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Comparison of ICD-9 Codes for Depression and Alcohol Misuse to Survey Instruments suggest these Codes should be used with Caution

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Abstract

Background—Research suggests depression and alcohol misuse are highly prevalent among chronic hepatitis C (CHC) patients, which is of clinical concern.

Aims—To compare ICD-9 codes for depression and alcohol misuse to validated survey instruments.

Methods—Among CHC patients, we assessed how well electronic ICD-9 codes for depression and alcohol misuse predicted these disorders using validated instruments.

Results—Of 4,874 patients surveyed, 56% were male and 52% had a history of injection drug use. Based on the PHQ-8, the prevalence of depression was 30% compared to 14% based on

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Ethical considerations: The investigation followed the guidelines of the U.S. Department of Health and Human Services regarding protection of human subjects. The study protocol was approved and renewed annually by each participating institution's institutional review board.

Disclaimer: The findings, opinions, and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the authors' affiliated institutions.

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ICD-9 codes within 12 months of survey, 37% from ICD-9 codes any time before or within 12 months after survey, and 48% from ICD-9 codes any time before or within 24 months after survey. ICD-9 codes predicting PHQ-8 depression had a sensitivity ranging from 59–88% and a specificity ranging from 33–65%. Based on the AUDIT-C, the prevalence of alcohol misuse was 21% compared to 3–23% using ICD-9 codes. The sensitivity of ICD9 codes to predict AUDIT-C score ranged from 9–35% and specificity from 80–98%. Overall 39% of patients reported ever binge drinking; with a sensitivity of ICD-9s to predict binge drinking ranging from 7–33% and a specificity from 84–98%. More than half of patients had either an ICD-9 code for depression, a survey score indicating depression, or both (59%); more than one-third had the same patterns for alcohol misuse (36%).

Conclusions—ICD-9 codes were limited in predicting current depression and alcohol misuse, suggesting that caution should be exercised when using ICD-9 codes to assess depression or alcohol misuse among CHC patient.

Keywords

Hepatitis C; Depression; Alcohol Misuse; PHQ-8; AUDIT-C; ICD-9 Codes

Introduction

Among persons with hepatitis C virus (HCV) infection, depression and alcohol misuse are important risk factors that need to be considered in the care and treatment of patients who are chronically infected with HCV. Misuse of alcohol is of particular concern because it accelerates disease progression (1–3), and HCV-infected patients have been reported to have higher rates of alcohol misuse (4, 5) as well as depression (4). Currently, electronic health record (EHR) data generated in the course of routine healthcare delivery are used extensively for health services and outcomes research, and other areas of applied clinical research (6) including behavioral health studies (7–10). However, the accuracy of these EHR data, especially those based on the use of International Classification Disease (ICD) codes have been reported to be limited (11–16). Typically, studies have reported high specificity but low sensitivity of ICD-based clinical case definitions (15). In the present study, we assessed the specificity and sensitivity of ICD-9 codes to predict current depression and alcohol misuse among a population of well-characterized patients with chronic hepatitis C (CHC) infection in whom these conditions were measured by survey instruments. The purpose of our investigation was to determine whether healthcare providers could rely on ICD codes as valid indicators of either depression or alcohol misuse in the care and treatment of CHC patients.

Methods

The CHeCS study methods have been described in detail previously (17). Briefly, the cohort was created based on EHRs of patients aged 18 years or older who had healthcare services provided between January 1, 2006 and December 31, 2012 at one of four large geographically and demographically diverse health systems representing over 2 million U.S. adults: Geisinger Health System, Danville, PA; Henry Ford Health System, Detroit MI; Kaiser Permanente-Northwest, Portland, OR; and Kaiser Permanente-Hawaii, Honolulu, HI.

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Patients were included in the hepatitis cohort based on fulfillment of a combination of laboratory-based and ICD-9-based criteria described elsewhere, including review by trained medical abstractors (17). The electronic data collected through 2014 included patient demographic information, medical encounter data, laboratory results, diagnosis and procedure data, and liver biopsy results. Electronic data used in this analysis were available retrospectively to January 1997 from the Detroit and Portland sites, to January 1998 from the Hawaii site, and to January 2001 from the Danville site (17). Patients who met laboratory and diagnostic criteria for chronic HCV infection were included in the cohort and were eligible for survey participation, if they were known to be alive at the time of the survey (2010–2012).

The CHeCS survey was designed to collect data on patient demographics, reported hepatitis risk factors, comorbidities, physical and mental functioning, use of alcohol, drug abuse, and chronic hepatitis treatment history (4). As reported previously, of more than 12,000 patients who met the hepatitis C cohort inclusion criteria, almost 8,000 were known to be alive and not institutionalized and sampled to be surveyed by mail and telephone during 2010–2012 (4). Up to 8 attempts were initiated in order to complete an interview with each patient. A small incentive was offered at each site to encourage survey participation. Patients who were found to be deceased, incarcerated, in long-term care institutions, or who had invalid addresses or disconnected telephone numbers were excluded from the denominator. As reported elsewhere, the survey response rate was approximately 60% (4).

For the current study, we included two survey measures as “gold standards” – the PHQ-8 scale (18, 19) and the AUDIT-C scale (20, 21). The PHQ-8 scale assesses current depression and has been clinically validated in population health research (18, 19). A PHQ-8 score of >10 has high sensitivity and specificity for both the presence of major depression and for the presence of any depressive disorders and was used to define current depression in this study (18, 19). The Alcohol Use Disorders Identification Test (AUDIT) is an alcohol screening instrument that was developed to identify problem drinkers in primary care settings (22). The AUDIT instrument includes questions related to alcohol consumption, drinking behavior, and alcohol-related problems and has been found to be a good measure of alcohol misuse/abuse (22, 23). The AUDIT-C is a brief version of the AUDIT and also has been found to be a good measure of alcohol misuse and alcohol abuse (20, 21, 23). In addition, we analyzed responses to a survey question about history of binge drinking, “Was there ever a time in your life when you drank 5 or more drinks of alcohol almost every day?”

For our study, we used a broad range of ICD-9 codes to define depression and alcohol misuse, respectively (Table 2, footnote). For example, for depression we included the ICD-9 codes for bipolar, major depressive disorders, atypical, dysthymic, and postpartum depression as indicative of the presence of depression. Similarly, for alcohol-use disorders, we included the ICD-9 codes not only for dependence and misuse, but also for alcoholic psychosis, delirium tremens, withdrawal, intoxication, amnesia, alcoholic poisoning, and alcoholic liver disease. In addition, to assess whether the timing of the ICD-9 code for each condition had an effect on diagnosis, we established three definitions. First, the patient had to have two or more ICD-9 codes for each condition within 12 months before or after the survey (definition #1). Second, the patient had to have two or more ICD-9 codes any time

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before or within 12 months after the survey date (definition #2). Third, the patient had to have one or more ICD-9 code any time before or within 24 months after the survey date (definition #3). We varied the timeframe for the ICD-9 codes because, as noted, past research suggested these codes were limited in diagnosing mental disorders (11–16), and we wanted to assess if expanding the diagnostic time frame improved these results. In addition, we also restricted the ICD-9 codes for depression and alcohol disorders, respectively, by eliminating less common diagnostic codes, such as those for postpartum depression and acute alcoholic hepatitis to assess how this may have affected our results.

Complete observation time for each patient was determined to be time from first evidence of hepatitis infection in the EHR including retrospective data prior to January 1, 2006, until either the last health system encounter or December 31, 2014. Data for clinical cofactors such as ever receipt of HCV therapy and presence of decompensated liver disease based on ICD-9 codes (24) were collected from the EHR. We calculated the Charlson comorbidity index score from standard diagnosis codes (25) while omitting liver diseases in inpatient, outpatient, and claims data during the year prior to survey; persons with Charlson scores of 2 or greater were considered to have significant comorbidity.

We used statistical software SAS version 9.1 (26) for descriptive statistics and multivariable analyses. Multivariate logistic regression analyses were performed to model the probability of self-reported depression and current problem drinking in the presence of demographic characteristics and clinical indicators. Odds ratios, 95% confidence intervals (CIs), and *P*-values were calculated for each variable. Additionally, specificity, sensitivity, positive predictive value (PPV) and negative predictive value (NPV) of ICD9-codes for depression and alcohol misuse were reported for each case definition.

Results

Table 1 presents a profile of the current study population among 4,874 patients having at least one encounter during the period of interest and also having a completed the PHQ-8 and/or the AUDIT-C survey questions. As shown, 48% of patients were aged 55–64 years, 56% were male, 73% were white, and 55% were privately insured. In terms of health-related behaviors, 32% were current smokers, 49% had been treated previously for hepatitis C, and over half (52%) reported a history of injection drug abuse.

Table 2 shows the prevalence of depression and alcohol misuse as measured by ICD-9 code (across the three definitions) compared with the prevalence of each condition as measured by the PHQ-8 and AUDIT-C survey scores. Based on the PHQ-8, the prevalence of depression was 30% compared with 14% as indicated by two or more depression-related ICD-9 codes within 12 months of survey (definition 1), 37% from two or more ICD-9 codes any time before or within 12 months after survey (definition 2), and 48% from one or more ICD-9 code any time before or within 24 months after survey (definition 3) (Table 2). More than half of patients (59%) had either an ICD9 code for depression, a self-report survey score indicating the disorder, or both. Among the 699 patients with two or more ICD-9 codes for depression within 12 months of survey, about half (n=367) had a survey score indicative of depression. Similarly, among 1,466 patients with a survey score indicating

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current depression, only about 25% had two or more ICD-9 codes for depression within a year before or after survey; as the time period expanded, this percentage increased to 65% with one or more ICD-9 code any time before or within 24 months after survey.

Based on the AUDIT-C, the prevalence of current alcohol misuse was 21% compared to 3% prevalence for having ICD-9 codes for alcohol-related disorders during the time period for definition 1, 15% for definition 2, and 23% for definition 3. A total of 1,998 (41%) patients reported ever binge drinking. More than one-third of patients (36%) had either an ICD-9 code for an alcohol-related disorder, a survey AUDIT-C score indicating current problem drinking, or both. Among 144 patients with two or more alcohol-related ICD-9 codes within 12 months of survey, just less than half (n=68) had a score indicative of problem drinking on the survey. Among 1,000 patients with a survey score indicating current problem drinking, only 7% had two or more alcohol-related ICD-9 codes within a year before or after survey; this increased to 35% as the time period expanded to any time before or within 24 months after the survey among patients with one or more ICD-9 code.

Table 3 shows multivariable results for demographic and clinical predictors of current depression as measured by the PHQ8 and alcohol misuse as measured by the AUDIT-C. Study site, age <65 years, female gender, and having decompensated liver disease were significant predictors of depression, as was having an ICD-9 depression code in the EHR (OR=3.15, $p < 0.0001$ using definition 1). For alcohol misuse, study site, younger age, and male gender were significant predictors, in addition to having an ICD-9 alcohol-related disorder code in the EHR (OR=5.81, $p < 0.0001$ using definition 1). A diagnosis of decompensated liver disease and a Charlson comorbidity score >2 were significantly associated with a lower likelihood of alcohol misuse. Separate models using ICD-9 based definitions 2 and 3 for both depression and alcohol misuse yielded the same results as those for definition 1 (data not shown).

The sensitivity, specificity, and positive and negative predictive values for using ICD-9 codes to define current depression and alcohol misuse compared with the “gold standard” of these conditions as measured by survey are shown in Table 4. Separate analyses were conducted for each of the three ICD-9-based case definitions; shifting denominators for each analysis included only those patients who answered survey questions of interest and had at least one visit to the health system during the varying time periods for ICD-9 ascertainment for each case definition. The ability of depression-related ICD-9 codes to predict report of current depression based on PHQ-8 scores at the time of survey revealed a sensitivity of 33%, a specificity of 88%, a PPV of 53%, and a NPV of 76% for definition 1. This pattern was similar for definitions 2 and 3, although sensitivity was slightly higher when the time frame increased. The ability of alcohol-related disorder ICD-9 codes to predict report (AUDIT-C) of current alcohol misuse at the time of survey showed a sensitivity of 9%, a specificity of 98%, a PPV of 47%, and a NPV of 82% for definition 1. Like depression, the pattern for alcohol misuse was similar for definitions 2 and 3, although again sensitively was higher when the time frame increased. The presence of ICD-9 codes for alcohol-related disorders predicted reported binge drinking with 7% sensitivity, 98% specificity, 75% PPV, and 61% NPV for definition 1 with similar patterns for definitions 2 and 3. As noted, we also restricted the ICD-9 codes for depression and alcohol misuse, respectively, by eliminating

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less common diagnostic codes in our analysis, such as those for postpartum depression and acute alcoholic hepatitis to assess how this may have affected our results. This diagnostic restriction had very little impact on the results.

Discussion

The high prevalence of reported depression (30%) and of excessive current drinking (21%) that we report here has been described previously among the CHeCS cohort (4). In the current analysis, we found that for depression, more than half of patients had an ICD-9 code for the disorder, a survey score indicating the disorder, or both; for alcohol misuse, the same pattern was observed for about one-third of patients. A recent report that examined data from the National Health and Nutrition Examination Survey (5) found that HCV-infected adults were estimated to ever drink five or more drinks/day almost every day at some time during their lifetime about 3.3 times more often (43.8% vs. 13.7%, $p<0.001$) than those who were never infected with HCV; a similar percentage (41%) of surveyed CHeCS patients responded affirmatively to the same question. Depression was a frequent complication of earlier interferon-based therapies, affecting as many as a quarter of patients (27), with duration of treatment lasting up to 52 weeks. As 49% of surveyed CHeCS HCV cohort patients were previously treated for HCV it is possible that among these patients past depression diagnoses may have been linked to treatment.

Our primary objective was to determine how well estimates of current depression and alcohol misuse as obtained from validated survey instruments, correlate with ICD-9 diagnosis codes in the EHR for depression and alcohol-related disorders among a cohort of patients with CHC. If good agreement was demonstrated, it would be possible to conduct depression/alcohol-related research without the additional burden of survey administration. However, overall correlation between ICD-9 codes and positive survey results for the conditions was modest. The positive predictive value of ICD-9 based case definitions for self-reported depression ranged only from 41–53% and the negative predictive value ranged from 76–80%. Similarly, the positive predictive value for ICD-9 codes to predict self-reported current problem drinking ranged from 31–47% and the negative predictive value ranged from 82–83%. However, results from our multivariable analysis revealed that patients with recent ICD-9 codes for depression were three times more likely and those with recent ICD-9 codes for alcohol-related disorders were almost six times more likely than other patients to have these conditions using validated screen instruments.

Because alcohol misuse adversely impacts disease progression among HCV-infected persons, clinician awareness of this condition is vital in the care, treatment, and follow-up of CHC patients. A recent review by Punzalan and colleagues examined the prevalence and clinical course of HCV infection and alcohol abuse, and the mechanisms for how these conditions individually and together affect the development and progression of liver disease (28). Their review showed a high prevalence of both conditions among study populations, which together speed up the progression of liver disease (from fibrosis to cirrhosis to hepatocellular carcinoma). Another recent paper by Innes et al. examined several outcome events, including alcohol intoxication, among a group of HCV-infected patients who had achieved a sustained viral response (SVR) (29). They found that SVR was associated with a

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reduced risk of alcohol intoxication. Thus, it might be important not only for the clinician to know whether the patient has a problem with alcohol which can guide them in terms of the overall care and treatment they provide, but this finding also suggests an added benefit for patients who achieve SVR.

Analyses of the survey and EHR data from CHeCS have some unavoidable limitations. Patients at the four large study sites might not be representative of all U.S. patients. As shown in Table 3, there were significant differences between study sites, likely due to demographic differences between the sites (30). The survey was conducted in English only which may have excluded some patients. Further, although the response rate was only about 60%, after exclusion of unavailable patients, demographic characteristics between respondents and non-respondents did not differ significantly. Self-reported survey data are subject to response biases, although patients may be more likely to respond to sensitive questions in an anonymous survey rather than face-to-face. While the ICD-9 data are longitudinal, the survey questions measured current depression and current alcohol misuse at one point in time, which may miss changes in behavior over time. Even when the ascertainment of codes was restricted to the year before or after survey, predictive value of the code-based case definitions for these current measures was relatively poor. Many patients with ICD-9 codes for the conditions did not report them on the survey; the reverse was also evident. It is difficult to ascertain the extent to which this disparity may be due to erroneous (false-positive) ICD-9 codes, changes in behavior over time, and/or patients' reluctance or failure to respond accurately to survey questions. To assess this, we also looked for mental health treatment visits among patients using CPT-4 codes and discovered that less than 9.8% had these visits in the year before or after the survey. In any case, given the chronic nature of these mental health disorders (31), it is unlikely that one or two treatment interventions had a measurable impact on these associations.

Regardless of method of ascertainment, the prevalence of depression and alcohol misuse was substantial among CHC patients by most measures. Prevalence of the conditions by depression and alcohol-related ICD-9 codes varied substantially by changing the time period of ascertainment and number of codes required during that time period (from 14–48% for depression and from 3–23% for alcohol-related disorders) and some patients even with recent ICD-9 codes did not report the conditions at the time of survey. Most patients who reported current depression and problem drinking did not have an ICD-9 code for these disorders. The ICD-9 codes had limited ability to predict current depression and alcohol misuse, with slightly higher sensitivity but lower specificity for predicting report of ever binge drinking than current problem drinking. The somewhat higher positive predictive value for binge drinking was to some extent a surprise, but not unexpected, given past research (32). Among patients with CHC, our findings suggest that researchers should be cautious in using ICD-9 codes to define the presence of current depression and alcohol misuse. The latter should be taken seriously, since CHC patients are known to have a high prevalence of both depression and alcohol use disorders and reliance on ICD-9 codes alone for surveillance could put these patient at even greater risk.

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References

1. Innes HA, Hutchinson SJ, Barclay S, Cadzow E, Dillon JF, Fraser A, Goldberg DJ, Mills PR, McDonald SA, Morris J, Stanley A, Hayes P. Hepatitis C Clinical Database Monitoring Committee. Quantifying the fraction of cirrhosis attributable to alcohol among chronic hepatitis C virus patients: implications for treatment cost-effectiveness. Hepatology. 2013; 57:451–460. [PubMed: 22961861]
2. Khan KN, Yatsuhashi H. Effect of alcohol consumption on the progression of hepatitis C virus infection and risk of hepatocellular carcinoma in Japanese patients. Alcohol Alcohol. 2000; 35:286–295. [PubMed: 10869250]
3. Vandenbulcke H, Moreno C, Colle I, Knebel JF, Francque S, Serste T, George C, de Galocsy C, Laleman W, Delwaide J, Orlent H, Lasser L, Trepo E, Van Vlierberghe H, Michielsen P, van Gossum M, de Vos M, Marot A, Doerig C, Henrion J, Deltenre P. Alcohol intake increases the risk of HCC in hepatitis C virus-related compensated cirrhosis: A prospective study. J Hepatol. 2016; 65:543–551. [PubMed: 27180899]
4. Boscarino JA, Lu M, Moorman AC, Gordon SC, Rupp LB, Spradling PR, Teshale EH, Schmidt MA, Vijayadeva V, Holmberg SD. Chronic Hepatitis Cohort Study (CHeCS) Investigators. Predictors of poor mental and physical health status among patients with chronic hepatitis C infection: the Chronic Hepatitis Cohort Study (CHeCS). Hepatology. 2015; 61:802–811. [PubMed: 25203533]
5. Taylor AL, Denniston MM, Klevens RM, McKnight-Eily LR, Jiles RB. Association of Hepatitis C Virus With Alcohol Use Among U.S. Adults: NHANES 2003–2010. Am J Prev Med. 2016; 51:206–215. [PubMed: 27178884]
6. Strom, BL., Kimmel, SE., Hennessy, S. Pharmacoepidemology. 5. John Wiley & Sons; Hoboken, NJ: 2012.
7. Casey JA, Schwartz BS, Stewart WF, Adler NE. Using Electronic Health Records for Population Health Research: A Review of Methods and Applications. Annu Rev Public Health. 2016; 37:61–81. [PubMed: 26667605]
8. Carey DJ, Fetterolf SN, Davis FD, Faucett WA, Kirchner HL, Mirshahi U, Murray MF, Smelser DT, Gerhard GS, Ledbetter DH. The Geisinger MyCode community health initiative: an electronic health record-linked biobank for precision medicine research. Genet Med. 2016; 18(9):906–913. [PubMed: 26866580]
9. Cifuentes M, Davis M, Fernald D, Gunn R, Dickinson P, Cohen DJ. Electronic Health Record Challenges, Workarounds, and Solutions Observed in Practices Integrating Behavioral Health and Primary Care. J Am Board Fam Med. 2015; 28(Suppl 1):S63–72. [PubMed: 26359473]
10. Stewart WF, Yan X, Boscarino JA, Maeng DD, Mardekian J, Sanchez RJ, Von Korff MR. Patterns of health care utilization for low back pain. J Pain Res. 2015; 8:523–535. [PubMed: 26316803]
11. Frayne SM, Miller DR, Sharkansky EJ, Jackson VW, Wang F, Halanych JH, Berlowitz DR, Kader B, Rosen CS, Keane TM. Using administrative data to identify mental illness: what approach is best? Am J Med Qual. 2010; 25:42–50. [PubMed: 19855046]

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12. Fiest KM, Jette N, Quan H, St Germaine-Smith C, Metcalfe A, Patten SB, Beck CA. Systematic review and assessment of validated case definitions for depression in administrative data. BMC Psychiatry. 2014; 14 289-014-0289-5.
13. Al Kazzi ES, Lau B, Li T, Schneider EB, Makary MA, Hutfless S. Differences in the Prevalence of Obesity, Smoking and Alcohol in the United States Nationwide Inpatient Sample and the Behavioral Risk Factor Surveillance System. PLoS One. 2015; 10:e0140165. [PubMed: 26536469]
14. Samuel AM, Lukasiewicz AM, Webb ML, Bohl DD, Basques BA, Davis KA, Grauer JN. ICD-9 diagnosis codes have poor sensitivity for identification of preexisting comorbidities in traumatic fracture patients: A study of the National Trauma Data Bank. J Trauma Acute Care Surg. 2015; 79:622–630. [PubMed: 26402537]
15. Kim HM, Smith EG, Stano CM, Ganoczy D, Zivin K, Walters H, Valenstein M. Validation of key behaviourally based mental health diagnoses in administrative data: suicide attempt, alcohol abuse, illicit drug abuse and tobacco use. BMC Health Serv Res. 2012; 12 18-6963-12-18.
16. Noyes K, Liu H, Lyness JM, Friedman B. Medicare beneficiaries with depression: comparing diagnoses in claims data with the results of screening. Psychiatr Serv. 2011; 62:1159–1166. [PubMed: 21969642]
17. Moorman AC, Gordon SC, Rupp LB, Spradling PR, Teshale EH, Lu M, Nerenz DR, Nakasato CC, Boscarino JA, Henkle EM, Oja-Tebbe NJ, Xing J, Ward JW, Holmberg SD. for the Chronic Hepatitis Cohort Study Investigators. Baseline Characteristics and Mortality Among People in Care for Chronic Viral Hepatitis: The Chronic Hepatitis Cohort Study. Clin Infect Dis. 2013; 56:40–50. [PubMed: 22990852]
18. Kroenke K, Strine TW, Spitzer RL, Williams JB, Berry JT, Mokdad AH. The PHQ-8 as a measure of current depression in the general population. J Affect Disord. 2009; 114:163–173. [PubMed: 18752852]
19. Strine TW, Mokdad AH, Balluz LS, Gonzalez O, Crider R, Berry JT, Kroenke K. Depression and anxiety in the United States: findings from the 2006 Behavioral Risk Factor Surveillance System. Psychiatr Serv. 2008; 59:1383–1390. [PubMed: 19033164]
20. Bush K, Kivlahan DR, McDonell MB, Fihn SD, Bradley KA. The AUDIT alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. Ambulatory Care Quality Improvement Project (ACQUIP). Alcohol Use Disorders Identification Test. Arch Intern Med. 1998; 158:1789–1795. [PubMed: 9738608]
21. Dawson DA, Grant BF, Stinson FS, Zhou Y. Effectiveness of the derived Alcohol Use Disorders Identification Test (AUDIT-C) in screening for alcohol use disorders and risk drinking in the US general population. Alcohol Clin Exp Res. 2005; 29:844–854. [PubMed: 15897730]
22. Saunders JB, Aasland OG, Babor TF, de la Fuente JR, Grant M. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption--II. Addiction. 1993; 88:791–804. [PubMed: 8329970]
23. Bradley KA, Bush KR, McDonell MB, Malone T, Fihn SD. Screening for problem drinking: comparison of CAGE and AUDIT. Ambulatory Care Quality Improvement Project (ACQUIP). Alcohol Use Disorders Identification Test. J Gen Intern Med. 1998; 13:379–388.
24. Xu F, Moorman AC, Tong X, Gordon SC, Rupp LB, Lu M, Teshale EH, Spradling PR, Boscarino JA, Trinacty CM, Schmidt MA, Holmberg SD, Holmberg SD, Teshale EH, Spradling PR, Moorman AC, Xing J, Tong X, Xu F, Gordon SC, Nerenz DR, Lu M, Lamerato L, Wang Y, Rupp LB, Akkerman N, Oja-Tebbe N, Zhang T, Li J, Sitarik A, Larkin D, Boscarino JA, Daar ZS, Curry PJ, Smith RE, Vijayadeva V, Parker JV, Schmidt MA, Donald JL, Keast EM. Chronic Hepatitis Cohort Study (CHeCS) Investigators. All-Cause Mortality and Progression Risks to Hepatic Decompensation and Hepatocellular Carcinoma in Patients Infected With Hepatitis C Virus. Clin Infect Dis. 2016; 62:289–297. [PubMed: 26417034]
25. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE, Ghali WA. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care. 2005; 43:1130–1139. [PubMed: 16224307]
26. SAS Institute Inc. SAS version 9.2. Cary, NC: SAS Institute Inc; 2010.
27. Udina M, Castellvi P, Moreno-Espana J, Navines R, Valdes M, Forns X, Langohr K, Sola R, Vieta E, Martin-Santos R. Interferon-induced depression in chronic hepatitis C: a systematic review and meta-analysis. J Clin Psychiatry. 2012; 73:1128–1138. [PubMed: 22967776]

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28. Punzalan CS, Bukong TN, Szabo G. Alcoholic hepatitis and HCV interactions in the modulation of liver disease. J Viral Hepat. 2015; 22:769–776. [PubMed: 25754333]

29. Innes HA, McDonald SA, Dillon JF, Allen S, Hayes PC, Goldberg D, Mills PR, Barclay ST, Wilks D, Valerio H, Fox R, Bhattacharyya D, Kennedy N, Morris J, Fraser A, Stanley AJ, Bramley P, Hutchinson SJ. Toward a more complete understanding of the association between a hepatitis C sustained viral response and cause-specific outcomes. Hepatology. 2015; 62:355–364. [PubMed: 25716707]

30. Boscarino JA, Sitarik A, Gordon SC, Rupp LB, Nerenz DR, Vijayadeva V, Schmidt MA, Henkle E, Lu M. Risk Factors for Hepatitis C Infection Among Vietnam Era Veterans Versus Nonveterans: Results from the Chronic Hepatitis Cohort Study (CHeCS). J Community Health. 2014; 39:914–921. [PubMed: 24682941]

31. Sadock, BJ., Sadock, VA., Ruiz, P. Kaplan & Sadock's Comprehensive Textbook of Psychiatry. 10. Vol. 1 & 2. New York, NY: Wolters Kluwer; 2017.

32. Adams RE, Boscarino JA, Galea S. Alcohol use, mental health status and psychological well-being 2 years after the World Trade Center attacks in New York City. Am J Drug Alcohol Abuse. 2006; 32(2):203–224. [PubMed: 16595324]

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Table 1

Demographic and clinical factors among 4,874 HCV-infected patients with survey data

Characteristic	n (%)
Study site	
Portland, OR	1665 (34)
Honolulu, HI	366 (8)
Detroit, MI	1710 (35)
Danville, PA	1133 (23)
Age group	
18–34 years	221 (5)
35–54 years	904 (19)
55–64 years	2332 (48)
≥65 years	1417 (29)
Male	2734 (56)
Race/ethnicity	
Black	929 (19)
White	3540 (73)
Asian/Other	405 (8)
Hispanic	225 (4.6)
Privately insured	2677 (55)
Married	2430 (50)
Currently employed	2255 (46)
Current smoker	1689 (35)
Reported history of injection drug use from survey	2456 (52)
Ever received HCV treatment	2404 (49)
Presence of decompensated liver disease[22]	1169 (24)

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Characteristic	n (%)
Charleson comorbidity score[23] ≥ 2 (omitting liver disease)	743 (15)

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Table 2

Prevalence of self-reported depression and alcohol misuse compared with ICD9 codes for the conditions among 4,874 HCV-infected patients with survey data

Depression			
	N=4,874	**Survey PHQ8 score >10 (indicates depression)[18,19] n=1466 (30%)**	**Survey PHQ8 score 10 (does not indicate depression)[18,19] n=3408 (70%)**
	n (%)	**n (%)**	**n (%)**
Prevalence of ICD-9 codes indicating depression *			
Case definition 1	699 (14)	367 (25)	332 (10)
≥2 codes within 12 months before or after the survey			
Case definition 2	1821 (37)	794 (54)	1027 (30)
≥2 codes any time before or within 12 months after the survey			
Case definition 3	2333 (48)	946 (65)	1387 (41)
≥1 code any time before or within 24 months after the survey			
Ever had depression by either ICD-9 code (case definition 3) or survey PHQ8 score, or both	2853 (59)		
Alcohol misuse			
		Survey AUDIT-C score indicates current problem drinking‡[20–23] n=1000 (21%)	Survey AUDIT-C score does not indicate current problem drinking‡[20–23] n=3874 (79%)
	n (%)	n (%)	n (%)
Prevalence of ICD-9 codes indicating alcohol abuse or alcohol-related liver disease †			
Case definition 1	144 (3)	68 (7)	76 (2)
Case definition 2	707 (15)	240 (24)	467 (12)
Case definition 3	1106 (23)	346 (35)	760 (20)
Answered yes to the survey question on binge drinking	1998 (41)	513 (51)	1485 (38)
Ever problem drinking by either ICD-9 code (case definition 3) or survey AUDIT-C score, or both	1760 (36)		

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Depression			
	N=4,874	**Survey PHQ8 score >10 (indicates depression)[18,19] n=1466 (30%)**	**Survey PHQ8 score 10 (does not indicate depression)[18,19] n=3408 (70%)**
	n (%)	**n (%)**	**n (%)**
		Answered yes to the survey question on binge drinking: *"Was there ever a time in my life when I drank 5 or more drinks almost every day?"* n= 1998 (41%)	Answered no to the survey question on binge drinking n= 2876 (59%)
	n (%)	n (%)	n (%)
Prevalence of ICD-9 codes indicating alcohol abuse or alcohol-related liver disease[†]			
Case definition 1	144 (3)	108 (5)	36 (1.25)
Case definition 2	707 (14.5)	456 (23)	251 (8.7)
Case definition 3	1106 (22.7)	651(33)	455 (15.8)
Ever alcohol misuse by either ICD-9 or survey (i.e. had an AUDIT-C score indicating current problem drinking, and/or reported history of binge drinking, and/or met Case definition 3)	2453 (50.3)		

[*] Analysis among n= 4874 patients who answered the depression questions on the survey and with at least one health care encounter during the 12 months prior to or after the survey were included in this analysis. ICD-9-codes used to define depression included: major depressive disorder single (296.2, 296.20–296.25) or recurrent episode (296.3, 296.30–296.35); depression not otherwise specified (311); bipolar I disorder- single (296.0, 296.00–296.05) or recurrent episode (296.1, 296.10–296.15), or most recent episode manic (296.4, 296.40–296.45) or depressed (296.5, 296.51–296.55) or mixed (296.6, 296.60–296.65) or unspecified (296.7); other and unspecified bipolar disorders (296.8, 296.80–296.82, 296.89); other and unspecified episodic mood disorder (296.9, 296.90, 296.99); dysthymic disorder (300.4); adjustment reaction with depressive symptoms (309.0, 309.1); adjustment disorder with mixed anxiety and depressed mood (309.28); postpartum depression or other mental disorders complicating the puerperium (648.4, 648.44); and suicidal ideation V62.84.

[†] Analysis among n= 4,841 patients who answered the survey questions on alcohol use and with at least one health care encounter during the 12 months prior to or after the survey were included in this analysis. ICD-9-codes used to define alcohol abuse included: delirium tremens 291.0, alcoholic amnestic syndrome 291.1, alcoholic dementia 291.2, alcoholic hallucinosis 291.3, pathologic alcohol intoxication 291.4, alcoholic jealousy 291.5, alcoholic psychosis 291.8 or alcohol withdrawal 291.81, alcohol induced sleep disorder 291.82, other alcohol psychosis 291.89, alcoholic psychosis not otherwise specified 291.9, alcohol intoxication- unspecified 303.00, alcohol intoxication-continued 303.01, alcohol intoxication-episodic 303.02, alcohol dependence unspecified 303.90, alcohol dependence continued 303.91, alcohol dependence- episodic 303.92, alcohol abuse- unspecified 305.00, alcohol abuse-continuous 305.01, alcohol abuse-episodic 305.02. We also included codes for the following alcohol-related liver disease diagnoses: alcoholic fatty liver 571.0, acute alcoholic hepatitis 571.1, alcoholic cirrhosis of liver 571.2, alcoholic liver damage unspecified 571.3, alcoholic affected fetus 760.71, toxic effect of alcohol 980.0.

[‡] AUDIT-C score ≥3 for women or ≥4 for men indicates problem drinking.

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Table 3

Multivariable logistic regression models predicting self-reported depression and current problem drinking

Depression (PHQ-8)[18,19]			
Variable	**Levels**	**OR (95% CI)**	**p-value**
Site	Danville vs. Detroit	1.68 (1.38,2.04)	<0.0001
	Hawaii vs. Detroit	0.77 (0.57,1.04)	
	Portland vs. Detroit	0.83 (0.69,0.99)	
Age	18–34 vs. 65+	1.36 (0.96,1.93)	<0.0001
	35–54 vs. 65+	1.8 (1.47,2.21)	
	55–64 vs. 65+	1.39 (1.18,1.63)	
Gender	Male vs. Female	0.83 (0.72,0.94)	0.0047
Race	Asian/Other vs. White	0.98 (0.76,1.27)	0.9676
	Black vs. White	0.98 (0.81,1.19)	
Decompensated liver disease[24]	Yes vs. No	1.27 (1.08,1.5)	0.0034
Charlson comorbidity score [25] ≥2	Yes vs. No	1.1 (0.91,1.33)	0.3061
ICD-9 codes for depression *	Yes vs. No	3.15 (2.65,3.75)	<0.0001
Current problem drinking (AUDIT-C)[20–23]			
Variable	Levels	OR (95% CI)	p-value
Site	Danville vs. Detroit	1.3 (1.04,1.63)	0.0425
	Hawaii vs. Detroit	1.46 (1.07,1.98)	
	Portland vs. Detroit	1.22 (1,1.49)	
Age	18–34 vs. 65+	2.27 (1.59,3.25)	<0.0001
	35–54 vs. 65+	1.54 (1.23,1.93)	
	55–64 vs. 65+	1.25 (1.04,1.5)	
Gender	Male vs. Female	1.17 (1.01,1.36)	0.0399
Race	Asian/Other vs. White	1.03 (0.78,1.35)	0.6974
	Black vs. White	0.91 (0.72,1.15)	
Decompensated liver disease[24]	Yes vs. No	0.6 (0.49,0.73)	<0.0001
Charlson comorbidity score[25] ≥2	Yes vs. No	0.7 (0.55,0.89)	0.0035
ICD-9 codes for alcohol misuse *	Yes vs. No	5.81 (3.97,8.52)	<0.0001

* Based on Case definition 1, ≥2 ICD-9 codes within 12 months before or after survey. See Table 1 footnotes for ICD-9 codes.

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Table 4

Sensitivity and specificity of ICD-9 codes* for depression and alcohol misuse to predict self-report of depression (PHQ-8),[15–16] current problem drinking (AUDIT-C),[18–21] and ever daily binge drinking.

	Specificity (%)	Sensitivity (%)	Positive predictive value (%)	Negative predictive value (%)
Depression (PHQ-8)				
Case definition 1	87.9	32.9	52.5	76.3
Case definition 2	69.9	54.2	43.6	78.0
Case definition 3	59.3	64.5	40.5	79.5
Alcohol misuse				
Current problem drinking (AUDIT-C)				
Case definition 1	97.5	9.2	47.2	81.8
Case definition 2	87.8	24.0	33.9	81.6
Case definition 3	80.2	34.6	31.3	82.5
Ever daily binge drinking				
Case definition 1	98.4	7.1	75.0	61.4
Case definition 2	91.2	22.8	64.5	62.7
Case definition 3	84.0	32.6	58.9	63.9

*See Table 1 footnotes for ICD-9 codes.