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Clinical Research Study

Closing the Gaps in Hepatitis C Knowledge Among Internal Medicine Residents in the United States

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ABSTRACT

Background: The introduction of direct-acting antivirals (DAA) has revolutionized hepatitis C virus (HCV) treatment but has not translated into an appreciable decline in HCV prevalence, which is estimated to be 2.4 million in the United States. Efforts are thought to be limited by the lack of experience among nonspecialist providers in managing HCV. However, there have been no comprehensive surveys assessing HCV knowledge among medical trainees to determine if trends have shifted since the discovery of DAAs.

Methods: We performed a retrospective observational study of internal medicine (IM) residents in the United States ($n = 1763$) who completed the Physician Education and Assessment Center HCV learning module between 2021 and 2022. Participant pre- and post-test performance was compared with further stratified analysis by training year, geography, training program type, and local HCV prevalence using ANOVA and Chi-squared tests of proportions, respectively.

Results: IM residents universally lacked baseline HCV knowledge (average score ± standard deviation, 43% ± 19%); less than 50% of participants answered correctly in the majority of tested domains. There were no consistent trends in performance regardless of resident characteristic used to stratify the participants. Knowledge gaps improved after completing an online educational training module ($P < .001$).

Conclusions: HCV knowledge remains limited among IM residents despite expansion of treatment options. Addressing these gaps during clinical training may substantially increase the availability of HCV treatment in the community, and online modules may be one means by which to integrate these efforts into medical training.

Introduction

The landscape of hepatitis C virus (HCV) treatment has shifted dramatically since the introduction of novel direct-acting antivirals (DAA). Drug regimens are increasingly accessible and affordable, and there are fewer pre-testing and monitoring requirements. Cure can be achieved in as short as 8-12 weeks. These advances have made HCV elimination an attainable goal, leading the World Health Organization (WHO) to set a target date of 2030.[1] However, success is contingent on increasing the capacity to diagnose and treat HCV.

The prevalence of HCV has not appreciably declined in the United States (US) since the publishing of the WHO report and subsequent complementary efforts by the Center for Disease Control and Prevention (CDC).[2,3] In 2022, there were an estimated 160,000 cases of newly diagnosed acute and chronic HCV in the US with an overall estimated prevalence of 2.4 million.[4,5] Unfortunately, only a fraction of individuals are aware of their diagnosis, and of those with known infection, less than a third will receive treatment.[6,7] Visits with nonspecialty providers are a critical opportunity to detect and treat HCV. Multiple national organizations, including the CDC, actively encourage primary care providers to manage uncomplicated HCV and to only refer complex patients for specialist care.[8-11]

Many established nonspecialist providers have received minimal or no training about current HCV treatments[12] and may lack experience

Abbreviation: CDC, Centers for Disease Control and Prevention; DAA, direct-acting antivirals; HCV, hepatitis C virus; IM, internal medicine; PEAC, Physician Education and Assessment Center; PGY, resident post-graduate year.

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Table 1
Characteristics of Internal Medicine Residents.

Characteristic	Total (%)
PGY level	
PGY-1	536 (30)
PGY-2	665 (38)
PGY-3	562 (32)
Program type	
Community	195 (11)
Community-based, University-affiliated	909 (52)
University	659 (37)
Program by region	
Midwest	387 (22)
Northeast	567 (32)
South	562 (32)
West	247 (14)

Table 2
Baseline HCV Knowledge, % Correct Residents (Number of Residents).

	% Correct (n = 1763)
Natural history	69 (1218)
Screening	71 (1244)
Preventive care	37 (611)
Routine evaluation	49 (862)
Treatment initiation	40 (707)
Regimen selection	26 (461)
Drug interactions	23 (414)

and confidence in managing HCV.[13,14] Internal and family medicine residency programs recognize the importance of addressing this knowledge gap given their role in shaping the practice patterns and treatment scope for a significant proportion of future primary care providers.[15-17] However, it is unclear the extent of the current HCV knowledge in programs across the country as prior studies have focused on established providers[12,18] or limited their sample to a single academic center[19] predating the approval of DAAs.

We assessed HCV knowledge among internal medicine (IM) trainees across the US since the broad adoption of DAAs as standard of care. We utilized a novel HCV education module developed by the Physician Education and Assessment Center (PEAC) to assess baseline knowledge and the ability of online modules to augment these deficits.

Materials and Methods

Module Development

The HCV module is hosted and maintained on the Johns Hopkins PEAC site (www.peaconline.org) by the Johns Hopkins Ambulatory Care Curriculum as described in Sisson, Hughes, Levine, and Brancati.[20] This curriculum is an education resource that offers 50 education modules on ambulatory IM topics, which was developed using Kern et al's[21] 6-step approach to curriculum development in medical education. Residents in IM programs that subscribe to the PEAC curriculum have access to the didactic modules, which are formatted in a pretest-didactics-posttest curricular format. The didactics sections are developed by physician experts in the specific module and include descriptive summaries and guidelines, with links to abstracts and key studies. Sections must be completed sequentially, and a module is considered complete when the post-test assessment is finished. Modules are self-paced, and pre- and post-test assessments are untimed.

The HCV training module was developed by an IM physician experienced in HCV care using CDC guidelines[22,23] and seminal literature regarding management of HCV[24] . Materials were subsequently reviewed by two separate IM physicians with active ambulatory practices that included HCV care. After the first year of implementation (2020), scores on the individual assessment items and the Cronbach alpha for all test items were used to refine and improve questions to ensure content validity. Scores from this first year were excluded from subsequent analyses discussed in this article. The final version of the pre-test included 8 multiple-choice questions spanning the following content areas: natural history, screening, preventive care, routine evaluation, treatment regimen selection, treatment initiation, and treatment side effects/interactions. The post-test questions also consisted of 8 multiple-choice questions and covered 4 of the 7 aforementioned content areas. Questions were designed to assess overall competency rather than by domain so only the overlapping content areas were included in the analysis comparing the pre- and post-test scores. See Supplementary Table 1 for questions pertaining to each section and Supplementary Table 2 for an outline of the module content.

Individuals who register for PEAC consent to release of their de-identified demographic information and test scores. All data were collected in accordance with the approved Johns Hopkins Institutional Review Board protocol (IRB#00336256).

Study Design and Data Collection

IM residents (post-graduate years 1-3) in the US who registered and completed the PEAC HCV learning module between 2021 and 2022 were included in the study. Training programs outside of the US and nonresident trainees (ie, attending physicians, nursing students, etc.) were excluded. Pre- and post-test performance on the HCV module in each content area (as defined above) was collated. Resident characteristics were also collected at time of registration, including resident post-graduate year (PGY) and residency program affiliation. Clinical training characteristics included region of country in which participants were training (Midwest, Northeast, South, or West) according to census region of the US, program type (community, community-based university-affiliated, university, or military) based on American Medical Association Fellowship and Residency Electronic Interactive Database Access categorization, and estimated prevalence of HCV positive patients in the practice location based on state. Estimated rate of people living with Hepatitis C per 100,000 population at the state level was determined using the HepVu online database.[5]

Statistical Analysis

The sample characteristics and overall percentage correct were summarized for each item. Items on the pre- and post-test were scored as correct vs incorrect in order to determine percentage correct across all participants, and P-values less than .05 were considered significant when comparing performance on individual test items. We also calculated the total as the mean number correct out of 8 and divided the corresponding mean and standard deviation by 8. We compared mean total scores using ANOVA and considered P-values less than .00625 to be significant after adjusting for multiple comparisons. Additionally, Chi-squared tests of proportions were used to compare the performance on pre- or post-test for each predictor variable. HCV prevalence was converted from a continuous variable to quartiles for the analysis. All statistical analyses and data manipulations were performed using Stata (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, Texas: StataCorp LP).

Results

As summarized in Table 1, 1763 responses were collected. Participants were evenly distributed across PGY level. The majority were in community-based university-affiliated programs (51.6%), and sites were primarily located in the Northeast (32.2%) and South (31.9%). The median local HCV prevalence for all programs was 900 with an interquartile range of 270 for every 100,000 people.

Table 3
Baseline HCV Knowledge Stratified by Resident Characteristic, % of Correct Residents (Number of Residents).

	Natural History	Screening	Preventive Care	Routine Evaluation	Treatment Initiation	Regimen Selection	Drug Interactions	Overall Score (Mean, SD)
PGY level								
PGY-1*	73 (389)	73 (390)	37 (199)	47 (251)	41 (221)	27 (146)	23 (121)	43, 19
PGY-2	69 (458)	71 (471)	38 (251)	47 (314)	40 (264)	25 (163)	24 (161)	42, 20
PGY-3	66 (371)	68 (383)	38 (211)	53 (297)	40 (222)	27 (151)	23 (132)	42, 20
P-value	.062	.241	.976	.075	.813	.49	.802	.564
Program type								
Community†	65 (127)	67 (130)	35 (68)	45 (87)	42 (81)	26 (50)	26 (50)	41, 20
Community-based, University-affiliated	69 (628)	68 (616)	36 (324)	48 (432)	37 (340)	28 (252)	24 (222)	42, 21
University	70 (463)	76 (498)	41 (269)	52 (343)	43 (286)	24 (158)	22 (142)	44, 19
P-value	.396	.002	.082	.094	.052	.1	.313	.12
Local HCV prevalance								
Quartile 1††	72 (440)	71 (434)	40 (245)	51 (312)	41 (255)	24 (147)	23 (139)	43, 19
Quartile 2	69 (208)	76 (229)	37 (112)	52 (156)	41 (123)	27 (80)	24 (72)	44, 21
Quartile 3	69 (301)	69 (299)	35 (150)	51 (220)	40 (172)	28 (122)	23 (98)	43, 21
Quartile 4	65 (269)	69 (283)	37 (154)	42 (174)	38 (157)	27 (112)	25 (105)	41, 20
P-value	.189	.151	.384	.019	.72	.008	.715	.336
Program by region								
Northeast#	72 (408)	70 (395)	38 (215)	50 (285)	43 (242)	25 (142)	23 (133)	43, 19
South	69 (386)	71 (405)	40 (224)	47 (262)	41 (233)	29 (162)	24 (135)	44, 21
Midwest	68 (264)	74 (286)	34 (133)	56 (217)	39 (150)	24 (94)	21 (83)	43, 19
West	65 (160)	64 (158)	36 (89)	40 (98)	33 (82)	25 (61)	26 (63)	39, 20
P-value	.211	.044	.358	<.001	.066	.02	.672	.016

* PGY-1 $n = 536$; PGY-2 $n = 665$; PGY-3 $n = 562$.
† Community $n = 195$; community based University-affiliated $n = 909$; University $n = 659$.
†† Quartile 1 (range 530-750 people living with HCV per 100,000 population) $n = 615$; quartile 2 (range 800-900 people living with HCV per 100,000 population) $n = 301$; quartile 3 (range 930-1020 people living with HCV per 100,000 population) $n = 434$; quartile 4 (range 1080-2340 people living with HCV per 100,000 population) $n = 413$.
# Northeast $n = 567$, South $n = 562$, Midwest $n = 387$, West $n = 247$.

Table 4
Pre- vs Post-test Performance (%) Stratified by Academic Year.

	PGY-1*			PGY-2			PGY-3		
	Pre	Post	*P*-value	Pre	Post	*P*-value	Pre	Post	*P*-value
Routine evaluation	47	64	<.001	47	66	<.001	53	70	<.001
Treatment initiation	41	73	<.001	40	72	<.001	40	70	<.001
Regimen selection	27	70	<.001	25	71	<.001	27	73	<.001
Drug interactions	23	54	<.001	24	57	<.001	23	54	<.001

* PGY-1 $n = 536$, PGY-2 $n = 665$, PGY-3 $n = 562$.

Overall, respondents answered fewer than half of the pre-test questions correctly (average total score ± standard deviation, 43% ± 19%). They performed relatively better on questions related to HCV natural history (69%) and screening (71%) compared to ones related to HCV management or treatment (23%-49%; Table 2). When residents were stratified by academic year, type of residency program, geographic region, or local HCV prevalence, there remained no statistical difference in overall score (Table 3, $P > .00625$).

There was no difference in performance on specific content areas among PGY-1 through PGY-3 trainees ($P > .05$; Table 3). When baseline HCV knowledge was analyzed by region of the US, there were statistical differences in performance in a few content areas without a clear regional trend. Respondents in the West appeared to perform worse compared to those in the South, Midwest, and Northeast ($P < .001$) regarding routine evaluation and screening ($P = .044$; Table 3). Trainees in the south performed better than those in other regions on regimen selection ($P = .020$). Furthermore, residents in university programs (76%) performed better on HCV screening than those in community (67%) and community-based university-affiliated programs (68%; $P < .01$, Table 3). Lastly, when examining performance in individual content areas while stratifying by state HCV prevalence, participants with the highest local prevalence did not necessarily score the highest even when there was a statistical difference among the quartiles (ie, routine evaluation $P = .019$, regimen selection $P = .008$; Table 3).

Following completion of the online module, performance was reassessed on a post-test. Performance improved across every content area (Table 4; $P < .001$), and this improvement was independent of PGY level (Figure).

Discussion

Our study demonstrates IM residents in the US knew less than half of the HCV knowledge expected by CDC guidelines. This deficit was independent of year of training, geography, type of training program, or local HCV prevalence. The PEAC online module was able to address these knowledge gaps, and respondents had significantly higher scores on post-test assessments.

Baseline performance was relatively higher on questions pertaining to HCV natural history and screening. A survey of HCV knowledge among residents at the Yale Primary Care HCV clinic similarly found higher baseline performance on questions regarding HCV diagnosis compared to HCV treatment although overall knowledge was still low (mean score 58% ± 13%).[15] Perhaps diagnostics are better integrated than HCV intervention topics into introductory medical school and residency didactics. Screening guidelines have evolved but not radically changed

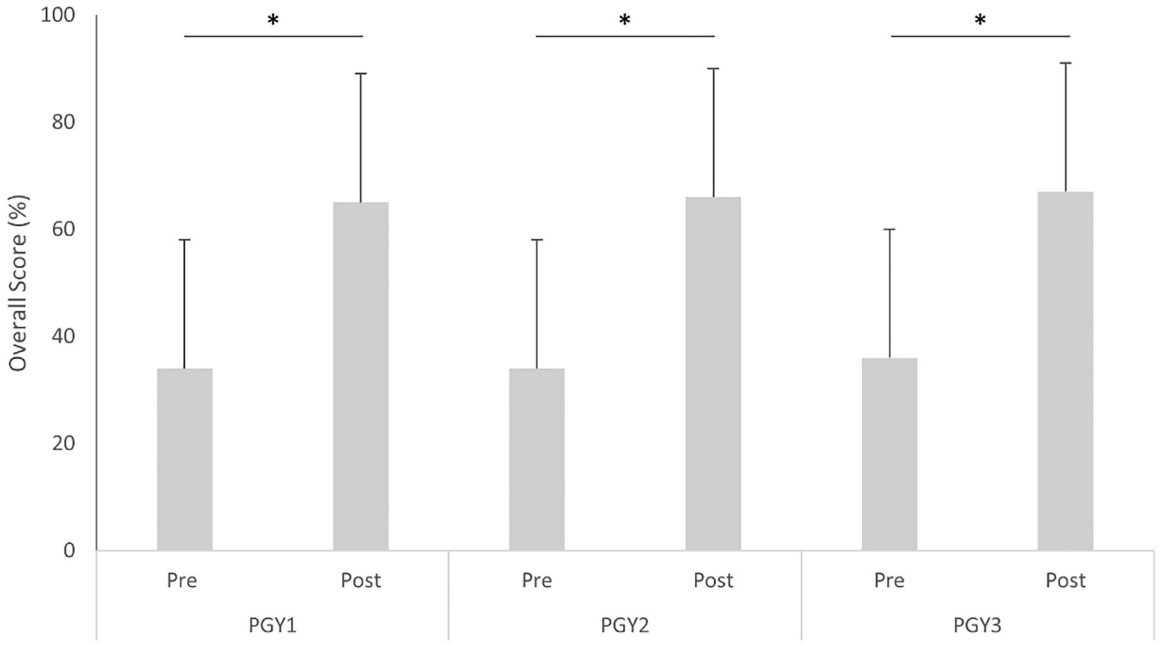

Figure. Overall pre- vs post-test performance stratified by academic year (mean ± standard deviation). *, $P < .001$.

since guidelines were released by the CDC in 1991 whereas there have been many novel advances in the treatment of HCV.

Performance was lower on treatment-related questions, which spanned medication initiation, regimen selection, and side effects/interactions. There seemed to be a uniform lack of familiarity with DAAs among IM residents, and more senior trainees (ie, PGY-3) did not score significantly higher. Over 75% of residents in one study strongly disagreed or disagreed with the statement "I know how to initiate treatment with an appropriate direct-acting antiviral for chronic hepatitis C and how to monitor patients after treatment."[17] This suggests that training programs are not providing sufficient clinical exposure to HCV. This problem is further compounded if clinical preceptors are uncomfortable with managing HCV and therefore referring patients to specialists. Johnson et al showed that only 21% of general practitioners prescribe HCV medications and only 30% had interest in managing HCV.[12] Furthermore, there have been multiple recent advances in the treatment of HCV with the advent of the DAAs in 2011 since many primary care providers last trained.[25] Trainees working with these providers will have lost the opportunity to gain competency.

Additionally, there was regional variation in performance on the core concepts, which might reflect local differences in curricula. The absence of a national supplemental curriculum to cover these concepts means that trainees may have received no training and/or not even had access to institution-specific modules. Clinical exposure is also highly variable between regions of the country based on local prevalence as well as between residents in the same program based on patient encounters. Therefore, development of a national standard in HCV education may ensure consistent and comprehensive education for IM physicians.

Online modules may be one medium by which trainees can improve their knowledge and potentially comfort in managing HCV. The PEAC module was able to increase performance in all tested domains regardless of participant characteristic. However, knowledge gaps remained, with a significant minority of participants still missing questions in all domains, suggesting that the module could be further refined to improve knowledge acquisition. Additionally, such modules may benefit from integration into a curriculum with a practical component to address the most commonly cited barriers to providing HCV care, including lack of training, the perception that HCV therapy should be managed by a specialist, and inadequate time in clinic.[12] Similar educational interventions in continuing medical education can facilitate updates in PCP knowledge and scope of practice.

The study is limited by the retrospective design. The module moreover was developed to improve HCV knowledge but was not designed to be a comprehensive assessment of this topic area, meaning that pre and post-tests only covered 4 of the same domains that could be analyzed. Additionally, while the pre- and post-tests enable assessment of participant conceptual knowledge, we are unable to determine from these data whether this translated into changes in practice as well as comfort and willingness to prescribe HCV treatments. Furthermore, there may be selection bias given that we do not know how specific programs determine what modules residents need to complete and whether this is elective or mandatory. Lastly, since testing is anonymous, it is possible that individual participants may have repeated the module in successive years or the same year. Further investigation is warranted to evaluate participant attitudes and practice patterns. Efforts should also include assessment of feasibility of integrating the online modules within an ambulatory curriculum with a practical component.

HCV knowledge remains limited among IM residents in the US even as treatment options have expanded. Given the role that nonspecialist providers can play in bridging gaps in the care of patients with HCV infection, addressing these gaps during clinical training could substantially increase the availability of these services in the community.

Declaration of competing interest

The author (Dr Megan E. Buresh) is an Editorial Board Member/Editor-in-Chief/Associate Editor/Guest Editor for AJMO and was not involved in the editorial review or the decision to publish this article. The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Johns Hopkins University receives payments from subscriptions to the PEAC curriculum. M.E.B., S.D.S., and D.R. receive annual stipends for maintaining and updating modules. These are managed in accordance with JHU technology licensing and conflict of interest policies. None of the authors have any other conflicts of interest to declare.

CRediT authorship contribution statement

Lucy X. Li: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Jessica S. Lin:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Sean Tackett:** Writing – review & editing, Methodology, Formal analysis. **Amanda Bertram:** Writing – review & editing, Project administration, Data curation. **Stephen D. Sisson:** Writing – review & editing, Resources. **Darius Rastegar:** Writing – review & editing, Resources. **Megan E. Buresh:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajmo.2024.100077.

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