

Chronic Liver Disease Mortality in the United States, 1990–1998

Sirenda Vong^{1,2} and Beth P. Bell¹

In 1998, chronic liver disease (CLD) was the tenth leading cause of death in the U.S. Alcohol and hepatitis C are thought to be important etiologies. However, traditional methods for calculating CLD mortality rates from death certificates may underestimate hepatitis C-related CLD mortality. We studied patterns of CLD deaths reported from 1990 through 1998, using an expanded definition that included death certificates where CLD, viral hepatitis, or CLD-related sequelae were reported as the underlying cause. We calculated overall age-specific and age-adjusted mortality rates, and according to demographic characteristics and recorded causes, and evaluated trends using linear regression modeling. CLD mortality declined 5% overall from 1990 through 1994 (12.1 to 11.6/100,000; $P = 0.002$), but remained unchanged from 1995 through 1998 ($P = 0.366$). Decreases were similar for all causes except hepatitis C, for which rates increased 220% from 1993 to 1998 (0.57 to 1.67/100,000). Rates declined in all racial-ethnic groups except American Indians and Alaska Natives (AI/AN), among whom rates were unchanged. Of 30,933 CLD deaths in 1998, 39% were coded as alcohol related, 15% as hepatitis C, 4% as hepatitis B, and 44% had no recorded cause. Age-adjusted rates were higher among males (47.6/100,000) than females (32.2/100,000) and among Hispanics (19.1/100,000) compared with non-Hispanics (10.8/100,000). Rates among AI/AN (28.7/100,000) were more than twice those of African Americans and whites (12.9/100,000 and 11.5/100,000, respectively). In conclusion, 1998 CLD deaths and the proportion attributable to viral hepatitis increased by 23% and 19%, respectively, compared with traditional methods. Mortality declines of the early 1990s were not sustained after 1994. Large disparities in CLD mortality remain, particularly among American Indians and Alaska Natives. (HEPATOLOGY 2004;39:476–483.)

In 1998, chronic liver disease (CLD) was classified as the tenth most frequent cause of death in the United States according to the national vital statistics report.¹ Excessive alcohol intake and viral hepatitis infections are thought to be two important causes. However, the contribution of viral hepatitis infections to CLD-related mortality has been difficult to determine.

Traditional methods used to calculate CLD mortality using death certificate data may result in underestimation of the proportion of CLD mortality attributable to viral hepatitis. These analyses use a single group of International Classification of Disease (ICD) codes to define deaths from CLD, which does not include one for viral hepatitis.^{1,2} Thus, deaths coded as resulting from viral hepatitis are not counted as CLD related. Further, causes of CLD-related deaths, when defined using traditional methods, can be designated essentially only as alcohol related or not.

Previous estimates of viral hepatitis-related CLD mortality have relied on extrapolation of data from morbidity studies. Population-based studies of patients diagnosed with chronic liver disease have found hepatitis C virus (HCV) infection, either alone or in combination with excessive alcohol consumption, to be the most frequently identified cause (40%–60%), and hepatitis B virus (HBV) infection to be related to a relatively small proportion of cases (<15%).^{3,4} However, extrapolation from morbidity studies may result in inaccurate estimates of deaths if the

Abbreviations: CLD, chronic liver disease; AI/AN, American Indians/Alaska Natives; ICD, International Classification of Diseases; HCV, hepatitis C virus; HBV, hepatitis B virus; A/PI, Asians or Pacific Islanders; UVH, unspecified viral hepatitis; PBC, primary biliary cirrhosis; NCHS, National Center for Health Statistics; HCC, hepatocellular carcinoma; CDC, Centers for Disease Control and Prevention.

From the ¹Division of Viral Hepatitis, National Center for Infectious Diseases, and ²Epidemic Intelligence Service, Epidemiology Program Office, Centers for Disease Control and Prevention, Atlanta, GA.

Received June 18, 2003; accepted November 12, 2003.

Reprint requests to: Sirenda Vong, M.D., M.Sc., Mailstop G-37, Division of Viral Hepatitis, Centers for Disease Control and Prevention, 1600 Clifton Road, NE, Atlanta, GA 30333. E-mail: svong@cdc.gov; fax: 404-371-5221.

Copyright © 2004 by the American Association for the Study of Liver Diseases. Published online in Wiley InterScience (www.interscience.wiley.com).

DOI 10.1002/hep.20049

contribution of these infections to mortality differed from that to morbidity.⁵

We report the results of an analysis death certificate data that makes use of all the information available on death certificates to identify deaths attributable to CLD of any cause. We describe rates and trends in CLD mortality in the United States from 1990 through 1998, according to recorded causes using this less restrictive definition of CLD.

Materials and Methods

Deaths occurring from 1990 through 1998 were analyzed using the Multiple-Cause Mortality Files, compiled annually from death certificates by the National Center for Health Statistics.⁶ Multiple-Cause Mortality Files include demographic and location of death information on each decedent, ICD Ninth Revision (ICD-9) codes for the underlying cause of death, and a list of up to 20 conditions contributing to the death listed on the death certificate. We used the record axis format, which applies an algorithm to what the physician enters on the death certificate, to determine the underlying cause of death, conditions contributing to death, and relative importance of these conditions.^{7,8} This format applies standard criteria to define the underlying cause of death and to improve the internal consistency of each certificate.

We defined CLD as chronic liver disease and cirrhosis (ICD-9 codes 571.0–571.9), all viral hepatitis except hepatitis A (ICD-9 codes 070.2–070.9, representing hepatitis B, hepatitis C, and unspecified viral hepatitis infections), and selected sequelae of chronic liver disease (ICD-9 codes 572.2–572.4, corresponding to hepatic coma, portal hypertension, and hepatorenal syndrome). We selected all records on which any of these CLD-defining conditions were recorded in the underlying cause of death field. We then looked for a potential cause of CLD in the underlying or contributing cause of death fields and categorized CLD cases into the following six etiologic disease groups: alcohol related, HCV related, HBV related, primary biliary cirrhosis related, unspecified viral hepatitis related, and no cause.

We calculated age-specific mortality rates by grouping age into 0 to 4 years of age and 10-year categories from 5 to 14 years of age to >85 years of age. We calculated age-adjusted annual mortality rates per 100,000 persons using direct standardization with the 2000 census population.⁹ We used the following racial and ethnic groups as provided in the mortality data: whites, African Americans, Asians or Pacific Islanders (A/PI), American Indians or Alaska Natives (AI/AN), Hispanics, and non-Hispanics. We also examined the geographic distribution of

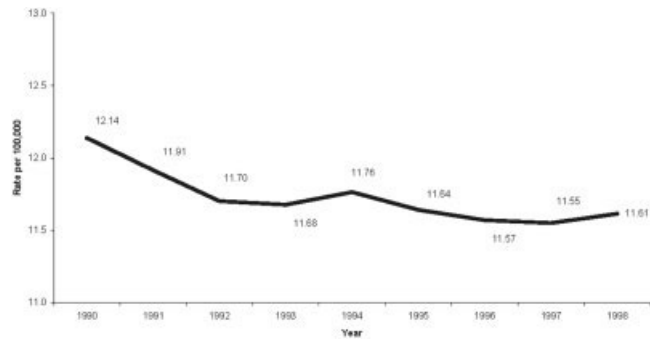


Fig. 1. Age-adjusted death rates of chronic liver disease by year in the United States, 1990 through 1998.

CLD by state. Population estimates for noncensus years were obtained from the U.S. Census Bureau.

Within each group, a linear model was fit to the annual age-adjusted mortality rates to assess the significance of the change in rates over time. The percentage change in rates was estimated using the linear model by dividing the estimated 9-year rate change by the estimated 1990 rate. Because effective testing to diagnose HCV infection only became available in the early 1990s, we assessed trends and calculated the change in the mortality rate for CLD related to hepatitis C beginning in 1993. The *F* statistic at *P* value < 0.05 was considered statistically significant.

Results

Trends in CLD Deaths, 1990–1998

From 1990 through 1998, the age-adjusted death rate for CLD decreased 4.5% from 12.1 to 11.6/100,000 (*P* = 0.002). The decline only occurred from 1990 through 1994; there was no change in the rate from 1995 through 1998 (Fig. 1). During this study period, age-adjusted death rates decreased in both genders, by 6.4% among males (*P* = 0.0002) and by 3.2% among females (*P* = 0.09). Age-adjusted death rates declined among African Americans (−29.7%; *P* < 0.001), A/PI (−17.4%; *P* = 0.041), and non-Hispanics (−3.7%; *P* = 0.003), but increased among AI/AN (10.8%; *P* = 0.058; Table 1). Rates remained unchanged for whites (−0.5%; *P* = 0.30) and Hispanics (−1.2%; *P* = 0.30).

In 1990, age-adjusted death rates for CLD were highest for the group with no cause identified. From 1990 through 1998, overall age-adjusted death rates for the group with no etiology identified decreased by 19.5% (*P* < 0.0001; Fig. 2). This decrease occurred in both genders and among most racial or ethnic groups, with the largest decrease among African Americans (−34.3%; *P* < 0.001); only among AI/AN were the rates not significantly different (−9.6%; *P* = 0.23; Table 2). Overall rates for alcohol-related CLD declined 10.5% (*P* =

Table 1. Trends in Age-Adjusted Chronic Liver Disease Death Rates (per 100,000) by Gender, Race, and Ethnicity in the United States, 1990–1998

	1990		1998		Linear Regression Model			P Value
	Rate	No.	Rate	No.	Annual Rate Change	Rate Change in 9 Years	Percentage Change in 9 Years	
Overall	12.14	28,361	11.61	30,933	-0.06	-0.54	-4.5	0.002
Gender								
Male	17.27	18,175	16.27	19,904	-0.12	-1.11	-6.4	0.000
Female	7.80	10,186	7.53	11,024	-0.03	-0.25	-3.2	0.090
By race								
White	11.42	23,517	11.45	26,367	0.01	0.05	0.5	0.308
African American	18.14	4,150	12.94	3,530	-0.59	-5.34	-29.7	0.000
American Indian or Alaska Native	25.30	355	28.70	519	0.31	2.77	10.8	0.058
Asians or Pacific Islanders	4.64	354	4.14	517	-0.09	-0.83	-17.4	0.041
Ethnicity								
Hispanic	19.51	2,520	19.14	3,574	-0.03	-0.24	-1.2	0.304
Non-Hispanic	11.13	24,588	10.79	26,712	-0.05	-0.41	-3.7	0.003

0.0004; Fig. 2), with the greatest decrease occurring among African Americans (-45.2%; $P < 0.001$). Among AI/AN, however, these rates increased by 14.1%, from 16.0/100,000 to 19.0/100,000 ($P = 0.071$). For primary biliary cirrhosis, the age-adjusted death rates increased overall (12.8%; $P = 0.002$) and among females, whites, and both Hispanics and non-Hispanics.

For HBV-related CLD, overall age-adjusted death rates remained unchanged from 1990 through 1998 (9.5%; $P = 0.125$; Fig. 2); this trend was similar to that among A/PI, the group with the highest HBV-related death rates, but increases occurred among Hispanics (40.5%; $P = 0.011$) and African Americans (31.3%; $P = 0.003$; Table 2). A 220% increase in HCV-related CLD deaths occurred from 1993 through 1998 (0.57–1.67/100,000; $P < 0.0001$; Table 2; Fig. 2), concurrent with a

45% decrease in deaths from unspecified viral hepatitis (0.11/100,000–0.06/100,000; $P = 0.004$). For HCV, similar trends were observed among both genders and all racial and ethnic groups.

Deaths and Death Rates in 1998

Chronic liver disease accounted for 30,933 (1.3%) of the 2,338,070 deaths that occurred in the United States during 1998 (mortality rate, 11.6/100,000). These deaths included 25,236 (81.6%) in which the ICD-9 code for chronic liver disease or cirrhosis (571.0–571.9 codes) was listed as the underlying cause of death. The remaining included 4,707 (15.2%) deaths related to viral hepatitis (070.2–070.9 codes) and 990 (3.2%) deaths from CLD sequelae (selected 572.2–572.4 codes). A total of 12,187 (39.4%) deaths

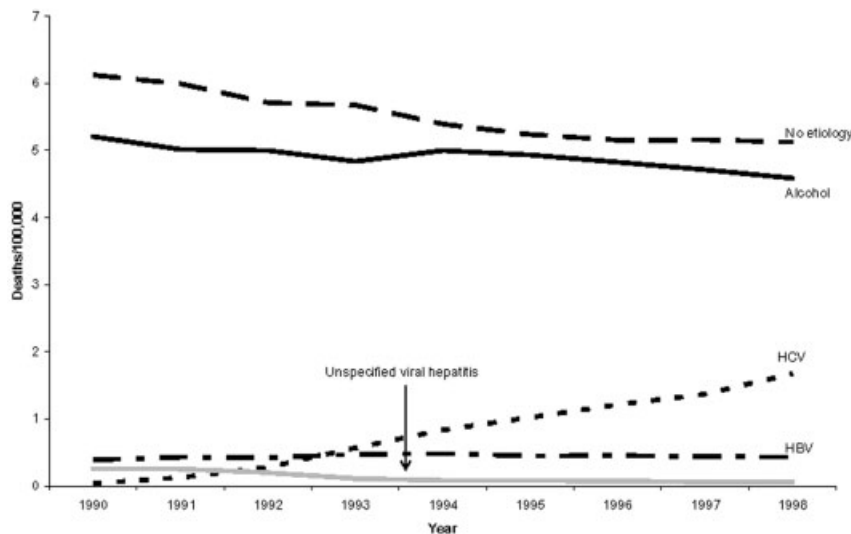


Fig. 2. Age-adjusted death rates of chronic liver disease by year and cause in the United States, 1990 through 1998.

Table 2. Age-Adjusted Chronic Liver Disease Death Rates (per 100,000) by Cause and Gender, Race, and Ethnicity, 1990-1998

Characteristics	1990		1998		Linear Regression Model			P Value
	Rate	No.	Rate	No.	Annual Rate Change	Rate Change in 9 Years	Percentage Change in 9 Years	
Alcohol related								
Overall	5.21	12,042	4.59	12,185	-0.06	-0.55	-10.5	0.001
Male	8.12	8,718	7.21	9,005	-0.09	-0.85	-10.4	0.001
Female	2.68	3,324	2.27	3,180	-0.04	-0.33	-12.7	0.001
White	4.72	9,542	4.52	10,266	-0.01	-0.09	-1.9	0.147
African American	9.54	2,206	5.27	1,464	-0.48	-4.35	-45.2	0.000
American Indian or Alaska Native	15.99	239	19.03	352	0.25	2.26	14.1	0.071
Asian or Pacific Islander	4.64	65	4.14	105	-0.09	-0.83	-17.4	0.041
Hispanic	9.15	1,279	8.03	1,609	-0.13	-1.21	-12.6	0.007
Non-Hispanic	4.72	10,260	4.19	10,262	-0.05	-0.47	-9.9	0.001
Hepatitis C virus related								
Overall	0.57*	1403*	1.67	4,443	0.21†	1.26‡	220.2‡	0.000
Male	0.73*	812*	2.26	2,827	0.29†	1.72‡	236.6‡	0.000
Female	0.43*	591*	1.12	1,626	0.13†	0.80‡	187.5‡	0.000
White	0.55*	1195*	1.60	3,653	0.20†	1.20‡	217.8‡	0.000
African American	0.70*	169*	2.34	646	0.30†	1.83‡	260.8‡	0.000
American Indian or Alaska Native	0.51*	7*	2.28	44	0.33†	1.95‡	383.4‡	0.000
Asian or Pacific Islander	0.52*	32*	1.35	100	0.14†	0.86‡	164.3‡	0.000
Hispanic	1.19*	190*	3.30	3,692	0.40†	2.42‡	202.4‡	0.000
Non-Hispanic	0.50*	1173*	1.50	4,368	0.19†	1.13‡	224.7‡	0.000
Hepatitis B virus related								
Overall	0.39	913	0.44	1,161	0.00	0.04	9.5	0.124
Male	0.59	633	0.67	835	0.01	0.06	9.7	0.146
Female	0.21	280	0.23	326	0.00	0.02	8.6	0.099
White	0.35	714	0.36	818	0.00	0.00	1.2	0.445
African American	0.46	115	0.65	183	0.02	0.15	31.3	0.003
American Indian or Alaska Native	0.32	4	0.60	11	0.03	0.30‡	N/A	
Asian or Pacific Islander	1.54	80	1.87	149	0.03	0.30	16.5	0.109
Hispanic	0.39	55	0.53	111	0.02	0.18	40.5	0.011
Non-Hispanic	0.37	809	0.42	1,030	0.00	0.04	10.7	0.112
No cause								
Overall	6.13	14,394	5.13	13,680	-0.13	-1.21	-19.5	0.000
Male	8.24	8,479	6.73	8,023	-0.20	-1.78	-21.4	0.000
Female	4.42	5,915	3.77	5,657	-0.09	-0.83	-18.6	0.001
White	5.94	12,388	5.15	11,988	-0.11	-1.00	-16.7	0.000
African American	7.70	1,724	5.25	1,396	-0.30	-2.67	-34.3	0.000
American Indian or Alaska Native	8.30	105	7.71	131	-0.10	-0.91	-9.6	0.229
Asian or Pacific Islander	4.64	187	4.14	168	-0.09	-0.83	-17.4	0.041
Hispanic	9.38	1,117	7.85	1,334	-0.18	-1.62	-17.2	0.000
Non-Hispanic	5.66	12,623	4.86	12,120	-0.12	-1.05	-18.1	0.000
Primary biliary cirrhosis								
Overall	0.16	380	0.18	485	0.00	0.02	12.8	0.024
Male	0.06	57	0.05	62	0.00	0.00	-6.7	0.322
Female	0.23	323	0.28	423	0.00	0.04	16.3	0.004
White	0.17	357	0.20	472	0.00	0.03	17.1	0.013
African American	0.07	16	0.02	7	0.00	-0.03‡	N/A	
American Indian or Alaska Native	0.31	4	0.11	2	0.00	-0.02‡	N/A	
Asian or Pacific Islander	0.08	3	0.05	4	-0.01	-0.10‡	N/A	
Hispanic	0.19	341	0.33	418	0.01	0.08	42.7	0.141
Non-Hispanic	0.15	374	0.16	473	0.00	0.02	13.1	0.025

Abbreviation: N/A, not applicable.

*Values in 1993.

†Percent change from 1993 to 1998.

‡Trends not interpretable because of small numbers of deaths.

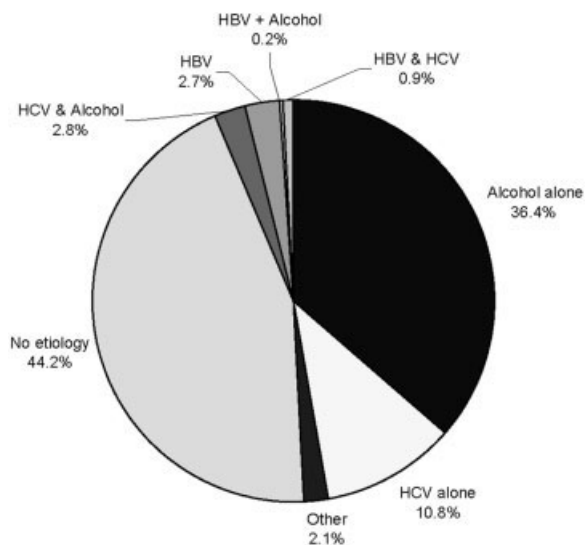


Fig. 3. Cause of chronic liver disease related deaths in the United States, 1998.

were alcohol related; 4,443 (14.5%) were HCV related, of which 3,340 deaths were the result of hepatitis C alone; 1,161 (3.8%) were HBV related; and for 13,683 (44.2%), no cause was recorded (Fig. 3).

Age-Specific Rates. Most (98%) decedents were aged 25 years and older, and the highest age-specific death rate (36.9/100,000) was in the 65- to 74-year age group. Among males, age-specific death rates peaked in the 65- to 74-year age group (47.6/100,000), but among females in the 75- to 84-year age group (32.2/100,000; data not shown). Among AI/AN compared with white persons and African Americans, and in the alcohol-related group compared with groups with other causes, the highest age-specific death rates occurred at an earlier age, in the 55- to 64-year age group (Figs. 4 and 5).

Age-Adjusted Rates. A total of 19,904 (64.3%) deaths occurred among men, and age-adjusted rates for men were more than two times higher than for women (16.3/100,000 vs. 7.5/100,000; $P < 0.001$). Eighty-five percent of deaths occurred among whites, 11% among African Americans, 2% among AI/AN, and 2% among A/PI. However, age-adjusted death rates were highest among AI/AN (28.7/100,000), followed by African Americans (12.9/100,000), whites (11.5/100,000), and A/PI (4.1/100,000; Table 1). Deaths among Hispanics accounted for 12% of CLD-related deaths, and their age-adjusted rates were more than 1.5 times more than among non-Hispanics (19.1/100,000 vs. 10.8/100,000; $P < 0.001$; Table 1).

In 1998, the highest age-adjusted CLD death rates continued to occur among persons with no cause identified (Table 2). Among deaths for which a cause was re-

corded, age-adjusted alcohol-related death rates were highest, and more than three times higher among AI/AN than among those in other racial or ethnic groups. A total of 68% of all CLD deaths among AI/AN were recorded as alcohol related. In contrast to 1993, the overall age-adjusted death rate for HCV-related CLD exceeded that for HBV-related and primary biliary cirrhosis-related CLD. In the HBV-related group, the highest death rates continued to occur in A/PI, and in the HCV-related group, death rates were highest among AI/AN, African Americans, men, and Hispanics compared with other racial groups, women, and non-Hispanics.

Discussion

Traditionally, CLD-related mortality data are tabulated and analyzed using the ICD-9 definition of CLD (coded as 571). Codes in this "571" group allow for designation of alcohol-related CLD but not for CLD related to viral hepatitis,⁷ leading to an underestimation of both the number of CLD-related deaths and the proportion attributable to viral hepatitis. Our study demonstrates that by expanding the definition of death from CLD to include codes for viral hepatitis and relevant sequelae of CLD listed in the underlying cause of death field, the number of 1998 CLD deaths increased by nearly 23%, and the proportion of CLD deaths attributable to viral hepatitis increased by 19%. Further, in contrast to reported trends defined only as 571 codes, the decline in CLD mortality observed during previous decades and sustained through the early 1990s did not continue after 1994, largely because of increases in HCV-related deaths.^{2,10}

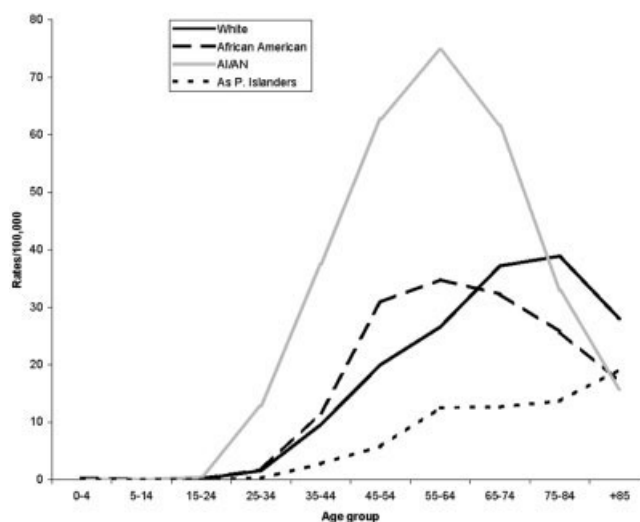


Fig. 4. Age-specific chronic liver disease death rates by race in the United States, 1998.

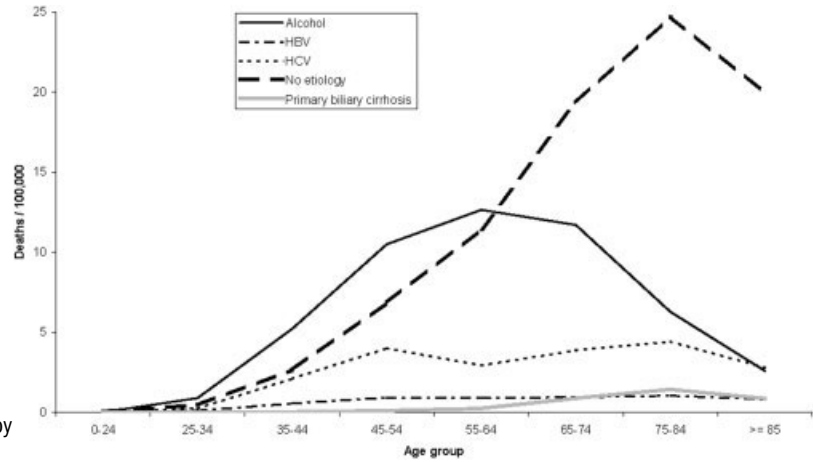


Fig. 5. Age-specific chronic liver disease death rates by cause in the United States, 1998.

The overall decrease in CLD mortality rates during the study period was 16% when restricted to the 571 codes in the underlying cause of death field, but only 5% when codes for viral hepatitis and CLD sequelae were included, suggesting that decreases in CLD deaths not related to viral hepatitis were counterbalanced by an increase in deaths from CLD caused by chronic hepatitis C. Large increases in HCV-related mortality rates occurred beginning in 1993, which likely were related primarily to improved awareness of and testing for HCV infection among CLD patients.¹¹ Consistent with this explanation is the finding that the percent increases in HCV-related mortality were similar across all demographic groups, whereas chronic infection rates are not.¹² Nonetheless, by 1998, hepatitis C was listed on the death certificates of less than 15% of decedents, and no cause was reported for approximately half of deaths. In studies of patients with CLD, approximately 40% to 60% have hepatitis C and less than 10% have cryptogenic disease.^{3,4}

The number of HCV-related CLD deaths identified in 1998 in this study was less than 4,500. When population-based studies of CLD morbidity were used to estimate annual mortality, 8,000 to 10,000 deaths from HCV-related CLD were estimated.⁵ These differences suggest that, similar to findings of studies examining the accuracy of death certificates in identifying respiratory and cardiovascular diseases as causes of death, hepatitis C may be underascertained among patients dying of chronic liver disease, underreported on death certificates, or both.^{3,4,13-16} In the only study to date of which we are aware that addressed this issue by comparing mortality data with medical records, the potential magnitude of underreporting of hepatitis C on death certificates was estimated to be approximately 50%.¹⁷ If this estimate was consistent across the country, hepatitis C should have been recorded as causing approximately 9,000 (30%) CLD deaths in 1998. Alternatively, mortality from

chronic hepatitis C may be much lower than morbidity from the disease.

Alcoholic liver disease was the CLD cause most frequently identified on the death certificates and had the highest age-adjusted mortality rate among deaths for which a cause appeared on the certificate. Other studies have suggested substantial underreporting of alcohol-related conditions on death certificates.¹⁰ The epidemiologic factors of alcohol-related CLD deaths we observed were consistent with the demographic distribution and temporal trends of heavy alcohol consumption in the United States,^{18,19} with higher death rates among men, AI/AN, and Hispanics and an overall 10% decline in alcohol-related CLD mortality during the decade.

AI/AN populations carried a disproportionate mortality burden from CLD, highlighting the need for improved primary and secondary prevention measures. Death rates among AI/AN were more than twice those of other racial groups, and in contrast to trends observed in other racial groups, age-adjusted rates increased during the decade. Excess CLD mortality observed among AI/AN may be attributed partly to documented higher rates of alcohol consumption in this population.²⁰ Although death rates from non-alcohol-related CLD were not higher among AI/AN compared with other racial groups, it is possible that because alcoholism is prevalent among AI/AN, deaths may be more often ascribed to alcoholic liver disease at the expense of other causes, compared with other racial groups.² The higher frequency of CLD mortality of unknown cause among whites compared with AI/AN may be an illustration of this phenomenon.

HBV-related death rates were highest among A/PI, as may be expected because of the high prevalence of HBV infection in this population.²¹ We also observed high rates among AI/AN, African Americans, and persons of Hispanic ethnicity and significant increases in death rates

during the study period among African Americans and Hispanics. These findings are consistent with results of national prevalence surveys,²¹ but to our knowledge have not been reported previously. Results of catalytic modeling indicated a decline in the prevalence of HBV infection between the time periods 1976 through 1980 and 1988 through 1994.²¹ It will be important to continue to monitor race- and ethnicity-specific HBV-related CLD mortality rates to determine if this predicted decline in the prevalence of infection is reflected in declines in mortality.

Deaths from hepatocellular carcinoma (HCC) were not included in this analysis. The addition of 1990 through 1998 HCC deaths would have increased overall CLD death rates only by approximately 4%, because death resulting from HCC is relatively uncommon compared with death from CLD in the United States.²² However, the effect of including HCC deaths on race- or ethnicity-specific mortality rates is unclear; a published study of recent trends in HCC deaths in the United States considered only whites and African Americans.²² The findings of this study with respect to the cause of HCC deaths were consistent with those of this analysis of CLD deaths in that the observed rising trend was attributed in part to increases in HBV- and HCV-related HCC.²²

Since 1999, the ICD-10 classification has been used to code causes of death on death certificates.²³ When the number of CLD deaths in 1999 coded with ICD-9 codes was compared with those coded with ICD-10 codes, the number of CLD deaths was 4% higher using ICD-10 codes.²⁴ Some ICD-9 conditions such as "alcohol dependence syndrome" (303 code) and "unspecified hepatitis" (573.3 code) have been included in the CLD category in ICD-10. Moreover, because of changes in algorithms for determining the underlying cause of death, CLD is selected as the underlying cause of death instead of, for example, pneumonia, when both are listed in the death certificate.²⁴ However, the number of viral hepatitis deaths was 18% lower when ICD-10 codes were used compared with ICD-9 codes,²⁴ mainly because human immunodeficiency virus infection was selected systematically as the underlying cause of death when the death certificate listed both human immunodeficiency virus and viral hepatitis infections. In addition, this revision carries forward coding conventions that may perpetuate under-recording of viral hepatitis as a cause of CLD deaths. Similar to the ICD-9 classification, the group of CLD codes is divided into alcoholic liver disease and other chronic liver disease; there is no category in this group of codes for viral hepatitis.²⁴ Thus, the coding conventions we have identified in ICD-9 that result in an underesti-

mation of the contribution of viral hepatitis to CLD mortality are likely to persist with ICD-10.

In conclusion, this analysis highlights large disparities in CLD mortality, demonstrating the need for social and public health interventions that target high-risk groups such as AI/AN and Hispanic Americans. CLD, as defined in ICD, cannot be used to monitor trends accurately in CLD mortality, and the divergence can be expected to increase as more deaths from HCV-related CLD are recorded using viral hepatitis rather than CLD ICD codes. In contrast to previously reported trends that relied on the CLD codes in ICD,²⁵ after a decline in CLD mortality in the early 1990s, overall mortality remained unchanged when an expanded definition of CLD was used. In general, cause-specific mortality is reflected poorly in death certificate data. Consistent with some authors' suggestions,^{26,27} future analyses of CLD mortality and its causes should include viral hepatitis and sequelae of CLD deaths because of the narrow definition of CLD in ICD. Further studies are needed to evaluate the validity of estimates of the mortality burden from CLD generated from national mortality data and to characterize better the causes of CLD deaths.

References

1. Martin JA, Smith BL, Mathews TJ, Ventura SJ. Births and deaths: preliminary data for 1998. In: National Center for Health Statistics. National Vital Statistics Report. Vol. 47, No. 25. Hyattsville, MD: National Center for Health Statistics, 1998.
2. Dufour MC. Chronic liver disease and cirrhosis. In: Everhardt JE, ed. Digestive Diseases in the United States: Epidemiology and Impact. Washington, DC: US Department of Health and Human Services, Public Health Service, National Institutes of Health, National Institutes of Diabetes and Digestives and Kidney Diseases, 1994:615-646.
3. Bell BP, Navarro VJ, Manos MM, Murphy RC, Leyden WA, St Louis TE, Kunze K, et al. The epidemiology of newly-diagnosed chronic liver disease in the United States: findings of population-based sentinel surveillance [abstract]. HEPATOLOGY 2001;34:468A.
4. Frieden TR, Ozick L, McCord C, Nainan OV, Workman S, Comer G, Lee TP, et al. Chronic liver disease in central Harlem: the role of alcohol and viral hepatitis. HEPATOLOGY 1999;29:883-888.
5. Centers for Disease Control and Prevention. Recommendations for prevention and control of hepatitis C virus infection and HCV-related chronic disease. MMWR 1998;47:1-33.
6. National Center for Health Statistics. Multiple Cause-of-Death Public-Use Files for 1990-1998 [computer tapes]. Bethesda, MD: National Center for Health Statistics, 1999.
7. National Center for Health Statistics. 1997 Mortality Documentation Detail Record Layout. Hyattsville, MD: Public Health Service, 1997.
8. Israel RA, Rosenberg HM, Curtin LR. Analytical potential for multiple cause-of-death data. Am J Epidemiol 1986;124:161-179.
9. U.S. Bureau of the Census. Census of population and housing, 2000: summary tape file 1. Washington, DC; 2001. Available at <http://www.census.gov/main/www/cen2000.html>.
10. Hurwitz ES, Holman RC, Strine TW, Chorba TL. Chronic liver disease mortality in the United States, 1979 through 1989. Am J Pub Health 1995; 85:1256-1260.
11. Larsen J, Skaug K, Maeland A. Second-generation anti-HCV tests predict infectivity. Vox Sang 1992;63:39-42.

12. Alter MJ, Kruszon-Moran D, Nainan OV, McQuillan GM, Gao F, Moyer LA, Kaslow RA, et al. The prevalence of hepatitis C virus infection in the United States, 1988 through 1994. *N Engl J Med* 1999;341:556–562.
13. Modelmog D, Rahlenback S, Trichopoulos D. Accuracy of death certificates: a population-based, complete-coverage, one-year autopsy study in East Germany. *Cancer Causes Control* 1992;3:541–546.
14. Nielsen GP, Bjornsson J, Jonasson JG. The accuracy of death certificates. Implications for health statistics. *Virchows Arch A Pathol Anat Histopathol* 1991;419:143–146.
15. Benavides FG, Boumar F, Peris R. Quality of death certificates in Valencia, Spain. *Am J Public Health* 1989;79:1352–1354.
16. Kircher T, Nelson J, Burdo H. The autopsy as a measure of accuracy of the death certificate. *N Engl J Med* 1985;313:1263–1269.
17. Wu C, Chang HG, McNutt LA, Smith PF. Mortality rate of hepatitis C in Upstate New York, 1997. Proceedings of 128th of Annual Meeting of the American Public Health Association [abstract 11681]. Boston, MA: 2000:12–16. Available at <http://apha.org/meetings>.
18. Greenfield TK, Rogers JD. Who drinks most of the alcohol in the US? The policy implications. *J Stud Alcohol* 1999;60:78–89.
19. Singh GK, Hoyert DL. Social epidemiology of chronic liver disease and cirrhosis mortality in the United States, 1935–1997: trends and differentials by ethnicity, socioeconomic status, and alcohol consumption. *Hum Biol* 2000;72:801–820.
20. National Institute on Alcohol Abuse and Alcoholism (NIAAA). 1996. Alcohol and minorities. *Alcohol Alert* 19(PH 329):1–4.
21. Coleman PJ, McQuillan GM, Moyer LM, Lambert SB, Margolis HS. Incidence of hepatitis B virus infection in the United States, 1976–1994: estimates from the National Health and Nutrition Examination Surveys. *J Infect Dis* 1998;178:954–999.
22. El-Serag HB, Mason AC. Rising incidence of hepatocellular carcinoma in the United States. *New Engl J Med* 1999;34:745–750.
23. Kochanek KD, Smith BL, Anderson RN. Deaths: preliminary data for 1999. In: National Center for Health Statistics. National Vital Statistics Report. Vol. 49, No. 3. Hyattsville, MD: National Center for Health Statistics, 1999.
24. Anderson RN, Minino AM, Hoyert DL, Rosenberg HM. Comparability of cause of death between ICD-9 and ICD-10: preliminary estimates. In: National Center for Health Statistics. National Vital Statistics Report. Vol. 49, No. 18. Hyattsville, MD: National Center for Health Statistics, 2001:1–32.
25. Centers for Disease Control and Prevention. Mortality patterns—preliminary data, United States, 1996. *MMWR* 1997;46:941–944.
26. Kim WR. The burden of hepatitis C in the United States. *HEPATOLOGY* 2002;36:S30–S34.
27. Kim WR, Brown RS Jr, Terrault NA, El-Serag H. Burden of liver disease in the United States: summary of a workshop. *HEPATOLOGY* 2002;36:227–242.