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PREVALENCE OF IRON DEFICIENCY ANEMIA AND HEMOGLOBINOPATHIES' CARRIERS AMONG SCHOOL CHILDREN IN AL-KHOBAR & MAKKAH CITIES, SAUDI ARABIA

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ABSTRACT

Iron deficiency anemia (IDA) is one of the most prevalent nutritional diseases in many parts of the world and the most common cause of anemia in KSA. Hemoglobin disorders as thalassaemia and sickle cell disease (SCD) have a big concern in many countries with high prevalence in KSA. The aim of this study was to determine the prevalence of IDA, sickle cell trait (SCT) and β-thalassaemia trait (βTT) among school children in Al-Khobar and Makkah cities, KSA. A multi stage random sample of 510 school children aged 12–18 years at both cities received health education about these disorders then investigated by complete blood count (CBC), serum iron, total iron binding capacity (TIBC), reticulocytic count and sickling test. Hemoglobin electrophoresis and high performance liquid chromatography (HPLC) were done in selected cases. Overall, the prevalence of IDA, SCT and βTT was 12.94%, 3.33% and 3.14% respectively with no significant difference between both cities. Significant variations were seen in the hematological parameters in students with IDA and βTT compared to normal students in each city but no significant differences in the hematological parameters between normal students and those with SCT. No significant differences were observed between both sexes for any of the blood characteristics examined except for iron and TIBC. Many factors contribute to the high prevalence of IDA, SCT and βTT in KSA including demographic factors, traditional and religious commonality and the high rate of consanguineous marriages in conjunction with genetic role. Strengthening public health education, nutritional programs and routine carrier screening for school children are recommended to help early discovery of different types of anemias.

KEYWORDS: Prevalence, Iron deficiency anemia, Sickle cell trait, β-thalassaemia trait, School children.

INTRODUCTION

Iron deficiency anemia (IDA) is one of the most prevalent nutritional diseases in many parts of the world.[1] In Saudi Arabia it affects particularly women and children.[2] Hemoglobinopathies (disorders of hemoglobin) are the most common single gene disorders in the world's population[3] that result in either production of structurally abnormal hemoglobin variants as sickle cell disease (SCD) and sickle cell trait (SCT) or reduction in the synthesis of structurally normal globin (β-thalassaemia).[4]

Saudi Arabia is well-known for its high prevalence of hereditary blood disorders.[5] During the past ten years, surveys for hemoglobinopathies by the premarital screening program have been conducted in different KSA areas. Many studies had documented relatively high frequencies of β-thalassaemia carriers in Eastern region (19.5%), Qunfudah (15.8%), Jazan (7.8%) and Northern border region (7.25%). Moderate frequencies were observed in Al-Ahsa area (3.4%), Makkah (2.7%), Riyadh (2.01%) and Jeddah (1.23%). Whereas, lower frequencies were reported in other areas as Taif (0.43%), Madinah (0.41%), Tabuk (0.30%), Qassim (0.16%), Jouf (0.07%) and Hail (0.02%).[5-9]

Various factors may contribute to the high prevalence of hemoglobinopathies in KSA including (1) demographic factors as the rapid increase in the population and increased number of Asian immigrants to KSA; (2) certain cultural, traditional and religious commonality including the high frequency of consanguineous marriages (exceeding 55%) especially first cousin unions, marriage at a young age, the large family size

and the high paternal and maternal ages[10-12]; and (3) the general low availability of public health measures directed at the care and prevention of these disorders.[13] Moreover, genetic diversity is observed among Saudi populations due to admixture with other nationalities especially from endemic areas of hemoglobinopathies in East and South Asia.[14]

Management of hemoglobinopathies faces many challenges at different levels (1) at the national level due to paucity of resources, presence of other competing priorities of communicable and non-communicable diseases, insufficient number of trained health professionals in this field with low genetic literacy among the health sector and insufficient data about the real magnitude and economic burden of hemoglobinopathies; (2) at the community level due to lack of public awareness about genetic risks and possibilities for prevention of these disorders coupled by the legal and religious restrictions to prenatal diagnosis and selective abortion of an affected fetus; and (3) at the family and individual levels as they drastically affect the family and personal life of sufferers due to the cultural fear of affected families to be stigmatized within their community which has significant psychosocial and emotional impact on the patients and their families.[13,15-16]

Attention to hemoglobinopathies by Saudi health authorities has targeted (1) newborn screening for SCD to initiate early therapeutic and preventive strategies prior to the development of clinical complications. However, it is useful only when there is appropriate genetic counseling and parental education coupled by adequate primary and follow-up care for those affected to reduce morbidity and mortality[17-19] and (2) premarital screening for carriers of β-thalassaemia and SCD to help couples who are at a high risk of having an affected baby to make an informed reproductive decision and choice. However, it should be implemented in a manner that respects the population's religious, traditional and cultural views and is burdened with social and ethical dilemmas, government policy and attitudes of the couples themselves.[20,21] If options are not made available to carrier couples, such screening programs will not be effective in reducing the burden of hemoglobinopathies.[13] One option to be explored is the introduction of screening during the school years.[22]

We suspect adolescent school students to be a good opportunity for screening and counseling for genetic blood disorders to be aware, at this age, of the potential risk of having affected children and have time to understand and appreciate the importance of the information before choosing a partner and therefore might be less likely to marry another carrier to reduce the risk of these diseases in their future families. In addition, such screening may help to increase awareness and education regarding these disorders in the screened students and the associated population group including parents, teachers, friends, siblings and employees.

The aim of this study was to portray the prevalence of and raise awareness about IDA and hemoglobinopathies especially SCT and βTT among adolescent school students in Al-Khobar and Makkah cities, Saudi Arabia that may help to highlight the need for defining priorities to implement prevention programs on a community level and to plan health services more efficiently.

MATERIALS AND METHODS

Study area and population

An institutional-based cross sectional descriptive study was conducted between September 2014 and February 2015 during the school months among preparatory and secondary school children aged 12 – 18 years in 20 public schools (10 for males and 10 for females) in Al-Khobar city, as a representative of the Eastern area, and in Makkah city, as a representative of the Western area, Saudi Arabia.

Sample size

The sample size was determined using the Statcalc from Epi Info version 6.04 (Centers for Disease Control and Prevention, Atlanta, USA) with a sample size of 454 at 95% level of confidence, 80% power, 5% expected prevalence of hemoglobinopathies and a margin of error of 2%. We tried to increase the sample size to compensate for possible losses and improve the validity of results, such that the final sample size was set at 550 students. After selection, we excluded 32 students due to refusal of sampling, missing blood reports and technical laboratory errors and another 8 students were excluded who have been diagnosed with thalassaemia major, sickle cell anemia or other recognized hematological diseases. Other non-Saudi nationalities were excluded and the final sample size enrolled in the study was 510 students.

Sampling method

The multistage sampling method was used in each city, whereby schools were stratified according to general education departments into east, west, north, south and middle with sub-stratification into two strata, preparatory and secondary schools. Schools were chosen randomly from each stratum to represent male and female students. Random selection of students was considered proportional to their size in the study schools. In each school, sampling frame was prepared from the student roster in each grade and students were selected from each grade by simple random sampling method. A total of 266 students were chosen randomly from 10 schools in Al-Khobar city and a total of 244 students were chosen randomly from 10 schools in Makkah city (with equal number of male and female schools in each city).

Procedures

In coordination with the managers in each school, prior to blood sampling, teachers and students were oriented

through lectures with distribution of posters and pamphlets and displaying banners. A 5ml venous blood sample was drawn from each student; first 3ml blood samples were drawn into an EDTA tube to analyse complete blood count (CBC), reticulocytic count and sickling test for all students and to do high performance liquid chromatography (HPLC) and hemoglobin electrophoresis in suspected cases. The remaining 2ml blood samples were clotted to measure serum iron and total iron binding capacity (TIBC) by a calorimetric procedure, for all students. From the 1st 3ml sample, a Cell-Dyn 3700 was used to determine CBC parameters [hemoglobin (Hb), hematocrit (HCT), red blood cell (RBC)]; Red cell indices [mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC)]; Red cell morphology (target, sickle, pencil, hypochromia); and RDW (red-cell distribution width) that contributes as a marker for differentiation between thalassaemia trait (carriers) and IDA.

Also, Reticulocytic count (RTX) was done for all students, by using Brilliant cresyl blue stain, to differentiate between types of hemolytic anemia and other types of anemia.[23] Also sickling test was done for all students for detecting the presence of HbS in SCD or SCT. All samples with evidence of anemia (Hb <11 g/dL and/or low MCV <68 fl) and/or high (RTX) and/or +ve sickling test were subjected to electrophoretic separation of (Hb-EPS) on cellulose acetate paper. Hb-EPS detects the abnormal Hb bands as (HbS, F and A2). We do another confirmatory test to detect actual level of HbA2 by microcolumn chromatography method.[24]

Comment

- IDA was diagnosed by the presence of low red cell indices (MCV <68 fl, MCH <23 pg), RBC morphology [as pencil cells], low RTX count (<0.5%), high RDW (>17%) and iron saturation (<15%).
- βTT was diagnosed in cases with abnormal RBC's morphology (as Ovalocytosis & Target), lower blood indices, low RDW (<13.5%), high RTX (>2.5%), with elevated HbA2 (>3.5%) and high iron saturation (>46.0 ug/dl). The actual level of HbA2 (was assayed by using column chromatography.
- SCT was diagnosed by +ve sickling test and confirmed by (Hb-EPS) and (HPLC) with near normal Hb, blood indices and RTX.

Quality assurance

To ensure quality of data, all laboratory activities were performed by strictly following manufacturers' instructions and specific standard operating procedures and all reagents were checked for their expiry date. Information about name, age, gender, school grade and laboratory results for each student were recorded on standard report formats according to specific identification number.

Ethical consideration

Ethical clearance was obtained from representatives of Ministries of Health and Education in both cities with second permission from each school director's office. Sampling was performed after obtaining a signed written informed consent from parents and an oral assent from the students. Privacy and confidentiality were maintained throughout the study process using a unique code number. Subjects' parents received written notification of laboratory results and students confirmed as having anemia/hemoglobinopathies were referred to healthcare consultation.

Statistical analysis

Statistical analysis was carried out using the SPSS computer package version 21.0 (SPSS Inc., Chicago, IL, USA). For descriptive statistics: the mean ± SD were used for quantitative variables while the number and percentage were used for qualitative variables. Fischer's exact test (FET) was used to assess the differences in frequency of qualitative variables. In order to assess the differences in means of quantitative variables, independent samples t-test was applied. The statistical methods were verified, assuming a significant level of $p < 0.05$.

RESULTS

A total of 510 Saudi students were enrolled in this study; 266 (52.16%) from Al-Khobar city (129 from preparatory and 137 from secondary schools) while the other 244 (47.84%) were from Makkah city (118 from preparatory and 126 from secondary schools). All students' age ranged between 12-18 years and nearly half of them (51.37%) were males.

Overall, 99 students (19.41%, 52 males and 47 females); 54 from Al-Khobar city and 45 from Makkah city exhibit either IDA or hemoglobinopathies. The prevalence of IDA, SCT and βTT was 12.94% (66 cases), 3.33% (17 cases) and 3.14% (16 cases) respectively with no significant difference between both cities. (Figure 1).

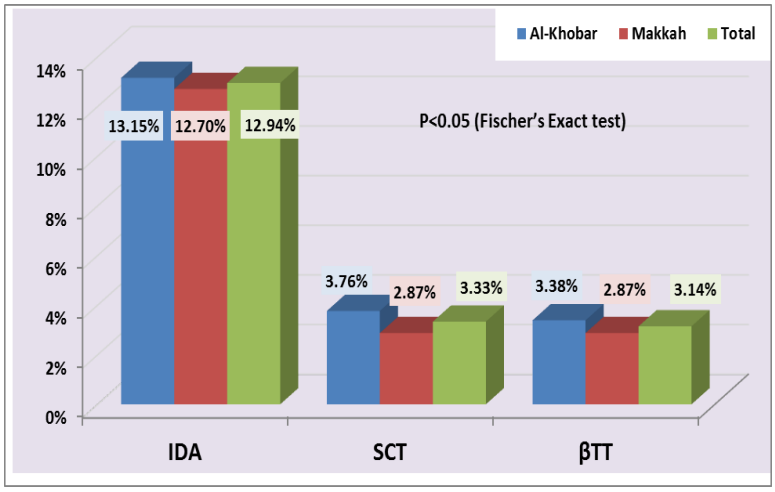

Figure (1): The prevalence of different types of anemias among school children in A-Khobar & Makkah cities.

The hematological characteristics between the normal students and those with IDA or carriers of hemoglobinopathies in both cities were shown in (Tables 1 & 2). The mean values of hematological characteristics associated with (IDA / SCT / βTT) among school children in Al-Khobar & Makkah cities were shown in (Table 3).

Table: (1) Mean values of hematological parameters of school children in Al-Khobar city.

Parameters	Al-Khobar (n=266)			
	Normal (n=212)	IDA (n=35)	SCT (n=10)	βTT (n=9)
Hb (g/dl)[1, 2]	13.6 ± 0.7	10.1 ± 1.8	12.1 ± 0.1	10.3 ± 1.4
HCT (%)[1,2]	41.0 ± 0.8	31.6 ± 0.5	36.2 ± 0.8	31.0 ± 0.4
MCV (fl)[1,2]	82.3 ± 3.1	67.2 ± 8.5	84.4 ± 4.5	68.5 ± 5.0
MCH (pg)[1,2]	27.3 ± 1.8	18.5 ± 5.1	26.8 ± 3.2	21.4 ± 3.8
MCHC (g/dl)	33.6 ± 0.8	32.5 ± 3.7	33.4 ± 4.5	31.5 ± 1.2
RBC's ($x10^6$/L)	4.9 ± 0.4	4.6 ± 1.8	4.7 ± 3.1	5.7 ± 0.5
WBC's ($x\ 10^3$/L)	8.1 ± 2.4	7.7 ± 2.2	9.2 ± 3.5	8.7 ± 1.9
Platelet ($x\ 10^3$/L)	419.6 ± 12	498.7 ± 74	336.3 ± 32	387.1 ± 35
RTX (%)[1,2]	1.5 ± 0.9	0.5 ± 0.3	1.8 ± 0.6	2.5 ± 0.3

[1] Values for normal and IDA were significantly different (P<0.05) (Independent samples t-test).
[2] Values for normal and βTT were significantly different (P<0.05) (Independent samples t-test).
Values for normal and SCT were not significantly different (P>0.05) (Independent samples t-test).

Table: (2) Mean values of hematological parameters of school children in Makkah city.

Parameters	Makkah (n=244)			
	Normal (n=199)	IDA (n=31)	SCT (n=7)	βTT (n=7)
Hb (g/dl)[1,2]	13.3 ± 0.9	9.7 ± 1.5	13.2 ± 1.1	9.8 ± 1.4
HCT (%)[1,2]	40.1 ± 1.1	29.9 ± 0.4	39.7 ± 0.2	30.3 ± 0.3
MCV (fl)[1,2]	83.0 ± 3.6	69.7 ± 9.1	85.4 ± 3.7	69.0 ± 7.1
MCH (pg)[1,2]	28.3 ± 1.8	20.1 ± 4.2	27.2 ± 1.7	21.8 ± 2.0
MCHC (g/dl)	34.8 ± 0.6	32.3 ± 0.7	32.9 ± 3.5	31.4 ± 1.2
RBC's ($x10^6$/L)	5.1 ± 0.6	4.9 ± 0.9	4.8 ± 2.9	5.5 ± 0.4
WBC's ($x\ 10^3$/L)	7.5 ± 2.6	8.1 ± 2.3	8.8 ± 2.1	7.7 ± 2.4
Platelet ($x\ 10^3$/L)	297.8 ± 44	524.1 ± 69	386.8 ± 54	301.3 ± 24
RTX (%)[1,2]	1.4 ± 0.5	0.4 ± 0.2	1.7 ± 0.4	2.7 ± 0.3

[1]Values for normal and IDA were significantly different (P<0.05) (Independent samples t-test).
[2]Values for normal and βTT were significantly different (P<0.05) (Independent samples t-test).
Values for normal and SCT were not significantly different (P>0.05) (Independent samples t-test).

Table: (3) Mean values of hematological parameters associated with (IDA / SCT / βTT) among school children in Al-Khobar & Makkah cities.

Parameters (Positive results)	IDA		SCT		βTT	
	Al-Khobar (n=35)	Makkah (n=31)	Al-Khobar (n=10)	Makkah (n=7)	Al-Khobar (n=9)	Makkah (n=7)
Hb (g/dl)	10.1 ± 1.8	9.7 ± 1.5	12.1 ± 0.1	13.2 ± 1.1	10.3 ± 1.4	9.8 ± 1.4
HCT (%)	31.6 ± 0.5	29.9 ± 0.4	36.2 ± 0.8	39.7 ± 0.2	31.0 ± 0.4	30.3 ± 0.3
MCV (fl)	67.2 ± 8.5	69.7 ± 9.1	84.4 ± 4.5	85.4 ± 3.7	68.5 ± 5.0	69.0 ± 7.1
MCH (pg)	18.5 ± 5.1	20.1 ± 4.2	26.8 ± 3.2	27.2 ± 1.7	21.4 ± 3.8	21.8 ± 2.0
MCHC (g/dl)	32.5 ± 3.7	32.3 ± 0.7	33.4 ± 4.5	32.9 ± 3.5	31.5 ± 1.2	31.4 ± 1.2
RBC's (x 10^6/L)	4.6 ± 1.8	4.9 ± 0.9	4.7 ± 3.1	4.8 ± 2.9	5.7 ± 0.5	5.5 ± 0.4
WBC's (x 10^3/L)	7.7 ± 2.2	8.1 ± 2.3	9.2 ± 3.5	8.8 ± 2.1	8.7 ± 1.9	7.7 ± 2.4
Platelet (x 10^3/L)	498.7 ± 74	524.1 ± 69	336.3 ± 32	386.8 ± 54	387.1 ± 35	301.3 ± 24
RTX (%)	0.5 ± 0.3	0.4 ± 0.2	1.8 ± 0.6	1.7 ± 0.4	2.5 ± 0.3	2.7 ± 0.3
RDW (%)	17.0 ± 2.3	16.5 ± 3.8	13.9 ± 1.9	13.5 ± 2.3	12.5 ± 3.1	12.1 ± 2.7
HbA2 (%)	1.5 ± 0.9	1.7 ± 0.3	3.6 ± 2.3	3.4 ± 1.8	5.5 ± 1.4	5.4 ± 1.7
Iron (ug/dl)	13.5 ± 3.7	11.6 ± 4.0	43.2 ± 1.7	41.6 ± 2.4	46.3 ± 1.1	43.2 ± 2.5
TIBC (ug/dl)	405.8 ± 63	438.2 ± 59	284.1 ± 44	313.4 ± 71	208.0 ± 39	232.5 ± 41
Hb-EPS	Predominant HbA, Low HbA2	Predominant HbA, Low HbA2	HbA, HbS, Slightly high HbA2	HbA, HbS, Slightly high HbA2	HbA, HbF, High HbA2	HbA, HbF, High HbA2
Sickle test	-	-	+ve	+ve	-	-

Iron deficiency anemia was diagnosed in 34 males and 32 females (12.94% total). Hemoglobin concentration, RBC's and HbA2 were exactly lower than normal. No statistically significant differences were observed between both sexes for any of the blood characteristics examined except for iron and TIBC. (Table 4).

Table: (4) Mean values of hematological parameters between males and females school children associated with (IDA / SCT / βTT).

Parameters (Positive results)	IDA		SCT		βTT	
	Male (n=34)	Female (n=32)	Male (n=10)	Female (n=7)	Male (n=8)	Female (n=8)
Hb (g/dl)	9.5 ± 1.5	8.7 ± 1.7	13.1 ± 0.4	12.1 ± 1.1	10.5 ± 1.4	10.1 ± 1.4
HCT (%)	28.1 ± 2.6	27.9 ± 2.2	37.8 ± 1.1	40.2 ± 0.4	38.0 ± 0.3	38.1 ± 0.9
MCV (fl)	52.3 ± 12.5	56.7 ± 13.1	84.1 ± 3.0	85.6 ± 3.8	60.5 ± 10.1	61.2 ± 11.2
MCH (pg)	17.5 ± 5.1	18.1 ± 4.0	26.1 ± 3.5	27.3 ± 2.8	21.6 ± 2.8	21.7 ± 3.0
MCHC (g/dl)	33.3 ± 3.7	35.8 ± 0.8	32.4 ± 5.1	32.6 ± 4.2	31.5 ± 1.2	31.4 ± 1.2
RBC's (x 10^6/L)	4.4 ± 1.6	4.3 ± 1.2	4.6 ± 3.1	4.8 ± 1.9	4.3 ± 0.5	4.5 ± 0.6
WBC's (x 10^3/L)	7.4 ± 3.2	7.6 ± 3.4	10.2 ± 3.6	10.6 ± 3.8	7.7 ± 1.8	7.8 ± 2.4
Platelet (x 10^3/L)	436.3 ± 76	486.8 ± 69	324.2 ± 33	398.7 ± 56	317.1 ± 36	331.3 ± 28
RTX (%)	0.5 ± 0.32	0.4 ± 0.24	2.1 ± 0.6	2.0 ± 0.4	2.6 ± 0.8	2.8 ± 0.2
RDW (%)	18.0 ± 1.6	18.4 ± 2.8	13.9 ± 1.9	13.5 ± 2.3	12.5 ± 3.1	12.1 ± 2.7
HbA2 (%)	1.4 ± 0.8	1.8 ± 0.5	4.1 ± 1.1	3.8 ± 1.4	5.6 ± 1.5	5.4 ± 1.8
Iron (ug/dl)*	13.6 ± 3.8*	9.6 ± 2.8 *	43.1 ± 1.8	42.8 ± 2.6	48.3 ± 1.2	45.2 ± 1.5
TIBC (ug/dl) *	388.4 ± 61*	425.3 ± 48*	310.3 ± 52	294.5 ± 62	219.1 ± 20	226.1 ± 31
Hb-EPS	Predominant HbA, Low HbA2	Predominant HbA, Low HbA2	HbA, HbS, High HbA2	HbA, HbS, High HbA2	HbA, HbF, High HbA2	HbA, HbF, High HbA2
Sickle test	-	-	+ve	+ve	-	-

* Statistical significant difference (P<0.05) (Independent samples t-test).

DISCUSSION

Iron deficiency anemia is a common hematological and public health problem worldwide. Studies on its prevalence among adolescent school students in KSA are generally lacking because most of previous studies focused on young children and pregnant females or girls.[25]

In our study, IDA was prevalent among adolescent school students (12.94%) that might be ascribed to various factors as increasing iron demands during puberty, menstrual losses, limited dietary iron intake, faulty dietary habits, deficiencies of other nutrients and poor iron absorption.[26] Recently, lifestyle factors as sedentary lifestyle, fast-food intake and preference for indoor activities have been associated with IDA.[27]

However, the prevalence was lower than that reported in earlier studies among school students performed in different regions of KSA that ranged from (16.1%) among primary school girls in Riyadh[28] with a recent prevalence of (16.7%) in male and (34.2%) in female adolescents aged 13–18 years[29], (20.5%) among a sample of 800 Saudi school children in Jeddah[30] and up to (24.8%) in different areas of the country with highest prevalence in Eastern province (41.3%) and lowest in central province (16.5%).[31] The lower prevalence in our study might be attributed to a number of factors, including the wide-spread inclusion of iron in the wheat flour fortification program. However, the persistence of such alarming levels of IDA among school children demands increased public health attention with improving nutrition and educational programs by the public health authorities.

Comparative nearby studies documented lower prevalence (5%) among adolescents in UAE[32] and (5.6%) among Turkish children [33]; nearly similar prevalence (11.18%) among school children in Jordan[34] and (12%) in Egypt [35]; but higher prevalence (17.9%) was reported among Arab migrating nomad school children in Iran[36], (20.35%) among adolescents intermediate school pupils in Iraq[37], (23%) among Kuwaiti students aged 15–19 years[38] and (35.2%) among Yemeni children aged 10–15 years.[39] The higher results in Iraq might be ascribed to low socioeconomic status and the economic embargo imposed on Iraq for the last decade, in Kuwait it might be related to bad dietary habits (delivery meal) and excessive calories that are widely consumed, as evidenced by the estimated 40% obesity rate[40] while in Yemen, more than half of the country's total population lives below the poverty line which might contribute to that high prevalence.[41]

Hemoglobinopathies are known to be prevalent inherited disorders in most Arab countries with varying prevalence rates and molecular characterization.[13] The overall prevalence of β-thalassaemia carriers among school children in our study was found (3.14%) with more prevalence in Al-Khobar group (3.38%) in comparison with Makkah group (2.87%).

The rate of β-thalassaemia carriage has a wide range worldwide. Other nearby studies reported prevalence of (1.06%) among 3571 high school Turkish students aged 12–22 years[42] (2.9%) among 5685 Bahraini students in the 11th grade between 16–17 years[43] and (3.5%) in another prospective Bahraini study during the annual student screening program[44], (3.04%) among school children aged 6–15 years in the north-eastern Badia region of Jordan[29], (3.22%) among children aged 9–12 years in Pakistan[45], (4.3%) among secondary school students in Gaza strip[46], (9%) among randomly selected school children aged 5–16 years of different geographical areas in Egypt[47] and (9.7%) among school children aged 6–18 years in Iran.[36] The difference from other studies may be related to variations in age groups studied or to socio-cultural differences between the regions or to differences of sample size.

Regarding SCT, the overall prevalence among the 2 cities was found (3.33%) with more prevalence among Al-Khobar group (3.76%) in comparison with Makkah group (2.87%) however, Ashour (2004) reported lower prevalence among primary school children in Makkah (1.71% in boys and 1.28% in girls).[48] Other studies in nearby countries reported prevalence of (13.8%) among Bahraini students aged 16–17 years[43], (6%) among Omani children under 5 years of age[49] and (2.06%) among Jordanian school children aged 6–15 years.[29] It may be difficult to explain such variation in the prevalence of hemoglobinopathies among these countries however; it might disclose variations in the study design, methodology applied during estimation and ethnicity.

This study was subject to some limitations; as a cross-sectional study it does not determine cause-effect relationship, small sample size, other types and mutations of hemoglobinopathies were not screened, students of the private schools were not included and the relative frequency in overall population cannot be judged from these data as this study was done on a specific group of population that may not reflect the true prevalence.

CONCLUSIONS

The study could provide new epidemiological data on prevalence of IDA and hemoglobinopathies among adolescent school students in KSA that can serve as a baseline for future studies and interventions and may be of value for genetic counseling and premarital screening. Strengthening public health education, especially before individuals plan to marry, through mass media messages with respect to local cultural and religious beliefs, updating the school curriculum, routine carrier screening among school children, updating medical and nursing college curriculums related to the practice of these disorders and integration of community genetic services into primary healthcare systems help to provide the planners and policy-makers with reliable information suitable for formulating health policies and planning to reduce morbidity, mortality, financial and socio-psychological burden of the affected families. Further follow up studies are necessary to evaluate the long-term impact of screening this age group regarding partners' testing and premarital counseling.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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