



Knowledge, Attitudes, and Perceptions regarding Sick Cell Disease among Secondary School Students in Tawergha, a High-Prevalence Region of Libya: A Pilot Study

Sarah Mohamed Alfaqaih

Department of Pediatrics, Faculty of Medicine, University of Misurata, Alrwesat, Misurata 2478, Libya

Keywords:

Sickle cell disease
Awareness
Libya
Premarital screening

ABSTRACT

Background: Sickle cell disease (SCD) is a significant hereditary hematological disorder in Libya, with high prevalence in specific regions such as Tawergha. Despite this, Libya lacks a national awareness or neonatal screening program. This study aimed to assess knowledge, awareness, and attitudes toward SCD among high school students in Tawergha. **Methods:** We conducted a pilot study between April and June 2026 among secondary school students in Tawergha. We distributed a self-administered questionnaire assessing demographic data and 17 knowledge-based questions. We analyzed data from 104 students using SPSS version 27, employing descriptive statistics and chi-square tests to evaluate gender-based differences. **Results:** Most participants were male (59; 56.7%), 65.4% were aged 17–18 years, and 53.8% were in their third year of secondary education. Parental consanguinity was 38.5%; 11 (10.6%) had a family member (siblings) affected by SCD, and 26 (25%) had an affected relative. Overall, 51.9% of students had heard of SCD; however, significant knowledge gaps remained: 52.9% could not define SCD, and only 16.3% correctly identified inheritance risks. Females demonstrated significantly higher awareness (68.9% vs. 39.0%, $p = 0.002$) and better knowledge of hereditary causes (64.4% vs. 6.8%, $p < 0.001$) than males. Although 62.5% recognized the importance of premarital screening, only 39.4% viewed SCD as a serious public health issue, and only 11.5% were willing to marry a partner with the disease. **Conclusions:** Tawergha secondary students showed significant uncertainty about SCD, especially inheritance and clinical effects. The results support testing locally tailored SCD education and counseling interventions.

المعرفة والاتجاهات والتصورات حول مرض أنيميا الدم المنجلية لدى طلاب المدارس الثانوية في تاورغاء: دراسة استطلاعية

سارة محمد الفقيه

قسم طب الأطفال، كلية الطب، جامعة مصراتة، الرويسات، مصراتة 2478، ليبيا

المصطلحات المفتاحية:	المخلص
مرض الخلايا المنجلية الوعي ليبيا فحص ما قبل الزواج	الخلفية: يُعدّ مرض الخلايا المنجلية من أمراض الدم الوراثية المهمة في ليبيا، مع ارتفاع معدل انتشاره في مناطق محددة مثل تاورغاء. ومع ذلك، تفتقر ليبيا إلى برنامج وطني للتوعية أو لفحص حديثي الولادة. هدفت هذه الدراسة إلى تقييم المعرفة والوعي والاتجاهات نحو المرض لدى طلاب المرحلة الثانوية في تاورغاء. الطرائق: أجرينا دراسة استطلاعية بين أبريل ويونيو 2026 على طلاب المدارس الثانوية في تاورغاء. وزّعنا استبياناً يُعبأ ذاتياً لتقييم البيانات الديموغرافية و17 سؤالاً معرفياً. حلّلنا بيانات 104 طالب باستخدام برنامج SPSS الإصدار 27، بالإحصاء الوصفي واختبار مربع كاي لتقييم الفروق بين الجنسين. النتائج: كان معظم المشاركين من الذكور (59؛ 56.7%)، و65.4% تراوحت أعمارهم بين 17 و18 سنة، و53.8% في السنة الثالثة الثانوية. بلغت نسبة زواج الأقارب بين الوالدين 38.5%؛ وكان لدى 11 مشاركاً (10.6%) فرد من الأسرة (الأشقاء) مصاب بالمرض، ولد لدى 26 (25%) قريب مصاب. إجمالاً، سمع 51.9% من الطلاب بالمرض؛ لكن ظلت فجوات معرفية كبيرة: 52.9% لم يتمكنوا من تعريف المرض، و16.3% فقط حددوا مخاطر الوراثة بشكل صحيح. أظهرت الإناث وعياً أعلى بدلالة إحصائية (68.9% مقابل 39.0%، بقيمة احتمالية 0.002) ومعرفة أفضل بالأسباب الوراثية (64.4% مقابل 6.8%، بقيمة احتمالية أقل من 0.001) مقارنة بالذكور. ومع أن 62.5% أدركوا أهمية فحص ما قبل الزواج، فإن 39.4% فقط عدّوا المرض مشكلة صحية عامة خطيرة، و11.5% فقط كانوا مستعدين للزواج من شريك مصاب.

*Corresponding author: Sarah Mohamed Alfaqaih

E-mail address: Sarah.alfaqaih@med.misuratau.edu.ly

Article History : Received 05 August 2026 - Received in revised form 25 September 2026 - Accepted 07 October 2026

1. Introduction

Sickle cell disease (SCD) is one of the most common hereditary hematological disorders worldwide, including in Arabic regions [1–3]. In Libya, no comprehensive national records exist on the prevalence of SCD. Records from different regions in Libya document the prevalence of the SCD trait (heterozygous Hb AS) ranging from 3% to 53.34% [4–7]. Homozygous Hb SS was detected in about 1% of samples in Tawergha city and in 10% of collected samples in the Marzouk region of Libya [4,5].

The pathophysiological process of SCD is hemoglobin polymerization caused by an inherited autosomal recessive single-point mutation that substitutes glutamic acid with valine at the sixth codon of the β -globin chain on chromosome 11, resulting in significant alterations in red blood cells. It transforms normally flexible, spherical, biconcave disc-shaped cells into stiff, sickle-shaped cells. These abnormal (sickled) red blood cells obstruct blood vessels, causing vaso-occlusive painful crises, which are a characteristic feature of SCD [8,9]. The goal of treatment is to prevent the complications of SCD and the associated morbidity. Treatment modalities include oral medications like folic acid and hydroxyurea, as well as recurrent blood transfusions. The curative treatment for SCD is bone marrow transplantation (BMT) [10]. Recently, a huge development in the targeted therapy for SCD has emerged. In December 2023, the Food and Drug Administration (FDA) approved the first gene therapy (Casgevy), which uses the patient's own (autologous) hematopoietic (blood) stem cells for patients aged more than 12 years [11]. However, in July 2026, the FDA approved it for a younger age group (2 to 12 years) after results from two clinical trials [12]. Neither advanced management approaches, BMT, nor gene therapy were available in Libya.

Madour et al. (2025) conducted a cross-sectional study in western Libya. The survey showed that almost half of the general public participants had never heard of SCD [13]. This result is not surprising, as it was conducted in a low-prevalence region for SCD. For this reason, we aimed to conduct such a survey in the high-prevalence area of Tawergha city, where SCD prevalence was 12.5% in 2013 [5].

Tawergha is located in northwestern Libya. It lies 38 kilometers southeast of Misrata and roughly 250 kilometers southeast of Tripoli. Before the 2011 conflict, about 40,000 to 50,000 people lived here. According to the United Nations Development Program (UNDP), around 7,000 to 18,000 had managed to return [14].

To date, the Libyan Ministry of Health has no national program for awareness and prevention of SCD in the general population, such as prenatal or neonatal screening programs. This study is the first to target young people in this high-prevalence region and estimate their knowledge and awareness of SCD.

2. Materials and Methods

2.1. Study design and setting

A cross-sectional pilot study using a printed, self-administered questionnaire distributed in classes to high school students at two target schools in Tawergha city between April 2026 and June 2026.

2.2. Participants

This study used a gender stratified simple random sample, and all secondary school students were eligible. We distributed 120 printed questionnaires and included only those who completed them in the final analysis (Fig. 1).

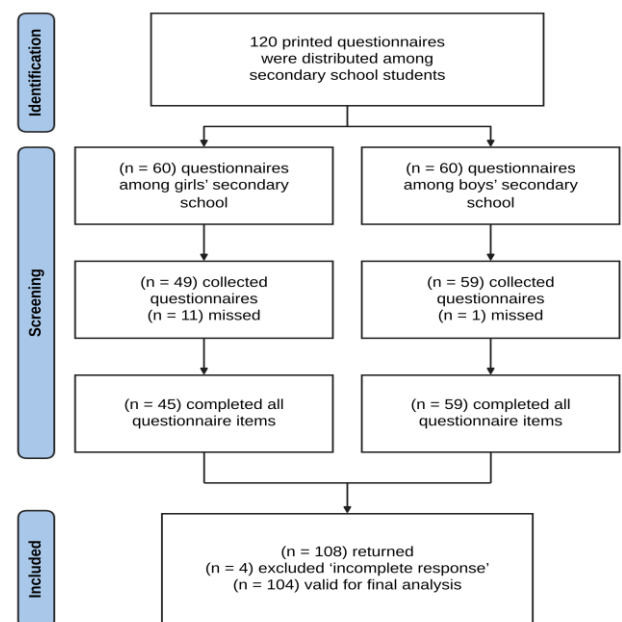


Fig. 1. Flow diagram of the data collection process.

2.3. Study questionnaire

The questionnaire was developed from previous literature and adapted to the study's target population [13,15,16]. The tool was initially designed in English and then translated into Arabic by experienced personnel. It consists of two sections: the first includes general demographic data (age, sex, and class), and the second includes 17 questions to assess awareness and knowledge of SCD.

A pilot sample was used to validate the questionnaire and ensure understanding of the terms used. Cronbach's alpha was 0.74.

2.4. Ethical considerations

The participants' school authorized the study, and students' guardians were notified and provided verbal consent for their teenagers to complete the questionnaire. We informed all students that they had the right to participate, that the study tool was anonymous, and that we would not collect or distribute personal data.

2.5. Statistical analysis

We conducted descriptive statistical analysis using SPSS version 27. We presented categorical variables as frequencies and percentages. We used the chi-square test to assess associations among the study variables. We used Spearman's rho to assess correlations. We considered results with a p -value < 0.05 statistically significant.

3. Results

A total of 108 high school students returned the survey, achieving a response rate of 90%, and 104 respondents were included in the analysis. Most participants were male (59, 56.7%), 65.4% were aged 17–18, and 53.8% were in their third year of secondary education. Parental consanguinity among participants was 38.5%; 11 (10.6%) had a family member affected by SCD, and 26 (25%) had a relative affected by SCD. The consanguinity rate within families with SCD was 45.5%. Table 1 shows the baseline characteristics of respondents.

Table 1. Baseline characteristics of respondents.

Variable	n	(%)
Gender		
Male	59	56.7%
Female	45	43.3%
Age category		
15–16	15	14.4%
17–18	68	65.4%
>18	21	20.2%
Academic class		
First Year Secondary	15	14.4%
Second Year Secondary	33	31.7%
Third Year Secondary	56	53.8%

Variable	n	(%)
Parental consanguinity		
Yes	40	38.5%
No	64	61.5%
Do you have an affected family member with SCD? (parents and siblings)		
Yes	11	10.6%
No	93	89.4%
Do you have a relative affected by SCD?		
Yes	26	25%
No	48	46.2%
I am not sure	30	28.8%
Do you believe sickle cell disease is a serious health problem in Libya?		
Yes	41	39.4%
No	12	11.5%
I am not sure	51	49%

SCD, sickle cell disease.

Regarding awareness, 54 (51.9%) have heard about SCD. The primary sources of information were school (21, 20.2%) and the internet/social media (14, 13.5%). However, a substantial portion, 55 (52.9%), of students lacked knowledge of SCD, with a notable gender disparity: male students (42, 71.2%) were more likely to be unaware than females (28.9%). Conversely, among those who knew what SCD is (45, 43.3%), females constituted the majority (32, 71.1%).

Knowledge gaps were evident across several key aspects of SCD. Only 17 (16.3%) of students correctly identified the risk of children becoming sickle cell patients if both parents are SCD trait. Furthermore, the majority of students demonstrated insufficient knowledge regarding SCD complications (62.5%), definitive cure (63.5%), appropriate measures for women of childbearing age with SCD (41.3%), and preventive measures for SCD (40.4%). Despite these knowledge gaps, most students (62.5%) recognized the need for premarital SCD screening. However, only 11.5% expressed willingness to marry a partner with SCD (Table 2).

Table 2. Students' awareness, knowledge and attitude about SCD.

Question statement	n	(%)
Have you heard of SCD before?		
Yes	54	51.9%
No	50	48.1%
Where have you heard about SCD (more than one answer can be selected)		
Family / Relatives	8	7.7%
Friends	10	9.6%
Internet / social media	14	13.5%
School	21	20.2%
Healthcare Professionals	4	3.8%
Other Sources	1	1%
What is SCD?		
A hereditary blood disorder*	45	43.3%
An infectious disease	2	1.9%
A sexually transmitted disease (STD)	2	1.9%
I do not know	55	52.9%
What is the cause of SCD?		
Acquired (occurs due to environmental or behavioral factors)	7	6.7%
Hereditary (transmitted from parents to children)*	42	40.4%
I do not know	55	52.9%
How is SCD diagnosed?		
By blood test*	54	51.9%
Urinary Test	3	2.9%
I Don't Know	47	45.2%
What is the risk for children to become sickle cell patients if both parents are sickle cell patients?		
All the children	14	13.5%
Half of the children	8	7.7%
A quarter of the children*	17	16.3%
I don't know	65	62.5%
What medical complications are caused by Sickle Cell Disease?		
Stroke	2	1.9%
Lung tissue damage	2	1.9%
Pain crises	6	5.8%
All of the above*	29	27.9%
I do not know	65	62.5%
Is there a definitive cure for Sickle Cell Disease?		
Yes*	20	19.2%
No	18	17.3%
I do not know	66	63.5%

Question statement	n	(%)
What is the appropriate measure for a woman of childbearing age diagnosed with Sickle Cell Disease?		
Regular exercise	3	2.9%
Taking vitamins	6	5.8%
Genetic counseling*	19	18.3%
Preventive medications	20	19.2%
I do not know	43	41.3%
Which of the following is a preventive measure for SCD?		
Medical advice	26	25%
Pre-marital screening*	36	34.6%
I Don't Know	42	40.4%
Do you think pre-marital screening for SCD is necessary?		
Yes*	65	62.5%
No	5	4.8%
I don't know	34	32.7%
Could your partner's genotype influence your decision to marry them?		
Yes*	35	33.7%
No	19	18.3%
I don't know	50	48.1%
If your future partner had sickle cell disease, would you still marry them?		
Yes	12	11.5%
No	39	37.5%
I don't know	53	51%
What should a couple do if they discover that their genotypes predispose them to give birth to a child with SCD?		
Separate / Break off the engagement	5	4.8%
Proceed with the marriage	5	4.8%
Consult a physician (Genetic Counseling)*	50	48.1%
I do not know	44	42.3%

(*) Correct answer. SCD, sickle cell disease; STD, sexually transmitted disease.

Gender-based differences in responses were statistically significant ($p < 0.05$) for several key questions, as detailed in Table 3. Females showed significantly higher awareness of SCD (68.9% compared to 39% in males), a better understanding of what SCD is (71.1% vs. 22%), its hereditary cause (64.4% vs. 6.8%), diagnosis methods (75.6% vs. 33.9%), awareness of a definitive cure (28.9% vs. 11.9%), knowledge of appropriate measures for childbearing women with SCD (42.4% vs. 8.6%), and recognition of the importance of consulting a physician for genetic counseling (80% vs. 23.7%).

Table 3. Gender-based differences in responses.

Question statement	Male (n = 59) n (%)	Female (n = 45) n (%)	p value
Have you heard of SCD before?			
Yes	23 (39%)	31 (68.9%)	0.002*
No	36 (61%)	14 (31.1%)	
Where have you heard about SCD (more than one answer can be selected)			
Family / Relatives	5 (20%)	3 (9%)	0.106
Friends	3 (12%)	7 (21.2%)	
Internet / social media	9 (36%)	5 (15.2%)	
School	5 (20%)	16 (48.5%)	
Healthcare Professionals	2 (8%)	2 (6.1%)	
Other Sources	1 (4%)	0	
What is SCD?			
A hereditary blood disorder ^s	13 (22%)	32 (71.1%)	<0.001*
An infectious disease	2 (3.4%)	0	
A sexually transmitted disease (STD)	2 (3.4%)	0	
I do not know	42 (71.2%)	13 (28.9%)	
What is the cause of SCD?			
Acquired (occurs due to environmental or behavioral factors)	13 (22%)	3 (6.7%)	<0.001*
Hereditary (transmitted from parents to children) ^s	4 (6.8%)	29 (64.4%)	
I do not know	42 (71.2%)	13 (28.9%)	
How is SCD diagnosed?			
By blood test ^s	20 (33.9%)	34 (75.6%)	<0.001*
Urinary Test	3 (5.1%)	0	
I Don't Know	36 (61%)	11 (24.4%)	
What is the risk for children to become sickle cell patients if both parents are sickle cell patients?			
All the children ^s	5 (8.5%)	9 (20%)	0.058
Half of the children	2 (3.4%)	6 (13.3%)	
A quarter of the children	10 (16.9%)	7 (15.6%)	

Question statement	Male (n = 59) n (%)	Female (n = 45) n (%)	p value
I don't know	42 (71.2%)	23 (51.1%)	
What medical complications are caused by Sickle Cell Disease?			
Stroke	2 (3.4%)	0	0.069
Lung tissue damage	0	2 (4.4%)	
Pain crises	3 (5.1%)	3 (6.7%)	
All of the above ^s	12 (20.3%)	17 (37.8%)	
I do not know	42 (71.2%)	23 (51.1%)	
Is there a definitive cure for Sickle Cell Disease?			
Yes ^s	7 (11.9%)	13 (28.9%)	<0.001*
No	4 (6.8%)	14 (31.1%)	
I do not know	48 (81.4%)	18 (40%)	
What is the appropriate measure for a woman of childbearing age diagnosed with Sickle Cell Disease?			
Regular exercise	2 (3.4%)	1 (3%)	<0.001*
Taking vitamins	3 (5.2%)	3 (9.1%)	
Genetic counseling ^s	5 (8.6%)	14 (42.4%)	
Preventive medications	12 (20.7%)	8 (24.2%)	
I do not know	36 (62.1%)	7 (21.2%)	
Which of the following is a preventive measure for SCD?			
Medical advice	13 (22%)	13 (28.9%)	<0.001*
Pre-marital screening ^s	12 (20.3%)	24 (53.3%)	
I Don't Know	34 (57.6%)	8 (17.8%)	
Do you think premarital screening for SCD is necessary?			
Yes ^s	33 (55.9%)	32 (71.1%)	0.271
No	3 (5.1%)	2 (4.4%)	
I don't know	23 (39%)	11 (24.4%)	
Could your partner's genotype influence your decision to marry them?			
Yes ^s	16 (27.1%)	19 (42.2%)	0.164
No	10 (16.9%)	9 (20%)	
I don't know	33 (55.9%)	17 (37.8%)	
If your future partner had sickle cell disease, would you still marry them?			
Yes	4 (6.8%)	8 (17.8%)	0.218
No	23 (39%)	16 (35.6%)	
I don't know	32 (54.2%)	21 (46.7%)	
What should a couple do if they discover that their genotypes predispose them to give birth to a child with SCD?			
Separate / Break off the engagement	4 (6.8%)	1 (2.2%)	<0.001*
Proceed with the marriage	5 (8.5%)	0	
Consult a physician (Genetic Counseling) ^s	14 (23.7%)	36 (80%)	
I do not know	36 (61%)	8 (17.8%)	

(S) Correct answer; (*) statistically significant ($p < 0.05$). p values from the chi-square test. SCD, sickle cell disease; STD, sexually transmitted disease. Regarding students' attitudes and perceptions toward SCD, only 39.4% of respondents considered SCD a serious public health problem, and 34.6% responded "yes" to premarital screening as a preventive measure. In addition, about half of students were hesitant to marry an individual with SCD.

Based on Spearman's rho correlation analysis in Table 4, consanguinity does not show a statistically significant correlation with any surveyed variable. However, there is a statistically significant negative correlation between whether an individual had a family member affected by SCD and their attitude toward the genotype of their future partner and their perception of SCD as a serious health problem ($p = 0.002$, $p = 0.032$, respectively).

Table 4. Spearman's rho correlations with specific study variables.

Variable	Consanguinity		Is there anyone in your family who has sickle cell anemia?	
	r	p value	r	p value
Consanguinity	1	–	0.049	0.618
If both parents carry SCD, what is the chance of having an affected child?	–0.064	0.517	–0.161	0.103
Could your future life partner's genotype influence your decision to marry them?	0.079	0.424	–0.298*	0.002*
If your future partner had sickle cell anemia, would you marry them?	–0.136	0.168	–0.086	0.385

Variable	Consanguinity		Is there anyone in your family who has sickle cell anemia?	
	r	p value	r	p value
What should a couple do if they discover that their genetic profiles put them at risk of having a child with sickle cell anemia?	0.034	0.735	–0.106	0.286
Is there anyone in your family who has sickle cell anemia?	0.049	0.618	1	–
Do you know someone outside your family who has sickle cell anemia?	0.015	0.881	0.154	0.119
Do you think sickle cell anemia is a serious health problem in Libya?	0.02	0.843	–0.210*	0.032*

(*) Statistically significant ($p < 0.05$). r , Spearman's rho correlation coefficient. SCD, sickle cell disease.

4. Discussion

This study assessed awareness, knowledge, and perceptions among secondary school students in Tawergha city, a region in Libya with high SCD prevalence. The results demonstrate a lack of overall knowledge about SCD. The absence of national screening programs and awareness is a fundamental reason for these results.

In this study, overall awareness was 51.9%, compared with a previous study in the western region in a low-prevalence area, where awareness was 13% among the general population, 40% among college students, and 46% among health care professionals [13]. However, studies in Saudi Arabia (Alzahrani et al., 2024 [17]; Alharbi et al., 2026 [18]) reported higher awareness among high school or premarital participants (71% and 93.2%, respectively), and 93% in a Bahrain public survey by Al Arrayed et al. [19]. This awareness gap clearly accounted for the Saudi government launching a mandatory national premarital screening program in 2004 through the Saudi Ministry of Health to combat high rates of sickle cell anemia and beta-thalassemia, which are lacking in Libya. This initiative emerged as a direct response to a heavy regional disease burden linked to high rates of consanguineous marriages [20–22]. Several countries have initiated premarital screening for hematological disorders, including Iran (1997), the United Arab Emirates (2011), Oman (1999), Bahrain (2004), and Cyprus (1973) [23–26]. The consanguinity rate in this study was 38.5%, consistent with previous studies in Libya [27], and falls within a higher level of consanguinity that mandates national programs for awareness and education about inherited diseases and premarital screening.

Identify particular knowledge gaps such as inheritance patterns, complications, definitive cures, and prevention methods, then compare these with results from similar research. For example, Alharbi et al. (2026) [18] observed substantial gaps in understanding of inheritance risks and complications, even though general awareness was present. Similarly, Oluwadamilola et al. (2021) in Nigeria reported low knowledge levels among secondary school students [28].

In this study, we observed a statistically significant gender difference, with females demonstrating higher awareness and knowledge. Al-Ghubishi et al. reported similar results [15], while Baba et al. and Durotoye et al. found no difference in knowledge level among secondary school students [16,29].

Our study results addressed a lack of attitude and perception toward SCD as a serious health problem, premarital screening, and marrying a partner with SCD. Shebani et al. (2024) conducted a cross-sectional study of Libyan higher education students and found that many did not believe hereditary diseases could be addressed through premarital screening [30]. This lack of knowledge raises concerns about underestimating the disease burden and possible delays in intervention.

This study showed that individuals with a family history of SCD are less influenced by their future partner's genotype when making marriage decisions ($r = -0.298$, $p = 0.002$) and less likely to perceive SCD as a serious health problem in Libya ($r = -0.21$, $p = 0.032$). This could reflect a more nuanced understanding of the disease or a sense of normalization from direct experience, leading to a less

alarmist view than among those without direct family exposure.

5. Conclusions

In this limited sample of secondary-school students in Tawergha, responses indicated substantial uncertainty about SCD, particularly its inheritance and clinical consequences. Because the sample was small and non-probability based, the findings should be considered hypothesis-generating rather than representative of Libya. The results support testing locally tailored SCD education and counseling interventions.

Acknowledgements

We acknowledge the participation of all study participants. Special acknowledgment also goes to Ms. Najia Hadia Almabrok, a member of Tawergha General Hospital, for their efforts in establishing connections and distributing the questionnaire to target schools.

Declarations

Author contributions: S.M.A.: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. The author read and approved the final manuscript.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of interest: The author declares no conflicts of interest.

Ethics approval and consent to participate: Ethics committee approval number: Not available. The participating schools authorized the study, and students' guardians were notified and provided verbal consent; participation was voluntary and anonymous.

Data availability: Not available.

Use of generative AI: Not available.

Supplementary material: Not applicable.

References

- [1] El-Hazmi MA, Al-Hazmi AM, Warsy AS. Sickle cell disease in Middle East Arab countries. *Indian J Med Res.* 2011;134(5):597–610. doi:10.4103/0971-5916.90984
- [2] GBD 2021 Sickle Cell Disease Collaborators. Global, regional, and national prevalence and mortality burden of sickle cell disease, 2000–2021: a systematic analysis from the Global Burden of Disease Study 2021. *Lancet Haematol.* 2023;10(8):e585–99. doi:10.1016/S2352-3026(23)00118-7
- [3] Pendharkar D, Nirmal G. Tracing the origin of sickle cell disease back to 50 000 years. *Blood Glob Hematol.* 2025;2(1):100041. doi:10.1016/j.bgl.2025.100041
- [4] Elasbali AM, Alaleem AM, Alshammari EMA, Khan S, Adnan M, Haque S. Prevalence of HbS gene in Marzouk region of southern Libya. *Egypt Acad J Biol Sci C Physiol Mol Biol.* 2015;7(1):27–37. doi:10.21608/eajbsc.2015.13700
- [5] Marwan MMB, Egrouda MM, Jornaz NA, Lamami YM, Gadmour HH. The incidence of hemoglobin S in Taourga region, Libya. *J Sebha Univ Pure Appl Sci.* 2013;12(1):21–7.
- [6] Jain RC. Abnormal haemoglobin, thalassaemia and G-6-PD deficiency in Libya. *Br J Haematol.* 1983;54(1):154–5. doi:10.1111/j.1365-2141.1983.tb02078.x
- [7] Jain RC. Haemoglobinopathies in Libya. *J Trop Med Hyg.* 1979;82(6):128–32.
- [8] Inusa BPD, Hsu LL, Kohli N, Patel A, Ominu-Evbota K, Anie KA, et al. Sickle cell disease—genetics, pathophysiology, clinical presentation and treatment. *Int J Neonatal Screen.* 2019;5(2):20. doi:10.3390/ijns5020020
- [9] Taher M, Aminondin SA, Nasir NA, Jasmadi NA, Nizam NIN, Shahrul IS, et al. Sickle cell disease: understanding pathophysiology, clinical features and advances in gene therapy approaches. *Front Pharmacol.* 2025;16:1630994. doi:10.3389/fphar.2025.1630994
- [10] Abdel-Hadi L, Ventura Carmenate Y, Castillo-Aleman YM, Sheikh S, Zakaria A, Phillips J. Treatment of sickle cell disease – options and perspective. *Am J Blood Res.* 2023;13(2):61–70.
- [11] Singh A, Irfan H, Fatima E, Nazir Z, Verma A, Akilimali A. Revolutionary breakthrough: FDA approves CASGEVY, the first CRISPR/Cas9 gene therapy for sickle cell disease. *Ann Med Surg (Lond).* 2024;86(8):4555–9. doi:10.1097/MS9.00000000000002146
- [12] Anderer S. FDA approves gene therapy for younger children with sickle cell disease. *JAMA.* 2026;336(7):539–40. doi:10.1001/jama.2026.9488
- [13] Madour A, Abduljalil M, Abduljalil S, Altam K, Elmaihub E. Sickle cell anaemia: knowledge and attitude toward the disease among the population in West Libya. *AlQalam J Med Appl Sci.* 2025;8(3):1714–20. doi:10.54361/ajmas.258363
- [14] Elmaghrebi M. When education services encourage returns in Tawergha [Internet]. New York: United Nations Development Programme; 2021 Mar 3 [cited 2026 Apr 8]. Available from: <https://www.undp.org/libya/stories/when-education-services-encourage-returns-tawergha>
- [15] Al-Ghubishi S, Al-Harbi A, Alshahrani E, Al-Zubaidi F, Al-Zahrani M, Al-Helisi R, et al. Survey on sickle cell disease (SCD) awareness amongst high school students in AlQunfudah, KSA. *Int J Med Res Health Sci.* 2021;10(4):9–18.
- [16] Baba P, Yakubu IZ, Yidana A. Knowledge and beliefs, towards sickle cell disease among senior high school students in Tamale Metropolis. *Asian J Pregnancy Childbirth.* 2023;6(1):120–30.
- [17] Alzahrani SSJ, Alghamdi NSA, Alzahrani EAM, Alzahrani FAM, Alghamdi MAA, Hafiz ZMS, et al. Knowledge of sickle cell disease among medical students at Al-Baha University, Saudi Arabia: a cross-sectional study. *Cureus.* 2024;16(1):e52616. doi:10.7759/cureus.52616
- [18] Alharbi I, Alsaedi BS, Alsaedi K, Alwadani F, Almohammadi Y, Alshinqiti A, et al. Knowledge and awareness of sickle cell disease among premarital screening participants in Makkah, Saudi Arabia: a cross-sectional study. *Cureus.* 2026;18(4):e106766. doi:10.7759/cureus.106766
- [19] Al Arrayed S, Al Hajeri A. Public awareness of sickle cell disease in Bahrain. *Ann Saudi Med.* 2010;30(4):284–8. doi:10.4103/0256-4947.65256
- [20] Alotaibi MM. Sickle cell disease in Saudi Arabia: a challenge or not. *J Epidemiol Glob Health.* 2017;7(2):99–101. doi:10.1016/j.jegh.2016.12.006
- [21] Alhamdan NA, Almazrou YY, Alswaidi FM, Choudhry AJ. Premarital screening for thalassemia and sickle cell disease in Saudi Arabia. *Genet Med.* 2007;9(6):372–7. doi:10.1097/GIM.0b013e318065a9e8
- [22] Ezzat H, Alshehri M, Alghamdi I, Alshehri F, Kariri N, Albalawi F, et al. Newborn screening program (NBS) for early detection of sickle cell disease and G6PD: the Saudi experience. *Blood.* 2024;144 Suppl 1:1121. doi:10.1182/blood-2024-204696
- [23] Amini A, Nadali F, Dereikvand G. Prevalence determination of sickle cell trait by premarital screening at Isfahan Thalassemia Prevention Center. 2005.
- [24] Al-Balushi AA, Al-Hinai B. Should premarital screening for blood disorders be an obligatory measure in Oman? *Sultan Qaboos Univ Med J.* 2018;18(1):e24–9. doi:10.18295/squmj.2018.18.01.004
- [25] Al Arrayed S, Al Hajeri A. Newborn screening services in Bahrain between 1985 and 2010. *Adv Hematol.* 2012;2012:903219. doi:10.1155/2012/903219
- [26] Bozkurt G. Results from the north Cyprus thalassemia prevention program. *Hemoglobin.* 2007;31(2):257–64. doi:10.1080/03630260701297204
- [27] Abudejaja AH, Khan MA, Singh R, Toweir AA, Narayanappa M, Gupta BS, et al. Experience of a family clinic at Benghazi, Libya, and sociomedical aspects of its catchment population. *Fam Pract.* 1987;4(1):19–26. doi:10.1093/fampra/4.1.19
- [28] Oluwadamilola AD, Akinreni TI, Adefisan MA, Olayiwola SD. Knowledge, attitude and control practices of sickle cell diseases among senior secondary students in Osun State, Nigeria. *Pan Afr Med J.* 2021;38:350. doi:10.11604/pamj.2021.38.350.20894
- [29] Durotoye IA, Salaudeen AG, Babatunde AS, Bosah EC, Ajayi FD. Knowledge and perception of sickle cell disease among senior secondary school students in Ilorin metropolis. *Trop J Health Sci.* 2013;20(2):1–7.
- [30] Shebani A, Mustafa AM, Elshwekh H, Hmmer A, Alhudiri IM. Knowledge and attitudes toward premarital screening programs among students at the University of Tripoli, Libya. *Cureus.* 2024;16(7):e64274. doi:10.7759/cureus.64274