

# Evaluating hepatitis C viremia and antiviral treatment barriers in hemodialysis patients in the post-HCV elimination era: Experience from Ain Shams University Hospitals

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## Abstract

Egypt historically maintained a high prevalence of hepatitis C virus (HCV) infection, with maintenance hemodialysis (HD) patients facing increased risk due to frequent invasive procedures. Following the 2014 launch of Egypt's National HCV Elimination initiative, overall population prevalence declined substantially. However, contemporary data evaluating active viremia and treatment barriers among prevalent HD patients remain limited. To assess the seroprevalence (anti-HCV antibodies) and active viremia (HCV RNA by PCR) among prevalent HD patients after implementation of the National Eradication Initiative, and to identify the barriers to antiviral treatment despite free therapy. A multicenter cross-sectional study was conducted between November 2023 and April 2024 across three affiliated hemodialysis units at Ain Shams University Hospitals, Cairo, Egypt. A total of 410 adult patients (aged  $\geq 18$  years) on regular maintenance HD for  $>6$  months were recruited using consecutive sampling. Anti HCV antibodies were determined using enzyme-linked immunosorbent assay (ELISA), and active infection was confirmed via quantitative real-time HCV RNA PCR testing. Sociodemographic features, dialysis vintage, treatment history, and self-reported reasons for non-treatment were evaluated. The mean age of participants was  $47.1 \pm 18.2$  years, with a male predominance (62.4%,  $n = 256$ ). Anti-HCV antibody positivity was identified in 113 of 410 patients (27.6%). Among anti-HCV-positive patients, active viremia (HCV PCR positive) was confirmed in only 14/113 cases (12.4% of seropositive patients; overall study population prevalence of active viremia: 14/410; 3.4%). Of the 113 anti-HCV-positive patients, 95/113 (84.1%) had received antiviral therapy, with 93/95 (97.8%) achieving viral clearance (sustained virological response, SVR). Un-treated patients were (15.9%,  $n=18$ ). Treatment barriers included lack of awareness regarding free treatment availability (27.8%), fear of side effects (22.2%), treatment refusal (11.1%), and incomplete paperwork (11.1%). HCV PCR positivity was significantly associated with a lack of prior DAA treatment (85.7% vs 6.1%,  $p<0.001$ ) and longer dialysis vintage ( $5.08 \pm 1.1$  vs  $2.96 \pm 1.13$  years,  $p=0.018$ ). In conclusion, the relatively reduced prevalence of HCV in this study reflects the success of the national eradication initiative. Nevertheless, gaps remain in awareness and accessibility, which may hinder complete eradication in high-risk groups such as hemodialysis patients. Enhanced patient

education, strict infection-control measures and targeted patient support is crucial to address residual gaps in high-risk dialysis units.

**Keywords:** HCV, ESRD, HD, Antiviral therapy, Treatment adherence, National Eradication Initiative.

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## Introduction

Hepatitis C is a global health problem, with an estimated 71.1 million individuals chronically infected worldwide, accounting for 1% (95% uncertainty interval: 0.8–1.1) of the population.<sup>1</sup> HCV is a blood-borne, hepatotropic RNA virus of the family Flaviviridae. The severity of the illness ranges from minor to severe, including liver cirrhosis and hepatocellular carcinoma (HCC).<sup>2</sup> HCV-related deaths are primarily due to chronic (or end-stage) liver disease and HCC.<sup>3</sup>

Egypt, with a population of 100 million, has experienced one of the highest burdens of HCV infections globally. By 2008, 15% of the population had antibodies to HCV (seropositive), indicating prior exposure to the virus, and approximately 10% of Egyptians aged 15 to 59 were living with chronic HCV infection.<sup>4</sup> The Demographic National survey in Egypt in 2015 reported that people who aged (1: 59 years) had prevalence of anti-HCV antibody was 5.3% but the positive PCR HCV RNA was 3.6%.<sup>5</sup> The risk of HCV infection tends to increase in patients with end-stage renal disease (ESRD) undergoing hemodialysis (HD) because this blood-borne virus is transmitted through parenteral routes through invasive procedures in HD and poor adherence to strict infection control measures.<sup>6</sup> Moreover, HD patients exhibit a high prevalence of metabolic disorders and impaired cellular immunity which increases their susceptibility to infections.<sup>7</sup>

The prevalence of HCV infection among hemodialysis patients varies both internationally and within individual facilities in the same country. Despite the implementation of infection control protocols, Egypt remains one of the countries with the highest prevalence of HCV. In Egypt, 50.7% of HD patients have tested positive for HCV.<sup>8</sup> HCV infections are associated with an elevated risk of end-stage liver disease, as well as extrahepatic complications. Previous studies

have shown that dialysis patients with HCV infection face a higher risk of mortality, increased hospitalization rates, and poorer quality of life compared to those without HCV infection.<sup>9</sup>

The introduction of direct-acting antiviral (DAA) drugs has shown a significant advance in the therapeutic outcomes of hepatitis C patients owing to their high efficacy and favorable safety profile.<sup>10</sup> Following the introduction of effective DAA agents in 2014, the National Committee for Control of Viral Hepatitis established a national strategy aimed at making treatment accessible to all, with the Egyptian government covering the costs. This initiative sought to expand treatment coverage to millions of individuals.<sup>11</sup> Egypt's National DAA treatment program, launched in October 2014 for hepatitis C is a public health initiative that has gathered international recognition for its success in combating a major health crisis. The National DAA treatment program was a collaborative effort between the Egyptian government, local pharmaceutical companies, and international health organizations.<sup>12</sup>

Egypt's national DAA treatment resulted in the treatment of more than 4 million HCV patients. HCV prevalence is estimated to have decreased from 6% of the population in 2015 to less than 0.5% of the population in 2021 (decrease from 5 million patients to less than 400,000 patients). Egypt achieved all the WHO elimination targets from the diagnosis of more than 90% of its HCV-infected population, offering treatment for more than 90% of them and a cure for more than 95% of them.<sup>13</sup>

Despite the success of DAA treatment, the prevalence of HCV infection among prevalent HD patients remains insufficiently studied. Therefore, this study aimed to assess the prevalence of HCV infection among prevalent HD patients after implementation of the National Eradication Initiative, and to identify

the reasons for treatment refusal or non-adherence despite free therapy.

## Patients and Methods

### *Study Design and Setting*

This multicenter cross-sectional study was conducted across three affiliated hemodialysis units within the Ain Shams University Hospital system in Cairo, Egypt. Patient recruitment was carried out over a 6-month period from November 2023 to April 2024. All participating units followed single-use dialyzer policies with zero dialyzer reuse and adhered strictly to standard infection-control protocols.

### *Eligibility Criteria and Sampling Procedure*

Consecutive sampling was utilized to recruit all adult ESRD patients (aged  $18 \geq$  years) undergoing maintenance HD (3 sessions per week) for more than 6 months across the participating centers. Patients aged  $<18$  years, patients undergoing temporary or acute hemodialysis for acute kidney injury, individuals with an active malignancy, and patients who declined to provide informed consent were excluded. Of all eligible patients approached during the recruitment timeframe, a total of 410 consecutive patients met all eligibility criteria and provided consent to be included in the final analysis.

### *Data Collection and Laboratory Assessments*

Sociodemographic information (age, gender, educational level, occupation, and residence) and clinical characteristics (etiology of ESRD, dialysis vintage, comorbidities, and history of HBV vaccination/infection) were recorded using a structured questionnaire and medical record review. Serological screening for anti-HCV antibodies was performed for all participants using standard third-generation enzyme-linked immunosorbent assay (ELISA). For all anti-HCV positive patients, quantitative real-time reverse transcription-polymerase chain reaction (RT-PCR) was performed to measure serum HCV RNA levels to identify active viremia. Active HCV infection was defined as a detectable HCV RNA viral load by PCR. Sustained virological response (SVR, defined clinical recovery) was defined as

undetectable HCV RNA by PCR at 12 or 24 weeks after completion of antiviral therapy. Patients categorized as having infection recurrence had documented undetectable HCV RNA post-treatment followed by subsequent positive PCR detection during follow-up.

### *Treatment History and Barrier Evaluation*

For all anti-HCV antibody-positive patients, complete records of prior DAA administration, treatment duration, and therapeutic outcome were extracted. For patients who had not received antiviral therapy, a pre-tested questionnaire analyzing specific reasons for non-treatment, including lack of awareness regarding treatment availability, fear of side effects, perceived lack of clinical need, administrative/ paperwork delays, or active treatment refusal.

### *Statistical Analysis*

Data were analyzed using IBM SPSS Statistics version 23.0. Descriptive statistics were generated: categorical variables were presented as absolute frequencies (n) and percentages (%), while continuous variables were expressed as mean  $\pm$  standard deviation (SD) or median with interquartile range (IQR). Categorical comparisons between HCV PCR-positive and PCR-negative subgroups were evaluated using Pearson's Chi-square test or Fisher's exact test as appropriate. Continuous variables were compared using Student's independent t-test or the Mann-Whitney U test. Statistical significance was set at  $p < 0.05$ .

## Results

### *Baseline Demographics and Clinical Characteristics*

A total of 410 maintenance HD patients were enrolled. The overall mean age was  $47.1 \pm 18.2$  years (range: 18–85 years), with 256 male (62.4%) and 154 female (37.6%) participants. The mean dialysis vintage was  $6.2 \pm 2.7$  years. Comorbidities were documented in 94.6% of patients, predominantly hypertension (60.5%) and diabetes mellitus (48.3%). Basic sociodemographic characteristics are summarized in Table 1.

**Table 1.** Basic sociodemographic and clinical characteristics of the study population.

| Variable                | No. = 410   |
|-------------------------|-------------|
| Gender                  |             |
| Male                    | 256 (62.4%) |
| Female                  | 154 (37.6%) |
| Age (years)             |             |
| Mean±SD                 | 47.1 ± 18.2 |
| Range                   | 18-85       |
| Educational level       |             |
| Illiterate              | 10 (2.4%)   |
| Read and write          | 41 (10%)    |
| Primary education       | 13 (3.2%)   |
| Preparatory education   | 62 (15.1%)  |
| Secondary education     | 126 (30.7%) |
| University education    | 136 (33.1%) |
| Postgraduate            | 22 (5.3%)   |
| Employment              |             |
| Employed                | 292 (71.2%) |
| Unemployed              | 118 (28.2%) |
| Residence               |             |
| Urban                   | 331 (80.7%) |
| Rural                   | 79 (19.3%)  |
| Comorbidities           |             |
| Hypertension            | 248 (60.5%) |
| Diabetes Mellitus       | 198 (48.3%) |
| Cardiovascular Disease  | 22 (5.4%)   |
| Autoimmune diseases     | 12 (2.9%)   |
| No                      | 22 (5.4%)   |
| Duration on HDx (years) |             |
| Mean±SD                 | 6.2±2.7     |
| Range                   | 1-19        |

#### *HCV Seroprevalence, Active Infection, and Treatment Uptake*

Among the studied population, anti-HCV antibodies were present in 113 of 410 patients, yielding an anti-HCV seroprevalence of 27.6%. Quantitative HCV RNA PCR testing among these 113 anti-HCV positive patients revealed active viremia in 14 cases (12.4% of seropositive patients), corresponding to an overall active HCV infection prevalence of 3.4% across the total dialysis cohort (14/410). Among those with prior HCV infection, 84.1% (n=95) received antiviral therapy (predominantly 12 weeks of oral Elbasvir/Grazoprevir), with 96.8% (n=92) achieving sustained virological response

(SVR/recovery) and 3.2% (n=3) experiencing viral recurrence. Conversely, 18 anti-HCV positive patients (15.9%) remained untreated. Evaluation of self-reported reasons among these untreated individuals identified a lack of awareness regarding free treatment availability as the predominant barrier (27.8%, n=5), followed by fear of side effects (22.2%, n=4). Additional barriers included treatment refusal (11.1%, n=2), perceived absence of clinical need (11.1%, n=2), incomplete administrative paperwork (11.1%, n=2), and other logistical factors (16.7%, n=3). Detailed viral hepatitis profiles, therapeutic outcomes, and non-treatment reasons are summarized in Table 2.

**Table 2.** Status of viral hepatitis and Treatment outcomes, and barriers among anti-HCV positive patients.

| Variable                           |                                     | Frequency/Percentage |
|------------------------------------|-------------------------------------|----------------------|
| Anti-HCV status (N=410)            | Negative                            | 297 (72.4%)          |
|                                    | Positive                            | 113 (27.6%)          |
| HbsAg status (N=410)               | Negative                            | 407 (99.3%)          |
|                                    | Positive                            | 3 (0.7%)             |
| HBV vaccination (N=410)            | Yes                                 | 210 (51.2%)          |
|                                    | No                                  | 200 (48.8%)          |
| Duration of HCV infection (years)  |                                     |                      |
| Mean±SD                            |                                     | 11±3.8               |
| Range                              |                                     | 3-16                 |
| HCV Complication (N=113)           | No                                  | 96 (85.0%)           |
|                                    | Cirrhosis                           | 12 (10.6%)           |
|                                    | Esophageal varices                  | 5 (4.4%)             |
| Treatment status (N=113)           | Treated                             | 95 (84.1%)           |
|                                    | Untreated                           | 18 (15.9%)           |
| Type of antiviral Treatment (N=95) | Oral                                | 93 (97.9%)           |
|                                    | IV                                  | 2 (2.1%)             |
| Recovery status (N=95)             | Yes                                 | 92 (96.8%)           |
|                                    | No                                  | 3 (3.2%)             |
| Reasons for non-treatment (N=18)*  | Unaware of treatment availability   | 5/18 (27.8%)         |
|                                    | Fear of side effects                | 4/18 (22.2%)         |
|                                    | Perceived lack of clinical need     | 2/18 (11.1%)         |
|                                    | Refusing treatment                  | 2/18 (11.1%)         |
|                                    | Incomplete administrative paperwork | 2/18 (11.1%)         |
|                                    | Others                              | 3/18 (16.7%)         |

\*Denominators for treatment barriers are calculated specifically among N=18 untreated anti-HCV positive patients.

#### Comparative Analysis of HCV PCR-Positive vs. PCR-Negative Subgroups

Comparing anti-HCV positive patients with active viremia (HCV PCR-positive, n=14) to those without active viremia (HCV PCR-negative, n=99), no significant differences were observed regarding age ( $51.38 \pm 16.36$  vs  $48.84 \pm 15.16$  years,  $p=0.574$ ), gender (64.3% vs 65.7% male,

$p=0.817$ ), or urban residence (76.9% vs 82.0%,  $p=0.658$ ).

However, PCR-positive patients exhibited a significantly longer mean duration of renal impairment ( $6.0 \pm 1.7$  vs  $3.3 \pm 1.5$  years,  $p=0.009$ ) and a longer mean dialysis vintage ( $5.08 \pm 1.1$  vs  $2.96 \pm 1.13$  years,  $p=0.018$ ) (Table 3).

**Table 3.** Comparison between HCV PCR-Positive and HCV PCR-Negative patients regarding Sociodemographic and clinical status (Seropositive patients N=113).

| Variable    |           | HCV PCR-Negative  | HCV PCR-Positive  | p-value |
|-------------|-----------|-------------------|-------------------|---------|
|             |           | No. = 99          | No. = 14          |         |
| Gender      | Male      | 65 (65.7%)        | 9 (64.3%)         | NS      |
|             | Female    | 34 (34.3%)        | 5 (35.7%)         |         |
| Age (years) | Mean ± SD | $48.84 \pm 15.16$ | $51.38 \pm 16.36$ | NS      |
|             | Range     | 16 – 85           | 17 – 66           |         |
| Residence   | Urban     | 82 (82.0%)        | 10 (76.9%)        | NS      |
|             | Rural     | 18 (18.0%)        | 3 (23.1%)         |         |

**Table 3.** Continued.

| Variable                             |                      | HCV PCR-Negative | HCV PCR-Positive | p-value |
|--------------------------------------|----------------------|------------------|------------------|---------|
|                                      |                      | No. = 99         | No. = 14         |         |
| Employment                           | Employed             | 59 (59.0%)       | 9 (69.2%)        | NS      |
|                                      | Unemployed           | 41 (41.0%)       | 4 (30.8%)        |         |
| Education                            | Illiterate           | 6 (6.0%)         | 1 (7.1%)         | NS      |
|                                      | Read and write       | 13 (13.0%)       | 1 (7.1%)         |         |
|                                      | Primary school       | 2 (2.0%)         | 1 (7.1%)         |         |
|                                      | Preparatory school   | 16 (16.0%)       | 5 (35.7%)        |         |
|                                      | Secondary school     | 36 (36.0%)       | 3 (21.4%)        |         |
|                                      | College Graduate     | 24 (24.0%)       | 1 (7.1%)         |         |
|                                      | Postgraduate studies | 3 (3.0%)         | 2 (11.7%)        |         |
| Duration of renal impairment (years) | Mean $\pm$ SD        | 3.3 $\pm$ 1.5    | 6 $\pm$ 1.7      | 0.009   |
|                                      | Range                | 2.7 – 26         | 1.8 – 25         |         |
| Dialysis vintage (years)             | Mean $\pm$ SD        | 2.96 $\pm$ 1.13  | 5.08 $\pm$ 1.1   | 0.018   |
|                                      | Range                | 1 – 17           | 1 – 19           |         |

$p > 0.05$  is not significant (NS).

#### Treatment Differences and Specific Barriers

A significantly lower proportion of patients in the PCR-positive group had received DAA treatment compared with the PCR-negative group (14.3%,  $n=2/14$  vs 93.9%,  $n=93/99$ ;

$p=0.000$ ). The 12 untreated PCR-positive patients reported primary barriers including lack of awareness regarding treatment access (41.7%,  $n=5/12$ ) and fear of drug-related complications (16.7%,  $n=2/12$ ) (Table 4).

**Table 4.** Comparison between HCV PCR-Positive and HCV PCR-Negative Patients regarding treatment history, and barriers to treatment (Seropositive patients  $N=113$ ).

| Variable                                         |                                     | HCV PCR Negative | HCV PCR Positive | p-value |
|--------------------------------------------------|-------------------------------------|------------------|------------------|---------|
|                                                  |                                     | No. = 99         | No. = 14         |         |
| HBV vaccination                                  | Yes                                 | 57 (57.6%)       | 3 (21.4%)        | 0.021   |
|                                                  | No                                  | 42 (42.4%)       | 11 (78.6%)       |         |
| Duration of HCV infection                        | Mean $\pm$ SD                       | 6 $\pm$ 1.3      | 9 $\pm$ 2.5      | 0.007   |
|                                                  | Range                               | 4.5 – 14         | 3 – 16           |         |
| Received HCV Treatment                           | Yes                                 | 93 (93.9%)       | 2 (14.3 %)       | 0.000   |
|                                                  | No                                  | 6 (6.1%)         | 12 (85.7 %)      |         |
| Complications                                    | No                                  | 86 (87.0%)       | 10 (71.4%)       | NS      |
|                                                  | Cirrhotic liver                     | 9 (9.0%)         | 3 (21.4%)        |         |
|                                                  | Esophageal varices                  | 4 (4.0%)         | 1 (7.1%)         |         |
| Specific barriers to treatment (N=18 untreated)* | Unaware of treatment availability   | 2/6 (33.3%)      | 5/12 (41.7%)     | 0.043   |
|                                                  | Perceived lack of clinical need     | 2/6 (33.3%)      | 2/12 (16.7%)     | NS      |
|                                                  | Fear of side effects                | 0/6 (0%)         | 2/12 (16.7%)     | 0.049   |
|                                                  | Refusing treatment                  | 1/6 (16.7%)      | 2/12 (16.7%)     | NS      |
|                                                  | Incomplete administrative paperwork | 1/6 (16.7%)      | 1/12 (8.3%)      | NS      |

\*:Denominators for barrier comparison correspond to untreated patients within each subgroup ( $n = 6$  PCR-negative vs  $n = 12$  PCR-positive).  $p > 0.05$  is not significant (NS).

## Discussion

Hepatitis C virus (HCV) has emerged as a significant global public health challenge over the past 30 years and continues to pose a serious threat. According to estimates by the World Health Organization (WHO), approximately 58 million individuals were living with chronic HCV infection worldwide in 2019. Approximately 1.5 million (1.3–1.8 million) newly infected individuals, and 290,000 deaths attributable to HCV-related complications.<sup>14</sup>

Hepatitis C virus (HCV) infection is common in dialysis patients and is associated with increased morbidity and mortality. HCV prevalence was nearly 10% in 2012–2015. Prevalence ranged from 4% in Belgium to as high as 20% in the Middle East, with intermediate prevalence in China, Japan, Italy, Spain, and Russia. HCV prevalence decreased over time in most countries, and prevalence was around 5% among patients who had recently (<4 months) initiated dialysis.<sup>15</sup>

Egypt is the country with the highest level of HCV prevalence worldwide, about 10% of the population, which is among the highest rates of HCV prevalence in the world.<sup>16</sup> Early detection and treatment of HCV patients is the goal of Egypt's treatment program starting in 2014, intending HCV prevalence reduction to < 2% in 10 years, in line with global targets. In addition, Egypt has aimed to treat 250,000 people annually up to 2020 in the first phase of their treatment program aiming at reducing the number of viremic patients, thus limiting the ongoing HCV transmission. With the availability of DAAs, Egypt is struggling to eliminate HCV and HCV-related morbidity by 2030.<sup>17</sup>

Therefore, this study aimed to assess the prevalence of HCV infection among prevalent HD patients after implementation of the National Eradication Initiative and to identify the reasons for treatment refusal or non-adherence despite free therapy.

Our multi-center cross sectional study included a heterogeneous group of 410 adult hemodialysis patients receiving sessions on regular basis (3 sessions/ week) at Ain Shams University Hospitals hemodialysis units. This cross-sectional study offers valuable insights into the epidemiological profile of HCV among

prevalent maintenance hemodialysis patients in a major Egyptian tertiary academic healthcare system following the national elimination program. Crucially, our findings demonstrate a marked divergence between anti-HCV antibody seroprevalence (27.6%) and active HCV RNA viremia (3.4%). In our study, overall seropositivity remained notable at 27.6%. This high antibody prevalence reflects historical exposure accrued prior to or during long-term dialysis treatment, as antibody positivity persists even after successful viral eradication.

In the present study, seropositive patients (27.6%,  $n = 113$ ) had a mean duration of infection of 11 years. These findings are comparable to those reported in a retrospective study by Abd El Fattah et al.,<sup>18</sup> which analyzed data from 1,600 patients admitted to the Nephrology Department of Ain Shams University Adult Hospital over a five-year period (2005–2009). In that study, 25.8% of patients tested positive for HCV antibodies.

Similarly, a study by Kerollos et al.<sup>7</sup> which reviewed the medical records of 1,435 hemodialysis patients from 14 dialysis units in Assiut governorate, Egypt, between January 2017 and January 2018, reported an HCV infection prevalence of 34.8% among the studied population. However, in a previous study by Zahran,<sup>19</sup> conducted on 514 patients in Menoufia Governorate, Egypt, and found the prevalence of HCV infection was 49.6% (notably higher than that reported in our study), a possible explanation for this difference may be attributed to geographical variation, as local epidemiology, healthcare access, and infection control practices can vary across governorates.

In the current study we found that the majority of patients had achieved at least secondary education. While less than 40 % of patients qualified to pursue university studies, this came in agreement with Murray et al.<sup>20</sup> study that revealed that end-stage kidney disease (ESKD) may adversely influence the progress in education and employment. The duration of HCV infection extended over several years. While most individuals did not develop liver-related complications, a subset progressed to advanced conditions such as cirrhosis or esophageal varices. Antiviral therapy was

administered to the majority of HCV-positive patients, predominantly through oral regimens. Among treated patients in our cohort, 96.8% achieved viral clearance, corroborating the real-world safety and therapeutic efficacy of DAAs in hemodialysis settings, like those reported by Shaibani et al.<sup>21</sup> who conducted a study on thirty-two hemodialysis patients with confirmed HCV infection. Following a 12-week course of antiviral therapy and one year of follow-up, the study concluded that direct-acting antivirals were both safe and effective, yielding a sustained negative virological response.

Among the 113 patients offered treatment, 14 tested positive for HCV PCR. The duration of dialysis was significantly longer in the HCV PCR-positive group compared to the HCV PCR-negative group. Given our study's cross-sectional design, these findings reflect clinical associations rather than direct causal relationships. Longer dialysis vintage increases lifetime exposure to nosocomial environments, parenteral interventions, and historical periods prior to universal DAA availability. Importantly, the primary driver of persistent active viremia in our cohort was a lack of antiviral treatment uptake rather than therapeutic failure. Untreated patients constituted 85.7% of the PCR-positive group. Evaluation of non-treatment reasons identified key modifiable barriers: 41.7% of untreated patients were unaware that free antiviral therapy was available, 16.7% expressed fear of treatment-related adverse events, and 8.3% experienced administrative delays due to incomplete paperwork.

In a previous study by Hashem et al.,<sup>22</sup> fear of treatment-related complications emerged as a prominent reason for refusing antiviral therapy among HCV-infected patients highlighting challenges particularly relevant to the hemodialysis population. Overall, these findings highlight important disparities in treatment access and outcomes, emphasizing the need for targeted patient education and administrative assistance to connect remaining viremic patients with care.

### *Limitations of the Study*

1. The cross-sectional study designs lack baseline pre-intervention data, or longitudinal tracking prevents establishing causal relationships or evaluating longitudinal trends directly attributable to the national elimination initiative.
2. Small PCR-Positive Sample Size: Only 14 patients were HCV PCR-positive, limiting statistical power for subgroup analyses and requiring cautious interpretation of statistical associations.
3. Single-Center System Setting: Patients were recruited from a single tertiary academic center (Ain Shams University Hospitals), which may limit the generalizability of findings to peripheral or community-based dialysis centers.
4. Recall and Selection Bias: Reliance on patient-reported reasons for treatment non-adherence may introduce recall bias.

### *Recommendations*

Based directly on the study findings, the following actions are recommended:

1. Routine Confirmatory PCR Screening: All anti-HCV antibody-positive hemodialysis patients should undergo immediate, routine quantitative HCV RNA PCR testing to distinguish resolved exposure from active viremia and avoid unnecessary clinical isolation or misclassification.
2. Targeted Patient Education: HD units should establish structured educational programs addressing common patient misconceptions, emphasizing the safety and efficacy of modern DAA regimens, and informing patients about free treatment access.
3. Streamlined Administrative Pathways: Hospital social services and nephrology teams should assist patients with administrative paperwork to minimize logistical delays in treatment initiation.
4. Rigorous Infection Control Surveillance: Strict adherence to universal infection control guidelines, single-use dialyzer policies, and ongoing viral surveillance must be maintained to prevent nosocomial transmission within hemodialysis units.

## Conclusion

While anti-HCV seroprevalence remains elevated (27.6%) due to historical exposure, active HCV RNA viremia is low (3.4%) among maintenance hemodialysis patients at Ain Shams University Hospitals. This low active prevalence reflects high treatment uptake and therapeutic response to direct-acting antivirals. Active viremia in this population is largely driven by persistent barriers to treatment uptake — such as lack of awareness and fear of side effects rather than treatment failure. Eliminating residual HCV infection in hemodialysis units requires targeted patient education, streamlined administrative pathways, and continued adherence to strict infection control practices.

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## Author Contributions

All authors contributed to study conception and design, participated in data acquisition, statistical analysis, and manuscript drafting and revision. All authors read and approved the final manuscript.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## Ethical approval

The study protocol was rigorously reviewed and officially approved by the Research Ethics Committee (REC) at the Faculty of Medicine, Ain Shams University, Egypt (Approval Reference Number: FMASU MS 193 / 2023). Furthermore, all research procedures were conducted in full accordance with

the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

## Informed consent

Written informed consent was obtained from all individual participants included in the study prior to their enrollment and any clinical intervention.

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