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Prevalence and risk factors of iron deficiency anemia among children in Yemen

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Abstract: Iron deficiency anemia (IDA) is the most common nutritional anemia and considered a major public health problem worldwide. This cross-sectional study was carried out to investigate the prevalence and risk factors of IDA among 187 children aged below 15 years from rural areas in Yemen. Clinical data was collected by measuring hemoglobin level (Hb), serum iron (SI), serum ferritin (SF), and total iron binding capacity (TIBC). Moreover, fecal samples were collected and examined for the presence of intestinal parasites. Demographic and socioeconomic data was collected by a pretested questionnaire. The overall prevalence of anemia and IDA was 48.7% and 34.2%, respectively with IDA represents 70.2% of all anemia cases. Univariate analysis showed significant associations between IDA and age, gender, parent educational level, monthly household income, intestinal parasitic infections. However, gender (female), low household monthly income and low level of mothers' education were retained by multivariate analysis as the risk factors of IDA. In conclusion, IDA is a serious health problem among children in rural Yemen and there is a need for national intervention strategies and programs to improve the socioeconomic status and health education which will help significantly in controlling anemia and IDA among these children.

Keywords: Anemia, Iron Deficiency Anemia, Risk Factors, Children, Yemen

1. Introduction

Anemia continues to be an important public health problem worldwide with prevalence of 43% in the developing countries and of 9% in the developed nations [1]. The World Health Organization (WHO) has estimated that more than 2 billion people worldwide are suffering anemia with 50 % of all anemia was attributed to iron deficiency [2]. Besides pregnant women, children (both preschool and school-age) are the most affected group by ID because of the rapid growth and the general cognitive development [3,4]. Anemia is a multi-factorial health problem in which the risk factors could be nutritional (iron, folate, and vitamin B12 deficiencies), clinical (infectious diseases such as malaria, helminth infections, tuberculosis, HIV/AIDS and general inflammatory disorders), socioeconomic factors (educational levels of parents and low household income), and demographic factors (age, gender, and family size) [5-7]. On the other hand, the associations of IDA with poor motor, mental and educational performances among children are well documented [4,8-11]. These negative impacts may also continue into adulthood and cause low work productivity with effects on the economic productivity which trap the communities at risk of infections in a cycle of poverty, underdevelopment and diseases [12,13].

In the Middle East region, the prevalence of anemia is high with about 63% of the preschool children are suffering IDA [14]. The prevalence of the anemia in this region varies from 17% to more than 70% among preschool children; from 14% to 42% among adolescents, and from 11% to more than 40% among pregnant women [15]. Amongst the Middle East countries, Yemen has the highest percentage of people living in poverty where more than half of the country's total population (25 million people) lives below the poverty line [16]. This situation might contribute to the high prevalence of many nutritional disorders including anemia among pregnant woman and children [17], and protein-energy malnutrition among school-age children [18,19]. Moreover, few studies have investigated the prevalence of anemia among children in Yemen and reported that the prevalence of anemia varies between 20% and 73.5% [15,18,20]. However, there has been no study on the status of IDA among Yemeni children. Thus, the present study aims to determine the current prevalence of anemia and IDA, and to investigate the risk factors of IDA among children in rural Yemen.

2. Methodology

2.1. Study Area and Study Population

This community-based cross-sectional study was conducted in Hodiedah and Taiz provinces, Yemen (Figure 1). Eight villages were selected randomly from the available villages list in collaboration with the health office in each province. The selected villages were Bait Al-Mokadi, Bany Battal, Al-Asakerah and Al-Magaren from Hodiedah, and Alakmah, Almkisab, Alkahfah and Alnaragah from Taiz, and data were collected between May and July 2012. These areas are considered rural and had farmlands which depend on streams, underground wells and rain (water tanks) as the main source of water for domestic and irrigation purposes. Agriculture was the main occupation of the people in these areas and almost all the mothers were not working while 56.1% of the fathers worked as farmers or laborers. Almost all the houses had no piped water supply while half of them had electricity (connected to generators during night time only).

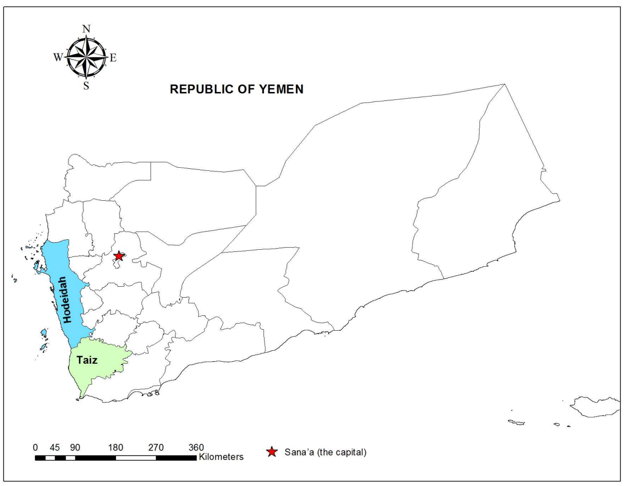

Figure 1 *A geographic map shows Taiz and Hodeidah provinces (study area) in Yemen.*

A total of 187 children were participated voluntarily in this study and delivered stool samples for examination. Questionnaires were administered to the head of households (face-to-face interview), and stool samples were collected from the children. The protocol of this study was approved by the Faculty of Medical Science, Hodiedah University, Yemen and permissions were also given from the related health offices in Taiz and Hodeidah provinces. Before starting sample collection, the parents, and their children were informed about the objectives of the study and a clear explanation about their involvement was given. Written and signed or thumb-printed informed consents were collected from parents or guardians, on behalf of their children.

2.2. Questionnaire Survey

Information on bio-data and socioeconomic status were collected through a pre-designed questionnaire. The questionnaire was designed to collect data about the demographic and socio-economic information of the participants. During the interviews, direct observations were made by an assistant on the personal hygiene of the children and household cleanliness including the availability of functioning toilets, piped water, cutting nails, wearing shoes when outside the house and washing hands.

2.3. Hemoglobin and Biochemical Analyses

About 3 mLs of venous blood were collected from each child in a plain tube and hemoglobin (Hb) level was measured directly after blood withdrawal using the HemoCue hemoglobinometer (HemoCue, AB, Angelhom, Sweden). Children with Hb levels lower than cut-off values recommended by WHO for the diagnosis of anemia were considered to be anemic (< 11 g/dl for children aged below 5 years, <11.5 g/dl for children aged 5-11 years, and < 12 g/dl for children aged 12-15 years [2]. The blood was left at room temperature for clot formation then the tubes were centrifuged at 3000 rpm for 10 minutes to obtain the serum that was stored at –20 ^{o}C till further analysis.

SF levels were analyzed by using ADVIA Centaur Analyzer (Bayer ADVIA Centaur), and children with SF levels of less than 10 μg/L were considered to have deficient iron stores. Meanwhile, SI and TIBC were determined colorimetrically using Cary 50 analyzer (Varian UV-VIS-NIR). Children were identified to have IDA if they were anemic and had low SF (less than 10 μg/L) and/or low SI (less than 10.6 μmol/L), and high TIBC (more than 75 μmol/L) [21,22].

2.4. Parasitology

Fresh fecal samples were collected into wide-mouth screw-cap 100 ml clean containers. The samples were examined by formalin-ether sedimentation and Kato-Katz techniques for the presence of intestinal helminths, including *Schistosoma mansoni*, STH, *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm [23,24].

2.5. Data Analysis

Statistical analysis of the data was performed using *Statistical Package for Social Sciences for Windows* SPSS version 18. For descriptive analysis, prevalence of infections and illnesses was expressed in percentage while mean (standard deviation; SD) or median (interquartile range; IQR) was used to present the quantitative data and results were presented in tables. All quantitative variables were examined for normality by Shapiro-Wilks test before analysis. Pearson's Chi Square test was used to investigate the association between the dependent variables (IDA) and the independent variables (age, gender, parents' educational status, parents' employment status, family size, family monthly income, and parasitic infections). Odd ratios (OR) and 95% confidence intervals (CI) were computed. Moreover, multiple logistic regression model was developed and used to identify the significant risk factors of IDA; OR and its corresponding 95% CI were calculated based on the final model. All tests were considered significant at $P < 0.05$.

3. Results

3.1. Demographic Characteristics of Participants

Table 1. *General characteristics of children participated in the study.*

Characteristics	Frequency (%)
Age groups	
< 5 years	41 (21.9)
5-10 years	60 (32.1)
> 10 years	86 (46.0)
Gender	
Boys	88 (47.1)
Girls	99 (52.9)
Socioeconomic status	
Fathers' education level (at least 6 years)	57 (30.5)
Mothers' education level (at least 6 years)	41 (21.9)
Low household income (< YER 20,000)	118 (63.1)
Working fathers	82 (43.9)
Working mothers	10 (5.3)
Large family size (≥ 7 members)	120 (64.2)
Electricity	92 (49.2)
Intestinal helminth infections	
Ascariasis	42 (22.5)
Trichuriasis	37 (19.8)
Hookworm infection	14 (7.5)
Schistosomiasis	33 (17.6)

One hundred and eighty seven children (88 boys; 99 girls) aged between 1-14 years with a 10 years (95% CI = 9.7, 10.2) participated voluntarily in this study. The general socioeconomic and health characteristics of these children are shown in Table 1. Less than one third (30.5%) of the fathers had formal education of at least 6 years (primary education) while only 21.9% of the mothers had finished their primary education. Poverty prevails in these communities with about two-thirds of the families had low monthly household income (< YER 20,000; US$1 = YER214). Moreover, there was no adequate or proper sanitation in these communities and all the houses had no safe piped water supply. Overall, about half of the children (51.9%) were found to be infected with intestinal parasitic infections. The overall prevalence of ascariasis, trichuriasis, hookworm infections and intestinal schistosomiasis was 22.5%, 19.8%, 7.5% and 17.6, respectively.

3.2. Prevalence of Anemia, Iron Deficiency and Iron Deficiency Anemia

The levels of serum iron parameters and prevalence of anemia and IDA among children according to age and gender are presented in Table 2. The mean Hb level was 11.2 g/dL (SD = 1.3) with the girls had significantly lower level when compared with the boys (10.9 vs 11.6; t = 3.070; $P = 0.002$). Similarly, the mean concentration of SF was 15.6 μmol/L (SD = 1.5), with the girls had significantly lower SF level when compared with the boys (14.6 vs 16.6; t = 2.053; $P = 0.041$). On the other hand, there were no significant differences in the levels of SI and TIBC between the girls and boys ($P > 0.05$). The total percentage of children with low SF and SI concentrations was 27.2% and 52.9% respectively and high TIBC was reported in 65.8% of the children.

Overall, 48.7% (91/187) of the children were anemic (low Hb levels). Moreover, the prevalence of IDA was 34.2%, which accounted for 70.2% of the anemic cases. The prevalence of anemia was significantly higher among the girls compared to the boys (61.6% vs 34.1%; $\chi^2 = 14.129$; $P < 0.001$). Similarly, the girls had significantly higher prevalence of IDA when compared with boys (49.5% vs 17.0%; $\chi^2 = 21.792$; $P < 0.001$). Likewise, the prevalence of IDA was significantly higher among children aged ≤ 10 years compared to those aged > 10 years (40.6% vs 26.7%; $\chi^2 = 3.958$; $P = 0.047$). The children aged ≤ 10 years had significantly higher prevalence rate of anemia compared to their counterparts (58.4% vs 37.2%; $\chi^2 = 8.362$; $P = 0.004$).

3.3. Potential Risk Factors of Iron Deficiency Anemia

Table 3 shows the association between IDA and some demographic and socioeconomic factors and the intestinal helminth infections among the participated children. Besides the significant association of IDA with gender and age of children, the table also indicated that the prevalence of IDA was significantly higher among children belong to fathers with low educational level when compared to their counterparts (P = 0.029). Similarly, children of mothers who had low educational level had significantly higher prevalence of IDA compared to those of educated mothers. Likewise, the prevalence of IDA was significantly higher among children of non educated mothers (40.4% vs 12.2%; OR = 4.9; 95% CI = 1.8, 13.2) and those from families with low household monthly income (43.2% vs 18.8%; OR = 3.3; 95% CI = 1.6, 6.6 when compared with the children of mothers with at least 6 years of formal education and those from families with household monthly income of ≥ YER20,000.

Surprisingly, it was found that children who were infected with *Ascaris* (21.4% vs 37.9%; OR = 0.5; 95% CI = 0.2, 0.9) and/or *Trichuris* (18.9% vs 38.0%; OR = 0.4; 95% CI = 0.2, 0.9) had significantly lower prevalence rate of IDA compared to non-infected children.

Three factors associated significantly with IDA were retained by multiple logistic regression model analysis (Table 4). Girls had three times the odds of suffering IDA when compared with boys (95% CI = 1.6, 6.2). Similarly, mothers' low educational level increased the odds for IDA by 4.1 times (95% CI = 1.3, 12.8) compared to children of educated mothers. Moreover, children from families with low household monthly income (< YER20,000) had significantly higher odds of having IDA when compared with those from families with higher household monthly income (OR=2.2; 95% CI = 1.1, 4.2).

Table 2. *Levels of serum iron parameters and prevalence of anemia, ID and IDA among Yemeni children according to age and gender (n = 187).*

Age/ Gender	Hemoglobin Mean±SD	S. ferritin Mean±SD	S. iron Median (IQR)	TIBC Mean±SD	Anemia n (%)	ID[1] n (%)	IDA[2] n (%)
Age groups (years)							
< 5 (n = 41)	10.9±1.5	13.4±1.1	10.2(8.9, 14.9)	73.0±4.2	24 (26.4)	9 (22.5)	24 (26.4)
5 – 10 (n = 60)	11.3±1.2	15.5±1.7	10.3(9.9, 15.4)	72.2±3.9	35 (38.5)	9 (22.5)	35 (38.5)
> 10 (n = 86)	11.4±1.3	16.7±1.4	11.2(9.7, 14.2)	73.2±3.6	32 (35.2)	22 (55.0)	32 (35.2)
Gender							
Boys (n = 88)	11.6±1.2	16.6±1.7	12.7(9.9, 15.7)	72.1±3.4	30 (34.1)	24 (27.3)	15 (17.0)
Girls (n = 99)	10.9±1.3	14.6±1.3	10.2(9.6, 12.8)	73.4±4.0	61 (61.6)	16 (16.2)	49 (49.5)
Total (n = 187)	11.2±1.3	15.6±1.5	10.6(9.7, 14.2)	72.8±3.7	91 (48.7)	40 (21.4)	64 (34.2)

SD: Standard deviation; IQR: Interquartile range

[1] Iron deficiency (ID): non-anemic; low SF and/or low SI and high TIBC

[2] Iron deficiency anemia (IDA): anemic with low SF; and/or low serum iron and high TIBC

Table 3. *Univariate analysis of factors associated with IDA among the rural children in Yemen (n = 187).*

Variables	Iron deficiency anemia		OR (95% CI)	*P* value
	No. examined	Infected n (%)		
Age				
≤ 10 years	101	41 (40.6)	1.9 (1.0, 3.5)	0.047*
> 10 years	86	23 (26.7)	1	
Gender				
Female	99	49 (49.5)	4.8 (2.4, 9.4)	< 0.001*
Male	88	15 (17.0)	1	
Family size				
≥7 members (large)	120	42 (35.0)	1.1 (0.6, 2.1)	0.765
<7 members	67	22 (32.8)	1	
Father's educational level				
Non educated	130	51 (39.2)	2.2 (1.1, 4.4)	0.029*
Educated (≥6 years)	57	13 (22.8)	1	
Mother's educational level				
Non educated	146	59 (40.4)	4.9 (1.8, 13.2)	0.001*
Educated (≥6 years)	41	5 (12.2)	1	
Father's employment status				
Not working	82	29 (35.4)	1.1 (0.6, 2.0)	0.771
Working	105	35 (33.3)	1	
Household monthly income				
< YER 20,000	118	51 (43.2)	3.3 (1.6, 6.6)	0.001*
≥ YER 20,000	69	13 (18.8)	1	
Ascariasis				
Yes	42	9 (21.4)	0.5 (0.2, 0.9)	0.047*
No	145	55 (37.9)	1	
Trichuriasis				
Yes	37	7 (18.9)	0.4 (0.2, 0.9)	0.028*
No	150	57 (38.0)	1	
Hookworm infections				
Yes	14	3 (21.4)	0.5 (0.1, 1.8)	0.294
No	173	61 (35.3)	1	
Schistosomiasis				
Yes	33	12 (36.4)	1.1 (0.5, 2.5)	0.775
No	154	52 (33.8)	1	

OR: odds ratio; CI: confidence interval; epg: eggs per gram feces

[*] Significant association (P <0.05)

4. Discussion

This is the first study to provide information on the prevalence and risk factors of IDA among children in rural Yemen. We found that anemia and IDA are serious health problems in rural Yemen as our findings showed high prevalence of anemia (48.7%) and IDA (34.2%) among the studied children. The reported prevalence of IDA was accounted for 70.2% of the anemic cases. A previous study among 469 schoolchildren in Hajr valley, southern Yemen revealed that the prevalence of anemia was 48.6% and the prevalence among children with malaria parasitemia was much higher (67.0%) [25]. However, the prevalence of anemia reported by our study was high compared to a recent study conducted among 400 rural children aged ≤ 15 years in 5 provinces in Yemen and reported that 39.5% of those children were anemic [20]. The study population of Sady et al. involved participants from other provinces including Sana'a (the capital), Dhamar and Ibb, and this may explain the variation in the results. On the other hand, a previous study was carried out in the Pediatric Department of Aden General Teaching Hospital among 103 pediatric patients who received blood transfusion and revealed that the common indication (54.4%) of blood transfusion was IDA [26]. Likewise, a recent study in Ibb city found that the prevalence of IDA among infants (aged 5 weeks to 24 months) and children (aged 25-48 months) was 69.0% and 37.0% respectively [27]. This is in accordance with the estimation by UNICEF that 68.0% and 85.0% of preschool children and pregnant women in Yemen were anemic [19].

Table 4. *Results of multivariate analysis of potential risk factors for IDA among the rural children in Yemen (n = 187).*

Variables	Iron deficiency anemia		
	Adjusted OR	**95% CI**	***P***
Age (≤ 10 years)	1.4	0.7, 2.8	0.329
Gender (female)	3.2	1.6, 6.2	0.001*
Father's educational level (non educated)	0.5	0.2, 1.4	0.182
Mother's educational level (non educated)	4.1	1.3, 12.8	0.014*
Household monthly income (< YER 20,000)	2.2	1.1, 4.2	0.024*
Ascaris infections	0.8	0.4, 1.6	0.466
Trichuris infections	0.7	0.3, 1.5	0.370

OR: odds ratio; CI: confidence interval
* Significant risk factor ($P \leq 0.05$)

To compare our findings with other studies conducting in other countries a review paper by Bagchi (2004) has showed that anemia among preschool children in Yemen was highly prevalent; 70% compared to their counterparts Saudi Arabia (17%) [15]. This high prevalence of IDA could be linked to poverty which resulted in insufficient nutrition and inadequate health care. The prevalence of anemia among children in the neighboring countries varied from as high as 60% in Somalia to as low as 14% in the United Arab Emirates [15,28]. Likewise, higher prevalence of anemia was reported in Zanzibar among schoolchildren (62.3%), in Kenya among preschool children (92.0%), and in Liberia among pregnant women (78.0), in which more than 80.0% of the anemic cases were attributed to IDA [29,30]. Globally, it has been reported that about 750 million children are suffering IDA, and it is considerably more prevalent in the developing countries [2]. In industrialized countries, IDA affects 18% and 30% of children and pregnant women respectively [31,32]. Surprisingly, a study from Canada has reported that IDA among Canadian infants and young children ranged from 1.5% to 79% [33].

Children are more commonly and severely affected by IDA due to the increased iron demands for growth. In this regard, 44% of the total population of Yemen is under the age of 15 years [34]. The findings of the present study showed that the prevalence of anemia and IDA among children ≤ 10 years were significantly higher than those aged >10 years in which the mean concentrations of Hb and SI were increased with age. These findings are consistent with a recent study which reported that IDA decreased with age until adolescence [35]. Similarly, many previous studies found higher prevalence of anemia and IDA among young children compared to their older counterparts [21,29,36]. This could be attributed to the increased body demands for iron and other trace elements required for body development including immunity and resistance against infections with age [2]. By contrast, few previous studies reported either a significantly higher prevalence among elder children compared to young children [6,37] or reported similar prevalence among both groups [38].

Girls are more prone to be anemic than boys particularly at reproductive age. The WHO has reported that more than 50% of the females at reproductive age are anemic worldwide [39]. In agreement with the global estimation, our study showed that girl subjects had significantly higher prevalence of anemia compared to male subjects (61.6% vs 34.1). Similarly, the prevalence of IDA was significantly higher among the girls than the boys (49.5% vs 17.0%). Our findings are consistent with a previous study conducted in rural India and revealed that 98% of the female participants were anemic compared to 56% of their male peers [40]. Besides the physiological variations, the higher prevalence of anemia among females could be explained by the traditional and cultural practices in rural Yemen in which families tend to give more priority and more rights to the males than females including biases in food distribution. By contrast, previous studies from Kenya and Zanzibar found that the prevalence of anemia and IDA was significantly higher in boys than girls [29,41].

Besides gender (female), investigating the possible risk factors associated with IDA among the participants revealed that the low maternal educational level was a significant risk factor of IDA. We found that children of mothers with low educational level (< 6 years of formal education) were four times more likely to develop IDA than children of mothers with higher educational levels. This is in agreement with data from the Indian National Family Health Survey [42]. While the gap between male and female illiteracy is closing in most world countries, this is not the case with Yemen where education inequity is still a challenging problem. The general rate of illiteracy is high in Yemen (53%) with almost a double rate more among women (74.7%) compared to the rate among men (32.5%) [43].

The findings of the present study further showed that children of families with a household monthly income of < YER20,000 (USD1 = YER216) had significantly higher prevalence of IDA compared to their counterparts. Yemen is classified among the lower middle income countries with more than 50% of the population lives below the poverty line and had a very low purchasing power [16]. Previous studies from many developing countries concluded a significant inverse relationship between the household income and the prevalence of malnutrition and anemia [44-46].

In general, rural populations are also exposed to other factors such as genetic factors (thalassemia and sickle cells) and some diseases that may cause blood loss including hookworm infections, schistosomiasis and malaria. The association of IDA with parasitic infections that cause bleeding (e.g. hookworm infection and schistosomiasis) or dysentery (e.g. trichuriasis and amoebiasis) is well documented [3,47,48]. Moderate-to-heavy hookworm infections (caused by *Ancylostoma duodenale* and/or *Necator americanus*) is known to drain nearly 50 ml of blood daily and thereby decreasing the blood cell count, hemoglobin and serum proteins. The chronic blood loss from the gastrointestinal tract considers the main mechanism that leads to iron deficiency and iron deficiency anemia [3,45]. Beside the blood loss, these infections may lead to loss of appetite which may cause a general malnutrition resulting in IDA [49,50]. Moreover, a significant association between *Ascaris lumbricoids* infections and IDA has been reported [22,51]. By contrast, findings of the present study showed that the prevalence of IDA was significantly lower among participants who were infected with *T. trichiura* and *A. lumbricoides* compared to non infected participants. The intensity of infections is proportional with morbidity and other consequences; however the present study did not consider the evaluation of intensity. Overall, these factors were not retained as significant risk factors by the multivariable analysis. Previous studies from Uganda, Nigeria and Nepal found no such significant association between parasitic infections and IDA [51-53]. Similarly, a recent study concluded that the association between anemia and trichuriasis is less clear [54]. Moreover, we found no significant associations between IDA and hookworm infections and schistosomiasis among these subjects.

We acknowledge some limitations of the present study. For stool examination, only a single fecal sample was collected from each participant because of a limitation of resources and the level of cooperation and response from the children and their parents. Hence, the prevalence of intestinal parasitic infections might be underestimated due to the temporal variation in egg excretion per days. Moreover, the dietary recall and diet assessment were not possible during our study because of the very low response rate of the parents to the long dietary assessment questionnaire. Furthermore, our findings regarding the associations and risk factors of IDA should be interpreted with caution due to the cross-sectional design which limits concluding causal relationships.

5. Conclusion

In conclusion, anemia and IDA are still highly prevalent and considered as serious health problems among children in rural Yemen. The findings showed that about half of the studied children were found to be anemic with 70% of them had IDA. Gender (female), low level of maternal education and low household monthly income were identified as the significant risk factors of IDA among these children. Overall, people in rural areas in Yemen almost live under the same conditions of socioeconomic status and health care levels. Hence, the findings of the present study could be generalized to rural populations in other provinces. However, further investigations are required to support this conjecture and the findings of the present study.

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