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

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Cirrhosis is morbid and increasingly prevalent, yet the U.S. health care system lacks enough physicians and specialists to adequately manage patients with cirrhosis. Although advanced practice providers (APPs) can expand access to cirrhosis-related care, their impact on the quality of care remains unknown. We sought to determine the effect on care quality and outcomes for patients managed by APPs using a retrospective analysis of a nationally representative American commercial claims database (Optum), which included 389,257 unique adults with cirrhosis. We evaluated a complication of process measures (i.e., rates of hepatocellular carcinoma [HCC] screening, endoscopic varices screening, and use of rifaximin after hospitalization for hepatic encephalopathy) and outcomes (30-day readmissions and survival). Compared with patients without APP care, patients with APP care had higher rates of HCC screening (adjusted odds ratio [OR] 1.23, 95% confidence interval 1.19, 1.27), varices screening (OR 1.20 [1.13, 1.27]), use of rifaximin after a discharge for hepatic encephalopathy (OR 2.09 [1.80, 2.43]), and reduced risk of 30-day readmission (OR 0.68 [0.66, 0.70]). Gastroenterology/hepatology consultation was also associated with improved quality metric performance compared with primary care; however, shared visits between gastroenterologists/hepatologists and APPs were associated with the best performance and lower 30-day readmissions compared with subspecialty consultation without an APP (OR 0.91 [0.87, 0.95]. Multivariate analysis adjusting for comorbidities, liver disease severity, and other factors including gastroenterology/hepatology consultation showed that patients seen by APPs were more likely to receive consistent HCC and varices screening over time, less likely to experience 30-day readmissions, and had lower mortality (adjusted hazard ratio 0.57, 95% confidence interval 0.55, 0.60). *Conclusion:* APPs, particularly when working with gastroenterologists/hepatologists, are associated with improved quality of care and outcomes for patients with cirrhosis. (Hepatology 2020;71:225-234).

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Cirrhosis is common, affecting up to 5 million Americans, and its prevalence is increasing.[1-4] It is characterized by poor quality of life and life-limiting complications such as variceal hemorrhage, ascites, hepatic encephalopathy (HE), and hepatocellular carcinoma (HCC).[5-7] There are standard measures that can be undertaken to forestall many of these complications and improve patient outcomes. In 2010, Kanwal et al. translated many key standards for the care of patients with liver disease into measurable quality indicators.[8] These indicators include imaging-based screening for HCC,[9] endoscopic screening for varices,[10] immunization against viral hepatitis, and optimal therapy for HE.[11] Both the American Association for the Study of Liver Diseases and advanced liver disease workgroups in the Department of Veterans Affairs (VA) have adopted these measures into practice guidelines. Unfortunately, substantial gaps in implementation persist.[12]

Abbreviations: APP, advanced practice provider; CI, confidence interval; HCC, hepatocellular carcinoma; HE, hepatic encephalopathy; HR, hazard ratio; IQR, interquartile range; MD, medical doctor; OR, odds ratio; VA, Veterans Affairs.

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A major barrier to optimal care for cirrhosis is limited access to subspecialty care. Most patients with cirrhosis are not co-managed by a gastroenterology-trained or hepatology-trained specialist.[13,14] Previous studies have demonstrated that advanced practice providers (APPs) provide care that is equivalent in quality to medical doctors (MDs) in both primary care and specialty care when their practice is focused on one condition.[15-18] However, data are lacking regarding quality metric performance for APPs in patients with cirrhosis. Herein, we examine a large commercial claims database to assess the quality of APP care and the impact on outcomes in patients with cirrhosis with or without subspecialty consultation.

Materials and Methods

We analyzed the 2001-2015 Optum Clinformatics DataMart (Eden Prairie, MN), which includes nationally representative information for 77,883,541 unique patients covered with private insurance, including Medicare Advantage. Enrollees are followed longitudinally across inpatient and outpatient settings. Data for the present study were limited to adults with at least two cirrhosis claims. All coding definitions are provided in Supporting Table S1.[19-21] This study was exempted from review by the University of Michigan Institutional Review Board.

QUALITY INDICATORS AND OUTCOMES

We chose four quality indicators that were easily abstracted from administrative data: screening for HCC, screening for varices, and prescription of rifaximin following a hospitalization for HE. We then examined two clinical outcomes: 30-day readmissions and mortality. The sources and definitions of denominators and numerators for quality metrics are detailed in Supporting Table S2. Finally, we examined health care expenditures by combining the charges associated with all procedures and visits (CPT and HCPCS codes) incurred by each patient per person-year. We excluded non-liver surgical procedures, non-liver oncologic therapies, and cardiac or electrophysiological procedures.

EXPOSURES

Provider type was our principal exposure variable. Specifically, we evaluated the impact of APP visits (nurse practitioners or physician's assistants). We included APP visits that occurred in either primary care or gastroenterology/hepatology clinics, some of which occurred as "shared visits" with gastroenterology/hepatology specialists on the same day of service. We collected additional exposure variables for complete description of the cohort and risk adjustment. These included age, sex, race, education, Charlson comorbidity index (modified to exclude liver disease),[22] etiology of liver disease, complications of cirrhosis, number of outpatient visits, and evaluation by a provider associated with a transplant facility. Liver disease severity was captured using a combination of diagnosis and procedure codes (cirrhosis complications such as HE and procedures such as paracentesis and portosystemic shunt placement). Transplant facility was defined as any center that performed a liver transplant within the same year of service.

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STATISTICAL ANALYSES

To analyze outcomes, we used four strategies. First, we performed logistic regression analyses to determine the relative impact of APP evaluation on practice metrics, limiting the cohort for evaluation to those with at least 12 months' follow-up (Fig. 1). To account for the effect of gastroenterology/hepatology consultation, we evaluated multiple scenarios:

1. Scenario 1: Patients with any APP visit versus no APP visits. (Analyses were adjusted for gastroenterology/hepatology consultation if it occurred.)

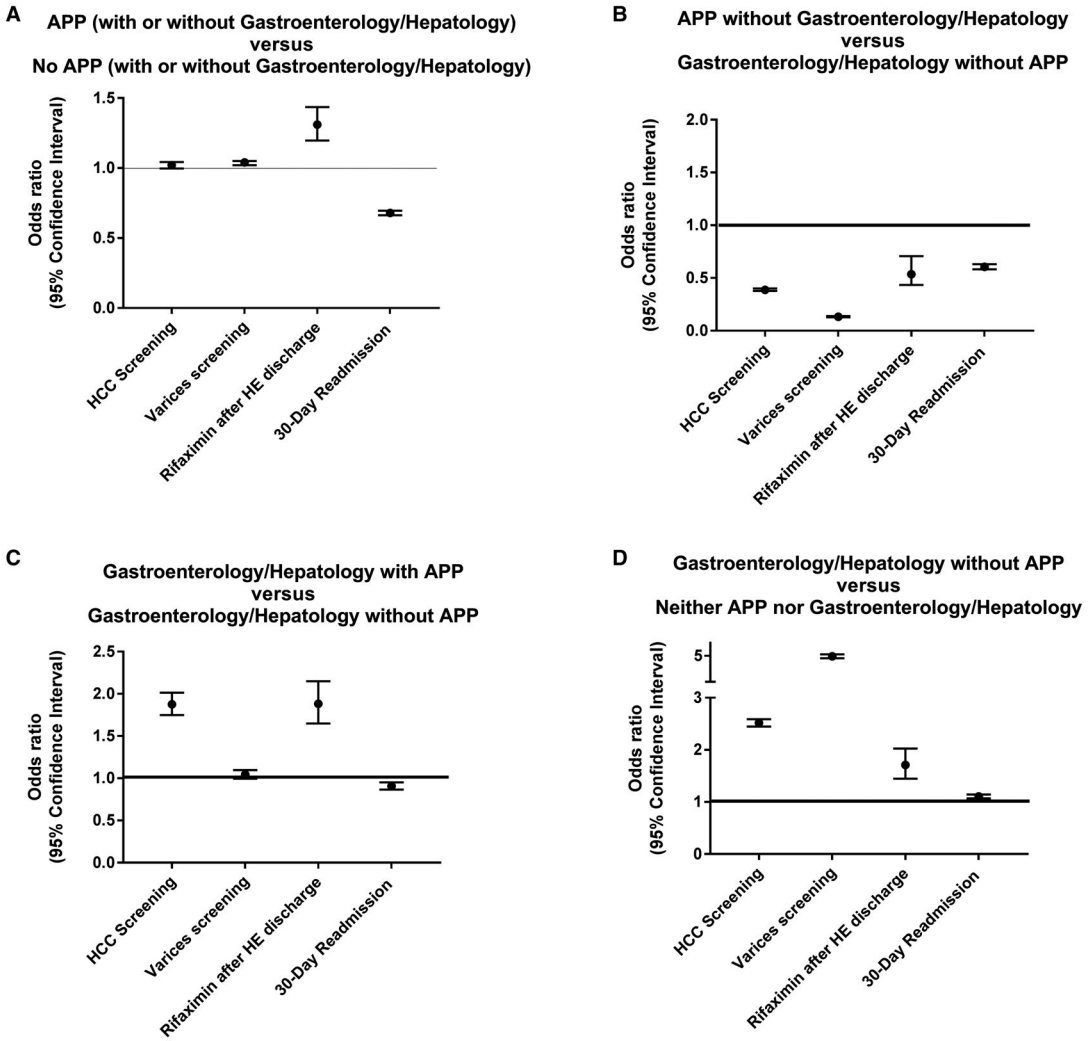

FIG. 1. Association of provider type with process measures and 30-day readmissions. Adjusted ORs for multiple metrics are presented to show the quality of care provided by various health care providers. Raw data including unadjusted estimates are presented in Supporting Table S3A-D. (A) Compared with patients who were never seen by an APP, those who were seen by an APP, regardless of presence or absence of gastroenterologist/hepatologist consultation, were marginally more likely to receive screening for HCC and varices, more likely to receive rifaximin after discharge for HE, and less likely to experience a 30-day readmission. (B) Patients seen by APPs without gastroenterologists/hepatologists were less likely to receive care that satisfies the practice metrics, but also less likely to experience a 30-day readmission compared with patients seen by gastroenterologists/hepatologists without APPs. (C) Patients seen by gastroenterologists/hepatologists with assistance from APPs received better care and had less readmissions compared with those seen by gastroenterologists/hepatologists alone, except for varices screening, in which there was no difference. (D) Patients seen by gastroenterologists/hepatologists alone received better care for all measures and had less readmissions compared with those not seen by gastroenterologists/hepatologists or APPs.

2. Scenario 2: Patients with neither APP nor gastroenterology/hepatology consultation versus gastroenterology/hepatology consultation without any APP visits.
3. Scenario 3: Patients with APP and gastroenterology/hepatology consultation versus gastroenterology/hepatology consultation but no APP.
4. Scenario 4: Patients with gastroenterology/hepatology consultation but no APP versus neither APP nor gastroenterology/hepatology consultation.

Second, we analyzed two "pre/post" cohorts to assess the impact of APP involvement (Table 2). In the first cohort, we included all patients with 6 months of coverage before and after a first visit with an APP. For the outcome of endoscopic screening, we excluded patients who had an endoscopy examination prior to the 1-year period analyzed, given the recommended interval for screening (Supporting Table S2). For this cohort, we adjusted for the impact of gastroenterology/hepatology consultation as a time-varying covariate in the event that a patient received such a consultation. In the second pre/post cohort, we included all patients with 6 months of coverage before and after a shared visit with a gastroenterologist/hepatologist MD and an APP (their first visit with either provider type in the database).

Third, we determined the incidence rate (per person-year) of each practice metric. Practice metric events were compared between groups of patients with and without APP involvement using incidence rate ratios derived from negative binomial regressions (Table 3).

Fourth, we used a time-dependent Cox proportional hazards model to determine the impact of APP evaluation on survival using time-varying covariates to adjust the hazard ratio (HR) (Table 4). Patients were censored if they received a liver transplant or were lost to follow-up due to loss of insurance coverage. The reasons for loss of coverage are not known but generally include changes in employment (and thus insurer) or transition to a public insurer (Medicare/Medicaid). This data set is linked to the social security death index and thus mortality data was complete in the data set's "death view." For those who died within 3 months after loss of coverage, death rather than loss of coverage was considered the outcome. Gastroenterologists and hepatologists were considered separately, as hepatology consultation may reflect management at a transplant facility. To adjust as fully as possible for severity of illness, we added covariates for common infections that are linked with adverse outcomes in patients with cirrhosis (Supporting Table S1).[23] We addressed biases in multiple ways. First, we used Fine-Gray modeling to account for the competing risk of liver transplantation.[24] Second, we addressed the risk of residual immortal time bias—despite the use of time-dependent Cox modeling—using a Landmark analysis,[25] setting the cohort entry as those seen by an APP or not at the time of cirrhosis diagnosis. Third, to further address confounding by indication, we performed a 1:1 propensity score matching for exposure to APP care.

Descriptive statistics are presented as the median and interquartile range (IQR) for continuous variables and as the number and percent for categorical variables. Comparisons of continuous variables were performed using the Student *t* test and the Wilcoxon rank sum test for parametric and nonparametric variables, respectively. Categorical variables were compared using a chi-squared test. All analyses were performed using R (packages dplyr, plyr, stringr, comorbidity, tidyr, survival, survminer, cmprsk2, knit, MatchIt, and haven).

Results

POPULATION CHARACTERISTICS

Descriptive statistics for our population are given in Table 1. Of the 389,257 patients included, 57% never had a visit with an APP. Although the differences in characteristics of the cohorts with and without APP visits were statistically significant in many aspects, they were small and not clinically meaningful except for medical comorbidities that were more common in the cohort with APP visits than those without (70% versus 53% with at least three comorbidities [$P < 0.001$]).

Overall, patients were followed for a median of 5.00 (IQR 2.33-9.00) person-years, and 5.92 (3.00-9.58) and 4.41 (2.00-8.33) for those with more than 1 and 0 APP visits, respectively. The median number of outpatient visits per person-year for patients seen by APP and those who were not was 8.8 (4.8-14.4) and

TABLE 1. Baseline Demographics and Clinical Characteristics

	Seen by APP (n = 166,708)	Never Seen by APP (n = 222,549)	*P* Value
Age (median IQR)	60 (48-70)	58 (46-69)	<0.001
Female	54.20%	50.27%	<0.001
Race			
Asian	1.93%	3.49%	
African American	10.30%	9.73%	<0.001
Hispanic	9.47%	12.14%	
White (non-Hispanic)	69.58%	62.26%	
Unknown	8.72%	12.39%	
Education			
<12th grade	0.83%	1.34%	
High school	32.62%	31.38%	
Less than bachelor's degree	50.94%	46.49%	<0.001
Bachelor's degree or greater	11.40%	12.07%	
Unknown	3.49%	9.26%	
Charlson comorbidity index			
0	4.49%	6.86%	
1-2	25.82%	39.60%	<0.001
3-4	28.96%	28.85%	
5+	41.05%	24.45%	
Alcoholic cirrhosis	33.94%	30.98%	<0.001
Hepatitis C	13.64%	16.31%	<0.001
Nonalcoholic, nonviral cirrhosis	62.43%	61.06%	<0.001
HE	18.31%	16.33%	<0.001
Ascites	31.19%	41.71%	<0.001
Varices	13.19%	14.00%	<0.001
HCC	4.42%	4.53%	0.12
Gastroenterology/hepatology consultation	70.31%	57.41%	<0.001
Hepatology consultation (subset of above)	7.81%	6.47%	<0.001

4.7 (2.3-8.5), respectively. The most common endpoint was censoring (303,139 [77.8%]; 134,936 censored patients were alive at the study end date), occurring within 5.25 (2.50-9.33) person-years. Overall, 83,647 (21.5%) died within 4.17 (1.91-7.58) person-years, and 2,471 (0.63%) received a liver transplant within 2.64 (1.11-5.34) person-years. We counted death and not loss of coverage as an outcome in 6,872 patients who lost coverage within 3 months prior to mortality; 9,366 patients died within 6 months and 13,874 died within 1 year of loss of coverage.

ASSOCIATION OF APP INVOLVEMENT WITH PRACTICE METRICS IN THE CONTEXT OF GASTROENTEROLOGY/ HEPATOLOGY CONSULTATION

The quality of care provided by APP in the presence and absence of gastroenterology/hepatology consultation is depicted in Fig. 1. In scenario 1 (Fig. 1A), we show that, compared with patients never seen by an APP, management by an APP with or without gastroenterologists/hepatologists was not different regarding rates of screening for HCC, but APP management was associated with a slightly higher rate of varices screening and much higher rates of rifaximin use after discharge for HE (OR 1.31 [1.20, 1.44]) and lower 30-day readmissions (OR 0.68 [0.66, 0.70]). When we compared APP management without gastroenterology/hepatology consultants to management by gastroenterologists/hepatologists without assistance by APPs (scenario 2, Fig. 1B), APP management alone was inferior for all measures except 30-day readmissions (OR 0.61 [0.58, 0.63]). In Fig. 1C (scenario 3), we show that management by gastroenterologists/hepatologists with APPs was superior to management by gastroenterologists/hepatologists without APPs in all practice metrics as well as 30-day readmissions (save for endoscopic screening). Finally, Fig. 1D (scenario 4) shows that patients seen by gastroenterologists/hepatologists without APPs received much higher quality management in all practice metrics, but also slightly higher 30-day readmissions than patients seen by neither gastroenterologists/hepatologists nor APPs.

PRACTICE METRICS BEFORE AND AFTER EVALUATION BY APPS: NATURAL EXPERIMENTS

In Table 2, we demonstrate the temporal association with practice metric completion in two pre/post analyses of patients evaluated by an APP with or without gastroenterology/hepatology consultation. In the first analysis, APP evaluation was associated with improved HCC screening (adjusted odds ratio [OR] 1.23 [1.19, 1.27]), varices screening (OR 1.20 [1.13, 1.27]), and use of rifaximin after a discharge for HE (OR 2.09 [1.80, 2.43]). In the second analysis, a similar and stronger relationship was observed for patients whose first APP visit was a shared visit with a

TABLE 2. Pre/Post "Experiments": Relative Practice Metric Performance After an APP Visit That Was (or Was Not) Shared With a Gastroenterologist/Hepatologist

	Screening for HCC	Endoscopy Screening for Varices	On Rifaximin After Discharge for HE
Before and after an APP visit			
Denominator	97,013	84,138	5,082
Metric satisfied prior to APP visit	26.1%	7.2%	7.9%
Metric satisfied after APP visit	30.1%	8.9%	14.8%
OR (95% CI)	1.27 (1.19, 1.24)	1.19 (1.15, 1.24)	2.02 (1.78, 2.30)
Adjusted OR (95% CI)	1.23 (1.19, 1.27)	1.20 (1.13, 1.27)	2.09 (1.80, 2.43)
Before and after visit with both GI/hep and APP			
Denominator	4,830	3,593	572
Metric satisfied prior to GI/hep and APP visit	44.8%	12.4%	9.3%
Metric satisfied after GI/hep and APP visit	55.6%	27.2%	27.4%
OR (95% CI)	1.54 (1.42, 1.67)	2.66 (2.35, 3.01)	3.70 (2.64, 5.19)
Adjusted OR (95% CI)	1.58 (1.45, 1.73)	2.84 (2.48, 3.24)	4.08 (2.34, 7.13)

Note: Patients in both cohorts were seen by primary care MDs prior to APP involvement; in the former they could have seen a gastroenterologist/hepatologist, but in the latter, a gastroenterology/hepatology consultation first occurred in a shared visit with an APP. Patients were censored from the evaluation of HCC screening at the time of an HCC diagnosis. Patients were excluded from the denominator for endoscopic screening if they experienced variceal bleeding at any point or if they had an endoscopy within 1 year prior to the period evaluated. All adjustments included age, sex, race, education, Charlson comorbidity index, etiology of liver disease, complications of cirrhosis, number of outpatient visits, and evaluation by gastroenterologists or hepatologists.
Abbreviations: GI, gastroenterologist; hep, hepatologist.

TABLE 3. Cumulative Adherence to Practice Metrics Associated With Visits to APP

	Screening for HCC (Screens per Person-Year)	Screening for Varices (Endoscopy per Person-Year)	30-Day Readmissions per Discharge
Number of events in patients seen by APP per person-year, median (IQR)	0.75 (0.40-1.46)	0.35 (0.21-0.59)	0 (0-0.46)
Number of events in patients never seen by APP per person-year, median (IQR)	0.45 (0.22-0.89)	0.24 (0.13-0.44)	0 (0.0-0.5)
Incidence rate ratio (95% CI)	1.73 (1.72, 1.74)	1.48 (1.47, 1.49)	0.90 (0.89, 0.91)
Adjusted incidence rate ratio (95% CI)	1.61 (1.60, 1.63)	1.51 (1.49, 1.54)	0.88 (0.87, 0.90)

Note: The incidence rate ratios present a measure of the relative rate of events between patients managed (at least in part) by APPs, accounting for the time under evaluation. The adjusted measures account for demographics, clinical factors (Table 1), consultation by gastroenterologists/hepatologists, number of outpatient visits, and interaction terms for APP and gastroenterology/hepatology. Patients were censored from all analyses at the time of death or loss of coverage. Patients were censored from HCC screening metrics at the time of HCC diagnosis and from screening varices metrics at the time of variceal hemorrhage.

gastroenterologist/hepatologist. Notably, the baseline rate of metric completion was higher for patients in the second analysis.

ASSOCIATION BETWEEN APP INVOLVEMENT AND QUALITY CARE AND OUTCOMES OVER TIME

To evaluate the consistency of effect as well as adjust for the time each patient is under evaluation, we analyzed the impact of APP visits on the average rate of quality metrics over time (Table 3). For all metrics, APP involvement was associated with improved delivery of care: increased HCC screening (adjusted incidence rate ratio 1.61 [1.60, 1.63]), increased varices screening (1.51 [1.49, 1.54]), and decreased 30-day readmissions (0.88 [0.87, 0.90]).

ASSOCIATION BETWEEN APP CARE AND MORTALITY

Table 4 details the associations between clinical and demographic features and mortality. As expected, older age, patients with more medical comorbidities, and those with more advanced cirrhosis had higher

TABLE 4. Association of Provider Type With Mortality

Variable	Univariate HR (95% CI)	Multivariate HR (95% CI)
Age (per year)	1.05 (1.05, 1.05)	1.04 (1.04, 1.04)
Female sex	0.76 (0.75, 0.77)	0.91 (0.89, 0.93)
Asian race	0.79 (0.75, 0.83)	0.75 (0.71, 0.79)
African American race	1.10 (1.07, 1.13)	1.07 (1.04, 1.09)
Hispanic	0.80 (0.78, 0.82)	0.67 (0.65, 0.69)
Charlson comorbidity index (per point)	1.20 (1.19, 1.20)	1.10 (1.09, 1.11)
Alcoholic cirrhosis	1.32 (1.30, 1.34)	1.09 (1.05, 1.12)
Hepatitis C	0.83 (0.81, 0.85)	0.98 (0.95, 1.01)
Nonalcoholic, nonviral cirrhosis	0.90 (0.88, 0.92)	1.01 (0.97, 1.02)
Ascites	2.30 (2.26, 2.34)	1.80 (1.76, 1.84)
Paracentesis	2.42 (2.37, 2.47)	1.75 (1.70, 1.79]
Spontaneous bacterial peritonitis	2.30 (2.20, 2.40)	1.07 (1.02, 1.13)
Varices	1.12 (1.10, 1.15)	1.00 (0.97, 1.02)
Transjugular intrahepatic portosystemic shunt	1.75 (1.63, 1.87)	1.01 (0.93, 1.10)
HE	2.05 (2.02, 2.09)	1.54 (1.51, 1.58)
HCC	2.33 (2.27, 2.40)	1.78 (1.72, 1.84)
Dialysis	1.69 (1.64, 1.75)	1.09 (1.05, 1.13)
APP visit	0.70 (0.69, 0.71)	0.57 (0.55, 0.60)
Gastroenterology visit (non-hepatology)	0.99 (0.97, 1.00)	1.39 (1.36, 1.43)
Hepatology visit	0.78 (0.75, 0.80)	0.93 (0.89, 0.98)
Transplant facility	0.84 (0.83, 0.86)	0.83 (0.81, 0.84)

Note: Patients were censored for transplant or loss of coverage more than 3 months prior to date of death. For adjusted models we also included adjustment for number of outpatient visits, shared visits between MDs and APPs, 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). To adjust further for illness severity, we included diagnosis codes for sepsis, bacteremia, urinary tract infection, pneumonia, clostridium difficile infection, cellulitis, and cholangitis.

HRs for mortality. APP involvement was associated with reduced risk of death (adjusted HR 0.57, 95% confidence interval [CI] 0.55, 0.60). When analyses account for the competing risks of death and transplant, the adjusted HRs for death and transplant associated with APP involvement were 0.57 (95% CI 0.55, 0.60) and 0.33 (95% CI 0.21, 0.50), respectively (Supporting Table S3). We performed a landmark analysis to further reduce the risk of immortal time bias (Supporting Table S4). In this case, the adjusted HR for death associated with APP management was 0.80 (95% CI 0.75, 0.85). In Supporting Table S5 we provide the results of a propensity-score matching procedure and show that APP care remains inversely associated with mortality (HR 0.43, 95% CI 0.41, 0.45).

ASSOCIATION BETWEEN APP AND HEALTH CARE EXPENDITURES

We evaluated the association between APP involvement and charges incurred per person-year (Supporting Table S6). APPs were associated with increased charges overall, $9,619 (IQR 5,041-18,183) compared with $4,450 (IQR 2,143-9,033) for patients who were not co-managed by APP. When the analysis was restricted to outpatient charges alone, the difference was a median of $6,196 per person-year compared with $2,756 for non-APP. Adjusting for confounders including gastroenterology/hepatology involvement and disease severity, APPs were associated with increased charges, incidence rate ratio 1.79 (95% CI 1.77-1.80). Overall, these charges reflect 8,858 unique procedure and visit codes. The top 20 sources of health care expenditure by weight (charges multiplied by frequency) included procedure codes related to transthoracic echocardiography, magnetic resonance and computed tomography, liver biopsy, laparoscopic liver resection, endoscopy, colonoscopy, and emergency department and outpatient visits.

Discussion

The prevalence of cirrhosis in the United States is increasing, outstripping the capacity of specialists to provide optimal care. This study of a large commercial claims database covering more than 380,000 patients with cirrhosis demonstrates that care from an APP was associated with improved quality metric adherence, reduced readmissions, and potentially decreased mortality.

APPS IMPROVE THE QUALITY OF CARE PROVIDED TO PATIENTS WITH CIRRHOSIS

Quality Metrics

We chose to examine screening for HCC, because it can be ordered by any provider and is associated

with the receipt of curative therapy and improved overall survival,[26] yet fewer than 1 in 5 patients with cirrhosis receives an HCC screening.[12] Efforts to improve HCC screening rates, including reminders in the electronic health record, mailed invitations, and staff dedicated to facilitating screen completion, have had modest effects.[12,27] We now report strong improvements in the rate of HCC screening associated with APP management (incidence rate ratio 1.61, 95% CI 1.60, 1.63). In contrast, likely because endoscopy has to be scheduled by gastroenterologists' offices, we found only modest improvements in endoscopic screening for varices after APP management (with or without gastroenterology consultation).

Rifaximin is recommended for secondary prophylaxis of HE. We observed a marked rate of improvement in rifaximin use after discharge for HE following an APP visit. Rifaximin use often requires an extensive prior-approval process. APPs may have a more important role in tasks that require additional efforts outside of the traditional clinical workflow.

Outcomes

One in every 4 patients with admissions for cirrhosis will be readmitted within 30 days.[12] Their individual risk is commensurate with disease severity, burden of comorbidities, and strength of social support. Few interventions aside from the use of rifaximin for HE have been linked with reduced readmissions.[12,28] In our study, we observed a reduced rate of 30-day readmissions in patients managed by APPs. Given the morbidity and costs of repeated hospitalizations among patients with cirrhosis, further research to explore the role of APPs in providing timely post-discharge clinic follow-up is warranted.

Finally, we found that care by an APP was associated with a lower risk of death, adjusting for gastroenterology or hepatology involvement. The magnitude of benefit associated with APP care was substantial and robust across landmark and competing-risk analyses. Both outcome measures evaluated (30-day readmissions and mortality) favored APPs independent of gastroenterology/hepatology consultation. Although the mechanism deserves further study, as informed by improved quality metric adherence, care provided by APPs appears to be detail-oriented and effective.

APPs and Health Care Charges

Consistent with our finding that APPs are associated with increased quality metric performance, which involves use of radiology tests and other procedures, we found that APPs were associated with a nearly 2-fold increase in health care expenditures. This translates to an incremental $5,169 in charges per person-year. The main procedures that drove charges were radiology tests, endoscopic procedures, and liver resection. Prospective costing analyses are needed to confirm these associations as well as the appropriateness of the ordered tests/procedures. In conjunction with the associated improvement in survival, these increased charges could be cost-effective.

APPS ARE AN INTEGRAL COMPONENT OF A MODEL FOR OPTIMAL CARE

APPs are viewed as a key component of primary care delivery, in which substantial data suggests that APPs provide care equivalent in quality to MDs.[15-18] A randomized controlled trial comparing nurse practitioners practicing independently versus physicians in primary care showed no differences in mortality or other important health outcomes.[29] APP visits are associated with lower hemoglobin A1C levels and systolic blood pressure, as well as longer duration of visits and frequently lower costs.[15,30] Further, APPs are not more likely to provide low-value care, such as magnetic resonance imaging for headache.[16] Beyond primary care, when APPs are experienced and the scope of practice is well-defined, such as care of patients infected with human immunodeficiency virus, the quality of care provided is no different than that of MDs.[17]

In this study, we extend the research on quality of APP care by examining its impact on patients with cirrhosis. Cirrhosis is a highly complex medical condition with multiple challenging needs, ranging from unique indications for screening tests to frequent needs for lab monitoring and adjustment of medications such as diuretics and life-threatening complications like variceal bleeding. Roughly half of our study cohort had decompensated cirrhosis. Even in the context of these highly specialized needs, our data show that patients with cirrhosis received higher quality care when seen by APPs. We showed that compared with patients never seen by an APP, APP visits were

associated with sustained increases in quality metric adherence over time as well as reduced 30-day readmission risk, even when adjusted for co-management by gastroenterologists/hepatologists.

Overall, our data suggest that the optimal care for patients with cirrhosis may require both gastroenterologists/hepatologists and APPs. Although APP involvement was associated with higher quality care compared with no APP, the quality of care provided by APPs without gastroenterologists/hepatologists was inferior to that provided by gastroenterologists/hepatologists alone in all categories except 30-day readmissions. Our findings confirm a prior study from the VA, in which gastroenterology/hepatology consultation was associated with improved outcomes in patients with cirrhosis.[14] However, access to gastroenterologists/hepatologists is limited; among Medicare and VA enrollees, 55% and 67% of patients with cirrhosis, respectively, are never evaluated by a gastroenterologist/hepatologist.[13,14] The key opportunity suggested by our data is to encourage care delivery that leverages broader availability of APPs, to implement a care plan that is co-developed with gastroenterologists/ hepatologists.

CONTEXTUAL FACTORS

Our data must be interpreted in the context of the study design. First, we adjusted for confounding factors as thoroughly as possible given these administrative data, including diagnostic codes and procedures for cirrhosis complications; however, without access to laboratory values, we cannot directly adjust for indices of liver disease severity such as Child-Pugh-Turcotte classification and Model for End-Stage Liver Disease score. Although our study period predates recommendations to consider foregoing endoscopic screening in patients with low liver stiffness and robust platelet counts, our data lack the factors needed to determine which patients could be safely excluded from the screening denominator. Second, as this is a study of a commercial insurance database, our findings may not generalize to patients with other insurance such as Medicaid, and are limited by the loss of follow-up when patients lost coverage after loss of employment or transition to public insurers. Third, we cannot know the reasons for test ordering. As indicated in Table 2, the preconsultation rate of metric completion was higher for patients who were referred to gastroenterologists/ hepatologists compared with those about to see an APP. It is possible that, in many cases, the "screening test" may have prompted the consultation (such as by disclosing ascites or varices). As the number of visits performed increases the likelihood that a provider satisfies any given practice metric simply due to opportunity, we adjusted for the number of visits attended and provided pre/post cohorts to evaluate the temporal effect of the first visit with a gastroenterologist/ hepatologist and/or APP. Fourth, we evaluated health care charges to the system, which are typically inflated over true costs. Furthermore, the charges we describe reflect the sum of all tests/procedures incurred for any given patient, to reflect the overall expenditures associated with APP care. Prospective studies are needed to determine the charges/costs attributed to specific providers. Finally, APPs may not be a part of the health care apparatus in some countries; even within the United States there are variations in their scope of practice. In general, APPs often provide independent full-service health care, but some regions/states specify whether visits must be shared with MDs or whether prescriptions must be co-signed. Although we carefully evaluated the relative impact of shared (MD/APP) and independent (APP alone) visits, future research could assess the impact of regional differences in policy as well as temporal (before and after rules to liberalize APP practice) differences.

In conclusion, APPs, particularly when working in conjunction with gastroenterology/hepatology consultation, are associated with improved quality of care and outcomes for patients with cirrhosis. These findings have important implications for the design of interventions to improve the quality of care among patients with cirrhosis. The modest incremental expenditures associated with APP care appear to be related to their association with improved quality metric performance and, in the context of reduced mortality, may prove justifiable within the conventional definitions of cost-effectiveness. Efforts to provide APPs with training in specialty care, and to facilitate team management involving specialists and APPs to coordinate care for patients with cirrhosis, appear warranted.

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