Title
Barriers to Care among Adults with Chronic Liver Disease in the United States

Author
Wong, Carrie

Publication Date
2023

UNIVERSITY OF CALIFORNIA

Los Angeles

Barriers to Care among Adults with Chronic Liver Disease in the United States

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Health Policy and Management

by

Carrie Ruby Wong

2023

ABSTRACT OF THE DISSERTATION

Barriers to Care among Adults with Chronic Liver Disease in the United States

by

Carrie Ruby Wong

Doctor of Philosophy in Health Policy and Management

University of California, Los Angeles, 2023

Professor Roshan Bastani, Co-Chair

Professor James Macinko, Co-Chair

Chronic liver disease is increasingly prevalent with high rates of morbidity and mortality, yet it receives less attention than other similar chronic diseases such as cardiovascular disease and chronic obstructive pulmonary disease. Barriers to timely medical care may preclude diagnosis and management and thus, exacerbate potentially avoidable morbidity and mortality for persons with chronic liver disease. This dissertation explored the extent of health care barriers among adults with chronic liver disease compared to other chronic conditions and identified latent classes derived from different health care barriers to phenotype those at highest risk for recurrent acute care use within the adult population with chronic liver disease in the United States.

The first paper, "Evaluation of the Extent of Health Care Barriers among Adults with Chronic Liver Disease vs. Other Chronic Diseases in the United States," compared estimates of any and the number of health care barriers and the association of recurrent acute care use by prevalence of barriers to care among adults with chronic liver disease versus those with cardiovascular disease and/or chronic obstructive pulmonary disease. Using a multivariable hurdle model, the study found that adults with chronic liver disease were significantly more likely to have any barriers to care (incident rate ratio, 1.12), but such a significant difference did not exist for the frequency of health care barriers. There was a dose-dependent relationship between likelihood of recurrent acute care use and prevalence of barriers to care. Inclusion of chronic liver disease as a high-risk group in future health policies that aim to improve access to care may help reduce challenges that persons with chronic liver disease encounter when seeking timely medical care and potentially reduce preventable acute care use.

The second paper, "Identification of Hidden Phenotypes Using Self-Reported Barriers to Care to Predict Risk of Recurrent Hospitalization or Emergency Department Visits among Adults with Chronic Liver Disease in the United States," identified latent classes within the adult population with chronic liver disease using self-reported barriers to care and assessed each phenotype's likelihood of recurrent acute care use. The best fitting model to the data included four latent classes or phenotypes: minimal barriers, unaffordability, care delays, and inability to establish care. The study used a multivariable multinomial logistic regression model to identify likelihood of class membership. The unaffordability phenotype was significantly associated with younger age, fair or poor health, functional limitation due to health, and uninsurance. Membership in the care delays class was significantly associated with Hispanics, fair or poor health, and functional limitation due to health. The inability to establish care phenotype was significantly associated with younger age, female sex, functional limitation due to health, and non-private insurance. The inability to establish care group had the highest odds of recurrent acute care use, followed by the care delays and unaffordability groups. An emphasis on risk stratification using health care barriers can potentially help improve interventions that aim to reduce recurrent acute care use among adults with chronic liver disease, particularly for those who struggle to establish care.

In summary, both chapters highlighted the prevalence of health care barriers and its association with recurrent acute care use for adults with chronic liver disease. Findings from the second chapter showed the consistent disparity in health care barriers for adults with chronic liver disease versus other chronic diseases and aimed to capture the attention of health policy makers to include chronic liver disease in future iterations of existing health policies or new programs that strive to improve outpatient care access to reduce preventable hospitalizations. The third chapter identified novel phenotypes of persons with chronic liver disease with different associated sociodemographic, health, and insurance characteristics and risks of recurrent acute care use. The third chapter also introduced the concept of using self-reported barriers to care as a way to risk stratify and allocate resources to the most vulnerable individuals with chronic liver disease. Both chapters intend to help improve health care access, reduce preventable acute care use, and potentially improve the morbidity and mortality trends among adults with chronic liver disease in the United States.

The dissertation of Carrie Ruby Wong is approved.

Catherine M. Crespi-Chun

Beth Ann Glenn-Mallouk

Steven-Huy B. Han

James A. Macinko, Jr., Committee Co-Chair

Roshan Bastani, Committee Co-Chair

University of California, Los Angeles

2023

DEDICATION

For my husband, daughter, and grandmother 婆婆

TABLE OF CONTENTS

LIST OF FIGURES

Chapter I:

Chapter II:

Chapter III:

LIST OF TABLES

Chapter II:

Chapter III:

ACKNOWLEDGMENTS

My journey in this graduate program would not have been possible without the steadfast support of the UCLA Vatche and Tamar Manoukian Division of Digestive Diseases, Specialty Training and Advanced Research Program, Department of Health Policy and Management in the Fielding School of Public Health, Center for Health Equity/ Cancer Control and Prevention, and the Ruth L. Kirschstein-National Research Service Award (HRSA T32 HP19001).

I am sincerely grateful for the members of my Dissertation Committee, Department of Health Policy Management faculty and staff, classmates, and statistical consulting through the UCLA Office of Advanced Research Computing. I am especially grateful for my advisor and dissertation chair, Dr. Roshan Bastani, for her constant support and guidance as I embark on this journey to becoming a researcher and mother. Under the tutelage of Dr. Bastani, she has taught me to think and conceptualize thoughtful and impactful questions and encouraged me to conduct high-quality research that has the practical intent of improving outcomes for vulnerable populations. I would like to express my deep appreciation for my dissertation co-chair, Dr. James Macinko, who has been an unwavering supporter, mentor, and teacher. I would also like to thank my committee members, Drs. Catherine Crespi, Beth Glenn, and Steven Han for their expertise and invaluable feedback. I am grateful for all of the mentors, advisors, and collaborators, who have openly shared their wisdom and experiences over the years to help me navigate this journey to becoming a clinician-investigator.

Finally, I would like to thank my parents, sister, and friends at UCLA for their support. I am fortunate to have my husband, Zander, as my guiding light and co-pilot in this journey. Thank you for caring for Thea on the weekends as I worked on this dissertation. Thank you to my daughter, Thea, for bringing such joy into my life beyond anything I could have ever imagined. I am also grateful for my grandmother, 婆婆, who survived advanced colon cancer during the COVID-19 pandemic as I was in graduate school and has remained a constant source of inspiration for me.

For Chapters II and III, Drs. Roshan Bastani, James Macinko, Catherine Crespi, Beth Glenn, and Steven Han provided direction and feedback on the study conceptualization, design, statistical analysis, interpretation of findings, and development of policy and practice recommendations. Dr. James Macinko provided guidance on data acquisition. Drs. Crespi and Macinko provided guidance on advanced statistical analyses. All authors contributed to manuscript review of this dissertation.

VITA

Education

2004-2008	B.A., Public Health: University of California, Berkeley
2010-2014	M.D.: Stony Brook University School of Medicine
2014-2015	Internship: Northwell Residency Program in Internal Medicine
2015-2017	Residency: Yale University Traditional Internal Medicine Residency Program
2017-2021	Gastroenterology Fellowship: University of California, Los Angeles
2021-2022	Transplant Hepatology Fellowship: University of California, Los Angeles
2018-2023	Ph.D. Candidate in Health Policy and Management, Epidemiology Cognate: University of California, Los Angeles

Peer-Reviewed Manuscript Publications

1. **Wong C.R.,** Lim J.K. Increasing contribution of non-alcoholic fatty liver disease to hepatocellular carcinoma incidence and mortality in U.S. Medicare. *Hepatobiliary Surgery and Nutrition* 2019;8(5):506-508.

2. **Wong C.R.,** Lim J.K. The Association between Nonalcoholic Fatty Liver Disease (NAFLD) and Cardiovascular Disease Outcomes. *Clinical Liver Disease* 2018;12(2):39-44.

3. **Wong C.R.**, Nguyen M.H., Lim J.K. Hepatocellular Carcinoma in Patients with Non-Alcoholic Fatty Liver Disease (NAFLD). *World J Gastroenterol* 2016;22(37):8294-8303.

4. **Wong C.R.**, Njei B., Nguyen M.H., Nguyen A., Lim J.K. Survival after treatment with curative intent for hepatocellular carcinoma among patients with vs. without non-alcoholic fatty liver disease. *Aliment Pharmacol Ther* 2017;46(11-12):1061-1069.

5. Wang C., Chen V., Vu V., Le A., Nguyen L., Zhao C., **Wong C.R.**, Nguyen N., Li J., Zhang J., Trinh H., Nguyen M.H. Poor adherence and low persistency rates for hepatocellular carcinoma surveillance in patients with chronic hepatitis B. *Medicine (Baltimore)* 2016;95(35):e4744.

6. Yee B.E., Nguyen N.H., Zhang B., Lin D., Vutien P., **Wong C.R.**, Lutchman G.A., Nguyen M.H. Sustained virological response and its treatment predictors in hepatitis C virus genotype 4 compared to genotypes 1, 2, and 3: a meta-analysis. *BMJ Open Gastroenterology* 2015;2(1):e000049.

7. Yee B.E., Nguyen N.H., Zhang B., Vutien P., **Wong C.R.**, Lutchman G.A., Nguyen M.H. Meta-analysis: influence of host and viral factors in patients with chronic hepatitis C genotype 4 treated with pegylated interferon and ribavirin. *European Journal of Gastroenterology & Hepatology* 2014;26(11):1189-1201.

8. Do A.L., **Wong C.R.,** Nguyen L.H., Nguyen V.G., Trinh H.N., Nguyen M.H. Hepatocellular Carcinoma Incidence in Noncirrhotic Patients With Chronic Hepatitis B and Patients With

Cirrhosis of All Etiologies. *Journal of Clinical Gastroenterology* 2014;48(7):644-649.

9. **Wong C.R.**, Bloomfield E.R., Crookes D.M., Jandorf L. Barriers and Facilitators to Adherence to Screening Colonoscopy among African-Americans: A Mixed-Methods Analysis. *Journal of Cancer Education* 2013;28(4):722-728.

10. Jandorf L., Braschi C., Ernstoff E., **Wong C.R.**, Thelemaque L., Winkel G., Thompson H.S., Redd W.H., Itzkowitz S.H. Culturally Targeted Patient Navigation for Increasing African Americans' Adherence to Screening Colonoscopy: A Randomized Clinical Trial. *Cancer Epidemiology, Biomarkers & Prevention* 2013;22(9):1577-1587.

11. Ha N.B., Trinh H.N., Nguyen T.T., Leduc T.S., Bui C., Ha N.B., **Wong C.R.**, Tran A.T., Nguyen M.H. Prevalence, risk factors, and disease knowledge of chronic hepatitis B infection in Vietnamese Americans in California. *Journal of Cancer Education* 2013;28(2):319-324.

12. Edwards T.A., Jandorf L., Freemantle H., Sly J., Ellison J., **Wong C.R.**, Villagra C., Hong J., Kaleya S., Poultney M., Villegas C., Brenner B., Bickell N. Cancer care in East and Central Harlem: community partnership needs assessment. *Journal of Cancer Education* 2013;28(1):171-178.

13. Yip B., Chaung K., **Wong C.R.**, Trinh H.N., Nguyen H.A., Ahmed A., Cheung R., Nguyen M.H. Tenofovir monotherapy and tenofovir plus entecavir combination as rescue therapy for entecavir partial responders. *Digestive Diseases and Sciences* 2012;57(11):3011-3016.

14. **Wong C.R.**, Trinh H.N., Yip B., Nguyen H.A., Garcia R.T., Ahmed A., Keeffe E.B., Nguyen M.H. High rate of complete viral suppression with combination therapy in patients with chronic hepatitis B and prior treatment failure. *Journal of Clinical Gastroenterology* 2011;45(10):900-905.

15. **Wong C.R.**, Garcia R.T., Trinh H.N., Lam K.D., Ha N.B., Nguyen H.A., Nguyen, Nguyen K.K., Levitt B.S., Nguyen M.H. Adherence to screening for hepatocellular carcinoma among patients with cirrhosis or chronic hepatitis B in a community setting. *Digestive Diseases and Sciences* 2009;54(12):2712-2721.

Select Peer-Reviewed Abstract Oral Presentations

1. **Wong C.R.**, May F.P., Macinko J. Association of Barriers to Care and Hospital Utilization for Chronic Liver Disease in the United States. *Gastroenterology* 2020;158(6):S1268-1269. *Digestive Disease Week 2020, Chicago, Illinois, USA.*

2. **Wong C.R.**, Limketkai B.N., Sauk J.S. Association of Inflammatory Bowel Disease (IBD) and Barriers to Medical Care: Results from a National Sample Representative of Over Three Million Adults with IBD in the United States. *Gastroenterology* 2020;158(6):S98. *Digestive Disease Week 2020, Chicago, Illinois, USA.*

3. **Wong C.R.**, May F.P., Han S.B., Macinko J. Chronic Liver Disease is Associated with Increased Barriers to Medical Care: Results from a National Sample Representative of Over 116 Million Individuals in the United States 2013-2017. *Hepatology* 2019;70(1):S83A. *The Liver Meeting 2019, Boston, Massachusetts, USA.*

CHAPTER I: INTRODUCTION

Chronic liver disease (CLD) contributes to significant morbidity and mortality as the 9th leading cause of death in the United States (US) (National Center for Health Statistics, 2023). Increasing disease-specific hospitalization rates and disability-adjusted life years (DALYs) reflect the growing public health burden of CLD. Liver-specific hospitalizations have increased 23% to 3,757 per 100,000 hospitalizations from 2012 to 2016 (Hirode, Saab, & Wong, 2020), and CLD-related DALYs have increased 27.3% to 2.33 million from 2007 to 2017 (Paik, et al., 2021).

CLD affects 4.5 million adults in the US (National Center for Health Statistics, 2023). However, estimates from the Centers for Disease Control and Prevention (CDC) are likely an underestimation based on rates of the leading types CLD, including alcohol- and metabolic dysfunction-associated steatotic liver disease (MASLD), which affect over 10 and 80 million Americans, respectively (Wong, Dang, Ladhani, Singal, & Wong, 2019; Younossi, et al., 2016). Additionally, CLD usually follows an indolent, asymptomatic course and is commonly found incidentally or in its advanced stages when one develops symptoms from liver disease complications (Schuppan & Afdhal, 2008; Bertot, et al., 2017). Therefore, population estimates of CLD using hospital- or health system-based data or diagnostic codes from administrative databases may undercount those who are asymptomatic and do not connect with health care. This is supported by the discrepant estimates of CLD using self-reports, community-based screening, and administrative databases.

Persons at-risk of the most common causes of CLD, including alcohol-associated liver disease (ALD) and MASLD, often share sociodemographic vulnerabilities. The disease burden of ALD disproportionately affects younger adults (Tapper & Parikh, 2018), women (Pollard, Tucker, & Green, 2020), and American Indian or Alaska Natives (Kulkarni, Wadhwa, Kanwal, & Chhatwal, 2023). From 2009 to 2016, adults aged 25 to 34 years old experienced the highest average annual percentage change in death from cirrhosis (10.5%), which was largely driven by alcohol-associated cirrhosis (Tapper & Parikh, 2018). Females, who have a biological susceptibility to ALD due to sex-based differences in alcohol metabolism (Frezza, et al., 1990), have been reported to have relatively more heavy drinking days (0.18 increase for women, 0.07 increase) in the setting of overall higher rates of alcohol use and ALD from 2019 to 2020 (Pollard, Tucker, & Green, 2020). Greater biological susceptibility and high-risk drinking patterns are likely contributing to worsening ALD trends for women compared to men. From 2015 to 2016, the prevalence of advanced fibrosis in the setting of ALD for women doubled from 0.05 to 0.1 in comparison to men (0.1 to 0.4) during the study period from 2001-2002 to 2015-2016 (Wong, Dang, Ladhani, Singal, & Wong, 2019). During the COVID-19 pandemic, ALD-related deaths increased by 22.4% (White, Castle, Powell, Hingson, & Koob, 2022), and the age-adjusted mortality rates between 2019 and 2020 were largest for American Indians or Alaskan Natives (34.3% from 20.1 to 27.0 per 100,000 people) (Kulkarni, Wadhwa, Kanwal, & Chhatwal, 2023).

MASLD disproportionately affects Hispanic individuals (Rich, et al., 2018) and those with economic hardship (Chen, Song, Suresh, Wadhwani, & Perumalswami, 2023; Golovaty, et al., 2020). Compared to White individuals, Hispanics were 36% were more likely to have MASLD and 24% more likely to have metabolic dysfunction-associated steatohepatitis (MASH), which is the more severe and progressive form of the disease (Rich, et al., 2018). A study that used neighborhood-level measurements of socioeconomic status found that individuals with MASLD who resided in disadvantaged areas had a two-fold higher risk of death (hazard ratio, 2.08) (Chen, Song, Suresh, Wadhwani, & Perumalswami, 2023). Similarly, food insecurity has been identified as an independent risk factor associated with MASLD among adults in low-income households (Golovaty, et al., 2020).

Food-insecure persons were 1.38 and 2.20 times more likely to have MASLD and advanced fibrosis, respectively compared to food secure individuals (Golovaty, et al., 2020).

Socioeconomic disparities among persons with ALD and MASLD also impact access to care. Women, non-White race/ethnicity, and differences in insurance coverage have been associated with disparities in barriers to care for ALD. Women were 16% less likely to receive face-to-face counseling visits and 15% less likely to receive Food and Drug Administration-approved alcohol use pharmacotherapy than men despite all persons being privately insured (Mellinger, et al., 2019). Non-White minorities, particularly Blacks and Hispanics, have historically had a lower likelihood of entering treatment and receiving specialty care for ALD (Schmidt, Ye, Greenfield, & Bond, 2007). Medicare beneficiaries, in comparison to those who pay via Medicaid, private insurance, or cash payment, have less local access to licensed substance use disorder treatment facilities (Cantor, et al., 2022). The literature on the influence of socioeconomic disparities for persons with MASLD is limited, but low awareness (Cleveland, et al., 2019) and underdiagnosis (Alexander, et al., 2018) of MAFLD have been identified as barriers to receiving timely and appropriate care for CLD.

Barriers to medical care are important in general to ensure that individuals receive timely diagnosis and treatment to prevent disease progression and associated morbidity and mortality. Barriers to care are particularly important to understand for the CLD population because of the likely underestimation of CLD in the US population given its asymptomatic and indolent course in early stages, association of socioeconomic vulnerabilities and differences in care access for CLD, and high disease-specific morbidity and mortality. Access to timely and appropriate medical care is imperative for prevention, earlier detection, and management of CLD before the development of advanced liver disease and to prevent avoidable and costly hospitalizations and reduce liver-related morbidity and mortality.

The literature has identified various multilevel barriers to care that are associated with poorer outcomes for persons with CLD. At the state-level, a lower density of specialty providers is associated with higher mortality from ALD (Lee, Dodge, & Terrault, 2022). County-level measurements of uninsurance, remoteness from specialty care, along with socioeconomic factors (racial/ethnic composition, poverty) explained approximately 60% of liver-related deaths (Goldberg, Ross-Driscoll, & Lynch, 2021). At the individual-level, lack of specialty care and financial hardships are associated with poorer health outcomes for CLD. A Veteran Affairs (VA)-based study revealed that patients, who saw a gastroenterologist or hepatologist after disease diagnosis, had improved five-year survival compared to those who did not (hazard ratio, 0.81) (Mellinger, et al., 2016). Studies have shown that financial hardships associated with medical care affected up to 30% of adults with CLD in the US (Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023; Lago-Hernandez, et al., 2021), and approximately 10% were unable to pay their medical bills (Lago-Hernandez, et al., 2021). Financial hardships were associated with a two-fold increased odds of inpatient admissions or emergency department (ED) visits (Lago-Hernandez, et al., 2021) and a 24% higher risk of all-cause mortality (Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023).

The accumulation of such health care barriers limits the ability to establish and sustain continuity of care in the ambulatory care setting for individuals with CLD. As such, individuals may seek care in the ED or hospital setting as demonstrated in prior work (Rust, et al., 2008). Rates of hospitalizations among persons with CLD have risen in the past decade. A study from a large health system in Texas showed that rates of disease-specific hospitalizations increased for CLD (92%), which exceeded rates for other similar chronic conditions, including heart failure (6.7%) and chronic obstructive pulmonary disease (COPD) (48.8%) from 2004 to 2013 (Asrani, et al., 2018). The same study revealed that more patients with CLD had early 30-day readmissions compared to the other chronic diseases (25% for CLD, 21.9% for heart failure, 20.6% for COPD) (Asrani, et al., 2018). Early readmissions are detrimental for patients with CLD because of associated high rates of mortality (90-day mortality for those with 30-day readmission 26.8% vs. 9.8%) (Berman, et al., 2011).

Efforts to reduce recurrent hospitalizations for CLD have been based in the health care setting. For example, a quality improvement program, which included a checklist and electronic decision support provided goal-directed treatment and prophylaxis for complications of liver cirrhosis (hepatic encephalopathy, spontaneous bacterial peritonitis), and was associated with lower odds of 30-day readmissions (odds ratio, 0.4) (Tapper, et al., 2016). However, this intervention was implemented in a dedicated liver unit at a tertiary care center, which is more commonly inaccessible for the larger US population with CLD (Goldberg, et al., 2014; Goldberg, Ross-Driscoll, & Lynch, 2021; Mellinger & Volk, 2013). A study demonstrated how a physician assistant-led post-discharge transitional liver clinic reduced 30-day hospital readmissions (subhazard ratio, 0.52) (Yoder, et al., 2022); however, this finding was modest and conditional that discharged patients could establish care in this transitional liver clinic. A study integrated patient-reported outcome measures to capture functional status and disease-specific quality of life in addition to clinical and socioeconomic variables to better predict readmissions for patients with cirrhosis (Orman E. S., et al., 2022). However, patients were asked to reflect on their pre-admission functional status and quality of life during their hospitalization, which is subject to recall bias especially during acute illness.

Factors beyond the health care setting affect hospital use and outcomes for individuals with CLD. There is increasing recognition of social determinants of health and social risks in CLD, including poverty (Chen, Song, Suresh, Wadhwani, & Perumalswami, 2023), unstable housing (Miller-Archie, et al., 2022; Yilma, et al., 2023), and food insecurity (Kardashian, Dodge, & Terrault, 2022). The prevalence of financial hardship and health care unaffordability among US adults with CLD has been shown to affect acute care use and mortality (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). However, despite these efforts, there is yet an investigation on the process of seeking care in a non-institutionalized setting, specifically barriers to care and how they may affect recurrent acute care utilization for the US adult population with CLD. As CLD remains under-recognized compared to other chronic diseases, including cardiovascular disease (CVD) and COPD, data on the extent of health care barriers among adults with CLD vs. other chronic diseases is needed to assess the scope of the problem in the US. More robust evidence to risk stratify adults with CLD is also needed to guide future interventions for more impactful change.

1.1. Objectives and Aims

The objectives of this dissertation are to create new knowledge on the extent of health care barriers and its relationship with recurrent acute care use and to uncover unique phenotypes using self-reported barriers to care to identify the most vulnerable persons at risk for recurrent acute care use in the US adult population with CLD. Through this dissertational work, I will apply a conceptual framework to employ robust statistical methods to produce nationally representative estimates that can encourage policy-level reforms for this commonly under-recognized chronic condition with high risk of morbidity and mortality.

Aim 1. Evaluating the extent of health care barriers and its relationship on recurrent acute care use among US adults with CLD vs. other chronic conditions

Liver-related hospitalizations are rising in concurrence with increasing CLD-related morbidity and mortality rates (Stepanova, et al., 2017; Asrani, et al., 2018; Hirode, Saab, & Wong, 2020; Centers for Disease Control and Prevention, n.d.). While higher hospitalization rates for CLD have been attributed to disease severity and medical complexity, rates of hospitalizations and recurrent admissions for CLD far exceed those of other similarly complex comorbidities such that disease complexity alone is insufficient to explain the increasing rates of acute care utilization for CLD (Asrani, et al., 2018). While determinants of acute care utilization are multifactorial, studies have shown that interventions aimed to reduce health care barriers for patients with chronic illness could reduce preventable hospitalizations (Naylor M. D., et al., 2004; Naylor M. D., et al., 1999; Rich, et al., 1995; Lorig, et al., 1999; Tapper, et al., 2021). The development of such interventions to reduce liver-related hospitalizations requires an understanding of specific health care barriers in relation to characteristics of the CLD population. While indicators of health care barriers, including access to specialty care and health care affordability have been explored (Mellinger, et al., 2016; Goldberg, Ross-Driscoll, & Lynch, 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023; Lee, Dodge, & Terrault, 2022), the extent of organizational, transportation, and affordability barriers and the cumulative effect of these health care barriers on recurrent acute care use among US adults with CLD vs. other chronic diseases remain unknown.

I hypothesize that the CLD population has a higher prevalence and probability of health care barriers than its non-CLD counterparts, and this higher prevalence of health care barriers is associated with increased probability of recurrent acute care use. This study will assess the extent of health care barriers from organizational, financial, and transportation domains in the care seeking process and measure the association between the prevalence of health care barriers and recurrent acute care use among US adults with CLD vs. COPD and/or CVD. COPD and CVD are selected as the non-CLD comparison because they share similar disease complexity and need for frequent health care encounters but unlike CLD, have disease-specific policies or interventions that aim to reduce health care barriers.

Aim 2. Identifying phenotypes using self-reported health care barriers to assess risk of recurrent acute care use among US adults with CLD

The burden of CLD is reflected in high rates of liver-related hospitalizations and health care costs (Asrani, et al., 2018; Hirode, Saab, & Wong, 2020; Dieleman, et al., 2020). There are increasing efforts to better predict risk of acute care use among patients with CLD in light of the disease population's risk of early readmissions and mortality (Berman, et al., 2011; Orman E. S., Ghabril, Emmett, & Chalasani, 2018; Garg, et al., 2021; Orman E. S., et al., 2022; Volk, Tocco, Bazick, Rakoski, & Lok, 2012). Recent predictive algorithms incorporated more specific patient-centered indicators including frailty, social stability, or patient-reported functional status and quality of life or used advanced predictive modeling with machine learning, yet the prognostic power of these tools remained modest at best (highest C-statistic 0.75) (Tapper, Finkelstein, Mittleman, Piatkowski, & Lai, 2015; Orman E. S., et al., 2022; Singal, et al., 2013; Hu, et al., 2021). These prior studies have been limited by their use of hospital-based parameters, which overlook the potential effect from noninstitutionalized experiences on one's likelihood of recurrent acute care use, particularly health care barriers in the outpatient care seeking process. The relationship between delays in receiving timely medical care and acute care use has been established (Rust, et al., 2008), but this association has not been investigated and leveraged to risk stratify the CLD population in the US for recurrent acute care use.

I hypothesize that the US adult CLD population is composed of subgroups that can be captured using self-reported health care barriers, and these subgroups have different probabilities of recurrent acute care use. In this study, I will use latent class analysis using self-reported barriers to care to uncover phenotypes within the CLD adult population and assess their respective probabilities of recurrent acute care use.

1.2. Review of the Literature

Health care barriers among persons with chronic liver disease

Individuals with CLD experience barriers to care across the disease spectrum from prevention and detection to treatment. While not all etiologies of CLD can be avoidable, hepatitis B virus (HBV) and hepatitis C virus (HCV) are preventable; however, screening and prevention strategies have not been widely successful. For instance, uptake of HBV vaccination was approximately 33% to 39% in 2018 for high-risk adults, including those with underlying CLD, travelers to countries where HBV is endemic, and adults with diabetes (Lu, et al., 2021). Screening for HCV has been low (approximately 11% to 14%) among baby boomers (Kasting, et al., 2018; Jemal & Fedewa, 2017) despite the availability of curative antiviral therapies and national guidelines that have recommended universal screening for all adults born between 1945 to 1965 (US Preventive Services Task Force, 2013; Smith, et al., 2012). Multilevel barriers to receipt of widely available screening and prevention efforts against HBV and HCV include lack of or variable insurance coverage (Wong, et al., 2018), potential need for referral to specialty care, lack of access to testing and treatment in the primary care provider's practice, lack of physician knowledge or time, patient unawareness, and stigma (Abara, Qaseem, Schillie, McMahon, & Harris, 2017).

At the point of decompensated liver cirrhosis or liver failure, orthotopic liver transplantation (OLT) is the only effective treatment for survival (Martin, DiMartini, Feng, & Brown, 2014). However, disparities in access to and receipt of OLT exist (Kanwal, et al., 2021; Yilma, et al., 2023). In a national VA cohort, over 20% of patients for whom OLT was considered were subsequently not referred for OLT because of social barriers including poverty (Kanwal, et al., 2021). In another cohort study from multiple safety-net hospitals, reasons for lack of referral among medically-eligible persons included insurance issues (21.3%), lack of social support (4%), undocumented status (1.9%), and unstable housing (1.5%) (Yilma, et al., 2023).

Lack of specialty care affects disease surveillance and is associated with worse survival. Close to 70% of veterans and 58% of Medicare beneficiaries with CLD do not connect with a specialist (Mellinger, et al., 2016; Mellinger & Volk, 2013). A VA-based study demonstrated that patients, who established care with a specialist after CLD diagnosis, had a better 5-year survival (hazard ratio, 0.8) than those who did not (Mellinger, et al., 2016). Similarly, Goldberg et al. showed how county-level variability in rates of uninsurance and distance from the closest liver transplant center along with sociodemographic factors (racial/ethnic composition, poverty) explained approximately 60% of liver-related deaths (Goldberg, Ross-Driscoll, & Lynch, 2021). More recently, Lee et al. demonstrated an association between higher state-level densities of gastroenterologists and lower ALD-related mortality and how such differences may explain up to 40% of ALD-related mortality in the US (Lee, Dodge, & Terrault, 2022).

In recent studies using US population-based data that assessed health care unaffordability, the prevalence of financial hardship was approximately 30% among adults with CLD (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). Inability to pay medical bills affected 14% of adults with CLD, which was associated with a two-fold increased risk of unplanned acute care use (Lago-Hernandez, et al., 2021). An extension of this study showed that US adults with CLD were almost two times more likely than those without CLD to experience financial distress, and those who experienced financial distress had a 24% higher risk of all-cause mortality (Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). Findings from both studies demonstrated how health care unaffordability, an indicator of health care barriers, can affect risk of acute care use and mortality.

Acute care utilization in the setting of chronic liver disease

The rate of CLD-related hospitalizations has increased over the past decade from 3,056 to 3,757 per 100,000 hospitalizations (2012 to 2016) (Hirode, Saab, & Wong, 2020). Trends in ED visits associated with CLD have also risen from 484.4 to 631.6 per 100,000 visits (2006 to 2014) (Yin, Barker, Teshale, & Jiles, 2019). In comparison to heart failure and COPD, rates of hospitalizations increased the most for CLD compared to the other conditions (92% for CLD, 48.8% for COPD, 6.7% for heart failure) from 2004 to 2013 (Asrani, et al., 2018). In this study based in a large Texas health care system, patients who were admitted for CLD had longer hospital length of stay (7.3 days) compared to those admitted for heart failure (6.2 days) or COPD (5.9 days) and higher rates of early 30-day readmissions (25% vs. 21.9% for heart failure, 20.6% for COPD) (Asrani, et al., 2018). Most patients with CLD who seek hospital-based care have cirrhosis or decompensated liver disease, which is associated with higher rates of 30- and 90-day readmission rates of up to 37% and 53%, respectively (Volk, Tocco, Bazick, Rakoski, & Lok, 2012; Orman E. S., Ghabril, Emmett, & Chalasani, 2018; Shaheen, Nguyen, Congly, Kapan, & Swain, 2019; Berman, et al., 2011; Bajaj, et al., 2016; Nguyen, et al., 2019; Tapper, Halbert, & Mellinger, 2016).

Most patients with CLD seek care in the hospital for symptoms related to complications of cirrhosis or liver failure, including ascites, variceal bleeding, and hepatic encephalopathy (Tapper, Halbert, & Mellinger, 2016). In fact, a multistate population-based study revealed that 68.6%, 48.4%, and 78.3% of index hospital admissions, 30-day readmissions, and 90-day readmissions, respectively included these symptomatic liver-related complications (Tapper, Halbert, & Mellinger, 2016).

As such, efforts to reduce readmissions for CLD have aimed to target these liver-related complications through earlier outpatient follow-up (Kanwal, et al., 2016), dedicated transitional care clinics (Yoder, et al., 2022), and inpatient electronic decision support (Tapper, et al., 2016). However, these studies have had mixed results. For example, a VA-based study that compared patients, who received early outpatient follow-up within seven days of discharge vs. not, found that those who had earlier follow-up had a higher risk of readmission (hazard ratio, 1.1) and lower risk of mortality (hazard ratio, 0.6) (Kanwal, et al., 2016). Reasons for readmission were undefined, but given the improved mortality, the authors suggested that earlier follow-up promoted improved care coordination and timely delivery of needed medical care (Kanwal, et al., 2021). Of note, this was a VA-based study and therefore, veterans faced less access barriers (e.g. insurance coverage) compared to non-veterans in a community-based setting.

Associated health care costs magnify the impact of frequent acute care utilization in the CLD population. The reported total national estimated cost for liver-related hospitalizations is $81.1 billion, and the adjusted mean cost per CLD-related hospitalization has increased by 0.62% in the last decade (Hirode, Saab, & Wong, 2020). While the mean cost per CLD-related hospitalization is estimated at $16,271, the mean cost per hospitalization for persons with end-stage disease (i.e. decompensated cirrhosis) with at least two cirrhosis-related complications is much higher (mean cost of $21,027 to $23,279 (Hirode, Saab, & Wong, 2020). Interestingly, the proportion of total estimated spending for inpatient costs is disproportionately higher among persons hospitalized for cirrhosis (62.9%) than it is for CVD (49.2%) and chronic respiratory disease (14.1%) even though there are less disease-specific treatments and hospital-based procedures available for cirrhosis (Dieleman, et al., 2020). As such, inpatient costs for patients with cirrhosis may be disproportionately higher because of critical illness or longer hospital length of stay. The high rates of acute care utilization and associated costs in the setting of CLD demonstrate the disease burden on individuals, populations, and the US health care system.

Gaps in the literature

Prior studies have provided new insights on the different challenges that persons with CLD encounter when pursuing medical care, including lack of specialty care (Mellinger, et al., 2016; Goldberg, Ross-Driscoll, & Lynch, 2021; Goldberg, et al., 2014; Lee, Dodge, & Terrault, 2022) and health care unaffordability (Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023; Lago-Hernandez, et al., 2021). However, the sample population and measures of these studies have limited their generalizability and potential to inform targetable interventions.

For example, findings from the VA-based study that revealed an association between lack of specialty care after liver disease diagnosis and reduced survival is conditional on the individual with CLD being a veteran or person who can access integrated health care from a single system that also provides health insurance coverage (US Department of Veteran Affairs, 2023). The study by Goldberg et al., which demonstrated that farther distance from a transplant center was associated with reduced survival, was also based on a VA population with similarly limited generalizability (Goldberg, et al., 2014). Other work have used county- or state-level variables as surrogate measures of individual-level factors, including rates of uninsurance, poverty, and access to specialty providers (Goldberg, Ross-Driscoll, & Lynch, 2021; Lee, Dodge, & Terrault, 2022). While these aggregate data have provided much needed information on the relationship between environmental-level factors and specific patient outcomes, there is risk of ecological fallacy (Robinson, 1950). In fact, a study by Davis et al. demonstrated poor agreement between neighborhood- and individual-level measures of income and identified risk of misclassification bias when using neighborhood-level measurement as a proxy to assess individual-level health outcomes (Davis, Mahar, & Strumpf, 2023). As such, while county-level measurements of socioeconomic conditions (Goldberg, Ross-Driscoll, & Lynch, 2021) and provider availability (Lee, Dodge, & Terrault, 2022) have been shown to affect risk of mortality among US persons with CLD, the reliability of aggregate data requires validation before any large-scaled interventions can be derived from such data.

Recent studies that used data from the National Health Interview Study (NHIS) have provided nationally representative estimates of community-dwelling persons with CLD, which offers greater potential for generalizability than earlier studies (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). Both studies focused on financial hardships and identified how those who experienced the most severe form of financial hardship, measured as the inability to pay medical bills, were associated with increased likelihood of acute care utilization (odds ratio, 1.9) (Lago-Hernandez, et al., 2021) or those who could not afford needed prescription medications had the highest likelihood of mortality (hazard ratio, 1.5) (Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). In the study by Lago-Hernandez et al., the CLD population was compared to the non-CLD population, which included healthy adults (Lago-Hernandez, et al., 2021). The inclusion of healthy individuals, who are less likely to seek medical care or encounter healthcare-related costs, as a comparison group limits the finding's reliability. Furthermore, its main findings reported associations among similar variables, specifically self-reports about concerns over paying medical bills, inability to pay medical bills, and cost-related nonadherence to medications (Lago-Hernandez, et al., 2021). It has been established that poverty and an inability to afford health care are related (Wier, Merrill, & Elixhauser, 2009); therefore, an assessment of these variables mainly confirms established findings for a specific disease population.

In the study by Ayyala-Somayajula et al., adults with CLD were compared to other disease groups, including cancer, emphysema, and coronary artery disease (Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). However, the authors did not account for comorbidities, which is important to capture because of previously reported relationships between co- or multi-morbidity and higher health care costs (Tran, et al., 2022; Jones, Chennupati, Nguyen, Fedorenko, & Ramsey, 2019; Zhou, et al., 2022). Additionally, in comparison to other chronic diseases like emphysema, cancer, and coronary artery disease, CLD has fewer prescribed medications available; therefore, the influence of comorbidities in the setting of CLD on prescription-related costs cannot be ignored. While health insurance was included as a confounder variable given its expected association with health care costs, the authors operationalized the variable as uninsured vs. insured, which limits the finding's potential policy implications because of known heterogeneity in shared costs and medication coverage among health insurance plans (Wray, Khare, & Keyhani, 2021; Cooper, Stiegman, Ndumele, Staiger, & Skinner, 2022). Both studies using NHIS data are valuable in raising awareness about financial challenges among persons with CLD; however, they are limited in their use of comparison groups and covariates and ultimately, their ability to target potentially modifiable measures to enact interventions or policy reforms.

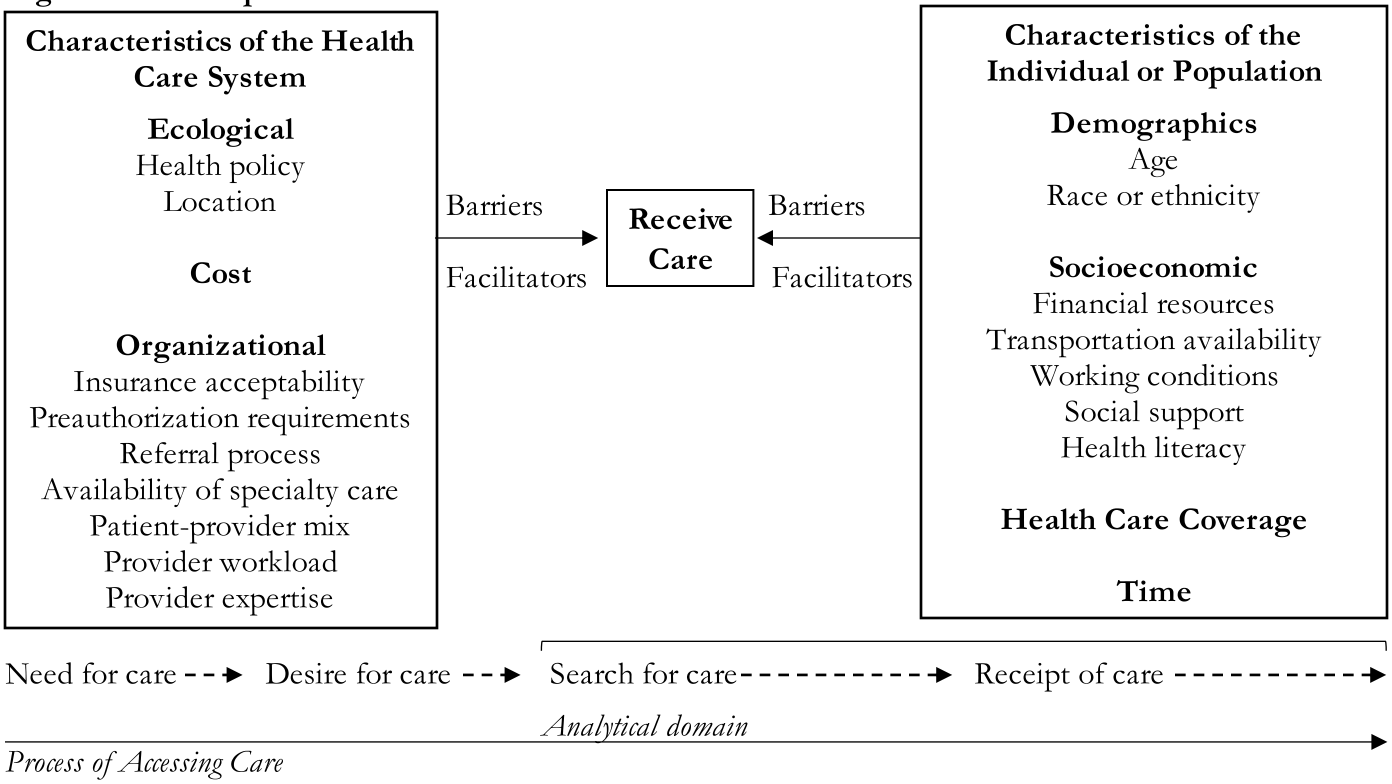
1.3. Significance

A study that employs a conceptual framework to understand the extent of health care barriers throughout the process of seeking care among community-dwelling persons with CLD could potentially help identify mutable factors and make meaningful impacts on policies and interventions that aim to improve health care access and reduce recurrent acute care use. The NHIS is enriched with self-reported data about health care experiences, including different types of health care barriers along the care seeking process at the point of entry and within the health care system, health care unaffordability, and transportation. As such, this dissertation will leverage the use of this data to demonstrate the extent of health care barriers and its association with recurrent acute care use among adults with CLD vs. other chronic diseases (without CLD). Additionally, given the large and nationally representative sample of the NHIS, this dissertation will uncover phenotypes within the larger adult CLD population to characterize different risk profiles based on self-reported health care barriers and their respective risk for recurrent acute care use. Findings from this dissertation could potentially capture the attention of policy makers to appreciate the extent of health care barriers for a commonly under-recognized disease and consider how health care reforms that target conditions with high morbidity and mortality risk could affect the growing population with CLD. Furthermore, findings from this dissertation could help identify individuals with CLD at highest risk for recurrent acute care use so that future interventions that aim to reduce rehospitalizations and frequent ED usage can efficiently and effectively allocate appropriate resources to the most vulnerable individuals.

1.4. Conceptual Framework

In this dissertation, I investigate health care barriers within the larger context of Donabedian and Frenk's conceptualization of health care access. Donabedian pioneered the concept that health care access is the "degree of adjustment" between the characteristics of the health care resource and population (Donabedian, 1973). Adapting Donabedian's conceptualization, Frenk proposed an analytical framework to measure health care access as a functional relationship between the obstacles that one encounters in the process of seeking care and the population's capability to overcome those obstacles (Frenk, 1992). Additionally, Frenk operationalized health care access using three domains of the care seeking process, including ecological (e.g. physical location of health care), financial (e.g. cost of health care), and organizational (e.g. logistics to see a provider) at the point of entry and within the health care system (Frenk, 1992).

Figure 1.1. Conceptual Framework

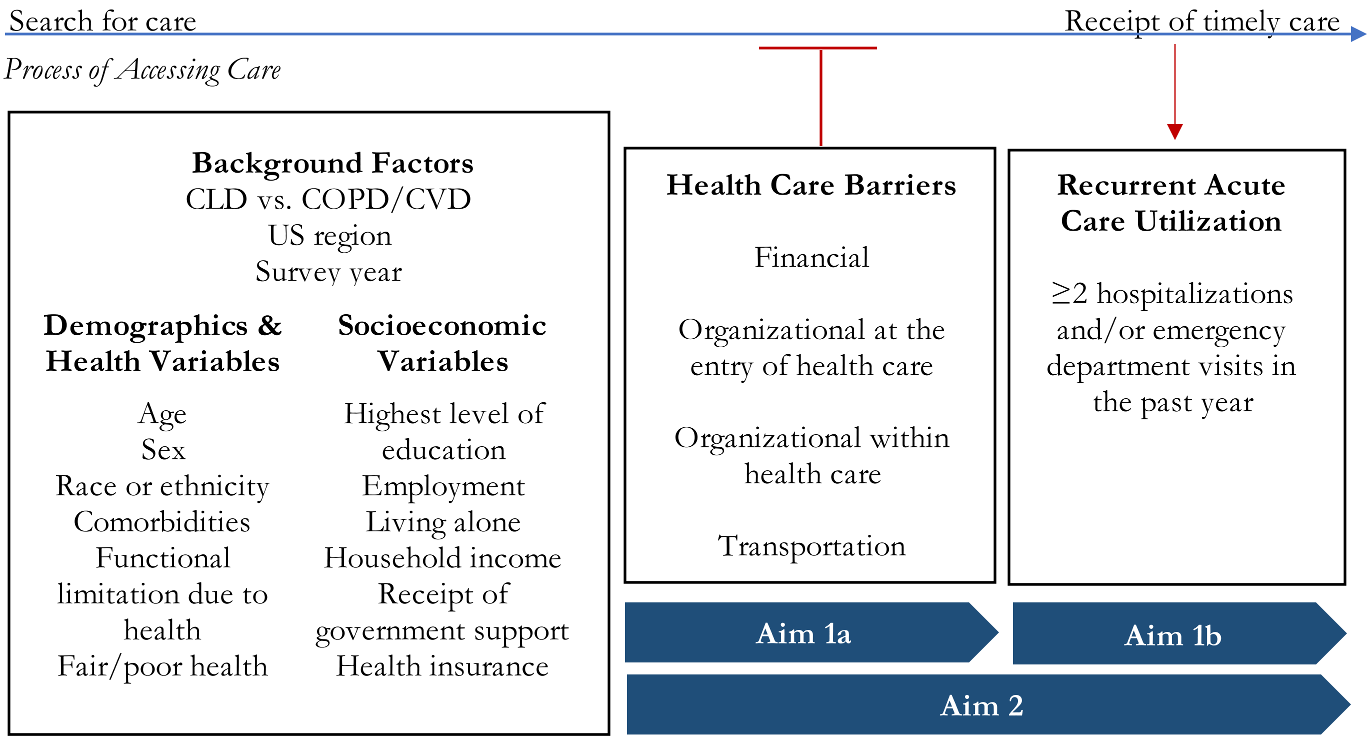


The conceptual framework (Figure 1.1) attempts to illustrate how timely receipt of medical care ("Receive Care") is a function of both the characteristics of the health care system and the individual or population, and there are barriers and facilitators from the health care system and individual or population that limit or enable receipt of care. A population's ability to achieve health care access is a function of the amount of health care barriers it encounters and its capability to overcome those barriers (Frenk, 1992). Characteristics of the health system include ecological factors, such as health policies, location of the resource, cost, and organizational factors, including health system-specific requirements for insurance, pre-authorizations, and referrals, provider and patient mix within the health system, and provider-specific characteristics, including expertise and workload. Characteristics of the individual includes demographics, such as age and race or ethnicity, socioeconomic factors, including financial and transportation resources, health coverage and time.

The framework also shows how this dynamic relationship between the health care system and individual influences the entire process of accessing care, starting from needing to receiving care. The scope of the dissertation focuses on the care seeking process starting at the point of entry into the health care system to the point of receiving care within the health care establishment (Figure 1.2). As such, we assume that care is needed and desired, which is appropriate for the study population in this dissertation, which only includes those with CLD or COPD and/or CVD. The respondents in the study population are aware of having a chronic disease and these diseases require frequent health care encounters. The analytic framework (Figure 1.2) shows how populations with CLD or COPD/CVD can encounter an accumulation of different health care barriers along the path of searching for and receiving timely care. We hypothesize that the accumulation of health care barriers will affect one's likelihood of recurrent acute care utilization. The relationship between the disease groups of interest (CLD, COPD/CVD) and extent of health care barriers (Aim 1a) and subsequently, the relationship between the prevalence of health care barriers and recurrent acute care use (Aim 1b) are influenced by background factors (US region, survey study) based on the use of annual NHIS data, and demographic, health, and socioeconomic variables. The different combinations of health care barriers also have the potential to uncover unique phenotypes within the larger CLD population, which can be used to predict risk of recurrent acute care use (Aim 2).

While system-level variables are considered in the conceptual model, the analysis will measure individual-level factors based on available self-reported data from the NHIS.

Figure 1.2. Analytic Framework



Financial barriers

Health care barriers are categorized as financial, organizational at the entry of health care, organizational within health care, and transportation barriers (Figure 1.2). Health care unaffordability or financial barriers to care remain a pervasive limitation in health care access especially for chronic conditions including heart, lung, and liver conditions (Mahajan, et al., 2021; Zhou, et al., 2022; Gaffney, et al., 2021; Gaffney, et al., 2020; Ufere, Satapathy, Philpotts, Lai, & Serper, 2022). In fact, US adults with CLD, who experience health care-related financial hardship, have foregone recommended care which is associated with increase acute care utilization and mortality (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). However, the cumulative effect of financial barriers on the CLD population in comparison to other chronic diseases has not been investigated, and the use of individual types of affordability barriers has not been analyzed to risk stratify those who have different probabilities of recurrent acute care use. We capture indicators of financial barriers using affirmative responses to forgoing any needed medical care, follow-up, specialty care, or prescription medication due to costs.

Organizational barriers

Organizational obstacles in health care access start at the point of seeking care and persist within the health care establishment regardless of financial conditions. For persons with chronic diseases, who require long-term care, navigation through a sequence of steps throughout the continuum of care is required to achieve timely receipt of medical care. Starting at the entry of health care, one who needs and desires medical care is required to identify a provider, determine whether or not the identified provider is accepting new patients, confirm insurance acceptability in the provider's practice, set-up an appointment, and establish regular care with a provider or at least within a practice. Once one enters the health care system and can establish regular care, additional steps are required to ensure receipt of timely medical care, including arranging for appointments based on the clinic's availability and communicating with the clinic. While at the provider's office, receipt of timely medical care is conditional on the wait time to see the provider and any needed care coordination.

Each sequential step in the process of seeking and obtaining care is a potential organizational barrier, and the intended population's ability to overcome these barriers is relative to its resources and tolerance of organizational barriers. A person's ability to overcome and tolerate organizational barriers is largely dependent on the individual's ability to navigate the health care system and amount of available time, which are conditional on one's health status, education level, employment status, household support, poverty, and health insurance.

We capture indicators of organizational barriers at the entry point of health care using affirmative responses to having trouble finding a provider, being declined as a new patient, having health coverage declined, or not having a usual place for sick or routine care. Organizational barriers within health care include affirmative responses to having perceived delays in care because no appointment was available soon enough, office was closed when one could get there, one could not reach the clinic by phone, or there was a long waiting time at the clinic.

Transportation barrier

Lack of transportation leading to delayed medical care is included because it can limit health care access regardless of health care affordability and organizational barriers. For example, one may have established care with a provider and can afford his or her medications but cannot have timely receipt of needed medical care if transportation is unavailable. Transportation barrier is captured using self-reports about delayed care due to transportation.

Covariates

We will assess age, sex, race or ethnicity, comorbidities, functional limitation due to health, fair or poor health status, employment status, household support (i.e. living alone), household income, receipt of government support, insurance coverage, US region, and survey year as covariates.

The identified covariates are relevant to financial barriers because the disease population's ability to overcome financial obstacles is a function of the population's financial means (e.g. household income above poverty threshold, ability to pay for basic needs, employment), health insurance, and presence of comorbidities as increasing number of chronic conditions is associated with health care unaffordability (Tran, et al., 2022; Jones, Chennupati, Nguyen, Fedorenko, & Ramsey, 2019; Zhou, et al., 2022). Differences in health care affordability exist among public and private insurance programs in the US. Prior work has shown that individuals with private health insurance are more likely to report difficulty in seeing providers or taking medications due to cost in comparison to individuals covered by Medicare (Wray, Khare, & Keyhani, 2021). Results that compared costs between those with Medicaid vs. private health insurance were mixed as Medicaid programs varied in cost sharing and copayments by states (Wray, Khare, & Keyhani, 2021). Nonetheless, those with private insurance were more likely to report medical debt than individuals covered by public health insurance (Wray, Khare, & Keyhani, 2021). We hypothesize that those with financial vulnerabilities, including less than high school graduate level education, unemployment, need for government support, household poverty and more comorbidities are more likely to experience financial barriers.

Our covariates are also pertinent to organizational barriers because those with multiple comorbidities, limited functional status, and poor health status may experience more challenges in navigating health care as one may require more health care needs and have less flexibility in scheduling available appointments. Individuals with lower educational levels, specifically less than a high school graduate level education, have lower health literacy defined as having basic or below basic understanding of health information (United States Department of Health and Human Services, 2023). Employed individuals may have less free time to wait for available providers or appointments which can lead to perceived delays in their medical care. Those who lack household support (i.e. living alone) may not have the additional resources needed to navigate a complex health care system. In fact, social isolation is associated with increased ED utilization (Dreyer, Steventon, Fisher, & Deeny, 2018). Lack of stability in one's basic necessities, including income, housing, and food may take priority over one's health. In fact, food insecurity has been associated with increased ED utilization (Dean, French, & Mortensen, 2020) and housing instability is related to poorer health outcomes (Chen, et al., 2022). Variation in coverage by major health insurance type also affects one's likelihood of organizational barriers. Consistent with prior studies, Wray et al. showed that individuals with Medicaid reported more difficulty in accessing health care providers compared to those insured through a private or Medicare-based health insurance program (Wray, Khare, & Keyhani, 2021; Hsiang, et al., 2019; Chaiyachati, et al., 2019). As such, we hypothesize that individuals with more comorbidities, functional limitation due to health, fair or poor health status, less than high school graduate level education, employment, need for government subsidy for basic necessities, and who live alone are less able to overcome organizational barriers at the entry of and within the health care system and therefore, will have more organizational barriers.

Lack of transportation leading to delayed medical care may be related to the individual's ability to afford travel resources, availability of social support to provide transportation, and any functional or medical limitations. A previous study that described the extent of transportation barriers among cancer survivors noted how younger working-age survivors, particularly those who were unmarried, poor, and had physical limitations due to health, were more likely to encounter limited transportation despite having insurance (Jiang, et al., 2022). Therefore, those with functional limitations due to health, more comorbidities, being below the federal poverty level, having any form of material hardship necessitating government assistance, or living alone may have a higher probability of delayed care due to transportation barriers.

CHAPTER II: Evaluation of the Extent of Health Care Barriers among Adults with Chronic Liver Disease vs. Other Chronic Diseases in the United States

ABSTRACT

Importance: The extent of health care barriers among adults with chronic liver disease (CLD) and its association with recurrent acute care use compared to other chronic diseases remains unknown.

Objective: To describe and compare the prevalence and probability of barriers to care

Design, Setting, and Participants: This was a pooled, cross-sectional study of 47,037 non-institutionalized US adults with versus without CLD using self-reported data from the National Health Interview Survey (NHIS) from 2011 to 2017. Data analysis was completed in August 2023.

Exposures: CLD vs. chronic obstructive pulmonary disease (COPD)/cardiovascular disease (CVD)

Main Outcomes and Measures: Incident rate ratios and predicted probabilities of any and frequency of barriers to care; odds ratio and predicted probability of recurrent acute care use by frequency of health care barriers and disease group

Results: The study sample included 47,037 adults (5,062 with CLD and 41,975 with COPD and/or CVD) (median [range] age 61 [18-85]; 51.8% female]. The CLD group included younger respondents (median [range] age 55 [18-85]), more Hispanics (17.5%), and higher rates of fair or poor health (41.4%), poverty (20.1%), receipt of government support (29.5%), and no insurance (11.2%) or public insurance (23.6%) compared to the non-liver disease group (median [range] age 62 (18-85); 8.6% Hispanic; 33.3% fair or poor health; 36.1% poverty; 21.5% receipt of government support; 7.9% no insurance; 15.7% public insurance). The proportion of respondents reporting any barriers to care was greater for the liver than non-liver disease group (44.7% vs. 34.4%). While adults with CLD were significantly more likely to experience any health care barriers (adjusted incident rate ratio [95% CI] 1.12 [1.01-1.24], *P*=0.03), they were not significantly more likely to have a higher frequency of barriers (1.05 [1.00-2.71], *P*=0.06). A higher prevalence of health care barriers was associated with increased probability of recurrent acute care use regardless of disease group.

Conclusions and Relevance: Findings from this nationally representative study suggest that adults with CLD have increased probability of experiencing any health care barriers likely related to the higher prevalence of socioeconomic vulnerabilities among persons with CLD vs. COPD/CVD, which carries implications for recurrent acute care use. More attention for persons with CLD in future iterations of health programs for targeted conditions are warranted.

INTRODUCTION

Chronic liver disease (CLD) contributes to significant morbidity and mortality in the United States (US) yet it remains under-recognized in comparison to other chronic diseases with similar complexity and risk of acute care utilization and mortality. Cardiovascular disease (CVD) and chronic obstructive pulmonary disease (COPD) along with CLD are leading causes of hospital readmissions and deaths in the US (National Center for Health Statistics, 2023; Dharmarajan, et al., 2013; Khan, et al., 2021; Bambhroliya, et al., 2018; Hirode, Saab, & Wong, 2020). To optimize care delivery and reduce early hospital readmissions, large-scaled programs like Get With The Guidelines (GWTH) for heart failure and stroke and the Hospital Readmissions Reduction Program (HRRP) have been established for high-risk conditions including COPD and CVD (Bergethon, et al., 2016; Howard, et al., 2018; Zuckerman, Sheingold, Orav, Ruhter, & Epstein, 2016). Such programs do not exist for persons with CLD despite the drastic rise in liver-related mortality (Centers for Disease Control and Prevention, National Center for Health Statistics., n.d.) and hospitalization rates over the past two decades (Asrani, et al., 2018; Hirode, Saab, & Wong, 2020).

The relationship between health care barriers and acute care use has been well described (Rust, et al., 2008; Allen, Call, Beebe, McAlpine, & Johnson, 2017; Cheung, Wiler, & Ginde, 2011; Kullgren, McLaughlin, Mitra, & Armstrong, 2012; Wolfe, McDonald, & Holmes, 2020). There have been increasing efforts to understand how such barriers, including health care affordability and access, influence outcomes for persons with CLD (Mellinger, et al., 2016; Goldberg, Ross-Driscoll, & Lynch, 2021; Lee, Dodge, & Terrault, 2022; Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023; Ufere, Satapathy, Philpotts, Lai, & Serper, 2022). Prior studies have identified associations between lack of specialty care and health care unaffordability with acute care use and mortality for persons with CLD (Mellinger, et al., 2016; Goldberg, Ross-Driscoll, & Lynch, 2021; Lee, Dodge, & Terrault, 2022; Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). Less is known about the accumulation of health care barriers across the care seeking continuum, including organizational barriers at the point of entry and within the health care system.

To our knowledge, the extent of barriers to care and the relationship between the prevalence of health care barriers and recurrent acute care use among US adults with CLD in comparison to other similarly complex chronic diseases that have existing programs aimed to improve health care access and delivery remains unknown. To evaluate the prevalence of health care barriers and its association with recurrent acute care use among US adults with CLD compared to other chronic diseases, we used annual data from the National Health Interview Survey (NHIS) to capture self-reported health care barriers among non-institutionalized persons representative of the national population with CLD or COPD and/or CVD.

METHODS

Data Source

We assembled a pooled cross-sectional study using annual NHIS data, from 2011 to 2017, obtained from the Integrated Public Use Microdata Series Health Surveys (Blewett, et al., 2022). The study period was selected to assess health care access after the implementation of the ACA (Affordable Care Act). NHIS is an annual in-person household interview survey conducted by the US Census Bureau to collect self-reported information about sociodemographic factors, health, behaviors, and health care experiences from civilian, non-institutionalized persons (National Center for Health Statistics, 2023). The survey uses a complex, multistage sample design that provides analytical weight adjustments to yield nationally representative estimates (National Center for Health Statistics, 2023). Data from the NHIS surveys have consistently provided nationally representative estimates of health care access and have been used to measure the effect of the ACA (Miller & Wherry, 2017; Mahajan, et al., 2021; Caraballo, et al., 2022). NHIS includes three main components, including the Family Core, Sample Adult Core, and Sample Child Core. From each randomly selected US household, information about the family, a sample adult, and a sample child, if available, are recorded in the Family, Sample Adult, and Sample Child Core, respectively. This study used the Sample Adult Core, which had a mean conditional response rate and final response rate of 80.7% and 60.4%, respectively during the study period.

The institutional review board at the University of California, Los Angeles exempted this study from review.

Study Population

Adult participants aged 18 years or older with *yes* or *no* responses to questions about CLD, COPD, and/or CVD from 2011 to 2017 were included in this study (Appendix Figure 2.1). We then selected adults, who affirmatively responded to questions about CLD, COPD, or CVD, into the study population. We compared respondents with CLD to those with COPD and/or CVD (COPD/CVD). While the COPD/CVD disease group did not include any persons with CLD, the CLD group includes adults with concomitant COPD or CVD to more accurately reflect the CLD population in which concomitant diseases (e.g. COPD, CVD) are common.

CLD was defined as answering *yes* to the questions, "Has a doctor or other health professional ever told you that you had any kind of chronic, or long-term liver condition" or "During the past 12 months, have you been told by a doctor or other health professional that you had any kind of liver condition?" Following the CDC definition of COPD (Centers for Disease Control and Prevention, 2023), COPD in this study was defined as answering *yes* to the questions, "Have you ever been told by a doctor or other health professional that you had chronic obstructive pulmonary disease, also called COPD?", "During the past 12 months, have you been told by a doctor or other health professional that you had chronic bronchitis?", or "Have you ever been told by a doctor or other health professional that you had emphysema?" CVD was defined as having an affirmative response to the following questions: "Have you ever been told by a doctor or other health professional that you had… coronary heart disease?", "… a heart attack?", "…any kind of heart condition or heart disease", "… angina", or "… a stroke?"

Study Outcomes

Health care barriers

We defined health care barriers as a *yes* response to any of the following questions about health care unaffordability, organizational barriers, and transportation in the past year:

1. Was there any time when you needed medical care but did not get it because of the cost?

2. Was there any time when you needed any of the following, but didn't get it because you couldn't afford it …prescription medicines?
3. Was there any time when you needed any of the following, but didn't get it because you couldn't afford it …follow-up care?
4. Was there any time when you needed any of the following, but didn't get it because you couldn't afford it …to see a specialist?
5. Did you have any trouble finding a general doctor or provider who would see you?
6. Were you told by a doctor's office or clinic that they would not accept you as a new patient?
7. Were you told by a doctor's office or clinic that they did not accept your health care coverage?
8. Have you delayed getting care for any of the following reasons in the past 12 months? …You couldn't get an appointment soon enough?
9. Have you delayed getting care for any of the following reasons in the past 12 months? …The clinic/ doctor's office wasn't open when you could get there?
10. Have you delayed getting care for any of the following reasons in the past 12 months? …You couldn't get through on the telephone?
11. Have you delayed getting care for any of the following reasons in the past 12 months? …Once you get there, you have to wait too long to see the doctor?
12. Have you delayed getting care for any of the following reasons in the past 12 months? …You didn't have transportation?

We also included any respondents who responded *no* to the following question:

13. Is there a place that you usually go to when you are sick or need advice about your health?

The primary outcome, health care barriers, was measured as a count of any of the 13 barriers to care. We also assessed the primary outcome as the presence of any health care barriers.

Recurrent acute care use

We defined the secondary outcome, recurrent acute care use, as having at least two emergency department (ED) visits and/or overnight hospital admissions in the past year. Recurrent acute care use is a reflection of both disease severity and limited health care access to outpatient services. While the HRRP focused on hospital readmissions, estimates of reduced rehospitalizations may have been related to an increase in ED visits that did not result in hospital readmission. In fact, a multi-state study revealed that approximately 40% of recurrent acute care encounters 30 days after hospital discharge were in the ED (Vashi, et al., 2013). As such, the secondary outcome of recurrent acute care utilization captures both ED and hospitalizations.

Covariates

We assessed the respondents' self-reported age, sex, race or ethnicity, number of comorbidities, functional limitation due to health, fair or poor health status, education, household structure (i.e. living alone), employment, household poverty, receipt of government support, insurance coverage, survey year (2011-2013, 2014-2017), and US Census region (Northeast, North Central/Midwest, South, West). Age group categories (18 to 34, 35 to 54, 55 to 64, 65 to 85 years) were selected based on increasing trends in liver-related mortality and cirrhosis among persons 34 years or younger and more cirrhosis- and hepatocellular-related deaths in persons at least 55 years old (Tapper & Parikh, 2018). We assessed for racial and ethnic differences using mutually exclusive racial and ethnic subgroups, including Non-Hispanic White, Hispanic, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic American Indian or Alaskan Native, and Non-Hispanic Other, as similarly done in prior work (Mahajan, et al., 2021). Health factors, including the number of comorbidities, functional limitation due to health, and fair or poor health status (vs. excellent, very good, or good health), were included because individuals with more complex health care needs and higher comorbidity burden are at risk of access and care coordination challenges (Osborn, et al., 2015; Bierman, Wang, O'Malley, & Moss, 2022). Education (less than high school graduate vs. high school graduate or higher) was assessed as a potential confounder given its established relationship with health care utilization and outcomes (Zajacova & Lawrence, 2018; Rust, et al., 2008). Living alone as a surrogate for social isolation is included based on the higher likelihood of health care barriers among isolated adults (Lewis, Shah, & Abrams, 2018). Competing personal priorities, including work and need for basic necessities, have been shown to contribute to delays in needed medical care (Diamant, et al., 2004). As such, we included employment and receipt of government support as possible confounders. Consistent with prior studies (Caraballo, et al., 2022), household poverty was defined as being above or below the federal poverty level (FPL) (<200% vs. ≥200% FPL), which was determined by comparing the reported total household income in the previous calendar year to the US Census Bureau's poverty benchmarks for the year in question (Blewett, et al., 2022). We included insurance (uninsured, public insurance, Medicare, private insurance) based on previously reported differences in health care barriers by type of coverage (Allen, Call, Beebe, McAlpine, & Johnson, 2017; Wray, Khare, & Keyhani, 2021).

Statistical Analysis

Each set of annual survey data was appended to create pooled data. Sample weights were divided by the number of years in the study period in accordance with NHIS recommendations (Blewett, et al., 2022). Survey weights were applied using the Stata *–svy-* command or person weights with clustering at the primary sampling unit.

We described the study population using sociodemographic, health, and health care characteristics following our conceptual and analytic frameworks (Figure 1.1 and 1.2) and compared the respondents in the CLD and COPD/CVD groups using descriptive statistics (ANOVA and Chi-squared tests). We also assessed for any relationship between the covariates and outcomes by disease group.

Model selection for our main analysis was based on the distribution of the primary outcome. We first compared count models, including Poisson, negative binomial regression (NBR), zero-inflated Poisson, zero-inflated NBR, hurdle logit-Poisson, and hurdle logit-NBR, using unweighted data which provided goodness of fit measures (AIC and BIC) and likelihood ratio tests. In addition to using the model fit statistics, we selected the hurdle logit-NBR model based on its assumption that all zero counts were from one source in contrast to the zero-inflated NBR model which assumed that zero counts were from two processes, including one that assumed that a subgroup of individuals, who may not have been sampled or not at risk for the outcome, existed (Feng, 2021; Long & Freese, 2001; Cragg, 1971). All respondents in our sample were asked the same set of questions about barriers to care; therefore, sampling zeros did not contribute towards the zero counts in this study.

Covariates were included in the multivariable regression analyses for the primary and secondary outcomes based on expected differences in frequency of the covariates between the CLD and COPD/CVD disease groups. In addition to selecting the covariates *a priori* based on our conceptual model, we performed nested hurdle logit-NBR models that sequentially added covariates to the prior model and tested the model fit using the adjusted Wald test for our main analysis. We also assessed for multicollinearity among the covariates using the mean and individual variance inflation factor (VIF) (Liao & Valliant, 2012). After fitting the regression model for the primary outcome, we determined the adjusted predicted probability using predictive margins (Williams, 2012). Stratified analyses were performed using logistic regression to estimate the predicted probability of any barriers to care by age, sex, race or ethnicity, receipt of government support, and insurance. As a sensitivity analysis, we repeated the main analysis using different permutations of the disease groups, including one that included only respondents with CLD without any concomitant COPD or CVD (vs. COPD/CVD) and another that included only persons with the most severe disease combinations (CLD with COPD/CVD vs. COPD and CVD).

We evaluated for an association between the prevalence of health care barriers and recurrent acute care use by disease group using multivariable logistic regression. We operationalized the secondary outcome of recurrent acute care use as a binary variable such that the use of logistic regression was appropriate, which is consistent with prior studies (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). After fitting the regression model, we also determined the adjusted predicted probability of recurrent acute care use in the past year using predictive margins.

Statistical significance was defined as a 2-sided *p*-value of less than 0.05 for all analyses. All analyses were performed using Stata SE version 18.0 (StataCorp).

RESULTS

Study Population Characteristics

The sample included 47,037 adults, which provided weighted estimates for 43,264,685 persons. The CLD group consisted of 5,062 adults (estimated 4,742,444 persons), and the non-CLD group (COPD/CVD) included 41,975 persons (estimated 38,522,241 adults). The CLD group included respondents with concomitant CVD (28.1%; 95% CI 26.5%-29.9%) or COPD (17.4%; 95% CI

16.1%-18.8%), which reflects a more accurate representation of the liver disease population in clinical settings (Minakata, et al., 2010; An, et al., 2014).

The CLD group was younger with a median age of 55 (18-85) vs. 62 (18-85) years and had more individuals who identified as Hispanic (17.5% vs. 8.6%) and with more fair or poor health (41.4% vs. 33.3%) compared to the COPD/CVD group. While there were more employed respondents with CLD (42.2% vs. 36.1%) than COPD/CVD, the CLD group had more household poverty (20.1% vs. 15.3%), received government support (29.5% vs. 21.5%), and were uninsured (11.2% vs. 7.9%). Additional study population characteristics are described in Table 2.1.

Health Care Barriers

There were more respondents in the CLD group that experienced any barriers to care compared to the COPD/CVD group (44.7% vs. 34.4%). Additional characteristics of health care accessibility by barrier type are described in Table 2.2. When we compared zero vs. at least one health care barrier among respondents in the CLD disease group, we found that younger persons (median age of 53 vs. 57 years), females, predominantly non-White race or ethnicity, and those with worse health based on higher rates of functional limitation due to health or fair or poor health, who lived alone, had household poverty, received government support, or had no or public insurance were significantly more prevalent in the group with at least one barrier to care vs. none (Appendix Table 2.1A and Appendix Table 2.2A). A similar distribution of covariates was present when assessing differences in covariates between respondents in the COPD/CVD group with zero vs. at least one health care barrier (Appendix Table 2.1B and Appendix Table 2.2B).

The distribution of the primary outcome or number of barriers to care revealed that 67.6% of the study population, 65.7% of the COPD/CVD group, and 55.3% of the CLD group had zero health care barriers. Goodness of fit measures and likelihood ratio tests of count models confirmed that the hurdle logit-NBR was the favored model (Appendix Table 2.3A and 2.3B).

Our main analysis used the multivariable hurdle logit-NBR model, which adjusted for age, sex, race or ethnicity, health factors, including prevalence of comorbidities, fair or poor health, and functional limitation due to health, education, employment, living alone, household poverty, receipt of government support, health insurance, US Census region, and survey year because of the significant differences in sociodemographic and health characteristics between the CLD and COPD/CVD groups and the association of these characteristics with the primary outcome. Nested models that sequentially assessed the inclusion of each covariate are shown in Appendix Table 2.4. The adjusted Wald test showed that each model with additional covariates was preferred over the prior model except for the one with employment (p=0.0625). The mean VIF for the model that included employment was 1.19, and the individual VIF for employment was 1.47; therefore significant correlation with the other independent covariates was not present. As we selected the employment variable *a priori* from our conceptual model, we included it in our final multivariable model.

Findings from our main analysis revealed that adults with CLD were significantly more likely to experience any barriers to care with an adjusted incident rate ratio (IRR) of 1.12 (95% CI 1.01-1.24, p-value 0.026) compared to those with COPD/CVD (Table 2.3). The adjusted predicted probability of any barriers to care for CLD and COPD/CVD was 0.38 (0.37-0.40) and 0.36 (0.35-0.37), respectively (Figure 2.1A). The predicted probabilities were similar to the unadjusted model (CLD 0.45, 95% CI, 0.43-0.47 vs. COPD/CVD 0.34, 95% CI, 0.34-0.35) (Figure 2.1B). Female sex, younger age, particular those under 55 years old, other non-White and non-Hispanic race or ethnicity, higher comorbidity burden, fair or poor health, functional limitation due to health, employment, living alone, receipt of government subsidy, lack of health insurance, Medicare insurance, and residing in US regions besides the Northeast were significantly associated with having any health care barriers (Table 2.3). The number of health care barriers was not significantly different between the two disease groups (IRR 1.05, 95% CI, 1.00-2.71, p=0.057).

In a sensitivity analysis that compared adults with only CLD without concomitant COPD or CVD vs. adults with COPD/CVD, the CLD group continued to have a higher likelihood of any (IRR 1.10, 95% CI, 0.92-1.30) and more barriers (IRR 1.04, 95% CI, 0.96-1.13), but these estimates did not reach statistical significance (Appendix Table 2.5). We also assessed the primary outcome with respondents with the most complex combination of disease groups, specifically those with both CLD and COPD/CVD vs. COPD and CVD (without CLD), and did not detect a significant association between the disease groups and any or the number of barriers to care.

We performed stratified analyses to assess probabilities of any barriers to care by sex, age, race or ethnicity, receipt of government support, and insurance. The unadjusted probability of any health care barriers was 0.05 greater for females than males for both disease groups, and the probabilities for CLD were 0.10 more than the COPD/CVD group for both sexes (Appendix Figure 2.2A). While adults, aged 18 to 34 years, in both CLD and COPD/CVD groups had similar probabilities of any barriers to care, those in the CLD group, starting at age 35, had a disproportionately higher probability of any barriers than the COPD/CVD group (Appendix Figure 2.2B). The unadjusted probability of any health care barriers was higher among non-White individuals with CLD vs. COPD/CVD (Appendix Figure 2.2C). Notably, the difference in probability between those with

CLD compared to COPD/CVD was largest for the non-Hispanic White group (CLD 0.44 vs. COPD/CVD 0.32). Adults with CLD had a higher unadjusted probability of any barriers to care compared with those with COPD/CVD whether or not they received government support, and recipients of government support in both disease groups had a higher probability of any health care barriers (CLD 0.59 vs. COPD/CVD 0.52) (Appendix Figure 2.2D). The unadjusted probability of barriers to care for adults with CLD and COPD/CVD were similar if they were uninsured, and the probability decreased with public, Medicare, and private insurance for both disease groups (Appendix Figure 2.2E). In this unadjusted subgroup analysis by insurance type, those with CLD had noticeably higher probability of any barriers to care than those with COPD/CVD if they had Medicare (CLD 0.42 vs. COPD/CVD 0.29) or private insurance (CLD 0.37 vs. COPD/CVD 0.27).

Recurrent Acute Care Use

Recurrent hospitalizations and/or ED visits in a year were more prevalent in the CLD than the COPD/CVD group (29.2% vs. 24.0%) (Table 2.2). Among persons with CLD, those with at least two (vs. up to one) episodes of acute care use were mostly female, non-White race or ethnicity, unemployed, lived alone, had household poverty, received government support, had more comorbidities, functional limitation due to health, fair or poor health, and lived in the South US Census region (Appendix Table 2.6A). Similar characteristics were significantly different between those with recurrent acute care use compared to those who did not in the past year for the COPD/CVD group (Appendix Table 2.6B).

There were more individuals with private insurance in both CLD and COPD/CVD groups, and recurrent acute care use was more frequent among those with public insurance and Medicare (Appendix Table 2.7A and 2.7B). More respondents in both disease groups with recurrent acute care use experienced any health care barriers (CLD 53.9%, COPD/CVD 44.3%) (Appendix Table 2.7A and 2.7B). Additional details that describe the distribution of different types of barriers by acute care use are in Appendix Table 2.7A and 2.7B).

After adjusting for disease group (CLD vs. COPD/CVD), sex, age, race or ethnicity, comorbidity count, fair or poor health, functional limitation due to health, education, employment, living alone, household poverty receipt of government support, insurance, US Census region, and survey year, we found that respondents with CLD vs. COPD/CVD were significantly more likely to have recurrent acute care use (odds ratio 1.12, 95% CI, 1.02-1.23, p=0.018), and more barriers were associated with increasing odds of recurrent acute care use. The adjusted probability of recurrent acute care use was highest for those with CLD vs. COPD/CVD with five or more barriers (CLD 0.39 vs. COPD/CVD 0.37 for five or more barriers) (Figure 2.2).

DISCUSSION

In this study representative of over 4.7 million US adults with CLD or COPD/CVD, we identified four main findings. First, we found that the CLD population had 10 percentage points more respondents who experienced any health care barriers compared to the COPD/CVD population. The CLD population was 54% more likely than the COPD/CVD population to experience any barriers to care, and this estimate remained significantly different at 12% after adjusting for socioeconomic, demographic, and health differences. Second, we found no difference in the extent of health care barriers between the two disease groups after adjusting for covariates. Third, this study described how adults with CLD were socioeconomically more vulnerable compared to their non-CLD counterparts, and how such differences in socioeconomic status, demographics, and health magnified the disparity in any health care barriers between the CLD and COPD/CVD populations. Fourth, our study identified a dose-dependent relationship between the prevalence of health care barriers and probability of recurrent acute care use.

Building on prior work (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023; Rust, et al., 2008), this study distinguishes itself in several ways. First, while prior studies (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023) have reported on financial hardships among US adults with CLD compared to those without CLD, the current study includes a more comprehensive list of different types of barriers throughout the process of seeking care, including organizational barriers at the point of entry and within the health care system, which are not isolated to only financial concerns. To our knowledge, this study is the first to report that the CLD population has a higher crude prevalence and probability of any self-reported health care barriers across the care continuum compared to similar chronic diseases (COPD/CVD) that share the same need for health care but have preexisting programs (GWTG) and policies (HRRP) aimed to improve outpatient care coordination. Second, this study employed a more fitting two-part hurdle model based on the distribution of the primary outcome, robust goodness of fit testing, and our understanding that the processes that drive any and frequent health care barriers are different. Third, this study is the first to compare the independent effect of the prevalence of health care barriers and recurrent acute care use between similarly complex comorbidities that share high risk for hospital use (CLD vs. COPD/CVD).

Different multi-level factors likely contribute to the disparity of encountering any health care barriers. At the individual level, our findings show how the population with CLD is more socioeconomically vulnerable than the COPD/CVD population, and how these differences contribute to the odds of encountering any and potentially the frequency of health care barriers.

Adjustment for covariates that were associated with health care barriers, including age, sex, race or ethnicity, health factors, socioeconomic status, and insurance attenuated the association between the disease group and primary outcome by 42%, which highlights the cumulative influence of these factors on the process of obtaining timely medical care for persons with CLD. Other unmeasured individual-level characteristics, such as time, could have potentially contributed to the difference in likelihood of having any health care barriers between the liver and non-liver disease groups.

Factors at the level of the health care system, which could not be measured in the current study, may have also contributed to the disparity in any health care barriers between the disease groups. For instance, there could have been a lack of provider expertise or availability in managing individuals with CLD as primary care physicians may be more comfortable treating patients with chronic heart or lung disease but not liver disease. In fact, a survey study revealed that over 70% of primary care physicians would refer their patients to a specialist to manage CLD (Younossi, et al., 2022). At the policy level, disease-specific health policies do not exist for those with CLD unlike the HRRP and GWTG programs that exist for persons with COPD/CVD.

We stratified our primary analysis about any health care barriers by sex, race or ethnicity (Mahajan, et al., 2021; Caraballo, et al., 2022), and age groups (Tapper & Parikh, 2018) based on prior work including receipt of government support for material hardship and insurance, which were considered potentially mutable factors. The stratified analyses supported our main findings, which demonstrated a persistently higher probability of any health care barriers for persons with CLD than COPD/CVD, and provided a more nuanced assessment to identify where disparities exist. We identified the most pronounced difference in probability of any barriers to care between the liver and non-liver disease groups for adults 65 years or older (+0.08 for CLD), Medicare enrollees (+0.18 for CLD), and non-Hispanic Whites (+0.12 for CLD).

The disparity among older adults at 65 may be a function of Medicare enrollment. While the overall probability of any barriers to care was lower for those aged 65 years or older compared to the other age groups and for Medicare compared to public or no insurance, the disparity in experiencing any barriers was potentially larger for the CLD vs. COPD/CVD group because of Medicare's unique role in the HRRP. The HRRP targeted hospitals with higher than expected readmission rates for specific medical conditions among Medicare beneficiaries (Centers for Medicare & Medicaid Services, 2023). While readmission rates for private and Medicaid beneficiaries with target conditions also declined after the implementation of the HRRP, it had the largest effect in reducing readmission rates for Medicare beneficiaries (Ferro, et al., 2019). Based on the HRRP's goal to reduce preventable rehospitalizations, it incentivized providers and systems to improve care coordination and reduce organizational barriers that post-discharge patients with targeted conditions (COPD/CVD) often faced (Centers for Medicare & Medicaid Services, 2023).

While non-Hispanic Whites generally had a lower likelihood of any health care barriers than their non-White counterparts, the larger disparity between non-Hispanic Whites with COPD/CVD vs. CLD may reflect the rising prevalence of MASLD and ALD among non-Hispanic Whites (Rich, et al., 2018; Kulkarni, Wadhwa, Kanwal, & Chhatwal, 2023), racial and ethnic disparities among non-White persons with COPD/CVD (Graham, 2015; Mamary, et al., 2018), and the representation of our sample. The prevalence of MASLD is highest for Hispanics (22.2%) using pooled population-based cohorts, but MASLD prevalence is highest for non-Hispanic Whites (55.5%) in pooled high-risk cohorts (e.g. persons with diabetes, undergoing bariatric surgery) (Rich, et al., 2018). Perhaps those who are more likely to report any barriers to care are more similar to persons in high-risk cohorts, such that they may have more frequent health care needs and thereby more likely to encounter health care barriers.

We recognize that the frequency of health care barriers is likely a function of one's attempts in seeking medical care; therefore, if one cannot overcome organizational barriers at the point of entry (i.e. establish care), one is less likely to encounter organizational barriers within the health care system (e.g. delays in care). In fact, a study that assessed changes in access after Medicaid expansion noted an increase in delayed medical care due to unavailable appointments or long waiting times (Miller & Wherry, 2017). As such, we employed a two-part hurdle model to investigate the likelihood of health care barriers as a binary and count, under the assumption that those who experience no barriers vs. at least one barrier are driven by different processes. The frequency of health care barriers was not significantly different between the CLD and COPD/CVD groups, which may be explained by the greater proportion of individuals in the CLD group, who encountered organizational barriers at the point of entry (17.6% CLD vs. 13% COPD/CVD). In fact, the most prevalent type of organizational barrier at the point of entry was being declined as a new patient (6.5% CLD vs. 3.5% for COPD/CVD). Therefore, if these respondents with organizational barriers at the point of entry had the counterfactual experience (i.e. did not have barriers at entry), they could have potentially experienced more organizational barriers within the health care system including transportation and financial barriers.

Our CLD study population more accurately reflected the CLD population in the US with concomitant COPD or CVD. Our sensitivity analysis included a comparison of the primary outcome with a subpopulation of adults with only CLD without COPD or CVD and found a similar

IRR although it did not reach statistical significance. When we compared those with the most severe disease with CLD and COPD/CVD vs. COPD and CVD, we found no difference between the two groups potentially due to protective factors from concomitant COPD or CVD.

Our study identified a dose-dependent relationship between frequency of health care barriers and probability of recurrent acute care use, and this relationship persisted even after controlling for socioeconomic, health, and insurance variables. While a difference in recurrent acute care use was already present at baseline, the frequency of health care barriers potentiated this difference.

In light of the 2024 election, this study provides several important policy implications. First, our findings highlight the discrepant prevalence and adjusted likelihood of any health care barriers between adults with CLD compared to those with COPD/CVD in the US. While both disease groups include chronic end-organ conditions that have higher risk of morbidity, hospitalization, and death, adults with CLD persistently have a higher likelihood of experiencing any health care barriers and the accumulation of such barriers are associated with increased risk of recurrent acute care use. As policies like the HRRP are under scrutiny (Figueroa & Wadhera, 2022), the election serves as an opportunity to revise such policies and consider the inclusion of CLD or at least its most advanced form, cirrhosis, among its list of targeted conditions. Second, consistent with prior work (Caraballo, et al., 2022; Allen, Call, Beebe, McAlpine, & Johnson, 2017), our study shows that health insurance alone is insufficient in mitigating barriers to care and heterogeneity in coverage exists among those with CLD vs. COPD/CVD even after controlling for socioeconomic and health variables. As more individuals with CLD have public and Medicare insurance, future reviews of state- and federal-sponsored insurance warrant evaluation of accessibility and affordability of care for persons with CLD to mitigate any delays in needed medical care. Third, this study demonstrates that the CLD population has different socioeconomic risks compared to the COPD/CVD population which contributes to the difference in health care barriers between the disease groups as suggested in our adjusted and unadjusted primary analyses. As such, it would be prudent for insurers, health systems, and providers to recognize how social risks coincide with health care barriers, which can lead to recurrent acute care utilization. As hospitalized adults will be screened for health-related social needs starting in 2024 (Billioux, Verlander, Anthony, & Alley, 2017), inclusion of direct questions about health care barriers across the care seeking continuum, can help direct appropriate resources to patients who have increased risk of health care barriers and subsequently recurrent acute care use.

LIMITATIONS

This study is not without its limitations. First, the study is a pooled cross-sectional study so findings from this observational study are not intended for any causal inferences. Findings are intended to be more exploratory and to provide nationally representative estimates about the extent and probability of health care barriers among US adults with CLD compared to other chronic diseases without CLD. Second, there may be an underestimation of the disease population because the survey questions used to illicit for CLD assumes that the individual has been in contact with a doctor or other health care professional to obtain a diagnosis. Therefore, our findings are conditional on a prior encounter with a health care provider that diagnosed the respondent with a chronic condition. However, the question stems were similar for the other disease groups. Third, we are unable to delineate the etiology or severity of liver disease given the unavailable of data, which may have implications on the type of care needed by the respondent (e.g. alcohol use treatment for those with ALD), but we adjusted for surrogate markers of health and well-being, including frequency of comorbidities, functional limitation due to health, and fair or poor health to balance differences between the comparison disease groups.

CONCLUSION

The findings from this nationally representative study reveal that US adults with CLD have a greater crude prevalence and likelihood of any health care barriers compared to other non-CLD chronic conditions and the cumulative effect of socioeconomic, demographic, and health risks among persons with CLD explained 42% of the disparity in odds of any health care barriers between CLD and COPD/CVD. Additionally, higher frequency of health care barriers is associated with increased probability of recurrent acute care use for CLD and COPD/CVD. This study highlights the need to include CLD in future iterations of health policies that target high-risk conditions and to assess for health care barriers along with socioeconomic risks in the health care setting for persons with CLD.

Table 2.1. Sociodemographic and Health Characteristics, by Chronic Liver Disease and Chronic Obstructive Pulmonary Disease/ Cardiovascular Disease (N=47,037)

Characteristic	**Chronic Liver Disease**[a]	**COPD and/or CVD**[b]	***P* value**
Respondents, unweighted no.	5,062	41,975	
Estimated population, weighted no.	4,742,444	38,522,241	
Age groups, y[c]			
18-34	13.3 (12.0-14.6)	10.5 (10.0-11.1)	<.001
35-54	35.5 (33.8-37.2)	23.5 (23.0-24.1)	
55-64	28.8 (27.2-30.4)	22.2 (21.7-22.8)	
65-85	22.5 (21.0-24.1)	43.7 (43.0-44.5)	
Biological female sex	51.5 (49.6-53.3)	51.8 (51.1-52.5)	.73
Race or ethnicity[d]			<.001
White	65.8 (64.0-67.6)	75.3 (74.5-76.1)	
Black or African American	8.4 (7.5-9.3)	11.1 (10.6-11.7)	
Hispanic	17.5 (16.0-19.1)	8.6 (8.1-9.1)	
Asian	5.0 (4.2-5.9)	2.6 (2.4-2.9)	
American Indian or Alaska Native	1.0 (0.7-1.5)	0.7 (0.5-0.8)	
Other	2.3 (1.8-2.9)	1.7 (1.5-1.9)	
Comorbidity burden			
Number of comorbidities, median (range)[e]	3 (1-10)	3 (1-9)	<.001
Functional limitation due to health[f] (n=46,933)	68.2 (66.4-69.8)	68.1 (67.4-68.8)	.95
Fair or poor health[g] (n=47,009)	41.4 (39.7-43.2)	33.3 (32.6-34.0)	<.001
Education attainment (n=46,792)			.13
Less than high school graduate level	7.2 (6.3-8.2)	6.5 (6.1-6.8)	
Employment (n=46,950)			<.001
Currently unemployed	57.8 (55.9-59.6)	63.9 (63.1-64.6)	
Living alone	23.2 (22.0-24.5)	24.6 (24.1-25.2)	.04
Household income[h] (n=43,616)			<.001
Below poverty threshold	20.1 (18.7-21.5)	15.3 (14.7-15.8)	
Receipt of any government support[i]	29.5 (27.9-31.1)	21.5 (20.8-22.2)	<.001
Income support[j] (n=46,957)	11.1 (10.1-12.2)	7.0 (6.7-7.4)	<.001
Rent assistance[k] (n=46,951)	6.3 (5.6-7.1)	5.3 (5.0-5.7)	.01
Food support[l] (n=46,976)	24.4 (22.9-26.0)	17.6 (17.0-18.2)	<.001

Other welfare[m] (n=46,935)	1.7 (1.3-2.2)	0.9 (0.8-1.0)	<.001
US region			<.001
Northeast	16.4 (15.0-17.9)	17.1 (16.3-17.9)	
North Central/ Midwest	19.8 (18.4-21.4)	24.8 (23.9-25.7)	
South	36.1 (34.2-38.0)	38.8 (37.8-39.9)	
West	27.7 (25.9-29.5)	19.3 (18.5-20.1)	

Source: National Health Interview Survey, 2011-2017

Abbreviations: COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; BMI, body mass index; USDA, United States Department of Agriculture; SSI, Supplemental Security Income; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; SNAP, Supplemental Nutrition Assistance Program

Data are reported as percent values with 95% confidence intervals unless otherwise indicated.

Denominators per disease category are reported as unweighted observations.

[a] Chronic liver disease status is based on self-reported responses about ever having any chronic liver condition and/or any kind of liver condition in the past year.

[b] COPD status is based on self-reported responses about ever being diagnosed with COPD, emphysema, and/ chronic bronchitis. CVD status is based on self-reported responses about ever being diagnosed with coronary heart disease, myocardial infarction, heart condition or disease, angina, and/or stroke.

[c] Age groups include the following years: 18-34, 35-55, 56-64, and 65-85 years old.

[d] Race or ethnicity includes self-reported Non-Hispanic White (*White*), Non-Hispanic Black (*Black or African-American)*, Hispanic (*Hispanic*), Non-Hispanic Asian (*Asian*), Non-Hispanic American Indian or Alaska Native (*American Indian or Alaska Native*), or Non-Hispanic Other (*Other*) which includes multiple race and race groups that are not releasable.

[e] Comorbidity count includes self-reported arthritis, asthma, BMI $\geq$ 30, cancer, CVD, chronic liver disease, COPD, diabetes, hypertension, and kidney disease.

[f] Functional limitation due to health includes responses about having any functional difficulty because of a health problem.

[g] Fair or poor health includes responses about self-reported health status and is compared to those with excellent, very good, or good health.

[h] Poverty threshold is based on family size, number of children under 18 years old, and reported before-tax combined money income from all sources, excluding noncash benefits, during the preceding calendar year as compared to the U.S. Census Bureau's poverty thresholds for the preceding calendar year. The household income category of *Below poverty threshold* includes persons who report household income below the poverty threshold (vs. at or above poverty threshold).

[i] Receipt of any government support includes receiving any support for income (SSI and/or cash assistance), housing (rent assistance), food (food stamps, SNAP, and/or WIC), and/or other welfare (assistance with getting a job, placement in education or job training programs, transportation, or childcare) in the previous calendar year.

[j] Income support includes responses about receiving income from SSI and/or cash assistance in the previous calendar year.

[k] Rent assistance includes responses about having received public rent assistance.

[l] Food support includes responses about receiving any food stamps, SNAP benefits, and/or WIC.

[m] Other welfare includes assistance with getting a job, placement in education or job training programs, transportation, or childcare).

Table 2.2. Characteristics of Health Care Accessibility and Acute Care Utilization, by Chronic Liver Disease and Chronic Obstructive Pulmonary Disease/ Cardiovascular Disease (N=47,037)

Characteristic	**Chronic Liver Disease**[a]	**COPD and/or CVD**[b]	***P* value**
Respondents, unweighted no.	5,062	41,975	
Estimated population, weighted no.	4,742,444	38,522,241	
Insurance coverage[c] (n=46,034)			
None	11.2 (10.1-12.4)	7.9 (7.5-8.3)	<.001
Public insurance	23.6 (22.0-25.2)	15.7 (15.2-16.2)	
Medicare	15.3 (13.9-16.7)	22.0 (21.4-22.7)	
Private insurance	50.0 (48.1-51.9)	54.3 (53.5-55.1)	
Any perceived barriers to care[d]	44.7 (42.9-46.5)	34.4 (33.7-35.0)	<.001
Number of perceived barriers to care, median (range)[e]	0 (0-13)	0 (0-13)	<.001
Financial barrier[f] (n=47,036)	27.5 (26.0-29.2)	18.8 (18.3-19.4)	<.001
Foregone medical care due to unaffordability (n=47,019)	13.5 (12.2-14.8)	9.8 (9.3-10.2)	<.001
Foregone follow-up care due to unaffordability (n=46,610)	9.5 (8.5-10.5)	6.0 (5.7-6.4)	<.001
Foregone specialty care due to unaffordability (n=46,609)	11.7 (10.5-12.9)	7.3 (6.9-7.6)	<.001
Foregone medication due to unaffordability (n= 46,628)	17.8 (16.5-19.2)	12.3 (11.9-12.8)	<.001
Organizational barrier at the entry of health care[g] (n= 46,722)	17.6 (16.3-19.1)	13.0 (12.6-13.5)	<.001
Trouble finding a provider (n=46,671)	6.3 (5.4-7.2)	4.2 (3.9-4.4)	<.001
Declined as a new patient (n=46,648)	6.5 (5.6-7.5)	3.5 (3.2-3.7)	<.001
Health coverage declined (n=46,632)	7.1 (6.2-8.0)	4.6 (4.3-4.9)	<.001
No usual place for care (n=46,718)	7.5 (6.6-8.6)	6.4 (6.0-6.7)	0.02
Organizational barrier within health care[h] (n=46,640)	19.5 (18.1-20.9)	14.2 (13.7-14.7)	<.001
No appointment soon enough (n=46,626)	12.2 (11.1-13.3)	8.7 (8.3-9.0)	<.001
Inconvenient clinic hours (n=46,618)	4.8 (4.2-5.6)	3.8 (3.5-4.0)	.001
Could not get through by phone (n=46,634)	5.5 (4.8-6.4)	3.8 (3.5-4.0)	<.001
Long waiting time at clinic (n=46,619)	8.8 (7.9-9.9)	6.5 (6.1-6.8)	<.001
Other barrier[i]			
Lack of transportation to receive timely care (n=46,631)	6.1 (5.4-7.0)	4.1 (3.8-4.3)	<.001
Acute care use[j] (n=47,023)	29.2 (27.7-30.8)	24.0 (23.4-24.5)	<.001
At least 2 hospitalizations (n=46,941)	9.9 (8.9-10.9)	7.6 (7.3-8.0)	<.001
At least 2 ED visits (n=46,416)	21.2 (19.8-22.7)	15.5 (15.1-16.0)	<.001

Source: National Health Interview Survey, 2011-2017

Abbreviations: COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; ED, emergency department

Data are reported as percent values with 95% confidence intervals unless otherwise indicated.

Denominators per disease category are reported as unweighted observations.

[a] Chronic liver disease status is based on self-reported responses about ever having any chronic liver condition and/or any kind of liver condition in the past year.

[b] COPD status is based on self-reported responses about ever being diagnosed with COPD, emphysema, and/ chronic bronchitis. CVD status is based on self-reported responses about ever being diagnosed with coronary heart disease, myocardial infarction, heart condition or disease, angina, and/or stroke.

[c] Insurance category *None* includes persons without any insurance coverage including having only single service plans, category *Public insurance* includes any public insurance via Medicaid, other state or local government program, Children's Health Insurance Program, or Medicare for dual enrollees, category *Medicare* includes Medicare only beneficiaries, and category *Private insurance* includes enrollment in any private insurance.

[d] Any perceived barriers to care includes affirmative responses to questions about needing but foregoing medical care, follow-up, specialty care, and/or prescription medication due to unaffordability, trouble finding a provider, being declined as a new patient, having health coverage declined, not having a usual place for routine or sick care, having delays in medical care because one could not get an appointment soon enough, clinic or doctor's office was closed, could not get through by phone, had a long wait time to see the doctor, and/or lacked transportation.

[e] Number of perceived barriers to care includes affirmative responses to questions about needing but foregoing medical care, follow-up, specialty care, and/or prescription medication due to unaffordability, trouble finding a provider, being declined as a new patient, having health coverage declined, not having a usual place for routine or sick care, having delays in medical care because one could not get an appointment soon enough, clinic or doctor's office was closed, could not get through by phone, had a long wait time to see the doctor, and/or lacked transportation.

[f] Financial barrier includes affirmative responses to questions about foregoing needed medical care, follow-up, specialty care, and/or prescription medications due to unaffordability in the past 12 months.

[g] Organizational barrier at the entry of health care includes affirmative responses to questions about having trouble finding a provider, being declined as a new patient, having health coverage declined, and/or not having a usual place for routine or sick care.

[h] Organizational barrier within health care includes self-reporting delayed medical care because one could not get an appointment soon enough, clinic or doctor's office was closed, could not get through by phone, and/or had a long wait time to see the doctor.

[i] Other barrier includes self-reported lack of transportation to receive timely care

[j] Acute care use is defined as at least 2 overnight admissions or emergency department visits in the past year

Table 2.3. Adjusted Incident Rate Ratios using Adjusted Hurdle Negative Binomial Model to Assess the Relationship between Health Care Barriers and Adults with Chronic Liver Disease vs. Chronic Obstructive Pulmonary Disease and/or Cardiovascular Disease (n=42,370)

	Any Barriers			**Number of Barriers**		
Characteristic	**IRR**	**95% CI**	***P*-value**	**IRR**	**95% CI**	***P*-value**
CLD (vs. COPD/CVD)	1.12	1.01-1.24	0.026	1.05	1.00-2.71	0.057
Biological female sex	1.12	1.03-1.21	0.006	1.22	1.18-3.25	<.001
Age (years) (vs. 65 and older)						
18 to 34	4.51	3.94-5.16	<.001	2.07	1.91-6.74	<.001
35 to 54	3.03	2.75-3.34	<.001	1.92	1.83-6.24	<.001
55 to 64	2.13	1.97-2.29	<.001	1.59	1.50-4.48	<.001
Race or ethnicity (vs. White)[a]						
Black/ African American	0.98	0.92-1.05	0.609	0.97	0.92-2.51	0.261
Hispanic	1.07	0.97-1.18	0.194	1.02	0.93-2.55	0.626
Asian	1.05	0.91-1.22	0.510	0.86	0.77-2.16	0.007
American Indian/ Alaskan Native	0.75	0.59-0.95	0.018	0.73	0.66-1.94	<.001
Other	1.20	1.04-1.39	0.012	1.05	0.98-2.66	0.201
Comorbidity count[b]	1.09	1.07-1.10	<.001	1.04	1.03-2.79	<.001
Fair/ poor health	1.37	1.30-1.45	<.001	1.21	1.13-3.09	<.001
Functional limitation due to health	1.81	1.64-2.01	<.001	1.47	1.40-4.04	<.001
Less than high school graduate education	0.97	0.91-1.02	0.219	0.99	0.93-2.54	0.624
Unemployment	0.89	0.83-0.97	0.005	0.97	0.92-2.51	0.214
Living alone	1.29	1.21-1.37	<.001	1.15	1.12-3.05	<.001
Below federal poverty level	1.08	0.98-1.18	0.105	1.09	1.04-2.83	<.001
Receipt of government support[c]	1.56	1.46-1.67	<.001	1.17	1.11-3.04	<.001
Insurance (vs. private insurance)[d]						
No insurance	5.50	4.99-6.07	<.001	1.72	1.63-5.11	<.001
Public insurance	1.08	0.94-1.23	0.270	1.14	1.06-2.90	<.001
Medicare	1.35	1.26-1.44	<.001	1.25	1.18-3.26	<.001
US region (vs. Northeast)						
North Central/ Midwest	1.23	1.07-1.40	0.003	1.08	1.03-2.80	0.001
South	1.26	1.19-1.33	<.001	1.11	1.05-2.87	<.001
West	1.45	1.36-1.55	<.001	1.29	1.23-3.41	<.001
Survey year (vs. 2011-2013)						
2014-2017	0.99	0.93-1.06	0.862	1.04	1.01-2.74	0.016

Source: National Health Interview Survey, 2011-2017

Abbreviations: IRR, incident rate ratio; CLD, chronic liver disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease

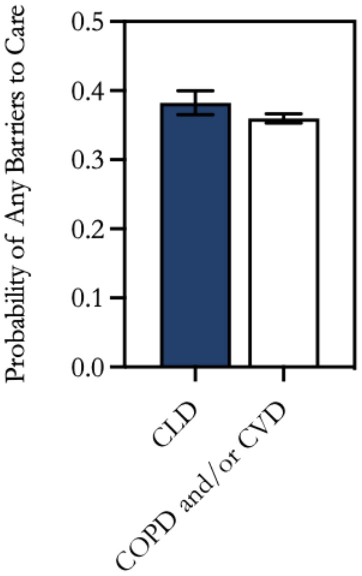
[a] Race or ethnicity includes self-reported Non-Hispanic White (*White*), Non-Hispanic Black (*Black or African-American)*, Hispanic (*Hispanic*), Non-Hispanic Asian (*Asian*), Non-Hispanic American Indian or Alaska Native (*American Indian or Alaska Native*), or Non-Hispanic Other (*Other*) which includes multiple race and race groups that are not releasable.

[b] Comorbidity count includes self-reported arthritis, asthma, BMI ≥ 30, cancer, CVD, chronic liver disease, COPD, diabetes, hypertension, and kidney disease.

[c] Receipt of any government support includes receiving any support for income (SSI and/or cash assistance), housing (rent assistance), food (food stamps, SNAP, and/or WIC), and/or other welfare (assistance with getting a job, placement in education or job training programs, transportation, or childcare) in the previous calendar year.

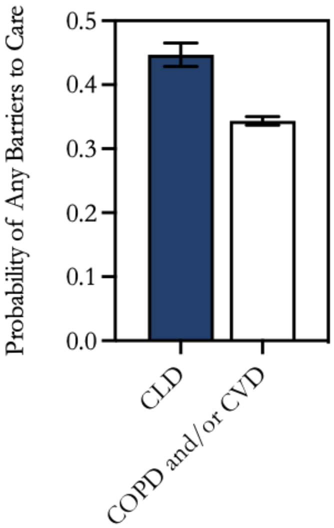
[d] Insurance category *None* includes persons without any insurance coverage including having only single service plans, category *Public insurance* includes any public insurance via Medicaid, other state or local government program, Children's Health Insurance Program, or Medicare for dual enrollees, category *Medicare* includes Medicare only beneficiaries, and category *Private insurance* includes enrollment in any private insurance.

Figure 2.1A. Adjusted probability of barriers to care for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease



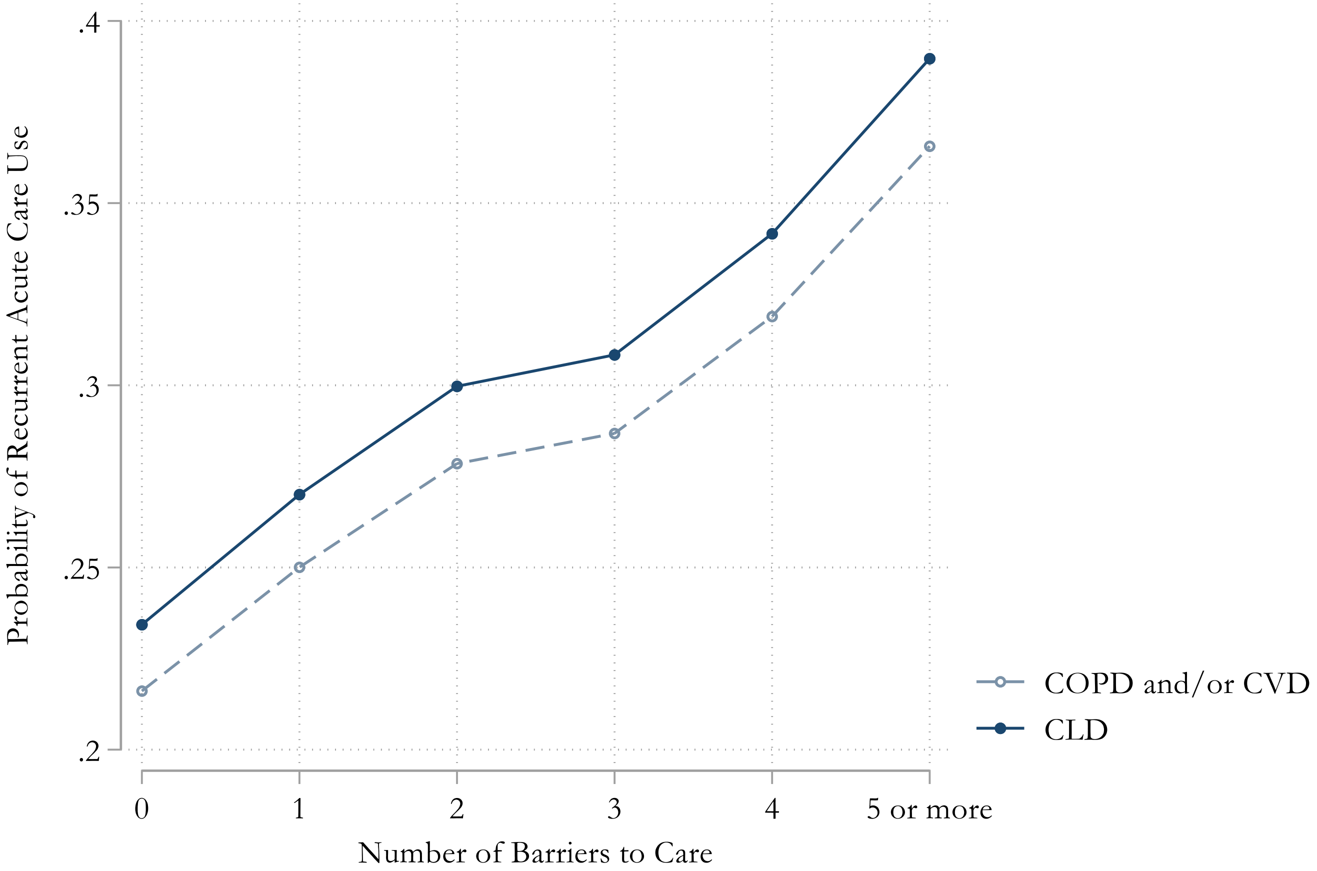
Source: National Health Interview Survey, 2011-2017
Abbreviations: COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; CLD, chronic liver disease.
Predicted probabilities are obtained from a logistic regression model that adjusts for disease group, sex, age, race or ethnicity, comorbidity count, fair or poor health, functional limitation due to health, education, employment, living alone, household poverty, receipt of government support, insurance, US Census region, and year.

Figure 2.1B. Unadjusted probability of barriers to care for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease (N=47,037)



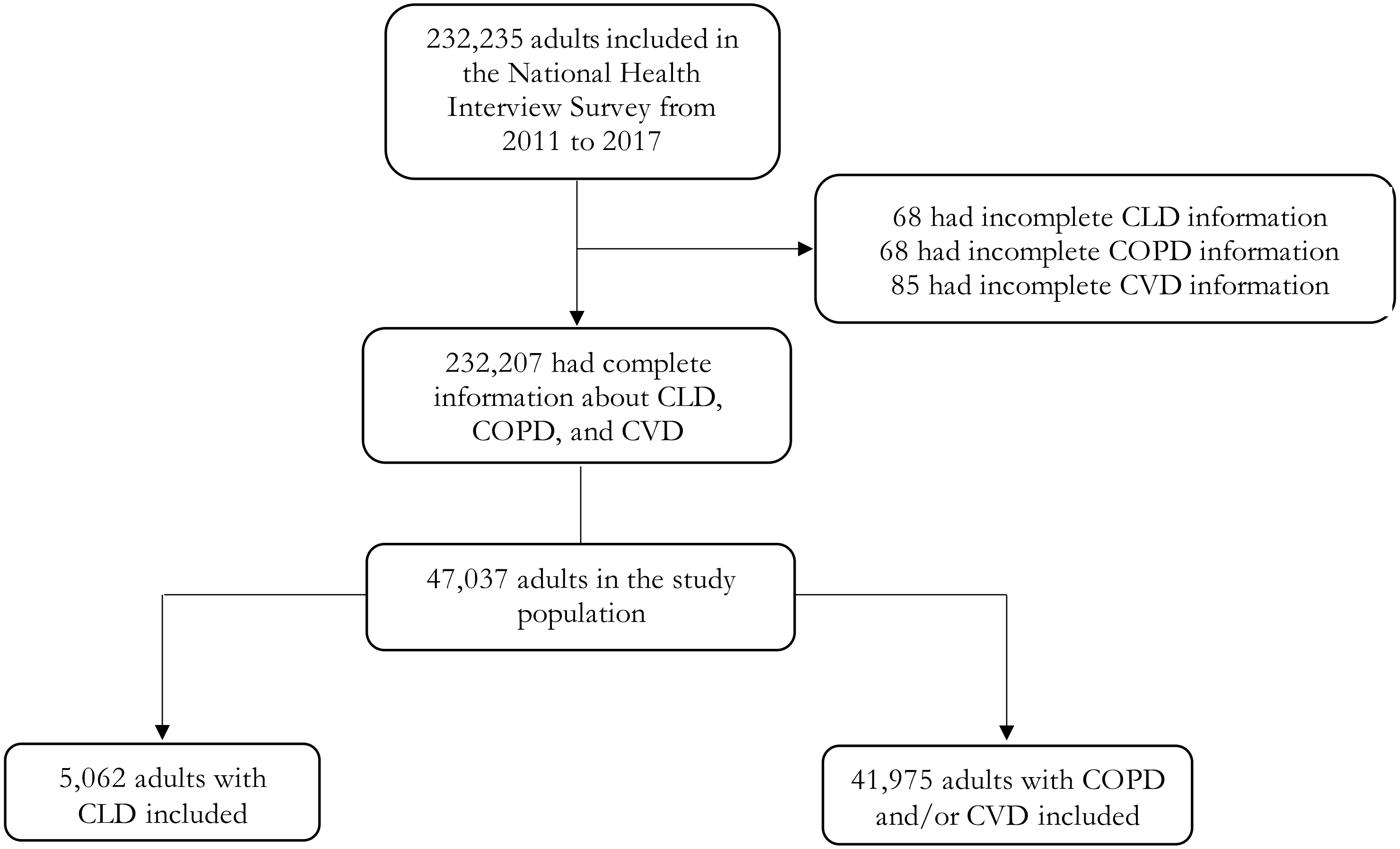
Source: National Health Interview Survey, 2011-2017
Abbreviations: COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; CLD, chronic liver disease.

Figure 2.2. Adjusted probability of recurrent acute care use in the past year for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease, by number of barriers to care (n=42,360)



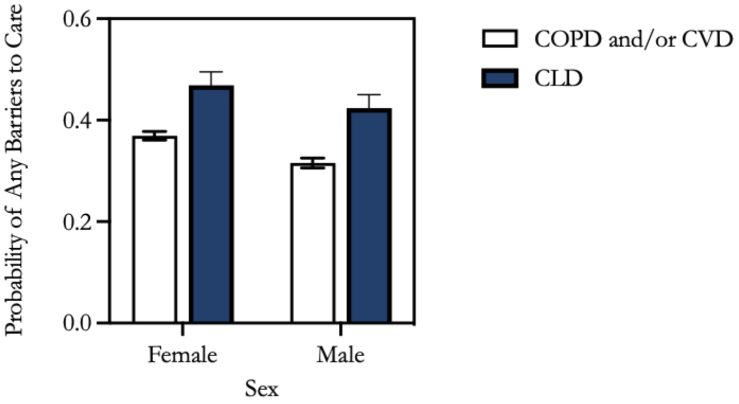
Source: National Health Interview Survey, 2011-2017Abbreviations: COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; CLD, chronic liver disease. Predicted probabilities are obtained from a logistic regression model that adjusts for disease group, sex, age, race or ethnicity, comorbidity count, fair or poor health, functional limitation due to health, education, employment, living alone, household poverty, material hardship, insurance, US Census region, and year

Appendix Figure 2.1. Study Population Flowchart

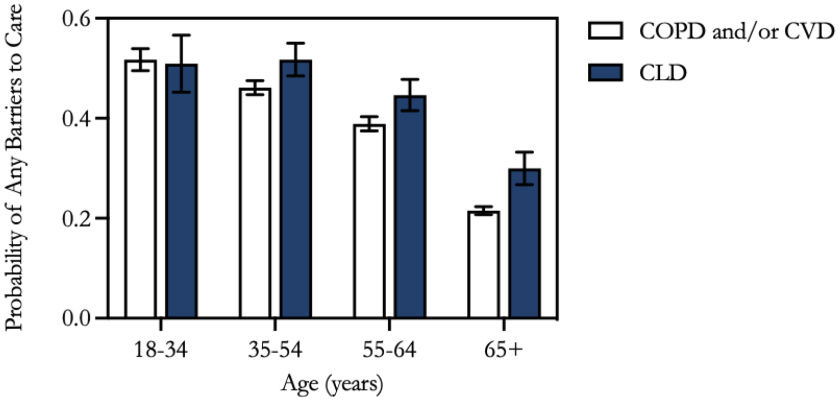


Abbreviations: CLD, chronic liver disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease

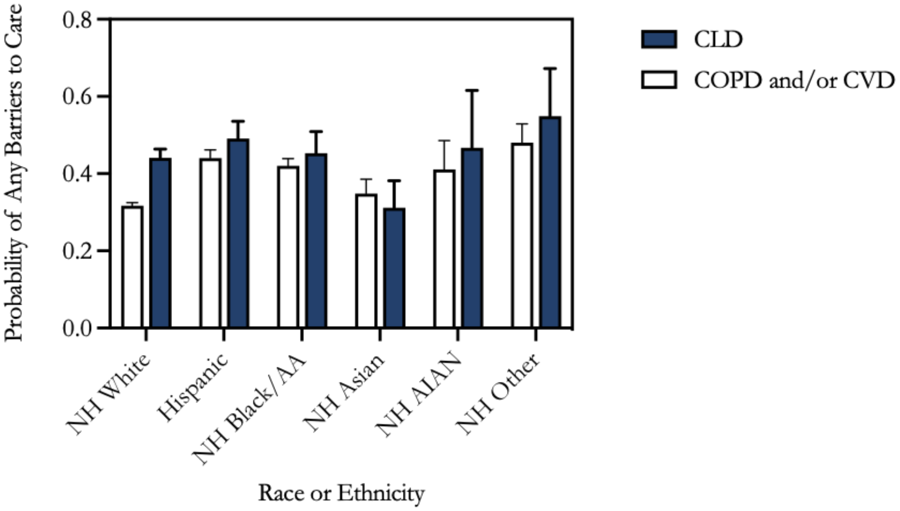
Appendix Figure 2.2A. Unadjusted probability of barriers to care for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease, by sex



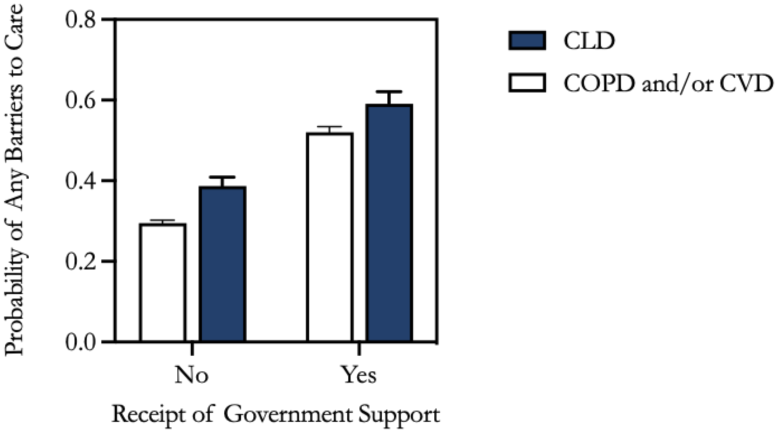
Appendix Figure 2.2B. Unadjusted probability of barriers to care for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease, by age



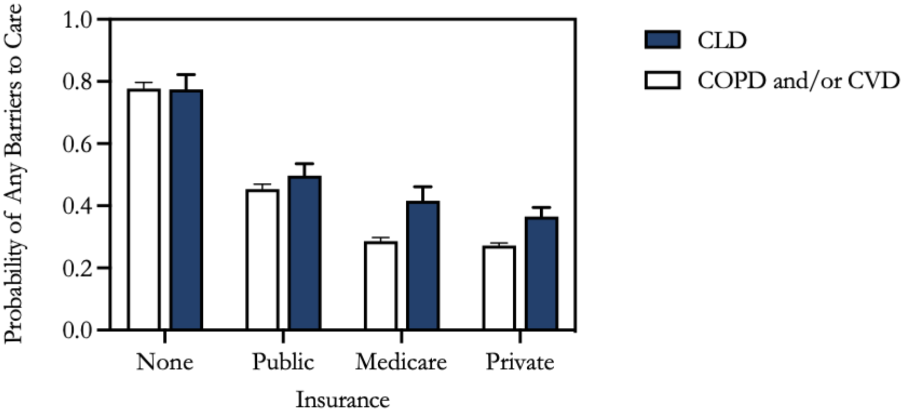
Appendix Figure 2.2C. Unadjusted probability of barriers to care for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease, by race or ethnicity



Appendix Figure 2.2D. Unadjusted probability of barriers to care for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease, by receipt of government support



Appendix Figure 2.2E. Unadjusted probability of barriers to care for adults with chronic liver disease compared to chronic obstructive pulmonary disease and/or cardiovascular disease, by insurance



Appendix Table 2.1A. Sociodemographic and Health Characteristics by Health Care Barriers for Chronic Liver Disease (n=5,062)

Characteristic	Zero Barriers	≥ 1 Barriers	*P* value
Respondents, unweighted no.	2,800	2,262	
Age groups, y[a]			
18-34	11.8 (10.1-13.6)	15.1 (13.2-17.2)	<.001
35-54	30.9 (28.7-33.3)	41.0 (38.3-43.8)	
55-64	28.8 (26.6-31.1)	28.8 (26.5-31.2)	
65-85	28.5 (26.4-30.8)	15.1 (13.3-17.1)	
Biological female sex	49.4 (46.9-51.9)	54.0 (51.2-56.8)	0.0213
Race or ethnicity[b]			
White	66.5 (64.0-68.9)	64.9 (62.3-67.4)	0.0016
Black or African American	8.3 (7.0-9.7)	8.5 (7.2-9.9)	
Hispanic	16.1 (14.1-18.3)	19.2 (17.2-21.5)	
Asian	6.2 (5.1-7.6)	3.5 (2.7-4.6)	
American Indian or Alaska Native	1.0 (0.6-1.6)	1.1 (0.7-1.7)	
Other	1.9 (1.3-2.7)	2.8 (2.0-4.0)	
Comorbidity burden			
Number of comorbidities, median (range)[c]	3 (1-10)	4 (1-10)	<.001
Functional limitation due to health[d] (n=5,056)	62.6 (60.2-64.8)	75.1 (72.5-77.5)	<.001
Fair or poor health[e] (n=5,056)	33.5 (31.2-35.8)	51.3 (48.6-53.9)	<.001
Education attainment (n=5,036)			
Less than high school graduate level	6.6 (5.5-7.9)	7.9 (6.6-9.5)	0.1523
Employment (n=5,052)			
Currently unemployed	56.2 (53.7-58.7)	59.7 (57.1-62.3)	0.0598
Living alone	21.4 (19.8-23.0)	25.5 (23.6-27.6)	0.0015
Household income[f] (n=4,791)			
Below poverty threshold	14.5 (13.0-16.2)	26.8 (24.6-29.1)	<.001
Receipt of any government support[g]	21.8 (19.9-23.8)	39.0 (36.4-41.6)	<.001
Income support[h] (n=5,058)	9.9 (8.6-11.4)	12.6 (11.1-14.2)	0.0088
Rent assistance[i] (n=5,060)	5.7 (4.8-6.7)	7.1 (6.0-8.3)	0.0591
Food support[j] (n=5,058)	17.2 (15.5-19.0)	33.4 (30.9-36.0)	<.001
Other welfare[k] (n=5,056)	0.9 (0.6-1.3)	2.7 (2.0-3.6)	<.001
US region			
Northeast	18.7 (16.7-20.9)	13.5 (11.8-15.5)	0.0027
North Central/ Midwest	19.5 (17.6-21.5)	20.3 (17.9-22.9)	
South	34.6 (32.3-37.0)	38.0 (35.2-40.8)	
West	27.2 (25.0-29.5)	28.3 (25.7-31.0)	

Appendix Table 2.1B. Sociodemographic and Health Characteristics by Health Care Barriers for Chronic Obstructive Pulmonary Disease and/or Cardiovascular Disease (n=41,975)

Characteristic	**Zero Barriers**	**≥ 1 Barriers**	***P* value**
Respondents, unweighted no.	27,557	14,418	
Age groups, y[a]			
18-34	7.7 (7.2-8.3)	15.9 (14.9-16.8)	<.001
35-54	19.3 (18.7-20.0)	31.6 (30.6-32.7)	
55-64	20.6 (20.0-21.4)	25.2 (24.2-26.2)	
65-85	52.3 (51.4-53.2)	27.4 (26.4-28.4)	
Biological female sex	49.7 (48.9-50.6)	55.7 (54.6-56.8)	<.001
Race or ethnicity[b]			
White	78.3 (77.5-79.1)	69.6 (68.4-70.7)	<.001
Black or African American	9.8 (9.3-10.4)	13.6 (12.8-14.5)	
Hispanic	7.3 (6.8-7.9)	11.0 (10.3-11.8)	
Asian	2.6 (2.4-2.9)	2.7 (2.3-3.1)	
American Indian or Alaska Native	0.6 (0.5-0.8)	0.8 (0.6-1.0)	
Other	1.3 (1.2-1.5)	2.4 (2.1-2.7)	
Comorbidity burden			
Number of comorbidities, median (range)[c]	3 (1-9)	3 (1-9)	<.001
Functional limitation due to health[d] (n=41,877)	64.9 (64.0-65.7)	74.3 (73.2-75.3)	<.001
Fair or poor health[e] (n=41,953)	28.9 (28.2-29.7)	41.7 (40.6-42.8)	<.001
Education attainment (n=41,756)			
Less than high school graduate level	6.4 (5.9-6.8)	6.7 (6.2-7.3)	0.2246
Employment (n=41,898)			
Currently unemployed	65.2 (64.4-66.1)	61.3 (60.1-62.4)	<.001
Living alone	23.9 (23.3-24.6)	25.9 (25.1-26.7)	<.001
Household income[f] (n=38,825)			
Below poverty threshold	11.3 (10.8-11.8)	22.6 (21.6-23.6)	<.001
Receipt of any government support[g]	15.7 (15.0-16.4)	32.5 (31.4-33.7)	<.001
Income support[h] (n=41,891)	5.8 (5.4-6.2)	9.5 (8.9-10.1)	<.001
Rent assistance[i] (n=41,891)	4.5 (4.1-4.9)	7.0 (6.4-7.6)	<.001
Food support[j] (n=41,918)	12.3 (11.7-12.9)	27.7 (26.6-28.8)	<.001
Other welfare[k] (n=5,056)	0.6 (0.5-0.7)	1.6 (1.3-1.8)	<.001
US region			
Northeast	18.9 (17.9-19.8)	13.7 (12.8-14.6)	<.001
North Central/ Midwest	25.0 (24.1-25.9)	24.4 (23.1-25.8)	
South	37.6 (36.5-38.7)	41.2 (39.7-42.6)	
West	18.5 (17.7-19.4)	20.7 (19.6-21.9)	

Source: National Health Interview Survey, 2011-2017

Data are reported as percent values with 95% confidence intervals unless otherwise indicated.

Denominators per disease category are reported as unweighted observations.

[a] Age groups include the following years: 18-34, 35-55, 56-64, and 65-85 years old.

[b] Race or ethnicity includes self-reported Non-Hispanic White (*White*), Non-Hispanic Black (*Black or African-American)*, Hispanic (*Hispanic*), Non-Hispanic Asian (*Asian*), Non-Hispanic American Indian or Alaska Native (*American Indian or Alaska Native*), or Non-Hispanic Other (*Other*) which includes multiple race and race groups that are not releasable.

[c] Comorbidity count includes self-reported arthritis, asthma, BMI ≥ 30, cancer, CVD, chronic liver disease, COPD, diabetes, hypertension, and kidney disease.

[d] Functional limitation due to health includes responses about having any functional difficulty because of a health problem.

[e] Fair or poor health includes responses about self-reported health status and is compared to those with excellent, very good, or good health.

[f] Poverty threshold is based on family size, number of children under 18 years old, and reported before-tax combined money income from all sources, excluding noncash benefits, during the preceding calendar year as compared to the U.S. Census Bureau's poverty thresholds for the preceding calendar year. The household income category of *Below poverty threshold* includes persons who report household income below the poverty threshold (vs. at or above poverty threshold).

[g] Receipt of any government support includes receiving any support for income (SSI and/or cash assistance), housing (rent assistance), food (food stamps, SNAP, and/or WIC), and/or other welfare (assistance with getting a job, placement in education or job training programs, transportation, or childcare) in the previous calendar year.

[h] Income support includes responses about receiving income from SSI and/or cash assistance in the previous calendar year.

[i] Rent assistance includes responses about having received public rent assistance.

[j] Food support includes responses about receiving any food stamps, SNAP benefits, and/or WIC.

[k] Other welfare includes assistance with getting a job, placement in education or job training programs, transportation, or childcare).

Appendix Table 2.2A. Characteristics of Health Care Access and Utilization by Health Care Barriers for Chronic Liver Disease

Characteristic	**Zero Barriers**	**≥ 1 Barriers**	***P* value**
Insurance coverage[a] (n=4,924)			
None	4.6 (3.6-5.8)	19.3 (17.2-21.6)	<.001
Public insurance	21.6 (19.5-23.8)	26.0 (23.6-28.6)	
Medicare	16.2 (14.4-18.1)	14.1 (12.3-16.2)	
Private insurance	57.7 (55.0-60.2)	40.6 (37.6-43.6)	
Acute care use (n=5,061)			
≥ 2 ED or hospital admissions	24.4 (22.4-26.5)	35.2 (32.8-37.7)	<.001
≥ 2 hospital admissions (n=5,055)	8.1 (7.0-9.4)	12.1 (10.5-13.9)	0.0002
≥ 2 ED visits (n=5,011)	15.5 (13.8-17.4)	28.3 (26.1-30.7)	<.001

Appendix Table 2.2B. Characteristics of Health Care Access and Utilization by Health Care Barriers for COPD/CVD

Characteristic	**Zero Barriers**	**≥ 1 Barriers**	***P* value**
Insurance coverage[a] (n=41,110)			
None	2.7 (2.4-3.0)	17.9 (17.0-18.9)	<.001
Public insurance	13.1 (12.5-13.7)	20.7 (19.8-21.7)	
Medicare	24.0 (23.2-24.7)	18.4 (17.5-19.3)	
Private insurance	60.3 (59.4-61.2)	43.0 (41.7-44.2)	
Acute care use (n=41,962)			
≥ 2 ED or hospital admissions	20.3 (19.7-21.0)	30.9 (29.9-31.9)	<.001
≥ 2 hospital admissions (n=41,886)	6.9 (6.5-7.3)	9.0 (8.4-9.6)	<.001
≥ 2 ED visits (n=41,405)	11.7 (11.2-12.2)	22.9 (22.0-23.8)	<.001

Source: National Health Interview Survey, 2011-2017

Abbreviations: ED, emergency department

[a] Insurance category *None* includes persons without any insurance coverage including having only single service plans, category *Public insurance* includes any public insurance via Medicaid, other state or local government program, Children's Health Insurance Program, or Medicare for dual enrollees, category *Medicare* includes Medicare only beneficiaries, and category *Private insurance* includes enrollment in any private insurance.

Appendix Table 2.3A. Unweighted Adjusted Incident Rate Ratios for Health Care Barriers for Chronic Liver Disease vs. Chronic Obstructive Pulmonary Disease and/or Cardiovascular Disease Using Different Count Models

	Model	Any Barriers			Number of Barriers		
		IRR	**95% CI**	***P*-value**	**IRR**	**95% CI**	***P*-value**
A	Poisson	--	--	--	1.10	1.07-1.13	<.001
B	Negative binomial	--	--	--	1.12	1.07-1.18	<.001
C	Zero-inflated poisson	1.15	1.06-1.25	0.001	1.05	1.02-1.09	0.003
D	Zero-inflated negative binomial	1.22	1.07-1.40	0.003	1.05	1.00-1.11	0.043
E	Hurdle poisson	1.16	1.08-1.24	<.001	1.05	1.02-1.09	0.002
F	Hurdle negative binomial	1.16	1.08-1.24	<.001	1.06	1.01-1.12	0.026

Source: National Health Interview Survey, 2011-2017
Abbreviations: IRR, incident rate ratio; CLD, chronic liver disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease
All models use an unweighted sample of 42,370 respondents with CLD or COPD and/or CVD and adjusts for sex, age, race or ethnicity, and comorbidity burden, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, poverty, receipt of government support, health insurance, US Census region, and survey year.

Appendix Table 2.3B. Goodness of Fit Measures for Different Count Models

	Model	AIC	BIC	*P*-value of LRT of Alpha
A	Poisson	111843.7	112120.7	N/A
B	Negative binomial	98565.42	98851.01	<.001
C	Zero-inflated poisson	99582.66	100136.5	N/A
D	Zero-inflated negative binomial	97128.88	97691.4	<.001
E	Hurdle poisson	99586.83	100140.7	N/A
F	Hurdle negative binomial	97117.73	97680.25	<.001

Source: National Health Interview Survey, 2011-2017
Abbreviations: LRT, likelihood ratio test; CLD, chronic liver disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease
All models use an unweighted sample of 42,370 respondents with CLD or COPD and/or CVD and adjusts for sex, age, race or ethnicity, and comorbidity burden, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, poverty, receipt of government support, health insurance, US Census region, and survey year.

Appendix Table 2.4. Unadjusted and Adjusted Weighted Incident Rate Ratios Using Nested Hurdle Negative Binomial Models to Assess the Relationship between Health Care Barriers and Chronic Liver Disease vs. Chronic Obstructive Pulmonary Disease and/or Cardiovascular Disease

Nested Model	Any Barriers				Number of Barriers				Adjusted Wald Test	Mean VIF
	IRR	**SE**	**95% CI**	***P*-value**	**IRR**	**SE**	**95% CI**	***P*-value**		
A. Disease group	1.54	0.02	1.43-1.67	<.001	1.22	0.03	1.16-1.28	<.001	--	--
B. Same as model A plus sex	1.55	0.02	1.44-1.67	<.001	1.22	0.02	1.17-1.28	<.001	<.001	1.00
C. Same as model B plus age	1.27	0.04	1.16-1.40	<.001	1.14	0.02	1.09-1.20	<.001	<.001	1.09
D. Same as model C plus race or ethnicity	1.25	0.04	1.14-1.37	<.001	1.14	0.04	1.08-1.20	<.001	<.001	1.06
E. Same as model D plus comorbidity	1.15	0.04	1.05-1.25	0.003	1.08	0.03	1.01-1.14	0.014	<.001	1.08
F. Same as model E plus fair or poor health	1.13	0.04	1.03-1.25	0.012	1.07	0.03	1.01-1.13	0.025	<.001	1.10
G. Same as model F plus functional limitation due to health	1.14	0.05	1.03-1.27	0.012	1.07	0.03	1.02-1.13	0.008	<.001	1.13
H. Same as model G plus education	1.12	0.05	1.01-1.25	0.028	1.07	0.03	1.01-1.13	0.013	<.001	1.14
I. Same as model H plus unemployment	1.12	0.05	1.01-1.24	0.031	1.07	0.03	1.02-1.13	0.011	0.0625	1.19*
J. Same as model I plus living alone	1.11	0.05	1.00-1.24	0.051	1.07	0.03	1.01-1.12	0.013	<.001	1.19
K. Same as model J plus poverty	1.12	0.05	1.01-1.24	0.037	1.07	0.03	1.01-1.12	0.016	<.001	1.22
L. Same as model K plus receipt of government support	1.11	0.05	1.00-1.24	0.058	1.06	0.03	1.01-1.12	0.019	<.001	1.26
M. Same as model L plus health insurance	1.13	0.05	1.02-1.26	0.022	1.06	0.03	1.01-1.12	0.015	<.001	1.34
N. Same as model M plus US Census region	1.12	0.05	1.01-1.25	0.030	1.05	0.03	1.00-1.11	0.057	<.001	1.42
O. Same as model N plus survey year	1.12	0.05	1.01-1.24	0.026	1.05	0.03	1.00-1.11	0.057	0.0135	1.40

Source: National Health Interview Survey, 2011-2017
Abbreviations: IRR, incident rate ratio; VIF, variance inflation factor; CLD, chronic liver disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease
Weighted estimates were obtained using probability weights (pweight) and clustering at the primary sampling units.
Model A compares 47,037 respondents by disease groups of interest CLD vs. COPD and/or CVD (without CLD).
Model B compares 47,037 respondents by disease groups (CLD vs. COPD and/or CVD) and adjusts for biological sex.
Model C compares 47,037 respondents by disease groups and adjusts for biological sex and age (65 years or older vs. 18-34, 35-54, 55-64 years old).

Model D compares 47,037 respondents by disease groups and adjusts for biological sex, age, and race or ethnicity (White vs. Black, Hispanic, Asian, American Indian/ Alaskan Native, Other).
Model E compares 47,037 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity (number of comorbidities).
Model F compares 47,009 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, comorbidity, and fair or poor health.
Model G compares 46,905 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity, fair or poor health, and functional limitation due to health.
Model H compares 46,663 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity, fair or poor health, functional limitation due to health, and less than high school graduate level education. * Individual VIF for unemployment is 1.47.
Model I compares 46,589 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity, fair or poor health, functional limitation due to health, less than high school graduate level education, and unemployment.
Model J compares 46,589 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, and living alone.
Model K compares 43,289 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, and poverty (household income below federal poverty level).
Model L compares 43,289 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity burden, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, poverty, and receipt of government support (receipt of government subsidy for income, food, other welfare).
Model M compares 42,370 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity burden, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, poverty, receipt of government support, and health insurance (private vs. no insurance, public, Medicare).
Model N compares 42,370 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity burden, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, poverty, receipt of government support, health insurance, and US Census region (Northeast vs. Midwest, South, West).
Model O compares 42,370 respondents by disease groups and adjusts for biological sex, age, race or ethnicity, and comorbidity burden, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, poverty, receipt of government support, health insurance, US Census region, and survey year (2011-2013 vs. 2014-2017).

Appendix Table 2.5. Sensitivity Analysis using Hurdle Negative Binomial Model to Assess the Relationship between Health Care Barriers and Disease Groups

	Any Barriers				**Number of Barriers**			
Disease Group	**IRR**	**SE**	**95% CI**	***P*-value**	**IRR**	**SE**	**95% CI**	***P*-value**
A. CLD vs. COPD and/or CVD	1.12	0.05	1.01-1.24	0.026	1.05	0.03	1.00-2.71	0.057
B. CLD only vs. COPD and/or CVD	1.10	0.08	0.92-1.30	0.293	1.04	0.04	0.96-1.13	0.317
C. CLD and COPD and/or CVD vs. COPD and CVD	0.98	0.07	0.85-1.11	0.710	1.05	0.03	0.98-1.13	0.152

Source: National Health Interview Survey, 2011-2017

Abbreviations: IRR, incident rate ratio; CLD, chronic liver disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease

Model A is the primary analysis, which compares 42,370 respondents with CLD vs. COPD and/or CVD (without CLD) and adjusts for biological sex, age group, race or ethnicity, comorbidity burden, fair or poor health, functional limitation due to health, less than high school graduate level education, unemployment, living alone, poverty, receipt of government support, insurance type, US Census region, and survey year.

Model B replicates the primary analysis using the same covariates and compares 40,483 respondents with CLD only vs. COPD and/or CVD.

Model C replicates the primary analysis using the same covariates and compares 7,073 respondents with CLD and COPD and/or CVD vs. COPD and CVD

Appendix Table 2.6A. Sociodemographic and Health Characteristics by Acute Care Use for Chronic Liver Disease (n=5,061)

Characteristic	**Acute Care Use in the Past Year**		***P* value**
	0-1 times	≥ 2 times	
Respondents, unweighted no.	3,581	1,480	
Age groups, y[a]			
18-34	13.5 (12.0-15.2)	12.7 (10.6-15.1)	0.8944
35-54	35.5 (33.3-37.7)	35.4 (32.3-38.7)	
55-64	28.5 (26.5-30.5)	29.6 (26.8-32.6)	
65-85	22.6 (20.8-24.5)	22.3 (19.8-24.9)	
Biological female sex	50.2 (48.0-52.3)	54.6 (51.4-57.7)	0.0184
Race or ethnicity[b]			
White	65.8 (63.6-67.9)	65.9 (62.8-68.9)	<.001
Black or African American	7.1 (6.1-8.3)	11.3 (9.6-13.2)	
Hispanic	18.8 (17.0-20.7)	14.4 (12.3-16.9)	
Asian	5.5 (4.5-6.6)	3.9 (2.7-5.5)	
American Indian or Alaska Native	0.8 (0.5-1.2)	1.6 (1.0-2.6)	
Other	2.1 (1.5-2.8)	2.9 (2.0-4.1)	
Comorbidity burden			
Number of comorbidities, median (range)[c]	3 (1-10)	4 (1-10)	<.001
Functional limitation due to health[d] (n=5,055)	62.0 (59.7-64.2)	83.1 (80.3-85.6)	<.001
Fair or poor health[e] (n=5,055)	32.6 (30.6-34.7)	62.8 (59.4-66.0)	<.001
Education attainment (n=5,035)			
Less than high school graduate level	6.9 (5.9-8.0)	7.9 (6.2-10.0)	0.3294
Employment (n=5,051)			
Currently unemployed	51.9 (49.8-54.1)	72.0 (68.7-75.0)	<.001
Living alone	21.8 (20.4-23.3)	26.6 (24.2-29.2)	0.0007
Household income[f] (n=4,790)			
Below poverty threshold	17.6 (16.0-19.2)	26.1 (23.5-28.8)	<.001
Receipt of any government support[g]	23.9 (22.2-25.7)	43.0 (39.7-46.3)	<.001
Income support[h] (n=5,057)	8.8 (7.7-9.9)	16.8 (14.6-19.4)	<.001
Rent assistance[i] (n=5,059)	5.0 (4.2-5.9)	9.4 (8.0-11.0)	<.001
Food support[j] (n=5,057)	20.2 (18.5-22.0)	34.6 (31.6-37.7)	<.001
Other welfare[k] (n=5,055)	1.0 (0.7-1.4)	3.3 (2.4-4.7)	<.001
US region			
Northeast	16.6 (14.9-18.5)	15.9 (13.5-18.6)	0.0013
North Central/ Midwest	18.7 (17.0-20.5)	22.7 (20.1-25.5)	
South	35.2 (33.0-37.5)	38.2 (35.3-41.2)	
West	29.5 (27.4-31.7)	23.2 (20.6-26.1)	

Appendix Table 2.6B. Sociodemographic and Health Characteristics by Acute Care Use for Chronic Obstructive Pulmonary Disease and/or Cardiovascular Disease (n=41,962)

Characteristic	**Acute Care Use in the Past Year**		***P* value**
	0-1 times	≥ 2 times	
Respondents, unweighted no.	31,904	10,058	
Age groups, y[a]			
18-34	10.5 (9.9-11.1)	10.7 (9.9-11.7)	0.0228
35-54	23.2 (22.5-23.8)	24.7 (23.6-25.9)	
55-64	22.6 (22.0-23.3)	21.0 (20.0-22.0)	
65-85	43.8 (43.0-44.6)	43.6 (42.3-44.9)	
Biological female sex	50.7 (49.9-51.4)	55.4 (54.1-56.6)	<.001
Race or ethnicity[b]			
White	76.7 (75.9-77.5)	70.9 (69.7-72.2)	<.001
Black or African American	9.8 (9.2-10.3)	15.4 (14.4-16.4)	
Hispanic	8.6 (8.1-9.1)	8.7 (8.0-9.5)	
Asian	2.8 (2.6-3.1)	1.9 (1.6-2.3)	
American Indian or Alaska Native	0.6 (0.5-0.8)	0.8 (0.6-1.1)	
Other	1.5 (1.4-1.7)	2.2 (1.9-2.7)	
Comorbidity burden			
Number of comorbidities, median (range)[c]	3 (1-9)	4 (1-9)	<.001
Functional limitation due to health[d] (n=41,864)	63.6 (62.8-64.4)	82.2 (81.1-83.3)	<.001
Fair or poor health[e] (n=41,940)	27.1 (26.4-27.8)	53.0 (51.8-54.1)	<.001
Education attainment (n=41,745)			
Less than high school graduate level	5.9 (5.6-6.3)	8.3 (7.6-9.1)	<.001
Employment (n=41,886)			
Currently unemployed	60.1 (59.3-60.9)	75.8 (74.5-76.9)	<.001
Living alone	24.0 (23.4-24.5)	26.7 (25.7-27.7)	<.001
Household income[f] (n=38,816)			
Below poverty threshold	12.8 (12.3-13.3)	23.1 (22.0-24.2)	<.001
Receipt of any government support[g]	17.6 (17.0-18.3)	33.8 (32.4-35.1)	<.001
Income support[h] (n=41,886)	5.6 (5.3-5.9)	11.7 (11.0-12.6)	<.001
Rent assistance[i] (n=41,879)	4.3 (4.0-4.7)	8.5 (7.8-9.3)	<.001
Food support[j] (n=41,906)	14.2 (13.6-14.8)	28.2 (27.0-29.5)	<.001
Other welfare[k] (n=41,866)	0.7 (0.6-0.8)	1.6 (1.3-2.0)	<.001
US region			
Northeast	17.2 (16.4-18.0)	16.8 (15.7-17.9)	0.0002
North Central/ Midwest	24.5 (23.6-25.4)	25.9 (24.5-27.3)	
South	38.5 (37.4-39.5)	40.0 (38.4-41.6)	
West	19.9 (19.1-20.8)	17.4 (16.2-18.6)	

Source: National Health Interview Survey, 2011-2017

Data are reported as percent values with 95% confidence intervals unless otherwise indicated.

Denominators per disease category are reported as unweighted observations.

[a] Age groups include the following years: 18-34, 35-55, 56-64, and 65-85 years old.

[b] Race or ethnicity includes self-reported Non-Hispanic White (*White*), Non-Hispanic Black (*Black or African-American)*, Hispanic (*Hispanic*), Non-Hispanic Asian (*Asian*), Non-Hispanic American Indian or Alaska Native (*American Indian or Alaska Native*), or Non-Hispanic Other (*Other*) which includes multiple race and race groups that are not releasable.

[c] Comorbidity count includes self-reported arthritis, asthma, BMI ≥ 30, cancer, CVD, chronic liver disease, COPD, diabetes, hypertension, and kidney disease.

[d] Functional limitation due to health includes responses about having any functional difficulty because of a health problem.

[e] Fair or poor health includes responses about self-reported health status and is compared to those with excellent, very good, or good health.

[f] Poverty threshold is based on family size, number of children under 18 years old, and reported before-tax combined money income from all sources, excluding noncash benefits, during the preceding calendar year as compared to the U.S. Census Bureau's poverty thresholds for the preceding calendar year. The household income category of *Below poverty threshold* includes persons who report household income below the poverty threshold (vs. at or above poverty threshold).

[g] Receipt of any government support includes receiving any support for income (SSI and/or cash assistance), housing (rent assistance), food (food stamps, SNAP, and/or WIC), and/or other welfare (assistance with getting a job, placement in education or job training programs, transportation, or childcare) in the previous calendar year.

[h] Income support includes responses about receiving income from SSI and/or cash assistance in the previous calendar year.

[i] Rent assistance includes responses about having received public rent assistance.

[j] Food support includes responses about receiving any food stamps, SNAP benefits, and/or WIC.

[k] Other welfare includes assistance with getting a job, placement in education or job training programs, transportation, or childcare).

Appendix Table 2.7A. Characteristics of Health Care Access and Utilization by Acute Care Use for Chronic Liver Disease (n=5,061)

Characteristic	**Acute Care Use in the Past Year**		***P* value**
	0-1 times	≥ 2 times	
Respondents, unweighted no.	3,581	1,480	
Insurance coverage[a] (n=4,923)			
None	11.7 (10.4-13.2)	9.9 (8.1-12.1)	<.001
Public insurance	19.1 (17.4-20.9)	34.6 (31.5-37.8)	
Medicare	14.7 (13.2-16.3)	16.6 (14.1-19.5)	
Private insurance	54.5 (52.3-56.7)	38.9 (35.7-42.2)	
Any perceived barriers to care[b]	40.9 (38.7-43.1)	53.9 (50.7-57.1)	<.001
Number of perceived barriers to care, median (range)[c]	0 (0-11)	1 (0-13)	<.001
Financial barrier[d]	23.7 (21.8-25.7)	36.8 (33.8-39.9)	<.001
Foregone medical care due to unaffordability (n=5,060)	12.1 (10.7-13.7)	16.7 (14.6-19.1)	0.0004
Foregone follow-up care due to unaffordability (n=5,026)	8.3 (7.2-9.5)	12.4 (10.5-14.6)	0.0003
Foregone specialty care due to unaffordability (n=5,025)	9.4 (8.2-10.8)	17.1 (14.7-19.8)	<.001
Foregone medication due to unaffordability (n=5,026)	14.2 (12.6-15.8)	26.5 (24.0-29.2)	<.001
Organizational barrier at the entry of health care[e] (n=5,039)	16.5 (14.9-18.1)	20.5 (17.9-23.4)	0.0094
Trouble finding a provider (n=5,034)	5.1 (4.3-6.2)	9.0 (7.2-11.1)	0.0001
Declined as a new patient (n=5,028)	5.1 (4.1-6.2)	9.8 (8.0-12.0)	<.001
Health coverage declined (n=5,031)	5.8 (4.9-6.9)	10.2 (8.5-12.3)	<.001
No usual place for care (n=5,038)	8.2 (7.1-9.5)	5.8 (4.4-7.7)	0.0312
Organizational barrier within health care[f] (n=5,027)	17.1 (15.5-18.8)	25.2 (22.5-28.0)	<.001
No appointment soon enough (n=5,027)	10.3 (9.1-11.6)	16.8 (14.6-19.3)	<.001
Inconvenient clinic hours (n=5,022)	3.6 (2.9-4.4)	7.8 (6.4-9.6)	<.001
Could not get through by phone (n=5,027)	4.9 (4.0-6.0)	7.1 (5.7-8.7)	0.0113
Long waiting time at clinic (n=5,025)	7.8 (6.7-9.0)	11.3 (9.6-13.4)	0.0014
Other barrier[g]			
Lack of transportation to receive timely care (n=5,027)	3.9 (3.1-4.7)	11.7 (9.9-13.7)	<.001

Appendix Table 2.7B. Characteristics of Health Care Access and Utilization by Acute Care Use for Chronic Obstructive Pulmonary Disease and/or Cardiovascular Disease (n=41,962)

Characteristic	**Acute Care Use in the Past Year**		***P* value**
	0-1 times	≥ 2 times	
Respondents, unweighted no.	31,904	10,058	
Insurance coverage[a] (n=41,097)			
None	7.9 (7.4-8.3)	8.2 (7.4-9.0)	<.001
Public insurance	12.5 (12.0-13.0)	25.8 (24.7-27.1)	
Medicare	21.5 (20.8-22.1)	23.8 (22.7-25.0)	
Private insurance	58.2 (57.3-59.0)	42.1 (40.8-43.5)	
Any perceived barriers to care[b]	31.2 (30.5-32.0)	44.3 (43.0-45.6)	<.001
Number of perceived barriers to care, median (range)[c]	0 (0-13)	0 (0-12)	<.001
Financial barrier[d] (n=41,961)	16.2 (15.6-16.8)	27.3 (26.2-28.4)	<.001
Foregone medical care due to unaffordability (n=41,946)	8.5 (8.1-9.0)	13.7 (12.8-14.6)	<.001
Foregone follow-up care due to unaffordability (n=41,572)	4.8 (4.4-5.1)	10.1 (9.3-11.0)	<.001
Foregone specialty care due to unaffordability (n=41,572)	6.0 (5.7-6.4)	11.1 (10.2-12.0)	<.001
Foregone medication due to unaffordability (n=41,590)	10.0 (9.6-10.5)	19.6 (18.6-20.7)	<.001
Organizational barrier at the entry of health care[e] (n=41,671)	12.4 (11.9-12.9)	14.9 (13.9-16.0)	<.001
Trouble finding a provider (n=41,625)	3.5 (3.2-3.7)	6.4 (5.8-7.1)	<.001
Declined as a new patient (n=41,609)	2.8 (2.5-3.0)	5.6 (5.0-6.3)	<.001
Health coverage declined (n=41,590)	3.8 (3.5-4.1)	7.0 (6.3-7.7)	<.001
No usual place for care (n=41,668)	6.8 (6.5-7.2)	4.8 (4.2-5.5)	<.001
Organizational barrier within health care[f] (n=41,601)	12.3 (11.7-12.8)	20.3 (19.2-21.4)	<.001
No appointment soon enough (n=41,587)	7.3 (6.9-7.7)	13.0 (12.2-13.9)	<.001
Inconvenient clinic hours (n=41,584)	3.2 (2.9-3.4)	5.7 (5.1-6.3)	<.001
Could not get through by phone (n=41,595)	3.1 (2.8-3.3)	6.0 (5.5-6.6)	<.001
Long waiting time at clinic (n=41,582)	5.3 (4.9-5.7)	10.1 (9.3-10.9)	<.001
Other barrier[g]			
Lack of transportation to receive timely care (n=41,592)	2.8 (2.6-3.0)	8.1 (7.4-8.8)	<.001

Source: National Health Interview Survey, 2011-2017

Abbreviations: COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease

Data are reported as percent values with 95% confidence intervals unless otherwise indicated.

Denominators per disease category are reported as unweighted observations.

[a] Insurance category *None* includes persons without any insurance coverage including having only single service plans, category *Public insurance* includes any public insurance via Medicaid, other state or local government program, Children's Health Insurance Program, or Medicare for dual enrollees, category *Medicare* includes Medicare only beneficiaries, and category *Private insurance* includes enrollment in any private insurance.

[b] Any perceived barriers to care includes affirmative responses to questions about needing but foregoing medical care, follow-up, specialty care, and/or prescription medication due to unaffordability, trouble finding a provider, being declined as a new patient, having health coverage declined, not having a usual place for routine or sick care, having delays in medical care because one could not get an appointment soon enough, clinic or doctor's office was closed, could not get through by phone, had a long wait time to see the doctor, and/or lacked transportation.

[c] Number of perceived barriers to care includes affirmative responses to questions about needing but foregoing medical care, follow-up, specialty care, and/or prescription medication due to unaffordability, trouble finding a provider, being declined as a new patient, having health coverage declined, not having a usual place for routine or sick care, having delays in medical care because one could not get an appointment soon enough, clinic or doctor's office was closed, could not get through by phone, had a long wait time to see the doctor, and/or lacked transportation.

[d] Financial barrier includes affirmative responses to questions about foregoing needed medical care, follow-up, specialty care, and/or prescription medications due to unaffordability in the past 12 months.

[e] Organizational barrier at the entry of health care includes affirmative responses to questions about having trouble finding a provider, being declined as a new patient, having health coverage declined, and/or not having a usual place for routine or sick care.

[f] Organizational barrier within health care includes self-reporting delayed medical care because one could not get an appointment soon enough, clinic or doctor's office was closed, could not get through by phone, and/or had a long wait time to see the doctor.

[g] Other barrier includes self-reported lack of transportation to receive timely care

CHAPTER III: Identification of Hidden Phenotypes Using Self-Reported Barriers to Care to Predict Risk of Recurrent Hospitalization or Emergency Department Visits among Adults with Chronic Liver Disease in the United States

ABSTRACT

Importance: Adults with chronic liver disease have high rates of recurrent hospitalizations, and prior efforts to identify those at highest risk are limited.

Objective: To identify unique phenotypes of adults with chronic liver disease based on self-reported health care barriers and determine whether these subgroups have increased risk for recurrent acute care use.

Design, Setting, and Participants: This is a cross-sectional study of non-institutionalized US adults with chronic liver disease using pooled, annual self-reported survey data from the National Health Interview Survey from 2011 to 2017. Data analysis was completed in September 2023.

Exposures: Health care barriers, including organizational, financial, and transportation barriers.

Main Outcomes and Measures: We used latent class analysis to identify unique phenotypes of individuals based on health care barriers. Additional outcomes included adjusted and unadjusted relative risk ratios of latent class membership and adjusted odds ratio of recurrent acute care use by latent class from multivariable logistic regression analyses.

Results: The study sample included 5,062 adults with chronic liver disease (median [range] age 55 [18-85]), of whom were mostly female (n=2,607; 51.5%), non-Hispanic White (n=3,331; 65.8%), and had health insurance (n=4,495; 88.8%). The latent class analysis model with the best fit to the data uncovered four unique phenotypes based on patterns of health care barriers: minimal barriers (n=3,953; 78.1%), unaffordability (n=540; 10.7%), care delays (n=328; 6.5%), and inability to establish care (n=240; 4.8%). Respondents with the unaffordability phenotype had the largest uninsured group (n=210; 38.9%). Of those insured, Medicare enrollees were more likely to be in the unaffordability risk group (relative risk ratio, 0.28, 95% CI, 0.17-0.46) compared with uninsured persons. The care delays phenotype was mostly insured (n=305; 93.1%). Hispanics (relative risk ratio, 1.56, 95% CI, 1.07-2.26) and persons with fair or poor health (relative risk ratio, 2.12, 95% CI, 1.48-3.03) or functional limitation due to health (relative risk ratio, 2.84, 95% CI, 1.78-4.51) were significantly more likely to be in the care delays group. The inability to establish care phenotype included the largest group of adults under 65 years old (n=220; 91.7%), females (n=156; 65.1%), and had the most social risks, including unemployment (n=169; 70.6%) and poverty (n=85; 35.3%). Adjusted relative risk ratio to predict membership in the inability to establish care class was significantly higher for females (1.86, 95% CI, 1.25-2.77) and those with functional limitation due to health (2.74, 95% CI 1.65-4.56). The risk of recurrent acute care use was highest for the inability to establish care phenotype (adjusted odds ratio, 1.89; 95% CI, 1.26-2.84, p=0.002).

Conclusions and Relevance: US adults with chronic liver disease can be categorized into four unique phenotypes based on different self-reported health care barriers and are associated with different sociodemographic, health, and insurance characteristics. The inability to establish care phenotype was associated with the highest probability of recurrent acute care use. Findings from this study are important for the development of future interventions and policies that aim to reduce recurrent acute care use for the highest-risk persons with chronic liver disease.

INTRODUCTION

Rates of hospitalizations have disproportionately increased for individuals with chronic liver disease (CLD) (Asrani, et al., 2018; Stepanova, et al., 2017; Hirode, Saab, & Wong, 2020). The pooled estimate of 30-day readmissions for cirrhosis, an advanced form of CLD, is 26% compared to 19.6% among hospitalized Medicare fee-for-service beneficiaries (Orman E. S., Ghabril, Emmett, &

Chalasani, 2018; Jencks, Williams, & Coleman, 2009). Morbidity and mortality in CLD are associated with early rehospitalization and limited health care access (Berman, et al., 2011; Mellinger, et al., 2016; Goldberg, Ross-Driscoll, & Lynch, 2021; Lee, Dodge, & Terrault, 2022; Orman E. S., Ghabril, Emmett, & Chalasani, 2018; Volk, Tocco, Bazick, Rakoski, & Lok, 2012). In fact, rates of 90-day mortality are significantly higher for patients with CLD who have early 30-day readmissions compared to those who do not have early rehospitalizations (26.8% vs. 9.8%) (Berman, et al., 2011).

There have been efforts to predict and reduce hospitalizations for persons with CLD. Despite intentions to include more patient-centered variables, including frailty assessments and patient-reported outcome measures for functional status and quality of life, prior efforts have had modest predictive accuracy (C-statistics 0.6-0.75) (Hu, et al., 2021; Berman, et al., 2011; Garg, et al., 2021; Tapper, Finkelstein, Mittleman, Piatkowski, & Lai, 2015; Singal, et al., 2013; Orman E. S., et al., 2022). These predictive algorithms focused on hospital-based clinical variables when one's chronic disease is less stable or captured patient-reported outcomes in the hospital setting when a patient may unreliably recall one's baseline quality of health, leading to biased estimates and imprecise predictive yield after hospital discharge.

Closer attention to non-hospital-based parameters, including one's experience with health care barriers in the community setting, can provide new knowledge on the potential influence of outpatient access to care on recurrent acute care use. Care coordination programs that aimed to reduce hospitalizations have shown that frequent interactions with care providers in the ambulatory setting (Peikes, Chen, Schore, & Brown, 2009), post-discharge home visits (Rich, et al., 1995; Naylor M. D., et al., 1999; Naylor M. D., et al., 2004), and coaches who helped navigate care (Coleman, Parry, Chalmers, & Min, 2006) have successfully reduced rehospitalizations, potentially through the elimination of some health care barriers in the care seeking process. To our knowledge, identification of different risk profiles for recurrent acute care in the US adult population with CLD using non-hospital-based variables, specifically measurements of health care barriers, has not been done. In this study, we used pooled, annual data from the National Health Interview Survey (NHIS) to perform latent class analysis (LCA) to uncover novel phenotypes based on self-reported health care barriers among respondents with CLD. We then evaluated the likelihood of class membership by sociodemographic, health, and insurance characteristics and measured the probability of recurrent acute care use by latent class.

METHODS

Data Source

We pooled annual NHIS data, from 2011 to 2017, to conduct a survey-based cross-sectional study that yielded nationally representative estimates from community-dwelling persons (National Center for Health Statistics, 2023). NHIS is an annual in-person household interview survey that collects self-reported data about demographics, health, socioeconomic status, and health care utilization (National Center for Health Statistics, 2023). Survey years were selected to capture the effect of the Affordable Care Act (ACA) after its implementation in 2010 as done in prior studies (Miller & Wherry, 2017; Mahajan, et al., 2021; Caraballo, et al., 2022). Additionally, we were interested in specific types of health care barriers that were included in the NHIS questionnaire that were only available from 2011 to 2017 (National Center for Health Statistics, 2023). We used the Sample Adult file, which included responses from randomly selected adults per randomly selected US household. During this study period, the mean conditional response and final response rates were 80.7% and 60.4%, respectively.

We used de-identified and publicly available data from the Integrated Public Use Microdata Series Health Surveys (Blewett, et al., 2022) and therefore exempt from institutional review board at the University of California, Los Angeles.

Study Population

Our study population consisted of respondents aged 18 years or older with CLD, which included persons who responded *yes* to the questions, “Has a doctor or other health professional ever told you that you had any kind of chronic, or long-term liver condition” or “During the past 12 months, have you been told by a doctor or other health professional that you had any kind of liver condition?” (Appendix Figure 3.1).

Measures

We selected 13 binary indicator variables derived from self-reported health care barriers that spanned the care seeking process including organizational barriers at the point of entry and within the health care system, health care affordability, and transportation. Respondents were considered to have a health care barrier if they responded *yes* to any of the following questions in the past year: “Was there any time when you needed medical care but did not get it because of the cost?”, “Was there any time when you needed any of the following, but didn’t get it because you couldn’t afford it …prescription medicines?”, “Was there any time when you needed any of the following, but didn’t get it because you couldn’t afford it …follow-up care?”, “Was there any time when you needed any of the following, but didn’t get it because you couldn’t afford it …to see a specialist?”, “Did you have any trouble finding a general doctor or provider who would see you?”, “Were you told by a doctor’s office or clinic that they would not accept you as a new patient?”, “Were you told by a doctor’s office or clinic that they did not accept your health care coverage?”, “Have you delayed getting care for any of the following reasons in the past 12 months? …You couldn't get an appointment soon enough?", "Have you delayed getting care for any of the following reasons in the past 12 months? …The clinic/ doctor's office wasn't open when you could get there?", "Have you delayed getting care for any of the following reasons in the past 12 months? …You couldn't get through on the telephone?", "Have you delayed getting care for any of the following reasons in the past 12 months? …Once you get there, you have to wait too long to see the doctor?", and "Have you delayed getting care for any of the following reasons in the past 12 months? …You didn't have transportation?" We also included any respondents who responded *no* to the following question: "Is there a place that you usually go to when you are sick or need advice about your health?"

We also assessed a parsimonious set of 10 covariates about the respondents' sociodemographic, health, and insurance: age, sex, race or ethnicity, presence of any functional limitation due to health, fair or poor health, education attainment, employment status, household poverty, household structure (i.e. living alone), and health insurance.

We included respondents' report of recurrent acute care use defined as having at least two emergency department (ED) visits and/or overnight hospital admissions in the past year.

Statistical Analysis

We conducted LCA to uncover unique subgroups of persons with CLD in the US population. These subgroups are the latent classes, which are derived from patterns and probabilities of responses to a set of indicator variables (Collins & Lanza, 2009). A fundamental assumption of LCA is that these patterns and relationships of indicator variables can explain membership in unobserved subgroups or latent classes (Goodman, 2002; Masyn, 2013; Collins & Lanza, 2009).

We selected LCA as a fitting statistical approach based on the study aims and previous work, which used aggregate secondary data to identify different subgroups of health care access (Li, et al., 2021) and social risk profiles (Daundasekara, Schuler, & Hernandez, 2022; McCarthy, et al., 2021). Alternate analyses, including cluster and factor analyses, were considered but they were incompatible with the research aims and data. While cluster analysis could help identify subgroups, it would not account for unobserved data and does not use data-driven statistical models to organize subgroups (Weller, Bowen, & Faubert, 2020). Factor analysis was another type of considered mixture modeling, but it is intended for continuous variables which would be incompatible with this study's binary indicators (Oberski, 2016).

For our LCA, we used our set of 13 self-reported barriers to care indicators. We selected maximum likelihood estimation with robust standard errors for its statistical efficiency (Muthen, Muthen, & Asparouhov, 2015). The number of latent classes *k* cannot be determined *a priori*, so we used a sequential exploratory approach by fitting different models with a successively increasing number of latent classes starting with one class (*k* = 1, 2, 3, 4, 5, 6) to determine the most appropriate model (Oberski, 2016; Masyn, 2013; Weller, Bowen, & Faubert, 2020; Sinha, Calfee, & Delucchi, 2021). As LCA fits a statistical model to the data, we conducted goodness of fit procedures to select the best fitting model (Oberski, 2016; Weller, Bowen, & Faubert, 2020). We evaluated each iteration of the latent class models using absolute fit statistics, sample sizes per class, diagnostic statistics, and conceptual interpretability (Masyn, 2013; Nylund, Asparouhov, & Muthen, 2007). We favored models that failed to reject the null hypothesis using the likelihood ratio (LR) Chi-square goodness-of-fit-test (Agresti, 2002; Collins & Lanza, 2009) and models with lower Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), and consistent AIC (CAIC) values (Oberski, 2016; Weller, Bowen, & Faubert, 2020). While optimal sample size per latent class remains undefined, a previous report recommended the smallest sample size in a latent class to be approximately 5% of the sample (Weller, Bowen, & Faubert, 2020). To supplement the fit statistics, we included classification diagnostics, including average posterior probabilities and entropy, to compare the accuracy of class membership (Masyn, 2013; Weller, Bowen, & Faubert, 2020; Wang, Deng, Bi, Ye, & Yang, 2017). The average posterior probability is the probability of the model accurately predicting class membership with the lowest acceptable average posterior probability being 0.8 (Masyn, 2013; Wang, Deng, Bi, Ye, & Yang, 2017). Entropy is a measure of separation between the latent classes, which assesses the overall precision of latent class membership with a value greater than 0.8 as acceptable (Celeux & Soromenho, 1996; Wang, Deng, Bi, Ye, & Yang, 2017; Sinha, Calfee, & Delucchi, 2021).

After identifying the model with the optimal *k*, we tabulated the prevalence of the study population in each latent class and distribution of health care barriers and sociodemographic, health, and insurance covariates for each latent class using Chi-square test of homogeneity as previously done (McCarthy, et al., 2021; Glenn B. , et al., 2018). Next, we used a multinomial logistic regression model, in which the outcome variable was the different latent classes, to predict class membership with the sociodemographic and health covariates (Appendix Figure 3.2). Selection of the multinomial logistic regression was based on the use of a nominal outcome variable. Using the same covariates, we also performed multivariable logistic regression, in which the primary independent variable of interest was the latent classes, to predict likelihood of recurrent acute care use. We then performed a stratified analysis to evaluate the association between latent class membership and recurrent acute care use by insurance type. Predicted probabilities were obtained from the regression models.

All analyses were performed using Stata SE version 18.0 (StataCorp). Descriptive statistics and regression analyses were performed using the Stata *–svy-* command to produce nationally representative estimates. While the study population only included those with CLD, all respondents in the Sample Adult file were included in the analysis to ensure accuracy in population-level point estimates and standard errors. Fit and diagnostic statistics were obtained using unweighted data to obtain likelihood ratios. Statistical significance was defined as a 2-sided *p*-value of less than 0.05.

RESULTS

Study Population Characteristics

The sample included 5,062 adults which provided weighted estimates for 4,742,444 persons with CLD. The sample was mostly female (51.5%), non-Hispanic White (65.8%) with a median age (range) of 55 (18-85) years. The adult population with CLD had suboptimal health as demonstrated by rates of fair or poor health (41.4%) and the presence of a functional limitation due to health (68.2%). Most respondents had at least a high school graduate level education (92.8%) and were unemployed (57.8%). Household poverty was identified among 20.1% of respondents. About a quarter of respondents lived alone (23.2%). Half of the adult CLD population had private insurance (50.0%), followed by public insurance (23.6%,), Medicare (15.3%), and no insurance (11.2%).

Comparison of Latent Class Models

Table 3.1 presents LCA results of fit and diagnostic statistics for different class models. The LR Chi-square goodness-of-fit test showed that the one class model was the only iteration that did not fit with the observed data, and the other fit statistics (AIC, CAIC, BIC) favored the models with the larger number of classes. However, the models with five and six classes had small latent classes (smallest class size approximately 3% of sample), which would limit conceptual interpretability (Weller, Bowen, & Faubert, 2020). The smallest average posterior probabilities and entropy values demonstrated that the precision of latent class membership for the models with two to five classes was acceptable (>0.8). Based on the fit and diagnostic statistics, class size, and conceptual interpretability, we selected the four latent class model.

Four Latent Class Model

We identified four unique classes derived from self-reported health care barriers (Figure 3.1). The majority of the sample (78.1%) was in the minimal barriers or reference class, followed by the classes of individuals who experienced unaffordability (10.7%), care delays (6.5%), and inability to establish care (4.8%). The prevalence of each health care barrier per latent class are listed in Table 3.2. In the unaffordability class, the majority of the respondents in this class could not afford recommended specialty care (78.5%). The vast majority of individuals in the care delays class experienced delays in medical care due to an inability to secure a timely appointment (90.1%). In the inability to establish care class, the predominant health care barrier was being declined as a new patient (95.0%).

Sociodemographic and Health Characteristics and Class Membership

The latent class with minimal barriers consisted of older adults (median age [range] 56 [18-85] years) with the lowest proportion with fair or poor health (36.9%), functional limitation due to health (64.6%), unemployment (56.4%), household poverty (17.4%), and uninsurance (7.7%), and the highest prevalence with Medicare (15.5%) and private insurance (54.5%) (Table 3.3). The unaffordability latent class included the youngest persons (median age [range] 50 [19-81] years) of whom had the largest proportion with the highest rate of uninsurance (38.9%) compared to the other latent classes. The care delays class was mostly insured (93.1%), had a higher rate of respondents with fair or poor health (61.6%), and included a larger proportion of respondents who identified as non-White, including Hispanics (23.3%), non-Hispanic Blacks (8.9%), American Indian or Alaskan Natives (1.2%), and non-Hispanic others (3.7%) in comparison to the other latent classes. The class with the inability to establish care was predominantly more female (65.1%) with more functional limitation due to health (84.6%), social risks, including unemployment (70.6%) and household poverty (35.3%), and public health insurance enrollees (39.2%) than the other classes.

After adjusting for significantly different sociodemographic and health characteristics, we found that younger age groups were associated with higher risk of class membership into the unaffordability, care delays, and inability to establish care classes, although this was not consistently significant (Table 3.4). Females were significantly more likely to be in the inability to establish care class (relative risk ratio; RRR, 1.86, p=0.002). Hispanics were significantly more likely to be in the care delays class (RRR, 1.56, p=0.020). While the presence of a functional limitation due to health was significantly associated with membership into the unaffordability, care delays, and inability to establish care classes, those with fair or poor health were significantly more likely to be in the unaffordability or care delays group and not the inability to establish care class. In comparison to the no insurance group, those who were in the unaffordability class were significantly more likely to have Medicare, followed by private and public insurance after adjusting for significant covariates including poverty. Insurance coverage was no longer significantly different after adjusting for covariates to assess for class membership between the care delays and minimal barriers classes, but there was a trend towards higher likelihood of being in the care delays class if one had public insurance (RRR, 1.68, 95% CI, 0.93-3.06). Private insurance was significantly associated with a lower likelihood of being in the inability to establish care class (RRR, 0.41, p=0.002).

Recurrent Acute Care Use and Class Membership

The latent class with the inability to establish care had the highest odds (adjusted odds ratio; OR, 1.89) and probabilities (adjusted probability, 0.40) of recurrent acute care use (Table 3.5). While respondents in the care delays class were over two times more likely to have recurrent acute care use compared with the reference class (OR, 2.21), this effect size attenuated after adjusting for age, sex, race or ethnicity, fair or poor health, functional limitation due to health, employment, poverty, and insurance (Appendix Figure 3.3). In the adjusted analysis, the classes with the care delays and unaffordability had similar likelihood of recurrent acute care use in the past year (Figure 3.2).

Our stratified analysis by insurance type demonstrated the consistency of our results for recurrent acute care use and class membership (Figure 3.3). The inability to establish care class had the highest probability of recurrent hospital and/or ED use in the past year compared to the other latent classes for all insurance types. Those with public insurance had the highest likelihood of recurrent acute care use compared to the other insurance types even among those in the minimal barriers class (adjusted predicted probability, 0.40). Our adjusted multinomial logistic regression model revealed that those with public insurance were 73% more likely to have recurrent acute care use compared to those without insurance).

DISCUSSION

In this US population-based study representative of community-dwelling adults with CLD, we identified four, previously unidentified, unique phenotypes based on self-reported health care barriers using LCA. These risk profiles were characterized by different health care barriers derived from the process of seeking care, including organizational barriers at the entry and within the health care system, transportation, and health care affordability. Our findings showed that each phenotype was associated with different socioeconomic, health, and insurance characteristics and risk for recurrent acute care utilization. This study provides new evidence and several practice and policy implications.

First, the inability to establish care phenotype was associated with the highest risk of recurrent acute care use in the past year, consisted of more females, and had less favorable health and socioeconomic profiles, including the highest rates of functional limitation due to health, unemployment, poverty, and public health insurance coverage. Our adjusted analyses showed that this group remained at highest risk for recurrent acute care use after controlling for sociodemographic and health factors. As such, the inability to establish care phenotype was significantly associated with higher rates of potentially preventable recurrent hospital and ED visits. Our stratified analysis by insurance type revealed that the phenotype with the highest risk of recurrent acute care use was the inability to establish care in the setting of public health insurance. This finding resonates with a meta-analysis that revealed a two- and three-fold lower likelihood of successful securement of medical appointments for primary and specialty care, respectively for Medicaid compared with private insurance (Hsiang, et al., 2019). Future interventions aimed to reduce rehospitalizations and frequent ED usage may be more effective by targeting these highest risk individuals with CLD.

Second, we showed that delays in timely receipt of care, despite having a usual source of medical care and health insurance, was associated with an approximately two-fold increased likelihood of recurrent hospitalization or ED usage similar to prior studies (Rust, et al., 2008; Caraballo, et al., 2022). We found a higher proportion of individuals, who identified as non-White, in the care delays phenotype, which resonates with previously reported trends in racial and ethnicity disparities in receipt of timely medical care (Caraballo, et al., 2022). This study distinguishes itself by comparing the effect of race or ethnicity by different phenotypes derived from health care barriers and accounting for sociodemographic, health, and insurance variables that are associated with disparities in health care access and outcomes. In this study, we identified a higher proportion of non-White respondents with the care delays phenotype compared to the other profiles and noted a significantly higher likelihood of membership in the care delays group for non-White Hispanics (adjusted OR, 1.56). We also learned that the care delays phenotype had the largest association with fair or poor health (adjusted OR, 2.12) and functional limitation due to health (adjusted OR, 2.84) compared with the other risk profiles.

As such, the care delays phenotype may reflect individuals with more complex medical needs who experience delays in receipt of medical care despite having health coverage. Furthermore, our findings revealed that the most prevalent type of health care barrier among respondents in the care delays group was the inability to schedule a timely appointment (90.1%). Future programs that aim to reduce delays in receipt of timely medical care are encouraged to optimize appointment availabilities, provide more flexibility in scheduling for persons with complex health care needs, and consider how patients of non-White race or ethnicity may encounter challenges in securing timely appointments differently from White patients.

Third, this study identified approximately 11% of the CLD population with the unaffordability phenotype similar to prior studies that investigated the extent and effect of financial hardships among US adults with CLD (Lago-Hernandez, et al., 2021; Ayyala-Somayajula, Dodge, Farias, Terrault, & Lee, 2023). Our findings are unique because we found that the type of insurance coverage had the most significant role in predicting whether or not one would have the unaffordability risk profile compared to the other phenotypes. In fact, the unaffordability group included the most uninsured persons (38.9%).

In our adjusted analysis, we identified that Medicare insurance, followed by private and public insurance were strongly associated with higher likelihood of membership in the unaffordability group. While Medicare and private insurance were considerably more favorable for the minimal barriers group, the minimal barriers phenotype included older persons in better self-reported health with lower rates of poverty. In contrast, the unaffordability group is the youngest phenotype (median [range] 50 [19-81]) with higher rates of fair or poor health and functional limitation due to health. Therefore, coverage through Medicare and private insurance may be adequate for those who share characteristics with the minimal barriers phenotype but may be insufficient for health care expenses among persons with the unaffordability phenotype (younger, worse health, poorer). A recent study revealed that medical indebtedness was associated with private insurance with high-deductibles and Medicare Advantage (Himmelstein, et al., 2022). While this study's data is limited in details about insurance coverage, our findings concur with existing work and suggest that health care unaffordability remains a risk factor for recurrent acute care use among insured individuals with Medicare or private insurance. In addition, our study showed that coverage through public insurance was more favorable relative to the other insurance plans for health care affordability consistent with previous studies (Wray, Khare, & Keyhani, 2021). Future programs that aim to reduce health care unaffordability among persons with CLD are encouraged to help individuals become medically insured and allocate subsidies or cost sharing resources for insured individuals who share similar characteristic with the unaffordability phenotype.

LIMITATIONS

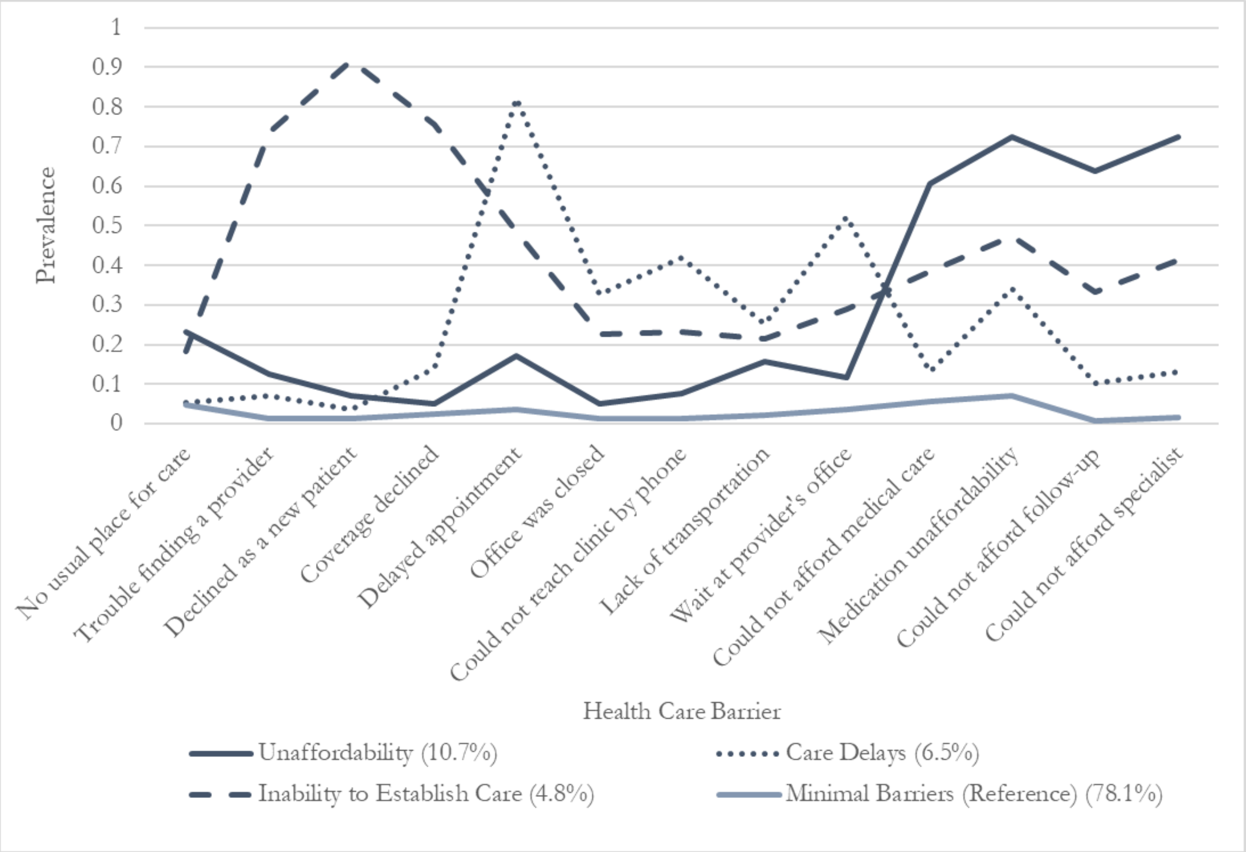
The study is limited in several ways. First, the study is unable to capture the etiology and severity of CLD. The majority of CLD-related hospitalizations occurs among persons with cirrhosis (Orman E. S., Ghabril, Emmett, & Chalasani, 2018; Scaglione, et al., 2017). Recent trends in hospitalizations and ED usage revealed that alcohol- and metabolic dysfunction-associated steatotic liver disease are the most common underlying causes of CLD requiring acute care use (Hirode, Saab, & Wong, 2020; Sharma, et al., 2021). While we were unable to discern the causes and severity of CLD in our study, we adjusted for self-reported fair or poor health, which has been a validated measurement to personally assess one's overall health, severity of illnesses, and any symptoms that may motivate one to seek medical care (DeSalvo, Fan, McDonell, & Fihn, 2005; Cho, et al., 2022), and functional limitation due to health to capture the severity of physical impairments related to health as most community-dwelling persons seek care in the ED or hospital due to concerning symptoms (Young, Wagner, Kellermann, Ellis, & Bouley, 1996; Tabriz, et al., 2023). In fact, acute symptomatic complications (e.g. hepatic encephalopathy) have been reported as the most common reasons for readmissions among patients with cirrhosis without alcohol-associated liver disease (Tapper, Halbert, & Mellinger, 2016).

A second weakness of this study is its limited information about the details of health insurance coverage plans (e.g. Medicare Advantage vs. Traditional Medicare, Medicaid HMO vs. full Medicaid). Inclusion of coverage details will be informative in future studies. The third limitation is the relatively smaller sample size (n=240; 4.8%) in the study's most vulnerable phenotype (i.e. inability to establish care). Nonetheless, we used a robust set of fit and diagnostic statistics to identify our four latent classes with the smallest average posterior class probability being 0.86.

CONCLUSION

This population-based study representative of over 4.7 million US adults with CLD is the first to employ LCA to uncover four unique, previously unidentified, phenotypes using self-reported health care barriers that were assessed in noninstitutionalized settings. Our findings reveal that adults with CLD in the US experience distinct categories of health care barriers, and these different risk profiles can be used to assess probability of recurrent hospitalizations or ED visits. Adults with CLD, who experience barriers in establishing medical care, potentially in the setting of public insurance, have the highest probability of recurrent acute care use and may benefit the most from targeted interventions.

Figure 3.1. Class Membership Based on Health Care Barriers in the Four Latent Class Model (N=5,062)



Source: National Health Interview Survey, 2011-2017
Weighted prevalence of class membership in the study population is reported for each class.

Table 3.1. Model Selection Using Fit and Diagnostic Statistics

Model	**Smallest Class Count (n)**	**Smallest Class Size (%)**	**Likelihood Ratio**	***P* value**[a]	**AIC**	**CAIC**	**BIC**	**Smallest APP**	**Entropy**
One class	5,062	100.0	9287.885	<.001	40406.85	40504.73	40491.73	--	--
Two classes	1,030	20.35	3654.451	1.00	34801.42	35004.71	34977.71	0.9459168	0.85922391
Three classes	460	9.09	2753.183	1.00	33928.15	34236.86	34195.86	0.8909682	0.88606131
Four classes	191	3.77	2253.773	1.00	33456.74	33870.86	33815.86	0.8570095	0.85788827
Five classes	146	2.88	1838.644	1.00	33069.61	33589.15	33520.15	0.8333157	0.89296331
Six classes	141	2.79	1704.957	1.00	32963.92	33588.87	33505.87	0.6743431	0.80503162

Source: National Health Interview Survey, 2011-2017
Abbreviations: AIC, Akaike's information criterion; CAIC, consistent Akaike's information criterion; BIC, Bayesian information criterion; APP, average posterior probability
All estimates are derived from an unweighted sample
[a] *P* value compares the model vs. a saturated model

Table 3.2. Prevalence of Health Care Barriers in the Total Sample and by Latent Class (N=5,062)

	Total Sample	**Class I** Minimal Barriers	**Class II** Unaffordability	**Class III** Care Delays	**Class IV** Inability to Establish Care
Class Prevalence (%)	100.0	78.1	10.7	6.5	4.8
Observations, unweighted	5,062	3,953	540	328	240
Observations, weighted	4,742,444	3,703,788	506,347	307,013	225,296
Health Care Barrier					
No usual place for care (n=5,039)	7.5 (6.6-8.6)	5.0 (4.2-5.9)	24.1 (19.4-29.6)	5.0 (2.5-9.7)	18.9 (13.2-26.4)
Trouble finding a provider (n=5,035)	6.3 (5.4-7.2)	1.2 (0.8-1.8)	13.8 (10.3-18.3)	7.3 (4.2-12.6)	77.9 (70.2-84.1)
Declined as a new patient (n=5,029)	6.5 (5.6-7.5)	1.6 (1.1-2.3)	7.9 (4.9-12.3)	3.1 (1.4-6.8)	95.0 (90.7-97.4)
Declined medical coverage (n=5,032)	7.1 (6.2-8.0)	2.9 (2.2-3.6)	5.3 (3.4-8.1)	13.7 (9.4-19.4)	78.9 (72.0-84.5)
Delayed appointment (n=5,028)	12.2 (11.1-13.3)	3.7 (2.9-4.6)	18.7 (14.9-23.3)	90.1 (85.4-93.5)	50.4 (42.3-58.5)
Office was closed when one could get there (n=5,023)	4.8 (4.2-5.6)	1.5 (1.1-2.1)	5.1 (3.3-7.9)	36.6 (30.3-43.4)	23.9 (18.2-30.7)
Could not reach provider's office by phone (n=5,028)	5.5 (4.8-6.4)	1.2 (0.8-1.8)	7.9 (5.3-11.5)	48.6 (41.8-55.6)	24.0 (18.3-30.9)
Lack of transportation (n=5,028)	6.1 (5.4-7.0)	2.4 (2.0-3.0)	16.2 (12.5-20.8)	28.3 (22.3-35.2)	21.9 (16.4-28.6)
Wait at the provider's office (n=5,026)	8.8 (7.9-9.9)	3.7 (3.0-4.6)	12.3 (9.2-16.3)	58.6 (51.6-65.3)	29.7 (22.9-37.5)
Could not afford recommended medical care (n=5,061)	13.5 (12.2-14.8)	6.0 (5.0-7.1)	63.4 (57.9-68.5)	12.0 (8.2-17.3)	36.9 (29.5-44.9)
Medication unaffordability (n=5,027)	17.8 (16.5-19.2)	7.7 (6.7-8.9)	75.3 (70.0-79.8)	34.1 (27.8-41.1)	46.8 (38.7-55.1)
Could not afford recommended follow-up (n=5,027)	9.5 (8.5-10.5)	0.6 (0.3-1.0)	69.4 (63.5-74.8)	9.8 (6.5-14.6)	33.2 (26.2-40.9)
Could not afford recommended specialty care (n=5,026)	11.7 (10.5-12.9)	1.5 (0.9-2.4)	78.5 (73.5-82.7)	13.4 (9.3-19.1)	40.6 (32.9-48.9)

Source: National Health Interview Survey, 2011-2017
All estimates are from a weighted sample.
Total sample includes 5,062 respondents which represents an estimated 4,742,444 persons with chronic liver disease.
Denominators are listed for each indicator or health care barrier if different from the total number of observations in the sample.
Prevalence is reported as proportions (%) with 95% confidence intervals.
Comparisons across latent classes were all statistically significant.
Shaded health care barriers are the prevalent indicators within each latent class.

Table 3.3. Sociodemographic and Health Characteristics of the Total Sample and by Latent Class (N=5,062)

	Total Sample	**Class 1** Minimal Barriers	**Class 2** Unaffordability	**Class 3** Care Delays	**Class 4** Inability to Establish Care
Observations, unweighted	5,062	3,953	540	328	240
Observations, weighted	4,742,444	3,703,788	506,347	307,013	225,296
Characteristic					
Age (median, range, year)	55 (18-85)	56 (18-85)	50 (19-81)	54 (19-85)	52 (18-85)
Age groups (year)					
18-34	13.3 (12.0-14.6)	13.1 (11.6-14.7)	12.9 (9.5-17.2)	13.9 (10.0-19.1)	16.4 (11.0-23.7)
35-54	35.5 (33.8-37.2)	32.5 (30.6-34.5)	53.6 (47.6-59.5)	37.2 (30.9-44.0)	45.0 (37.1-53.3)
55-64	28.8 (27.2-30.4)	29.2 (27.4-31.2)	24.3 (20.0-29.1)	29.2 (23.5-35.7)	30.3 (23.5-38.2)
65-85	22.5 (21.0-24.1)	25.2 (23.5-27.0)	9.2 (6.2-13.5)	19.7 (14.8-25.7)	8.3 (5.4-12.5)
Female	51.5 (49.6-53.3)	49.7 (47.7-51.7)	57.2 (51.7-62.5)	55.3 (48.2-62.2)	65.1 (56.4-72.8)
Race or ethnicity					
NH White	65.8 (64.0-67.6)	65.9 (63.9-67.9)	64.3 (58.7-69.5)	61.1 (54.5-67.2)	73.3 (66.5-79.1)
Hispanic	17.5 (16.0-19.1)	16.9 (15.2-18.7)	21.1 (17.0-25.9)	23.3 (18.3-29.1)	14.0 (10.1-19.0)
NH Black	8.4 (7.5-9.3)	8.5 (7.5-9.6)	8.0 (5.6-11.4)	8.9 (6.3-12.3)	6.2 (3.7-10.3)
NH Asian	5.0 (4.2-5.9)	5.6 (4.7-6.7)	2.6 (1.4-4.8)	2.0 (0.8-4.9)	4.0 (1.7-9.0)
NH AIAN	1.0 (0.7-1.5)	1.1 (0.7-1.6)	0.5 (0.2-1.4)	1.2 (0.5-2.8)	0.9 (0.3-2.8)
NH Other	2.3 (1.8-2.9)	2.1 (1.6-2.7)	3.5 (1.5-7.6)	3.7 (1.6-8.1)	1.7 (0.7-4.2)
Fair or poor health (n=5,056)	41.4 (39.7-43.2)	36.9 (35.0-38.9)	59.8 (53.7-65.7)	61.6 (54.6-68.1)	54.7 (46.3-62.8)
Functional limitation due to health (n=5,056)	68.2 (66.4-69.8)	64.6 (62.6-66.5)	80.1 (75.2-84.3)	84.0 (78.0-88.7)	84.6 (78.1-89.4)
Less than high school graduate level education (n=5,036)	7.2 (6.3-8.2)	6.7 (5.8-7.8)	9.6 (6.9-13.1)	8.4 (5.5-12.6)	8.7 (4.9-15.1)
Unemployment (n=5,052)	57.8 (55.9-59.6)	56.4 (54.2-58.4)	61.8 (56.3-67.1)	60.5 (53.3-67.4)	70.6 (63.1-77.2)
Household poverty[a] (n=4,791)	20.1 (18.7-21.5)	17.4 (15.9-18.9)	31.1 (26.2-36.4)	26.3 (21.4-31.8)	35.3 (28.1-43.2)
Lives alone	23.2 (22.0-24.5)	22.6 (21.3-24.1)	24.1 (20.2-28.5)	28.2 (23.1-34.0)	25.8 (20.2-32.3)
Insurance (n=4,924)					
No insurance	11.2 (10.1-12.4)	7.7 (6.6-8.9)	38.9 (33.4-44.6)	6.9 (4.2-11.2)	15.8 (10.5-23.0)
Public insurance	23.6 (22.0-25.2)	22.4 (20.6-24.2)	18.5 (14.6-23.2)	37.7 (31.4-44.4)	39.2 (31.5-47.5)

Medicare	15.3 (13.9-16.7)	15.5 (14.0-17.1)	14.5 (11.2-18.6)	14.6 (10.1-20.6)	13.9 (9.3-20.3)
Private insurance	50.0 (48.1-51.9)	54.5 (52.3-56.6)	28.1 (23.2-33.5)	40.9 (33.8-48.4)	31.1 (23.9-39.4)

Source: National Health Interview Survey, 2011-2017
Abbreviations: NH, Non-Hispanic; AIAN, American Indian or Alaskan Native
Denominators are listed for each indicator or health care barrier if different from the total number of observations in the sample.
All estimates are derived from a weighted sample and reported as proportions (%) with 95% confidence intervals unless otherwise indicated.
Comparisons across latent classes were all statistically significant except for education (p=0.1806) and living alone (p=0.1668).
[a] Household poverty is based on reported annual household income below federal poverty level

Table 3.4. Association of Sociodemographic and Health Characteristics and Latent Class Membership (n=4,646)

	Class 2 vs. Class 1 Unaffordability vs. Minimal Barriers		**Class 3 vs. Class 1** Care Delays vs. Minimal Barriers		**Class 4 vs. Class 1** Inability to Establish Care vs. Minimal Barriers	
Characteristic	**RRR (95% CI)**	***P* value**	**RRR (95% CI)**	***P* value**	**RRR (95% CI)**	***P* value**
Age group (years)						
18-34 (reference)	1.0		1.0		1.0	
35-54	1.19 (0.73-1.95)	0.478	0.79 (0.48-1.29)	0.344	0.75 (0.43-1.31)	0.308
55-64	0.60 (0.36-0.99)	0.044	0.67 (0.39-1.16)	0.155	0.54 (0.30-0.99)	0.045
65-85	0.30 (0.14-0.62)	0.001	0.58 (0.32-1.06)	0.079	0.10 (0.05-0.21)	<.001
Female	1.23 (0.95-1.61)	0.122	1.07 (0.79-1.44)	0.658	1.86 (1.25-2.77)	0.002
Race or ethnicity						
NH White (reference)	1.0		1.0		1.0	
Hispanic	1.01 (0.70-1.45)	0.962	1.56 (1.07-2.26)	0.020	0.70 (0.46-1.05)	0.088
NH Black	0.78 (0.46-1.32)	0.355	1.00 (0.63-1.58)	0.992	0.49 (0.26-0.91)	0.024
NH Asian	0.57 (0.30-1.09)	0.088	0.53 (0.20-1.44)	0.216	0.82 (0.31-2.16)	0.683
NH AIAN	0.22 (0.06-0.87)	0.031	0.83 (0.35-1.98)	0.679	0.38 (0.10-1.44)	0.153
NH Other	1.09 (0.52-2.29)	0.813	1.73 (0.72-4.17)	0.223	0.42 (0.14-1.27)	0.123
Fair or poor health	1.96 (1.42-2.71)	<.001	2.12 (1.48-3.03)	<.001	1.08 (0.69-1.67)	0.739
Functional limitation due to health	2.35 (1.63-3.40)	<.001	2.84 (1.78-4.51)	<.001	2.74 (1.65-4.56)	<.001
Unemployment	1.02 (0.72-1.45)	0.912	0.68 (0.45-1.03)	0.070	1.30 (0.81-2.10)	0.276
Household poverty	1.34 (0.96-1.88)	0.088	1.12 (0.77-1.64)	0.556	1.41 (0.89-2.24)	0.143
Insurance						
No insurance (reference)	1.0		1.0		1.0	
Public insurance	0.13 (0.09-0.21)	<.001	1.68 (0.93-3.06)	0.088	0.83 (0.49-1.38)	0.463
Medicare	0.28 (0.17-0.46)	<.001	1.27 (0.64-2.52)	0.492	0.82 (0.40-1.66)	0.576
Private insurance	0.15 (0.10-0.22)	<.001	1.13 (0.60-2.14)	0.698	0.41 (0.23-0.73)	0.002

Source: National Health Interview Survey, 2011-2017
Abbreviations: RRR, relative risk ratio; CI, confidence interval; NH, Non-Hispanic; AIAN, American Indian or Alaskan Native
Latent classes 2, 3, and 4 are compared to the reference latent class 1 (minimal barriers).

Table 3.5. Odds Ratios and Predicted Probabilities of Recurrent Acute Care Use by Latent Class

	Odds Ratio (95% CI)	***P* value**	**Predicted Probability (95% CI)**
Model (vs. Minimal Barriers)			
Unaffordability			
Unadjusted	1.85 (1.45-2.37)	<.001	0.39 (0.34-0.45)
Adjusted	1.55 (1.17-2.05)	0.002	0.36 (0.30-0.41)
Care Delays			
Unadjusted	2.21 (1.65-2.94)	<.001	0.44 (0.37-0.50)
Adjusted	1.57 (1.12-2.20)	0.008	0.36 (0.29-0.42)
Inability to Establish Care			
Unadjusted	2.57 (1.85-3.58)	<.001	0.47 (0.39-0.55)
Adjusted	1.89 (1.26-2.84)	0.002	0.40 (0.31-0.48)

Source: National Health Interview Survey, 2011-2017
Total observations in the unadjusted and adjusted model included 5,061 and 4,645 respondents, respectively.
Adjusted model accounted for age, sex, race or ethnicity, fair or poor health, functional limitation due to health, employment, household poverty, and insurance.

Figure 3.2. Adjusted Probability of Recurrent Acute Care Use by Latent Class

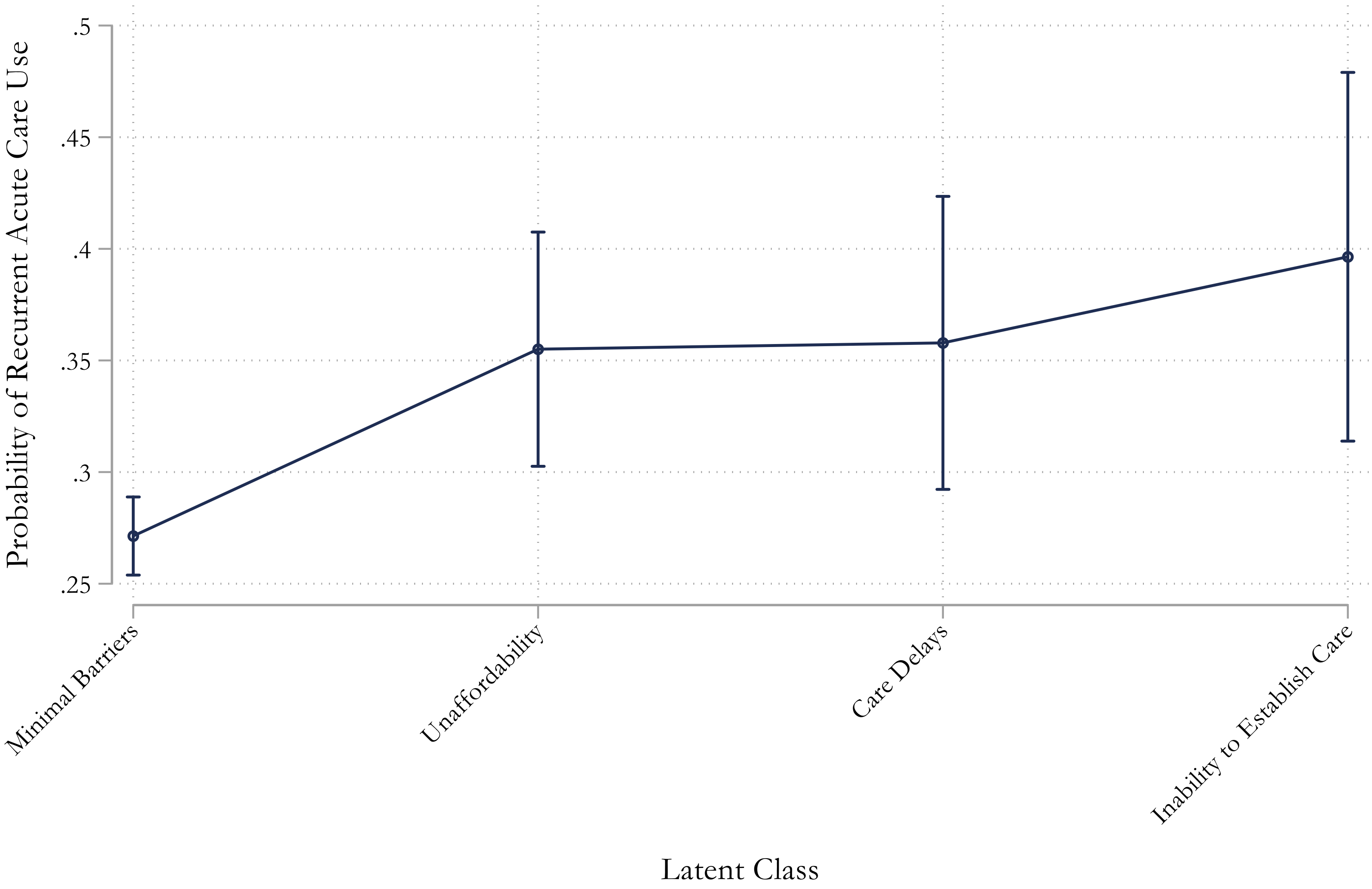
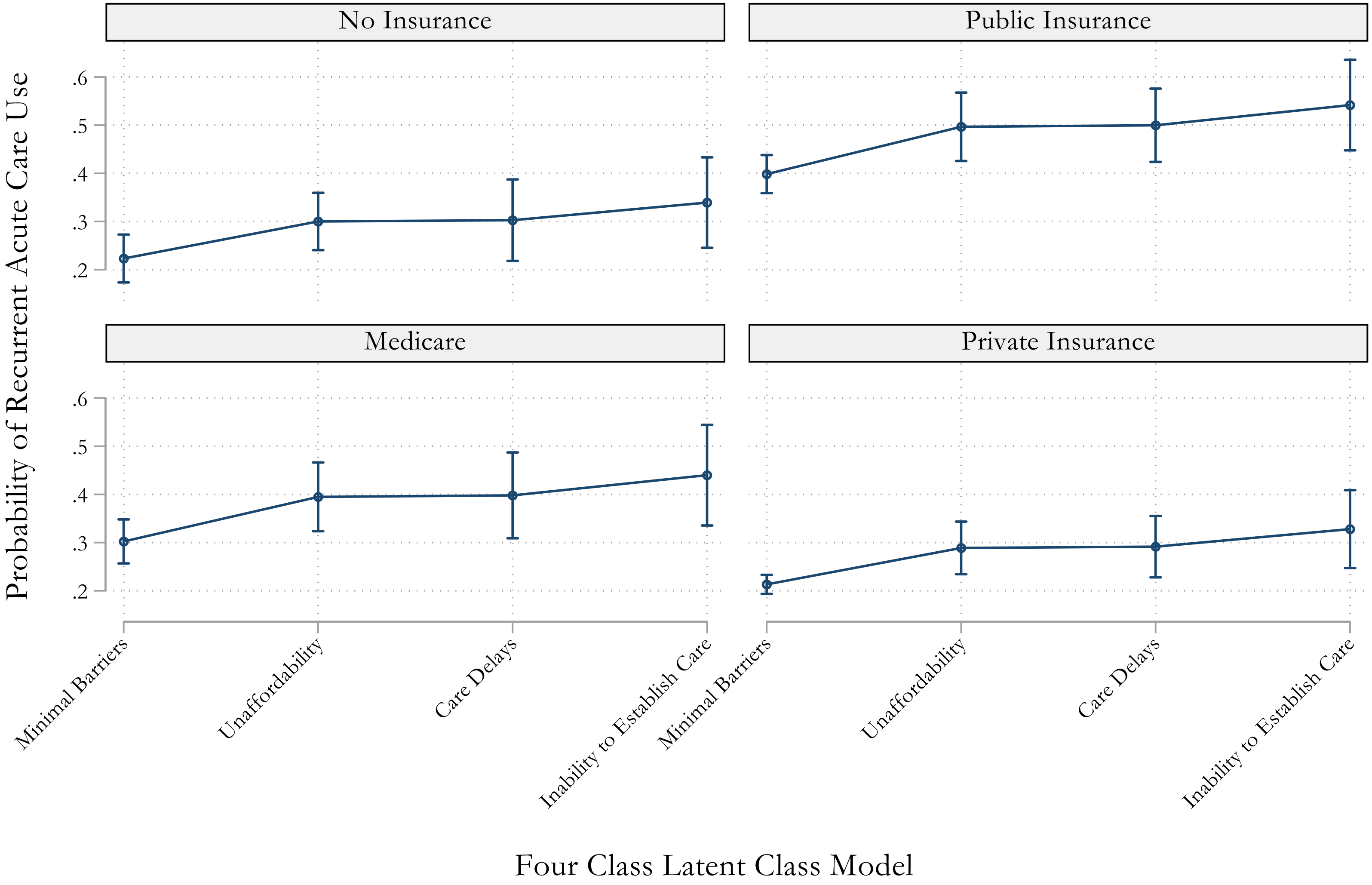
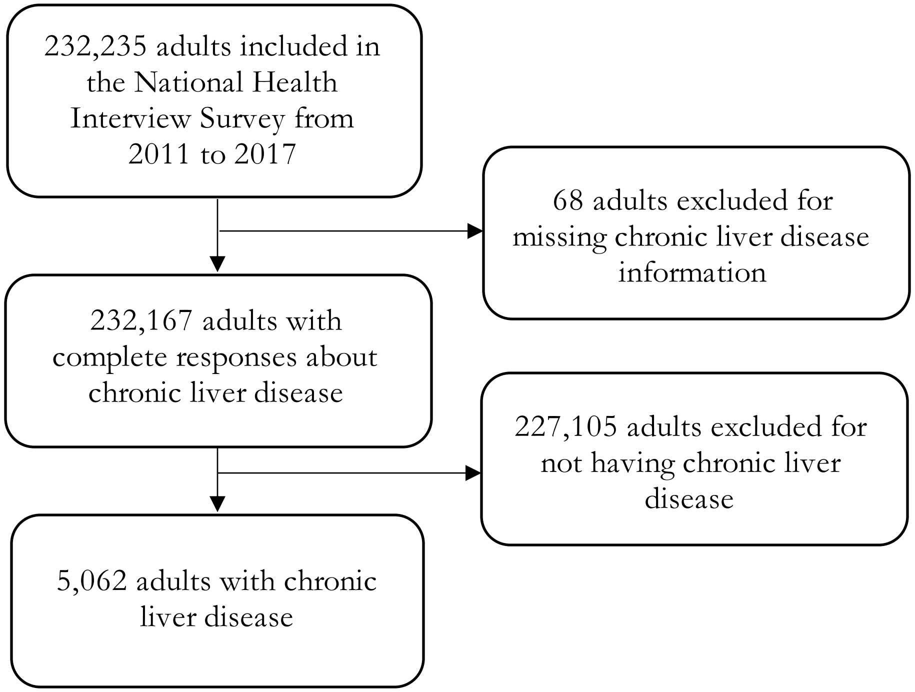


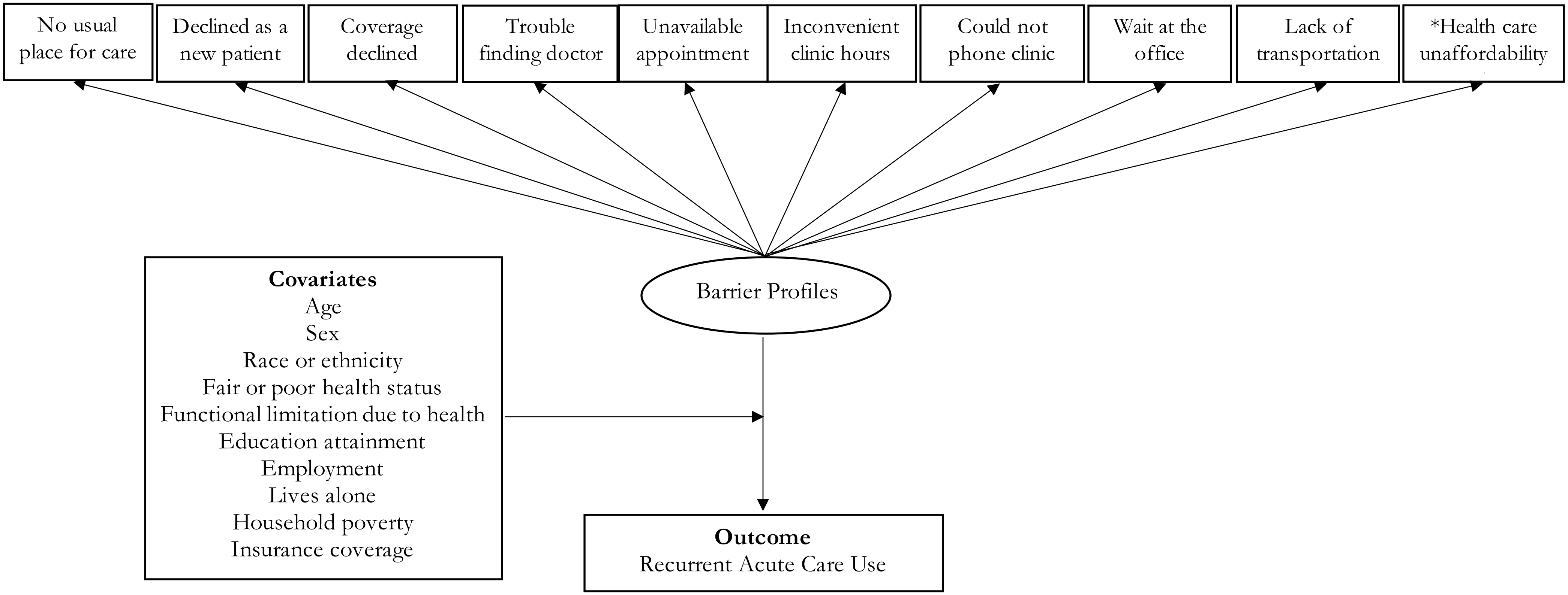
Figure 3.3. Adjusted Probability of Recurrent Acute Care Use by Latent Class and Insurance



Appendix Figure 3.1. Study Population Flowchart

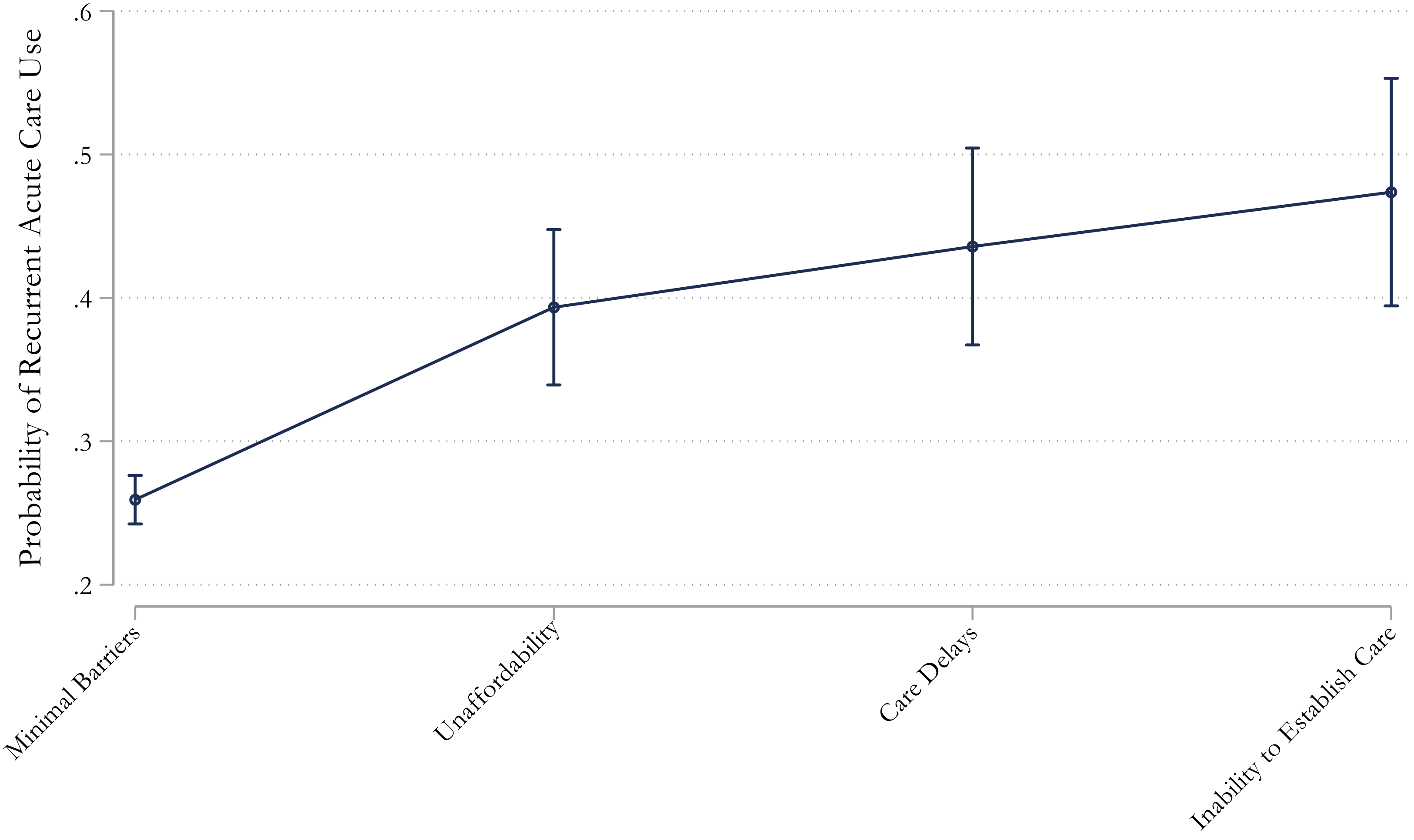


Appendix Figure 3.2. Analytic Model for Latent Class Analysis



* Health care unaffordability includes 4 indicators including forgoing needed medical care, follow-up care, specialty care, or medication due to cost

Appendix Figure 3.3. Unadjusted Probability of Recurrent Acute Care Use by Latent Class



CHAPTER IV: CONCLUSIONS

This dissertation characterized the probability of any and more health care barriers and its association with recurrent acute care use among US adults with CLD vs. other chronic conditions (COPD/CVD) and uncovered novel phenotypes based on self-reported health care barriers that were associated with different probabilities of recurrent acute use for adults with CLD using nationally representative data from the NHIS from 2011 to 2017.

Chapter II compared the prevalence and probability of any and more health care barriers among adults with CLD vs. COPD/CVD. Findings from this study revealed that the CLD population had a higher prevalence of individuals with any barriers to care by 10 percentage points (44.7% vs. 34.4%). In the adjusted analysis, CLD was 1.12 times more likely than COPD/CVD to encounter any health care barriers. The frequency of health care barriers was similar between the disease groups, although there was a trend towards a higher prevalence of health care barriers for CLD. Higher prevalence of barriers was associated with increased probability of recurrent acute care use, although this relationship was not significantly different between the disease groups.

Chapter III investigated the use of self-reported health care barriers and latent class analysis to uncover unique phenotypes that were associated with different risks of recurrent acute care use for the CLD population. The study identified four unique subgroups including minimal barriers, unaffordability, care delays, and inability to establish care. Persons with the inability to establish care phenotype were almost two times more likely than those with the minimal barriers phenotype to have recurrent acute care use. The inability to establish care phenotype, particularly with public insurance, were at the highest risk of recurrent acute care utilization (predicted probability, 0.54).

4.1 Policy Implications and Recommendations

Targeting CLD as a high-risk condition in future health reforms

Main findings from Chapter II demonstrated the persistent disparity in likelihood of any health care barriers for adults with CLD vs. COPD/CVD as seen in the adjusted, unadjusted, and stratified analyses. While the extent of health care barriers was similar between both disease groups and the relationship between the frequency of health care barriers and recurrent acute care use was not dependent on the disease group, the CLD population generally fared worse in terms of any health care barriers (44.7% vs. 34.4%) and recurrent acute care use (29.2% vs. 24.0%) compared to the non-CLD population.

Unlike the COPD/CVD population, which has disease-specific programs aimed to reduce health care barriers to prevent rehospitalizations, the CLD population lacks support from similar programs. Future health reforms that aim to reduce preventable rehospitalizations for conditions with high morbidity and mortality rates like CLD are encouraged to include CLD, or at least its more advanced form, cirrhosis, as a targetable condition. By doing so, there can be concerted efforts to improve care coordination and reduce health care barriers in the care seeking process for persons with CLD. The inclusion of CLD as a high-risk condition in future health reforms can facilitate the timely receipt of needed medical care at the ecological level, which in turn can incentivize payers, systems, hospitals, and providers to reduce organizational level barriers and help offset individual-level barriers that limit one from receiving timely care.

Recognizing the CLD population as an under-resourced population

This dissertation highlighted differences in sociodemographic and health characteristics between the CLD and non-CLD adult population with other chronic diseases in the US. The CLD population is younger, included more Hispanics, Asians, American Indians or Alaskan Natives, or other non-White race or ethnicity, and had higher reports of fair or poor health, and more material hardship based on higher rates of poverty, need for government assistance for basic necessities, and lack of insurance.

The presence of socioeconomic vulnerabilities affects the timely receipt of medical care at the level of the individual, provider, and insurance plan. The prevalence of such socioeconomic risks can hinder an individual from receiving timely medical care and can also influence the provider's willingness to care for patients with socially complex needs. Earlier work have shown that socially disadvantaged patients received shorter medical visits (Blumenthal, et al., 1999; Cooper, et al., 2003) and were more likely to be deemed non-adherent (Fiscella & Epstein, 2009).

At the insurance plan level, while Medicare Advantage may be a preferred option for more socioeconomically disadvantaged persons (Meyers, Gadbois, Brazier, Tucher, & Thomas, 2020), disparities in quality exist for Medicare Advantage enrollees of low socioeconomic status or minority groups (Blacks, Hispanics) (Meyers, Rahman, Mor, Wilson, & Trivedi, 2021). Interestingly, in the study by Meyers et al., the Medicare Advantage plans with a larger proportion of enrollees of low socioeconomic status and Black and Hispanic individuals had less disparities in quality (Meyers, Rahman, Mor, Wilson, & Trivedi, 2021). Therefore, plans with a higher density of similar beneficiaries may be able to contract with insurance provider networks that are more familiar with the beneficiary population and be able to address their needs with potentially additional supplemental benefits or programs. While future research is needed to understand the mechanisms by which insurance plans may be able to help reduce disparities among ethnic minorities and those with socioeconomic vulnerabilities, such findings, including policies like the CHRONIC Care Act of

2018, are encouraging and suggest that plans that serve specific populations may be able to leverage and tailor interventions and programs that are most suitable for their beneficiaries.

Starting in 2020, Medicare Advantage plans offered special supplemental benefits for enrollees, who had at least one complex chronic condition, were at high risk of rehospitalization, and required intensive care coordination through the CHRONIC Care Act (Hostetter & Klein, 2020). In response to the CHRONIC Care Act, a Medicare Advantage health plan, UCare, identified acupuncture benefits without copayments as a supplementary service that would fit the needs of its 105,000 members given the prevalence of individuals with chronic pain and the plan's overall goal to reduce opiate dependency (Hostetter & Klein, 2020). A similar plan-level approach based on needs assessments may be useful given the CLD population's higher proportion of persons with fair or poor health (41.4% vs. 33.3%), poverty (20.1% vs. 15.3%), and need for government subsidy for material necessities (20.1% vs. 15.3%) compared to the non-CLD population.

Such plans that tend to benefit those with lower socioeconomic status may already exist as previously suggested (Meyers, Rahman, Mor, Wilson, & Trivedi, 2021). As such, social workers and care coordinators, who are more versed with specific benefits, may be able to help persons with CLD navigate and find the most fitting Medicare plan based on socioeconomic and health needs, among the approximately 4,000 different Medicare Advantage plans that are available nationally (Freed, Biniek, Damico, & Neuman, 2022).

Given the higher proportion of persons with CLD with public insurance (e.g. Medicaid) (23.6%) than Medicare alone (15.3%), plan-specific supplementary benefits that can assist Medicaid enrollees with CLD and health-related social needs can provide more appropriate coverage and potentially reduce health care barriers and recurrent acute care use. For example, California's Whole Person Care pilot program, which provided Medicaid enrollees at high-risk of rehospitalizations (e.g. people with multiple chronic conditions, severe drug addiction or mental health problems, undomiciled, recently incarcerated) with support for housing, transportation, education, job security, and legal assistance, contributed to a reduction in acute care utilization (45 fewer hospitalizations and 130 fewer ED visits per 1,000 beneficiaries per year) and health care costs ($383 less per beneficiary per year) (Pourat, et al., 2022). Similar population-specific interventions implemented at the level of the insurance plan can be large-scaled yet tailored approaches to mitigating disparities in health care barriers and recurrent acute care use for adults with CLD.

4.2 Practice Implications and Recommendations

Screening for social needs and barriers to care in the clinical setting

Recurrent acute care use has been described as a reflection of socioeconomic conditions (Figueroa & Wadhera, 2022). Findings from this dissertation add that the accumulation of health care barriers, regardless of disease, increases one's risk of recurrent acute care use, and socioeconomic vulnerability is associated with increased likelihood of any health care barriers. As such, screening for social needs and barriers to care in the ambulatory care setting can help health systems and clinics identify and address the socioeconomic needs and health care barriers that hinder patients' abilities to receiving timely medical care and thereby, potentially reducing recurrent acute care use.

There is increasing evidence that support health-related social needs interventions to reduce acute care utilization and health care costs (The Commonwealth Fund, 2019; Berkowitz, et al., 2019; Carter, et al., 2021). The Centers for Medicare and Medicaid Services is requiring mandatory screening for health-related social needs starting in 2024 among hospitalized patients (Sandhu, Liu,

& Wadhera, 2022). Questions using the standardized Accountable Health Communities Model screening tool include topics such as housing instability, food insecurity, transportation needs, utility needs, and interpersonal safety (Billioux, Verlander, Anthony, & Alley, 2017). While such universal screening among hospitalized patients can be informative in identifying health-related social needs of the population, it misses the opportunity to identify the practical health care barriers that individuals encounter when seeking medical care after hospitalization.

In Chapter II, we showed that persons, who required government assistance with basic necessities, including food, housing, income, or other welfare, were 1.6 times more likely to have any health care barriers and 1.2 times more likely to have more barriers compared to those who did not. After controlling for receipt of government assistance, the association between the prevalence of health care barriers and recurrent acute care use persisted. Therefore, screening for health care barriers in addition to social needs can potentially help identify and address more specific factors to prevent recurrent acute care use. For example, an individual may not receive timely medical care because he or she struggles to establish care as a new patient while experiencing food insecurity. Interventions that target only food insecurity would not directly help the individual establish medical care. Direct questions about challenges throughout the process of seeking care can help pinpoint one's unique barriers to care and practically address specific barriers with appropriate resources to facilitate timely receipt of medical care.

Ensuring establishment of care for persons with CLD

Findings from Chapter III highlighted that individuals, who were unable to establish care, are at highest risk of recurrent acute care utilization. Therefore, ensuring post-hospitalization care in the outpatient setting would be a high-value target to reduce recurrent acute care use for the CLD population. Prior work has shown that the use of community health workers to assist recently hospitalized patients with clinical access helped reduce 30-day readmissions (odds ratio, 0.44) and missed clinic appointments (odds ratio, 0.56) compared to patients who received routine care (Carter, et al., 2021). The community health workers used multiple communication strategies, including phone calls and home visits and directly communicated with the patient's outpatient team (e.g. primary care physician, care management, nursing) (Carter, et al., 2021).

Similar interventions can be pursued for the CLD population. At the hospital-level, case managers and social workers can ensure that outpatient follow-up appointments, along with any organizational and transportation barriers (e.g. pre-authorizations, need transportation, costs) are addressed prior to discharge. Furthermore, case managers and social workers can help screen for accompanying health-related social needs and determine whether or not the patient may qualify for supplementary programs or benefits through one's insurance plan. At the insurance plan-level, there could be care coordinators who help patients navigate the process of receiving timely medical care after hospitalization. At the provider-level, physicians can be alerted to patients, who share characteristics and barriers with the inability to establish care phenotype, to ensure that they are getting timely post-hospitalization follow-up potentially through special post-discharge clinics.

4.3 Limitations and Future Directions

There are limitations to both studies. First, we used NHIS data that relied on self-reports about CLD. Therefore, findings from this dissertation are conditional on respondents who have had a health care encounter where they received a diagnosis and may not capture individuals, who encounter health care barriers and have yet to establish any care with a provider. Our reported estimates in the probability and extent of any and more health care barriers may be less than the true estimates of the CLD population, because we may have missed individuals with even more health care barriers that limited them from getting a CLD diagnosis. Additionally, our inability to fully capture the CLD population may affect the probability of class membership in our latent class model such that there could have been a higher prevalence of individuals with the inability to establish care phenotype. As the NHIS collects data among community-dwelling persons, its data will miss individuals who are institutionalized in a hospital or rehabilitation center. Therefore, our findings may have missed the sickest individuals with CLD, and this could have affected the association between barriers to care and recurrent acute care utilization.

Second, while we pooled annual NHIS data to create a cross-sectional study over seven years to provide nationally-representative estimates, our findings are limited to describing associations as no causal inferences can be made. Therefore, more frequent acute care use may affect one's likelihood of experiencing health care barriers just as more health care barriers may contribute to a higher risk of recurrent acute care use. Directionality in the relationship between health care barriers and acute care use cannot be proven in this dissertation; however, the use of health care barriers to assess risk of acute care utilization is a more preventative approach to risk stratify individuals with CLD.

Third, we recognize that geographic differences in health care access exist, especially between rural and urban locations in the US (van Dis, 2002), which were not captured in this dissertation. We accounted for geographic variability using US Census regions for the first study, which reported the prevalence and extent of any and more health care barriers by disease type, but we understand that controlling for a US Census region merely allows us to understand the independent effect of the chronic disease and outcome and is insufficient to characterize state- and county-level differences in barriers to care.

To address the limitation of self-reports using NHIS data, future research can prospectively capture individuals with CLD using physician verification or clinical data. A comparison of the rates of CLD between diagnoses captured using clinical data and self-reports to determine any difference will help assess the accuracy of our findings. Prospective measurement of health care barriers over time among non-hospitalized patients to predict risk of acute care use will clarify the temporal relationship between barriers to care and hospital use. Given expected geographic differences, future research can assess for differences in health care utilization by rurality and at the county, state, and US region levels. The use of fixed effects by county, state, and region and sensitivity analyses without the use of fixed effects can demonstrate the robustness of estimates by geographic variables.

Despite the aforementioned limitations, this dissertation highlights the CLD population as a more socioeconomically vulnerable group relative to the non-CLD population and such differences in population characteristics are related to the persistent disparity in experiencing any health care barriers among those with CLD vs. COPD/CVD. Additionally, this dissertation uncovered that adults with CLD, who experienced barriers to establishing care, were the most vulnerable for recurrent acute care utilization. I hope findings from this dissertation can bring more attention to persons with CLD at the policy-, hospital-, insurance plan-, and provider-levels, provide evidence on the utility of identifying and measuring barriers to care, and motivate the implementation of programs to make outpatient care more accessible to mitigate the increasing morbidity and mortality rates for the US population with CLD.

REFERENCES

Abara, W. E., Qaseem, A., Schillie, S., McMahon, B. J., & Harris, A. M. (2017). Hepatitis B Vaccination, Screening, and Linkage to Care: Best Practice Advice From the American College of Physicians and the Centers for Disease Control and Prevention. *Annals of Internal Medicine*, 761-836.

Aday, L. A., & Andersen, R. (1974). A Framework for the Study of Access to Medical Care. *Health Services Research*, 208-220.

Agresti, A. (2002). *Categorical Data Analysis.* Hoboken, NJ: John Wiley & Sons, Inc.

Allen, E. M., Call, K. T., Beebe, T. J., McAlpine, D. D., & Johnson, P. J. (2017). Barriers to Care and Healthcare Utilization among the Publicly Insured. *Medical Care*, 207-214.

An, J., Shim, J. H., Kim, S.-O., Lee, D., Kim, K. M., Lim, Y.-S., . . . Lee, Y. S. (2014). Prevalence and Prediction of Coronary Artery Disease in Patients With Liver Cirrhosis. *Circulation*, 1353-1362.

Aneja, S., Ross, J. S., Wang, Y., Matsumoto, M., Rodgers, G. P., Bernheim, S. M., . . . Krumholz, H. M. (2011). US Cardiologist Workforce From 1995 To 2007: Modest Growth, Lasting Geographic Maldistribution Especially In Rural Areas. *Health Affairs*, 2301-2309.

Askgaard, G., Leon, D. A., Kjaer, M. S., Gerds, T. A., & Tolstrup, J. S. (2016). Risk for alcoholic liver cirrhosis after an initial hospital contact with alcohol problems: A nationwide prospective cohort study. *Hepatology*, 929-937.

Asrani, S. K., Kouznetsova, M., Ogola, G., Taylor, T., Masica, A., Pope, B., . . . Kanwal, F. (2018). Increasing Health Care Burden of Chronic Liver Disease Compared With Other Chronic Diseases, 2004-2013. *Gastroenterology*, 719-729.

ASTRAL-1 Investigators. (2015). Sofosbuvir and Velpatasvir for HCV Genotype 1, 2, 4, 5, and 6 Infection. *New England Journal of Medicine*, 2599-2607.

Ayyala-Somayajula, D., Dodge, J. L., Farias, A., Terrault, N., & Lee, B. P. (2023). Healthcare affordability and effects on mortality among adults with liver disease from 2004-2018 in the United States. *Journal of Hepatology*, 1-33.

Bajaj, J. S., Reddy, K. R., Tandon, P., Wong, F., Kamath, P. S., Garcia-Tsao, G., . . . Thacker, L. R. (2016). The 3-month readmission rate remains unacceptably high in a large North American cohort of patients with cirrhosis. *Hepatology*, 200-208.

Bajaj, J., O'Leary, J., Tandon, P., Wong, F., Kamath, P., Biggins, S., . . . Reddy, K. (2020). Insurance Status But Not Race and Ethnicity Are Associated With Outcomes in a Large Hospitalized Cohort of Patients With Cirrhosis. *Clinical Gastroenterology and Hepatology*, 565-572.

Bambhroliya, A. B., Donnelly, J. P., Thomas, E. J., Tyson, J. E., Miller, C. C., McCullough, L. D., . . . Vahidy, F. S. (2018). Estimates and Temporal Trend for US Nationwide 30-Day Hospital Readmission Among Patients With Ischemic and Hemorrhagic Stroke. *JAMA Network Open*, e181190.

Bergethon, K. E., Ju, C., DeVore, A. D., Hardy, N. C., Fonarow, G. C., Yancy, C. W., . . . Hernandez, A. F. (2016). Trends in 30-Day Readmission Rates for Patients Hospitalized With Heart Failure: Findings From the Get With The Guidelines-Heart Failure Registry. *Circulation: Heart Failure*, e002594.

Berkowitz, S. A., Terranova, J., Randall, L., Cranston, K., Waters, D. B., & Hsu, J. (2019). Association Between Receipt of a Medically Tailored Meal Program and Health Care Use. *JAMA Internal Medicine*, 786-793.

Berman, K., Tandra, S., Forssell, K., Vuppalanchi, R., Burton Jr., J. R., Nguyen, J., . . . Chalasani, N. (2011). Incidence and predictors of 30-day readmission among patients hospitalized for advanced liver disease. *Clinical Gastroenterology & Hepatology*, 254-259.

Bertot, L. C., Jeffrey, G. P., Wallace, M., MacQuillan, G., Garas, G., Ching, H. L., & Adams, L. A. (2017). Nonalcoholic fatty liver disease-related cirrhosis is commonly unrecognized and associated with hepatocellular carcinoma. *Hepatology Communications*, 53-60.

Bierman, A. S., Wang, J., O'Malley, P. G., & Moss, D. K. (2022). Transforming care for people with multiple chronic conditions: Agency for Healthcare Research and Quality's research agenda. *Health Services Research*, 973-979.

Billioux, A., Verlander, K., Anthony, S., & Alley, D. (2017, March 15). Standardized screening for health-related social needs in clinical settings: The accountable health communities screening tool. Discussion Paper. *National Academy of Medicine*, pp. 1-9. Retrieved from https://nam.edu/wp-content/uploads/2017/05/

Billioux, A., Verlander, K., Anthony, S., & Alley, D. (2017, March 15). Standardized screening for health-related social needs in clinical settings: The accountable health communities screening tool. Discussion Paper. *National Academy of Medicine*, (pp. 1-9). Washington, DC. Retrieved from https://nam.edu/wp-content/uploads/2017/05/

Billioux, A., Verlander, K., Anthony, S., & Alley, D. (2017). *Standardized Screening for Health-Related: The Accountable Health Communities Screening Tool.* Washington, DC: National Academy of Medicine.

Blackwell, D. L., Lucas, J. W., & Clarke, T. C. (2014). Summary health statistics for U.S. adults: national health interview survey, 2012. *Vital Health Stat 10*, 1-161.

Blewett, L. A., Rivera Drew, J. A., King, M. L., Williams, K. C., Del Ponte, N., & Convey, P. (2022, August 23). IPUMS Health Surveys: National Health Interview Survey, Version 7.1 [dataset]. Minneapolis, Minnesota, USA. Retrieved from https://nhis.ipums.org/

Blumenthal, D., Causino, N., Chang, Y., Culpepper, L., Marder, W., Saglam, D., . . . B, S. (1999). The duration of ambulatory visits to physicians. *Journal of Family Practice*, 264-271.

Bradley, E. H., Curry, L., Horwitz, L. I., Sipsma, H., Wang, Y., Walsh, M. N., . . . Krumholz, H. M. (2013). Hospital strategies associated with 30-day readmission rates for patients with heart failure. *Circulation: Cardiovascular Quality and Outcomes*, 444-450.

Braveman, P. A., Cubbin, C., Egerter, S., Sekai, C., Marchi, K. S., Metzler, M., & Posner, S. (2005). Socioeconomic Status in Health Research: One Size Does Not Fit All. *JAMA*, 2879-2888.

Bronstein, L. R., Gould, P., Berkowitz, S. A., James, G. D., & Marks, K. (2015). Impact of a Social Work Care Coordination Intervention on Hospital Readmission: A Randomized Controlled Trial. *Social Work*, 248-255.

Browning, J. D., Szczepaniak, L. S., Dobbins, R., Nuremberg, P., Horton, J. D., Cohen, J. C., . . . Hobbs, H. H. (2004). Prevalence of hepatic steatosis in an urban population in the United States: Impact of ethnicity. *Hepatology*, 1387-1395.

Canbay, A., Kachru, N., Haas, J. S., Sowa, J.-P., Meise, D., & Ozbay, A. B. (2020). Patterns and predictors of mortality and disease progression among patients with non-alcoholic fatty liver disease. *Alimentary Pharmacology & Therapeutics* , 1185-1194.

Canterberry, M., Figueroa, J. F., Long, C. L., Hagan, A. S., Gondi, S., Bowe, A., . . . Powers, B. W. (2022). Association Between Self-reported Health-Related Social Needs and Acute Care Utilization Among Older Adults Enrolled in Medicare Advantage. *JAMA Health Forum*, e221874.

Canterberry, M., Figueroa, J. F., Long, C. L., Hagan, A. S., Gondi, S., Bowe, A., . . . Powers, B. W. (JAMA Health Forum). Association Between Self-reported Health-Related Social Needs and Acute Care Utilization Among Older Adults Enrolled in Medicare Advantage. *2022*, e221874.

Caraballo, C., Ndhumele, C. D., Roy, B., Lu, Y., Riley, C., Herrin, J., & Krumholz, H. M. (2022). Trends in Racial and Ethnic Dispariites in Barriers to Timely Medical Care Among Adults in the US, 1999 to 2018. *JAMA Health Forum*, e223856.

Caraballo, C., Ndumele, C. D., Roy, B., Lu, Y., Riley, C., Herrin, J., & Krumholz, H. M. (2022). Trends in Racial and Ethnic Disparities in Barriers to Timely Medical Care Among Adults in the US, 1999 to 2018. *JAMA Health Forum*, e223856.

Carter, J., Hassan, S., Walton, A., Yu, L., Donelan, K., & Thorndike, A. N. (2021). Effect of Community Health Workers on 30-Day Hospital Readmissions in an Accountable Care Organization Population: A Randomized Clinical Trial. *JAMA Network Open*, e2110936.

Celeux, G., & Soromenho, G. (1996). An entropy criterion for assessing the number of clusters in a mixture model. *Journal of Classification*, 195-212.

Centers for Disease Control and Prevention. (2023, 4 May). *Chronic Liver Disease and Cirrhosis*. Retrieved from National Center for Health Statistics: https://www.cdc.gov/nchs/fastats/liver-disease.htm

Centers for Disease Control and Prevention. (2023, 2 May). *Chronic Obstructive Pulmonary Disease (COPD)*. Retrieved from National Trends in COPD: https://www.cdc.gov/copd/data-and-statistics/national-trends.html

Centers for Disease Control and Prevention. (2023, May 1). *National Center for Health Statistics*. Retrieved from Kidney Disease: https://www.cdc.gov/nchs/fastats/kidney-disease.htm

Centers for Disease Control and Prevention. (n.d.). *National Vital Statistics System, Mortality 2018-2021*. Retrieved from National Center for Health Statistics: http://wonder.cdc.gov/ucd-icd10-expanded.html

Centers for Disease Control and Prevention, National Center for Health Statistics. (n.d.). *National Vital Statistics System, Mortality 2018-2021*. Retrieved from CDC Wonder Online Database: http://wonder.cdc.gov/ucd-icd10-expanded.html

Centers for Medicare & Medicaid Services. (2023, February 23). *Hospital Readmissions Reduction Program*. Retrieved from https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program#:~:text=The%20Hospital%20Readmissions%20Reduction%20Program,in%20turn%2C%20reduce%20avoidable%20readmissions

Centers for Medicare & Medicaid Services. (2023, September 6). *Hospital Readmissions Reduction Program (HRRP)*. Retrieved from Prospective Payment Systems: https://www.cms.gov/medicare/payment/prospective-payment-systems/acute-inpatient-pps/hospital-readmissions-reduction-program-hrrp

Chaiyachati, K., Hom, J. K., Wong, C., Nasseh, K., Chen, X., Beggin, A., . . . Grande, D. (2019). Access to primary and dental care among adults newly enrolled in Medicaid. *The American Journal of Managed Care*, 135-139.

Chen, K. L., Miake-Lye, I. M., Begashaw, M. M., Zimmerman, F. J., Larkin, J., McGrath, E. L., & Shekelle, P. G. (2022). Association of Promoting Housing Affordability and Stability With Improved Health Outcomes: A Systematic Review. *JAMA Network Open*, e2239860.

Chen, V. L., Song, M. W., Suresh, D., Wadhwani, S. I., & Perumalswami, P. (2023). Effects of social determinants of health on mortality and incident liver-related events and cardiovascular disease in steatotic liver disease. *Alimentary Pharmacology & Therapeutics*, 537-545.

Chetty, R., Stepner, M., Abraham, S., Lin, S., Scuderi, B., Turner, N., . . . Cutler, D. (2016). The Association Between Income and Life Expectancy in the United States, 2001-2014. *JAMA*, 1750-1766.

Cheung, P. T., Wiler, J. L., & Ginde, A. A. (2011). Changes in Barriers to Primary Care and Emergency Department Utilization. *Archives of Internal Medicine*, 1393-1400.

Cho, H., Wang, Z., Yabroff, K. R., Liu, B., McNeel, T., Feuer, E. J., & Mariotto, A. B. (2022). Estimating life expectancy adjusted by self-rated health status in the United States: national health interview survey linked to the mortality. *BMC Public Health*, 141.

Coleman, E. A., Parry, C., Chalmers, S., & Min, S.-j. (2006). The Care Transitions Intervention: Results of a Randomized Controlled Trial. *Archives of Internal Medicine*, 1822-1828.

Collins, L. M., & Lanza, S. T. (2009). *Latent Class and Latent Transition Analysis: With Applications in the Social, Behavioral, and Health Sciences.* Hoboken, NJ: John Wiley & Sons, Inc.

Cooper, L. A., Roter, D. L., Johnson, R. L., Ford, D. E., Steinwachs, D. M., & Powe, N. R. (2003). Patient-centered communication, ratings of care, and concordance of patient and physician race. *Annals of Internal Medicine*, 907-915.

Cooper, Z., Stiegman, O., Ndumele, C. D., Staiger, B., & Skinner, J. (2022). Geographical Variation in Health Spending Across the US Among Privately Insured Individuals and Enrollees in Medicaid and Medicare. *JAMA Health Policy*, e2222138.

Cragg, J. G. (1971). Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. *Econometrica*, 829-844.

Croft, J. B., Lu, H., Zhang, X., & Holt, J. B. (2016). Geographic Accessibility of Pulmonologists for Adults with COPD: United States, 2013. *Chest*, 544-553.

Cullaro, G., Sarkar, M., & Lai, J. C. (2018). Sex-based disparities in delisting for being "too sick" for liver transplantation. *American Journal of Transplantation*, 1214-1219.

Dang, A., Thakker, R., Li, S., Hommel, E., Mehta, H. B., & Goodwin, J. S. (2022). Hospitalizations and Mortality From Non–SARS-CoV-2 Causes Among Medicare Beneficiaries at US Hospitals During the SARS-CoV-2 Pandemic. *JAMA Network Open*, e221754.

Daundasekara, S. S., Schuler, B. R., & Hernandez, D. C. (2022). A latent class analysis to identify socio-economic and health risk profiles among mothers of young children predicting longitudinal risk of food insecurity. *PLoS One*, e0272614.

Davis, L. E., Mahar, A. L., & Strumpf, E. C. (2023). Agreement between individual and neighborhood income measures in patients with colorectal cancer in Canada. *Journal of the National Cancer Institute*, 514-522.

Dean, E. B., French, M. T., & Mortensen, K. (2020). Food insecurity, health care utilization, and health care. *Health Services Research*, 883-893.

DeSalvo, K. B., Fan, V. S., McDonell, M. B., & Fihn, S. D. (2005). Predicting mortality and healthcare utilization with a single question. *Health Services Research*, 1234-1246.

Deutsch-Link, S., Jiang, Y., Peery, A. F., Barritt, A. S., Bataller, R., & Moon, A. M. (2022). Alcohol-Associated Liver Disease Mortality Increased From 2017 to 2020 and Accelerated During the COVID-19 Pandemic. *Clinical Gastroenterology and Hepatology*, 2142-2144.

Dharmarajan, K., Hsieh, A. F., Lin, Z., Bueno, H., Ross, J. S., Horwitz, L. I., . . . Krumholz, H. M. (2013). Diagnoses and Timing of 30-Day Readmissions After Hospitalization for Heart Failure, Acute Myocardial Infarction, or Pneumonia. *JAMA*, 355-363.

Diamant, A. L., Hays, R. D., Morales, L. S., Ford, W., Calmes, D., Asch, S., . . . Gelberg, L. (2004). Delays and unmet need for health care among adult primary care patients in a restructured urban public health system. *American Journal of Public Health*, 783-789.

Dieleman, J. L., Cao, J., Chapin, A., Chen, C., Li, Z., Liu, A., . . . Kaldjian, A. e. (2020). US Health Care Spending by Payer and Health Condition, 1996-2016. *JAMA*, 863-884.

Division of Health Interview Statistics, National Center for Health Statistics, Centers for Disease Control and Prevention, US Department of Health and Human Services. (2023, April 25). *Survey Description Document.* Retrieved from National Health Interview Survey, 1997-2018: https://www.cdc.gov/nchs/nhis/1997-2018.htm

Donabedian, A. (1973). *Aspects of Medical Care Administration: Specifying Requirements for Health Care.* Cambridge, Massachusetts: Harvard University Press.

Dorner, S. C., Jacobs, D. B., & Sommers, B. D. (2015). Adequacy of Outpatient Specialty Care Access in Marketplace Plans Under the Affordable Care Act. *JAMA*, 1749-1750.

Dreyer, K., Steventon, A., Fisher, R., & Deeny, S. R. (2018). The association between living alone and health care utilisation in older adults: a retrospective cohort study of electronic health records from a London general practice. *BMC Geriatrics*, 269.

Eder, M., Henninger, M., Durbin, S., Iacocca, M. O., Martin, A., Gottlieb, L. M., & Lin, J. S. (2021). Screening and Interventions for Social Risk Factors: Technical Brief to Support the US Preventive Services Task Force. *JAMA*, 1416-1428.

Estes, C., Razavi, H., Loomba, R., Younossi, Z., & Sanyal, A. J. (2018). Modeling the epidemic of nonalcoholic fatty liver disease demonstrates an exponential increase in burden of disease. *Hepatology*, 123-133.

Feng, C. X. (2021). A comparison of zero-inflated and hurdle models for modeling zero-inflated count data. *Journal of Statistical Distributions and Applications*, 1-19.

Ferro, E. G., Secemsky, E. A., Wadhera, R. K., Choi, E., Strom, J. B., Wasfy, J. H., . . . Yeh, R. W. (2019). Patient Readmission Rates For All Insurance Types After Implementation Of The Hospital Readmissions Reduction Program. *Health Affairds*, 585-593.

Figueroa, J. F., & Wadhera, R. (2022). A Decade of Observing the Hospital Readmission Reductions Program—Time to Retire an Ineffective Policy. *JAMA Network Open*, e2242593.

Figueroa, J. F., & Wadhera, R. K. (2022). A Decade of Observing the Hospital Readmission Reductions Program—Time to Retire an Ineffective Policy. *JAMA Network Open*, e2242593.

Fiscella, K., & Epstein, R. M. (2009). SO MUCH TO DO, SO LITTLE TIME: CARE FOR THE SOCIALLY DISADVANTAGED AND THE 15-MINUTE VISIT. *Archives of Internal Medicine*, 1843-1852.

Flemming, J. A., Dewit, Y., Mah, J. M., Saperia, J., Groome, P. A., & Booth, C. M. (2019). Incidence of cirrhosis in young birth cohorts in Canada from 1997 to 2016: a retrospective population-based study. *The Lancet Gastroenterology and Hepatology*, 217-226.

Freed, M., Biniek, J. F., Damico, A., & Neuman, T. (2022, November 10). *Kaiser Family Foundation.* Retrieved from Medicare Advantage 2023 Spotlight: First Look: https://www.kff.org/medicare/issue-brief/medicare-advantage-2023-spotlight-first-look/#:~:text=In%20total%2C%203%2C998%20Medicare%20Advantage,2%3B%20Appendix%20Table%201).

Frenk, J. (1992). The Concept and Measurement of Accessibility. In K. L. White, *Health Services Research: An Anthology* (pp. 842-855). Washington, DC: Pan American Health Organization.

Gaffney, A. W., Hawks, L., Bor, D., White, A. C., Woolhandler, S., McCormick, D., & Himmelstein, D. U. (2021). National Trends and Disparities in Health Care Access and Coverage Among Adults With Asthma and COPD: 1997-2018. *Chest*, 2173-2182.

Gaffney, A., White, A., Hawks, L., Himmelstein, D., Woolhandler, S., Christiani, D. C., & McCormick, D. (2020). High-Deductible Health Plans and Healthcare Access, Use, and Financial Strain in Those with Chronic Obstructive Pulmonary Disease. *Annals of the American Thoracic Society*, 49-56.

Gao, X., Ly, F., He, X., Zhao, Y., Liu, Y., Zu, J., . . . Nguyen, M. H. (2023). Impact of the COVID-19 pandemic on liver disease-related mortality rates in the United States. *Journal of Hepatology*, 16-27.

Garg, S. K., Hemant, G., Obaitan, I., Shah, P. A., Sarvepalli, Shashank, . . . Leise, M. D. (2021). Incidence and predictors of 30-day hospital readmissions for liver cirrhosis: insights from the United States National Readmissions Database. *Annals of Translational Medicine*, 1052.

Glenn, B., Crespi, C., Rodriguez, H., Nonzee, N., Phillips, S., Sheinfeld Gorin, S., . . . Rohweder, C. e. (2018). Behavioral and Mental Health Risk Factor Profiles among Diverse Primary Care Patients. *Preventive Medicine*, 21-27.

Goldberg, D. S., French, B., Forde, K. A., Groeneveld, P. W., Bittermann, T., Backus, L., . . . Kaplan, D. E. (2014). Association of Distance From a Transplant Center With Access to Waitlist Placement, Receipt of Liver Transplantation, and Survival Among US Veterans. *JAMA*, 1234-1243.

Goldberg, D., Ross-Driscoll, K., & Lynch, R. (2021). County Differences in Liver Mortality in the United States: Impact of Sociodemographics, Disease Risk Factors, and Access to Care. *Gastroenterology*, 1140-1150.

Goodman, L. A. (2002). Latent Class Analysis: The Empirical Study of Latent Types, Latent Variables, and Latent Structures. In J. A. Hagenaars, & A. L. McCutcheon, *Applied Latent Class Analysis* (pp. 3-55). Cambridge, UK: Cambridge University Press.

Grimm, C. A. (2022, April). *U.S. Department of Health and Human Services.* Retrieved from Some Medicare Advantage Organization Denials of Prior Authorization Requests Raise Concerns about Beneficiary Access to Medically Necessary Care: https://oig.hhs.gov/oei/reports/OEI-09-18-00260.pdf

Gupta, A., Allen, L. A., Bhatt, D. L., Cox, M., DeVore, A. D., Heidenreich, P. A., . . . Fonorow, G. C. (2018). Association of the Hospital Readmissions Reduction Program Implementation With Readmission and Mortality Outcomes in Heart Failure. *JAMA Cardiology*, 44-53.

Herringa, S. G., West, B. T., & Berglund, P. A. (2017). Preparation for Complex Sample Survey Data Analysis. In *Applied Survey Data Analysis: Second Edition* (pp. 97-123). Boca Raton, FL: CRC Press.

Himmelstein, D. U., Dickman, S. L., McCormick, D., Bor, D. H., Gaffney, A., & Woolhandler, S. (2022). Prevalence and Risk Factors for Medical Debt and Subsequent Changes in Social Determinants of Health in the US. *JAMA Network Open*, e2231898.

Hirode, G., Saab, S., & Wong, R. J. (2020). Trends in the Burden of Chronic Liver Disease Among Hospitalized US Adults. *JAMA Network Open*, e201997.

Hostetter, M., & Klein, S. (2020, January 9). *CHRONIC Care Act Prompts Some Medicare Advantage Plans to Incorporate Social Services*. Retrieved from The Commonwealth Fund: https://www.commonwealthfund.org/publications/2020/jan/chronic-care-act-prompts-some-medicare-advantage-plans-incorporate-social

Howard, G., Schwamm, L. H., Donnelly, J. P., Howard, V. J., Jasne, A., Smith, E. E., . . . Albright, K. C. (2018). Participation in Get With The Guidelines–Stroke and Its Association With Quality of Care for Stroke. *JAMA Neurology*, 1331-1337.

Hsiang, W. R., Lukasiewicz, A., Gentry, M., Kim, C.-Y., Leslie, M. P., Pelker, R., . . . Wiznia, D. H. (2019). Medicaid Patients Have Greater Difficulty Scheduling Health Care Appointments Compared With Private Insurance Patients: A Meta-Analysis. *Inquiry*, 1-9.

Hsiang, W. R., Lukasiewicz, A., Gentry, M., Kim, C.-Y., Leslie, M. P., Pelker, R., . . . Wiznia, D. H. (2019). Medicaid Patients Have Greater Difficulty Scheduling Health Care Appointments Compared With Private Insurance Patients: A Meta-Analysis. *Inquiry: The Journal of Health Care Organization, Provision, and Financing*, 56.

Hsuan, C., Carr, B. G., Hsia, R. Y., & Hoffman, G. J. (2020). Assessment of Hospital Readmissions From the Emergency Department After Implementation of Medicare's Hospital Readmissions Reduction Program. *JAMA Network Open*, e203857.

Hu, C., Anjur, V., Saboo, K., Reddy, K. R., O'Leary, J., Tandon, P., . . . Fallon, M. B. (2021). Low Predictability of Readmissions and Death Using Machine Learning in Cirrhosis. *The American Journal of Gastroenterology*, 336-346.

Huang, D. Q., Mathurin, P., Cortez-Pinto, H., & Loomba, R. (2023). Global epidemiology of alcohol-associated cirrhosis and HCC: trends, projections and risk factors. *Nature Reviews Gastroenterology & Hepatology*, 37-49.

Ibrahim, A. M., Dimick, J. B., Sinha, S. S., Hollingsworth, J. M., Nuliyalu, U., & Ryan, A. M. (2018). Association of Coded Severity With Readmission Reduction After the Hospital Readmissions Reduction Program. *JAMA Internal Medicine*, 290-292.

ION-1 Investigators. (2014). Ledipasvir and sofosbuvir for untreated HCV genotype 1 infection. *New England Journal of Medicine*, 1889-1898.

Jemal, A., & Fedewa, S. A. (2017). Recent Hepatitis C Virus Testing Patterns Among Baby Boomers. *American Journal of Preventive Medicine*, e31-e33.

Jencks, S. F., Williams, M. V., & Coleman, E. A. (2009). Rehospitalizations among Patients in the Medicare Fee-for-Service Program. *NEJM*, 1418-1428.

Jiang, C., Yabroff, R., Deng, L., Wang, Q., Perimbeti, S., Shapiro, . . . Han, X. (2022). Self-reported Transportation Barriers to Health Care Among US Cancer Survivors. *JAMA Oncology*, 775-778.

Johansen, K. L., Chertow, G. M., Gilbertson, D. T., Herzog, C. A., Ishani, A., Israni, A. K., . . . Saeed, F. e. (2022, April 30). US Renal Data System 2021 Annual Data Report: Epidemiology of Kidney Disease in the United States. *American Journal of Kidney Diseases*, A8-A12.

Jones, S. M., Chennupati, S., Nguyen, T., Fedorenko, C., & Ramsey, S. D. (2019). Comorbidity is associated with higher risk of financial burden in Medicare beneficiaries with cancer but not heart disease or diabetes. *Medicine*, e14004.

Joshi, S., Nuckols, T., Escarce, J., Huckfeldt, P., Popescu, I., & Sood, N. (2019). Regression to the Mean in the Medicare Hospital Readmissions Reduction Program. *JAMA Internal Medicine*, 1167-1173.

Julien, J., Ayer, T., Tapper, E. B., Barbosa, C., Dowd, W. N., & Chhatwal, J. (2022). Effect of increased alcohol consumption during COVID-19 pandemic on alcohol-associated liver disease: A modeling study. *Hepatology*, 1480-1490.

Kanwal, F., Asch, S. M., Kramer, J. R., Cao, Y., Asrani, S., & El-Serag, H. (2016). Early outpatient follow-up and 30-day outcomes in patients hospitalized with cirrhosis. *Hepatology*, 569-581.

Kanwal, F., Hernaez, R., Liu, Y., Taylor, T. J., Rana, A., Kramer, J. R., . . . Asch, S. M. (2021). Factors Associated With Access to and Receipt of Liver Transplantation in Veterans With End-stage Liver Disease. *JAMA Internal Medicine*, 949-959.

Kardashian, A., Dodge, J. L., & Terrault, N. A. (2022). Food Insecurity is Associated With Mortality Among U.S. Adults With Nonalcoholic Fatty Liver Disease and Advanced Fibrosis. *Clinical Gastroenterology and Hepatology*, 2790-2799.

Kardashian, A., Dodge, J. L., & Terrault, N. A. (2022). Racial and ethnic differences in diet quality and food insecurity among adults with fatty liver and significant fibrosis: a U.S. population-based study. *Alimentary Pharmacology & Therapeutics*, 1383-1393.

Kasting, M. L., Giuliano, A. R., Reich, R. R., Roetzheim, R. G., Nelson, D. R., Shenkman, E., & Vadaparampil, S. T. (2018). Hepatitis C Virus Screening Trends: Serial Cross-Sectional Analysis of the National Health Interview Survey Population, 2013-2015. *Cancer Epidemiology, Biomarkers & Prevention*, 503-513.

Khan, M. S., Sreenivasan, J., Lateef, N., Abougergi, M. S., Greene, S. J., Ahmad, T., . . . Butler, J. (2021). Trends in 30- and 90-Day Readmission Rates for Heart Failure. *Circulation: Heart Failure*, e008335.

Kim, D., Bonham, C. A., Konyn, P., Cholankeril, G., & Ahmed, A. (2021). Mortality Trends in Chronic Liver Disease and Cirrhosis in the United States, Before and During COVID-19 Pandemic. *Clinical Gastroenterology and Hepatology*, 2664-2666.

Kim, D., Kim, W. R., Kim, H. J., & Therneau, T. M. (2013). Association between noninvasive fibrosis markers and mortality among adults with nonalcoholic fatty liver disease in the United States. *Hepatology*, 1357-1365.

Kotagal, M., Carle, A. C., Kessler, L. G., & Flum, D. R. (2014). Limited Impact on Health and Access to Care for 19- to 25-Year-Olds Following the Patient Protection and Affordable Care Act. *JAMA Pediatrics*, 1023-1029.

Kullgren, J. T., McLaughlin, C. G., Mitra, N., & Armstrong, K. (2012). Nonfinancial Barriers and Access to Care for U.S. Adults. *Health Services Research*, 462-485.

Kushner, T., & Reau, N. (2021). Changing epidemiology, implications, and recommendations for hepatitis C in women of childbearing age and during pregnancy. *Journal of Hepatology*, 734-741.

Lago-Hernandez, C., Nguyen, N. H., Khera, R., Loomba, R., Asrani, S. K., & Singh, S. (2021). Financial Hardship From Medical Bills Among Adults With Chronic Liver Diseases: National Estimates from the United States. *Hepatology*, 1509-1522.

Le, M. H., Devaki, P., Ha, N. B., Jun, D. W., Te, H. S., Cheung, R. C., & Nguyen, M. H. (2017). Prevalence of non-alcoholic fatty liver disease and risk factors for advanced fibrosis and mortality in the United States. *PLoS One*, e0173499.

Le, P., Chaitoff, A., Rothberg, M. B., McCullough, A., Gupta, N. M., & Alkhouri, N. (2019). Population-Based Trends in Prevalence of Nonalcoholic Fatty Liver Disease in US Adults With Type 2 Diabetes. *Clinical Gastroenterology and Hepatology*, 2377-2378.

Lee, B. P., Dodge, J. L., & Terrault, N. A. (2022). Geographic Density of Gastroenterologists Is Associated With Decreased Mortality From Alcohol-Associated Liver Disease. *Clinical Gastroenterology and Hepatology*, 1-16.

Lewis, C., Shah, T., & Abrams, M. K. (2018, January 12). *Sick and Alone: High-Need, Socially Isolated Adults Have More Problems, but Less Support*. Retrieved from The Commonwealth Fund: https://doi.org/10.26099/xrjq-2871

Li, L., Zhan, S., Hu, L., Wilson, K. M., Mazumdar, M., & Liu, B. (2021). Examining the role of healthcare access in racial/ethnic disparities in receipt of provider-patient discussions about smoking: A latent class analysis. *Preventive Medicine*, 106584.

Liao, D., & Valliant, R. (2012). Variance inflation factors in the analysis of complex survey data . *Survey Methodology*, 53-62.

Long, J., & Freese, J. (2001). Models for Count Outcomes. In *Regression Models for Categorical Dependent Variables Using Stata* (pp. 223-260). College Station, Texas: Stata Press.

Loomba, R., Wong, R., Fraysse, J., Shreay, S., Li, S., Harrison, S., & Gordon, S. C. (2020). Nonalcoholic fatty liver disease progression rates to cirrhosis and progression of cirrhosis to decompensation and mortality: a real world analysis of Medicare data. *Alimentary Pharmacology & Therapeutics*, 1149-1159.

Lorig, K. R., Sobel, D. S., Stewart, A. L., Brown, B. W., Bandura, A., Ritter, P., . . . Holman, H. R. (1999). Evidence Suggesting That a Chronic Disease Self-Management Program Can Improve Health Status While Reducing Hospitalization: A Randomized Trial. *Medical Care*, 5-14.

Lovasik, B. P., Zhang, R., Hockenberry, J. M., Schrager, J. D., Pastan, S. O., Mohan, S., & Patzer, R. (2016). Emergency Department Use and Hospital Admissions Among Patients With End-Stage Renal Disease in the United States. *JAMA Internal Medicine*, 1563-1565.

Lu, P.-J., Hung, M.-C., Srivastav, A., Grohskopf, L. A., Kobayashi, M., Harris, A. H., . . . Williams, W. W. (2021). Surveillance of Vaccination Coverage Among Adult Populations -United States, 2018. *MMWF Surveillance Summaries*, 1-26.

Lumley, T., Diehr, P., Emerson, S., & Chen, L. (2022). The importance of the normality assumption in large public health data sets. *Annual Review of Public Health*, 151-169.

Mahajan, S., Caraballo, C., Lu, Y., Valero-Elizondo, J., Massey, D., Annapureddy, A. R., . . . Krumholz, H. M. (2021). Trends in Differences in Health Status and Health Care Access and Affordability by Race and Ethnicity in the United States, 1999-2018. *JAMA*, 637-648.

Marrufo, G., Colligan, E. M., Negrusa, B., Ullman, D., Messana, J., Shah, A., . . . Hirth, R. A. (2020). Association of the Comprehensive End-Stage Renal Disease Care Model With Medicare Payments and Quality of Care for Beneficiaries With End-Stage Renal Disease. *JAMA Internal Medicine*, 852-860.

Martin, P., DiMartini, A., Feng, S., & Brown, R. J. (2014). Evaluation for liver transplantation in adults: 2013 practice guideline by the American Association for the Study of Liver Diseases and the American Society of Transplantation. *Hepatology*, 1144-1165.

Masyn, K. E. (2013). Latent class analysis and finite mixture modeling. In T. D. Little, *The Oxford handbook of quantitative methods: Statistical analysis, Vol. 2* (pp. 551-611). Oxford, UK: Oxford University Press.

McCarthy, M. L., Zheng, Z., Wilder, M. E., Elmi, A., Kulie, P., Johnson, S., & Zeger, S. L. (2021). Latent Class Analysis To Represent Social Determinant Of Health Risk Groups in the Medicaid Cohort of the District of Columbia. *Medical Care*, 251-258.

Meernik, C., Dorfman, C. S., Zullig, L. L., Lazard, A. J., Fish, L., Farnan, L., . . . Akinyemiju, T. (2023). Health Care Access Barriers and Self-Reported Health Among Adolescent and Young Adult Cancer Survivors. *Journal of Adolescent and Young Adult Oncology*, Epub ahead of print.

Mellinger, J. L., & Volk, M. L. (2013). Multidisciplinary Management of Patients With Cirrhosis: A Need for Care Coordination. *Clinical Gastroenterology & Hepatology*, 217-223.

Mellinger, J. L., Fernandez, A., Shedden, K., Winder, G. S., Fontana, R. J., Volk, M. L., . . . Lok, A. S. (2019). Gender Disparities in Alcohol Use Disorder Treatment Among Privately Insured Patients with Alcohol-Associated Cirrhosis. *Alcoholism: Clinical and Experimental Research*, 334-341.

Mellinger, J. L., Moser, S., Welsh, D. E., Yosef, M. T., Van, T., McCurdy, H., . . . Su, G. L. (2016). Access to Subspecialty Care And Survival Among Patients With Liver Disease. *American Journal of Gastroenterology*, 838-844.

Meyers, D. J., Gadbois, E. A., Brazier, J., Tucher, E., & Thomas, K. S. (2020). Medicare Plans' Adoption of Special Supplemental Benefits for the Chronically Ill for Enrollees With Social Needs. *JAMA Network Open*, e204690.

Meyers, D. J., Mor, V., & Rahman, M. (2018). Medicare Advantage Enrollees More Likely To Enter Lower-Quality Nursing Homes Compared To Fee-For-Service Enrollees. *Health Affairs*, 78-85.

Meyers, D. J., Rahman, M., & Trivedi, A. N. (2022). Narrow Primary Care Networks in Medicare Advantage. *Journal of General Internal Medicine*, 488-491.

Meyers, D. J., Rahman, M., Mor, V., Wilson, I. B., & Trivedi, A. N. (2021). Association of Medicare Advantage Star Ratings with Racial, Ethnic, and Socioeconomic Disparities in Quality of Care. *JAMA Health Forum*, e210793.

Meyers, D. J., Ryan, A. M., & Trivedi, A. N. (2022). How Much of an "Advantage" Is Medicare Advantage? *JAMA*, 2112-2113.

Miller, S., & Wherry, L. R. (2017). Health and Access to Care during the First 2 Years of the ACA Medicaid Expansions. *NEJM*, 947-956.

Miller-Archie, S. A., Walters, S. C., Bocour, A., Moore, M. S., Wiewel, E., Singh, T., & Lim, S. (2022). The Impact of Supportive Housing on Liver-Related Outcomes Among Persons With Hepatitis C Virus Infection . *Journal of Infectious Diseases*, S363-S371.

Minakata, Y., Ueda, H., Akamatsu, K., Kanda, M., Yanagisawa, S., Ichikawa, T., . . . Ichinose, M. (2010). High COPD prevalence in patients with liver disease. *Internal Medicine*, 2687-2691.

Morgan, T. R., Mandayam, S., & Jamal, M. M. (2004). Alcohol and hepatocellular carcinoma. *Gastroenterology*, S87-96.

Moylan, C. A., Brady, C. W., Johnson, J. L., Smith, A. D., Tuttle-Newhall, J. E., & Muir, A. J. (2008). Disparities in liver transplantation before and after introduction of the MELD score. *JAMA*, 2371-2378.

Mullin, B., Cervantes, B. S., & Billimek, J. (2019). Material Need Insecurity and Its Concurrent Barriers to Diabetes Management Among Low-Income Latino Adults Receiving Medical Care. *Diabetes Care*, e31-e33.

Muthen, B., Muthen, L., & Asparouhov, T. (2015, March 24). *Estimator choices with categorical outcomes.* Retrieved from https://www.statmodel.com/download/EstimatorChoices.pdf

Nagin, D. S. (2005). *Group-Based Modeling of Development.* Cambridge, MA: Harvard Universtiy Press.

Natarajan, Y., Kramer, J. R., Yu, X., Li, L., Thrift, A. P., El-Serag, H., & Kanwal, F. (2020). Risk of Cirrhosis and Hepatocellular Cancer in Patients With NAFLD and Normal Liver Enzymes. *Hepatology*, 1242-1252.

National Center for Health Statistics. (2023, April 30). *Centers for Disease Control and Prevention*. Retrieved from National Health Interview Survey: https://www.cdc.gov/nchs/nhis/index.htm

National Center for Health Statistics. (2023, January 17). *Chronic Liver Disease and Cirrhosis*. Retrieved from FastStats Homepage: https://www.cdc.gov/nchs/fastats/liver-disease.htm

National Center for Health Statistics. (2023, April 30). *Leading Causes of Death*. Retrieved from National Center for Health Statistics: https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm

Naylor, M. D., Brooten, D. A., Campbell, R. L., Maislin, G., McCauley, K. M., & Schwartz, J. S. (2004). Transitional Care of Older Adults Hospitalized with Heart Failure: A Randomized, Controlled Trial. *Journal of the American Geriatrics Society*, 675-684.

Naylor, M. D., Brooten, D., Campbell, R., Jacobsen, B. S., Mezey, M. D., Pauly, M. V., & Schwartz, J. S. (1999). Comprehensive Discharge Planning and Home Follow-up of Hospitalized Elders: A Randomized Clinical Trial. *JAMA*, 613-620.

Ndumele, C. D., Cohen, M. S., & Cleary, P. D. (2017). Association of State Access Standards With Accessibility to Specialists for Medicaid Managed Care Enrollees. *JAMA Internal Medicine*, 1445-1451.

Nguyen, M. H., Ozbay, A. B., Liou, I., Meyer, N., Gordon, S. C., Dusheiko, G., & Lim, J. K. (2019). Healthcare resource utilization and costs by disease severity in an insured national sample of US patients with chronic hepatitis B. *Journal of Hepatology*, 24-32.

Noureddin, M., Ntanios, F., Malhotra, D., Hoover, K., Emir, B., McLeod, E., & Alkhouri, N. (2022). Predicting NAFLD prevalence in the United States using National Health and Nutrition Examination Survey 2017–2018 transient elastography data and application of machine learning. *Hepatology Communications*, 1537-1548.

Nylund, K. L., Asparouhov, T., & Muthen, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling*, 535-569.

Oberski, D. (2016). Mixture Models: Latent Profile and Latent Class Analysis. In J. Robertson, & M. Kaptein, *Modern Statistical Methods for Human-Computer Interaction Series* (pp. 275-287). Switzerland: Springer.

Ochieng, N., Biniek, J. F., Freed, M., Damico, A., & Neuman, T. (2023, August 9). Retrieved from Medicare Advantage in 2023: Enrollment Update and Key Trends: https://www.kff.org/medicare/issue-brief/medicare-advantage-in-2023-enrollment-update-and-key-trends/

Orman, E. S., Ghabril, M. S., Desai, A. P., Nephew, L., Patidar, K. R., Gao, S., . . . Chalsani, N. (2022). Patient-Reported Outcome Measures Modestly Enhance Prediction of Readmission in Patients with Cirrhosis. *Clinical Gastroenterology & Hepatology*, e1426-e1437.

Orman, E. S., Ghabril, M., Emmett, T. W., & Chalasani, N. (2018). Hospital Readmissions in Patients with Cirrhosis: A Systematic Review. *Journal of Hospital Medicine*, 490-495.

Osborn, R., Moulds, D., Schneider, E. C., Doty, M. M., Squires, D., & Sarnak, D. O. (2015). Primary Care Physicians in Ten Countries Report Challenges Caring for Patinets With Complex Health Needs. *Health Affairs*, 2104-2112.

Paik, J. M., Golabi, P., Biswas, R., Alqahtani, S., Venkatesan, C., & Younossi, Z. M. (2020). Nonalcoholic Fatty Liver Disease and Alcoholic Liver Disease are Major Drivers of Liver Mortality in the United States. *Hepatology Communications*, 890-903.

Patel, A. A., Bui, A., Prohl, E., Bhattacharya, D., Su, W., Branch, A. D., & Perumalswami, P. V. (2020). Innovations in Hepatitis C Screening and Treatment. *Hepatology Communications*, 371-386.

Peeraphatdit, T. (., Ahn, J. C., Choi, D. H., Allen, A. M., Simonetto, D. A., Kamath, P. S., & Shah, V. H. (2020). A Cohort Study Examining the Interaction of Alcohol Consumption and Obesity in Hepatic Steatosis and Mortality. *Mayo Clinc Proceedings*, 2612-2620.

Peikes, D., Chen, A., Schore, J., & Brown, R. (2009). Effects of Care Coordination on Hospitalization, Quality of Care, and Health Care Expenditures Among Medicare Beneficiaries: 15 Randomized Trials. *JAMA*, 603-618.

Pihoker, C., Braffett, B., Songer, T., Herman, W., Tung, M., Kuo, S., . . . Zeitler, P. (2023). Diabetes Care Barriers, Use, and Health Outcomes in Younger Adults With Type 1 and Type 2 Diabetes. *JAMA Network Open*, e2312147.

Pourat, N., Chuang, E., O'Masta, B., Haley, L. A., Chen, X., Zhou, W., & Haile, M. (2022, December). *Final Evaluation of California's Whole Person Care Program.* Retrieved from UCLA Center for Health Policy Research: https://healthpolicy.ucla.edu/sites/default/files/2023-04/final-evaluation-of-ca-whole-person-care-report.pdf

Pourat, N., Davis, A. C., Chen, X., Vrungos, S., & Kominski, G. F. (2015). In California, Primary Care Continuity Was Associated With Reduced Emergency Department Use And Fewer Hospitalizations. *Health Affairs*, 1113-1120.

Press, V. G., Myers, L. C., & Feemster, L. C. (2021). Preventing COPD Readmissions Under the Hospital Readmissions Reduction Program. *Chest*, 996-1006.

Ranji, U., Salganicoff, A., & Rousseau, D. (2019). Barriers to Care Experienced by Women in the United States. *JAMA*, 2154.

Restrepo, B. J. (2022). Obesity Prevalence Among U.S. Adults During the COVID-19 Pandemic. *American Journal of Preventive Medicine*, 102-106.

Rich, M. W., Beckham, V., Wittenberg, C., Leven, C. L., Freedland, K. E., & Carney, R. M. (1995). A Multidisciplinary Intervention to Prevent the Readmission of Elderly Patients with Congestive Heart Failure. *New England Journal of Medicine*, 1190-1195.

Rinella, M., & Charlton, M. (2016). The globalization of nonalcoholic fatty liver disease: Prevalence and impact on world health. *Hepatology*, 19-22.

Robinson, W. (1950). Ecological Correlations and the Behavior of Individuals. *American Sociological Review*, 351-357.

Rojas, J. C., Chokkara, S., Zhu, M., Lindenauer, P. K., & Press, V. G. (2022). Care Quality for Patients with Chronic Obstructive Pulmonary Disease in the Readmission Penalty Era. *American Journal of Respiratory and Critical Care Medicine*, 29-37.

Rojas-Garcia, A., Turner, S., Pizzo, E., Hudson, E., Thomas, J., & Raine, R. (2017). Impact and experiences of delayed discharge: A mixed-studies systematic review. *Health Expectations*, 41-56.

Rust, G., Ye, J., Baltrus, P., Daniels, E., Adesunloye, B., & Fryer, G. E. (2008). Practical Barriers to Timely Primary Care Access: Impact on Adult Use of Emergency Department Services. *Archives of Internal Medicine*, 1705-1710.

Ryan, J. L., Franklin, S. M., Canterberry, M., Long, C. L., Bowe, A., Roy, B. D., . . . Gottlieb, L. M. (2023). Association of Health-Related Social Needs With Quality and Utilization Outcomes in a Medicare Advantage Population With Diabetes. *JAMA Network Open*, e239316.

Sabbatini, A. K., Joynt-Maddox, K. E., Liao, J. M., Basu, A., Parrish, C., Kreuter, W., & Wright, B. (2022). Accounting for the Growth of Observation Stays in the Assessment of Medicare's Hospital Readmissions Reduction Program. *JAMA Network Open*, e2242587.

Sandhu, S., Liu, M., & Wadhera, R. K. (2022). Hospitals and Health Equity — Translating Measurement. *New England Journal of Medicine*, 2395-2397.

Sandhu, S., Liu, M., & Wadhera, R. K. (2022). Hospitals and Health Equity — Translating Measurement into Action. *NEJM*, 2395-2397.

Sanyal, A. J., Banas, C., Sargeant, C., Luketic, V. A., Sterling, R. K., Stravitz, R. T., . . . Mills, A. S. (2006). Similarities and differences in outcomes of cirrhosis due to nonalcoholic steatohepatitis and hepatitis C. *Hepatology*, 682-689.

Sanyal, A. J., Van Natta, M. L., Clark, J., Neuschwander-Tetri, B. A., Diehl, A., Dasarathy, S., . . . Yales, K. P. (2021). Prospective Study of Outcomes in Adults with Nonalcoholic Fatty Liver Disease. *New England Journal of Medicine*, 1559-1569.

Scaglione, S. J., Metcalfe, L., Kliethermes, S., Vasilyev, I., Tsang, R., Caines, A., . . . Cotler, S. J. (2017). Early Hospital Readmissions and Mortality in Patients With Decompensated Cirrhosis Enrolled in a Large National Health Insurance Administrative Database. *Journal of Clinical Gastroenterology*, 839-844.

Schillie, S., Wester, C., Osborne, M., Wesolowski, L., & Ryerson, A. B. (2020). CDC Recommendations for Hepatitis C Screening Among Adults - United States, 2020. *MMWF Recommendations and Reports*, 1-17.

Schuppan, D., & Afdhal, N. H. (2008). Liver Cirrhosis. *Lancet*, 838-851.

Shaheen, A.-A., Nguyen, H. H., Congly, S. E., Kapan, G. G., & Swain, M. G. (2019). Nationwide estimates and risk factors of hospital readmission in patients with cirrhosis in the United States. *Liver International*, 878-884.

Shahid, R., Shoker, M., Chu, L. M., Frehlick, R., Ward, H., & Pahwa, P. (2022). Impact of low health literacy on patients' health outcomes: a multicenter cohort study. *BMC Health Services Research*, 1148.

Sharma, R. A., Subedi, K., Gbadebo, B. M., Wilson, B., Jurkovitz, C., & Horton, T. (2021). Alcohol Withdrawal Rates in Hospitalized Patients During the COVID-19 Pandemic. *JAMA Network Open*, e210422.

Siddique, S. M., Tipton, K., Leas, B., Greysen, R. S., Mull, N. K., Lane-Fall, M., . . . Tsou, A. Y. (2021). Interventions to Reduce Hospital Length of Stay in High-risk Populations: A Systematic Review. *JAMA Network Open*, e2125846.

Singal, A. G., Rahimi, R. S., Clark, C., Ma, Y., Cuthbert, J. A., Rockey, D. C., & Amarasingham, R. (2013). An Automated Model Using Electronic Medical Record Data Identifies Patients With Cirrhosis at High Risk for Readmission. *Clinical Gastroenterology & Hepatology*, 1335-1341.

Sinha, P., Calfee, C. S., & Delucchi, K. L. (2021). Practitioner's Guide to Latent Class Analysis: Methodological Considerations and Common Pitfalls. *Critical Care Medicine*, e63-e79.

Slusher, A. L., Hu, P., Samuels, S., Tokoglu, F., Lat, J., Li, Z., . . . Caprio, S. (2023). Rising NAFLD and metabolic severity during the Sars-CoV-2 pandemic among children with obesity in the United States. *Obesity*, 1171-1454.

Smith, B. D., Morgan, R. L., Beckett, G. A., Falck-Ytter, Y., Holtzman, D., Teo, C.-G., . . . Ward, J. W. (2012). Recommendations for the identification of chronic hepatitis C virus infection among persons born during 1945-1965. *MMWF Recommendations and Reports*, 1-32.

Stepanova, M., De Avila, L., Afendy, M., Younossi, I., Pham, H., Cable, R., & Younossi, Z. M. (2017). Direct and Indirect Economic Burden of Chronic Liver Disease in the United States. *Clinical Gastroenterology & Hepatology*, 759-766.

Stoltzfus, J. C. (2011). Logistic Regression: A Brief Primer. *Academic Emergency Medicine*, 1099-1104.

Strengthening the Reporting of Observational Studies in Epidemiology. (2023, 30 April). *STROBE*. Retrieved from STROBE Checklist: https://www.strobe-statement.org/

Syed, S. T., S, G. B., & Sharp, L. K. (2013). Traveling Towards Disease: Transportation Barriers to Health Care Access. *Journal of Community Health*, 976-993.

Tabriz, A. A., Turner, K., Hong, Y.-R., Gheytasvand, S., Powers, B. D., & Lafata, J. E. (2023). Trends and Characteristics of Potentially Preventable Emergency Department Visits Among Patients With Cancer in the US. *JAMA Network Open*, e2250423.

Takahashi, P. Y., Ryu, E., Jenkens, G. D., Yost, K. J., Kirt, C. R., Larson, N. L., . . . Olson, J. E. (2022). Employment Characteristics and Risk of Hospitalization Among Older Adults Participating in the Mayo Clinic Biobank. *Mayo Clinic Proceedings: Innovations, Quality & Outcomes*, 552-563.

Tapper, E. B., & Parikh, N. D. (2018). Mortality due to cirrhosis and liver cancer in the United States, 1999-2016: observational study. *BMJ*, k2817.

Tapper, E. B., Finkelstein, D., Mittleman, M. A., Piatkowski, G., & Lai, M. (2015). Standard assessments of frailty are validated predictors of mortality in hospitalized patients with cirrhosis. *Hepatology*, 584-590.

Tapper, E. B., Finkelstein, D., Mittleman, M. A., Piatkowski, G., Chang, M., & Lai, M. (2016). A Quality Improvement Initiative Reduces 30-Day Rate of Readmission for Patients With Cirrhosis. *Clinical Gastroenterology and Hepatology*, 753-759.

Tapper, E. B., Halbert, B., & Mellinger, J. (2016). Rates of and Reasons for Hospital Readmissions in Patients With Cirrhosis: A Multistate Population-based Cohort Study. *Clinical Gastroenterology and Hepatology*, 1181-1188.

Tapper, E. B., Halbert, B., & Mellinger, J. (2016). Rates of and Reasons for Hospital Readmissions in Patients With Cirrhosis: A Multistate Population-based Cohort Study. *Clinical Gastroenterology and Hepatology*, 1181-1188.

Tapper, E. B., Hao, S., Lin, M., Mafi, J. N., McCurdy, H., Parikh, N. D., & Lok, A. S. (2021). The Quality and Outcomes of Care Provided to Patients with Cirrhosis by Advanced Practice Providers. *Hepatology*, 225-234.

The Commonwealth Fund. (2019, July 1). *Review of Evidence for Health-Related Social Needs Interventions*. Retrieved from The Commonwealth Fund: https://www.commonwealthfund.org/sites/default/files/2019-07/COMBINED-ROI-EVIDENCE-REVIEW-7-1-19.pdf

Timbie, J. W., Kranz, A. M., Mahmud, A., & Damberg, C. L. (2020). Specialty Care Access for Medicaid Enrollees in Expansion. *American Journal of Managed Care*, e83-e87.

Tran, P. B., Kazibwe, J., Nikolaidis, G. F., Linnosmaa, I., Rijken, M., & van Olmen, J. (2022). Costs of multimorbidity: a systematic review and meta-analyses. *BMC Medicine*, 1-15.

U.S. Department of Health and Human Services. (2022, March 17). *About the Affordable Care Act*. Retrieved from Young Adult Coverage: https://www.hhs.gov/healthcare/about-the-aca/young-adult-coverage/index.html

U.S. Department of Health and Human Services Office of Inspector General. (2018, September 25). Retrieved from Medicare Advantage Appeal Outcomes and Audit Findings Raise Concerns About Service and Payment Denials: https://oig.hhs.gov/oei/reports/oei-09-16-00410.asp

Ufere, N., Satapathy, N., Philpotts, L., Lai, J. C., & Serper, M. (2022). Financial burden in adults with chronic liver disease: A scoping review. *Liver Transplantation*, 1920-1935.

United States Census Bureau. (2023, April 30). *Geographic Levels*. Retrieved from Census Regions and Divisions of the United States: https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf

United States Department of Health and Human Services. (2023, May 1). *Agency for Healthcare Resource and Quality*. Retrieved from America's Health Literacy: Why We Need Accessible Health Information: https://www.ahrq.gov/sites/default/files/wysiwyg/health-literacy/dhhs-2008-issue-brief.pdf

United States Renal Data System. (2023, April 30). *End Stage Renal Disease: Hospitalization*. Retrieved from 2022 Annual Data Report: https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/5-hospitalization

Unuigbe, A., Cintina, I., & Koenig, L. (2022). Beneficiary Switching Between Traditional Medicare and Medicare Advantage Between 2016 and 2020. *JAMA Health Forum*, e224896.

US Department of Health and Human Services. (2023, May 1). *United States Renal Data System*. Retrieved from CKD in the General Population: https://usrds-adr.niddk.nih.gov/2022/chronic-kidney-disease/1-ckd-in-the-general-population

US Department of Veteran Affairs. (2023, September 7). *Veterans Health Administration*. Retrieved from https://www.va.gov/health/aboutvha.asp#:~:text=The%20Veterans%20Health%20Administration%20(VHA,Veterans%20enrolled%20in%20the%20VA

US Preventive Services Task Force. (2013). Screening for hepatitis C virus infection in adults: U.S. Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*, 349-357.

US Preventive Services Task Force. (2020). Screening for Hepatitis C Virus Infection in Adolescents and Adults: US Preventive Services Task Force Recommendation Statement. *JAMA*, 970-975.

van Dis, J. (2002). Where We Live: Health Care in Rural vs Urban America. *JAMA*, 108.

Vashi, A. A., Fox, J. P., Carr, B. G., D'Onofrio, G., Pines, J. M., Ross, J. S., & Gross, C. P. (2013). Use of Hospital-Based Acute Care Among Patients Recently Discharged From the Hospital. *JAMA*, 364-371.

Volk, M. L., Tocco, R. S., Bazick, J., Rakoski, M. O., & Lok, A. S. (2012). Hospital readmissions among patients with decompensated cirrhosis. *American Journal of Gastroenterology*, 247-252.

Wadhera, R. K., Yeh, R. W., & Joynt Maddox, K. E. (2019). The Hospital Readmissions Reduction Program — Time for a Reboot. *NEJM*, 2289-2291.

Wadhera, R. W., Joynt Maddox, K. E., Kazi, D. S., Shen, C., & Yeh, R. W. (2019). Hospital revisits within 30 days after discharge for medical conditions targeted by the Hospital Readmissions Reduction Program in the United States: national retrospective analysis. *BMJ*, I4563.

Walker, M., El-Serag, H. B., Sada, Y., Mittal, S., Ying, J., Duan, Z., . . . Kanwal, F. (2016). Cirrhosis is Under-recognized in Patients Subsequently Diagnosed with Hepatocellular Cancer. *Alimentary Pharmacology & Therapeutics*, 621-630.

Wang, M.-C., Deng, Q., Bi, X., Ye, H., & Yang, W. (2017). Performance of the entropy as an index of classification accuracy in latent profile analysis: A Monte Carlo simulation study. *Acta Psychologica Sinica*, 1473-1482.

Weiss, A. J., & Jiang, J. (2021, July). Overview of Clinical Conditions With Frequent and Costly Hospital Readmissions by Payer, 2018. HCUP Statistical Brief #278. Rockville, Maryland, USA. Retrieved from https://hcup-us.ahrq.gov/reports/statbriefs/sb278-Conditions-Frequent-Readmissions-By-Payer-2018.pdf

Weller, B. E., Bowen, N. K., & Faubert, S. J. (2020). Latent Class Analysis: A Guide to Best Practice. *Journal of Black Psychology*, 263-343.

White, A. M., Castle, I.-J. P., Powell, P. A., Hingson, R. W., & Koob, G. F. (2022). Alcohol-Related Deaths During the COVID-19 Pandemi. *JAMA*, 1704-1706.

Wier, L. M., Merrill, C. T., & Elixhauser, A. (2009). *Hospital Stays among People Living.* Rockville, MD: Agency for Healthcare Research and Quality.

Williams, R. (2012). Using the margins command to estimate and interpret adjusted predictions and marginal effects. *The Stata Journal*, 308-331.

Wolfe, M. K., McDonald, N. C., & Holmes, G. M. (2020). Transportation Barriers to Health Care in the United States: Findings From the National Health Interview Survey, 1997–2017. *American Journal of Public Health*, 815-822.

Wong, R. J., & Singal, A. K. (2020). Trends in Liver Disease Etiology Among Adults Awaiting Liver Transplantation in the United States, 2014-2019. *JAMA Network Open*, e1920294.

Wong, R. J., Jain, M. K., Therapondos, G., Shiffman, M. L., Kshirsagar, O., Clark, C., & Thamer, M. (2018). Race/ethnicity and insurance status disparities in access to direct acting antivirals for hepatitis C virus treatment. *American Journal of Gastroenterology*, 1329-1338.

Wong, T., Dang, K., Ladhani, S., Singal, A. K., & Wong, R. J. (2019). Prevalence of Alcoholic Fatty Liver Disease Among Adults in the United States, 2001-2016. *JAMA*, 1723-1725.

Wray, C. M., Khare, M., & Keyhani, S. (2021). Access to Care, Cost of Care, and Satisfaction With Care Among Adults With Private and Public Health Insurance in the US. *JAMA Network Open*, e2110275.

Yilma, M., Kim, N. J., Shui, A. M., Tana, M., Landis, C., Chen, A., . . . Zhou, K. (2023). Factors Associated With Liver Transplant Referral Among Patients With Cirrhosis at Multiple Safety-Net Hospitals. *JAMA Network Open*, e2317549.

Yilma, M., Kim, N. J., Shui, A. M., Tana, M., Landis, C., Chen, A., . . . Zhou, K. (2023). Factors Associated With Liver Transplant Referral Among Patients With Cirrhosis at Multiple Safety-Net Hospitals. *JAMA Network Open*, e2317549.

Yin, S., Barker, L., Teshale, E. H., & Jiles, R. B. (2019). Rising Trends in Emergency Department Visits Associated With Hepatitis C Virus Infection in the United States, 2006-2014. *Public Health Reports*, 685-694.

Yoder, L., Mladenovic, A., Pike, F., Vuppalanchi, R., Hanson, H., Corbito, L., . . . Orman, E. S. (2022). Attendance at a Transitional Liver Clinic May Be Associated with Reduced Readmissions for Patients with Liver Disease. *The American Journal of Medicine*, 235-243.

Young, G. P., Wagner, M. B., Kellermann, A. L., Ellis, J., & Bouley, D. (1996). Ambulatory visits to hospital emergency departments. Patterns and reasons for use. 24 Hours in the ED Study Group. *JAMA*, 460-465.

Younossi, Z. M., Koenig, A. B., Abdelatif, D., Fazel, Y., Henry, L., & Wymer, M. (2016). Global epidemiology of nonalcoholic fatty liver disease—Meta-analytic assessment of prevalence, incidence, and outcomes. *Hepatology*, 73-84.

Younossi, Z., Ong, J., Takahasi, H., Yilmaz, Yusuf, Hi, Y. E., . . . Chan, W.-K. e. (2022). A Global Survey of Physicians Knowledge About Nonalcoholic Fatty Liver Disease. *Clinical Gastroenterology and Hepatology*, e1456-e1468.

Younossi, Z., Stepanova, M., Younossi, Y., Golabi, P., Mishra, A., Rafiq, N., & Henry, L. (2020). Epidemiology of chronic liver diseases in the USA in the past three decades. *Gut*, 564-568.

Zajacova, A., & Lawrence, E. M. (2018). The relationship between education and health: reducing disparities through a contextual approach. *Annual Review of Public Health*, 273-289.

Zhou, T., Liu, P., Dhruva, S. S., Shah, N. D., Ramachandran, R., Berg, K. M., & Ross, J. S. (2022). Assessment of Hypothetical Out-of-Pocket Costs of Guideline-Recommended Medications for the Treatment of Older Adults With Multiple Chronic Conditions, 2009 and 2019. *JAMA Internal Medicine*, 185-195.

Zuckerman, R. B., Sheingold, S. H., Orav, E. J., Ruhter, J., & Epstein, A. M. (2016). Readmissions, Observation, and the Hospital Readmissions Reduction Program. *New England Journal of Medicine*, 1543-1551.

Zulman, D. M., Maciejewski, M. L., Grubber, J. M., Weidenbacher, H. J., Blalock, D. V., Zullig, L. L., . . . Smith, V. A. (2020). Patient-Reported Social and Behavioral Determinants of Health and Estimated Risk of Hospitalization in High-Risk Veterans Affairs Patients. *JAMA Network Open*, e2021457.