Heliyon 5 (2019) e02249

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.heliyon.com

Geospatial epidemiology of hepatitis C infection in Egypt 2017 by governorate

Engy Mohamed El-Ghitany *, Azza Galal Farghaly

Tropical Health Department, High Institute of Public Health, Alexandria University, Egypt

ARTICLE INFO

Keywords:
Microbiology
Virology

ABSTRACT

Background: Geographic Information Systems (GIS) and spatial epidemiological methods may provide a basis for disease investigation through which hotspots and disease determinants can be identified. Applying these methods for hepatitis C virus (HCV) in Egypt would support a more effective strategy to control its transmission. Therefore, this study used GIS software to draw one of the first HCV maps in Egypt elucidating and analyzing geographical and epidemiological differences in HCV distribution within the country.

Methods: A cross-sectional survey of 21 governorates (n = 12169, 8080 rural, 3733 urban and 356 slums areas) was completed. All participants were interviewed regarding potential exposures to HCV. Third generation ELISA was used to test serum for HCV antibody. Quantitative real-time RT-PCR was used to test anti-HCV positive subjects for HCV-RNA.

Results: The participants ranged in age from 14-90 years. Overall, anti-HCV sero-prevalence was 14.8%. The prevalence of HCV-RNA, was 9.5%. Proportionally, 65.8% of anti-HCV positives were positive for HCV-RNA. The map of Egyptian governorates highlighted the darkest spot of HCV infection in Menoufeya (37.8%) followed by Beni Suef (29.2%) and Minya (28.6%). Anti-HCV prevalence was higher among males and logistic regression models revealed a strong independent association with increasing age, rural residence and parenteral anti-schistosomal therapy.

Conclusions: Rural residences and HCV hotspots should be prioritized for HCV prevention programs. The unique age distribution first shown in this study shows that the older age groups (≥60 years old) constitutes a considerable reservoir of infection and must not be neglected.

1. Introduction

Since the emergence of hepatitis C virus (HCV) infection, it has always been a public health threat in Egypt. HCV overtook the liver disease burden after schistosomiasis [1]. Egypt had the highest HCV prevalence in the world. In 2008, according to the Egyptian Demographic Health Survey (EDHS), that was conducted on a nationally representative sample, HCV antibody prevalence was estimated to be 14.7% in the 15-59 year-old age group, 10% HCV RNA positive, and 90% genotype 4 [2]. The Egyptian Health Issues Survey (EHIS), conducted in 2015, reported a significant reduction of 32% and 29% in HCV antibody positive and HCV RNA positive individuals respectively. The latest HCV seroprevalence reached 10% and 7% viremia, in the 15-59 year-old age group. EHIS included younger age groups and estimated an overall seroprevalence of 6.3% [3].

In terms of numbers, nearly 5.3 million persons aged 1–59 years have HCV antibodies, of whom, approximately 3.7 million individuals (69.5%) have chronic HCV infection in 2015. This is an underestimation of the total human HCV reservoir in Egypt because older age groups (>59 years) were not included in the 2015 EHIS [3].

There are variable and unique factors associated with HCV infection in Egypt [4]. Extensive parenteral anti-schistosomal treatment (PAT) campaigns during the second half of the twentieth century was highly incriminated [5]. Evidence of ongoing transmission was reported that might be due to infection control or behavioral issues [6].

Residence in Egypt is one of the most important risk factors [4]. Areas with higher prevalence infection can also become areas of risk for higher HCV transmission where screening and treatment might have the biggest effect in controlling HCV burden. However, little is known about the geographic grouping patterns of hepatitis C infections, especially in Egypt, which limit the efforts to better understand disease transmission and develop targeted responses. Previous studies have shown that HCV

* Corresponding author.
E-mail address: ingy.elghitany@gmail.com (E.M. El-Ghitany).

https://doi.org/10.1016/j.heliyon.2019.e02249
Received 19 January 2019; Received in revised form 17 May 2019; Accepted 5 August 2019

infection can be eliminated globally in the next 15–20 years with focused strategies to screen and cure current infections as well as prevent new infections [7]. Recently, integrated governmental and non-governmental screening efforts have been initiated in Egypt. In order to get the maximum benefit, these efforts have to be prioritized to HCV hotspots. The use of geospatial epidemiological approaches to identify and characterize HCV aggregates can reduce costs and time. This approach has been used for HCV and other infectious diseases in other areas of the world for public health surveillance, allowing policy makers to better understand the geographic distribution of infectious diseases and factors associated with disease pooling. For HCV control in Egypt, spatially prioritized interventions were previously recommended [8]. This approach might also be beneficial in forecasting other infections that have risk factors in common [9].

This study was conducted to estimate the overall HCV prevalence in Egypt and to use geographic information system (GIS) software to draw one of the first maps elucidating HCV distribution in Egyptian governorates.

2. Methods

2.1. Sample size

Using G-power 3.1.9.2 software, a minimum sample of 7,000 (4,010 rural and 2,990 urban) persons was calculated to be required to estimate a prevalence of HCV antibody among Egyptians of 10% with a precision of 1%, $\alpha = 0.05$ and a design effect = 2.

2.2. Study design and sample selection

In the current cross-sectional study, all Egyptian governorates were meant to be included using proportional allocation to each governorate size according to latest population estimate from 2015. The rural urban ratio was maintained in the whole sample as well as in each governorate. A number of districts from each governorate was randomly chosen using simple random sample technique, then a cluster sampling design was used as the sampling method where individuals above 14 years were recruited. Owing to some logistic, political or security reasons, six governorates were excluded namely; Aswan, New Valley, Red Sea, North and South Sinai and Qena, leaving twenty-one governorates included in the survey.

2.3. Selection of households

Due to lack of sample frame for households, starting point for selection was determined by choosing some central point in the community such as market, club, church, mosque, or similar landmark and then a random direction from that point was made. The next household was the door nearest to the current household until the cluster sample was fulfilled or all households within the selected dwelling were covered. The number of starting points were variable and depended upon the sample size and population variation in each governorate.

Data were collected over nearly two years and ended in February 2017.

2.4. Interview

An informed written consent was signed by all participants invited after elaborating on the study aim and concerns. They were interviewed using a modified version of EGCRISC that inquires about factors associated with HCV antibody in Egypt [10, 11, 12]. Although the EGCRISC has four versions that are based on age and gender, we combined all questions in one sheet and added questions regarding visiting dentist and HCV status and treatment.

The present study involved human participants and was approved by the ethics committee and institutional review board of the High Institute of Public Health, Alexandria University (Egypt). The research conformed to the ethical guidelines of the Declaration of Helsinki (2013) and the International Conference on Harmonization Guidelines for Good Clinical Practice.

2.5. Laboratory analysis

All participants were invited to provide a blood sample for HCV antibody testing using 3rd generation ELISA kits (DIALAB©, Austria). Confirmation was done using a different ELISA supplier (DiaSorin Murex©, version 4.0, Italy) [13]. Quantitative real time RT-PCR was done for ELISA positive subjects to test for HCV-RNA.

2.6. Case definitions

Double reactive ELISA testing was considered as HCV infection exposure and referred to as anti-HCV seroprevalence. Serological evidence of past or present infection (anti-HCV +) in addition to HCV RNA positive indicated chronic HCV infection [14]. Reactive ELISA and negative PCR were interpreted as either spontaneous resolution or cure after successful treatment [15].

2.7. Statistical analysis

After data collection, data sheets were revised, coded and entered into the statistical software SPSS IBM version 20.

Descriptive statistics in the form of frequencies and percent were used for categorical data, while mean and standard deviation were used for continuous data. For comparison of data, Chi-square tests were performed for categorical data, while student test or Mann–Whitney U-test was performed for continuous parametric and nonparametric data respectively. All statistical analysis was done using two tailed tests and an alpha error of 0.05. Anti-HCV prevalence was calculated as the proportion of positive antibody ELISA testing to the total sample. Chronic infection prevalence was the proportion of positive PCR testing to the total sample. Prevalence of persistent infection among seropositive individuals was calculated as the number of PCR positive tests in proportion to positive ELISA antibody tests. QGIS 2.4.0-Chugiak software was used for map drawing and geospatial representation.

Each governorate was analyzed separately regarding factors associated with HCV seropositivity using odds ratio and 95% confidence interval. Univariate significant risk factors were included in a stepwise logistic regression model to reveal the independent factors associated with HCV infection in each governorate separately.

3. Results

The study interviewed and tested a total of 12,169 participants (50.7% males); 8080 from rural areas, 3733 from urban areas and 356 from slums areas, recruited from 21 different governorates in Egypt respecting demographic distribution in each governorate as presented in Table 1. The mean age of participants in years was 38.95 ± 13.3 ranging from 14 to 90. HCV antibodies were detected in 1,795 individuals. Anti-HCV prevalence was 14.75% (14.1–15.4) 95% CI. Chronic infection prevalence, defined as the frequency of HCV-RNA by PCR was 9.5% (8.96–10.04) 95% CI. The proportion of persistent infection denoted by positive PCR among anti-HCV positive individuals was 65.8% (63.49–68.11) 95% CI. This estimate ranged widely between governorates; from 31.6% in Beni Suef to 85% in Qalubeya.

Most HCV-RNA positive individuals were unaware of their infection status (66.3%). The frequency of unawareness differed significantly between different governorates ($p < 0.05$), it ranged from 40.6% in Sharkeya to 100% in Giza and Canal governorates (Ismailia, Suez and Port Said) and Damietta. Among HCV-RNA positive patients; 3.5%, 3.7%, 3.6%, 8.7% respectively stated that they are not infected, non-responders to treatment, cured after treatment and being under treatment. While

Table 1
HCV prevalence and quantitation of viremia by governorate in Egypt, 2016/2017.

Governorate	Total no	Anti-HCV		Antibody prevalence %	Number of PCR positive	Mean (x10ˆ6)	SD	Chronic HCV prevalence %	Persistent infection among seropositive (%)
		-ve	+ve						
Alexandria	2349	2205	144	6.1	100	4.36	2.97	4.3	69.4
Asyut	217	171	46	21.2	33	4.18	2.50	15.2	71.7
Beheira	935	781	154	16.5	82	3.84	2.37	8.8	53.2
Beni suef	260	184	76	29.2	24	3.76	2.44	9.2	31.6
Cairo*,#	328	294	34	10.4	9	4.74	2.78	6.9	50.0
Dakahlia*	274	228	46	16.8					
Damietta	146	115	31	21.2	20	3.96	2.12	13.7	64.5
Faiyum	291	235	56	19.2	41	4.14	2.55	14.1	73.2
Gharbia*	440	334	106	24.1					
Giza	336	297	39	11.6	24	4.89	2.97	7.1	61.5
Ismailia	119	93	26	21.8	13	3.76	2.20	10.9	50.0
Kafr El-Sheikh	2750	2435	315	11.5	232	3.95	2.57	8.4	73.7
Luxor	1052	948	104	9.9	72	3.78	2.88	6.8	69.2
Marsa matruh	374	319	55	14.7	37	2.69	1.82	9.9	67.3
Menoufeya	362	225	137	37.8	98	3.66	2.43	27.1	71.5
Minya	469	335	134	28.6	94	3.67	2.94	20.0	70.1
Port Said	71	67	4	5.6	2	2.59	0.80	2.8	50.0
Qalubeya	363	283	80	22.0	68	3.67	2.35	18.7	85.0
Sharqeya	371	275	96	25.9	50	3.71	2.13	13.5	52.1
Sohag	443	364	79	17.8	51	4.04	2.54	11.5	64.6
Suez	219	186	33	15.1	20	3.92	2.29	9.1	60.6
Total	12169	10374	1795*	14.8	1070	3.88	2.57	9.5**	65.8##

* The total number of anti-HCV positive were 1795, but only 1627 underwent PCR. The remaining 168 were 16 in Cairo, 106 of Gharbia and 46 of Dakahlia.
# In Cairo, the chronic infection rate was calculated from the 130 individuals whose blood has been tested for viremia when anti-HCV was positive.
** The total chronic HCV prevalence was calculated from a total of 11257 after exclusion of Dakahlia and Gharbia populations and 198 individuals in Cairo who did not undergo PCR testing when anti-HCV tests were positive.
The total persistent infection prevalence was calculated from a total of 1625 anti-HCV positive cases in whom PCR testing was done.

14.2% have reported their awareness of being HCV-RNA positive, they never sought medical treatment. The latter group varies in distribution among different governorates, the highest frequencies were in Sharqeya (27.1%), Qalubeya (26.3%), Minya (25.4%), Asyut (23.9%), Menoufeya (20.8%) and Marsa matrouh (18.2%), while none in Beni Suef, Faiyum, Giza, Damietta and Canal governorates.

For comparison purpose with the DHS, 2008 and EHIS, 2015, the 15–59 years age group had a sample size of 10,073, of whom 1379 (13.7%) had HCV antibodies and 829 (8.2%) were positive for HCV-RNA. The map illustrated in Fig. 1 shows the anti-HCV prevalence by governorate. There is wide variations in prevalence among different governorates. From the map in Fig. 1 it is easy to highlight the darkest spot being Menoufeya governorates followed by Beni Suef and Minya. Table 1 describes in details anti-HCV prevalence and quantitation of viremia by governorate. The mean viremia was $3.88 \times 10^6 \pm 2.57 \times 10^6$, it neither differed between governorates nor in respect to rural/urban residence ($p = 0.502$ and 0.172 respectively).

Anti-HCV prevalence among males (16.1%) was significantly higher ($p = 0.000038$) compared to females (13.4%). Anti-HCV prevalence increases dramatically with age (Table 2). Fig. 2 illustrates this pattern and compares it to the similar pattern of EHIS 2015. They almost overlap except in the age groups (30–34) and (45–49) where the prevalence differed significantly ($p = 0.03$ and 0.000067 respectively). It was 5.4 and 7.1% among the age group (30–34) in the current study and EHIS 2015 respectively and was 22.5 and 16.3% among the age group (45–49) in the current study and EHIS 2015 respectively. Fig. 2 also demonstrated the continuous increase in prevalence with age until the 60–64 age group followed by a sharp decline.

For more reflection and quantification of the current HCV burden in terms of the number of HCV-RNA positive patients, we estimated a number by multiplying the viremia prevalence in each governorate weighted by its population according to 2015 census. The pattern of results are shown in Table 3 in the 19 governorates where HCV-RNA was assessed. The estimated total reservoir of HCV-RNA positive patients in these governorates, which constitutes 81.41% of total Egyptian population, was 6,803,142. The contribution of each of these governorates to the total number of HCV-RNA positive cases is also shown.

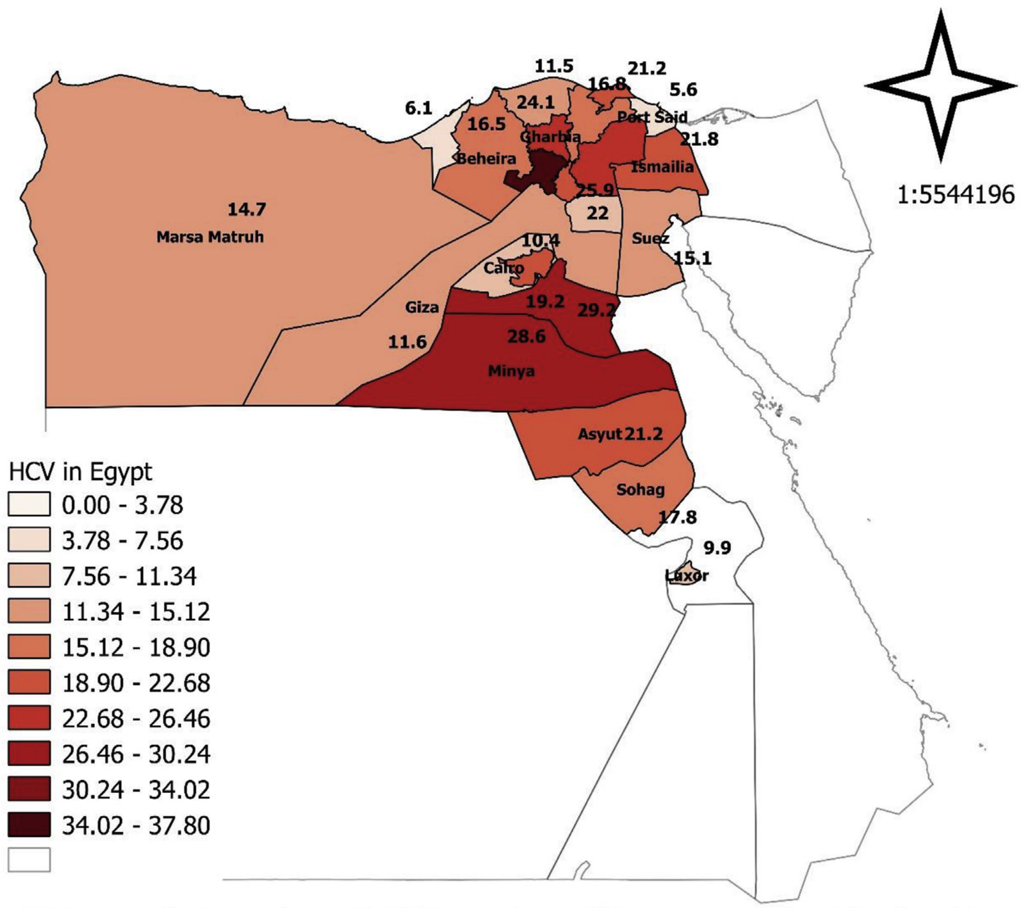
The results of the stepwise logistic regression models regarding factors associated with HCV infection are shown in Table 4. Age was the most common independent factor associated with anti-HCV antibody positivity. Anti-HCV increases in a range of 4%–19% per one-year increase in age. Rural residence and parenteral anti-schistosomal therapy (PAT) were also strongly associated in most governorates that include both rural and urban settings. Female gender was a protective factor in three governorates. No independent risk factor was shown in Port-Said.

4. Discussion

Since the beginning of the plan of action for the prevention, care and treatment of viral hepatitis that was launched by the Egyptian Ministry of Health and Population in 2014, the main focus has been on treatment with noted success. The current main challenge to control HCV in Egypt is to detect asymptomatic HCV carriers in the community [16]. Accordingly, in the present study, GIS software was used to draw the first map elucidating HCV distribution in 21 Egyptian governorates aiming to analyze the geographical and epidemiological differences in HCV distribution.

The 2015 EHIS study reported a significant reduction in the overall prevalence of anti-HCV from 14.7% to 10% and of HCV RNA from 9.9% to 7% between 2008 and 2015 among those aged 15–59 years. The authors attributed this reduction to the disappearance of the group infected during mass PAT campaigns to outside the age range covered (<59 years) by their survey. They also declared that this could be an underestimate of the total human HCV reservoir in Egypt [17].

The above justification is supported in the present study, as the results revealed an increased prevalence of anti-HCV (14.8%) and HCV-RNA (9.5%) among a total of 12,169 participants of wider age range (14–90 years). A higher percentage of anti-HCV and HCV-RNA was evident in the same age group (15–59 years) as compared with EHIS results in 2015 (13.7% vs. 10% and 8.2% vs. 7%) respectively. This latter finding together with the high prevalence of persistent infection (65.8%) observed in this study indicates ongoing HCV transmission and that



This map illustrates the anti-HCV prevelance (%) among people older than 14 years in 21 Egyptian governorates. The colour density correlates with the prevalence to easily recognize the hotspots.

Fig. 1. Prevalence of anti-HCV across 21 Egyptian governorates in 2016/2017.

Table 2
HCV prevalence and quantitation by age groups in 2016/2017.

Rate Age group	Total sample size	PCR sample size*	Anti-HCV negative (no)	Anti-HCV positive (no)	PCR analysis (no)#	Anti-HCV prevalence (%)	Positive PCR (no)	Chronic HCV prevalence (%)	Persistent infection
14–19	782	733	773	9	9	1.15	6	0.82	66.67
20–24	1075	1010	1049	26	24	2.42	14	1.39	58.33
25–29	1434	1333	1365	69	60	4.81	37	2.78	61.67
30–34	1663	1553	1574	89	81	5.35	59	3.80	72.84
35–39	1546	1411	1401	145	138	9.38	97	6.87	70.29
40–44	1458	1346	1262	196	178	13.44	99	7.36	55.62
45–49	1171	1084	908	263	236	22.46	162	14.94	68.64
50–54	1136	1054	824	312	280	27.46	193	18.31	68.93
55–59	808	742	538	270	245	33.42	162	21.83	66.12
60–64	733	651	420	313	281	42.70	173	26.57	61.57
65–69	207	189	141	66	58	31.88	45	23.81	77.59
70–90	155	151	118	37	35	23.87	23	15.23	65.71
Total	**12169**	**11257**	**10373**	**1795**	**1625**	**14.75**	**1070**	**9.5**	**65.85**

* The number of population whose sera were tested for viremia when anti-HCV results were positive. This sample size was used as denominator when chronic HCV prevalence was calculated.

The number of anti-HCV positive population who were tested for viremia by PCR. This number was used as denominator for calculating the rate of persistent infection.

treatment has not yet demonstrated a noticeable impact on the decline of HCV prevalence in Egypt. The start of the current survey almost coincides with the beginning of HCV treatment by the effective oral direct acting anti-viral drugs (DAAs). This might not allow enough time for treatment to show a considerable effect on the rate of clearance. Similar finding was also documented by Gomaa et al. [18] in their recent published review and by Kouyoumjian et al. in their meta-analyses study [19].

The magnitude of HCV problem in Egypt cannot be evaluated by looking only at the tip of the iceberg. Infected, but undiagnosed persons are an important source for further transmission [20]. Most infections are

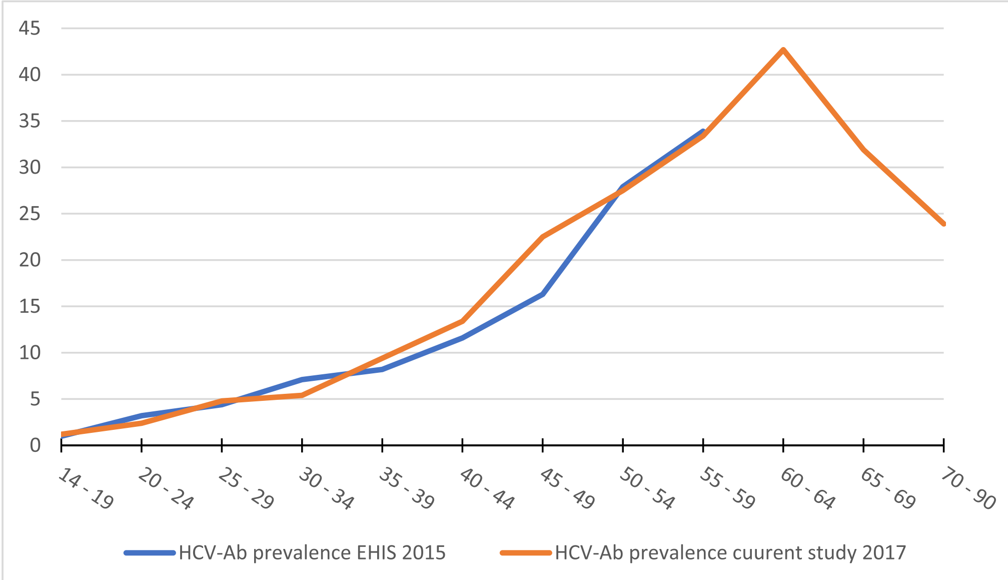


Fig. 2. Anti-HCV prevalence by age in the current study and EHIS, 2015.

Table 3
Burden of chronic HCV population in Egyptian governorates in 2016/2017.

Governorate	Chronic HCV %	Population in 2015 No.	Estimated chronic HCV No.	Contribution to the total chronic HCV %
Alexandria	4.3	4812186	206924	2.4
Asyut	15.2	4245215	645273	7.6
Beheira	8.8	5804262	510775	6.0
Beni suef	9.2	2856812	262827	3.1
Cairo	6.9	9278441	640212	7.5
Damietta	13.7	1330843	182326	2.1
Faiyum	14.1	3170150	446991	5.3
Giza	7.1	7585115	538543	6.3
Ismailia	10.9	1178641	128472	1.5
Kafr El-Sheikh	8.4	3172753	266511	3.1
Luxor	6.8	1147058	78000	0.9
Marsa matruh	9.9	447846	44337	0.5
Menoufeya	27.1	3941293	1068090	12.6
Minya	20.0	5156702	1031340	12.2
Port Said	2.8	666599	18665	0.2
Qalubeya	18.7	5105972	954817	11.3
Sharqeya	13.5	6485412	875531	10.3
Sohag	11.5	4603861	529444	6.2
Suez	9.1	622859	56680	0.7
Total	14.8			

diagnosed either accidentally or late in the course of the disease after development of clinical liver pathology [21]. The majority of chronically infected population (66.3%) in this study were not aware of their infection status. Due to the silent course of HCV infection, this high level of unawareness is typical unless there is a robust strategy of screening and health education. Other studies reported an unawareness rate ranging from 50-59% [22, 23].

Exploratory disease mapping has shown to identify areas with high risks (hotspots) for prioritizing future interventions for HCV [24]. The map in the present study highlighted the darkest spot of HCV infection in Menoufeya (37.8%) followed by Beni Suef (29.2%) and Minya (28.6%). The factors associated with HCV revealed in these governorates by this study cannot explain their higher prevalence as they are neither unique in number nor in type. They should be prioritized for further study to identify main prevailing contributing factors for high prevalence and transmission and more important for implementing control strategies including screening, infection control measures and awareness campaigns. The lowest anti-HCV prevalence was seen in Alexandria (6.1%) and Port-Said (5.6%). Similar results were also reported by other authors [25].

In the present study, in spite the evident variation in anti-HCV seroprevalence between governorates, the percentage of persistent infection, HCV-RNA, was high in almost all governorates ranging from 31.6%-85%. This variation could be in part due to difference in treatment-seeking behavior and other host/viral factors that affect spontaneous clearance rate. This finding has important public health significance indicating the urgent need for a more effective strategy to control HCV transmission in Egypt. Identifying infected individuals and early treatment strategies was reported to be effective in supporting prevention measures and reducing transmission [26]. In the current study, a considerable proportion (14.2%) did not seek treatment despite awareness of their infection status. At the time of the survey, they might have been still unaware of highly effective, low adverse effects oral DAAs treatment relative to the previous interferon therapy widely known in Egypt of its poor response and side effects.

Identifying clusters of disease help detecting common causal exposure and socio-economic risk factors that could facilitate targeted prevention efforts [27]. The logistic regression models in the present work documented the age to be the most common independent HCV-associated factor. The age-specific pattern of anti-HCV antibody was epidemiologically close to that of EHIS 2015 results with higher prevalence in the age group 45–49 years. A cross-sectional survey conducted in Upper Egypt revealed also same results with marked increase in HCV prevalence in the fourth decades [28]. This phenomenon of increased anti-HCV prevalence with age has been described in many studies from Egypt. It was attributed to the continuing parenteral exposure to the virus by age [17, 29]. Matched with Kandeel et al. (2017) [17], the lowest anti-HCV prevalence was found among age group 14–39 years. This age group was not exposed to anti-schistosomal parenteral therapy. However the high percentage of persistent infection among this age group (63%) necessitates the need to enforce infection control measures throughout Egypt in parallel with an effective treatment campaign using the new DAAs therapy.

The decline in anti-HCV prevalence revealed in the present study among those in the age group older than 60–64 years might be explained by the increased HCV-related mortality in the older age group. Similar results were also published by other authors [16, 30].

Table 4
Independent HCV risk factors in Egyptian governorates in 2016.

Risk Factor			Governorate																				
			Alexandria	Asyut	Beheira	Beni suef	Cairo	Dakahlia	Damietta	Faiyum	Gharbia	Giza	Ismailia	Kafr El-Sheikh	Luxor	Marsa matruh	Menoufeya	Minya	Port Said	Qalubeya	Sharqeya	Sohag	Suez
Age	OR		1.04	1.07	1.08	1.11	1.09		1.19	1.09	1.11	1.15		1.04	1.10	1.15	1.04	1.10		1.09	1.10	1.09	1.08
	95%	U	1.01	1.00	1.05	1.10	1.01		1.03	1.05	1.02	1.07		1.02	1.07	1.07	1.00	1.03		1.04	1.05	1.04	1.04
	CI	L	1.06	1.13	1.10	1.17	1.18		1.37	1.12	1.13	1.23		1.05	1.13	1.23	1.08	1.11		1.15	1.16	1.14	1.12
Female gender	OR							0.06										0.29			0.15		
	95%	U						0.01										0.10			0.03		
	CI	L						0.62										0.93			0.80		
Rural residence	OR				3.16		2.90								0.24			2.10			2.24		
	95%	U			1.34		1.18								0.09			1.03			1.01		
	CI	L			7.45		7.15								0.70			4.10			4.96		
Low educational level	OR		0.85																				
	95%	U	0.72																				
	CI	L	0.99																				
Occupation	OR														0.30								
	95%	U													0.10								
	CI	L													0.85								
Ear or body puncture	OR														0.40								
	95%	U													0.18								
	CI	L													0.88								
Blood (products) transfusion	OR		2.8								3.66			1.74									
	95%	U	1.54								1.54			1.14									
	CI	L	5.1								8.72			2.66									
Animal bite	OR													0.55									
	95%	U												0.38									
	CI	L												0.78									
Contaminated needle prick	OR						8.26											4.29					
	95%	U					1.93											1.32					
	CI	L					35.29											13.88					
Schistosomiasis	OR		2.33												2.44								
	95%	U	1.35												1.27								
	CI	L	3.99												4.66								
PAT	OR		6.4		3.43			3.13	61.57					2.34	3.05	5.14							
	95%	U	3.47		2.14			1.00	2.50					1.72	1.63	1.41							
	CI	L	11.66		5.50			9.80	1515.66					3.18	5.72	18.77							
Non-invasive intervention	OR																						
	95%	U																					
	CI	L																					
Labor at home	OR												17.29										
	95%	U											1.82										
	CI	L											164.00										
Sharing sharp tools	OR				1,60												1.54						
	95%	U			1.38												1.29						
	CI	L			1.93												2.00						
Sex during menstruation	OR			65.83																			
	95%	U		1.3																			
	CI	L		3353.46																			
IDU																						4.69	
	95%	U																				1.41	
	CI	L																				15.76	
Fatigue during last 6 months	OR															2.58							
	95%	U														1.08							
	CI	L														6.13							
Jaundice	OR										6.81										5.11		
	95%	U									2.30										1.25		
	CI	L									20.15										20.9		

Several reports concluded that governorates that are rural in nature show higher prevalence of anti-HCV and HCV-RNA than cities [31, 32]. Lavanchy [33] and others [6] also documented the abundance of HCV cases in rural residences. They mentioned that the large reservoir of chronic HCV infection established in the course of PAT campaigns and related concurrent infection control measures remains the most likely reason for the high prevalence of HCV, which may be largely responsible for the continuing endemic transmission of HCV in Egypt today. Other modes of transmission such as poor infection control and equipment sterilization procedures used in rural medical and dental settings also contribute to ongoing iatrogenic HCV infections and continue to fuel spread of disease [1]. The above results find support in the present study, as rural residence and PAT were found to be common risk factors in most governorates that include rural and urban settings. Rural settings should be prioritized in control strategies.

Other significant socio-economic factors associated with increased anti-HCV prevalence elicited in the present work is male gender. Similarly El Zanaty and Way [3] reported higher anti-HCV sero prevalence in males than females in all age groups studied. Some authors attributed this difference to be in part due to the fact that males were more affected by schistosomiasis disease burden and hence were main target of PAT campaign [34]. Other reported explanation for this male preponderance could be attributed to their life style that makes them more exposed to various risk factors of HCV transmission [35]. These findings contradict the results of other studies where prevalence of anti-HCV was higher among females as compared to males [36].

5. Conclusion

There is a spatial heterogeneity of HCV prevalence in Egypt, the drivers of which are suspected but not yet well established by prospective studies which remain lacking. However, rural residences and HCV hotspots should be prioritized in control programs. Older age group population constitute a considerable reservoir of infection and must not be neglected. Screening and awareness campaigns are mandatory to detect and treat hidden HCV-RNA positive populations and prevent transmission.

Declarations

Author contribution statement

Engy Mohamed El-Ghitany: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Azza Galal Farghaly: Performed the experiments; Wrote the paper.

Funding statement

This work was supported financially by the Science and Technology Development Fund (STDF), Egypt; Project No. 3469.

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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