The Quality and Outcomes of Care Provided to Patients with Cirrhosis by Advanced Practice Providers

Elliot B. Tapper MD, Shengchen Hao, Menghan Lin, John N. Mafi, Heather McCurdy NP, Neehar D. Parikh MD, Anna S. Lok MD

SUPPLEMENTARY MATERIAL

Table 1: Condition Definitions using ICD-9 Codes

	ICD-9 code
Cirrhosis	571.2, 571.5, 571.6
Cirrhosis complications	456.0, 789.59, 572.2, 567.23, 572.4
History of alcohol use	571.2, 571.1, 571.3, 790.3, 425.5, 535.30, 535.51, 577, 357.5, 291.x, 303.x, 305.0x, V113.0, E860.01-.03, 980.x
Hepatitis C	070.41, 070.44, 070.51, 070.54, 070.70, 070.71, v02.62
Hepatitis B	070.22, 070.23, 070.32, 070.33, 070.2, 070.3, V02.6
Non-alcohol-related, non-viral	571.5 NOT Alcohol use, Hepatitis C or Hepatitis B
Hepatic encephalopathy	572.2
Liver Transplant	ICD-9CM 50.5; CPT 47135, 47136
Hepatocellular Carcinoma	155.0
Paracentesis	ICD9CM: 54.91; CPT: 49080, 49081, 49082, 49083, 49084
Portosystemic shunt	ICD9CM: 39.1; CPT: 37182, 37183, 37140
Endoscopy	ICD9CM: 45.16; CPT 43200, 43202, 43204, 43234; CPT: 43235, 43239, 43243, 43244, 43255,43227, 43204, 43205, 43251
Hepatitis A vaccine	CPT 90632, 90633, 90634, 90636
Hepatitis B vaccine	CPT 90739, 90740, 90743, 90747; CPT 90636, 90748
Liver cancer Screening	CT scan: CPT 74177, 74178, 74160, 74170; MRI CPT 74183; Ultrasound: CPT: 76700, 76705
Infections	pneumonia (481, 482.xx, 483.0, 483.1, 483.8, 484.3, 484.5, 484.8, 485.x, 486.x), sepsis (995.91, 995.92, 785.52, 0380, 0381, 03811, 03812, 03819, 0382–0384, 03840–44, 03849, 0388, 0389), urinary tract infection (599.0, 590.10, 590.11, 590.80), cellulitis (682.0–682.9), bacteremia (790.7), cholangitis (576.1), *Clostridium difficile* infection (008.45), and spontaneous bacterial peritonitis (567.23)

Table 2: Definition of Quality Metrics

Metric	Source	Denominator	Numerator	Limitations
Hepatocellular carcinoma (HCC)	**(1)**	All patients with cirrhosis without HCC. Patients are censored at the time of HCC diagnosis.	All patients with a liver imaging test performed in the outpatient setting. It is recommended to be performed every 6-12 months.	Screening can be deferred in patients with Child C cirrhosis and life-limiting comorbidities. Recent guidelines recommend screening every 6 months.
Screening for varices	**(2, 3)**	All patients with cirrhosis without variceal bleeding within 3 months of the index visit.	All patients with an upper endoscopy performed in the outpatient setting. It is recommend to be performed every 2-3 years in patients with compensated cirrhosis and annually in patients with decompensated cirrhosis	Inpatient endoscopies were not considered screening tests. Unable to accurately account for differences in recommendations for patients with compensated vs. decompensated cirrhosis.
Rifaximin after discharge for hepatic encephalopathy (HE)	**(4)**	All patients with an admission for HE (inpatient code ICD-9 572.2) on lactulose	All patients who received rifaximin after discharge	Clinicians may defer prescription if out-of-pocket costs are expected to be high. Some HE episodes with clear provoking factor may not benefit from addition of rifaximin.

Table 3: Competing Risks Analysis

Variable	Mortality Sub Hazard Ratio (95% Confidence Interval)	Transplantation Sub Hazard Ratio (95% Confidence Interval)
Age (per year)	1.038 (1.037 1.038)	0.973 (0.968 0.978)
Female Sex	0.913 (0.895 0.93)	0.758 (0.658 0.874)
Asian Race	0.745 (0.705 0.788)	1.149 (0.801 1.647)
African American Race	1.071 (1.042 1.101)	0.851 (0.692 1.047)
Hispanic	0.678 (0.657 0.699)	0.76 (0.61 0.947)
Charlson comorbidity Index (per point)	1.098 (1.092 1.103)	1.221 (1.175 1.269)
Alcoholic Cirrhosis	0.941 (0.907 0.976)	3.937 (3.123 4.963)
Hepatitis C	0.879 (0.848 0.912)	5.512 (4.351 6.984)
Non-alcoholic, non-viral cirrhosis	0.843 (0.812 0.875)	n/a
Ascites	1.796 (1.754 1.839)	1.169 (1.006 1.358)
Paracentesis	1.734 (1.681 1.79)	1.219 (1.013 1.468)
Spontaneous Bacterial Peritonitis	1.046 (0.984 1.113)	0.979 (0.756 1.268)
Varices	0.978 (0.949 1.008)	2.261 (1.908 2.679)
Transjugular Intrahepatic Portosystemic Shunt	0.947 (0.866 1.036)	1.954 (1.5 2.545)
Hepatic Encephalopathy	1.528 (1.492 1.566)	2.455 (2.07 2.911)
Hepatocellular Carcinoma	1.723 (1.656 1.793)	2.103 (1.787 2.474)
Dialysis	1.101 (1.055 1.149)	0.464 (0.299 0.72)
Advanced Practice Provider (APP) visit	0.574 (0.551 0.599)	0.326 (0.213 0.498)
Gastroenterology visit (non-Hepatology)	1.379 (1.346 1.413)	1.483 (1.228 1.791)
Hepatology visit	0.826 (0.784 0.871)	2.066 (1.706 2.502)

Subdistribution-hazard ratios are the product of a Cox Proportional Hazards model for competing risks. 3 competing risks were considered: death, transplantation, and loss-to-follow up. For adjusted models we also included adjustment for number of outpatient visits, shared visits between MDs and APP as well as interaction terms for APP and gastroenterology as well as APP and hepatology. The variable for APP visits included any APP visit (alone or in conjunction with an MD). Finally, in order to adjust further for illness severity, we included diagnosis codes for sepsis, bacteremia, urinary tract infection, pneumonia, clostridium difficile, cellulitis and cholangitis. The number of patients with non-alcoholic, non-viral cirrhosis who received transplant was too few for the transplant outcome (hence 'n/a').

Table 4: Landmark Analysis

Variable	Univariate Hazard Ratio (95% Confidence Interval)	Multivariate Hazard Ratio (95% Confidence Interval)
Age (per year)	1.05 [1.05,1.05]	1.04 [1.04, 1.04]
Female Sex	0.73 [0.71,0.75]	0.88 [0.85, 0.90]
Asian Race	0.70 [0.65, 0.76]	0.75 [0.69, 0.82]
African American Race	1.03 [0.97, 1.07]	0.96 [0.93, 1.00]
Hispanic	0.84 [0.81, 0.88]	0.72 [0.69, 0.75]
Charlson comorbidity Index (per point)	1.31 [1.30, 1.32]	1.17 [1.16, 1.18]
Alcoholic Cirrhosis	1.63 [1.59, 1.67]	0.97 [0.93 ,1.02]
Hepatitis C	0.95 [0.93, 0.98]	0.98 [0.94, 1.02]
Non-alcoholic, non-viral Cirrhosis	0.76 [0.74, 0.78]	0.87 [0.83, 0.91]
Ascites	2.50 [2.43, 2.57]	1.80 [1.75, 1.86]
Paracentesis	3.83 [3.71, 3.95]	2.10 [2.03, 2.19]
Spontaneous Bacterial Peritonitis	2.98 [2.80, 3.16]	1.05 [0.98, 1.12]
Varices	2.50 [2.43, 2.57]	1.80 [1.75, 1.86]
Transjugular Intrahepatic Portosystemic Shunt	2.24 [2.06, 2.44]	0.91 [0.83, 1.00]
Hepatic Encephalopathy	2.50 [2.43, 2.57]	1.80 [1.75, 1.86]
Hepatocellular Carcinoma	2.54 [2.44, 2.65]	1.58 [1.50, 1.66]
Dialysis	2.79 [2.66, 2.93]	1.30 [1.23, 1.37]
Advanced Practice Provider (APP) visit	0.88 [0.85, 0.90]	0.80 [0.75, 0.85]
Gastroenterology visit (non-Hepatology)	1.14 [1.11, 1.17]	1.09 [1.06, 1.13]
Hepatology visit	0.88 [0.84, 0.92]	0.80 [0.75, 0.85]

To account for the risk of immortal time bias, we performed a landmark analysis setting cohort entry for all patients as the time of first cirrhosis diagnosis. For adjusted models we also included adjustment for number of outpatient visits, shared visits between MDs and APP as well as interaction terms for APP and gastroenterology as well as APP and hepatology. The variable for APP visits included any APP visit (alone or in conjunction with an MD). Finally, in order to adjust further for illness severity, we included diagnosis codes for sepsis, bacteremia, urinary tract infection, pneumonia, clostridium difficile, cellulitis and cholangitis.

Table 5: Propensity Score Matching

	No-APP (n=101,830)	APP (n=101,830)
Age (average)	57.00	57.15
Female Sex	55%	55%
Asian Race	2.1%	2%
African American Race	10.1%	10.1%
Hispanic	9.6%	9.7%
Alcoholic Cirrhosis	22.5%	23.0%
Hepatitis C	11.0%	11.1%
Ascites	38.5%	38.8%
Paracentesis	1.4%	1.4%
Spontaneous Bacterial Peritonitis	0.4%	0.5%
Varices	7.4%	7.5%
Transjugular Intrahepatic Portosystemic Shunt	0.1%	0.1%
Hepatic Encephalopathy	8.0%	8.3%
Hepatocellular Carcinoma	1.2%	1.3%
Dialysis	1.7%	1.9%
Advanced Practice Provider (APP) visit	Hazard Ratio (95%CI)	0.43 (0.41, 0.45)

To further account for the risk of confounding by indication, we performed a propensity score matching analysis. Using a 1:1 greedy matching algorithm with a caliper width of 0.2. The association between APP visits and survival is presented as a hazard ratio for transplant-free survival that is further adjusted the number of outpatient visits, shared visits between MDs and APP as well as interaction terms for APP and gastroenterology as well as APP and hepatology. The variable for APP visits included any APP visit (alone or in conjunction with an MD). Finally, in order to adjust further for illness severity, we included diagnosis codes for sepsis, bacteremia, urinary tract infection, pneumonia, clostridium difficile, cellulitis and cholangitis.

Table 6: Costs Associated with Advanced Practice Providers (APP)

	Crude Charges, 2015 USD (Median, IQR)		Incidence Rate Ratios (95% CI)	
	APP	Non-APP	APP	APP
			Unadjusted	Adjusted
Inpatient charges per person year	1,244 (455-3,095)	561 (204-1464)	1.340 (1.327, 1.354)	1.644 (1.625. 1.664)
Outpatient Charges per person year	6,196 (2,967-12,520)	2,756 (1,213-5,974)	1.378 (1.368, 1.389)	1.825 (1.810, 1.840)
Total Charges	9,619 (5,041-18,183)	4,450, (2,143-9,033)	1.403 (1.392 1.413)	1.785 (1.771, 1.799)

CI= confidence interval, IQR = interquartile range, USD= US dollars

This analayis of healthcare charges per person-year demonstrates that APP are associated with an increase in expenditures adjusting for confounders. We adjusted estimates for age, race, charlson comorbidities, liver disease etiology, gastroenterology/Hepatology involvement (with an interaction term for APP-GI/Hepatology care), and disease severity (codes for cirrhosis complications). All cost analyses were censored at transplantation.

References

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