Seroprevalence of Hepatitis A, B and C Among a Sample of Refugees in Egypt: An Exploratory Survey

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Abstract

Background Estimating the prevalence of infectious diseases, including viral hepatitis, among refugees is important for evaluating their health needs and predicting the burden on the health system of the host country. This study aimed at estimating the seroprevalence of viral hepatitis among refugees in Egypt.

Methods This cross-sectional study involved a heterogeneous group of 501 refugees. Enzyme-linked immunosorbent assays were used to detect IgG antibodies against hepatitis A virus (HAV), B virus (HBV) surface antigen (anti-HBsAg), C virus (HCV), and HBV surface antigen (HBsAg).

Results Anti-HAV was the most prevalent marker (n = 482, 96.2%), followed by anti-HBs (n = 142, 28.3%) and HBsAg (n = 21, 4.2%), while only four refugees (0.8%) had positive anti-HCV IgG. Anti-HBs was higher in males (p < 0.05). Older refugees and non-working subjects had significantly higher seropositive rates of anti-HAV (p = 0.051 and p = 0.023, respectively), while students and those below 15 years of age had higher rates of anti-HBs (p < 0.05). Positive HBsAg results were associated with history of hepatitis (p < 0.001). Obese participants were more likely to be positive for HBsAg (p = 0.025) and anti-HBs (p < 0.05). Sudanese refugees had significantly higher rates of anti-HAV antibodies (p = 0.049), while Yemini refugees had significantly higher rates for HBsAg (p = 0.019) positivity. Residents of Dakahlia had significantly higher rates of anti-HAV (p = 0.008) and anti-HBs (p < 0.05). None of the studied risk factors was significantly associated with anti-HCV.

Conclusion Refugees in Egypt have poor immunity against HBV with intermediate to high HBV and low HCV prevalence rates. Despite that 65% of refugees received the HAV vaccine, almost all had IgG anti-HAV, denoting previous infection.

Keywords HCV • HBV • HAV • Refugees • Immigrants • Seroprevalence

Abbreviations

Ag Antigen
BMI Body mass index
EEA European economic area
ELISA Enzyme-linked immunosorbent assay
EPI Expanded Programme on Immunization
EU European Union
HAV Hepatitis A virus
HBV Hepatitis B virus
HCV Hepatitis C virus
IgG Immunoglobulin G
UNHCR United Nations High Commissioner for Refugees
UNICEF United Nations Children’s Fund

1 Introduction

As of 31 January 2022, the refugee population registered in Egypt by the United Nations High Commissioner for Refugees (UNHCR) comprised 137,599 Syrians, representing almost 50% of all refugees in Egypt, while the remaining refugees were from Sudan, Eritrea, Ethiopia, South Sudan and more than 50 other nations [1]. In Egypt, refugees mostly reside in urban areas across the country and are mainly concentrated in Giza, Cairo, followed by Alexandria. Refugees
continue to have access to public education and health services at the same scale as Egyptians [2].

Neighbouring countries that provide asylum and safe shelter for those who migrate are witnessing increased demographic and economic hardships. Population mobility is also associated with the introduction of new diseases in the host community, including infections of the respiratory tract, diarrhoeal diseases, tuberculosis, hepatitis A, B and C (HAV, HBV and HCV, respectively) and others [3]. Fleeing of refugees from their countries might interrupt the completion of their vaccination schedule against some of the vaccine-preventable diseases such as HBV. Moreover, the living conditions of such individuals might often involve overcrowding and inadequate hygienic practices, which might in turn raise their odds of contracting infectious diseases in their host country [4, 5].

Between 1990 and 2013, the worldwide reported mortalities from viral hepatitis had surged from 0.89 million to 1.45 million [6]. With an estimated 8–10 million persons living with viral hepatitis in Egypt alone, viral hepatitis represents a significant public health concern in the country [7]. In 2015, Egypt’s HCV infection prevalence of 7% in adults was among the highest in the world and accounted for 7.6% of the country’s mortality [8]. Between 2014 and 2020, Egypt screened more than 50 million and treated more than 4 million residents for HCV [8].

Identification of the prevalence of infectious diseases among refugees is important for estimating their health needs, predicting the burden on the health system and accurately planning the response at all different public health levels [4]. Since viral hepatitis is a major health problem in Egypt, the estimation of its magnitude among refugees would help in estimating any additional disease burden as well as provision of adequate prevention and control measures for such individuals.

This study aimed at estimating the seroprevalence of hepatitis A, B and C viruses among a sample of refugees in Egypt.

2 Methods

The study was conducted in different Syrian and migrants/refugees community centres in Giza, Alexandria, Dakahlia and Damietta governorates. These centres provide services and activities for Syrians such as women empowerment, workshops on how to run a business and improve marketing skills, educational sessions for children and awareness sessions for public on topics such as health and law.

Refugees of both genders with no age restrictions were recruited by inviting all those attending any of the study settings during the data collection days. Migrants should have been residing in Egypt for at least 6 months.

The sample size was calculated to be 385 refugees at a 95% confidence level with a 5% margin of error. The number of recruited participants was 501 from different age groups of both genders.

2.1 Data Collection Methods and Tools

After obtaining written consent from each participant, a pre-designed structured questionnaire was filled out by the interviewer to collect the following: socio-demographic data, date since fleeing their home country and entering Egypt, history of viral hepatitis and vaccination history for HBV and HAV. The questionnaire was piloted to test for its validation [9, 10].

This included four parameters:

- **Face validation**: to ensure that the respondents’ understanding of the questions was aligned with our goals.
- **Pilot data preparation**: in this step, we ensured that response bias was minimized and the possibility of predicting missing data was investigated.
- **Content validation**: in this step, we verified that the question items targeted the aim of the study.
- **Content reliability**: in this step, we investigated the relevance of the question items.

Weight was measured by a calibrated weighing scale. The height of each participant was measured and recorded to calculate the body mass index (BMI) of each participant. Weight (kg) and height (cm) were obtained using a standard office scale. BMI = kg/m². Obesity was defined according to age; adults were considered obese if BMI > 30 kg/m² and for children (< 18 years) a BMI equal to or greater than the 95th percentile was considered obese [11].

2.2 Laboratory Tests

Five millilitres of blood were drawn from all participants and transferred to an ice box without delay to be processed at the laboratory of the High Institute of Public Health, Alexandria University. To separate the serum, 5000 rpm centrifugation was done. Sera aliquots were stored at −20 °C until used for detection of anti-HAV, HBsAg, anti-HBs and anti-HBe by enzyme-linked immunosorbent assay (ELISA) (kits manufactured by Precheck Bio, INC., CA, USA). Correlation of HBV protection was considered when anti-HBs IgG exceeded 10 mIU/mL [12].

2.3 Statistical Analysis

Data were extracted, revised, coded and fed to statistical software IBM SPSS version 25 (SPSS, Inc. Chicago, IL). All statistical analysis was done using two-tailed tests. P values
less than 0.05 were statistically significant. Qualitative
data were described using frequency and percentage, while
quantitative data were described using range (minimum and
maximum), mean, and standard deviation. The Chi-square
test was used to test the association between categorical vari-
ables, while Fisher’s exact or Monte Carlo correction was
used as a correction for Chi-square when more than 20% of
the cells have an expected count of less than 5.

3 Results

A total of 501 participants were included, the majority of
whom were 35–44 years old ($n = 115, 23.0\%$). Females con-
stituted 68.1\% ($n = 341$), and 41.7\% ($n = 209$) of all partici-
pants were housewives. The majority of adult participants
received secondary education ($n = 116, 29.7\%$) or university
degree ($n = 112, 28.6\%$). Syrians were the most represented
nationality ($n = 332, 66.3\%$). Alexandria was the main repre-
sented governorate ($n = 203, 40.5\%$), and most participants
($n = 213, 42.5\%$) reported duration of stay of 7–9 years.
Most participants ($n = 333, 66.5\%$) reported receiving HBV
vaccines and 326 (65.1\%) received HAV vaccines. Obesity
was prevalent in 30.3\% of the participants. Only six par-
ticipants (1.2\%) reported a history of viral hepatitis. Some
participants did not know whether they were vaccinated or
not against HAV (29.7\%) and HBV (28.7\%) (Table 1).

The majority of participants (69.5\%) were positive for
only one of the three tested antibodies, 27.3\% were posi-
tive for two antibodies, and 0.4\% were positive for all three
antibodies, while 2.8\% were negative for all of the three
viral antibodies.

As seen in Table 2, the most commonly positive viral hep-
atitis marker was anti-HAV IgG ($n = 482, 96.2\%$), followed
by anti-HBs IgG ($n = 142, 28.3\%$) and then HBsAg ($n = 21,
4.2\%$), while only four participants (0.8\%) were positive for
anti-HCV IgG.

Concerning the titre of anti-HBs, the majority of par-
ticipants ($n = 359, 71.7\%$) had titres < 10 mIU/mL, while 74
participants (14.8\%) had titres ranging between 10 and 100
mIU/mL, and only 13.6\% of participants ($n = 68$) had titres
exceeding 100 mIU/mL.

Among the 501 participants, the majority ($n = 343$)
were negative for both anti-HBs and HBsAg, represent-
ing 71.5\% of all HBsAg-negative tests ($n = 480$), while 137 participants were positive for anti-HBs but negative
for HBsAg (28.5\%). Among the 21 participants with posi-
tive HBsAg, 16 (76.2\%) were negative for anti-HBs, while
5 (23.8\%) were also positive for anti-HBs. The five cases
positive for both HBsAg and anti-HBs had a mean age of
25 years, two were males and three females, three Syrians
and two Sudanese and all were anti-HCV negative and four
of them were anti-HAV positive. Four of them received the

| Age (years) | No | %  |
|------------|----|----|
| <15        | 66 | 13.2|
| 15–24      | 90 | 18.0|
| 25–34      | 76 | 15.2|
| 35–44      | 115| 23.0|
| 45–54      | 90 | 18.0|
| 55+        | 64 | 12.8|
| Min–max    | 5–85|
| Mean ± SD  | 35.3 ± 16.56|

| Gender     | No | %  |
|------------|----|----|
| Male       | 160| 31.9|
| Female     | 341| 68.1|

| Marital status | No | %  |
|----------------|----|----|
| Single/child   | 175| 34.9|
| Married        | 283| 56.5|
| Divorced       | 22 | 4.4 |
| Widowed        | 21 | 4.2 |

| Education (for adults older than 18 yrs, n = 391) | No | %  |
|--------------------------------------------------|----|----|
| Illiterate                                       | 14 | 3.6 |
| Primary                                          | 59 | 15.1|
| Preparatory                                     | 90 | 23  |
| Secondary                                       | 116| 29.7|
| University                                      | 112| 28.6|

| Nationality   | No | %  |
|---------------|----|----|
| Syrian        | 332| 66.3|
| Sudanese      | 64 | 12.8|
| Yemeni        | 26 | 5.2 |
| Eritrean      | 66 | 13.2|
| Others        | 13 | 2.6 |

| Current governorate of residence in Egypt | No | %  |
|------------------------------------------|----|----|
| Alexandria                               | 203| 40.5|
| Giza                                     | 164| 32.7|
| Dakahlia                                 | 67 | 13.4|
| Damietta                                 | 67 | 13.4|

| Duration of living in Egypt (years) | No | %  |
|-------------------------------------|----|----|
| <1                                  | 26 | 5.2 |
| 1–3                                 | 117| 23.4|
| 4–6                                 | 101| 20.2|
| 7–9                                 | 213| 42.5|
| >9                                  | 44 | 8.8 |

| History of receiving HBV vaccine | No | %  |
|---------------------------------|----|----|
| No                               | 24 | 4.8 |
HBV vaccine and one participant was not sure whether he received it or not. None of them were smokers. The titre of their anti-HBs was 10–100 mIU/mL in two of them, while the other three participants had titres exceeding 100 mIU/mL.

Regarding HBsAg seropositivity, significantly higher rates were reported among Yemeni participants (11.5%) followed by Sudanese (10.9%), while the lowest rates were among Eritreans (1.5%), $p = 0.019$. There was a significant difference in HBsAg positivity in relation to the duration of stay in Egypt ($p = 0.024$). Receiving the HBV vaccine was not associated with HBsAg positivity. Obese participants and those who reported a history of viral hepatitis were more likely to be positive for HBsAg ($p = 0.025$, $p = 0.000$, respectively) (Table 3). Of the 21 HBsAg-positive participants, only three had a history of viral hepatitis (14.3%).

Higher seropositivity rates of anti-HBs IgG were noted among refugees younger than 15 years of age (56.1%, $p < 0.001$), students (51.9%, $p < 0.001$), males (36.3%, $p < 0.01$), obese individuals (81.6%, $p = 0.001$) and refugees residing in Dakahlia (41.8%, $p = 0.025$) (Table 4). Of the 142 participants with positive anti-HBs IgG, only one had a history of viral hepatitis. Receiving the HBV vaccine was not associated with anti-HBs IgG positivity or titre (data not shown)

Only four participants (0.8%) were positive for anti-HCV and none of them gave a history of viral hepatitis. Those four anti-HCV seropositive participants had negative HBsAg results. Twenty-one had HBsAg-positive results and 4 had anti-HCV IgG.

Higher seropositive rates of anti-HAV IgG were recorded among participants who were older in age ($p = 0.051$), Sudanese (100%, $p = 0.049$), and not working (compared to students) $p = 0.023$ and residents of Dakahlia compared to Giza (100% versus 92.1%, $p = 0.008$). Receiving the HAV vaccine was not associated with anti-HAV IgG positivity (Table 5). Of the 482 participants with positive anti-HAV, only 6 reported a clinical history of hepatitis (1.24%).

There was no statistical association in the seropositivity between the anti-HAV IgG or anti-HBV IgG. The low number of anti-HCV IgG positive cases did not allow statistical analysis of their associated risk factors.

### Discussion

There is a disparity among countries and overall scarce information regarding the presence of national guidelines for screening infectious diseases among migrants and refugees [13]. Of the countries in the European Union and European Economic Area, 16 (59%) had implemented screening programmes and 15 (56%) had national guidelines [6]. No such guidelines are available in Egypt, and to the best of the authors’ knowledge, no such studies on refugees in Egypt have been published.

In our study, Syrians were the most represented nationality ($n = 332$, 66.3%), and this is in agreement with the large contribution of Syrians among all refugees in Egypt. Alexandria was the main represented governorate in our study ($n = 203$, 40.5%), and most participants ($n = 213$, 42.5%) reported a duration of stay of 7–9 years, which is in line with the time point at which the war in Syria erupted, 12 years ago.

Only 2.8% of our study participants were negative for antibodies against the three viruses: HAV, HBV and HCV, indicating that the majority of participants (97.2%) were exposed to at least one of the three tested viruses,
either through infection or vaccination. This underscores the importance of studying these highly prevalent hepatic serum markers for appropriate prevention and control. In contrast to the high seroprevalence of viral hepatitis markers, a very low percentage of our participants (1.2%, $n=6$) reported a history of viral hepatitis (diagnosed clinically,

| Table 3 | Distribution of HBsAg among a sample of refugees in Egypt |
|---------|----------------------------------------------------------|
|         | HBsAg | Negative | Test of significance |
|         | Positive | No | % | No | % | ($p$ value) |
| Age (years) | | | | | | |
| Less than 15 | 2 | 3 | 64 | 97 | Fisher exact = 3.742 |
| 15–24 | 3 | 3.3 | 87 | 96.7 |
| 25–34 | 2 | 2.6 | 74 | 97.4 | $p = 0.514$ |
| 35–44 | 7 | 6.1 | 108 | 93.9 |
| 45–54 | 6 | 6.7 | 84 | 93.3 |
| 55+ | 1 | 1.6 | 63 | 98.4 |
| Gender | | | | | | |
| Male | 6 | 3.8 | 154 | 96.3 | $X^2 = 0.114$ |
| Female | 15 | 4.4 | 326 | 95.6 | $p = 0.735$ |
| Nationality | | | | | | |
| Syrian | 9 | 2.7 | 323 | 97.3 |
| Sudanese | 7 | 10.9 | 57 | 89.1 | Fisher exact = 12.835 |
| Yemeni | 3 | 11.5 | 23 | 88.5 | $p = 0.019$ |
| Eritrean | 1 | 1.5 | 65 | 98.5 |
| Others | 1 | 7.7 | 12 | 92.3 |
| Occupation | | | | | | |
| Student | 6 | 4.6 | 125 | 95.4 |
| Housewife | 9 | 4.3 | 200 | 95.7 | Fisher exact = 0.461 |
| Not working | 2 | 3.9 | 49 | 96.1 | $p = 0.99$ |
| Manual labourer | 2 | 3 | 65 | 97 |
| Professional job | 2 | 4.7 | 41 | 95.3 |
| Current governorate of residence in Egypt | | | | | | |
| Alexandria | 11 | 5.4 | 192 | 94.6 | Fisher exact = 1.778 |
| Dakahlia | 1 | 1.5 | 66 | 98.5 | $p = 0.528$ |
| Damietta | 2 | 3 | 65 | 97 |
| Giza | 7 | 4.3 | 157 | 95.7 |
| Duration of living in Egypt (years) | | | | | | |
| < 1 | 3 | 11.5 | 23 | 88.5 |
| 1–3 | 2 | 1.7 | 115 | 98.3 | Fisher exact = 11.069 |
| 4–6 | 8 | 7.9 | 93 | 92.1 | $p = 0.024$ |
| 7–9 | 5 | 2.3 | 208 | 97.7 |
| >9 | 3 | 6.8 | 41 | 93.2 |
| History of having HBV vaccine | | | | | | |
| No | 3 | 12.5 | 21 | 87.5 | $X^2 = 4.412$ |
| Yes | 12 | 3.6 | 321 | 96.4 | $p = 0.11$ |
| Do not know | 6 | 4.2 | 138 | 95.8 |
| History of viral hepatitis | | | | | | |
| No | 18 | 3.6 | 477 | 96.4 | $X^2 = 31.731$ |
| Yes | 3 | 50 | 3 | 50 | $p = 0.000$ |
| Obesity | | | | | | |
| No | 10 | 2.9 | 339 | 97.1 | $X^2 = 5.039$ |
| Yes | 11 | 7.2 | 141 | 92.8 | $p = 0.025$ |
or due to recall bias of some participants who might have under-reported their viral hepatitis infections or vaccination status. More than a quarter of our participants did not

Table 4 Distribution of anti-HBs IgG among a sample of refugees in Egypt

| Age (years)     | Anti-HBs IgG | p value |         |         |
|-----------------|--------------|---------|---------|---------|
|                 | Positive     | Negative|         |         |
|                 | No | %   | No | %   |
| Less than 15    | 37 | 56.1 | 29 | 43.9 |
| 15–24           | 43 | 47.8 | 47 | 52.2 |
| 25–34           | 20 | 26.3 | 56 | 73.7 |
| 35–44           | 13 | 11.3 | 102 | 88.7 |
| 45–54           | 14 | 15.6 | 76 | 84.4 |
| 55+             | 15 | 23.4 | 49 | 76.6 |
| Gender          |              |         |         |         |
| Male            | 58 | 36.3 | 102 | 63.8 |
| Female          | 84 | 24.6 | 257 | 75.4 |
| Nationality     |              |         |         |         |
| Syrian          | 95 | 28.6 | 237 | 71.4 |
| Sudanese        | 24 | 37.5 | 40 | 62.5 |
| Yemeni          | 7 | 26.9 | 19 | 73.1 |
| Eritrean        | 14 | 21.2 | 52 | 78.8 |
| Others          | 2 | 15.4 | 11 | 84.6 |
| Occupation      |              |         |         |         |
| Student         | 68 | 51.9 | 63 | 48.1 |
| Housewife       | 37 | 17.7 | 172 | 82.3 |
| Not working     | 16 | 31.4 | 35 | 68.6 |
| Manual labourer | 16 | 23.9 | 51 | 76.1 |
| Professional job| 5 | 11.6 | 38 | 88.4 |
| Current governorate of residence in Egypt |            |         |         |         |
| Alexandria      | 46 | 22.7 | 157 | 77.3 |
| Dakahlia        | 28 | 41.8 | 39 | 58.2 |
| Damietta        | 20 | 29.9 | 47 | 70.1 |
| Giza            | 48 | 29.3 | 116 | 70.7 |
| Duration of living in Egypt (years) |            |         |         |         |
| < 1             | 8 | 30.8 | 18 | 69.2 |
| 1–3             | 38 | 32.5 | 79 | 67.5 |
| 4–6             | 23 | 22.8 | 78 | 77.2 |
| 7–9             | 58 | 27.2 | 155 | 72.8 |
| > 9             | 15 | 34.1 | 29 | 65.9 |
| History of having HBV vaccine |            |         |         |         |
| No              | 5 | 20.8 | 19 | 79.2 |
| Yes             | 103 | 30.9 | 230 | 69.1 |
| Do not know     | 34 | 23.6 | 110 | 76.4 |
| Obesity         |            |         |         |         |
| No              | 235 | 67.3 | 114 | 32.7 |
| Yes             | 124 | 81.6 | 28 | 18.4 |
| History of viral hepatitis |            |         |         |         |
| No              | 141 | 28.5 | 354 | 71.5 |
| Yes             | 1 | 16.7 | 5 | 83.3 |
1 3

Know whether they were vaccinated or not against HAV (29.7%) and HBV (28.7%).

In our study, anti-HAV was the most prevalent serum marker for hepatitis (n = 482, 96.2%), denoting either previous vaccination (65.1% of participants had a history of receiving HAV vaccine) or previous HAV infection, whether clinical or sub-clinical. Despite the high seroprevalence of anti-HAV, only six participants reported a history of viral hepatitis (1.24%), indicating a mild course of infection.

The anti-HAV seroprevalence rate reported in this study among refugees is higher than that reported among Egyptians in a recent meta-analysis (71.5%) [14]. This might be due to the higher prevalence of HAV in countries of origin of those refugees, or due to the deteriorated sanitary and housing conditions of refugees, or since the majority of participants in our study were adults rather than children. The reported anti-HAV seroprevalence rates in a meta-analysis from Syria and Yemen were 88.8 and 86.6%, respectively [14], and 100% in a study on Eritrean asylum seekers residing in the Netherlands [15]. The high seroprevalence of anti-HAV IgG indicates that those refugees are immune to future HAV infections and that they pose little or no risk of HAV transmission to the Egyptian community.

In developing countries, immunity against HAV is acquired through infection rather than vaccination, as this infection is endemic in most African countries [16]. The vaccine is not among the Expanded Programme on Immunization (EPI) of Egypt and most developing countries [16] (probably due to its cost and/or unavailability and good prognosis of the natural infection). Immigrants and travelers from areas of low disease rates are therefore at high risk of infection when residing in countries where the infection is endemic [17]. Hepatitis A infection is transmitted through the faeco-oral route and in conditions with reduced sanitary conditions, such as during natural disasters and wars. On September 9, 2018, the Governorate of Aleppo, Syria, informed the World Health Organization office in Syria that internally displaced persons (displaced since early 2018) in the northwestern and western parts of Aleppo were experiencing a suspected HAV outbreak, with a total of 638 cases of HAV infection. A high displacement rate, deteriorated sanitary and health conditions and poor water quality likely contributed to this outbreak [17].

In our study, higher anti-HAV seropositivity was recorded among participants who were older in age and this was statistically close to significance (p = 0.051). Kaddoura et al. reported that among internally displaced Syrians who suffered an outbreak of HAV disease, 98.6% of them were below 15 years of age [17]. In Egypt, 50% or more of the population develop immunity by the age of 15 years [16]. Collectively, this data indicates contracting HAV infections during childhood, with higher seropositivity developing

| Table 5 | Distribution of anti-HAV IgG among a sample of refugees in Egypt |
|---------|---------------------------------------------------------------|
|                       | Anti-HAV IgG | p value |
|                       | Positive | Negative |
|                       | No | % | No | % |
| Age (years) |
| Less than 15          | 60 | 90.9 | 6 | 9.1 |
| 15–24                | 84 | 93.3 | 6 | 6.7 |
| 25–34                | 73 | 96.1 | 3 | 3.9 |
| 35–44                | 113 | 98.3 | 2 | 1.7 |
| 45–54                | 89 | 98.9 | 1 | 1.1 |
| 55+                  | 63 | 98.4 | 1 | 1.6 |
| Gender               |
| Male                | 152 | 95 | 8 | 5 |
| Female              | 330 | 96.8 | 11 | 3.2 |
| Nationality          |
| Syrian              | 321 | 96.7 | 11 | 3.3 |
| Sudanese            | 64 | 100 | 0 | 0 |
| Yemen               | 23 | 88.5 | 3 | 11.5 |
| Eritrean            | 61 | 92.4 | 5 | 7.6 |
| Others              | 13 | 100 | 0 | 0 |
| Occupation           |
| Student             | 120 | 91.6 | 11 | 8.4 |
| Housewife           | 205 | 98.1 | 4 | 1.9 |
| Not working         | 51 | 100 | 0 | 0 |
| Manual labourer      | 65 | 97 | 2 | 3 |
| Professional job     | 41 | 95.3 | 2 | 4.7 |
| Current governorate of residence in Egypt |
| Alexandria          | 198 | 97.5 | 5 | 2.5 |
| Dakahlia            | 67 | 100 | 0 | 0 |
| Damietta            | 66 | 98.5 | 1 | 1.5 |
| Giza                | 151 | 92.1 | 13 | 7.9 |
| Duration of living in Egypt(years) |
| < 1                 | 26 | 100 | 0 | 0 |
| 1–3                 | 110 | 94 | 7 | 6 |
| 4–6                 | 95 | 94.1 | 6 | 5.9 |
| 7–9                 | 208 | 97.7 | 5 | 2.3 |
| > 9                 | 43 | 97.7 | 1 | 2.3 |
| History of having HAV vaccine |
| No                  | 26 | 100 | 0 | 0 |
| Yes                 | 312 | 95.7 | 14 | 4.3 |
| Do not know         | 144 | 96.6 | 5 | 3.4 |
| Obesity             |
| No                  | 333 | 95.4 | 16 | 4.6 |
| Yes                 | 149 | 98 | 3 | 2 |
| History of viral hepatitis |
| No                  | 476 | 96.2 | 19 | 3.8 |
| Yes                 | 6 | 100 | 0 | 0 |
with older age. However, there has been a recent change in the age distribution of HAV infections, shifting to older age groups, making them more prone to severe clinical presentations and complications [14, 16, 18].

In the present study, other factors associated with sero-positivity of anti-HAV IgG were being Sudanese (100%, \( p = 0.049 \)), not working (compared to students, \( p = 0.023 \)) and among residents of Dakahlia (\( p = 0.008 \)). Higher sero-prevalence might indicate more frequent environmental exposure to HAV among those risk groups.

Despite that 66.5% of participants reported receiving HBV vaccines, anti-HBs was positive in only 28.3% of them. The low sero-prevalence rate despite higher reported vaccination rates may reflect waning immunity due to the lapse of a long time since vaccination, vaccination failure or the possibility of recall bias. Incomplete vaccine schedules might have led to lower immune response. Administration of three doses of HBV vaccine during childhood is known to be almost 95% effective in preventing infection [19, 20].

The HBV vaccine has been part of the compulsory childhood vaccination programme in Egypt since 1992 and has resulted in a dramatic drop in HBV infections ever since, evidenced by decreased sero-prevalence of HBsAg (in which HBsAg-positive individuals are potentially infectious carriers), and a decreased sero-prevalence of HBV anti-core antibodies (anti-HBcAb) (which indicates HBV infection) [19]. Unfortunately, in our study anti-HBcAb was not done, so it was not possible to determine whether cases with positive anti-HBs were vaccinated or previously infected. Nevertheless, the importance of these cases lies in them being potentially infectious to others and thus requiring treatment and adoption of prevention and control measures (including vaccination) for their contacts.

According to the UNICEF estimates of immunization coverage in 2020, the percentage of surviving infants who received the three doses of HBV vaccine following the birth dose was 95% in Eritrea, 94% in Egypt, 90% in Sudan, 72% in Yemen and only 49% in Syria [21]. Since most of our study participants were from Syria (66.3%), it is noteworthy to mention that since the introduction of HBV in their EPI vaccination programme, low rates of HBsAg (5.6%) were reported in the following years. Unfortunately, since the war in Syria began in 2011, vaccination rates have fallen significantly with the subsequent rise of HBV infections among the younger Syrian generations who have not received their childhood vaccinations [18]. The discontinuation of vaccine schedules in countries with conflicts raises hazards of vaccine-preventable diseases among refugees in host countries.

In our study, concerning the titre of anti-HBs, only 74 participants (14.8%) had a titre ranging between 10 and 100 mIU/mL, and only 13.6% of participants (\( n = 68 \)) had a titre exceeding 100 mIU/mL. The declining rate of anti-HBs seroprotection with age is reported to reach its lowest level in individuals aged 11–20 years [22]. Anti-HBs IgG concentrations between 10 and 100 IU/L indicate a low level of immune protection against HBV, whereas concentrations > 100 IU/L indicate a high level of protection [23]. Consequently, we could conclude that there was a high risk of infection among the majority of participants in our study. This necessitates vaccination of these refugees against HBV to protect them, their families and the Egyptian community.

In the present study, the sero-prevalence of HBsAg was 4.2% (\( n = 21 \)), which was higher than the rate reported by the Egyptian Health Issues Survey, 2015, in a large population-based study (1%) [8]. Refugees from Syria had the lowest sero-prevalence of HBsAg (2.7%) compared to Sudanese (10.9%) and Yemeni (11.5%) refugees. Comparable sero-prevalence rates have been published in a meta-analysis in Sudanese (9.76%), Syrian (2.62%), Yemeni (8.38%) and Eritrean (2.49%) populations [25], denoting that the sero-prevalence rates in the present study reflect the rates in the country of origin of refugees, rather than their host country. In our study, the rates of HBsAg among refugees of all nationalities were higher than the rates reported in the Egyptian community, which poses a risk of transmission of HBV to the community, thus mandating treatment and vaccination of refugees to reduce such risk.

There was no significant difference between Egyptian governorates regarding HBsAg (\( p = 0.528 \)) and this was consistent with another study [Elsabawy, 2011 #31]. However, there was a significant difference in anti-HBsAg among governorates (\( p = 0.025 \)), where Dakahlia Governorate had the highest anti-HBsAg (41.8%) but the lowest HBsAg, denoting probable higher vaccination of this group of refugees.

Among our 501 participants, the majority (\( n = 343 \)) were negative for both anti-HBs IgG and HBsAg, representing 71.5% of all HBsAg-negative tests (\( n = 480 \)), while 137 participants were positive for anti-HBs IgG but negative for HBsAg (28.5%). Among the 21 participants with positive HBsAg, 16 (76.2%) were negative for anti-HBs IgG, while 5 (23.8%) were also positive for anti-HBs. These five cases might be cases of chronic active hepatitis. A review study reported that the prevalence of concurrent HBsAg/anti-HBs in patients with HBV infection can vary from less than 5% to almost 30%, and was usually associated with chronic active hepatitis. Mutations in the viral genomes, immune status and genetic factors of hosts may contribute to the concurrent coexistence of HBsAg/anti-HBs [24].

Obese participants were more likely to be positive for HBsAg (\( p = 0.025 \)), denoting a higher risk of complications among obese individuals. This was also reported in other studies and was attributed to impaired dendritic cell functions among obese subjects, leading to decreased anti-HB surface and core antigen-specific immune responses [26].

Higher positivity rates of anti-HBs were noted among: refugees younger than 15 years of age (56.1%, \( p < 0.001 \),...
students (51.9%, \( p < 0.001 \)), males (36.3%, \( p < 0.01 \)), obese individuals (81.6%, \( p = 0.001 \)) and refugees residing in Dakahlia (41.8%, \( p = 0.025 \)). Young participants (< 15 years), who were most probably students, had higher positivity rates, which might have been due to the relatively shorter time lapse between receiving HBV vaccine and testing. Regarding residence, however, there was no significant difference between governorates regarding HBsAg (Fisher exact \( = 1.778, p = 0.528 \)). This was consistent with another study which reported that the morbidity rate of HBV was not significantly different between populations in Egyptian governorates. However, there was a significant difference in anti-HBsAg among governorates (\( p = 0.025 \)), where Dakahlia Governorate had the highest anti-HBsAg (41.8%) but the lowest HBsAg, denoting probable higher vaccination of this group of refugees.

In our study, only four participants (0.8%) were positive for anti-HCV, but none of them gave a history of viral hepatitis. These cases should be considered as presumptively infected with HCV. A repeatedly reactive result is consistent with current or past HCV infection; however, a positive PCR test to detect viral RNA test should have been done to confirm a current infection [Control, 2017 #30]. These cases might thus pose a public health hazard, owing to their probable infectivity. Our seroprevalence of anti-HCV is extremely lower than the rates in the Egyptian community reported by the Egyptian Demographic and Health Surveys (2015), where the total seroprevalence in those aged < 60 years was 6.3% [7]. A study in 2017 involving 21 Egyptian governorates reported an overall anti-HCV seroprevalence of 14.8% [27]. The low seroprevalence of anti-HCV in refugees in our study might reflect the lower HCV rates in their countries compared to rates in Egypt.

In a meta-analysis on refugees from intermediate and high endemic countries, the overall pooled anti-HCV seroprevalence in migrants was 1.9% (1.4–2.7%) [13], which is comparable to the rate reported in our group of refugees. Differences in prevalence rates of viral hepatitis among studies might be attributed to the composition of the migrant/refugee study population where the studies were carried out [15]. In March 2019, refugees, asylum seekers and migrants in Egypt were included in the national campaign “100 Million Seha (health)” campaign, which offered free screening and treatment against HCV, and by the end of September 2019, 30,000 refugees and migrants underwent the screening of HCV all over Egypt [28]. In our study, positive anti-HCV results were not associated with any of the study’s factors, probably due to the small number of positive anti-HCV individuals. A study by El-Ghitany et al. reported that a higher prevalence of anti-HCV was found among males, older age and in rural residence [27].

In the present study, a higher prevalence of HAV compared to HBV and HCV among refugees is consistent with a large Egyptian study, which compared the prevalence of the three viral infections to rates reported by surveillance from 2001 to 2004, and found a significant increase in the proportion of HAV infections from 40.2 to 89.7% with reductions in the proportions of HBV and HCV infections from 30.0 to 2.8% and 29.8 to 3.0%, respectively [29]. Therefore, the pattern of viral infections among refugees in our study is similar to that in the Egyptian community. Public health efforts towards refugees regarding viral hepatitis should thus be targeted in the same manner as in the Egyptian community.

Some imported infectious diseases (including viral hepatitis) may remain asymptomatic for months or years, whilst early diagnosis and treatment may prevent complications in later life and break the cycle of transmission in the host country [5]. Consequently, the burden on the health system secondary to viral hepatitis should extend to possible complications of cirrhosis and hepatocellular carcinoma in untreated cases. This underscores the importance of early screening of such infections among refugees, especially when we consider their financial and social constraints in host countries, which should not be further complicated by health-related problems.

5 Conclusion

Despite that 65% of refugees received the HAV vaccine, almost all had IgG anti-HAV, denoting previous infection. HBsAg had a lower seropositivity rate (\( n = 21, 4.2\% \)) and only four refugees (0.8%) had positive anti-HCV IgG. Different socio-demographic and clinical factors were associated with each of anti-HAV, anti-HBs IgG and HBsAg. Screening of HBV among refugees is recommended along with vaccination of seronegative individuals.

5.1 Limitations

Our study included a majority of Syrian refugees, and refugees from other nationalities might have been under-represented. Moreover, testing for HBV in our study should have been coupled with testing for anti-HBc IgG to differentiate whether positive results of HBsAg were due to acute or chronic HBV infections. Moreover, cases with positive anti-HCV IgG should have been confirmed as current HCV infection by performing PCR test. Another limitation of our study was the recall bias faced during data collection, particularly the history of vaccination and viral hepatitis.

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Author contributions EME: (1) conception and design of the work, analysis and interpretation of data; (2) revision of the work critically.
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**Data availability** Available and kept confidentially.

**Declarations**

**Conflict of interest** None to declare.

**Ethical approval and consent to participate** The study was conducted in compliance with the Helsinki Declaration and was approved by the Ethics Committee of the Faculty of Medicine, Alexandria University, Egypt [IRB number:00012098]. Written informed consent was collected from all participants. Anonymity and confidentiality were confirmed.

**Consent for publication** All authors consented to submission for publication.

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