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Health care–related transportation insecurity is associated with adverse health outcomes among adults with chronic liver disease

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Abstract

Background: Health care–related transportation insecurity (delayed or forgone medical care due to transportation barriers) is being increasingly recognized as a social risk factor affecting health outcomes. We estimated the national burden and adverse outcomes of health care–related transportation insecurity among US adults with chronic liver disease (CLD).

Methods: Using the U.S. National Health Interview Survey from 2014 to 2018, we identified adults with self-reported CLD. We used complex weighted survey analysis to obtain national estimates of health care–related transportation insecurity. We examined the associations between health care–related transportation insecurity and health care–related financial insecurity, food insecurity, self-reported health status, work productivity, health care use, and mortality.

Abbreviations: CAD, coronary artery disease; CLD, chronic liver disease; ED, emergency department; IPUMS, Integrated Public Use Microdata Series; NHIS, National Health Interview Survey.

Nneka N. Ufere and Carlos Lago-Hernandez are co-first authors.

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Results: Of the 3643 (representing 5.2 million) US adults with CLD, 267 [representing 307,628 (6%; 95% CI: 5%–7%)] reported health care–related transportation insecurity. Adults with CLD experiencing health care–related transportation insecurity had 3.5 times higher odds of cost-related medication nonadherence [aOR, 3.5; (2.4–5.0)], 3.5 times higher odds of food insecurity [aOR, 3.5; (2.4–5.3)], 2.5 times higher odds of worsening self-reported health status over the past year [aOR, 2.5; (1.7–3.7)], 3.1 times higher odds of being unable to work due to poor health over the past year [aOR, 3.1; (2.0–4.9)], and 1.7 times higher odds of being in a higher-risk category group for number of hospitalizations annually [aOR, 1.7; (1.2–2.5)]. Health care–related transportation insecurity was independently associated with mortality after controlling for age, income, insurance status, comorbidity burden, financial insecurity, and food insecurity [aHR, 1.7; (1.4–2.0)].

Conclusions: Health care–related transportation insecurity is a critical social risk factor that is associated with health care–related financial insecurity, food insecurity, poorer self-reported health status and work productivity, and increased health care use and mortality among US adults with CLD. Efforts to screen for and reduce health care–related transportation insecurity are warranted.

INTRODUCTION

Chronic liver disease (CLD) is a leading cause of morbidity and mortality among working-age adults in the United States.[1] Social risk factors, such as health care–related financial insecurity and food insecurity, are individual-level adverse social determinants of health that have been linked to health disparities and poor health outcomes among adults with CLD.[2–5] Many social risk factors may co-occur, particularly among low-income individuals. Therefore, a deeper understanding of social risk factors affecting adults with CLD and their independent and combined effects is needed to provide social needs-targeted care to improve their outcomes.[2,6]

Health care–related transportation insecurity (delayed, missed, or forgone medical care due to transportation barriers) is being increasingly recognized as a social risk factor that is estimated to affect ~6 million (1.8%) of US adults.[7] Health care–related transportation insecurity has been found to be more prevalent among adults with chronic illnesses, affecting 3.1% of adults with cancer and 4.5% of adults with coronary artery disease (CAD).[7–9] Prior studies of patients with CLD and their providers have highlighted lack of transportation as a critical barrier to access to hepatitis C treatment, liver transplantation evaluation, and HCC surveillance.[10–15] However, the burden and outcomes of health care–related transportation insecurity, as well as its association with other social risk factors, among the population with CLD in the US remains unknown. To address this knowledge gap and inform future interventions, we sought to examine: (1) the prevalence and risk factors of health care–related transportation insecurity, (2) associations between health care–related transportation insecurity and other social risk factors such as health care–related financial insecurity and food insecurity, and (3) associations between health care–related transportation insecurity and self-reported health status, work productivity, health care utilization and mortality in a nationally representative sample of US adults with CLD.

METHODS

Data source

We pooled 5 years of data (2014–2018) from the National Health Interview Survey (NHIS) using the Integrated Public Use Microdata Series (IPUMS).[16] The National Center for Health Statistics compiles the NHIS. It consists of annual, cross-sectional national surveys that collect data through questionnaires delivered by trained interviewers and collect information on demographic, socioeconomic, and self-reported health information for at least 1 randomly selected adult household member and through complex, multistage sampling provides estimates that are generalizable to the national US population.[16,17]

Study period

We selected the five-year period from 2014 to 2018 after meticulous consideration. Two key developments during early 2014 led to a paradigm shift in liver disease care: the Affordable Care Act and the introduction of interferon-free therapy for Hepatitis C. Within months of the Affordable Care Act roll out, 60% of newly insured adults visited a doctor or hospital that they previously could not have afforded, likely contributing to the 870 liver-related deaths-per-year reduction (4350 for the 2014–2018 period).[18,19] Contemporaneously, the approval of sofosbuvir-daclatasvir heralded the era of direct-acting antiviral agents, which were transformative in the fight against Hepatitis C by achieving cure rates of > 95%.[20] Since our study focuses mainly on outcomes directly and abruptly affected by these developments, we opted to study a circumstantially homogenous period to maintain our results' generalizability and external validity. Analogously, technical reasons precluded the inclusion of data beyond 2018. Aggregating and harmonizing pre-2019 data with later years is statistically unfeasible mainly due to procedural changes in sampling weight creation and the discontinuation of Whole-Household data collection that resulted from the 2019 NHIS survey redesign, leading IPUMS NHIS to advise against it formally.[21]

Study population

From a sample consisting of noninstitutionalized adult respondents, patients were selected for inclusion if they identified as having a diagnosis of CLD based on information collected in the Sample Adult Core component of the survey, in which respondents responded affirmatively to either of the following questions: “Ever had any chronic liver condition?” or “Told had a liver condition, past 12 months?”[22,23] We restricted our sample to adults ≥ 18 years of age.

Exposure

Health care–related transportation insecurity

Health care–related transportation insecurity was the primary exposure and was defined as delayed medical care due to transportation barriers. Patients were identified as having health care–related transportation insecurity if they responded affirmatively to the DELAYTRANS survey item: “Have you delayed getting care in the past 12 months because you did not have transportation?”[9]

Covariates

Information on sociodemographic and clinical characteristics are ascertained by self-report and were collected from the NHIS Household Module and Family Core components of the survey as follows: age, sex, race/ethnicity, educational level, marital status, health insurance coverage, family income as a percentage of the federal poverty limit from the Census Bureau for the respective year [high-income (≥ 400%), middle-income (200%–399%), low-income (100%–199%), and very low-income (< 100%)], geographical region, alcohol use (never, former, or current use), self-reported physical functional limitation, and self-reported chronic comorbidities (coronary artery disease, chronic obstructive pulmonary disease, chronic kidney disease, obesity, limiting mental illness, type 2 diabetes) determined *a priori* by a review of prior literature.[4,22,23]

Study Outcomes

Our study had 3 objectives: (1) to examine the sociodemographic and clinical risk factors associated with a higher prevalence of health care–related transportation insecurity, (2) to investigate the association of health care–related transportation insecurity with other social risk factors such as financial insecurity (defined as financial hardship from medical bills or cost-related medication nonadherence) and food insecurity, and (3) to assess the association of health care–related transportation insecurity with self-reported health status, work productivity, outpatient and acute health care utilization, and mortality, either alone or when co-occurring with other social risk factors. Our conceptual figure and modeling strategy are shown in Figure 1 and Supplemental Figure S1, http://links.lww.com/HC9/A715, respectively.

Health care–related financial insecurity

Financial hardship due to medical bills:[22,23] Patients were identified as having financial hardship due to medical bills if they (or anyone in their family) responded affirmatively to any one of the 3 following survey items: (1) “Do you or anyone in your family currently have any medical bills that you are unable to pay at all?”; (2) “Do you or anyone in your family have any medical bills being paid off over time?”; and (3) “Have you or anyone in your family had problems paying or being unable to pay medical bills at some point in the past 12 months?”

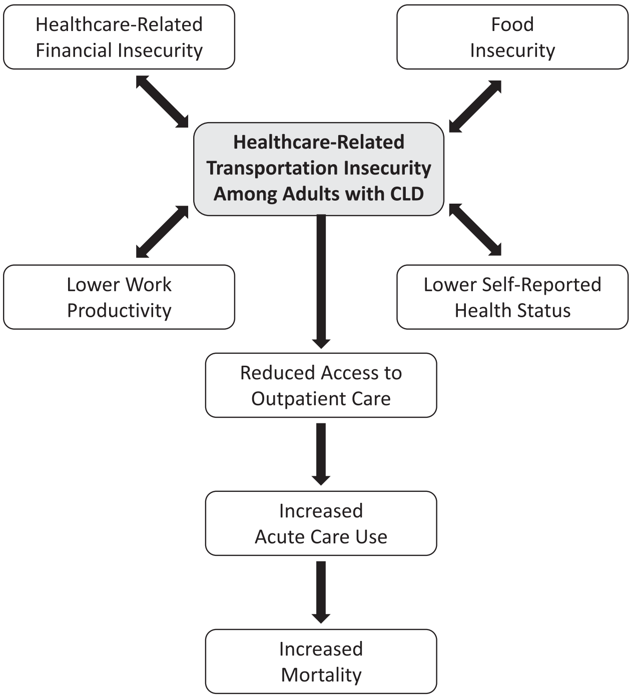

FIGURE 1 Study conceptual framework. Abbreviation: CLD, chronic liver disease.

Cost-related medication nonadherence[22,23]: Patients were identified as having cost-related medication nonadherence if they responded affirmatively to any of the following four survey questions: (1) "In the past 12 months, did you need prescription medication but could not afford it?"; (2) "In the past 12 months, did you take less medication to save money?"; (3) "In the past 12 months, did you skip medication doses to save money?"; and (4) "In the past 12 months, did you delay refilling your medication to save money?"

Food insecurity

We defined food insecurity using the 10-item US Department of Agriculture Economic Research Service questionnaire, which assesses concerns that include food running out, the ability to afford balanced meals, cutting portions, and skipping meals due to costs.[24] To categorize respondents, we created a raw score on the 30-day food security scale and grouped them into three categories: Food Secure (raw score 0–2), Low Food Security (raw score 3–5), or Very low Food Security (raw score 6–10). Participants with low and very low food security were classified as food insecure as per prior studies.[23]

Self-reported health status

Self-reported health status metrics were assessed using the following four NHIS survey questions from the adult general health, mental health, and quality of life/functioning and disability supplements: (1) "Compared with 12 months ago, would you say your health is better, worse, or about the same?" (respondents were categorized as those reporting worse health versus those reporting better/same health); (2) "Do you have difficulty remembering or concentrating?" (a lot/some vs. no difficulty); (3) "During the past 30 days, how often did you feel that everything was an effort?" (all/most vs. some/a little/none of the time); (4) "How often do you feel depressed? Would you say daily, weekly, monthly, a few times a year, or never?" (daily vs. other time points).

Work productivity

Work productivity metrics were assessed using the following two NHIS survey questions: (1) "Did you have a job or business at any time in the past 12 months?" to assess employment during the prior year and (2) "Does a physical, mental, or emotional problem keep you from working?" to assess whether a respondent was unable to work due to poor health.

Health care access and utilization

Outpatient care access was assessed by the following 6 NHIS survey questions: "Needed but could not afford (1) medical care; (2) follow-up care; (3) specialist care; or (4) mental health care" in the past 12 months and "Saw/talked to a (1) general doctor or (2) specialist in the past 12 months."

Acute health care utilization, as defined by emergency department (ED) or emergency room visits and hospital admissions, was derived from the following two NHIS survey questions: (1) "Were you in an ED/emergency room in the past 12 months?" and (2) "Were you in a hospital overnight in the last 12 months?"

Statistical analysis

All statistical analyses were performed with survey-specific tools using Stata, version 18 (StataCorp, College Station, Texas).

Setting up survey data

Generating accurate aggregate key survey design variables is crucial for a multiyear, survey-based study. The NHIS sampling method involves multiple stages of probability sampling, including stratification, clustering, and oversampling of specific subpopulations, which vary each year.[25] To extract our variables while maintaining appropriate stratification, clustering, and weighting, we used the publicly available IPUMS NHIS tool.[17] This tool enables the aggregation of multiyear data and automatically harmonizes key survey design variables, including strata, primary sampling units, and sampling weights, to accurately estimate variance and form representative population estimates while preserving the complex survey structure.[26] Next, per NHIS recommendations, we divided the resulting participant-level weights by the number of years (5) to obtain adjusted sampling weights for our multiyear dataset.[27] Survey-weighted values were used to describe prevalence throughout the article.

Survey diagnostics

All variables in our models had $< 4\%$ missingness. Such data were missing completely at random and were automatically removed by Stata via listwise deletion. Ninety-eight percent of the CLD cohort was eligible for mortality analysis.

Collinearity estimation commands compatible with survey-set data are unavailable in Stata. However, given that weights are only part of the survey design that affects collinearity, forgoing survey-setting the data and incorporating person weights into a linear regression model will enable the postestimation of variance inflation factors and tolerance levels for specified variables. Our dataset had a mean variance inflation factor $= 1.5$, all individual variable variance inflation factor values were < 2.5, and all tolerance levels were > 0.40, showing no evidence of multicollinearity.

Multiple testing

We used the Bonferroni method to obtain adjusted alpha-significance level thresholds for all nonmortality analyses. We adjusted our Cox proportional hazards model using the Benjamini-Hochberg method.

Health care–related transportation insecurity as an outcome

We employed the RaoScott χ^2 test to examine potential differences in the prevalence of sociodemographic characteristics and clinical factors across cohorts based on their transportation insecurity status. Survey-specific univariate and multivariable logistic regression models were used to evaluate the association between these characteristics and the odds of having health care–related transportation insecurity. Survey-specific multivariable logistic regression models accounted for baseline sociodemographic and clinical characteristics: age, sex, marital status, race/ethnicity, education level, family income, insurance status, geographic region, self-reported alcohol use, presence of functional limitations, and comorbidities (CAD, chronic kidney disease, chronic obstructive pulmonary disease, limiting mental illness, obesity, and type 2 diabetes).

Significant predictors were selected to develop a risk factor scoring scale to examine the impact of varying levels of risk-factor burden on health care–related transportation insecurity prevalence. The risk-factor scoring scale was defined as the cumulative sum of the 6 following binary categories: “nonmarried,” “high school nongraduate,” “functionally limited,” “low/very low income,” “nonprivately insured,” “>4 comorbidities”; for a maximum raw score of 6 were all to be true. Based on quartile analysis, the raw score was subsequently refined to four risk categories, ultimately used in the analysis (ie, $\Sigma \leq 1$, $\Sigma = 2$, $\Sigma = 3$, $\Sigma \geq 4$).

Health care–related transportation insecurity as a predictor

We employed the RaoScott x2 test to examine potential differences in the prevalence of each previously defined metric assessing financial hardship from medical bills, cost-related medication nonadherence, food insecurity, self-reported health status, and work productivity based on transportation insecurity status. Survey-specific univariate and multivariable logistic regression models were used to evaluate the association between transportation insecurity and the odds of experiencing these outcomes. For nonbinary, ordinal outcome variables (ie, *# ED visits*, *# Admissions*), multivariable ordinal logistic regression analysis was used. This statistical method allows us to measure the odds of the ordinal dependent variable progressing to the next level tier (eg, in the case of # ED visits from “0–1” to “2–3” visits or from “2–3” to “$>$ 3” visits) per each 1-U increase in the predictor variable (eg, transportation insecurity from “none” to “present”), while all other covariates in the model remain unchanged. Survey-specific multivariable logistic regression models accounted for baseline sociodemographic and clinical characteristics: age, sex, marital status, race/ethnicity, education level, family income, insurance status, geographic region, self-reported alcohol use, presence of functional limitations, and comorbidities (CAD, chronic kidney disease, chronic obstructive pulmonary disease, limiting mental illness, obesity, and type 2 diabetes).

Mortality

All mortality-related analyses were limited to mortality-eligible sample respondents identified by the “mortelig” variable using the NHIS Public Use Linked Mortality file as linked to the US National Death Index. Survey data were weighted using the sample adult weight adjusted to the response rate in mortality analysis as recommended by IPUMS NHIS.[27] Follow-up commenced on the interview date (January 2014–December 2018) and ended on the date of death or study's end (December 31, 2019), whichever occurred first. Kaplan-Meier methods were used to compare all-cause mortality by transportation insecurity status. HR and 95% CI were estimated by building a Cox proportional hazards model and adjusted for age, income (very low/low vs. middle/high), insurance status, numbers of comorbidities, and the presence of other social risk factors such as financial insecurity (financial hardship due to medical bills and cost-related medication nonadherence) and food insecurity. Models were assessed for appropriate fit using Cox-Snell residuals. Wald's Test, a nonparametric Cox regression-based test that accounts for sampling weights, was used to assess for nonequality of survivor functions. Logistic regression model results were reported as adjusted OR (aORs) and corresponding 95% CIs. For all statistical analyses, $p < 0.05$ was considered the level of statistical significance.

RESULTS

From 2014 to 2018, the NHIS total sample was 152,836 surveyed US adults over the age of 18 years, of which 3643 (representing 5.2 million or ~2%) self-reported having CLD. Overall, 40% (95% CI: 38%–42%) belonged to very low-income or low-income families, and 8% (95% CI: 7%–9%) were uninsured. Additional sociodemographic and clinical characteristics are shown in Supplemental Table S1, http://links.lww.com/HC9/A716.

Prevalence of health care–related transportation insecurity among adults with CLD

Overall, 267 (representing 307,628) adults with CLD (survey-weighed proportion, 6%; 95% CI: 5%–7%) reported health care–related transportation insecurity. On multivariable analysis (Table 1), being unmarried (aOR, 1.9; 95% CI: 1.3–2.8), not completing high school (aOR, 1.9; 95% CI: 1.2–2.9), being low income (aOR, 3.0; 95% CI: 1.5–6.1) or very low income (aOR, 4.3; 95% CI: 2.0–9.1), having nonprivate insurance (aOR, 2.3; 95% CI: 1.5–3.6) or being uninsured (aOR, 2.9; 95% CI: 1.6–5.3), having physical function limitations (aOR, 3.6; 95% CI: 1.9–6.8), or having > 4 comorbid conditions (aOR, 2.8; 95% CI: 1.2–7.4) were found to be independently associated with higher odds of health care–related transportation insecurity.

The prevalence of health care–related transportation insecurity by sociodemographic characteristics among adults with CLD is shown in Figure 2. There were no significant differences in the prevalence of health care–related transportation insecurity among adults with CLD by age, sex, race and ethnicity, geographic region, or self-reported alcohol use history. Unmarried adults had a 3-fold higher prevalence of transportation insecurity than married adults (9% vs. 3%, $p < 0.001$). There was an inverse relationship between family income and transportation insecurity, with those from the lowest income households having a 16-fold higher prevalence of transportation insecurity compared to those from the highest income households (16% vs. 1%, $p < 0.001$). The prevalence of transportation insecurity also varied by insurance status, with a 5-fold higher prevalence reported among adults who were uninsured or with nonprivate insurance compared to those with private insurance (10% vs. 2%, $p < 0.001$). The prevalence of transportation insecurity increased with the increasing burden of comorbidities as well as among those reporting physical function limitations (8% vs. 2%, $p = 0.001$).

We observed an increase in the prevalence of health care–related transportation insecurity with an increasing number of high-risk sociodemographic and clinical features (Supplemental Figure S2, http://links.lww.com/HC9/A717). Individuals with ≥ 4 high-risk features had a prevalence of transportation insecurity of 17% (95% CI: 14%–20%) compared to 1% (95% CI: 0.3%–1%) among individuals with ≤ 1 high-risk feature.

Association of health care–related transportation insecurity with health care–related financial insecurity and food insecurity among adults with CLD

Health care–related transportation insecurity was independently associated with worse health care–related financial insecurity and food insecurity among adults with CLD after adjusting for sociodemographic and clinical covariates. Patients with CLD with transportation insecurity had higher odds of cost-related medication nonadherence (aOR, 3.5; 95% CI: 2.4–5.0), financial hardship from medical bills (aOR, 2.1; 95% CI: 1.4–3.0), and food insecurity (aOR, 3.5; 95% CI: 2.4–5.3) (Figure 3, Supplemental Table S2, http://links.lww.com/HC9/A716).

Association of health care–related transportation insecurity with self-reported health status and work productivity among adults with CLD

Patients with CLD with health care–related transportation insecurity had higher odds of self-reported

TABLE 1 Sample characteristics associated with health care–related transportation insecurity among adults with chronic liver disease: Logistic regression analysis

	Univariate regression		Multivariable regression	
	aOR (95% CI)	***p*[a]**	**aOR (95% CI)**	***p*[a]**
Age category				
≥ 65	(Reference)	—	(Reference)	—
40–64	1.2 (0.9–1.8)	0.259	1.3 (0.8–1.9)	0.270
18–39	1.2 (0.7–2.1)	0.589	1.7 (0.9–3.1)	0.070
Sex	—	—	—	—
Female	1.3 (0.9–1.8)	0.121	1.3 (0.9–1.9)	0.147
Marital status				
Not married	3.7 (2.5–5.5)	< **0.001**	1.9 (1.3–2.8)	**0.003**
Race and Ethnicity				
Non-Hispanic White	(Reference)	—	(Reference)	—
Non-Hispanic Black	2.0 (1.3–3.1)	**0.003**	1.3 (0.8–2.2)	0.349
Non-Hispanic Asian	0.2 (0.1–0.6)	0.005	0.2 (0.1–1.0)	0.055
Hispanic	0.9 (0.6–1.4)	0.768	0.7 (0.4–1.2)	0.256
Other	2.2 (0.8–6.2)	0.153	1.2 (0.5–3.0)	0.630
Graduated high school				
No	2.9 (2.0–4.2)	< **0.001**	1.9 (1.2–2.9)	**0.004**
Family income[b]				
High	(Reference)	—	(Reference)	—
Middle	2.2 (1.0–5.0)	0.049	1.5 (0.7–3.4)	0.341
Low	7.1 (3.5–14.3)	< **0.001**	3.0 (1.5–6.1)	**0.003**
Very low	14.2 (6.9–29.0)	< **0.001**	4.3 (2.0–9.1)	< **0.001**
Insurance status				
Private	(Reference)	—	(Reference)	—
Nonprivate	5.6 (3.7–8.5)	< **0.001**	2.3 (1.5–3.6)	< **0.001**
Uninsured	5.8 (2.9–11.3)	< **0.001**	2.9 (1.6–5.3)	**0.001**
Region				
Northeast	(Reference)	—	(Reference)	—
Midwest	1.3 (0.8–2.2)	0.333	1.2 (0.7–2.1)	0.592
South	1.2 (0.7–1.9)	0.542	0.8 (0.5–1.3)	0.391
West	0.8 (0.5–1.4)	0.410	0.8 (0.5–1.6)	0.588
Alcohol use				
Lifetime abstainer	(Reference)	—	(Reference)	—
Former	1.3 (0.8–2.1)	0.322	1.0 (0.6–1.7)	0.974
Current	0.9 (0.6–1.4)	0.643	1.1 (0.7–1.8)	0.683
Functional limitation				
Present	4.8 (2.8–8.3)	< **0.001**	3.6 (1.9–6.8)	< **0.001**
Number of comorbidities[c]				
0	(Reference)	—	(Reference)	—
1–2	1.1 (0.7–1.8)	0.570	0.7 (0.5–1.1)	0.137
3–4	2.0 (1.2–3.4)	0.010	0.9 (0.5–1.5)	0.576
> 4	4.5 (1.7–12.1)	**0.003**	2.8 (1.2–7.4)	**0.037**

[a]ORs, 95% CIs, and p values were obtained through survey-specific logistic regression. Multivariable model included the following: age, sex, marital status, race and ethnicity, education status, family income, insurance status, region, alcohol use, presence of functional limitations, and comorbidity burden. Adjusted α significance thresholds were obtained through Bonferroni where appropriate. Bold indicates p-values < 0.05.
[b]Very low < 100% NPR; low = 100–199% NPR; mid = 200–399% NPR; high ≥ 400% NPR.
[c]Coronary artery disease, chronic kidney disease, chronic obstructive pulmonary disease, mental illness, obesity, and type 2 diabetes.
Abbreviations: aOR, adjusted OR; NPR, national poverty rate.

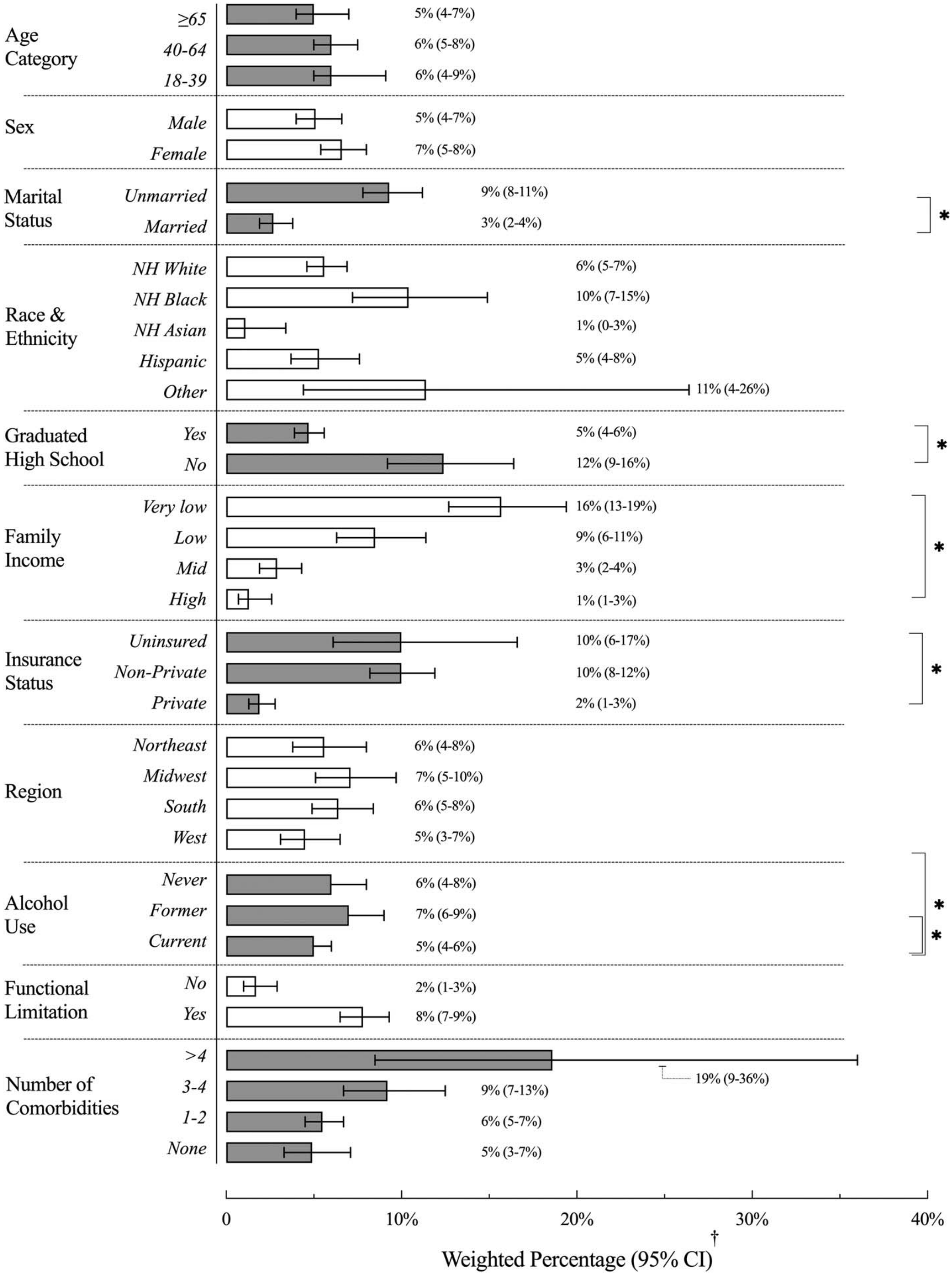

FIGURE 2 Sample characteristics and weighted prevalence of health care–related transportation insecurity among adults with chronic liver disease. Abbreviations: NH, non-Hispanic; NPT, national poverty rate.

worsening health status over the past year (aOR, 2.5; 95% CI: 1.7–3.7), difficulty concentrating or remembering (aOR, 2.6; 95% CI: 1.5–4.5), reporting that everything feels like an effort most of the time (aOR, 2.3; 95% CI: 1.5–3.6), and feeling depressed on a daily basis (aOR, 2.7; 95% CI: 1.5–4.9) (Figure 4A, Supplemental Table S3, http://links.lww.com/HC9/A716). Transportation insecurity was independently associated with being unable to work due to poor health (aOR, 3.1; 95% CI: 2.0–4.9) and lower odds of employment during the past year (aOR, 0.5; 95% CI: 0.3–0.7) (Figure 4B, Supplemental Table S4, http://links.lww.com/HC9/A716).

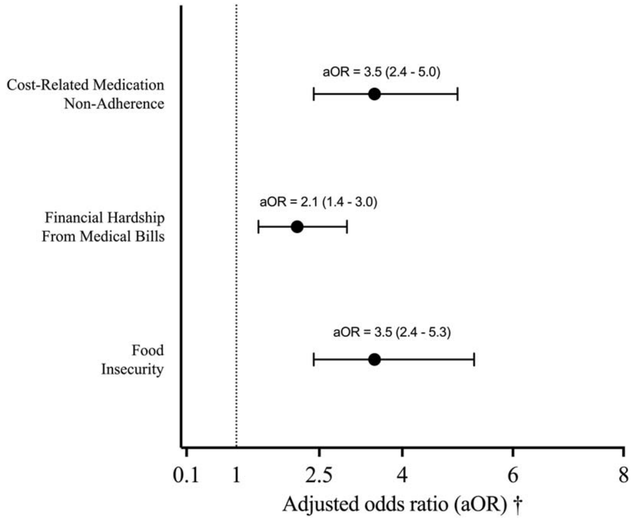

FIGURE 3 Association of health care–related transportation insecurity with other social risk factors among adults with chronic liver disease. Abbreviation: aOR, adjusted OR.

Association of health care–related transportation insecurity with health care utilization among adults with CLD

Health care–related transportation insecurity was significantly associated with reduced access to outpatient care and higher risk and burden of acute health care utilization among adults with CLD.

On multivariate ordinal regression modeling, health care–related transportation insecurity was associated with needing but being unable to afford medical care (aOR, 3.0; 95% CI: 2.1–4.4), follow-up care (aOR, 6.1; 95% CI: 4.0–9.4), specialist care (aOR, 5.8; 95% CI: 3.9–8.7), or mental health care (aOR, 6.7; 95% CI: 4.2–10.6) over the preceding year (Figure 5A, Supplemental Table S5, http://links.lww.com/HC9/A716). Notably, there was no association of health care–related transportation insecurity with having seen or talked to a general doctor or specialist over the preceding year. On multivariate ordinal regression modeling, transportation insecurity was additionally associated with being in a higher-risk category group for number of visits to the ED (aOR, 2.1; 95% CI: 1.5–3.0) and hospital admissions (aOR, 1.7; 95% CI: 1.2–2.5) during the previous year (Figure 5B, Supplemental Table S6, http://links.lww.com/HC9/A716).

Association of health care–related transportation insecurity with mortality among adults with CLD

Among adults with CLD, the presence of health care–related transportation insecurity was associated with a higher risk of all-cause mortality ($p = 0.024$) (Figure 6). Transportation insecurity was independently associated with mortality (aHR, 1.7; 95% CI: 1.4–2.0) after controlling for age, income, insurance status, comorbidity burden, and presence of other social risk factors (financial hardship from medical bills, cost-related medication nonadherence, and food insecurity) (Table 2).

DISCUSSION

In a nationally representative of US adults with self-reported CLD, ~308,000 (6%) identified delaying medical care due to transportation barriers. We found higher rates of health care–related transportation insecurity among those living in poverty, those with self-reported functional limitations, and the underinsured and uninsured. Adults with CLD experiencing reporting health care–related transportation insecurity also had a higher likelihood of having other social risk factors such as financial insecurity and food insecurity.

FIGURE 4 (A) Association of health care–related transportation insecurity with self-reported health status metrics among adults with chronic liver disease. (B) Association of health care–related transportation insecurity with work productivity metrics among adults with chronic liver disease. Abbreviation: aOR, adjusted OR.

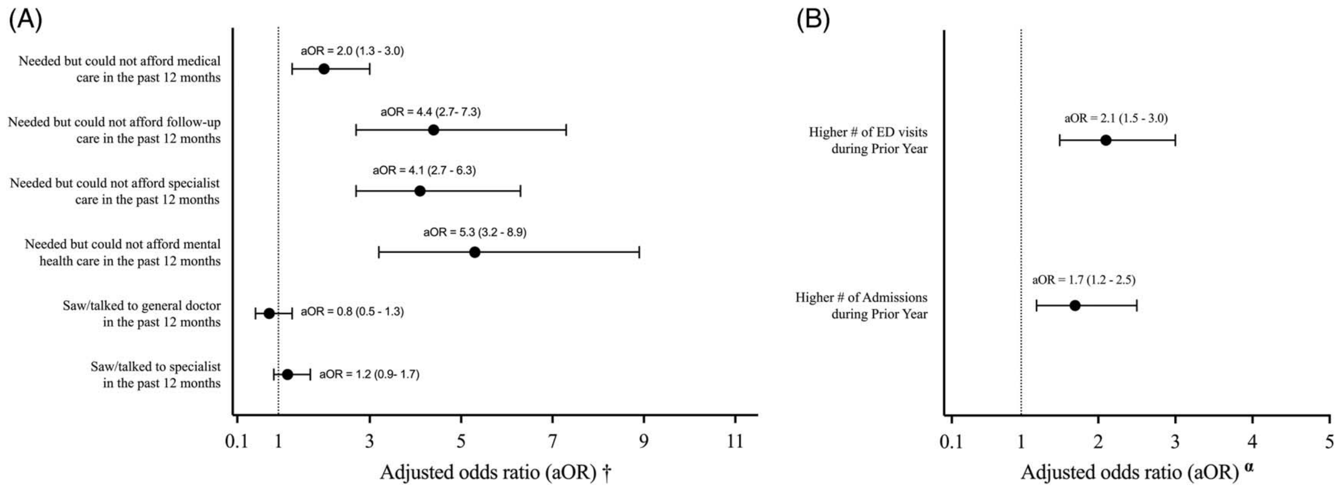

FIGURE 5 (A) Association of health care–related transportation insecurity with access to outpatient care among adults with chronic liver disease. (B) Association of health care–related transportation insecurity with acute health care utilization among adults with chronic liver disease. Abbreviations: aOR, adjusted OR; ED, emergency department.

Health care–related transportation insecurity was independently associated with poorer self-reported health status, work productivity loss, reduced access to outpatient care, and increased acute health care utilization. Notably, adults with CLD experiencing health care–related transportation insecurity were found to have an ~2-fold higher risk of mortality after controlling for income and the presence of social risk factors such as financial and food insecurity. Our findings establish transportation insecurity as a critical social risk factor for patients with CLD.

Health care–related transportation insecurity as a critical social risk factor among adults with CLD

The 6% rate of health care–related transportation insecurity among adults with CLD is higher than that reported in the general population (1.8%) or among patients with cancer (3.1%) and CAD (4.5%).[7–9] We have further demonstrated that health care–related transportation insecurity is unique from other social risk factors such as food insecurity and financial insecurity (eg, cost-related medication nonadherence) in that it is independently associated with mortality after controlling for income. This finding is important for 2 reasons. First, because health care–related transportation insecurity is not a surrogate for poverty, it is a potentially more modifiable and intervenable social risk factor and thus represents a critical target for interventions to improve the health of adults with CLD by health care systems. Second, examining mechanisms for health care–related transportation insecurity beyond income level is an important aspect of future intervention and policy work.

Travel distance and health care–related transportation insecurity among adults with CLD

The poor health outcomes associated with health care–related transportation insecurity among patients with CLD may additionally be related to the travel burden experienced by this population in accessing specialty hepatology care. Several studies using Veterans Health Administration data have examined the relationship between travel distance and access to care for patients with CLD.[28,29] In one study by Goldberg et al, Veterans with cirrhosis who lived in the highest quintile of distance from their assigned center were less likely to undergo surveillance imaging for HCC.[29] Prior work has shown an increase in cirrhosis-related mortality in rural areas in the United States, which may be due in part to distance from tertiary-level care at liver transplant centers.[30–32]

Impact of hepatic encephalopathy on health care–related transportation insecurity

Among adults with CLD, those with HE may be at particularly high risk of experiencing health care–related transportation insecurity. We notably found an independent association of transportation insecurity with self-reported difficulty concentrating and remembering. HE has been associated with impaired driving performance in multiple studies.[33–37] It is currently recommended that patients with a recent episode of overt hepatic HE avoid driving for 3 months based on expert consensus.[37,38] However, there are no clear guidelines on how to assess driving fitness among patients with

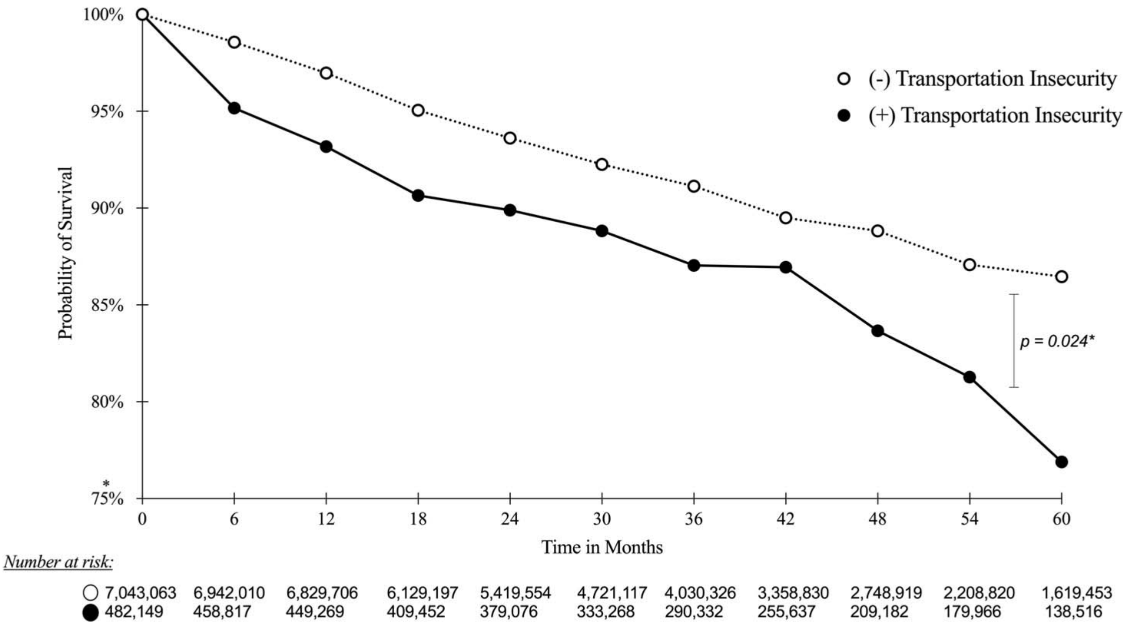

FIGURE 6 Kaplan-Meier survival estimates by presence of health care–related transportation insecurity among adults with chronic liver disease.

minimal HE. This may cause patients with HE to be at higher risk of experiencing transportation barriers due to potentially inappropriate driving restrictions for this population, despite recent evidence demonstrating that a diagnosis of minimal HE should not be used alone to restrict driving.[37,39]

Potential solutions

Health care–related transportation insecurity is an easily identifiable and modifiable social risk factor to improve the health care of patients with CLD. Health care–related transportation insecurity can be quickly assessed at the point of clinical care using single-item questions such as the one used in the NHIS or questions such as "Do you have difficulty with transportation to get to and from care?"[40] The Transportation Barriers Measure is a validated tool to assess barriers in access to both private and public transportation in urban settings.[41] Patients who screen positive for health care–related transportation insecurity should also be screened for other health-related social risk factors that often co-occur with it, such as financial insecurity and food insecurity. Broader screening for social risk factors may be done using tools such as the Accountable Health Communities Screening Tool or the Supportive Needs Assessment Tool for Cirrhosis.[42–45]

At the clinic and hospital levels, the travel burden for patients with CLD and their caregivers may be reduced by expanding access to telemedicine and hospital-at-home models of care.[46,47] Telemedicine is shown to be highly feasible and acceptable to patients and clinicians and can enhance usual care.[48–51] However, telehealth can exacerbate health care disparities among patients with low digital literacy and low access to technology; furthermore, threats to telehealth include the reintroduction of interstate licensure requirements and changes to reimbursement.[52] Future studies need to prospectively examine the costs and outcomes associated with telemedicine for patients with chronic health conditions and transportation barriers.

Rideshare-based or transportation and parking voucher programs may be scalable approaches to increase the access of patients with CLD to hepatology and transplant clinics as well as HCC and variceal screening.[53–55] Clearer clinical guidelines are needed regarding the duration of driving restrictions and pragmatic approaches to assessing driving fitness for patients with HE, who may be particularly vulnerable to transportation insecurity. Lastly, there is a need for advocacy through hepatology societies and governmental organizations to support research funding and policy reform that address social determinants of health and social risk factors in CLD care.[56]

Limitations

Our results should be interpreted in the context of the study design. First, given the observational nature of our study, we are unable to establish causality or the directionality of the associations we observed. Even with adjusting for relevant sociodemographic and clinical characteristics, unmeasured and residual confounding may persist. Second, the NHIS relies on self-reported

TABLE 2 Impact of health care–related transportation insecurity on mortality among adults with chronic liver disease: Proportional Cox regression hazard estimates

	Respondent status		Univariate regression		Multivariable regression	
	Alive % (95% CI)	Deceased (95% CI)	HR (95% CI)	p[a]	aHR (95% CI)	p[a]
Transportation insecurity						
Insecure	83 (76–88)	17 (12–24)	2.4 (2.0–2.8)	**< 0.001**	1.7 (1.4–2.0)	**< 0.001**
Secure	89 (88–91)	11 (10–12)	—	—	—	—
Age						
≥ 65	79 (75–81)	21 (19–25)	10.0 (9.3–10.8)	**< 0.001**	7.8 (7.0–8.6)	**< 0.001**
< 65	93 (91–94)	7 (6–9)	—	—	—	—
Income						
Low/very low	86 (84–88)	14 (12–16)	1.7 (1.6–1.8)	**< 0.001**	1.9 (1.7–2.2)	**< 0.001**
Middle/high	91 (89–92)	9 (8–11)	—	—	—	—
Insurance						
Nonprivate/uninsured	85 (83–87)	15 (13–17)	2.3 (2.2–2.5)	**< 0.001**	1.4 (1.3–1.6)	**< 0.001**
Private	93 (91–94)	7 (6–9)	—	—	—	—
Comorbidities[b]						
Any	89 (87–90)	11 (10–13)	2.3 (2.1–2.5)	**< 0.001**	1.5 (1.4–1.7)	**< 0.001**
None	90 (88–92)	10 (8–12)	—	—	—	—
Financial hardship from medical bills						
Present	91 (89–93)	9 (7–11)	1.3 (1.2–1.4)	**< 0.001**	1.2 (1.1–1.4)	**0.001**
Absent	94 (92–95)	6 (5–8)	—	—	—	—
Food insecurity						
Insecure	87 (83–90)	13 (10–17)	1.7 (1.5–1.8)	**< 0.001**	1.1 (0.9–1.2)	0.201
Secure	94 (92–95)	6 (5–7)	—	—	—	—
Cost-related medication nonadherence						
Present	91 (88–94)	9 (6–12)	1.1 (1.0–1.2)	**0.08**	1.1 (0.9–1.3)	0.201
Absent	92 (90–94)	8 (6–10)	—	—	—	—

[a]HRs, 95% CIs, and p values were obtained through the survey-weighted Cox proportional hazards model. aHRs were obtained through multivariable Cox regression controlling for the covariates included above. Expected and known interactions were modeled to account for effect modification. Interactions between income and financial hardship; insurance status and income; and age over 65 and CRN were found to be significant and included in the final model. FDR was calculated through the Benjamin-Hochberg method, and corresponding adjusted p values are shown. Bold indicates p-values < 0.05. Collinearity was assessed and appropriate with a mean VIF of 1.50.
[b]Coronary artery disease, chronic obstructive pulmonary disease, chronic kidney disease, obesity, mental illness, type 2 diabetes.
Abbreviations: aHR, adjusted HR; FDR, false discovery rate; VIF, variance inflation factor.

diagnoses as opposed to a validated assessment of CLD. However, the data from the NHIS serve as the basis for official estimates of the burden of CLD in the United States by the Centers for Disease Control and Prevention.[57] Third, we lack clinical data on the etiology, complications, and severity of CLD. Assessing the effect of clinical factors, especially HE, on health care–related transportation insecurity and vice versa in the population with CLD should be an area of future investigation. Fourth, there was no information in the NHIS dataset on rural-urban classification of participants over the study period, which would have allowed for a closer examination of the impact of geography on the observed outcomes. Fifth, given the study time period from 2014 to 2018, we did not capture the impact of temporal trends in telemedicine use post-COVID-19 pandemic on health care–related transportation insecurity. Lastly, the NHIS uses a single item to capture transportation insecurity. However, health care–related transportation insecurity can be due to multiple factors: financial barriers (inability to pay for gas, public transportation, or parking); limited access to public transit; physical distance from primary, specialty, and pharmacy care; physical or cognitive impairments limiting use of personal or public transportation; and limited caregiver support. More granular data are needed to examine the multifaceted contributors to transportation insecurity in the population with CLD to guide approaches to screening and future intervention development.

In conclusion, ~308,000 (6%) adults with CLD report health care–related transportation insecurity, which is associated with poor self-reported health status and increased health care utilization and mortality. Health care–related transportation insecurity is a critical social risk factor in CLD, and there is an urgent need for feasible and scalable interventions, clinical programs, and policy reform to address transportation barriers and improve clinical outcomes.

AUTHOR CONTRIBUTIONS

Ufere, Lago-Hernandez, and Serper: Study concept and design; Ufere, Lago-Hernandez, Alejandro-Soto, and Serper: analysis and interpretation of data; Ufere, Lago-Hernandez, and Walker: Drafting of the manuscript; Ufere, Lago-Hernandez, Alejandro-Soto, Walker, Li, Schoener, Keegan, Gonzalez, Bethea, Singh, El-Jawahri, Nephew, Jones, and Serper: Critical revusion of the manuscript for important intellectual content; Lago-Hernandez: Statistical analysis; Ufere: Guarantor of the article.

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CONFLICTS OF INTEREST

Siddharth Singh received grants from Pfizer and AbbVie. Areej El-Jawahri consults for Incyte, GlaxoSmithKline, Novartis, and Tuesday Health. Marina Serper received grants from Grifols SA. The remaining authors have no conflicts to report.

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