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Investigating knowledge and attitudes toward genetic testing and counseling among palestinians

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Genetic testing is important in the diagnosis of genetic disorders. Genetic counseling integrates the interpretation of the results of genetic testing to reach informed decisions concerning genetic disorders. Palestine has an increased incidence of genetic disorders primarily due to the continued practice of consanguineous marriage. Nevertheless, limited research has been conducted to explore public awareness regarding genetic testing and genetic counseling. The current study aimed to assess the public knowledge, attitudes, and practices of Palestinians toward genetic testing and genetic counseling. A cross-sectional study was performed using an online questionnaire that gathered information from Palestinians whose ages were 18 years or older between April and July 2024. The questionnaire gathered demographic information about the participants and assessed their genetic test usage patterns and their knowledge, practices, and attitudes toward genetic testing and counseling. A total of 1056 participants (408 males and 648 females) completed the questionnaire. The mean age of participants was 31.18 years. Sixty-seven point 6% of the participants reported their knowledge about the term genetic testing; however, only 35.5% of them knew the term genetic counseling. Knowledge of genetic testing was significantly associated with younger ages, higher levels of education, and higher income ($p < 0.05$). Knowledge of genetic counseling was significantly associated with higher income and was more familiar among married participants and those who underwent routine check-ups. Only 9% indicated that they underwent genetic testing which was higher among older ages, married participants, among those undergoing routine check-ups, and among participants who had hereditary disorders in their families. Among the 95 participants who had genetic tests, 52.6% of them performed it for marriage. Other reasons for undergoing genetic testing were diagnosis (22.1%), followed by carrier testing (17.9%), and predictive and pre-symptomatic testing (10.5%). Sixty-point-6% of respondents reported they would like to perform genetic testing as a predictive test for cancer risk. Participants with higher levels of education were more likely to perform cancer-predictive genetic testing ($p < 0.05$). Participants who were undergoing routine check-ups, those who had reported their health status as poor, and those who had hereditary disorders in their families were more likely to perform predictive cancer genetic testing. In conclusion, there is insufficient knowledge about genetic counseling among Palestinians. Despite the relatively good knowledge of genetic testing, this has not translated into appropriate practice. Genetic testing is still not widely practiced and the most common for performing it is pre-marriage testing rather than medical reasons. It is strongly recommended to increase awareness about genetic testing and genetic counseling among Palestinians. In particular, these programs should be directed toward people with lower levels of education, and toward families with a high degree of consanguinity and consequently a high incidence of genetic disorders.

Keywords Genetic testing, Genetic counseling, Consanguinity, Genetic disorders, Knowledge

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The term genetic testing refers to the examination of genetic material and the identification of the relationships of its variants with inherited genetic disorders[1]. Genetic testing helps in the accurate diagnosis, prognosis, selection of a therapy, and even the prevention of genetic diseases[2]. Genetic counseling can be defined as "the process of helping people understand and adapt to the medical, psychological, and familial implications of genetic contributions to diseases[3]. Genetic counseling integrates the interpretation of family history regarding genetic diseases and educates families and individuals about the inheritance patterns of genetic disorders, and the results of genetic testing to reach informed decisions and adaptations to the disorder or the risk of developing it. In recent years, there has been a surge in the popularity of genetic testing and genetic counseling due to their rapidly expanding and evolving applications in modern healthcare settings[4].

Nonetheless, there is a critical need for infrastructure, facilities, and health education that need further enhancement to promote public awareness regarding genetic testing and counseling[5]. Public knowledge and awareness are critical for the successful application of genetic testing and counseling in improving health and quality of life[6]. Understanding the factors that influence attitudes toward genetic testing is a critical concern in the genomic era. Several studies have shown that individual attitudes toward genetic testing are connected to their genomic literacy. As expected, a lack of knowledge about the importance of genetic testing and counseling contributes to an increase in the incidence of inherited diseases. In contrast, persons who are aware of genetic testing are more interested in undergoing them[7]. A previous study conducted on Arab Middle Eastern primary care practitioners revealed that the lack of knowledge and expertise about genetic testing was considered a major barrier against requesting such tests, thus education about genetic testing and counseling could be used to encourage the use of genetic services in the medical field[8].

Palestine has a high incidence of several genetic disorders, likely due to the high rates of consanguineous marriages[9,10]. Nevertheless, there is limited research regarding the public awareness of genetic testing in Palestine[11]. A recent study concluded that Palestinian university students' genetic knowledge and genetic familiarity were inadequate[10]. According to a recent survey, the genetic familiarity and knowledge of Palestinian university students were inadequate. Another recent study examined the lack of public awareness of the contribution of genetic testing to the reduction of genetic diseases, and it was conducted in the Palestinian community in a major city in the West Bank[12]. Genetic counseling has not been previously addressed in the Palestinian context. An update on the public knowledge and applications of genetic testing and counseling is necessary to fill this knowledge gap and to create conditions that enable decision-makers to plan for the prevention and reduction of the incidence of genetic disorders. This study aimed to examine the public's knowledge and attitudes regarding genetic testing and genetic counseling in Palestine, as well as their potential to use genetic testing for identifying cancer risk. This is the first study that investigated community knowledge about genetic testing and genetic counseling at the national level in Palestine.

Methodology

Study design

A cross-sectional questionnaire-based study was conducted from April to July 2024 to assess knowledge, attitudes, and practices regarding genetic testing and counseling in Palestine.

Study setting

The study involved a population survey of Palestinians aged 18 years and older. The population included individuals from all governorates of the West Bank in Palestine. The participants in this study were targeted from different settings across the West Bank in Palestine to ensure a representation of the population. Participants were recruited by selecting individuals from local community centers, universities, and social media platforms. The questionnaire was shared and targeted at people and friends, including researchers' accounts, to connect with a larger number of participants from the community, allowing for a deeper understanding of the study's findings within the context of Palestinian society.

Study instrument

A web-based questionnaire, administered through Google Forms, was used to survey participants. The questionnaire included a consent form which introduced the study's objectives and assured that participation is voluntary and that data would be evaluated and analyzed anonymously. The questionnaire consisted of four sections. Section One collected demographic information, including gender, age, academic level, economic status, marital status, the presence of parental consanguinity, as well as whether the participant performs routine check-ups, suffers from a genetic disorder, or has a family history of a genetic disorder. The participants were also asked to rate their health compared to people of the same gender and age. Section two focused on participants' knowledge about genetic testing and counseling and whether they had undergone a genetic test. Section three was designed for participants who have had genetic tests and they were asked about the test type, request source, the presence of consenting step before testing and the its form, and their satisfaction with the test. The last section explored participants' attitudes toward performing genetic testing for cancer diagnosis in the future, attitudes were measured using a 4-point Likert scale with scores ranging from ''very likely" to ''very unlikely". The Arabic version of the validated questionnaire, developed by Ahram, Soubani, Abu Salem, Saker, & Ahmad was distributed electronically to participants[13].

Sampling methods

The participants were targeted using various methods, including recruitment through local community centers, universities, and social media platforms. Efforts included sharing the survey link widely, leveraging researchers' networks, and engaging with the community through various platforms to maximize participation and representation.

Sample size
The sample size was calculated using the Raosoft formula (www.raosoft.com), which utilized a reference proportion of 50%, a 95% confidence interval, and a 5% margin of error. We set the sample size at 385 to effectively represent the broader population and accommodate potential non-response errors. Ultimately, 1056 respondents participated in the study. Selecting a large sample size to boost analytical power and accurately reflect the differences in the study population. Despite the calculated sample size being smaller than the chosen one, this was done to enhance the quality and reliability of the results and a more thorough comprehension of the population.

Statistical analysis
The data were entered and analyzed using the Social Sciences Statistical Package (SPSS) version 21, by IBM Corp., Armonk, N.Y., USA. The sample was tested for normality The sample was tested for normality using the Kolmogorov-Smirnov test, and it was found to be normally distributed. A pilot study was carried out to evaluate the reliability of the questionnaire and it was found to be reliable (Cronbach alpha: 0.73). Descriptive statistics were used to report sample characteristics (frequencies and percentages). Pearson correlation coefficient and Chi-square were used to assess the relationship between the demographic variables and the attitudinal statements regarding genetic testing, genetic counseling, performing genetic tests, and the probability of conducting genetic testing for cancer. Pearson correlation was used for the associations that involved ordinal variables such as age group, level of education, and family income level, while Chi-square was used for nominal variables such as gender and marital status. The Pearson correlation coefficient was also utilized to assess the relationship between consent and the level of satisfaction with the service received. A p-value of less than 0.05 was considered significant.

Ethical approval
All aspects of the study protocol were approved by the An-Najah National University Institutional Review Board (IRB), Nablus, Palestine (Ref: Med. April 2024/12). The study complied with the Declaration of Helsinki guidelines for the use of data from human subjects. The participants provided informed consent prior to their participation. The informed consent form explained the premise of the study and ensured the anonymity of the participants and the confidentiality of the data.

Results
Knowledge of genetic testing and genetic counseling
Knowledge of genetic testing and genetic counseling was assessed among 1056 Palestinians. The respondents had a mean age of 31.18 ± 14.27. 67.6% of participants reported being familiar with the term genetic testing; however, only 35.5% of them were familiar with the term genetic counseling (Table 1). Knowledge of genetic testing was significantly associated with younger ages, higher educational levels, and higher income ($p < 0.05$). Additionally, the genetic testing term was more familiar to females, married participants, and those undergoing routine check-ups ($p < 0.05$). Knowledge of genetic counseling was significantly associated with higher income and was more familiar among married participants and those who are doing routine check-ups ($p < 0.05$). The Results are presented in Table 1.

Undergoing genetic testing
In the studied sample, 9% indicated that they underwent genetic testing. Undergoing genetic testing was significantly associated with older ages and negatively with the level of education ($p < 0.001$), but was not associated with income or health status. Additionally, undergoing genetic testing was significantly higher among married individuals, those undergoing routine check-ups, those with hereditary disorders in their families, and as expected those who knew about genetic testing and counseling ($p < 0.001$). However, undergoing genetic testing was not affected by gender and the parents' relativity (Table 2).

Reasons, request source, consenting and satisfaction of genetic testing
Among the 95 participants who had genetic tests, 52.6% of them performed it for marriage. Other reasons for undergoing genetic testing were diagnosis (22.1%), followed by carrier testing (17.9%), and predictive and pre-symptomatic testing (10.5%). 9.5% of the participants performed genetic testing for other purposes, and only 7.4% did not know the reason for their genetic testing. More than a third of the participants underwent genetic testing as a request from the court for marriage purposes, 28.4% performed genetic testing as a request from a specialist physician, 12.6% from a clinical geneticist, 10.5% of individuals performed testing on their own, 8.4% as a request from a general physician, only two respondents did not know who requested the genetic test, and one respondent underwent testing as a request from a genetic counselor. Consent is an important process before genetic testing. However, 14.7% of the respondents were not consented at all. 77.9% consented either verbally (30.5%), in writing (17.7%), or both (29.5%). 7.4% of the respondents did not remember if they were consented. Even though 7.4% of the participants were not satisfied with the privacy they received during the genetic testing procedure, the majority of respondents were satisfied (86.3%). 6.3% did not know if they were satisfied or not. Results are shown in Table 3. There was no significant association between satisfaction and consenting or demographic factors (Data are not shown).

Genetic testing for cancer
All respondents were asked the probability of performing genetic testing to determine their risk of developing cancer. As shown in Table 4., 60.6% of respondents reported they would like to perform genetic testing as a predictive test for cancer risk. However, 39.4% were unlikely to perform this genetic testing. Participants with

Have you ever heard about:	Genetic testing?		Genetic counselors?	
	No (%)	Yes (%)	No (%)	Yes (%)
Total responses (1056)	342 (32.4)	714 (67.6)	681 (64.5)	375 (35.5)
Gender				
Male (408)	167 (40.9)	241 (59.1)	270 (66.2)	138 (33.8)
Female (648)	175 (27)	473 (73)	411 (63.4)	237 (36.6)
χ2 (P)	**22.17 (<0.001)**		0.83 (0.363)	
Age group				
18–29 (629)	193 (30.7)	436 (69.3)	402 (63.9)	227 (63.1)
30–39 (174)	55 (31.6)	119 (68.4)	108 (62.1)	66 (37.9)
40–49 (117)	34 (29.1)	83 (70.9)	77 (65.8)	40 (34.2)
50–59 (80)	22 (27.5)	58 (72.5)	51 (63.8)	29 (36.3)
60 and more (56)	38 (67.9)	18 (32.1)	43 (76.8)	13 (23.2)
r (P)	**-0.098 (0.001)**		-0.04 (0.189)	
Level of education				
Less than secondary school (57)	23 (40.4)	34 (59.6)	31 (54.4)	26 (45.6)
Secondary school (99)	45 (45.5)	54 (54.4)	70 (70.7)	29 (29.3)
Bachelor or diploma (780)	246 (31.5)	534 (68.5)	523 (67.1)	257 (32.9)
Higher education (120)	28 (23.3)	92 (76.7)	57 (47.5)	63 (52.5)
r (P)	**0.103 (0.001)**		0.046 (0.134)	
Family income				
less than 2000 (353)	126 (35.7)	227 (64.3)	240 (68)	113 (32)
2000–3999 (332)	112 (33.7)	220 (66.3)	227 (68.4)	105 (31.6)
4000–6000 (220)	64 (29.1)	156 (70.9)	137 (62.3)	83 (37.7)
More than 6000 (151)	40 (26.5)	111 (73.5)	77 (51)	74 (49)
r (P)	**0.071 (0.021)**		**0.11 (<0.001)**	
Marital status				
Single (577)	197 (34.1)	380 (65.9)	391 (67.8)	186 (32.2)
Married (438)	118 (26.9)	320 (73.1)	256 (58.4)	182 (41.6)
Others (41)	27 (65.9)	14 (34.1)	34 (82.9)	7 (17.1)
χ2 (P)	**27.72 (<0.001)**		**15.77 (<0.001)**	
Undergoing routine check-ups				
No (687)	264 (38.4)	423 (61.6)	483 (70.3)	204 (29.7)
Yes (369)	78 (21.1)	291 (78.9)	198 (53.7)	171 (46.3)
χ2 (P)	**32.77 (<0.0001)**		**29.05 (<0.001)**	

Table 1. Knowledge of the Palestinian population of genetic testing and genetic counselors.

higher levels of education were more likely to perform cancer-predictive genetic testing ($p < 0.05$). Participants who were undergoing routine check-ups, those who had reported their health status as bad, and those who had hereditary disorders in their families were more likely to perform predictive cancer genetic testing ($p < 0.05$). There was no significant association between the likelihood of performing predictive cancer genetic testing and gender, age, income, marital status, previous knowledge of genetic testing, genetic counselor, or the presence of relativity between parents. Results are shown in Table 4.

Discussion

The current study explored the knowledge and attitudes of the Palestinian population about genetic testing and addressed the public knowledge about genetic counseling. In a country where genetic disorders are prevalent, these subjects often fall short of health priorities due to the limited or non-existent availability of national genetic resources.

Notably, the current results indicated that more than two-thirds of the studied sample were aware of genetic knowledge. However, only about one-third of the participants heard of genetic counseling. This is a disquieting outcome because, even though genetic testing is important for identifying genetic disorders, accompanying genetic counseling is essential to reducing the burden of genetic disorders in society[14]. A previous Palestinian study reported a good public level of knowledge about genetic disorders. However, this study included a small sample, which included parents of children affected by genetic disorders[11]. A recent study reported a good level of genetic testing among the Palestinian population, but it was based on a sample from a single large city[12]. The current study included a larger sample at the national level. These studies, as well as international ones, concluded that despite relatively good knowledge of genetic testing, this knowledge has not consistently translated into positive attitudes and decisions concerning genetic disorders[5]. A significant and novel finding from the

Did you ever undergo a genetic test?	No (%)	Yes (%)
Total responses (1056)	961 (91)	95 (9)
Gender		
Male (408)	363 (89)	45 (11)
Female (648)	598 (92.3)	50 (7.7)
χ2 (P)	3.36 (0.067)	
Age group (years)		
18–29 (629)	599 (95.2)	30 (4.8)
30–39 (174)	150 (86.2)	24 (13.8)
40–49 (117)	92 (78.6)	25 (21.4)
50–59 (80)	73 (91.3)	7 (8.8)
60 and more (56)	47 (83.9)	9 (16.1)
r (P)	**0.144 (<0.001)**	
Level of education		
Less than secondary school (57)	40 (70.2)	17 (29.8)
Secondary school (99)	87 (87.9)	12 (12.1)
Bachelor or diploma (780)	729 (93.5)	51 (6.5)
Higher education 120)	105 (87.5)	15 (12.5)
r (P)	**-0.116 (<0.001)**	
Family income (Dollar)		
less than 538.5 (353)	332 (94.1)	21 (5.9)
538.5–1076 (332)	292 (88)	40 (12)
1077-1615.5(220)	207 (94.1)	13 (5.9)
More than 1615.5 (151)	130 (86.1)	21 (13.9)
r (P)	0.06 (0.053)	
Marital status		
Single (577)	562 (97.4)	15 (2.6)
Married (438)	361 (82.4)	77 (17.6)
Others (41)	38 (92.7)	3 (7.3)
χ2 (P)	**68.4 (<0.001)**	
Undergoing routine check-ups		
No (687)	648 (94.3)	39 (5.7)
Yes (369)	313 (84.8)	56 (15.2)
χ2 (P)	**26.46 (<0.001)**	
Knowledge of genetic testing		
No (342)	329 (96.2)	13 (3.8)
Yes (714)	632 (88.5)	82 (11.5)
χ2 (P)	**16.67 (<0.001)**	
Knowledge of genetic counselor		
No (681)	648 (95.2)	33 (4.8)
Yes (375)	313 (83.5)	62 (16.5)
χ2 (P)	**40.35 (<0.001)**	
How would you rate your health status in comparison to others of your same age and gender?		
Very bad (12)	11 (91.7)	1 (8.3)
Bad (60)	52 (86.7)	8 (13.3)
Good (429)	388 (90.4)	41 (9.6)
Very good (472)	436 (92.4)	36 (7.6)
Excellent (83)	74 (89.2)	9 (10.8)
r (P)	-0.025 (0.413)	
Is there any hereditary disorder in the family?		
No (633)	592 (93.5)	41 (6.5)
Yes (423)	369 (87.2)	54 (12.8)

Continued

Did you ever undergo a genetic test?	No (%)	Yes (%)
$\chi 2$ (P)	**12.25 (<0.001)**	
Are your parent's relatives?		
No (733)	669 (91.3)	64 (8.7)
Yes (323)	292 (90.4)	31 (9.6)
$\chi 2$ (P)	0.21 (0.65)	

Table 2. The practice of genetic testing.

Reasons for undergoing genetic testing:	Frequency (%)
1. Diagnosis	21 (22.1)
2. Carrier testing	17 (17.9)
3. Predictive and pre-symptomatic testing	10 (10.5)
4. Pre-marriage testing	50 (52.6)
5. Do not know	7 (7.4)
6. Other test	9 (9.5)
The genetic test request is from:	
1. No one	10 (10.5)
2. General physician	8 (8.4)
3. Specialist physician	27 (28.4)
4. Clinical genetics	12 (12.6)
5. Genetic counselor	1 (1.1)
6. Court-for-marriage	35 (36.8)
7. Do not know	2 (2.1)
Consenting to perform the genetic test	
1. No	14 (14.7)
2. Yes, verbal consent	29 (30.5)
3. Yes, written consent	17 (17.9)
4. Yes, verbal and written consent	28 (29.5)
5. I do not know	7 (7.4)
Satisfaction of genetic testing:	
1. Very satisfied	28 (29.5)
2. Satisfied	54 (56.8)
3. Unsatisfied	6 (6.3)
4. Very Unsatisfied	1 (1.1)
5. I do not know	6 (6.3)

Table 3. Descriptive statistics of reasons, request source, consenting, and satisfaction of genetic testing ($n = 95$).

current study is that the general public has little knowledge of genetic counseling. This finding requires careful consideration because the public's degree of awareness of genetic counseling influences access to genetic services as well as understanding and interpreting genetic testing results. Low public knowledge about genetic counseling has previously been recorded, even in wealthy countries such as the United States[15], Canada[6], Australia[16], and European countries[17]. Notably, a recent Indian study found that even clinicians have low knowledge of genetic counseling[14].

Our data showed that knowledge of genetic testing was significantly higher among females, younger individuals, married persons, those with higher education, and income, and those who had routine checkups. Genetic testing is used to address health issues, particularly those related to prenatal care and children's future outcomes, and generally, women tend to be more concerned about health issues. Several earlier local and worldwide surveys found that females demonstrated a stronger interest in health and genetic testing compared to males[18–21]. The association of better knowledge of genetic testing among younger people, educated and married, is expected, as these issues raise concerns regarding marriage, pregnancy, and the future health of their children and themselves. Better genetic testing knowledge comes with better income, as also reported in a recent study from Jordan[22]. This could be explained by the fact that people with low income have less access to the resources for genetic knowledge and services. Because most Palestinians have low incomes and high rates of genetic disorders due to consanguineous marriages and inbreeding, this is concerning. This may discourage people from performing genetic testing. Approximately one-third of the study participants reported parental consanguineous marriage which is nearly similar to the percentage reported in a previous study conducted

	Very unlikely (%)	Unlikely (%)	Likely (%)	Very likely (%)
Total responses (1056)	95 (9)	321 (30.4)	469 (44.4)	171 (16.2)
Gender				
Male (408)	42 (10.3)	122 (29.9)	182 (44.6)	62 (15.2)
Female (648)	53 (8.2)	30.7 (321)	287 (44.3)	109 (16.8)
r (P)	0.029 (0.348)			
Age group				
18–29 (629)	56 (8.9)	196 (31.2)	286 (45.5)	91 (14.5)
30–39 (174)	14 (8)	51 (29.3)	80 (46)	29 (16.7)
40–49 (117)	11 (9.4)	31 (26.5)	53 (45.3)	22 (18.8)
50–59 (80)	6 (7.5)	29 (36.3)	33 (41.3)	12 (15)
60 and more (56)	8 (14.3)	14 (25)	17 (30.4)	17 (30.4)
r (P)	0.027 (0.372)			
Level of education				
Less than secondary school (57)	7 (12.3)	28 (49.1)	10 (17.5)	12 (21.1)
Secondary school (99)	11 (11.1)	31 (31.3)	41 (41.4)	16 (13.2)
Bachelor or diploma (780)	68 (8.7)	233 (29.9)	363 (46.5)	116 (14.9)
Higher education 120)	9 (7.5)	29 (24.2)	55 (45.8)	27 (22.0
r (P)	**0.081 (0.008)**			
Family income				
less than 2000 (353)	28 (7.9)	121 (34.3)	151 (42.80	53 (15)
2000–3999 (332)	36 (10.8)	92 (27.7)	148 (44.6)	56 (16.9)
4000–6000 (220)	22 (10)	60 (27.3)	98 (44.5)	40 (18.2)
More than 6000 (151)	9 (6)	48 (31.8)	72 (47.7)	22 (14.6)
r (P)	0.028 (0.36)			
Marital status				
Single (577)	49 (8.50	178 (30.8)	261 (45.2)	89 (15.4)
Married (438)	39 (8.9)	134 (30.6)	196 (44.7)	69 (15.8)
Others (41)	7 (17.1)	9 (22)	12 (29.3)	13 (31.7)
r (P)	0.009 (0.78)			
Undergoing routine check-ups				
No (687)	66 (9.6	223 (32.5)	304 (44.3)	94 (13.7)
Yes (369)	29 (7.9)	98 (26.6)	165 (44.7)	77 (20.90
r (P)	**0.093 (0.002)**			
Knowledge of genetic testing				
No (342)	39 (11.40	100 (29.2)	154 (45)	49 (14.3)
Yes (714)	56 (7.8)	221 (31)	315 (44.1)	122 (17.10
$\chi 2$ (P)	4.61 (0.203)			
r (P)	0.045 (0.144)			
Knowledge of genetic counselor				
No (681)	70 (10.3)	206 (30.20	296 (43.50	109 (16)
Yes (375)	25 (6.7)	115 (30.7)	173 (46.1)	62 (16.5)
r (P)	0.041 (0.18)			
How would you rate your health status in comparison to others of your same age and gender?				
Very bad (12)	2 (16.7)	2 (16.7)	3 (25)	5 (41.7)
Bad (60)	2 (3.3)	19 (31.7)	25 (41.7)	14 (23.3)
Good (429)	33 (7.7)	130 (30.3)	196 (45.7)	70 (16.3)
Very good (472)	41 (8.70	142 (30.1)	215 (45.6)	74 (15.70
Excellent (83)	17 (20.5)	28 (33.7)	30 (36.1)	8 (9.6)
r (P)	**-0.01 (0.001)**			
Is there any hereditary disorder in the family?				
No (633)	60 (9.5)	208 (32.9)	281 (44.4)	84 (13.3)
Yes (423)	35 (8.3)	113 (26.70	188 (44.4)	87 (20.6)
Continued				

	Very unlikely (%)	Unlikely (%)	Likely (%)	Very likely (%)
r (P)	**0.091 (0.003)**			
Are your parent's relatives?				
No (733)	66 (9)	222 (30.3)	325 (44.3)	120 (16.4)
Yes (323)	29 (9)	99 (30.7)	144 (44.6)	51 (15.8)
r (P)	-0.005 (0.875)			

Table 4. Probability of undergoing genetic testing for cancer.

among Palestinian university students, which also found that low genetic knowledge is associated with a higher consanguinity rate[10]. As expected, although genetic testing is not part of routine checkup programs in Palestine; the knowledge of genetic testing was positively correlated with the performance of routine checkups[23]. Despite this, it is clear that individuals who undergo routine checkups have better knowledge about genetic testing and this could be used as an efficient method for community awareness at medical laboratories.

Significantly, genetic counseling did not show the previously mentioned significant associations with the level of knowledge about genetic testing. This is anticipated by the Palestinian health system, as genetic counseling is a novel concept. Genetic counseling is not yet widely practiced or well-known. Genetic counseling was significantly associated with higher education, marital status, and routine checkups. This suggests that genetic counseling is increasing for those who have enough access to genetic facilities and for those who need it for marriage and health issues.

A key aim of this study is to identify the attitudes of the Palestinians towards genetic testing and counseling. A minority of the studied sample performed genetic testing. Those who have undergone routine checkups are significantly more likely to undergo genetic testing. This finding underscores the importance of primary healthcare workers in educating individuals about genetic testing. Including genetic counselors and geneticists in routine checkups is important for integrating medical genetics into primary health care to help identify and manage people who are at increased risk of having genetic disorders. Expectedly, the presence of family members with inherited disorders positively encouraged genetic testing. However, the presence of parental consanguinity did not affect people's attitudes toward performing genetic testing, despite the well-ascertained role of parental consanguinity in the appearance of genetic disorders in general, mainly autosomal recessive disorders[24]. This is worrying as it indicates that people's knowledge about the health impact of consanguinity is still lacking. These findings contrast with what was found in a recent study from Sudan[25], but they align with other studies that found a low level of awareness of people toward consanguinity[9].

The current study revealed that medical reasons have not been the main focus for performing genetic testing. Indeed, the primary reason for the vast majority of those who performed genetic testing was the marriage issues as requested by the court. These findings indicate that the public's awareness of genetic testing may not necessarily translate into practical applications in this field. These results are in accordance with a recent study performed on the Jordanian population[26]. Even though verbal and/or written consent was taken from the majority of people who had undergone genetic testing before testing, 14.7% of them had not given consent to perform genetic testing. Defining the core concepts necessary for informed consent for genetic testing establishes a foundation for quality patient care across a variety of healthcare providers and clinical indications[27]. Informed consent is a fundamental component of the ethical practice of both clinical care and clinical research, and unique features of genetic testing introduce ethical complexities to informed consent[28,29]. Nevertheless, the majority of participants were satisfied with performing the genetic testing.

Cancer is a global health problem worldwide and poses a major challenge to the Palestinian health system[30]. A recent study reported that approximately 10–30% of cancer cases in Palestine were attributed to genetic defects[31]. These findings highlight the importance of performing genetic testing for cancer prediction. The current study found that more than half of the participants were willing to perform predictive tests for cancer risk. This willingness was significantly associated with regular checkups. This highlights the importance of integrating genetic awareness about cancer during these checkups. Notably, having family members with hereditary disorders encouraged participants to perform cancer-predictive tests. This is significant because it could indicate that Palestinians are beginning to comprehend the connection between cancer and genetic defects. However, the presence of consanguinity did not affect the participants' attitudes. Many studies indicate that consanguinity has little or no effect on the incidence of cancer[32]. Some studies suggest that consanguinity increases the risk of certain rare cancers[33,34], while other studies found that consanguinity has a protective effect against breast cancer[35]. However, several studies revealed an association between genetic variants and breast cancer and the identification and screening of those variants could improve clinical management strategies for women with inherited pathogenic variants in the general population[36,37].

The current study highlighted a vital topic by investigating the Palestinians' knowledge, attitudes, and practices regarding genetic testing and genetic counseling. Nevertheless, the study had some limitations. First, misreporting and recall bias should be considered because the questionnaire was self-reported. Second, the study's cross-sectional nature makes it difficult to establish cause-and-effect relationships. Third, using online questionnaire might have led to sampling bias as participants may be overrepresented in terms of literacy and internet access, which could lead to the more positive results concerning the level of awareness toward genetic testing and genetic counseling. So as to reduce the sampling bias we distributed the questionnaire by various online channels to improve its visibility among the participants, and by the large sample size enrolled in the current study (1056 while the minimal calculated sample size was 385). It is noteworthy that using an

anonymous online questionnaire could help participants to answer honestly with more accurate answers about issues like genetic testing as this topic is sensitive and families with affected members with genetic disorders still feel stigmatized and have concerns about their future generations.

Conclusion

In conclusion, Palestinians have good knowledge of genetic testing, which has been significantly associated with performing routine health check-ups. However, there is a gap in knowledge about genetic counseling. Notably, Palestinians' understanding of genetic testing has not led to effective practices for conducting genetic testing. Moreover, in most cases, genetic testing has been done for marriage rather than for medical purposes, and many participants did not provide consent before performing genetic testing. We strongly recommend initiating public awareness programs about the importance of genetic testing and genetic counseling particularly for those with low levels of education and income. It is also vital to integrate the role of genetic counselors and geneticists in primary health care services, especially to promote predictive genetic testing for cancer. Empowering genetic counselors is important as they can provide services not only to patients but also to their families and to the community. Further studies should be conducted in Palestine to explore the challenges to and autonomous effective genetic testing and counseling.

Data availability

The data supporting the findings of this study are available in the paper.

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Author contributions

MG and MR: conceptualization; MR: data analysis; MG: administration and supervision; All authors participated in data collection, manuscript writing, editing, and reviewing.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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