry. 2020).

3. RESULTS

Based on the study's results, the DNA sequencing of the Garmian specimen was predominantly linked to Iran, with a rate of 41% (which includes Loristan at 29.7%, Talesh County at 5.7%, and Mazandaran at 4.3%). Armenia had the second highest rate of 26.7%

(in the Ararat province at 26.7%), followed by Iraq with a rate of 10.5% (in Shekhan at 10.4%), Pakistan with a rate of 10.1% (in Hunza at 9.6%), and finally, Lebanon with a rate of 8.3% (in south Lebanon at 8.30%), as shown in Fig. 1.

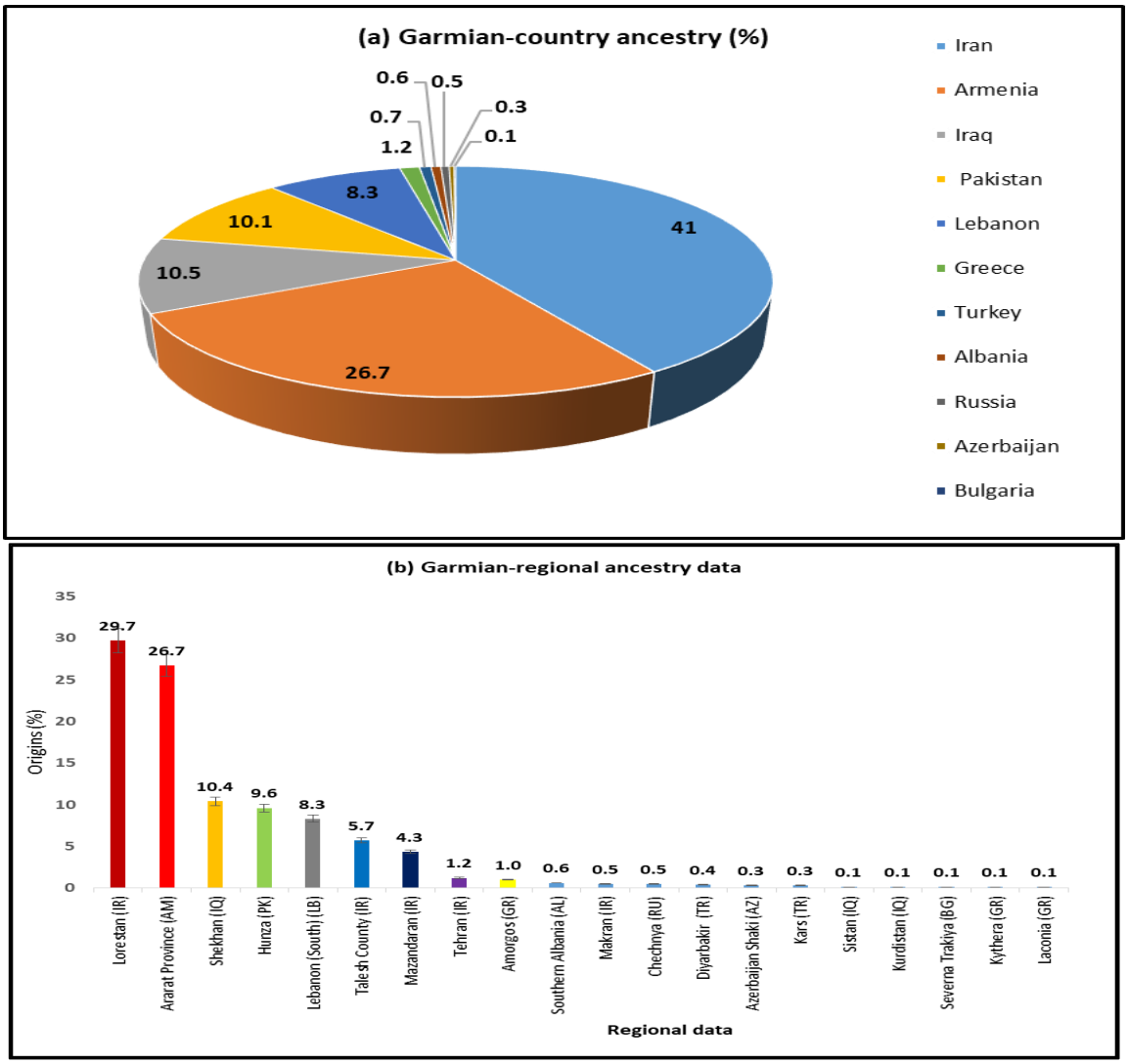
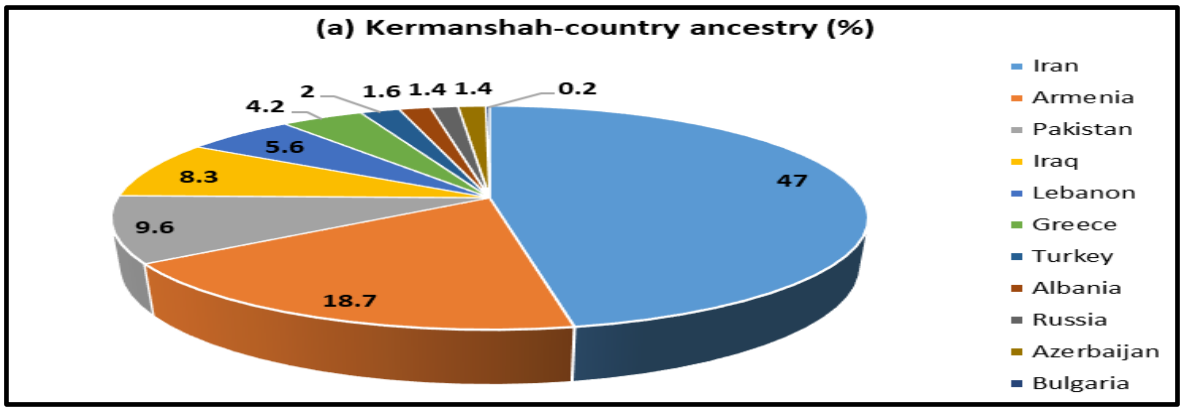


Fig. (1): DNA country ancestry origin (a), and regional ancestry origin (b) for Kurdish ethnicity from Garmian.

Analysis of the Kermanshah specimen indicated that 47% of the samples originated from Iran, which includes Loristan at 25.7%, Kermanshah at 8.3%, and Mazandaran at 5.6%. Additionally, 18.7% of the samples originate from Armenia, specifically from the Ararat province, while 8.3% came from Iraq, from the Shekhan region. 9.6% of the samples were linked to Pakistan, specifically the Hunza area, and 5.6% came from Lebanon, specifically South Lebanon, as displayed in Fig. 2.



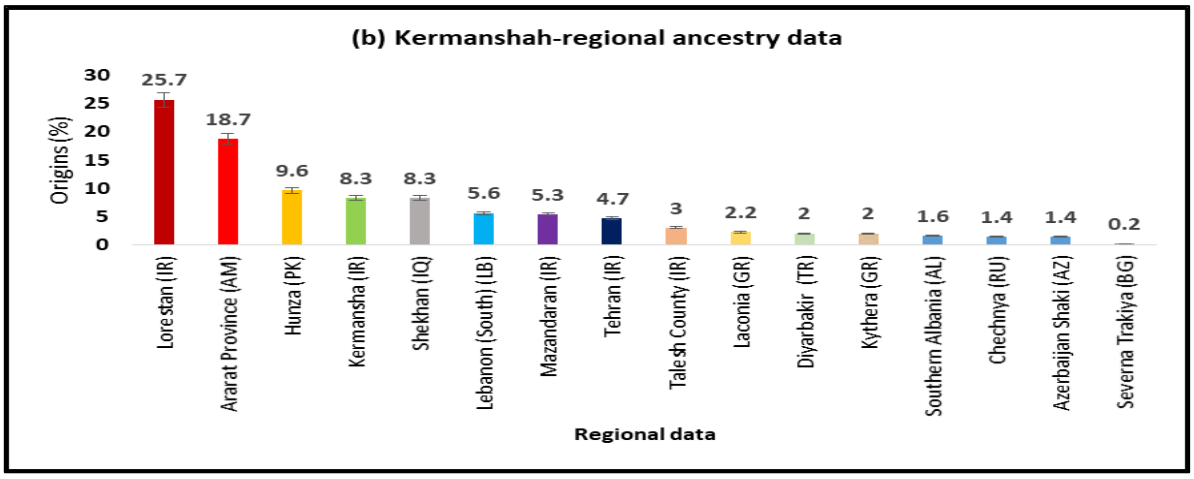
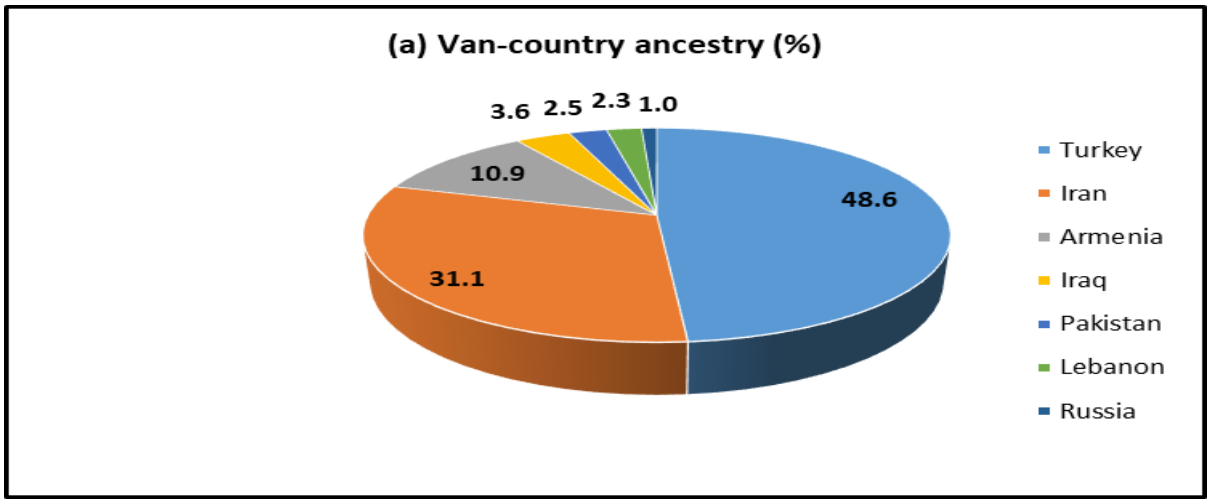


Fig. (2): DNA country ancestry origin (a), and regional ancestry origin (b) for Kurdish ethnicity from Kermanshah.

As shown in Fig. 3, the DNA sequencing of the Van City specimen has indicated a 48.6% link to Turkey, especially in Van Province at 30% and Hakari at 17.8%, followed by Iran at 31.1%, including Loristan at 13.2%, West Azerbaijan at 12.8%, and Talesh County at 5.10%. 9.9% of the specimen's DNA was related to Aragats Armenian. Finally, Iraq (Shekhan), Pakistan (Hunza), and Lebanon (Lebanon south) were linked at 3.3%, 2.5%, and 2.3% of the sequencing, respectively.



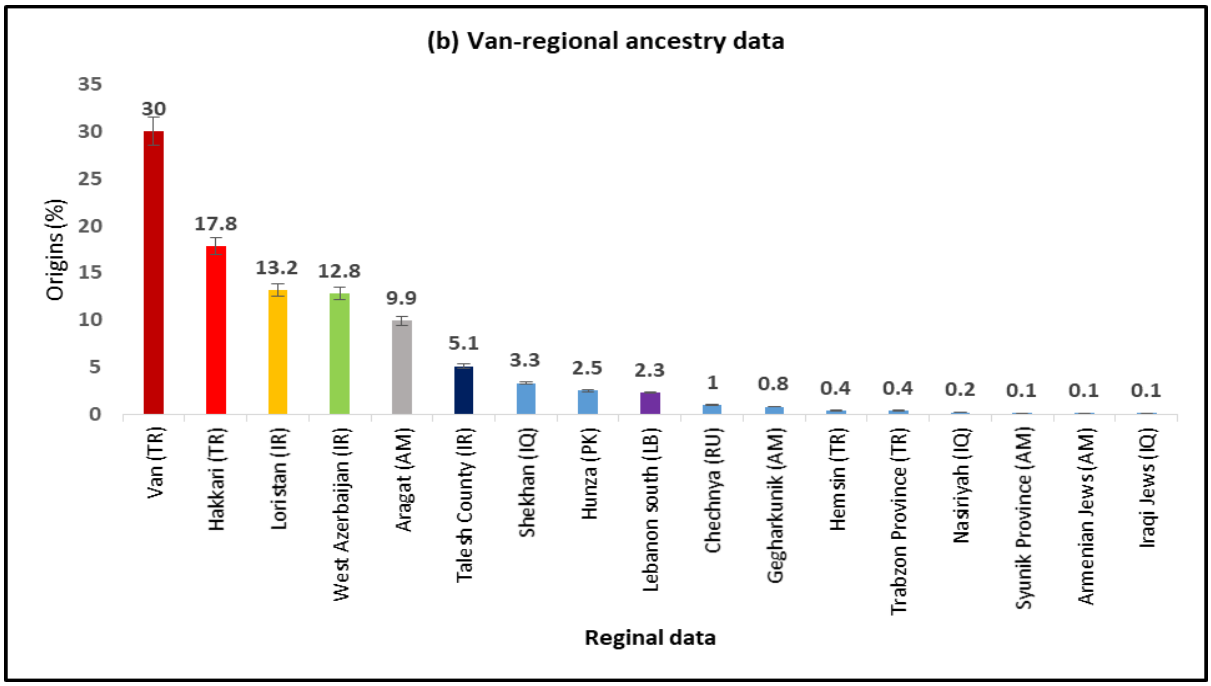
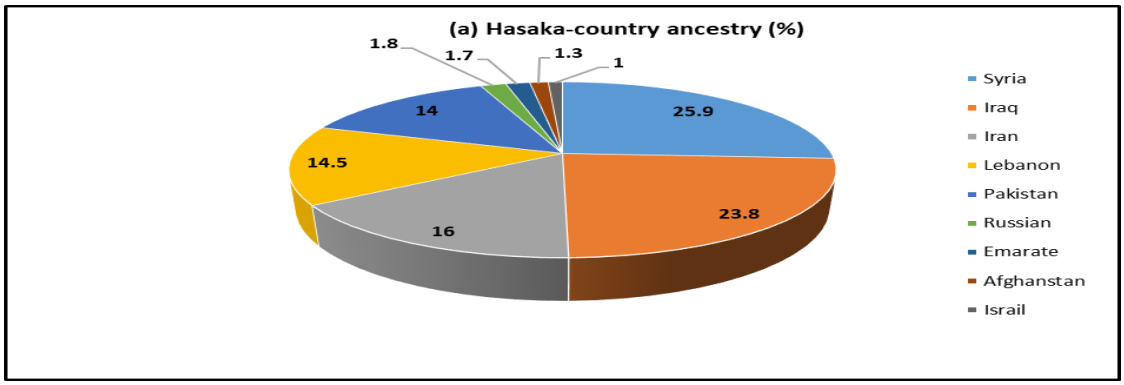


Fig. (3): DNA country of ancestry origin (a), and regional ancestry origin (b) for Kurdish ethnicity from Van.

According to the results of the DNA sequencing analysis of a Hasaka sample, the majority of the sample (25.9%) was related to Syria, mainly Hasaka. The sequencing also revealed that 23.8% of the sample was from Iraq, specifically Shekhan (21.1%), and 16% was from Iran, specifically Loristan (8.1%) and Khuzestan (7.9%). In addition, 14.5% of the sequencing was linked to Lebanon, with south Lebanon at 9.3% and Beqaa Governorate at 5.2%. Moreover, 14% of the sequencing was related to Pakistan, specifically Hunza, Makran, and Balochistan, which accounted for 6.1%, 4.4%, and 3.5%, respectively. These findings are illustrated in Fig. 4.



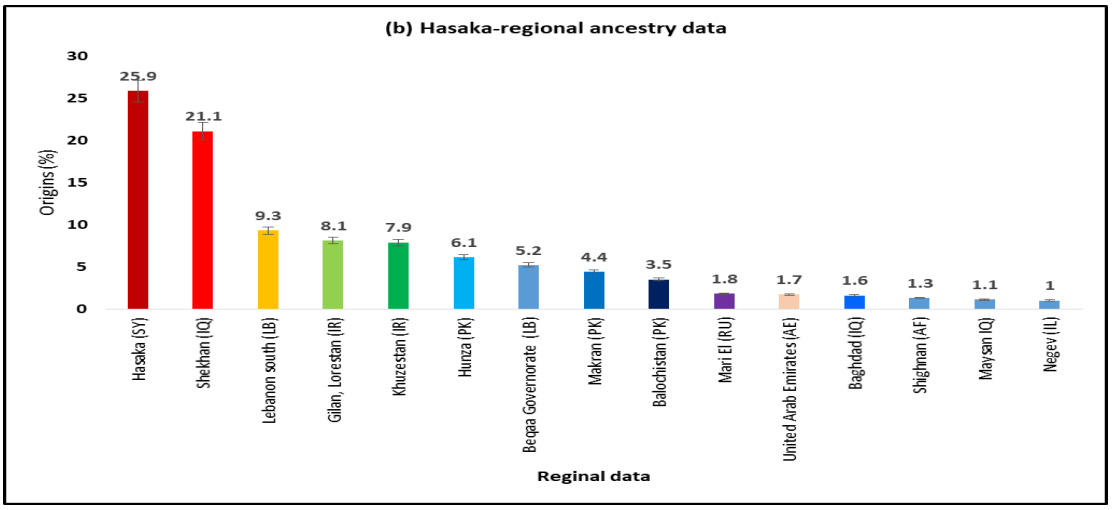
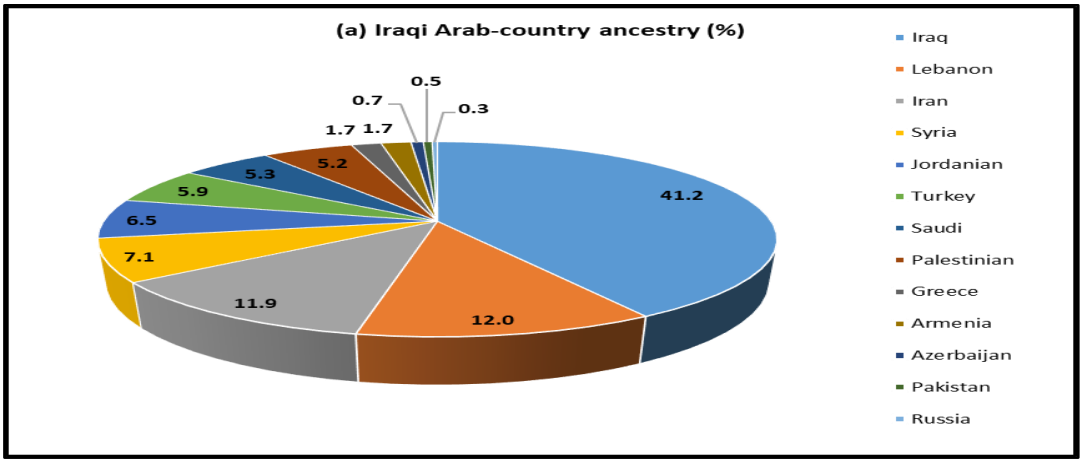


Fig. (4): DNA country ancestry origin (a), and regional ancestry origin (b) for Kurdish ethnicity from Hasaka.

The DNA sequencing of the Baghdad specimen, which represents Iraqi Arabs and serves as a Middle-Eastern control, revealed a 41.2% link to Iraq, with Al-Najaf accounting for 20.7%, Samara accounting for 13.1%, and Baghdad accounting for 5.1%. 12% to Lebanon (including Lebanon's south at 7.3% and Rashaya at 4.7%), and 11.9% to Iran (Khuzestan at 8.2% and Hormozgan at 3.7%). 7.1% of the specimen's DNA was linked to Syria (specifically Halab at 7.1%), followed by Jordanians at 6.5% (Mafraq), while 5.9% was related to Turkey (Adana at 4.3% and Istanbul at 1.6%). Finally, 5.3% went to the Saudi Hail province and 5.2% to the Palestinian Nablus. As displayed in Fig. 5.



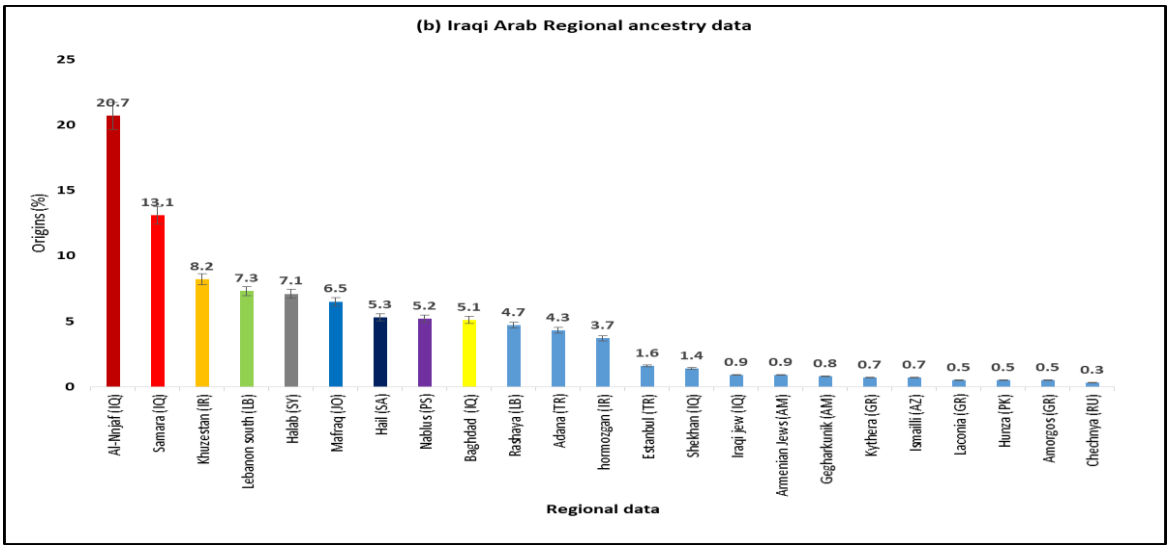


Fig. (5): DNA country of ancestry origin (a) and regional ancestry origin (b) for Iraqi Arabs from Baghdad.

An Iranian Persian ethnic sample from Yazd was also used as a control specimen in the Middle East. The DNA sequencing was related predominantly to Iran at 74.9%, including Yazd, Isfahan, and Tehran at 45.7%, 15.3%, and 10.7%, respectively. Followed by Armenia at 5.7% (mainly Ararat Province) and Turkey at 5.3% (Van Province). Finally, the DNA sequencing of this specimen originated in Iraq and Azerbaijan at 3.9% and 3.7%, respectively. As shown in Fig. 6

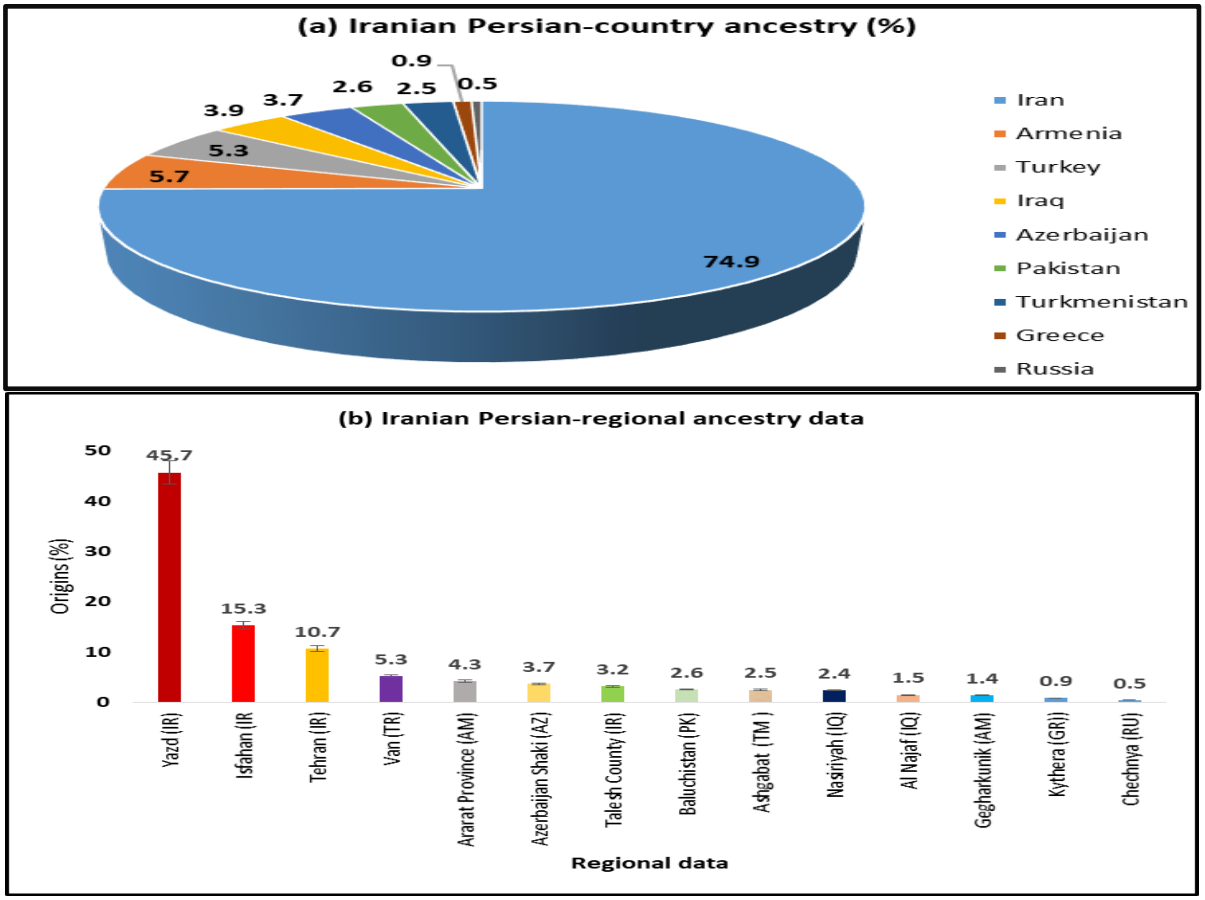


Fig. (6): DNA country ancestry origin (a), and regional ancestry origin (b) for Iranian Persian ethnicity from Yazd.

Another control specimen in the Middle East used to compare with the Kurdish specimens was from a Turkish ethnic group in the Konya province, Turkey. The DNA sequencing revealed that the majority of the DNA was linked to Turkey at 65.1%, with Konya at 48.2%, Bursa at 12.7%, and Ankara at 4.2%. The next highest-related regions were linked to Armenia at 9.2%, specifically Syunik Province at 6.1% and Gegharkunik at 3.1%, followed by Iran at 7.6%, mainly East Azerbaijan province at 6%. Azerbaijan, at 7.4% (Nakhchivan, at 7.4%), was the next highest related region, followed by Greece (primarily Pontic Greeks), Bulgaria (Kurdzhali), and others at 6.3%, 2.8%, and 1.6%, respectively (Fig. 7).

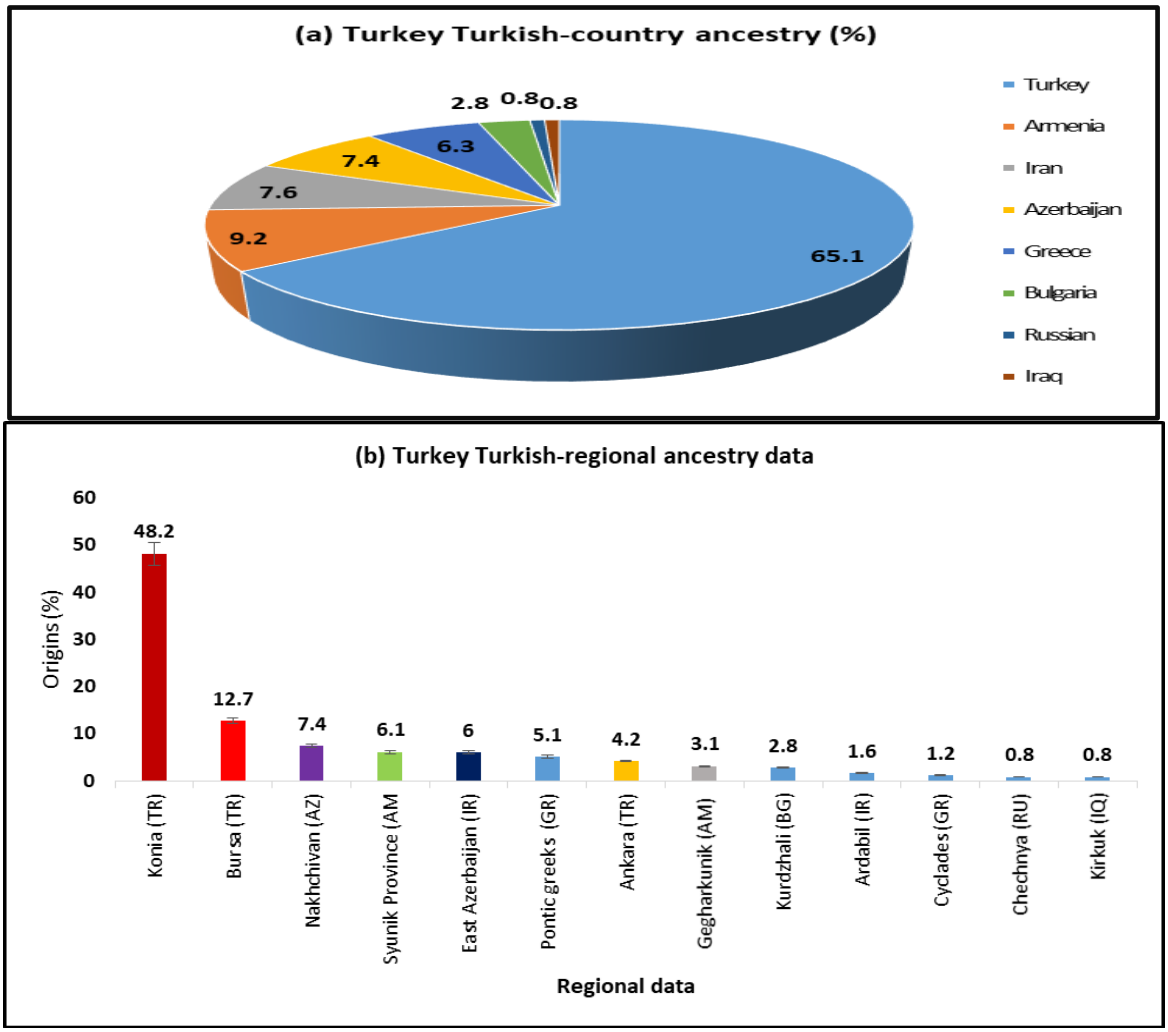


Fig.(7): DNA country ancestry origin (a), and regional ancestry origin (b) for Turkish ethnicity from Konya-Turkey

The last specimen used as a Middle Eastern control was Jewish. The results of the study indicate that individuals of Jewish ethnicity from the UK with Israeli origins, mainly Ashkenazi Jews, had the highest rate of genetic markers associated with the Jewish race at 60.2%. Greece had the next highest rate at 14%, particularly in the Peloponnese (8%), followed by the Dodecanese (3.5%) and Andros (2.5%). Italy had a rate of 7.4%, with the highest rate observed in Liguria at 5%. The rates in Portugal, Lebanon (specifically south Lebanon), and Syria (specifically Syrian Jews) were 3%, 27%, and 2.5%, respectively. Finally, individuals with Sephardic and other Jewish ancestry represented approximately 6.8% of the sample. It is imperative to highlight that these findings reflect the results of a specific study and may not be generalizable to other populations or regions as shown in Fig. 8.

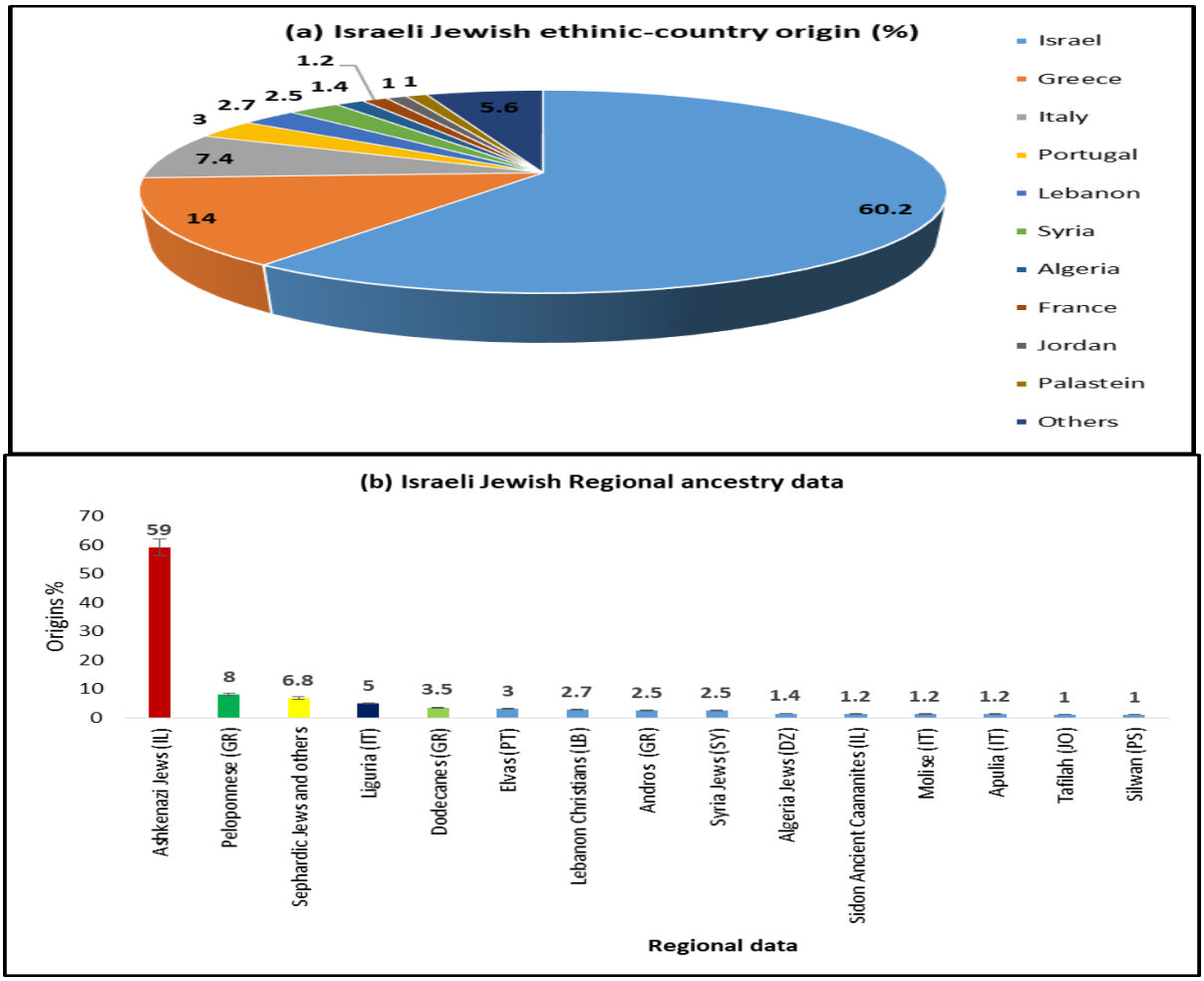


Fig. (8): DNA country ancestry origin (a), and regional ancestry origin (b) for Israeli Jewish ethnicity.

The DNA sequencing results for individuals with Spanish and ethnic origins (outside of the Middle East) showed the percentage of the genetic makeup of each individual that is linked to different countries or regions.

The DNA sequencing result of a specimen of Spanish ethnic origin shows that 69.4% of their genetic makeup can be linked to Spain, 13.5% to France, and 6.6% to Portugal. The remaining percentages are linked to Kenya, Morocco, Italy, and Belarus, as shown in Table 1. The results of a sample of English ancestry show that 43.9% of their genetic makeup can be linked to Great Britain, with a specific region of Essex Mediaeval (UK) at 42.4%. In addition, 21% of their genetic makeup can be linked to Italy, 16.1% to Greece, and 8.2% to the Netherlands. The rest of their genetic makeup is linked to other countries or regions, as shown in Table 1.

Table (1): DNA country ancestry and regional ancestry origins for Spanish in the (left) and English ethnic in the (right).

Spanish from Spain				English from UK			
Country Origin	%	**Regional Origin**	%	**Country Origin**	%	**Regional Origin**	%
Spain	69.4	**Galicia (SP)**	31.0	**Great Britain**	43.9	**Essex Medieval (UK)**	42.4
France	13.5	**Castilla Leon (SP)**	16.0	**Italy**	21	**Tyrol (AT)**	16.1
Portugal	6.6	**Picardy (FR)**	11.5	**Austria**	16.1	**Apulia (IT)**	11.9
Kenya	4.4	**Castilla Leon Soria (SP)**	10.8	**Greece**	8.2	**Lombardy (IT)**	9.1
Morocco	3.4	**Cataluna Comarques (SP)**	8.2	**Netherlands**	5.6	**Utrecht (NL)**	5.6
Italy	1.5	**Portugal Algarve (PT)**	6.6	**Switzerland**	2.5	**Crete (GR)**	3.7

Belarus	1.2	**Valencia Alicante (SP)**	3.4	**Finland**	2	**Kythera (GR)**	3
		Morocco Khemisset (MA)	3.4	**Georgia**	0.7	**Romandy (CH)**	2.5
		Kenya Narok Maasai (KE)	3.0			**Finland Karelia (FI)**	2
		Brittany (FR)	2.0			**Andros (GR)**	1.5
		Sardinia (IT)	1.5			**Cornwall (UK)**	1.5
		Kenya Kilifi (KE)	1.4			**Kutalisi (GE)**	0.7
		Vitebsk (BY)	1.2				

In the current study, the Hg profile distribution among Kurds shows ten major Hg in the Y chromosome Hg gene pool. These Hg are named T, BT, E1b, G, I1, J, L, N, Q, R1a, and R1b, as shown in Table 2.

Table (2): Frequencies of the most prevalent Y-chromosome haplogroups (Hg) in this study

	Y-chromosome haplogroups										
Regions	**T**	**BT**	**E1b**	**G**	**I1**	**J**	**L**	**N**	**Q**	**R1a**	**R1b**
Garmian (IQ)	7.04	1.4	10.04	11.6	2.81	44.68	1.4	1.81	1.4	4.22	13.6
Kermanshah (IR)	4.3	0.9	11.37	11.2	2	40	3.01	0.9	1.1	8.32	16.9
Van (TR)	6.75	1.35	6.75	15.2	2.7	44.7	1.35	2.7	1.35	5.05	12.1
Hasaka (SY)	6.1		15.3	9.8	3	37.7	4		1.9	6.5	15.7
Baghdad-Arab (IQ)	1.5		17.9	7	1.2	53.8	1.2		1.4	7	9
Yazd-Persian (IR)	5.1		11.5	9.7	4.97	41	5.23		4.4	9.3	8.8
Konya-Turkish (TR)	2		14.7	10.2	4	39	1.1	3.1	1.2	7	17.7
Israel-Jewish (IL)	3.2		22.4	9.5	4.5	39.2			2.3	3.9	15
Segovia-Spanish (SP)	1.6		12.5	1.5	9.6	5.1				3.3	66.4
Birmingham-English (UK)			3		21	2				5.1	68.9

Fig. (9): Map of sample sites and the geographic distribution of Y-chromosome haplogroups in Europe (a), and the Middle East (b). Frequencies of the major Y-chromosome haplogroups in the present investigation (pie chart)

4. DISCUSSION

The DNA sequencing results for individuals from different regions of Kurdish ethnic origin suggest that individuals from various Kurdish regions (Garmian in Iraq, Hasaka in Syria, Kermanshah in Iran, and Van in Turkey) share similar country origins, with links to Turkey, Iran, Iraq, Syria, Lebanon, Armenia and similar geographical regions; Shekhan (IQ), Lorestan (IR), Mazndaran (IR), Kermanshah (IR), Tehran (IR), West Azarbaijan (IR), Kalat (IR), Kurdistan (IR), Khuzestan (IR), Talesh county (IR), Van (TR), Hakari (TR), Diyarbakir (TR), Hasaka (SY), North Syria (SY), Ararat province (AM), Lebanon south (LB), Hunza (PK), Makran (PK), Balochistan (PK), and Chechnya (RU) as shown in Figs. 1-4. Historically, Kurds have lived in these countries and regions, so they are considered to be part of greater Kurdistan. These results are consistent with and supported by scientific research, books, and papers by scientists, historians, and archaeologists about Kurds. The geographical area of greater Kurdistan (a land of Kurds) occupies parts of Turkey, Iran, Iraq, and Syria. Most people who live in the area are ethnic Kurds. Additionally, Kurds also live in Lebanon, Armenia, Azerbaijan, and Turkmenistan. Besides Kurds, many other minorities, like Arabs, Armenians, Assyrians, Turkomans, Turks, and Iranians, also live in greater Kurdistan (Gunter, 2004, Bayır, 2013, Arnaiz-Villena *et al*., 2017).

In this study, the Kurds link to Iraq, especially Shekhan, as shown in Figs. 1–4, is conventional because there is no doubt about the presence of Kurds in Iraq. The Kurdish population is among the largest ethnic groups in Iraq and have inhabited the region for millennia. They have their own language and culture, and they have played an essential role in creating the country's history and politics. The majority of Kurds in Iraq adhere to Sunni Islam, while a small number identify as Shiite, Yezidi, Shabak, or Christian (Ghafour, 2011). Yazidis are a heterodox Kurdish community that is the second largest non-Muslim group in Iraq (Fuccaro, 1997). It is one of the Middle East's oldest indigenous ethnic and religious groups. According to a Yazidi researcher (Khider Domle), Yezidism is considered one of the oldest Kurdish religions in the Middle East. Their followers (Yazidis) mainly predominate in the areas surrounding Shingal Mountain and the Shekhan district in the north-west of Iraq (Zoonen & Wirya 2017); Shaikhan is considered the main centre of the religion due to the presence of the Lalish temple that dates back 4000 years (Omarkhali, 2014); additionally, some sources suggest that the temple was built as early as 500–512 BC (Hann *et al*., 2015); and it is essential to emphasize that all Iraqi Yazidis are Kurds and speak Kurdish as their first language (Omarkhali, 2014, Allison, 2017). Yazidis live in other areas of Kurdish settlement, including Syria, Turkey, Iran, and the former Soviet Union (Fuccaro, 1997).

In this study, individuals from various Kurdish regions (Garmian in Iraq, Hasaka in Syria, Kermanshah in Iran, and Van in Turkey) were linked to several regions in Iran, as shown in Figs. 1–4. Historically, these findings have been supported. Since the medieval period, Kurds are recognized as an ethnic group. Kurdish prehistory is poorly known, but the Mesopotamian early empire records numerous allusions are made to mountain tribes with names similar to "Kurd" They occupy huge territories from Azerbaijan to Khuzestan (Grugni *et al*., 2012). McDowall, D. (2004) indicated that Kurdish people have lived in the Middle East for centuries, and their history can be traced back to ancient times. The first historical records that mention the Kurds come from Assyrian sources dating back to the 9th century BC. The name "Kurd" may have originated from the ancient Medes, who were people who lived in the same region.

Links between Kurds and various regions in Iran (Lorestan, Mazndaran, Kermanshah, Tehran, West Azarbaijan, Kalat, Kurdistan, Khuzestan, Talesh County) can be supported by various references; the Kurdish area of Iran includes most of West Azarbaijan, all of Kurdistan, Kermanshah, Ilam, and Luristan (Curtis & Hooglund 2008). In 1947, for the first time, a detailed map of the Kurdistan region was published, which included the entirety of Loristan (Luristan) and the south of the Gulf as part of Kurdistan. The authors of the map concluded that the Lors people were often more Kurdish than other Kurds. During the Parthian era (247 BC–226 AD), there were seven semi- or completely independent territories around the area, including Mada (Media), Elymais (Loristan), Kerm (Kermanshah), Mukriyan (Mahabad), Shahrezur (Sulaimaniya), Barchan (Barzan), and Sanak (Sahna); all these states would later be known as Kurdistan. During

Sultan Sanjar's rule in the 12th century, a Kurdish province under the control of a non-Kurd, Sulaiman Shah, became the largest state-recognized area to bear the name Kurdistan. It was the first time the name Kurdistan province was used officially. This province occupied the entire area between Azerbaijan and Loristan, including regions such as Kermanshah, Hamadan, Dinawar, and Sanandaj, to the west of Shahrizur and east of the Zagros Mountains. However, in the 16th century, both Hamadan and Loristan were detached from Kurdistan (O'Shea, 2004).

A close relationship between the Kurds and Lors in the present study (Figs. 1–4) is consistent with other studies. For example, according to a study on genetic polymorphisms in selected populations in Iran, the Lors who live in Loristan are related to the Kurds. The study suggests that there is a genetic link between the two groups (Ashouri, 2016, Izady, 1992). Even Sharaf Khan Bitlisi's Sharafnameh, which was written in 1596 and is an epic history of the Kurdish nation that covers the period between 1290 and 1596, referred to the Lurs, who inhabited parts of western Iran, as Kurds (Izady, 1992).

10–12 million Kurds are estimated to inhabit Iran (Moradpour *et al*., 2021). The Iranian Kurds' main characteristic is diversity, as most of them live in Kurdistan province and parts of three neighbouring provinces: West Azerbaijan in the north, Kermanshah and Ilam in the south. Approximately one million Kurds also live in scattered communities in the northern countries of Mazandaran and Khorasan (Farzanfar, 1992, Bayat, 2008, Chalechale *et al*., 2013). During the Qajar period, Aqa Muhhamad Shah (1779–1797) brought various tribes to settle in Mazandaran, including some Kurdish tribes (Kazembeyki, 1997).

Using human leukocyte antigen (HLA) class II profiles, polymerase chain reaction/restriction fragment-length polymorphism (PCR/RFLP), and polymerase chain reaction/sequence-specific primer (PCR/SSP), the genetic relationship between Kurds and Azeris of Iran was studied. The results revealed a strong genetic link between the two groups. Both populations appear to share a common genetic origin (Farjadian *et al*., 2004).

It is also interesting to note that the Yarsan religion is believed to have Kurdish origins and dates back to the preceding Zoroaster period. They live primarily in Iraq but also in western and northwestern Iran, such as in Loristan, east and west Azerbaijan, and Mazandaran Province (Hosseini, 2022).

Concerning the ethnic groups in Khuzestan, the province is in the southwest of Iran and is surrounded by five other provinces: Lorestan to the north, Ilam to the northwest, Bushehr to the southeast, and Chahar Mahal, Bakhtiyari, Kohkiloye, and Boyerahmad to the east (Dehghani *et al*., 2009). During the early Islamic centuries, the Kurds of Fars and Khuzestan were the most important ethnic groups in southwest Iran (Khuzestan) (Siahpour, 2010). Kashipazha *et al*. (2015) found that divers ethnic group such as Arabs, Persians, Turks, Lors (including Bakhtiari people), and Kurds are among the people who live in Khuzestan (Kashipazha *et al*., 2015). According to Rubin, (2003), Lor and Bakhtiari were Iranian tribesmen of Kurdish origin (Rubin, 2003).

In this study, Kurds originate in the Talesh region. Talesh is a county in Gilan Province. Five Iranian languages are spoken in Gilan: Gilaki, Rudbari, Taleshi, Tati, and Kurdish (Pakpour, 2015). Kurdish, Taleshi, and Mazandarani are related to or part of the ancient Indo-Iranians, and at the same time, The Indo-Iranian subgroup of the Indo-European family constitutes the Indo-Aryan languages.

Furthermore, Western Asia has a sizable immigrant population of Indo-Aryan-speaking communities (Masica, 1993).

Kurds reside predominantly in the northern regions of Greater Khorasan, where there are approximately 696 Kurdish villages, some of which are in the city of Kalat. It is impossible to correctly estimate the size of Iran's Kurdish population due to the lack of official census statistics. Yet, demographic reasons suggest that there are close to one million Kurds living in Khorasan. It is thought that the Khorasani Kurds moved from Kurdish-populated regions of modern-day Turkey to the South Caucasus region of modern-day Armenia and Azerbaijan. The Khorasani Kurds' forefathers originated from the Van Lake Basin, Bidlis, Mush, and Diarbakr regions, according to their oral history (Madih, 2007).

The present study on ties between Kurds and several regions in Turkey, particularly Van, Hakari, and Diyarbakir, is highly supported because there is no doubt that these locations are Kurdish territory and that Kurds have a long history in these areas. The majority of Kurds in Turkey reside in the country's eastern and southeastern areas, notably the cities of Bingol,

Hakkari, Van, Mardin, Diyarbakir, and Batman, which are regarded as being part of Kurdistan. Due to historical factors such as forced deportations and migration, there are also Kurdish populations in other regions of Turkey (Bayır, 2013, Öztürk, 2013).

North Caucasians, like Chechens and Dagestanis, migrated to Turkey and the Middle East after the 18th century. Many of them settled in the Marmara region, western and northern Anatolia, Jordan, Syria, Palestine, and Iraq. These immigrants are commonly referred to as Circassians (Yıldız, 2006, Katav & Duman, 2012). Most of the Circassians have been assimilated into the cultures of the places where they settled, including becoming Arabized, Kurdified, and Turkmenized. Circassians can be found living in most Iraqi cities, such as Duhok, southern Erbil, Kirkuk, Tuz Khourmatu, Diyala, Fallujah, and Sulaymaniyah (Katav & Duman, 2012). While some Kurds in the present study may have genetic ancestry that can be traced back to regions in or around Russia (Figs. 1-4).

DNA sequencing analysis of a sample from Hasaka showed that 19.2% of the sample was associated with Syria, specifically Hasaka. The majority of Kurds reside in a geocultural zone in northeastern Syria. This region encompasses the majority of the Al-Hasakah governorate. Al-Qamishli and Hasakah are the two major cities in this region (Ziadeh, 2009, Neriah, 2012).

The DNA sequencing results indicate tie genetic links between individuals of Kurdish ethnic origin and the Ararat province and Mount Aragat in Armenia, as shown in Figs. 1–4. Several references, including Hovsepyan *et al*. (2016) and Shockey (2018), support this finding. They mention that Kurmanji-speaking people, who are a Kurdish-Yezidi ethnic minority, are the largest ethnic minority in Armenia and mainly reside in the region of Mount Aragats and the Ararat Valley (Hovsepyan *et al*., 2016, Shockey, 2018). Furthermore, as Yunusov (2005) points out, there is historical evidence of Kurdish migration from Iran to Karabakh by the end of the sixteenth century (Yunusov, 2005). There were also migrations of Yezidi people from Shekhan to Georgia and Armenia, which largely followed the eighteenth century (O'Shea, 2004). The Anabasis of Xenophon also indicates that Kurds have lived withArmenians and that their name appears in Armenian history (Bryce, 1877, Mofidi, 2020).

It appears that the Kurds in the present study share genetic links with various ethnic groups in Lebanon (South Lebanon and Beqaa Governorate), as shown in Figs. 1–4. This finding may be consistent with the historical presence of Kurds in Lebanon. Kurds are known to have been living in Lebanon since World War I, and before 1985, their numbers varied between 60,000 and 90,000. However, many Kurds fled the country during the civil war (Meho & Kawtharani, 1995).

The genetic data of the Kurds and Balochs in the present study suggest that the two ethnic groups share a common origin and have been living in the same geographical region for centuries, especially in Hunza, Makran, and Balochistan, as shown in Figs. 1–4. It is interesting to note that there may be a genetic link between the Kurdish and Hunza (Pakistan) populations, despite their geographic distance. Hunza people, also called Burusho people, live in northern Pakistan, especially in Hunza and Nagar, as well as in India, mainly in Jammu and Kashmir (Ahmed, 2016). It appears that there is some uncertainty about their origin or history, but there is a hypothesis suggesting that Burusho people may have been settled in their current location by Indo-Aryan migrations around 1800 B.C. to the subcontinent (South Asia), i.e., Hunza people may be descended from ancient populations that once inhabited the Middle East and Central Asia, and that this shared ancestry may explain the genetic link between the two groups. However, there is no definitive evidence to support this hypothesis (West, 2010). Moorjani *et al*. (2013) presented three possible scenarios for the integration of Indian and west Eurasian cultures: First, migrations before the development of agriculture (30,000–40,000 B.P.), and the evidence is Genetic analysis of mitochondrial DNA indicates that ancestral North Indians (of north Pakistan) and ancestral South Indians are related to West Eurasians (people of Central Asia, the Middle East, the Caucasus, and Europe), sharing the mitochondrial Hg (U2, U7, and W). Second, western Asians migrated with the spread of agriculture between 8,000 and 9,000 years ago; third, western Eurasians migrated between 3,000 and 4,000 years ago. There are still many unanswered questions about the complex history of human migrations and genetic mixing in this region. Further research will be required to clarify the nature of this relationship and to shed more light on the history and origins of both the Kurds and the Hunza people (Moorjani *et al*., 2013).

Genetically, the Y-chromosome Hg F-M89 (formerly known as Hg FT) and J2 (M172) are prominent among the Burusho and are related to the spread of agriculture from the Neolithic Near East, according to a prior study. M89 presumably originated in South Asia and appeared at least 50,000 years ago, according to estimates (Sengupta *et al*., 2006, Karafet *et al*., 2008). F-M89 and J2 Hg are common in many different ethnic groups, including Middle Eastern and Hunza people (Wells *et al*., 2001), which may indicate that these groups share genetic traits. According to this study, it is interesting to note that there may be a genetic link between the Kurdish and Hunza people (Pakistan) despite their geographic distance. The precise nature of the relationship between the Kurds and the Hunza people is still not well understood and is the subject of ongoing research.

Regarding links of Kurds to other regions in Pakistan, geographically, Makran is a region on the southern coastlines of Iran and Pakistan (Heidarzadeh *et al*., 2008). On the Pakistani side, Makran is located in the southern part of Balochistan, which is the largest province of Pakistan (Jamil & Shah, 2015). Ahmed and Khan, (2020) assert that the Baloch are an ethnically diverse group that includes the Kurds.

In another reference, Dashti (2012), suggested that both the Kurds and Balochs have common linguistic and cultural origins and may have lived in the same region at some point in history. It is believed that both groups were part of the Indo-Iranic tribes and lived in an area called Balashakan, which is the area between the Caspian Sea and Lake Van in modern-day Turkey and Azerbaijan, along with other tribes such as the Cadusii, Caspians, and Mardis. The Baloch were then all moved to Balochistan, while the Kurds persisted in their original location. However, some of the Kurdish tribes decided to move with the Baloch tribes, and they are now completely integrated into the Baloch nation (Dashti, 2012). Dashti (2012), in his book, also indicated that the Kurds and Lors are believed to be descended from the Cyrtii or Cyrtians, who were inhabitants of Balashagan or lived around Balashagan.

DNA sequencing of Kurdish ethnic individuals in this study revealed high accuracy, especially when compared to other ethnic groups in the Middle East, such as individuals from Baghdad-Iraq (Iraqi Arabs), Konya-Turkey (Turkish Turks), Yazd-Iran (Iranian Persians), and Israel Jewish residents in the UK, as shown in Figs. 5-8, as well as other volunteers from Spanish and English ethnic groups (Table 1). The distinction between the origins of Kurds and other people was stark. These substantial differences show the accuracy of the result; however, the fact that the sample size was small is an important limitation to consider. Small sample sizes can result in a lack of statistical power and limit the generalizability of findings to the broader population. Therefore, further research with larger sample sizes would be necessary to confirm and extend these findings.

In the current study, the Y-chromosome gene pool of Kurdish individuals showed a diverse genetic background (T, BT, E1b, G, I1, J, L, N, Q, R1a, and R1b). Table 2. Hg T is associated with West Asia (also called Southwest Asia, the Near East, or the Middle East) (Mendez *et al*., 2011), while Hg BT and E1b are associated with Africa (Cruciani *et al*., 2011, Secondini *et al*., 2011). Hg G is associated with neighbouring Eastern Anatolia, Armenia, and Western Iran (Rootsi *et al*., 2012), while Hg I1 is linked to Europe (Karafet *et al*., 2008). Hg J is associated with West Asia (the Arabian Peninsula/Yemen) (Ambrosio *et al*., 2010) and Hg L is linked to West Asia (Magoon *et al*., 2013). Hg N is associated with Southeast Asia (Rootsi *et al*., 2007) or Africa (Winters, 2010), and Hg Q is linked to Asia or southwest Siberia (Sharma *et al*., 2007, Grugni *et al*., 2019). Hg R1a is linked to West Asia or the Middle East, possibly near present-day Iran (Underhill *et al*., 2015), while Hg R1b is linked to West Asia (Myres *et al*., 2011) (Table 2 and Fig. 9).

According to the present result, the most common Hg are J, R1b, G, E, and T. These haplogroups are shared among Kurds with similar frequencies. This suggests that the Kurdish population has a long genetic exchange and admixture history. In the present study, an examination of the Y-chromosome gene pool among Kurds revealed the following: The J Hg is the most prevalent, at about 40% of the population. R Hg accounts for roughly 17–25% (primarily R1b), followed by G or E Hg. Kurds share significantly similar frequencies of the Hg (Table 2 and Fig. 9). Several studies have examined the genetic diversity of the Kurdish population, including studies of both the Y-chromosome and mitochondrial DNA. One of these studies was about Sorani Kurds, and the result showed that Hg J and R are the most common among Kurds, with frequencies of

around 40% and 20%, respectively (Albarzinji *et al*., 2022). The predominant Hg (J, R, and E) are among Kurds, with frequencies that are similar to those found in neighbouring populations in the Middle East (Table 2 and Fig. 9), indicating that the Kurdish people have experienced a significant amount of gene flow from other populations. Various study and academic works, such as those by Izady (1992) and Van Bruinessen (1992), reveal that the Kurdish people are believed to have heterogeneous roots, combining several earlier tribal or ethnic groups (Van Bruinessen, 1992, Izady, 1992). Gunter (2004) stated that regardless of the exact origin of the Kurds, it is evident that today's Kurds are a mixture of several groups due to earlier invasions and migrations.

Most Kurds belong to Y-DNA J haplogroup, which is usually linked to the Middle East and thought to have come from Mesopotamia's Fertile Crescent region. It has been found at high frequencies in many populations of the region, including Kurds, Arabs, Persians, Turks, and Jews. Followed by R, G, and E Hg, which are found at frequencies of 10–17% for each Hg. While Kurdish haplogroups L, N, Q, BT, and I1 ranged between 0.5 and 3%, they showed minor fractions in these regions: West Asia (L), Southeast Asia or Africa (N), Asia or southwest Siberia (Q), Africa (BT), and Europe (I1). It's interesting to note that there are little differences in haplogroup frequencies observed among all Kurd samples from different regions. Despite the variety of samples from all parts of greater Kurdistan, the results revealed close genetic relationships among them. This suggests a high degree of genetic homogeneity among Kurds, which is consistent with their shared history and cultural heritage (Table 2, Fig. 9).

5. CONCLUSION

In conclusion, based on the findings of this study, the genetic diversity of Kurds appears to be complex, that there is a high degree of admixture among different ethnic groups, and that other methods such as anthropological analysis and historical records are necessary for a better understanding of the relationship between different population genetic histories and their genetic histories. By combining these approaches, scientists can gain a more comprehensive understanding of the complex interactions and migrations that have shaped human populations over time. Further research is required.

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