Hepatitis C virus epidemiology in Yemen: Systematic review

Yemen'de hepatit C virüsü epidemiyolojisi: Sistematik derleme

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Bacground and Aims: *To identify and well-characterize the prevalence of hepatitis C virus infection in different populations in Yemen. Also, to determine the future epidemiological study areas in Yemen.* ***Materials and Methods:*** *A systematic review was conducted with the use of the PRISMA guidelines. Between 1980 to 2020, a comprehensive search was done for any epidemiological data on hepatitis C in Yemen that were conducted in each PubMed, web of Science, Scopus, and Google Scholar.* ***Results:*** *Forty-nine (49) studies were matching the inclusion and exclusion criteria from the four databases. After analyzing these 49 studies we found that in the general group of the population the prevalence was ranged between 0.07%-8.5%. Where the highest prevalence was in pregnant women (up to 8.5%) then the public (up to 6%) then blood donors and children up to 3% and 2.8% respectively. In the intermediate-risk group, hepatitis C virus infection prevalence was ranged between 1.03%-3.5% where all population was from the health department workers. In the high-risk group, the range was between 6.4%-62.7%, and the highest prevalence was recorded in liver disease patients. In the patient's group the range of hepatitis C virus infection prevalence was between 0%-46%, while the sickle cell anemia patients were the lowest prevalence the chronic renal failure patients had the highest prevalence.* ***Conclusion:*** *This systemic review demonstrates a high prevalence of hepatitis C infection in Yemen. There is also a need to expand the scope of research and pay attention to new research groups and other cities to get a more comprehensive idea of the prevalence of the hepatitis C virus in Yemen.*

Key words: *Hepatitis C virus, epidemiology, Yemen, systematic review*

Giriş ve Amaç: *Yemen'deki farklı popülasyonlarda hepatit C virüsü enfeksiyonunun prevalansını belirlemek, iyi karakterize etmek ve ayrıca, Yemen'de gelecekteki epidemiyolojik çalışma alanlarını belirlemektir.* ***Gereç ve Yöntem:*** *PRISMA yönergelerinin kullanımıyla sistematik bir inceleme yapıldı. Yemen'deki hepatit C ile ilgili; PubMed, web of Science, Scopus ve Google Scholar'da 1980 ile 2020 arasında yürütülen, herhangi bir epidemiyolojik veri için kapsamlı bir araştırma yapıldı.* ***Bulgular:*** *Kırk dokuz (49) çalışma, dört veri tabanındaki dahil etme ve dışlama kriterleriyle eşleşti. Bu 49 çalışmanın analizi ile nüfusun genel grubunda prevalansın %0.07-%8.5 arasında değiştiğini bulduk. En yüksek prevalansın hamile kadınlarda olduğu (%8.5'e kadar), ardından genel (%6'ya kadar), ardından da sırasıyla %3 ve %2.8 ile kan bağışçıları ve çocuklarda olduğu görüldü. Orta risk grubunda, tüm popülasyon sağlık departmanı çalışanlarından olmak üzere, hepatit C virüsü enfeksiyonu prevalansı %1.03-3.5 arasında değişiyordu. Yüksek riskli grupta, prevalans aralığı %6.4-%62.7 arasında olup, en yüksek prevalans karaciğer hastalığı olanlarda kaydedilmiştir. Hasta grubunda hepatit C virüsü enfeksiyonu prevalansı aralığı %0-%46 arasındayken, orak hücreli anemili hastalar en düşük prevalansa, kronik böbrek yetmezliği olan hastalarsa en yüksek prevalansa sahipti.* ***Sonuç:*** *Bu sistemik derleme, Yemen'deki hepatit C enfeksiyonu prevalansının yüksek olduğunu göstermektedir. Yemen'deki hepatit C virüsünün prevalansı hakkında daha kapsamlı bir fikir edinmek için araştırma kapsamını genişletmeye ve yeni araştırma gruplarına ve diğer şehirlere dikkat etmeye ihtiyaç vardır.*

Anahtar kelimeler: *Hepatit C virüs, epidemiyoloji, Yemen, sistematik derleme*

INTRODUCTION

Hepatitis C virus (HCV) is causing chronic liver disease, hepatocellular carcinoma, and cirrhosis. where this virus is a blood-borne disease and progresses from acute to chronic infection in the liver. Also, it associates with several morbidities, and it is the reason for a lot of liver transplantation in many countries (1,2). Also, it considers as The seventh leading cause of death globally and the fifth in the Middle East and North Africa (MENA) (3,4). Globally about 71 million people infected with HCV where the most affected region is MENA region with nearly 15 million infected persons (5). Even though the related mortality of HCV strains healthcare systems worldwide, the Direct-acting antivirals (DAAs) give promising prospects to clear HCV infection and reduce HCV disease burden in the soon future (6). Whereas the elimination of hepatitis C virus by 2030 is a global goal for the World Health Organization (WHO). The epidemiology of hepatitis C in Yemen is still not well described, and it needs to define the prevalence in different populations and define the areas of a future epidemiological study in Yemen which are the objectives of this systematic review (7,8).

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MATERIALS and METHODS

The preparation of this systematic review was done according to the PRISMA guideline (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (9). The articles were searched in four main biomedical and health databases of Scopus, PubMed, Web of Science, and Google Scholar. In the first three databases, the research was done without any language restriction, but the period of the search was restricted from 1980 to the end of 2020 because the discovery of HCV was in 1989 (10). The search was done using the terms of "hepatitis C or HCV or anti-HCV or HCV antibody or core HCV antigen or HCVcAg or HCV RNA and Yemen or limited to Yemen" in the three databases to determine all publications about HCV from Yemen. All identified articles from these databases were exported to endnote for processing. But in Google Scholar, the research was done by using keywords of "hepatitis C or HCV and Yemen" and the same period restriction as in the other database by screening the titles of all the articles that could be related to our inclusion and exclusion criteria and then exported to the Endnote. The duplicate articles were identified and excluded from all the articles in the Endnote. The remaining unique articles were undergone to a two-stage screening process. In the first stage, all the articles' titles and abstracts were screened for relation to the aim. The related or it could be related articles proceeded to the next stage of screening, wherein this stage full-texts were evaluated according to our inclusion/exclusion criteria. Eligible articles were included in this study, and ineligible articles were excluded according to criteria. The summary of the whole process can be found in the diagram in Figure 1 that was produced according to the PRISMA guideline.

The Inclusion and Exclusion Criteria

Briefly, every article reporting any epidemiological data of the prevalence and incidence of Hepatitis C virus in Yemen was included. The excluded articles were case reports, case series, reviews, articles that contained duplicate information, articles that their full text is not available, and if the study population was Yemeni nationals residing outside Yemen.

Data Analysis and Population Classification

The rest articles were analyzed by identifying and presenting as tables in Excel included these data: authors, year of sample collection, year of publishing, type of study, sample size, prevalence, study site, prevalence by gender, Governorate, population, and test type. Then the population was divided into four groups 1-General population (low-risk group): included blood donors, public people, pregnant women, children, and healthy controls. 2-Inter-

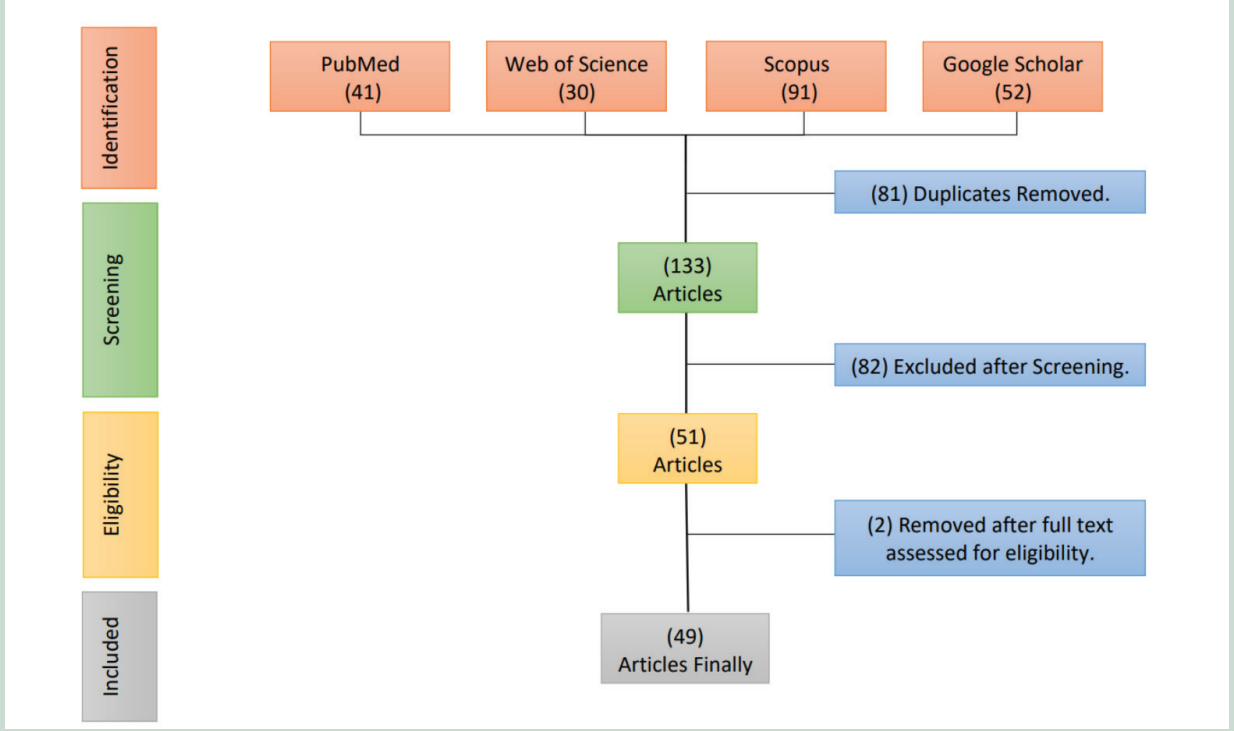

Figure 1. PRISMA's diagram for HCV epidemiology in Yemen.

mediate risk group: included workers in various medical fields or in health departments. 3- High-risk group: included patients with hepatocellular carcinoma, liver disease, and hemodialysis. 4- Patient from other diseases: included all other patients from different clinics and diseases.

RESULTS

The results and the steps for the articles search were summarizing in flow diagram (Figure 1). From the four databases a total of 214 articles were identified; about 81 duplicates articles were removed, then 82 articles were removed after the title and abstract screening. The remaining 51 publications that met the inclusion criteria were screened again with the full text, two of them were excluded due to not meeting the inclusion criteria. Finally, 49 studies were meeting the inclusion criteria for result analysis.

From our result we can found that in the year of publishing the period between 2016-2020 was having the highest publishing numbers (n = 20, 40.8%) then 2011-2015 with (n = 16, 32.6%), where 2006-2010, 2001-2005, 1996-2000, and 1990-1995 have the number of publishing n = 5, n = 3, n = 2, and n = 3 respectively (Figure 2). While the study type of all the researches were cross-sectional studies except one research was case-control where it has a 9.9% HCV of prevalence in it (11). Also, among the studies reporting the prevalence of hepatitis C by gender (n = 30 studies) the prevalence range for both genders was similar, where it was in the females between 0%- 62.5% and the males between 0%-63.3%. According to the governorate, about 27 studies were conducted in the Sana'a governorate altogether involved a prevalence range between 0.2%-54.2%. The governorate distribution of studies was Aden (n = 8), Al-hudaydah (n = 6), Ibb (n = 5), Taiz (n = 4), Hadhramaut (n = 2), Hajjah (n = 2), and for each of Amran, Dhamar, Raymah, Sa'dah, and Socotra one study as seen in (Figure 3). Where sample sizes across the forty-nine stud-

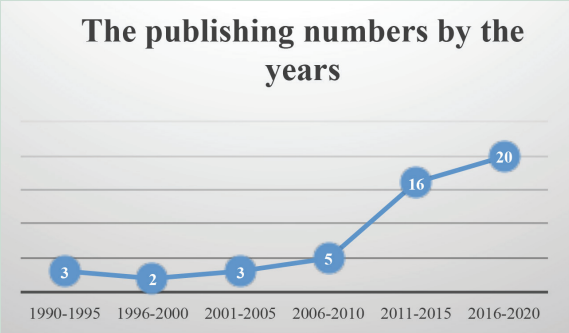

Figure 2. The publishing numbers by the years.

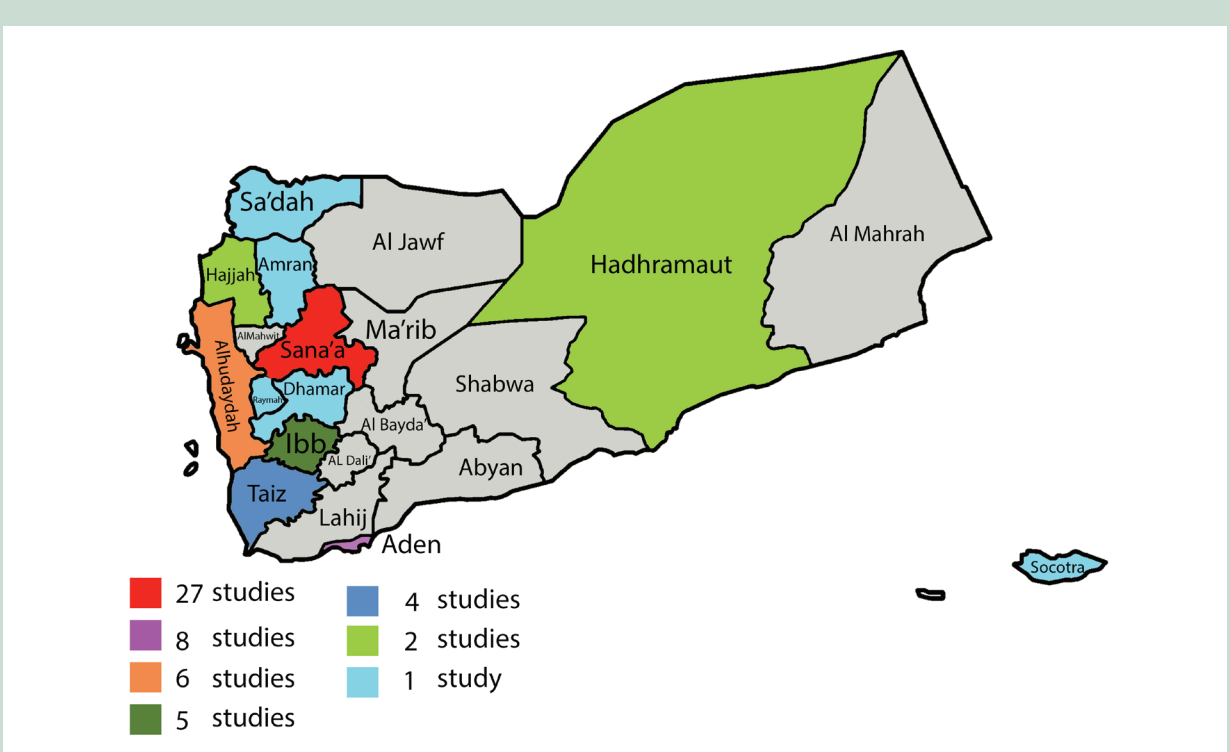

Figure 3. Distribution of HCV studies in Yemen.

Table 1. General population group

Authors, References	Year of Sample Collection	Year of Publishing	Type of Study	Sample Size	Prevalence of HCV	Prevalence by Gender	Study Site	Governo-rate	Population	Test Type
Scott et al. (12)	1988	1992	CS	348	6%	M=2.8%, F=2.2	Schools, houses	Sana'a, Hajjah, Taiz, Alhudaydah	Public	ELISA, RIBA*
El Guneid. et al. (13)	Na	1993	CS	294	1.00%	Na	Blood bank	Taiz	Blood doners (as control)	EIA
El Guneid et al. (13)	Na	1993	CS	243	3.30%	Na	Hospital	Taiz	Pregnant women (as control)	EIA
Gray et al. (14)	1992	1999	CS	627	0.30%	Na	Houses	Ibb, Hajjah	Public	EIA
Al-Moslih & Al-Huraibi (15).	Na	2001	CS	120	4.20%	Na	Hospital	Sana'a	Public (health control)	ELISA
Sallam et al. (16)	Na	2003	CS	Aden=494, Sana'a=493	Aden=0.6, Sana'a=0.2	Na	Blood bank	Sana'a, Aden	Blood donors	EIA, RIBA*
Sallam et al. (16)	Na	2003	CS	African Ethnic=97, and Soqotra Island=99	African=5.2%, Soqotra Island=5.1%	African Residents (F=4.3%, M=5.9%), Soqotra (F=2%, M=7.8%)	Blood bank	Sana'a, Socotra İsland	Public	EIA, RIBA*
Sultan et al. (17)	2008-2010	2010	CS	3602	1.05%	M=1.05%	Blood bank	Sana'a	Blood donors	MEIA
Bin Selm (18)	2007	2010	CS	100	0.80%	Na	Blood bank	Aden	Blood donors (as control)	NA
Al-Shamiri et al. (19)	2007-2009	2011	CS	214	2.80%	Na	Schools	Taiz	Children	NA
Saghir et al. (20)	2008- 2010	2012	CS	1483	0.79%	Na	Blood bank	Alhudaydah	Blood donors	ICT
Alodini (21)	2010	2012	CS	3000	3%	Na	Blood bank	Sana'a	Blood donors	ELISA
Al-Waleedi & Khader (22)	2007	2012	CS	469	1.30%	Na	Blood bank	Aden	Blood donors	EIA
Gacche & Al Mohani (23)	2010	2012	CS	554	1.99%	M=0.18%, F=1.81%	Hosues	İbb	Public	ICT, EIA*
Gacche & Al-Mohani (24)	2010-2011	2012	CS	2379	1.30%	M=0.29%, F=1.01%	Houses	Ibb	Public	ICT, ELISA*
Murad et al. (25)	2011	2013	CS	400	8.50%	Na	Hospital	Sana'a	Pregnant women	ELISA
Al-Nabehi et al. (26)	Na	2015	CS	501	Sana'a (1.5%), Taiz (0.6%) and Aden (0%).	Na	High, schools universities	Sana'a, Aden, Taiz	Public	ELISA
Al-Zubiery et al. (27)	2016	2017	CS	11374	1%	M=1%, F=0.9%	Blood bank	Sana'a	Blood donors	ECLIA
Al-Zubiery et al. (28)	2016-2017	2017	CS	3606	1.60%	M=1.60%	Blood bank	Sana'a	Blood donors	EIA
Al-Kadassy et al. (29)	2012-2015	2017	CS	1286	1.60%	M=1.6%	Houses	Alhudaydah	Public	ELISA
Al-Hatheq et al. (30)	2018	2019	CS	500	2.80%	Na	Blood bank	Amran	Blood donors	ICT, ELISA*
Ghaleb et al. (31)	2017	2020	CS	340	1.20%	Na	Blood bank	Sana'a	Blood doners	ECLIA, ELISA*
Bin Barkat & Naseeb (32)	2019	2020	CS	300	0.07%	F=0.07%	Clinics	Hadhramaut	Pregnant women	ELISA

*=Confirmed test.

HCV: Hepatitis C virüs, ELISA: Enzyme-linked immunosorbent assay, RIBA: Recombinant immunoblot assay, EIA: Enzyme immunoassay, MEIA: Microparticle enzyme immunoassay, NA: Not available, ICT: Immune-chromatographic technique, ECLIA: Electrochemiluminescence immunoassay analyzer, CS: Cross-sectional, F: Female, M: Male,

ies ranged from 30 to 11 374 participate. On the other hand, seven different techniques used to test HCV in the 46 studies where 3 studies did not clarify what technic was used. Twenty-nine studies used Enzyme-Linked Immunosorbent Assay (ELISA) as the main test for HCV and 3 studies used it as a confirmed test. Enzyme immunoassay (EIA) was used in 8 studies as main and in one study was as a confirmed test. The immune-chromatographic technique (ICT) in five studies, electrochemiluminescence immunoassay analyzer (ECLIA) in two studies, but each of microparticle enzyme immunoassay (MEIA), and Chemiluminescent Microparticle Immunoassay (CMIA) was used only one study. While recombinant Immunoblot Assay (RIBA) and Polymerase Chain Reaction (PCR) used only as a confirmed test. RIBA was in 3 studies and PCR was in one study. Besides that, all the articles were HCV prevalence only there were not any incidence studies.

The prevalence of HCV was different according to the population groups as we divided the population into four groups, the prevalence according population is:

General Group (low risk group)

In the general group of the population, the prevalence was ranged between 0.07%-8.5%. about twenty-one studies were done on the general population as the main group or control group. wherein 11 studies blood donors were the sample population two of them were control groups and the range of HCV prevalence in blood donors was (0.2%-3.0%) with the mean of 1.27%. Also, eight studies on the public one of them were the control group and the range of HCV prevalence was (0%-6%) with the mean 2.8%. For the pregnant women, only three studies were done on them one of them as a control group and the prevalence range was 0.07%-8.5% with the mean of the HCV prevalence 3.95%. On the other hand, just one study was done on the children with a prevalence of 2.8% (Table 1).

Intermediate Risk Group

In the intermediate-risk group, three studies were done on the health workers and dental clinic, and public health center cleaners. Where HCV prevalence was ranged between 1.03%-3.5% (Table 2).

High Risk Group

In the high-risk group, about 17 studies were done with a range between 6.4%-62.7%. All these studies are patients but with different diseases. For the hemodialysis patients, 8 studies show us the range between 10.7%-27.6% and the mean 19.8%. And for Hepatocellular carcinoma five studies are found with range 28.4%-43.7% and mean 37.5%. On the other hand, 4 studies had liver disease patients as sample group one is acute liver disease and one chronic liver disease with prevalence ranged between 6.4%-62.7% with the mean 33.3% (Table 3).

Patients Group

Each of the other patients' groups has one study except non-Hodgkin's lymphomas patients which are two studies. The other patients are chronic renal failure, renal failure, non-Hodgkin's lymphomas, leprous, cataract surgery, diabetes, endoscopic, eye camps, sickle cell anemia, surgical department, and clinic visitors. The range of HCV prevalence was between 0%-46%.

DISCUSSION

In our systematic review, it was noted in the last decade that there has been an increase in research activity in hepatitis C, where the number of researches was nearly three times that in the first two decades, and this indicates a high awareness of the seriousness hepatitis C, but most of this research was limited to the city of Sana'a for being the capital of Yemen and a suitable city for researchers to work where it provides a better level of

Table 2. Intermediate risk population group

Authors, References	Year of Sample Collection	Year of Publishing	Type of Study	Sample Size	Prevalence of HCV	Prevalence by Gender	Study Site	Governorate	Population (Workers of)	Test Type
Shidrawi et al. (33)	NA	2004	CS	567	3.50%	NA	Hospital	Sana'a	Healthcare	EIA
Al-Kebsi et al. (34)	2014	2017	CS	509	1.60%	M=1.2%, F=1.9%	Dental clinics	Sana'a	Dental clinic	ELISA
Al-Marrani & Al-Shamahy (35)	2015	2018	CS	388	1.03%	M=0.6%, F = 2.9%	Hospital,health centers	Sana'a	Public health center cleaners	ELISA

*=Confirmed test.

HCV: Hepatitis C virus, ELISA: Enzyme-linked immunosorbent assay, EIA: Enzyme immunoassay, CS: Cross-sectional, F: Female, M: Male,

services than other cities and most of the patients come to it to receive treatment there. On the other hand, we cannot rely on this epidemiological information to give us a correct idea of the prevalence of the hepatitis C virus because most of this research focused on only 12 cities and neglected the rest of the Yemeni governorates. Also, the difference in techniques used in hepatitis C tests may be an influencing factor on the true prevalence of hepatitis C, as there was a difference in the use of techniques in the research conducted on the prevalence rate (60). It was also noted that there were no researches on the incidence of HCV, while all researches were on the prevalence of hepatitis C virus. also, There was not any difference in the HCV prevalence between the gender in Yemen.

The prevalence of HCV was different according to the population group. According to the WHO report 2017 the prevalence of HCV infection in WHO regions vary from 0.5% to 2.3% which indicates that the prevalence in Yemen is high and the Yemeni population is considered at risk of HCV infection. In the general population, the prevalence was less than in Central Asia but it is more than that in the middle east and north Africa MENA (61,62). In the healthy blood donors group, the prevalence in Yemen was close to that in Iraq, but compared to those in gulf countries (Kuwait, Qatar, Saudi Arabia) it was considered to be lower except that in Oman (63). Also, the prevalence of HCV in blood donors in Yemen consider higher than that in Somalia (64). Unfortunately, the prevalence of HCV in pregnant women was higher

Table 3. High risk group population

Authors, References	Year of Sample Collection	Year of Publishing	Type of Study	Sample Size	Prevalence of HCV	Prevalence by Gender	Study Site	Governorate	Population (Patients of)	Test Type
El Guneid et al. (13)	NA	1993	CS	108	21.50%	NA	NA	NA	Acute liver hepatitis	EIA
Gunaid et al. (36)	NA	1997	CS	78	6.40%	NA	Hospital	Aden	Chronic liver disease	ELISA
Al-Moslih & Al-Huraibi (15)	NA	2001	CS	143	37.10%	NA	Hospital	Aden	Hemodialysis	NA
Al-Selwi et al. (37)	2004-2007	2009	CS	54	27.60%	NA	Hospital	Ibb	Hemodialysis	ELISA
Bin Selm (38)	2007	2010	CS	76	17.90%	NA	Hospital	Sana'a	Hemodialysis	ELISA
Bin Selm (18)	2007	2010	CS	51	62.70%	M=39.2%, F=23.5%	Hospital	Alhudaydah, Raymah, Sa'dah	Hemodialysis	ELISA
Bin Selm (39)	2006-2007	2011	CS	316	43.70%	M=62%, F=12%	Hospital	Aden	Hemodialysis	NA
Saeed et al. (40)	2008-2010	2012	CS	88	28.40%	M=28.1%, F=28.6%	Hospital	Sana'a	Hemodialysis	ELISA, PCR*
Salem et al. (41)	2001- 2008	2012	CS	251	38.20%	NA	Hospital	Dhamar	Hemodialysis	ELISA
Baghza (42)	2010	2014	CS	200	22.50%	M=60%, F=40%	Hospital	Sana'a	Hemodialysis	ELISA
Aman et al. (43)	2000-2013	2015	CS	219	40.20%	NA	Hospital	Sana'a	Hepatocellular carcinoma	ELISA
Al-Haimi et al. (44)	2009-2013	2016	CS	120	54.20%	NA	Hospital	Sana'a	Hepatocellular carcinoma	ELISA
Gaballah et al. (45)	NA	2018	CS	30	16.70%	M=63.3%, F=36.6%	Hospitals	Sana'a, Aden, Hadhramaut	Hepatocellular carcinoma	ELISA
Amran et al. (11)	2018	2019	CC	202	9.90%	M=11.5%, F=15%	Hospital	Sana'a	Hepatocellular carcinoma	ELISA
Hanash et al. (46)	2016	2019	CS	159	10.70%	M=14.3%, F=8.7%	Hospital	Sana'a	Hepatocellular carcinoma	ELISA
Al-Yousofi (47)	2018	2019	CS	349	17.20%	M=9.5%, F=7.7%	Hospital	Sana'a	Liver disease	ELISA
Almezgagi et al. (48)	2013-2016	2020	CS	100	21%	M=14.28%, F=29.54%	Hospital	Taiz	Liver disease	EIA

*= Confirmed test.

HCV: Hepatitis C virus, EIA: Enzyme immunoassay, ELISA: Enzyme-linked immunosorbent assay, PCR: Polymerase chain reaction, CC: Case-control, CS: Cross-sectional, F: Female, M: Male, NA: Not available.

Table 4. Patients population group

Authors, References	Year of Sample Collection	Year of Publishing	Type of Study	Sample Size	Prevalence of HCV	Prevalence by Gender	Study Site	Governorate	Population (Patients of)	Test Type
Denis et al. (49)	1988-1990	1994	CS	1309 (From 7 countries)	7.1% (Yemenis = 21%)	(F = 8.9%, M = 5.5%)	NA	NA	Leprous	EIA, RIBA*
Salem (50)	2005-2007	2009	CS	192	15.10%	M = 17.6%, F = 10.7 %	Hospital	Sana'a	Non-Hodgkin's lymphoma	ELISA
Salem (50)	2005-2007	2009	CS	20329	4%	M = 4.3%, F = 3.5%	Hospital	Sana'a	Other clinics as control	ELISA
Al-Mansoob et al. (51)	2009-2011	2013	CS	394	14.20%	M = 6.8%, F = 7.4%	Hospital	Sana'a	Surgical department	ELISA
Thabet et al. (52)	NA	2014	CS	50	10%	M = 60%, F = 40%	Hospital	NA	Diabetes	ELISA
Al-Hegami et al. (53)	2013-2014	2015	CS	243	46.01%	M = 40.13%, F = 62.5%	Hospital	Aden	Chronic renal failure	ELISA
Al Awfi et al. (54)	2011-2015	2017	CS	278	1.07%	M = 1.18%, F = 0.92%	Blood dialysis center	Alhudaydah	Renal failure	ELISA
Al-Kadassy et al. (55)	2014-2016	2018	CS	121	0%	M = 0%, F = 0%	Hospital	Alhudaydah	Sickle cell anemia	ELISA
Ghanem & Al-Rabeei (56)	2017	2018	CS	1592	1.50%	M = 12.8%, F = 17.9%	Patients	Sana'a	Endoscopic clinic	ELISA, PCR*
Alhaj et al. (57)	2014-2015	2018	CS	144	2.80%	M = 3%, F = 2.2%	Hospital	Sana'a	Non-Hodgkin's lymphoma	CMIA
Al-Shaer et al. (58)	2016-2017	2019	CS	376	1.30%	NA	Patients	Sana'a, Ibb	Eye camps	ICT
Bamashmus & Abdulrahim (59)	2012	2019	CS	1203	4.10%	M = 44.9%, F = 55.1%	Eye hospital	Sana'a	Cataract surgery	ELISA
Al-Hatheq et al. (30)	2018	2019	CS	300	28.00%	NA	Blood banks, hospitals	Amran	Clinic visitors	ICT, ELISA*

*= Confirmed test.

HCV: Hepatitis C virus, EIA: Enzyme immunoassay, RIBA: Recombinant immunoblot assay, ELISA: Enzyme-linked immunosorbent assay, CMIA: Chemiluminescent microparticle immunoassay, ICT: Immune-chromatographic technique, CS: Cross-sectional, F: Female, M: Male, NA: Not available.

than blood donors in Yemen and even that from the pregnant women in Saudi Arabia and Iraq, but compared with that in Egypt it considers lower (63, 65). Besides that, the prevalence of HCV in the Yemensi public is considered higher than that in Lebanon and Iraq (63). On the other hand, the children have only one study for the prevalence of HCV with 2.8% which is higher than that in Somalia, but lower than that in Egyptian children (64,65). The situation in Yemen could be one of the reasons to have a high prevalence in the general population which they suppose to be the health group with a low prevalence.

In the intermediate-risk group in Yemen, the health workers have the highest prevalence of 3.5%, then the dental worker (1.6%), then the cleaners in health facilities (1.03%) where the range of the prevalence in Yemen is close to that of Iraq, but in Iraq, the high prevalence of HCV was high in dental workers group (63). However, the range of HCV in Yemen was higher than in Jordon, and Kuwait, but lower than in Egypt (63,65). This indicates that there is more need for adequate training of working safely for workers in the health facilities in Yemen and regularly test for HCV infection in this group as a control for safety.

In the high-risk group, the range of the prevalence of HCV in Yemen was up to 62.7% which is less than the range of the risk group of Fertile Crescent (63). Where the prevalence of hepatitis C in the hemodialysis group considered higher than the prevalence in the Middle East and African regions (66-68). While it was less than Oman, Kuwait, and Saudi Arabia (69). But the prevalence of HCV in hemodialysis patients is close to that in Lebanon and Palestine (63). Also, it was found that the more number of hemodialysis times the more risk of getting infected with the virus in Yemenis patients (11). This high prevalence in hemodialysis considers the high-risk level of infections in the centers of hemodialysis in Yemenis patients where there are difficulties of controlling the in-

fections because of the poor level of health. In chronic liver disease the prevalence was found only in one study where it is less than Somalia's and United Arab Emirates' prevalence, but in acute liver disease, it was higher than united Arab emirates and less than in Saudi Arabia (64,69).

In the fourth group of patients, the diabetic patients had a prevalence more than that of Kuwait, but less than in Iraq and Egypt (65, 69). Beside in non-Hodgkin patient, the prevalence in Yemenis patients were lower than in Saudi Arabia and Egypt (65,69). But for the hemolytic anemia, there was no relation with the infection of HCV where the prevalence was 0% but in the study in Jordon, it was 40.5% (63). Also, in the other patients, the prevalence of Yemenis patients was higher than Saudi Arabia and lower than Kuwaiti patients (69) we can figure that there is a need for doing tests for HCV for all patients to facilitate the elimination of HCV infections in Yemen.

In conclusion, we can say that there is an increase in the prevalence of hepatitis C in Yemen in all population groups compared to the global prevalence. The reasons for this are due to the current situation in Yemen, including war, and a decline in the level of living, economic, and health. Where there is an urgent need to support the health sector and make periodic checks for all patients who are at risk of getting infected with the virus due to blood transfusion or dialysis, and attention to providing treatment to patients also doing periodic checks for the workers in the health departments. There is also a need to expand the scope of research and pay attention to new research groups and other cities to get a more comprehensive idea of the prevalence of the hepatitis C virus in Yemen. Knowing that awareness and raising awareness of prevention and hygiene methods and the importance of treatment for the disease will help Yemenis to reduce the prevalence and try to keep pace with the World Health Organization's plan to limit the hepatitis C virus infection in 2030.

Ethics statement: *Our systematic review does not require any ethics approval as it relies entirely on previously published data.*

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