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Underestimation of Liver-Related Mortality in the United States

SUMEET K. ASRANI^{1,2}, JOSEPH J. LARSON³, BARBARA YAWN^{4,5,6}, TERRY M. THERNEAU³, and W. RAY KIM^{1,4}

¹Division of Gastroenterology and Hepatology, Mayo Clinic College of Medicine, Rochester, Minnesota

²Baylor University Medical Center, Dallas, Texas

³Division of Biomedical Statistics and Informatics, Mayo Clinic College of Medicine, Rochester, Minnesota

⁴Division of Health Sciences Research, Mayo Clinic College of Medicine, Rochester, Minnesota

⁵Department of Research, Olmsted Medical Center, Rochester, Minnesota

⁶Rochester Epidemiology Project, Rochester, Minnesota

Abstract

BACKGROUND & AIMS—According to the National Center for Health Statistics (NCHS), chronic liver disease and cirrhosis is the 12th leading cause of death in the United States. However, this single descriptor might not adequately enumerate all deaths from liver disease. The aim of our study was to update data on liver mortality in the United States.

METHODS—Mortality data were obtained from the Rochester Epidemiology Project (1999–2008) and the National Death Registry (1979–2008). Liver-specific mortality values were calculated. In contrast to the narrow NCHS definition, updated liver-related causes of death included other specific liver diagnoses (eg, hepatorenal syndrome), viral hepatitis, and hepatobiliary cancers.

RESULTS—The Rochester Epidemiology Project database contained information on 261 liver-related deaths, with an age- and sex-adjusted death rate of 27.0/100,000 persons (95% confidence interval: 23.7–30.3). Of these, only 71 deaths (27.2%) would have been captured by the NCHS definition. Of cases for which viral hepatitis or hepatobiliary cancer was the cause of death, 96.9% and 94.3% had liver-related immediate causes of death, respectively. In analysis of data from the National Death registry (2008), use of the updated definition increased livermortality by >2-fold (from 11.7 to 25.7 deaths/100,000, respectively). Using NCHS definitions, liver-related deaths decreased from 18.9/100,000 in 1979 to 11.7/100,000 in 2008—a reduction of 38%. However, using the updated estimate, liver-related deaths were essentially unchanged from 1979 (25.8/100,000) to 2008 (25.7/100,000). Mortality burden was systematically under-estimated among non-whites and persons of Hispanic ethnicity.

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Address requests for reprints to: W. Ray Kim, MD, Division of Gastroenterology and Hepatology, Mayo Clinic College of Medicine, 200 First Street SW, Rochester, Minnesota 55905. kim.ray@mayo.edu; fax: 507-538-0254.

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Conflicts of interest

The authors disclose no conflicts.

Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Gastroenterology* at www.gastrojournal.org, and at <http://dx.doi.org/10.1053/j.gastro.2013.04.005>.

CONCLUSIONS—Based on analyses of the Rochester Epidemiology Project and National Death databases, liver-related mortality has been under-estimated during the past 2 decades in the United States.

Keywords

Hepatocellular Carcinoma; Rate of Death; HCV; HBV; Population

Cirrhosis, similar to congestive heart failure and chronic obstructive pulmonary disease, represents end-stage damage to a major vital organ and is an important source of morbidity and mortality. According to the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention (CDC), chronic liver disease and cirrhosis is the 12th leading cause of death, claiming 30,000 lives annually in the United States.¹ In particular, among persons aged 45 to 54 years and 55 to 64 years, chronic liver disease and cirrhosis are the 4th and 7th leading cause of death, respectively.

Although these statistics point to the important health burden of chronic liver disease in the United States, questions have been raised concerning about whether the NCHS/CDC data underestimate mortality attributable to liver disease.² For example, current estimates are solely based on one diagnostic category, namely chronic liver disease and cirrhosis, which fails to capture deaths attributed to other uniquely liver-related descriptors, such as hepatic encephalopathy or hepatorenal syndrome. Similarly, deaths associated with viral hepatitis or liver cancer are not included, and most deaths due to these conditions are caused by complications of liver disease.³ For example, the current estimates of liver-related deaths might not include the demise of a person with hepatitis C cirrhosis who died of hepatorenal syndrome.

Accurate data are an important prerequisite for sound public health and health care policies and guidelines. Ideally, health burden should drive decisions for resource allocation aimed toward extending the understanding of disease mechanisms, investigating the optimal means for diagnosis and treatment and disseminating accurate information to health professionals, patients, and the public. The need for accurate data in liver disease is further highlighted by the current epidemiology of liver disease, which is in a rapid flux. For example, the prevalence of chronic liver disease due to hepatitis C virus (HCV) infection and nonalcoholic fatty liver disease has increased in the recent past.^{4–7} In addition, to the degree that these and other liver diseases tend to affect minority populations in the United States, exclusion of the relevant conditions from liver-related mortality statistics leads to underestimation of the burden of liver disease in those populations, aggravating the disparities.

In this work, we analyze mortality data in the United States and assess the extent to which the NCHS/CDC mortality reports underestimate the true burden of liver disease. This is accomplished by incorporating additional descriptors specific to liver disease, as well as viral hepatitis and hepatobiliary cancers, in enumerating total deaths attributable to liver-related causes. The analysis is based on 2 population-based data, one from Olmsted County, Minnesota and the other the National Death data.

Materials and Methods

Data Sources

Olmsted County data—Epidemiologic research in Olmsted County, Minnesota (2010 population of 144,248) is possible as the county is medically isolated with only 2 major providers, Mayo Clinic and the Olmsted Medical Center, covering >98% of the health care

needs of the population.⁸ An extensive, easily retrievable, linkage database of clinical records contains details of all inpatient, outpatient, and emergency visits, laboratory data, and correspondences. This database, the Rochester Epidemiology Project (REP) affords population-based studies of diseases as it provides access to records of essentially all medical care for residents of Olmsted County, Minnesota. The REP database has been used extensively in epidemiological investigations of a variety of disease conditions, producing >2000 publications to date.⁹

As a part of the REP, death records of Olmsted County residents are tracked from multiple sources, including the county and state vital records, as well as individual medical charts. Using this REP Death Data system, we extracted death records of Olmsted County residents between 1999 and 2008. In-hospital deaths within the community provided opportunities to examine whether death certificates accurately capture causes of death. Using the REP resources, we assessed whether the causes of death in the death certificate data were accurate in comparison with the medical records. The study was approved by the Institutional Review Board at both institutions in Olmsted County.

National mortality data—Information on all deaths is collected by state registries and provided to the National Center for Health Statistics in the CDC. These data form the basis of estimates of mortality and leading causes of death that are published annually by the NCHS/CDC. Public use data files (“mortality multiple cause of death”) were obtained from the National Center for Health Statistics for years 1979–2008.¹⁰ All deaths occurring in the 50 states and the District of Columbia were analyzed.

Classification of Causes of Death

Death records from both data sources were based on information provided in death certificates. The standard death certificate lists the immediate and underlying causes of death (part I), as well as a list of contributing causes of death (part II). The underlying cause of death is determined as the “the disease or injury which initiates the train of events leading directly to death.” When more than one cause or condition is listed on the death certificate, the underlying cause is determined by the sequence of conditions and associated selection rules using standard algorithms.¹¹ The contributing causes of death are other “significant conditions contributing to death but not resulting in the underlying cause given in Part I.” Variables in addition to these causes of death are included in the data: age, sex, year of death, race (American Indian or Alaska Native, Asian or Pacific Islander, Black or African American, White), and ethnicity (Hispanic or Latino).

Cause of death was classified in accordance with the International Classification of Diseases (ICD). Deaths for 1979–1998 were classified using the 9th revision (ICD-9), and the 10th revision (ICD-10) was used for data since 1999. Supplementary Table 1 lists ICD-9 and ICD-10 categories to identify liver-related deaths. First, the current estimates by NCHS are based on underlying cause of death being chronic liver disease and cirrhosis, which corresponds to a single ICD-9 code of 571 and ICD-10 codes of K70, K73, and K74 (CDC definition). Supplementary Table 1 also lists ICD-9 and ICD-10 codes, if designated as the underlying cause of death, should be included in enumerating deaths from liver disease. Our updated definition incorporates expanded liver diagnosis, namely, additional diagnoses specific to liver disease yet excluded in the CDC definition, as well as viral hepatitis and malignant neoplasm of the liver and intrahepatic bile ducts.

The Olmsted County data were used to evaluate whether the updated definition is appropriate to identify liver-related deaths. First, we identified cases where viral hepatitis or hepatobiliary neoplasm was listed as the underlying cause of death. Next, we determined the subset of patients that had an immediate or additional cause of death listed in part I that was

liver related (eg, hepatic failure, end-stage liver disease, or complications of portal hypertension). An example of this would be a decedent with viral hepatitis as the underlying cause of death and esophageal varices as the immediate or additional cause. If both viral hepatitis and hepatocellular carcinoma (HCC) were listed in part 1 of the certificate, we followed the standard algorithm and designated HCC as the underlying cause of death.

Finally, we assessed the degree to which liver disease accounted for deaths in decedents with viral hepatitis. Of all the cases where viral hepatitis was listed as the contributing cause of death, we determined the proportion of cases where the immediate or underlying cause indicated liver-related death. In contrast to the example above, a non-liver-related death would include a patient who might have died due to a car accident (underlying cause) and incidentally have a history of viral hepatitis (contributing cause) among other comorbidities.

Data Analysis

Age- and sex-adjusted death rates were calculated for the diagnoses of interest for the Olmsted County data and the National Death data. Standardized rates were calculated by adjusting estimates to the US 2000 Census population using the direct method.¹¹ Only adult patients (ie, aged 15 years or older) were included. Separate rates were derived for liver-related deaths classified by the CDC and updated definitions. Additional age-specific (by deciles), sex-specific, and race-specific rates were derived for updated estimates of liver-related mortality in the United States.

Results

Mortality Data in Olmsted County, Minnesota

When the CDC definition was used, there were 71 liver-related deaths among Olmsted County residents between 1999 and 2008. In contrast, if the updated definition was applied, there were 261 residents whose death certificate included diagnostic codes consistent with liver-related death. Table 1 describes characteristics of those decedents. Eighty-five of the deaths (32.6%) were due to viral hepatitis, 70 deaths (26.8%) were due to hepatobiliary malignancies, and 106 deaths (40.6%) were due to the expanded liver-related causes (inclusive of the 71 deaths meeting the CDC definition). Mean age at death was 59 years (SD = 15 years). Overall, 51 deaths (19.5%) were in women and 137 deaths (52.5%) occurred in individuals ages 45 to 64 years.

Of the decedents, 211 were white (81%), 36 (14%) were African American, and 14 (5%) were of Hispanic ethnicity. As compared with deaths captured by the CDC definition (n = 71), the rest of the liver-related deaths (n = 190) consisted of a higher proportion of African Americans (16.3% vs 7%), other races (5.7% vs 4.2%), and Hispanic ethnicities (5.8% vs 4.2%), and occurred in the community (inpatient deaths 25% vs 52%).

There were 84 deaths that occurred in an inpatient setting, which allowed comparison of death certificate diagnosis and the actual circumstance of death as revealed in the medical records. Of the 84 deaths, 32 (38%) were recorded as meeting CDC definition, 13 (15.5%) as expanded liver, 26 (30.9%) as viral hepatitis, and 13 (15.5%) as hepatobiliary malignancies. Detailed review of medical records verified that all of the 84 deaths were from complications of liver disease. The immediate cause of death was end-stage liver disease or liver failure in 24% (n = 20); complications of portal hypertension (eg, hepatorenal syndrome, variceal bleeding, and hepatic encephalopathy) in 25% (n = 21); sepsis, infection, or multiorgan failure in patients with underlying liver disease in 37% (n = 31); hepatobiliary cancer-related deaths in 5% (n = 4); and other causes in 9% (n = 8). In addition, it was judged that, in the vast majority, the death certificate accurately assigned correct causes of death. There were only 2 death certificates (2.4%) that misclassified the cause of death. One

death due to cholangiocarcinoma was not recorded (cause of death was hepatic failure) on the death certificate and the other death was due to viral hepatitis rather than a liver malignancy.

Next, all information available on the death certificate was reviewed in cases with viral hepatitis and/or hepatobiliary neoplasms. In 98 cases, viral hepatitis was mentioned as the underlying cause of death—only 13 of those might have possibly been captured by the CDC definition, and the remaining 85 would not have. Among these cases, 73.4% (n = 72) had a liver-related diagnosis listed in the immediate or part I of the certificate. Of the remaining, 23 decedents had diagnosis descriptors consistent with end-stage liver disease on the certificate (eg, portal hypertension) and multiorgan failure or sepsis as an immediate cause of death. Therefore, 96.9% (n = 95) of deaths with viral hepatitis as underlying cause of death were judged to be liver related. Similarly, 85.7% of deaths (n = 60) with hepatobiliary malignancy as an underlying cause of death had a liver-related diagnosis listed in the immediate cause or part I of the certificate. When the additional causes of death listed here were included, 94.3% (n = 66) were judged to be liver related.

We examined all death certificates (separate from the 261 cases discussed here) between 2000 and 2008, where viral hepatitis was mentioned as a contributing cause of death (n = 57). None of these deaths were liver related. For the ensuing analysis of the national data, deaths that had viral hepatitis or hepatobiliary malignancy as the underlying cause of death were included as liver-related deaths, and those in which viral hepatitis was a contributing cause of death were excluded from the analysis.

National Mortality Data

In 2008, according to the CDC definition, there were 29,951 deaths due to liver disease in the United States (Table 2). If the updated definition is used, the total number of deaths increases to 66,007. A total of 36,056 deaths are added, including 10,256 from the expanded liver disease diagnosis, 7625 from viral hepatitis and 18,175 from hepatobiliary malignancies. The corresponding death rates (per 100,000 persons) are 11.7 per 100,000 (16.2 for men and 7.6 for women) for the CDC definition and 25.7 per 100,000 (35.7 for men and 16.8 for women) for the updated definition.

Supplementary Table 2 compares age-specific death rates between the CDC and updated definitions. Regardless of which definition is used, it is clear that liver disease caused a large number of premature deaths. By both definitions, the largest number of liver death occurred among 45- to 64-year-olds (16,746 deaths by CDC definition and 34,460 deaths by updated definition). As expected, however, when death rates were calculated, the highest rates were seen in the oldest age group. Deaths were higher among men than in women across all age groups.

Supplementary Table 3 shows race-specific and age-adjusted death rates using the updated definition for liver-related mortality in 2008. Per the CDC definition, liver-related mortality (per 100,000 persons) was highest among American Indians and Alaska Natives (30.0) and Hispanics (17.8) followed by whites (12.2) and lowest among African Americans (8.7), and Asian Pacific Islanders (4.3). With the updated definition, liver-related mortality was even higher among American Indians and Alaska Natives (50.9) and Hispanics (38.8), followed by African Americans (26.2), whites (25.5), and Asian Pacific Islanders (22.1). The magnitude of under-estimated liver disease mortality by the CDC definition varied by race (Figure 1). For example, in whites, mortality rate by the CDC definition was 47% of that by the expanded definition, and in Asian and African Americans, the CDC definition captured only 20% and 34.3% of all liver-related deaths, respectively. Similarly, for persons of Hispanic ethnicity, only 48% of deaths were captured by the CDC definition. For Asians and

African Americans, a majority of excess deaths were due to hepatobiliary malignancy (56%), followed by viral hepatitis (14%). For Hispanics, the additional deaths were due to a combination of expanded liver diagnosis (13.7%) and viral hepatitis (14%) in a pattern similar to that observed among whites. For American Indians and Alaska Natives, the discrepancy was driven by expanded liver diagnosis (16%). The CDC accurately captured a majority of deaths among American Indians and Alaska Natives, which is potentially a reflection of higher rates of alcohol-related mortality.

Figure 2 describes longitudinal trends in the age- and sex-adjusted death rates (per 100,000 persons) in the United States from 1979–2008. In addition, we examined the deaths over the following eras: 1979–1988 (era 1), 1989–1998 (era 2), and 1999–08 (era 3). When the CDC definition was used, deaths due to liver disease (per 100,000 persons) decreased from 16.5 in era 1 to 13.0 in era 2 to 11.7 in era 3, a reduction of 38% between era 1 and era 3. However, when the updated definition was applied, the downward trend disappeared: liver-related mortality (per 100,000 persons) was 23.9 in era 1, 22.8 in era 2, and 24.4 in era 3. This discrepancy was accounted for by deaths due to viral hepatitis, which increased from 0.5 to 2.5 per 100,000 and hepatobiliary cancer, which increased from 3.1 to 6.4 per 100,000 between era 1 and era 3. Expanded liver deaths increased from 3.1 in era 1 to 3.8 in era 3 (Figure 3). Similar trends were seen in both men and women.

Figure 4 shows longitudinal trends in the age-specific death rates for liver-related mortality. From 1979 to 2008, age at death decreased in persons younger than 45 years (decline by 42%–56%) and deaths among persons older than 75 years increased (increase by 30%–46%) (Supplementary Table 4). In the recent era (1999–2008), the largest increase in age-specific mortality was seen in people aged 45–54 years and 55–64 years. The largest rise between 1998 and 2008 was seen in people 55–64 years old. This was driven in part by an increase in hepatobiliary malignancies in this age group (8.8 in 1999 and 14.1 in 2008).

Comparison of Liver Death Data Between Olmsted County and United States

Figure 5 examines the age- and sex-adjusted death rates in Olmsted County between 1999 and 2008. As a comparison, national data between 1999 and 2008 are also reported. Using the CDC definition, liver-related death was 7.3 per 100,000 (vs 11.7 per 100,000 nationally). When the updated definition was used, liver-related death rate (27.0 per 100,000; 95% CI: 23.7–30.3) was modestly higher in Olmsted County than in the national data (24.5 per 100,000). Interestingly, mortality secondary to viral hepatitis was much higher in Olmsted County (8.6 per 100,000; 95% CI: 6.8–10.4) than nationally (2.5 per 100,000). In contrast, mortality in the expanded liver category was lower in Olmsted County (11.0 per 100,000; 95% CI: 8.9–13.1) than the national data (15.5 per 100,000). In national estimates, unspecified hepatic failure and unspecified liver disease accounted for the higher rates (data not shown). Mortality from malignancies was marginally higher (7.4 per 100,000 persons; 95% CI: 5.7–9.2) in Olmsted county as compared with the national estimate (6.4 per 100,000).

As compared with the national data (34.0 per 100,000), there were a higher number of deaths among men in Olmsted County (46.4 per 100,000 persons; 95% CI: 40.0–52.7). Among women, the mortality rate was lower in Olmsted County (9.2 per 100,000, 95% CI 6.6–11.8) as compared with national estimates (16.2 per 100,000). The burden of death was higher among individuals aged 45 to 54 years (48.6 vs 33.8 per 100,000 persons) and similar among individuals aged 55 to 64 years (46.0 vs 46.7 per 100,000 persons) in Olmsted County as compared with national data.

Discussion

The results of this analysis highlight the importance of liver disease as a leading cause of death in the United States. We show that, when compared with a comprehensive and logical definition, the current liver-related mortality reported by NCHS/CDC is under-estimated. The significance of this is made clearer when the longitudinal trends are considered. Although CDC estimates show a decline in liver-related mortality by 38% during the last 3 decades, our updated estimates both at the county and national levels show that there is no reduction in liver-related mortality.¹² In addition, both county level and national data show that the disease burden is systematically underestimated among non-whites and persons of Hispanic ethnicity.

Mortality burden of a condition at the population level is determined by the incidence and prevalence of the condition, as well as the effectiveness of interventions applied at the population level. For example, HCV infection is one of the most significant causes of liver disease, the impact of which has been increasing. Although much progress has been made in the treatment of HCV infection, data shown in Figures 2 and 3 indicate that mortality from viral hepatitis, apart from deaths from HCC, has been on a progressive rise.¹³

The example of hepatitis C provides additional justification that viral hepatitis should be considered as a part of liver mortality. Before development of serologic testing for hepatitis C in the early 1990s, deaths from undiagnosed hepatitis C would have been classified under another category, such as alcoholic liver disease, representing a case of misclassification bias. In fact, earlier publications have shown a rapid increase in HCV-related deaths with a concurrent decline in alcohol-related mortality in the 1990s.¹⁴ Not taking viral hepatitis into account would result in a spurious assessment that mortality from alcoholic liver disease decreased.¹⁵ In our study, an apparent decline in CDC-related deaths might simply represent accurately accounting for viral-related deaths in the viral hepatitis category in the more recent era. In addition, there has likely been an increase in hepatobiliary malignancies during the last 30 years. The incidence and mortality of HCC has been rising, especially among persons with HCV.¹⁶ Similarly, a recent increase in intrahepatic cholangiocarcinoma has been described with dismal 5-year survival.¹⁷ Similarly, because most HCCs occur in patients with cirrhosis, excluding cases with hepatobiliary malignancy leads to underestimation of the true burden of chronic liver disease and cirrhosis.

It is also notable that the pattern of incidence and prevalence of liver disease has changed over time, as described in recent population-based studies.^{18–21} Substantial progress has been made in the treatment of certain subsets, such as persons with hepatitis B. There has been a significant reduction in acute hepatitis B infection as a result of successful public health efforts. In addition, the advent of potent and effective antiviral agents against hepatitis B is thought to have decreased the incidence of end-stage consequences of chronic hepatitis B–related liver disease. In addition, our study suggests that the age at death might have shifted during the last 3 decades. Deaths in persons younger than 45 years have decreased and deaths among persons older than 75 years have increased. Therefore, although overall liver-related mortality might have not changed, persons with liver disease might be living longer.

There are also several worrisome epidemiological trends in liver disease in the United States that need to be highlighted. First, it is forecast that liver-related morbidity and mortality due to viral hepatitis and hepatobiliary cancers will increase. This is due, in part, to the lengthening duration of HCV infection and aging of the “baby-boomer” generation affected by the epidemic. Deaths due to viral hepatitis are expected to peak during the next 20 years^{22,23} and are anticipated to affect older people (60 to 80 years) the most.^{4,24} HCC,

along with its dismal survival rate, is also expected to increase in parallel.^{25,26} Second, minority populations in the United States have a disproportionately high burden of viral hepatitis and its ensuing complications. These include population subgroups, such as African Americans, Hispanics, Alaska natives, and Asian/Pacific Islander Americans.²⁷ Our study showed that liver-related deaths among non-whites were not effectively captured by the CDC definition, under-estimating the disease burden. Finally, future liver-related deaths might be potentiated by the epidemic of obesity, in addition to deaths directly related to nonalcoholic fatty liver disease.^{6,7,25,26,28,29}

Our study has substantial implications for public policy. Current NCHS/CDC estimates do not adequately reflect the actual burden of liver disease encountered by providers at the national level. Potentially, this might be related to significant resources that would be required by federal agencies to amend data collection and reporting at the national level in the presentation of liver-related mortality data. However, this leads to lack of awareness of the true magnitude of the problem, not only by health care providers, but also by the community at large.⁵ Underappreciation of the prevalence and natural history of liver disease can lead to suboptimal care.³⁰ The Institute of Medicine highlights the need for health care providers to be prepared for the anticipated increase in the burden of chronic liver disease during the next decade.⁵ Economic impact and health care utilization can also be substantial.^{31–33}

The major strength of our data lies in capturing longitudinal trends and examining individual-level data both at the county and national level during the last 25 years. This allowed us to examine and compare population-wide data and gain unique insight in liver-related mortality from a wide range of etiologies, including viral hepatitis and hepatobiliary cancer. Death certificate data can be inaccurate in general, and can under-report alcohol or viral hepatitis diagnoses.^{3,34,35} There is often a disconnect between the physician completing the death certificate and the primary physician most attuned to a decedent's medical problems and cause of death.³⁶ Contributions of viral hepatitis and alcoholic liver disease to liver-related mortality can be underestimated if based solely on death records.³

Another unique feature of our study is access to medical records in Olmsted County, which provided helpful insights to understanding death certificate data at the national level. In our data, 98% of inpatient death certificates captured deaths due to liver-related mortality accurately, which did not seem to be affected by the change in the coding scheme from ICD-9 to ICD-10.³⁷ Whether the high correlation between medical records and death certificate data in an isolated medical community such as Olmsted County is generalizable elsewhere remains to be evaluated; however, similar results have been reported with analyses of other health care databases.^{3,38}

In addition, results from studies in Olmsted County as part of the REP have been consistent with national data.⁹ We included deaths due to infectious complications in persons with underlying liver disease as liver related. This approach is complementary to recent work showing that infections constitute a direct cause of death in cirrhotic patients.³⁹ It has also been proposed that development of infection or sepsis be considered as a penultimate stage (critically ill cirrhotic) in the evolution of natural history of cirrhosis, in addition to traditional markers of decompensation, such as ascites or variceal bleeding.^{39,40}

In conclusion, liver-related mortality in the United States is underestimated, in part, as a result of incomplete ascertainment of liver-related deaths. These data support that deaths due to viral hepatitis and hepatobiliary cancers should be included in the enumeration of liver-related deaths to accurately represent the burden of chronic liver disease.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The manuscript represents valid work and neither this manuscript nor one with substantially similar content under our authorship has been published or is being considered for publication elsewhere.

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Abbreviations used in this paper

CDC	Centers for Disease Control and Prevention
CI	confidence interval
HCC	hepatocellular carcinoma
HCV	hepatitis C virus
ICD	International Classification of Diseases
NCHS	National Center for Health Statistics
REP	Rochester Epidemiology Project

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Figure 1.

Liver-related mortality, 2008. Percent of overall liver related deaths in 2008 by the predefined categories (CDC, expanded (exclusive of CDC), viral hepatitis and hepatobiliary) as stratified by race. The sum of all the rates comprises the updated estimate of liver-related mortality by race. Adjusted to US Census 2000 population, only individuals older than 15 years at risk. AA, African American; AI/AN, American Indian and Alaska Native.

Figure 2.

Liver-related mortality in the United States, 1979–2008. Separate trend lines for viral hepatitis, liver cancer, and expanded liver (CDC definition and other causes of liver-related mortality) are provided. The updated estimate includes these 3 diagnosis groups. As a comparison, the current CDC estimate is provided (*black line*). Adjusted to US Census 2000 population, only individuals older than 15 years at risk.

Figure 3.

Liver-related deaths by era. Era 1: 1979–1988; era 2: 1989–1998; era 3: 1999–2008. Adjusted rates per 100,000 are provided by category (CDC, expanded [exclusive of CDC], viral hepatitis, and hepatobiliary malignancies). Adjusted to US Census 2000 population, only individuals older than 15 years at risk.

Figure 4. Age-specific death rates (per 100,000 persons) for liver disease-related mortality in 10-year age groups in the United States, 1979–2008.

Figure 5.

Age- and sex-adjusted death rates (per 100,000 persons) in Olmsted County, Minnesota vs national estimate, 1999–2008. Adjusted to US Census 2000 population, only individuals older than 15 years at risk.

Table 1

Decedent Characteristics: Liver-Related Deaths in Olmsted County

	CDC definition	Liver-related deaths, not including CDC	Updated definition, including CDC
Total, n	71	190	261
Age, y, mean (SD)	57.7 (12.6)	59.3 (15.6)	59 (15)
Women, n (%)	16 (22.5)	35 (18.4)	51 (19.5)
Race, n (%)			
White	63 (88.7)	148 (77.9)	211 (81)
African American	5 (7.0)	31 (16.3)	36 (14)
Other	3 (4.2)	11 (5.7)	14 (5)
Hispanic	3 (4.2)	11 (5.8)	14 (5)
Inpatient, n (%)	37 (52.1)	47 (24.9)	84 (32)

Table 2

Deaths Due to Liver-Related Causes of Death by Category and Selected Subdiagnoses in the United States, 2008

Cause of death	No. of deaths	Rate per 100,000 ^a
CDC definition	29,951	11.7
Alcoholic liver disease	14,864	5.2
Chronic hepatitis	92	0.2
Fibrosis and cirrhosis of the liver	14,995	5.8
Expanded definition		
Other liver diagnosis	10,256	4.0
Hepatic failure, unspecified	3613	1.4
Fatty (change of) liver, not elsewhere classified	793	0.3
Hepatorenal syndrome	467	0.2
Liver disease, unspecified	3688	1.4
Other	1695	NA
Viral hepatitis	7625	2.9
Chronic viral hepatitis B	162	0.1
Chronic viral hepatitis C	6834	2.6
Acute hepatitis B	509	0.2
Other	120	NA
Hepatobiliary cancer	18,175	7.1
Liver cell carcinoma	7561	2.9
Intrahepatic bile duct carcinoma	4037	1.6
Liver, unspecified	6551	2.6
Other	26	NA
Updated estimate ^b	66,007	25.7

NOTE. National rates might not add up due to rounding.

NA, not available.

^a Considering individuals aged older than 15 years at risk.

^b Updated estimate = expanded liver (CDC + other liver diagnosis) + viral hepatitis + hepatobiliary cancer.