Knowledge and Awareness of Glucose -6-Phosphate Dehydrogenase Deficiency in Saudi Arabia

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ABSTRACT

Background: To ensure better early detection, appropriate treatment timing, and better prevention of triggering events, a broad health education program about Glucose-6-Phosphate Dehydrogenase Deficiency (G6PD) deficiency is needed. This study aimed to evaluate the public's knowledge and awareness level towards G6PD in Saudi Arabia.

Methods: This is a cross-sectional survey study that was conducted in Riyadh, Saudi Arabia between October 2023 and June 2024. Patients and visitors referring to IMAMU medical center in Riyadh, Saudi Arabia formed the study population. Convenience sampling technique was used to recruit the study participants. The questionnaire tool measured the population's knowledge level about G6PD, its anemic attack, and the disorder-triggering factors.

Results: A total of 214 participants were included in our analysis. The majority of participants (n= 84, 39.3%) believed that a child must have both parents as carriers to be affected by G6PD deficiency anemia. Most participants (n= 130, 60.7%) recognized G6PD deficiency as an inherited disorder. More than half of the participants (n= 118, 55.1%) believed they didn't have G6PD deficiency. The majority (n= 94, 43.9%) did not believe there was a link between the G6PD deficiency anemia and the gender of the baby. Most participants (n= 150, 70.1%) believed that neonatal diagnosis of G6PD deficiency anemia is beneficial for the child's care. Participants showed a similar response regarding whether certain medications could trigger an attack of G6PD deficiency anemia, with 88 participants (41.1%) responding "yes". Approximately half of the participants (n= 102, 47.7%) agreed that jaundice is one of the symptoms of G6PD deficiency anemia attack. None of the demographic variables showed a statistically significant association with knowledge scores.

Conclusion: The majority of the participants recognized G6PD deficiency as an inherited disorder. The majority of the participants demonstrated a satisfactory level of knowledge concerning G6PD and its risk factors. Continuous educational campaigns are warranted to increase public knowledge of the diseases and help in their prevention. Besides, ongoing screening campaigns for all genetic diseases are needed to decrease the probability of developing complications associated with these diseases.

Keywords: Awareness; Glucose-6-Phosphate Dehydrogenase Deficiency; Knowledge; Population; Saudi Arabia

INTRODUCTION

Glucose-6-phosphate dehydrogenase deficiency (G6PD) is an X-linked genetic disorder, and most people with G6PD deficiency have no symptoms [1]. However, when people eat beans or are exposed to certain diseases or medications, they can develop severe hemolytic anemia and severe jaundice during the neonatal period. Glucose-6-phosphate dehydrogenase deficiency is a global health problem [2, 3].

The relationship between glucose-6-phosphate dehydrogenase deficiency and hemolysis is still not fully understood. Glucose-6-phosphate dehydrogenase deficiency commonly affects more than 200 million people worldwide [4, 5]. Glucose-6-phosphate dehydrogenase (G6PD) is the only enzyme that has a role in determining the rate of the pentose phosphate pathway. Rapidly proliferating cells require G6PD metabolites to synthesize ribonucleotides and maintain intracellular redox balance [6].

Most studies confirm that more than 400 million people worldwide suffer from G6PD deficiency, which is the most common enzyme deficiency and has been observed to occur in areas where malaria is endemic [7]. Glucose-6-phosphate dehydrogenase deficiency, caused by an X-linked mutation, results in reduced activity of an enzyme essential for protecting cells from oxidative stress. In contrast, oxidizing drugs, infections, or ingestion of beans can cause acute hemolysis, which can lead to hemoglobinuria, anemia, lethargy, and jaundice. Therefore, studies suggest avoiding certain medications, such as methylene blue, primaquine, and rasburicase, unless a diagnostic test has been performed in advance [8]. In India, this disorder appears to be the most predictable and preventable inborn error of metabolism and Mediterranean has been observed to be the most common mutation with a severe phenotype and low enzyme activity [9].

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Glucose-6-phosphate dehydrogenase is an important enzyme that protects cells, especially red blood cells, from oxidative damage caused by reactive oxygen species (ROS). G6PD deficiency is a genetic condition and can lead to acute hemolytic anemia when ROS production is increased, due to stress, certain foods such as beans, or medications, especially antimalarials. Some common medications that can cause hemolytic crises in these patients are: acetaminophen, acetylsalicylic acid, chloroquine, sulfonamides, primaquine, and vitamin K. A comprehensive list is available from the Italian G6PD Deficiency Association [10]. Phenazopyridine, dapsone, toluidine blue, methylthioninium blue, nitrofurantoin, and rasburicase are the drugs for which there are definitive studies on contraindications for use in patients with G6PD deficiency. As for the rest of the drugs, there is no evidence contradicts their use at normal therapeutic doses in patients with G6PD deficiency [11]. Hemolysis in G6PD deficiency varies and is classified according to the proportion of enzyme deficiency to the extent of the deficiency [12].

To ensure better early detection, appropriate treatment timing, and better prevention of triggering events, a broad health education program about this disease is needed [13]. There is a lack of local research related to G6PD awareness in the Kingdom of Saudi Arabia. A previous study was conducted to assess parents' knowledge of the causes, inheritance patterns, triggers and symptoms of the disease and in an attempt to correct misinformation and increase community awareness of the disease, its symptoms, and complications. This study found a significant lack of knowledge and widespread misconceptions concerning G6PD [14]. A difference and disparity in awareness of this enzyme deficiency was noted among parents in the Kingdom of Saudi Arabia between the regions, with the central region showing the highest level of awareness [15]. The urgent need to raise awareness and avoid the potential and fatal consequences of enzyme deficiency has been the reason for the increase in this topic in several studies, as many families from all countries where G6PD deficiency is prevalent move to Western countries [16]. The aim of this study was to evaluate the public's knowledge and awareness level towards G6PD in Saudi Arabia.

METHODS

Study design

This is a cross-sectional survey study that was conducted in Riyadh, Saudi Arabia between October 2023 and June 2024.

Study population and sampling technique

Patients and visitors referring to IMAMU Medical Center in Riyadh, Saudi Arabia formed the study population. The inclusion criteria were individuals aged 18 years and older. We did not exclude the participants based on their gender or sociodemographic characteristics. The participants were recruited using a convenience sampling technique. Participants were invited to participate in the study and those who agreed to participate and were available were involved in this study.

Study tool

The questionnaire tool used in this study was derived from previous research [17]. The questionnaire is divided into two parts, the first section is general demographic data, and the second section is compromises of 20 questions that measure the population's knowledge level about G6PD, its anemic attack, and the disorder-triggering factors. Patients and people who participated in this research were notified that their answers would be anonymized and confidential, and informed consent was obtained before taking the survey.

Sample size

Based on survey monkey sample size calculator, using a 95% confidence interval, a standard deviation (SD) of 0.5, and an error margin of 5%, the minimum required sample size is 385 individuals.

Ethical approval

Ethical approval for this study was obtained from the Institutional Review Board at Al-Imam Muhammad Ibn Saud Islamic University, Riyadh, Saudi Arabia (Ref: 553/2023).

Data analysis

Statistical methods were used to analyze the data, including the calculation of descriptive statistics such as the frequency and percentage for categorical variables, the mean, the median, the standard deviation (SD), and the minimum and maximum for the continuous variables. The Kolmogorov-Smirnov test of normality was applied, and since the data supports parametric assumptions, the analysis of variance (ANOVA) and the independent t-test were performed when applicable. Multiple logistic regression was performed to assess the factors associated with the G6PD knowledge score as dependent variable. The results from the regression analyses are presented as odds ratios (OR) with 95% confidence intervals (CI) and corresponding p-values. The level of significance was defined as $\alpha = 0.05$. All calculations and analyses were carried out with the SPSS (Statistical Package of Social Sciences Demo Version 27.0) software program.

RESULTS

A total of 214 participants were included in our analysis. The majority of participants (n= 108,50.5%) were aged between 18 and 30 years, followed by those aged 31 to 50 years (n= 96, 44.9%). Most participants were female (n= 155, 72.4%), while males comprised 59 participants (27.6%). Regarding nationality, the majority were Saudi nationals (n= 195, 91.1%), with the remainder being non-Saudi. Only 12 participants (5.6%) had an inherited disease (5.6%). Additional details about participants' demographics are presented in Table 1.

Table 1. Demographic characteristics of study participants.

Variable		Frequency	Percentage
Age:	18-30 years	108	50.5%
	31-50 tears	96	44.8%
	50-70 years	10	4.7%
Gender	Female	155	72.4%
	Male	59	27.6%
Nationality	Non-Saudi	19	8.9%
	Saudi	195	91.1%
What is your level of education?	Bachelor/diploma	147	68.7%
	Graduate (master's/PhD)	16	7.5%
	Primary education	6	2.8%
	Secondary education	45	21.0%
Marital status	Divorced/Widower	7	3.3%
	Married	91	42.5%
	Single	116	54.2%
Do you have any inherited hematological disorder	No	202	94.4%
	Yes	12	5.6%

The table below presents participants' awareness of G6PD deficiency. A total of 85 participants (39.7%) reported having heard about fava bean anemia (G6PD deficiency) before. The majority of participants (n= 84, 39.3%) believed that a child must have both parents as carriers to be affected by G6PD deficiency anemia, while 70 participants (32.7%) disagreed. Most participants (n= 130, 60.7%) recognized G6PD deficiency as an inherited disorder. More than half of the participants (n= 118, 55.1%) believed they did't have G6PD deficiency, while 59 participants (27.6%) were uncertain. Additional details about awareness regarding G6PD deficiency are presented in Table 2.

Table 2. Awareness and Family History of G6PD Deficiency Anemia

Variable		Frequency	Percentage
Have you heard about fava bean anemia (G6PD deficiency)?	No	129	60.3%
	Yes	85	39.7%
Do you believe that for a child to be affected with G6PD deficiency anemia, both parents must be carriers?	No	70	32.7%
	Yes	84	39.3%
	I do not know	60	28.0%
Do you think G6PD deficiency is an inherited disorder?	No	34	15.9%
	Yes	130	60.7%
	I do not know	50	23.4%
Do you know if you have G6PD deficiency anemia?	No	118	55.1%
	Yes	37	17.3%
	I do not know	59	27.6%
Do you have a family history of G6PD deficiency anemia?	No	151	70.6%
	Yes	19	8.9%
	I do not know	44	20.6%

Regarding participants' knowledge and perception concerning G6PD deficiency, the majority (n= 94, 43.9%) did not believe there is a link between the G6PD deficiency anemia and the gender of the baby. Most participants (n= 150, 70.1%) believed that neonatal diagnosis of G6PD deficiency anemia is beneficial for the child's care. Participants showed a similar response regarding whether certain medications could trigger an attack of G6PD deficiency anemia, with 88 participants (41.1%) responding "yes" and 85 (39.7%) responding "I don't know". Approximately half of the participants (n= 102, 47.7%) agreed that jaundice is one of the symptoms of G6PD deficiency anemia attack. Additional details about one of the symptoms of G6PD deficiency anemia attack are provided in Table 3.

Table 3. Knowledge and Perceptions Regarding G6PD Deficiency Anemia

Variable		Frequency	Percentage
Is the gender of the baby linked to G6PD deficiency anemia?	No	94	43.9%
	Yes	48	22.4%
	I do not know	72	33.6%
Do you presume that the neonatal diagnosis of G6PD deficiency anemia is beneficial to your child's care?	No	29	13.6%
	Yes	150	70.1%
	I do not know	35	16.4%
Can Fava beans trigger an attack of G6PD deficiency anemia?	No	49	22.9%
	Yes	101	47.2%
	I do not know	64	29.9%
Can certain medications trigger an attack of G6PD deficiency anemia?	No	41	19.2%
	Yes	88	41.1%
	I do not know	85	39.7%
Are nausea, vomiting, anorexia, and diarrhea symptoms of G6PD deficiency anemia attack?	No	48	22.4%
	Yes	83	38.8%
	I do not know	83	38.8%
Is pallor one of the symptoms of a G6PD deficiency anemia attack?	No	21	9.8%
	Yes	129	60.3%
	I do not know	64	29.9%
Is jaundice one of the symptoms of G6PD deficiency anemia attack?	No	48	22.4%
	Yes	102	47.7%
	I do not know	64	29.9%
Is shortness of breath one of the symptoms of a G6PD deficiency anemia attack?	No	63	29.4%
	Yes	88	41.1%
	I do not know	63	29.4%
Do you think that a laboratory test for G6PD deficiency anemia is included in premarital testing?	No	61	28.5%
	Yes	74	34.6%
	I do not know	79	36.9%
Do you believe that G6PD deficiency anemia can lead to death or handicap?	No	77	36.0%
	Yes	71	33.2%
	I do not know	66	30.8%

The total mean score for knowledge was 5.46±2.76, ranging from a minimum of 0 to a maximum of 12. The table below presents the statistics for knowledge scores across the demographic characteristics of the participants.

Table 4. Knowledge Scores Regarding G6PD Deficiency Based on Demographic Characteristics

Variable		Mean ± SD	Median (Min-Max)	P-value
Age:	18-30 years	5.32±2.90	5.00 (0.00-12.00)	0.54
	31-50 years	5.52±2.70	5.00 (0.00-12.00)	
	51-70 years	6.30±1.57	7.00 (3.00-8.00)	
Gender	Male	5.17±2.60	5.00 (0.00-12.00)	0.37
	Female	5.57±2.82	5.00 (0.00-12.00)	
Nationality	Non-Saudi	5.42±2.14	5.00 (2.00-11.00)	0.95
	Saudi	5.46±2.82	5.00 (0.00-12.00)	
Education level	Bachelor	5.37±2.80	5.00 (0.00-12.00)	0.29
	Graduate	4.56±3.03	5.00 (0.00-9.00)	
	Primary	5.67±3.78	5.50 (1.00-12.00)	
	Secondary	6.02±2.35	6.00 (1.00-11.00)	
Marital status	Divorced/ Widowed	6.86±1.07	7.00 (5.00-8.00)	0.36
	Married	5.32±2.79	5.00 (0.00-12.00)	
	Single	5.48±2.80	5.00 (0.00-12.00)	
Do you have any inherited hematological disorder	No	5.37±2.73	5.00 (0.00-12.00)	0.04
	Yes	7.00±2.95	7.00 (2.00-12.00)	

Logistic regression analysis was conducted to examine the association between demographic characteristics and knowledge scores. None of the demographic variables showed a statistically significant association

with knowledge scores. Participants with inherited disorders had an odds ratio of 1.53 (95% CI: 0.46–5.13, p = 0.48) compared to those without inherited disorders, but this result was not statistically significant.

Table 5. Logistic regression analysis of demographic characteristics and knowledge scores

Variable		OR (95% CI)	P-value
Age	18-30 years	Reference	
	31-50 years	0.96 (0.47–1.97)	0.917
	51-70 years	2.33 (0.47–11.63)	0.301
Gender	Male	Reference	
	Female	0.88 (0.47–1.63)	0.679
Nationality	Non-Saudi	Reference	
	Saudi	1.47 (0.51–4.21)	0.473
Education level	Bachelor	Reference	
	Graduate	0.96 (0.31–2.97)	0.946
	Primary	0.93 (0.16–5.38)	0.939
	Secondary	1.80 (0.88–3.68)	0.105
Marital status	Divorced/ Widowed	Reference	
	Married	0.15 (0.02–1.36)	0.092
	Single	0.17 (0.02–1.52)	0.112
Do you have any inherited hematological disorder(s)	No	Reference	
	Yes	1.53 (0.46–5.13)	0.489

DISCUSSION

The main objective of this study is to determine people's awareness of G6PD deficiency. Based on the results that appeared in this study, the following was observed: most participants (39.3%) believed that both parents should be carriers of G6PD deficiency anemia. Most participants also acknowledged that G6PD deficiency anemia is a hereditary disease (60.7%). However, half of the participants did not believe that there was a relationship between G6PD deficiency anemia and the sex of the child, and most participants believed that the diagnosis of G6PD deficiency anemia would be helpful in the care of the child. Moreover, regarding whether certain medications cause G6PD deficiency anemia, 41.1% said they do. Nearly half of the participants (47.7%) agreed that jaundice is a symptom of G6PD deficiency anemia attacks. Moreover, participants with hereditary disorders had significantly higher knowledge scores than those without a hereditary condition.

In this study, participants with hereditary conditions had significantly higher knowledge scores than those without hereditary conditions, and most participants believed that both parents should be carriers of G6PD deficiency anemia (39.3%). In comparison to another study conducted in Saudi Arabia, the percentage of Saudis with this condition was 4.76% [18]. According to the results of the Saudi study, most mothers knew very little about G6PD deficiency anemia, and the majority of mothers had not heard of G6PD deficiency. Mothers who had received premarital counseling, had already undergone genetic testing, or had their children diagnosed with G6PD deficiency all scored statistically significantly higher than less educated mothers [18]. Therefore, these results indicate the importance of increasing awareness of this enzyme deficiency to avoid complications. Another study indicated the importance of establishing a newborn screening for G6PD deficiency and increasing public awareness and family counseling, about the disease, as the incidence of G6PD deficiency is very high in the Kingdom of Saudi Arabia and varies from one governorate to another. The prevalence of G6PD deficiency in the Kingdom of Saudi Arabia is 8.4% among males, as stated by the Saudi Ministry of Health. Therefore, early detection, characterization, and understanding of the phenotypic and molecular patterns of G6PD deficiency in the Kingdom of Saudi Arabia is essential for better management and control of the disease [19].

In this study, the results were about whether some medications cause G6PD deficiency anemia, (41.1%) said that they do. Almost half of the participants agreed that jaundice is a symptom of G6PD deficiency anemia attacks, and compared to another study conducted in Saudi Arabia, it was found that pallor was identified as a risk factor, as mothers included in the study who frequently consumed legumes were more susceptible to it than others. Therefore, the consumption of legumes and some medications are the reasons for the appearance of symptoms [18]. According to another study of the clinical features of four different age groups and the factors, it was found that some symptoms appeared only in specific age groups and the severity of symptoms is higher in younger children or pregnant women. On the other hand, other symptoms appeared in all patients such as jaundice, increased bilirubin, enlarged spleen, enlarged liver, discolored urine, rapid heartbeat, pallor, abdominal pain, distress, vomiting, nausea, and dizziness [20]. Based on the above, studies confirmed that the general symptoms of this condition are jaundice and pallor, and they appear in the event of consuming legumes or some types of medications that have an effect on this enzyme.

Participants with hereditary conditions showed significantly higher knowledge scores in this study than those without hereditary conditions. Another study was conducted in Saudi Arabia in 2017 and reported that there was low awareness of the causes and prevalence factors of G6PD deficiency and they had poor knowledge [15]. In one study in the Eastern Province of Saudi Arabia, 56.3% of people knew very little about the disease and about 58.3% knew a lot about genetic transmission, also 46.7% of respondents knew very little about the causes. Additionally, 81.3% of respondents knew little about the nutrition of those with G6PD deficiency, and 59.3% knew little about the diet of those with sickle cell disease. This study found that sickle cell patients have many misconceptions, especially regarding their nutrition [21]. In another study in North America, the relationship between foods, including food additives, and factors that stimulate acute hemolysis was examined. The findings reported that beans are the only food for which there is conclusive clinical evidence linking the risk of hemolytic anemia to individuals suffering from G6PD deficiency [22]. Thus, this evidence indicates that knowledge of this disease is relatively low among individuals from different countries, however, the knowledge is increasing among families suffering from the disease due to exposure to it because they have to avoid harmful symptoms.

In this study, most participants believed that both parents should be carriers of G6PD deficiency anemia. Most participants also agreed that G6PD deficiency anemia is a genetic disease. However, half of the participants did not believe that there was a relationship between

G6PD deficiency anemia and the sex of the child. In comparison to a previous study conducted in Bahrain, most participants had heard of sickle cell disease and knew that it could be diagnosed through blood tests, however, 51% did not know how common it was in Bahrain. The majority knew that it was a genetic condition and believed that it could be passed down through generations. Women were more knowledgeable than men, so there was a good level of knowledge about sickle cell disease among the general public. Sickle cell prevention campaigns implemented in Bahrain, such as pre-marital services and student screening programs, have been widely accepted and appreciated [23, 24]. A study was conducted in Saudi Arabia to assess parents' awareness of G6PD deficiency and identify misconceptions. It was found that the disparities in awareness among parents in Saudi Arabia are clear, while the central region showed the highest level of awareness [25]. According to the results of one study on thalassemia, 40.5% were aware that both parents must be carriers for a child to have beta-thalassemia, and 65.1% had heard about the condition. (77.8%) strongly felt that beta thalassemia could be avoided through premarital screening. Women were more knowledgeable than men and married people appeared to know more about beta thalassemia than unmarried people. Therefore, it is advisable to emphasize the importance of ongoing screening campaigns for all genetic diseases, with emphasis on student screening programs, premarital counseling, and newborn screening services [23, 24]. Therefore, it can be confirmed that most people in Saudi Arabia do not have sufficient awareness of G6PD and that premarital services, student screening programs, and educational and awareness programs specific to the region can raise awareness.

Most of the participants in this study believed that the diagnosis of G6PD deficiency anemia would be beneficial in childcare, in contrast to the remaining mothers who were not aware of G6PD deficiency anemia. Therefore, these results indicate that knowledge levels are low. Most of the participants also acknowledged that G6PD deficiency anemia is a genetic disease, and half of the participants did not believe that there was a relationship between G6PD deficiency anemia and the sex of the child. In contrast, 52.7% of mothers in another study reported that consanguineous marriage was a contributing factor to G6PD deficiency anemia, and 44.6% of mothers believed that the condition was serious [18]. This indicates that increasing awareness of this disease has a significant impact in reducing it, so health education programs for G6PD deficiency anemia are recommended to improve the prevention of pathogens.

In the current study, almost half of the participants agreed that jaundice is a symptom of G6PD deficiency anemia. Furthermore, participants with hereditary conditions had significantly higher knowledge scores than those without a hereditary condition. Most participants believed that diagnosing G6PD deficiency anemia would be helpful in childcare. In another study, 18.9% of mothers surveyed in Kfar Batanoun had adequate knowledge regarding neonatal jaundice, with a significant impact on age, parity, history, and educational background. Age and parity were significant factors; only 25.3% sought prompt care, while only 48.0% had a positive attitude. 95.8% of respondents were in favor of seeking medical help despite misunderstandings about the causes and complications [26]. The results reinforce the idea that common symptoms are well-known and the family who have a member with the disease significantly increases the family's knowledge of the disease compared to others.

There are some drawbacks to our study, such as the sampling strategy and being a single-center study, which might restrict the generalizability of our study findings. Besides, this is a cross-sectional study, which might limit the ability to examine causality among the study variables. Therefore, the study findings should be interpreted carefully.

CONCLUSION

The majority of the participants recognized G6PD deficiency as an inherited disorder. The majority of the participants demonstrated a satisfactory level of knowledge concerning G6PD and its risk factors. Continuous educational campaigns are warranted to increase public knowledge of the diseases and help in its prevention. Besides, ongoing screening campaigns for all genetic diseases are needed to decrease the probability of developing complications associated with these diseases.

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