Elimination of Hepatitis C Virus in a Dialysis Population: A Collaborative Care Model in Taiwan

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Rationale & Objective: Hemodialysis facilities are high-risk environments for the spread of hepatitis C virus (HCV). Eliminating HCV from all dialysis facilities in a community may be achieved more effectively under a collaborative care model.

Study Design: Quality improvement study of multidisciplinary collaborative care teams including nephrologists, gastroenterologists, and public health practitioners.

Setting & Participants: All dialysis patients in Changhua County, Taiwan were treated using an interdisciplinary collaborative care model implemented within a broader Changhua-Integrated Program to Stop HCV Infection (CHIPS-C).

Quality Improvement Activities: Provision of an HCV care cascade to fill 3 gaps, including screening and testing, diagnosis, and universal direct-acting antiviral (DAA) treatment implemented by collaborating teams of dialysis practitioners and gastroenterologists working under auspices of Changhua Public Health Bureau.

Outcome: Outcome measures included quality indicators pertaining to 6 steps in HCV care ranging from HCV screening to treatment completion to cure.

Analytical Approach: A descriptive analysis.

Results: A total of 3,657 patients from 31 dialysis facilities were enrolled. All patients completed HCV screening. The DAA treatment initiation rate and completion rate were 88.9% and 94.0%, respectively. The collaborative care model achieved a cure rate of 166 (96.0%) of 173 patients. No virologic failure occurred. The cumulative treatment ratios for patients with chronic HCV infection increased from 5.3% before interferon-based therapy (2017) to 25.6% after restricted provision of DAA (2017-2018), and then to 89.1% after universal access to DAA (2019).

Limitations: Unclear impact of this collaborative care program on incident dialysis patients entering dialysis facilities each year and on patients with earlier stages of chronic kidney disease.

Conclusions: A collaborative care model in Taiwan increased the rates of diagnosis and treatment for HCV in dialysis facilities to levels near those established by the World Health Organization.

Editorial, p. 487

With the introduction of direct-acting antivirals (DAAs) for treating chronic hepatitis C virus (HCV) infection, a major global disease burden,1 governments around the world have envisaged various strategies to achieve the World Health Organization (WHO) goal of HCV elimination by 2030.1,2 The Taiwanese government has also set an ambitious target to treat 80% of HCV patients by 2025.3

Achieving HCV elimination is a great challenge because there is wide variation in the distribution pattern of cases and subpopulations.4 The microelimination approach, which focuses on treating smaller, targeted high-risk subpopulations, has been proposed as an effective means to tackle HCV.5 Although several microelimination programs have been developed, most of them have been implemented in high-income countries where HCV preponderates among vulnerable populations.6 In contrast, few programs have targeted high-risk populations in health care settings although health care–associated HCV infections among such institutes are prevalent, particularly in middle- and low-income countries.6

Hemodialysis settings have long been recognized as high-risk environments for contamination by HCV.9,10 Molecular virology techniques have unequivocally shown that patients are at greater risk for acquiring HCV while receiving hemodialysis,9 and numerous HCV outbreaks within hemodialysis units have been reported.9-11 Studies have suggested the incidence of newly acquired HCV infections in dialysis facilities ranges from 1.1% to 3.6% per 100 patient-years, amounting to more than 20,000 cases annually worldwide.9,11 In the pre-DAA era, HCV infection was seldom treated in patients on dialysis.12 To prevent this potentially lethal condition, novel strategies are required to achieve the “treatment as prevention” outcome of eventually eradicating HCV from dialysis units.11

Taiwan is reported to have one of the highest prevalence rates of HCV in Northeast Asia13 and one of the highest incidences and prevalence rates of treated kidney failure worldwide.14,15 Notably, around 90% of patients with

Visual Abstract online

Complete author and article information (including a list of the members of the Changhua Hepatitis C Elimination Task Force) provided before references.

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kidney failure are treated by hemodialysis in Taiwan. To stop HCV transmission in hemodialysis facilities, we developed a novel collaborative care model for eliminating HCV from the dialysis population with the integration of rigorous HCV screening into a robust infection control program. This strong linkage, leading to prompt diagnosis and DAA treatment, was enabled via active collaboration between dialysis teams and gastroenterologists. We describe the use of a collaborative care model for elimination of HCV among 3,657 dialysis patients in 31 dialysis facilities under the jurisdiction of the Changhua Public Health Bureau (CHPHB) in Changhua County, Taiwan.

Methods

Dialysis Populations in Changhua

Changhua County is located in central Taiwan, with a population of 1,277,824 in 2018. The prevalence rate of HCV infection among adults is around 3% to 4%, with more than 60% of HCV cases aged 60 years and older. To achieve HCV microelimination for people living in Changhua, an integrated care model dubbed the Changhua-Integrated Program to Stop HCV Infection (CHIPS-C) was developed in a phase-in approach. It began with the current targeted dialysis patients and was further extended to other candidate populations at risk for HCV (including chronic kidney disease [CKD] patients, people with diabetes, people living with human immunodeficiency virus [HIV], people who inject drugs, prisoners, and other high-risk groups) identified from various health care settings overseen by the CHPHB.

This collaborative care approach to achieve HCV microelimination among dialysis patients was nested within CHIPS-C and was launched on January 1, 2019. In total, there were 31 registered dialysis facilities (Fig 1), 15 (48%) consisting of hospitals and the remainder being freestanding dialysis clinics. Most of the facilities were in urban areas. Only one-third (10 of 31 [32%]) were staffed with gastroenterologists. Because the dialysis population is dynamic, both the patients who were already undergoing dialysis at the launch date and those who started dialysis after the launch date were prospectively recruited until the end of the enrollment (September 30, 2019). Thus, the study participants included the entire dialysis population of the 31 facilities in Changhua County during the period of January 1, 2019 to September 30, 2019.

Access to DAAs for HCV Treatment

Before 2017, only interferon-based therapy for HCV patients was reimbursed by Taiwan’s National Health Insurance (NHI). As of January 2017, DAAs were only reimbursed for HCV patients who previously had failed interferon-based therapy and/or with a fibrosis score of stage 3 and above. In 2019, the criteria were broadened to include all chronic HCV cases.

HCV Screening and Treatment

According to the infection control guideline issued by Taiwan Centers for Disease Control, all dialysis patients should have a mandatory baseline screening for HCV upon admission to the facility and then an annual test if the patient tests negative. Patients with anti-HCV antibodies detected should be isolated to separate dialysis machines and in a separate ward or a segregated zone, only being moved out when assessed as nonviremic. The guideline also recommends strict adherence to universal hygiene precautions and a ban on the reuse of dialyzers in HCV-positive patients. However, testing for HCV viremia was not a routine procedure.

CHPHB officials retrieved data from medical records to review information regarding HCV screening and the history of antiviral therapy for each dialysis patient. The information was documented and maintained by the dialysis teams and was also inspected periodically by the local health authority, and the details of previous antiviral therapy and its outcome were further evaluated by the gastroenterologists of the collaborative care teams. Patients without records of HCV testing within 1 year before enrollment were retested upon entry into the program. Importantly, all patients with anti-HCV antibodies had serum HCV RNA level determined and HCV genotyping performed. Patients were eligible to receive treatment under this program if they were at least 18 years of age, on hemodialysis or peritoneal dialysis, and had positive anti-HCV antibody titer as well as detectable HCV RNA levels at study entry. They could be either naïve to HCV treatment or with a history of failed antiviral treatment.
Antiviral treatment was administered to all eligible patients in accordance with the WHO guidelines. The treatment regimen included either grazoprevir/elbasvir (GZP/EBV; Merck) or glecaprevir/pibrentasvir (GLE/PIB; AbbVie). The treatment duration was 12 weeks for GZP/EBV in noncirrhotic patients, and 8 weeks of GLE/PIB for noncirrhotic patients, or 12 weeks of GLE/PIB in cirrhotic patients. The choice of regimen was based on the individual pretreatment assessment findings, including HCV genotypes and potential drug-drug interactions. All patients who received treatment underwent a follow-up evaluation at 12 and 24 weeks after the end of treatment. Also collected for further assessment were baseline variables related to demographics, viral markers, and Fibrosis-4 (FIB-4) score. The FIB-4 score is a marker of hepatic fibrosis in HCV infection using the following formula: \( \text{FIB-4} = \frac{\text{age} \times \text{AST}}{(\text{platelets} \times \text{ALT}^{1/2})} \), where age is in years, AST (aspartate transaminase) and ALT (alanine aminotransferase) are in U/L, and platelets are expressed as a count \( 10^9/\text{L} \).

**Collaborative Care Team for HCV Elimination**

Historically, HCV care has been delivered in gastroenterology centers in Taiwan. Nephrologists in Taiwan are not permitted to prescribe DAAs for HCV treatment. To overcome this limitation, our program adopted a collaborative care approach under the auspices of the CPHPB to enhance the clinical management of HCV infection in dialysis facilities (Table 1). An interactive meeting led by senior gastroenterologists and nephrologist leaders was held to discuss the implementation of the latest evidence-based guidelines before the launch of the program. Under the coordination of CPHPB and the guidance of members of Changhua Hepatitis C Elimination Task Force of the CHIPS-C, who had expertise in public health and liver disease management, multidisciplinary HCV care teams were established for each setting. In dialysis facilities already staffed with gastroenterologists (always hospital based), gastroenterologist-nephrologist collaborative care teams were composed of members from the same institutions. In other settings without gastroenterologists, outreach care teams from hospitals collaborated with nephrologists in the dialysis teams. Additionally, several strategies were adopted to overcome barriers to linkages in care (Table 1).

**Outcome Measures**

The delivery of DAA therapy involved multiple steps from diagnosis, referral, and evaluation, to final treatment. We therefore used population-level indicators of the HCV care cascade to measure the outcomes of this model. The quality indicators along 6 key steps of the continuum of care included the following: (1) the proportion of persons with an HCV infection diagnosis, (2) the proportion of patients with confirmed HCV RNA, (3) the proportion of patients engaged in collaborative care, (4) the treatment initiation rate, (5) the treatment completion rate, and (6) the cure rate. The cure rate was represented by the proportion of patients with a sustained virological response at week 12 after completing treatment (SVR12, where sustained virological response was defined as HCV RNA less than the lower limit of quantification).

HCV microelimination was defined according to the WHO criteria as diagnosis of more than 90% and treatment of more than 80% of the population, corresponding to reaching at least 72% treatment coverage of the total target population.

**Ethical Aspects**

During the Taipei Medical University Joint Institutional Review Board review process, these services and the data collected for this study were permitted to be part of program implementation and evaluation, and specific informed consent was not required from patients (TMU-JIRB No. N201912093). All data were deidentified to protect patient confidentiality.

**Results**

**Characteristics of Participants**

A total of 3,657 kidney failure patients treated in dialysis facilities were ultimately enrolled in the study from January 1, 2019 to September 30, 2019 (Fig 2). Nearly 40% of the patients were older than 70 years; 92.7% of the patients were treated by hemodialysis, and 38.8% were treated in freestanding dialysis facilities. All patients completed HCV screening, with an overall anti-HCV seroprevalence of 11.0% (Table 2). The HCV seropositive rates increased with age and the duration of dialysis. Notably, the prevalence rate of HCV was higher for patients on hemodialysis than for those on peritoneal dialysis (11.4% vs 5.6%, respectively). Freestanding settings also had a significantly higher HCV seropositive rate than hospital-based settings (13.0% vs 9.7%, respectively) (Table 2), which might be due to a higher HCV prevalence in the geographic areas where the latter are located (Fig 1).

**Treatment Outcomes**

Among the 403 patients positive for anti-HCV antibodies, 4 were undergoing DAA therapy at enrollment in the study (later confirmed to be cured), and 7 died before HCV RNA testing (Fig 2). Of the remaining 392 HCV-seropositive participants, 216 (55.1%) patients were viremic by HCV RNA testing (had a detectable serum HCV RNA level). After excluding 1 patient who had previously failed DAA therapy and was not eligible for retreatment due to insurance reimbursement, 215 patients were eligible for HCV treatment. Of these 215, there were 9 deaths before starting treatment. In addition, 14 patients refused to receive treatment after it was explained to them. Furthermore, 8 patients did not receive treatment due to serious medical comorbidities or an expected life expectancy of
Table 1. Key Strategies to Address Barriers and Challenges to HCV Elimination in the Dialysis Population, Changhua, Taiwan

<table>
<thead>
<tr>
<th>Barriers and Challenges</th>
<th>Key Strategies</th>
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<tbody>
<tr>
<td>The high cost of DAAs and the restricted criteria of treatment coverage had prevented access to HCV treatment for those in need</td>
<td>Provision of unrestricted access to DAA therapy. As of 2019, DAAs are reimbursed for all chronic HCV patients by Taiwan’s National Health Insurance.</td>
</tr>
<tr>
<td>A lack of coordination between different levels of care and care settings to overcome all barriers of HCV treatment (the so-called silo effect)</td>
<td>Strong leadership support of integration efforts at the local level. Changhua is the first county/city government in Taiwan to initiate an HCV elimination program. The coordination of multiple strategies and service arrangements was led by CHPHB. A committee comprising expertise in public health and liver disease management was established to guide the implementation of the HCV elimination program. Regular meetings were held monthly to review progress and treatment outcomes and provided the solutions to overcome barriers.</td>
</tr>
<tr>
<td>Nephrologists’ lack of awareness and motivation for HCV care in dialysis facilities</td>
<td>Collaboration between gastroenterology and nephrology. An interactive meeting led by senior gastroenterologists and nephrologist leaders was held to discuss the issue of implementation of the latest evidence-based guidelines before the launch of the program. The senior experts helped to overcome and solve the discrepancy in awareness between nephrologists and gastroenterologists.</td>
</tr>
<tr>
<td>Inadequate and infeasible HCV RNA tests in dialysis facilities due to the lack of awareness among nephrologists and lack of expertise for this test</td>
<td>Diagnostic laboratory support. CHPHB coordinated all the hospital-based and contracted laboratories to offer reflex testing for HCV RNA for all HCV antibody–positive samples to eliminate the need to arrange a second blood collection for all antibody-positive patients.</td>
</tr>
<tr>
<td>HCV treatment confined to gastroenterology centers; nephrologists not permitted to prescribe DAAs</td>
<td>Establishment of multidisciplinary collaborative care team. The collaborative care teams, composed of nurses, case managers, and appropriate specialists, were led by gastroenterologists who collaborated with nephrologists from the dialysis settings, either in hospital or local clinics.</td>
</tr>
<tr>
<td>Disparity in HCV diagnosis and linkage to care (partly due to patients’ lack of awareness or unwillingness)</td>
<td>Nurse-led case management. The HCV nurse case managers assessed barriers, customized individual care plans, and provided patient navigation and telephone-based support to facilitate patients’ adherence.</td>
</tr>
<tr>
<td>Difficulty in making appointments with specialists</td>
<td>Automatic prescheduled appointment with gastroenterologists at the time of referral. The mechanism was based on organized regional networks that provided optimal referral pathways from the dialysis settings to the gastroenterology centers.</td>
</tr>
<tr>
<td>Limited public transportation in rural areas</td>
<td>Medical transportation services. On-demand medical transportation was offered to ensure that no patients missed a scheduled appointment.</td>
</tr>
<tr>
<td>Increased stress and demand on staffs of resource-limited settings for HCV care</td>
<td>Mobile clinic. Outreach gastroenterology care teams provided co-located comprehensive HCV care (ie, dialysis patients stay in the facilities and do not need to visit the hospital for HCV treatment), especially for patients whose disability, serious illness, and/or personal reasons make travel difficult for them.</td>
</tr>
<tr>
<td>Lack of integration of laboratory and clinical data into public health surveillance records</td>
<td>Integration of program data systems. Uniform templates for patient registry and program evaluation were created. The data managers of CHPHB were responsible for ensuring timely entry of relevant data and generating updated reports for monitoring progress of HCV elimination without creating new data systems.</td>
</tr>
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</table>

Abbreviations: CHPHB, Changhua Public Health Bureau; DAA, direct-acting antiviral; HCV, hepatitis C virus.

less than 1 year as determined by physicians (4 patients had advanced stages of hepatocellular carcinoma and/or decompensation, and liver transplantation was not indicated; the other 4 patients were excluded due to urinary bladder cancer, unstable comorbidities, disability, and being bed-ridden). Accordingly, 184 patients started DAA treatment under the present program (including 3 cases who had previously failed interferon-based therapy).

After initiating DAA treatment, 11 patients did not complete treatment (Fig 2), including 7 who died during treatment, 1 with treatment interruption due to limited adherence and 3 who did not adhere to the visit schedule owing to a lack of reminders for appointments (however, 1 of these patients did reach SVR12). Eventually, 173 completed treatment. Of these, 7 patients died during the follow-up period, before SVR12 evaluation. Among the 166 patients who completed the follow-up 12 weeks after treatment, no virologic failure was found.

As illustrated in Table S1, at baseline, most patients initiating DAA therapy had mild/moderately altered levels...
of biochemical and hematological markers. The mean patient age and the mean dialysis vintage were 65.9 ± 11.3 (SD) and 10.3 ± 9.5 years, respectively. The median HCV RNA level was 500,187 (range, 34-33,600,000) IU/mL. Most of the patients had genotype 1 (50.0%) or genotype 2 (39.7%) HCV. Most cases (83.7%) received a GLE/PIB-based treatment regimen for 8 weeks or 12 weeks based on cirrhotic status. A total of 14.1% of patients received GZP/EBV treatment for 12 weeks. The remaining 4 patients received ledipasvir/sofosbuvir (LDV/SOF, n = 3) or sofosbuvir/velpatasvir (SOF/VEL, n = 1) therapy.

Compared with the patients who survived, patients who died during or after treatment had a higher mean age and a higher mean FIB-4 score, but a lower mean platelet count and lower mean body mass index (Table S1). They were all naïve to HCV treatment and undergoing hemodialysis. The causes of death were reported as sepsis, aspiration pneumonia, lower respiratory tract infection, epilepsy, injury, subarachnoid hemorrhage, rhabdomyolysis, oral cancer, and severe cardiopulmonary insult (such as acute myocardial infarction, pulmonary edema, and valvular heart disease) (Table S2). A chart review by specialists of the task force found after careful assessment that none of these deaths were related to the treatment.

**Cascade of Care**

The indicators of the cascade of care are shown in Figure 3A. All patients on dialysis (n = 3,657) were tested for anti-HCV antibodies (step 1). Of those who tested positive for anti-HCV antibodies (n = 403), the proportion who underwent HCV RNA testing (step 2) was 98.3% (396 of 403), and the proportion of those with viremia who engaged in collaborative care (step 3) was 95.8% (207 of 216). The treatment initiation rate (step 4) and the treatment completion rate (step 5) were 88.9% (184 of 207) and 94.0% (173 of 184), respectively. Ultimately, our model achieved a cure rate of 96.0% (166 of 173) (step 6). Among all patients with viremia, 166 (77%) of 216 were cured.

Figure 3B shows the cumulative proportion treated for patients with chronic HCV infection during 3 periods: before 2017 (when only interferon-based therapy was available), 2017-2018 (when DAAs were restricted), and after 2019 (universal access to DAAs). Including individuals who received treatment before the collaborative care model launched, 285 of the 403 HCV antibody–positive (70.7%) individuals had HCV viremia (Fig S1). Among these, 15 patients received interferon-based therapy before 2017. Five of these individuals experienced virologic failure and were retreated with DAA regimens in the following 2 periods (2 cases in 2017-2018 and 3 cases in 2019). Sixty patients received DAA regimens during 2017-2018. Taking 285 as the denominator, the cumulative treatment ratios of these 3 periods increased from 5.3% to 25.6%, and then to 89.1%.

**Discussion**

This study documents a novel countywide treatment-delivery collaborative care model for treating HCV-infected dialysis patients in Taiwan. Of dialysis patients in the county with antibody evidence of HCV infection, 98.3% were diagnosed with chronic infection by HCV RNA testing, and we achieved 89.1% treatment coverage. By achieving these results within a short period of time, we met the criteria of HCV microelimination. Although elimination of HCV in dialysis patients at a single center has been reported,23 to our knowledge there are currently no published real-world data on the effectiveness of DAA treatment for HCV elimination in dialysis patients on a population level.

As expected, most patients achieved SVR12 with acceptable tolerance to treatment. The high cure rate achieved in the present study confirms the feasibility and effectiveness of the “treatment as prevention” strategy in
Table 2. Characteristics of Changhua, Taiwan, Dialysis Population

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All</th>
<th>Anti-HCV Antibody</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>No. of patients</td>
<td>Negative</td>
<td>Positive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,657 (100%)</td>
<td>3,254 (89.0%)</td>
<td>403 (11.0%)</td>
<td></td>
</tr>
<tr>
<td>Dialysis modality</td>
<td></td>
<td></td>
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<tr>
<td>Peritoneal dialysis</td>
<td>268 (73%)</td>
<td>253 (94.4%)</td>
<td>15 (5.6%)</td>
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</tr>
<tr>
<td>Hemodialysis</td>
<td>3,389 (92.7%)</td>
<td>3,001 (88.6%)</td>
<td>388 (11.4%)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1,951 (53.3%)</td>
<td>1,752 (89.8%)</td>
<td>199 (10.2%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1,706 (46.7%)</td>
<td>1,502 (88.0%)</td>
<td>204 (12.0%)</td>
<td></td>
</tr>
<tr>
<td>Age&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40 y</td>
<td>169 (5.0%)</td>
<td>163 (96.4%)</td>
<td>6 (3.6%)</td>
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<tr>
<td>40-49 y</td>
<td>293 (8.7%)</td>
<td>269 (91.8%)</td>
<td>24 (8.2%)</td>
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<tr>
<td>50-59 y</td>
<td>590 (17.5%)</td>
<td>513 (86.9%)</td>
<td>77 (13.1%)</td>
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<tr>
<td>60-69 y</td>
<td>995 (29.5%)</td>
<td>862 (86.6%)</td>
<td>133 (13.4%)</td>
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<tr>
<td>70-79 y</td>
<td>811 (24.0%)</td>
<td>710 (87.5%)</td>
<td>101 (12.5%)</td>
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<tr>
<td>80+ y</td>
<td>518 (15.3%)</td>
<td>456 (88.0%)</td>
<td>62 (12.0%)</td>
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<tr>
<td>Dialysis facilities</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hospital-based</td>
<td>2,237 (61.2%)</td>
<td>2,019 (90.3%)</td>
<td>218 (9.7%)</td>
<td></td>
</tr>
<tr>
<td>Freestanding</td>
<td>1,420 (38.8%)</td>
<td>1,235 (87.0%)</td>
<td>185 (13.0%)</td>
<td></td>
</tr>
<tr>
<td>Dialysis vintage&lt;sup&gt;b&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤5 y</td>
<td>1,203 (54.0%)</td>
<td>1,023 (85.0%)</td>
<td>180 (15.0%)</td>
<td></td>
</tr>
<tr>
<td>6-10 y</td>
<td>564 (25.3%)</td>
<td>499 (87.2%)</td>
<td>72 (12.8%)</td>
<td></td>
</tr>
<tr>
<td>11-15 y</td>
<td>227 (10.2%)</td>
<td>196 (86.3%)</td>
<td>31 (13.7%)</td>
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</tr>
<tr>
<td>16-20 y</td>
<td>123 (5.5%)</td>
<td>82 (66.7%)</td>
<td>41 (33.3%)</td>
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</tr>
<tr>
<td>21-25 y</td>
<td>63 (2.8%)</td>
<td>35 (55.6%)</td>
<td>28 (44.4%)</td>
<td></td>
</tr>
<tr>
<td>26+ y</td>
<td>48 (2.2%)</td>
<td>17 (35.4%)</td>
<td>31 (64.6%)</td>
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</tr>
</tbody>
</table>

Abbreviation: HCV, hepatitis C virus.

<sup>a</sup>Statistically significant at the P < 0.05 level.

<sup>b</sup>Data on age and duration of dialysis were not available for 281 and 1,429 cases, respectively.

high-risk groups. The key elements contributing to the success of the present program are of potential relevance to scale up treatment strategy and reach the WHO targets for eliminating HCV.

With the advent of easy-to-administer DAA regimens, with favorable tolerability and high cure rates, HCV treatment rates have been expected to increase. However, a recent US study revealed that only 7% of patients with advanced CKD were treated in the DAA era. The situation was similar in Taiwan. After 2 years of unrestricted reimbursement for DAA regimens, there were only a few dialysis facilities achieving HCV microelimination in a single setting. To our knowledge, before the present study involving only a single or a limited number of settings, our model included the dialysis settings in the whole county. To deliver this kind of universal HCV care, service arrangements must be tailored to distinct individual needs in various settings and treatment capacities, as mentioned earlier (Table 1).

Second, experience from previous HCV elimination programs revealed that successful and widespread implementation of a newly effective therapy is challenging. In general, there is a lack of awareness and motivation for HCV care in dialysis facilities. Also, there is no clear referral pathway between nephrologists and gastroenterologists for HCV treatment. Our program facilitated clinical interaction via leadership of senior experts in these respective fields.

Third, in the past, anti-HCV antibody–positive patients in dialysis settings in Taiwan did not routinely undergo screening for HCV RNA, which might lead to the spread of HCV in the unit. As illustrated in Figure 3A, the proportion of HCV RNA tests reached nearly 100% shortly after starting the program. The results revealed a high rate of HCV viremia, highlighting the risk for this population. Compared to the current standard of care, our collaborative care model had a substantially shorter lag time between diagnosis and treatment. Because the present study integrated HCV elimination and an infection control program,
this provided the benefit of delivering HCV care through health services already available to this population.28 Several case studies have suggested that high-level political commitment is crucial for HCV elimination.1,8 While numerous national plans are under development, many countries still lack the necessary funding to provide HCV-related services.8 Taiwan is one of the few Asian countries that has implemented unrestricted access to DAA therapy.3 The strong budgetary commitment has laid a solid foundation for achieving the goal of HCV elimination. Taiwan is one of the few Asian countries that has implemented unrestricted access to DAA therapy.3 The strong budgetary commitment has laid a solid foundation for achieving the goal of HCV elimination. Notably, Changhua is the first county/city government in Taiwan to initiate an HCV elimination program. To our knowledge, this is the first report of HCV microelimination for dialysis patients in a countywide population. The coordination of multiple strategies and service arrangements was dependent on the accountability and responsiveness of the local government. The current study has further demonstrated a successful model of synergy between central and local governments for HCV elimination.

The high cure rates of DAAs achieved among elderly dialysis patients of the present program are worth mentioning as well. A previous systematic review, comprising a total of 264 patients with stages 4-5 CKD from 11 studies, concluded that non–sofosbuvir-based DAA therapies achieved a pooled SVR12 of 94.7% (95% CI, 91.0%-97.5%).29 More recent studies with similar target populations suggested an SVR12 rate of 94% to 100%.30,31 The 96.0% (166 of 173) cure rate of our model is comparable to those studies. Of note, the participants in our study had a higher mean age (65.9 ± 11.3) (Table S1) compared with the aforementioned studies (mean age < 60 years). Elderly dialysis patients with HCV infection have been reported to be at a very high risk of death, with a mortality rate higher than 139.5 per 1,000 person-years.12 The rate we observed (7.4%; 30 of 403) (Fig 2) was much lower. When we exclude patient deaths during the posttreatment follow-up (n = 7), the SVR12 rate was 100%. The high cure rate is valuable and important for future implementation of other HCV elimination programs.

There are some limitations in our study. First, previous studies have revealed that false-negative HCV antibody tests might be present among patients undergoing hemodialysis due to impaired immune function.32,33 Because we did not perform HCV RNA testing for HCV antibody–negative patients, we cannot exclude the possibility that some viremic individuals were left undiagnosed and untreated. A prospective study may be considered to elucidate this issue. Second, only short-term outcomes were measured in the program. The long-term effect of a large-scale DAA intervention could be assessed in the future. Third, the high prevalence rate of HCV infection in advanced CKD patients can become a potential source of new HCV infection when patients reach kidney failure. Because the incidence of kidney failure is estimated to be 450 per million people in Taiwan,16 it is expected that there will be approximately 600 new dialysis patients each year in Changhua County. Thus, an early HCV surveillance and elimination program is necessary for patients with earlier stages of CKD.

Finally, although the present study demonstrated the safety and effectiveness of DAA treatment for HCV in older people undergoing dialysis, there is concern about the cost utility, which is affected by fibrosis stage, age, frailty, and drug price.34 Our results could be used to inform future economic evaluation on the impact of HCV microelimination in the dialysis population.
In conclusion, our study demonstrates that a novel collaborative care model, implemented by gastroenterology and nephrology specialists and directed by health authorities to accelerate HCV eradication, achieved high HCV treatment coverage in a countywide dialysis population.

Supplementary material
Supplementary File (PDF)

Figure S1: History of antiviral therapy for HCV infection among the dialysis population in Changhua.
Table S1: Clinical characteristics of DAA-treated patients by different treatment outcomes.
Table S2: Clinical characteristics of patients who died during or after antiviral HCV treatment.

Article Information


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References


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### HCV Elimination in the Dialysis Population: A Collaborative Care Model in Taiwan

<table>
<thead>
<tr>
<th>Setting &amp; Participants</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
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<tbody>
<tr>
<td>All dialysis patients in Changhua County, Taiwan</td>
<td><strong>Collaborative Care Model Major Components</strong>&lt;br&gt; gastroenterologist-nephrologist collaboration&lt;br&gt; unrestricted access to direct-acting antivirals (DAAs)&lt;br&gt; medical transportation&lt;br&gt; integration of data systems&lt;br&gt; synergic action of central and local governments</td>
<td><strong>Reached the goal of HCV micro-elimination</strong>&lt;br&gt; 98.3% diagnosis confirmed by HCV RNA (396/403)&lt;br&gt; 89.1% treatment coverage (254/285)</td>
</tr>
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**CONCLUSION:** A collaborative care model increased the rates of HCV diagnosis and treatment for patients undergoing dialysis to levels near those established by the WHO.