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Association between Insurance Status and Hospital Outcomes among Acute Kidney Failure Patients

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Abstract

Objectives: To investigate the relationship between insurance status and the risk of acute kidney failure (AKF) and consequential hospitalization outcomes.

Methods: A cross-sectional regression analysis was conducted for inpatients ages 18-64 in South Carolina 2012–2013. One dichotomous dependent variable - diagnosed with AKF at hospital admission, and two continuous dependent variables of hospital outcomes - total charge and length of stay, were examined. The key explanatory variable was the patient's insurance status. Other covariates included patient's age, gender, and race as well as AKF risk factors - Type 2 diabetic mellitus (T2DM), chronic kidney disease (CKD), hypertension, and proteinuria.

Results: No insurance was significantly associated with an increased risk of AKF. The odds of having AKF with concurrent CKD diagnosed among the uninsured patients (OR 10.00) is about 1.5 times as high as that among Medicaid (OR 6.40) or private insurance patients (OR 6.91). Patients without insurance coverage incurred lower charges and were discharged earlier than those with Medicaid or private insurance. However, the presence of T2DM reversed this trend. Self-pay AKF patients with T2DM were charged 6% more and stayed in hospital 25% longer than similar patients with Medicaid. Likewise, their charges and hospital stay were 9% more than patients with private insurance.

Discussion: Insurance coverage could play a role in determining the risk of AKF and hospital outcomes. Insurance coverage could reduce underlying risk factors for AKF and its adverse consequences. Hospital investment to treat diabetes among the uninsured people in the catchment area might reduce uncompensated care and improve community health.

Keywords

Acute Kidney Failure, Uninsured, Hospital Length of Stay, Total Charges

Cover Page Footnote

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INTRODUCTION

Acute kidney failure (AKF) is one of the most common and severe conditions of hospitalized patients (Lameire et al. 2005; Waikar et al. 2006; Bagshaw et al. 2008; Bellomo at al. 2012). Incidence of AKF has gradually increased during past decades (Waikar et al. 2006; Xue et al. 2006; Li et al. 2013). Xue et al. examined the incidence of AKF using data from hospitalized Medicare beneficiaries and found that between 1992 and 2001, the overall incidence rate of AKF was 23.8 cases per 1000 discharges and the annual rate increased by approximately 11% (Xue et al. 2006). There was a significant increase of hospitalizations due to acute kidney injury, from 953,926 in 2000 to 1,823,054 in 2006 and 3,959,560 in 2014 (Pavkov ME, Harding JL, Burrows NR, 2018). Older patients, male, African Americans, and patients with chronic kidney diseases were more likely to suffer from AKF (Xue et al. 2006; Liangos et al. 2006). It was estimated that the prevalence of AKF was approximately 2% of hospitalized patients in the U.S. based on a national representative database of hospitalized patients (Liangos et al. 2006). Risk factors of AKF included diabetes mellitus, hypertension, cardiovascular disease, chronic liver disease, cancer, and cardiac surgery, etc. and improved management of these chronic diseases may decrease the risk of developing AKF for some patients (Ali et al. 2007; Hsu et al. 2008; Lafrance et al. 2010; Girman et al. 2012).

AKF poses a significant therapeutic challenge to healthcare services, with increased risk of mortality (Lameire et al. 2013). Upon diagnosis, the majority of patients with AKF are treated in inpatient settings; some of whom are treated in intensive care units (Cruz and Ronco 2007). Comprehensive therapy and close monitoring are commonly required for patients with AKF, which was associated with higher costs and prolonged hospital stay compared with other non-acute injury (Fischer et al. 2006; Chertow et al. 2005). AKF was associated with significantly increased mortality, hospital length of stay and costs across a broad spectrum of conditions (Chertow et al. 2005). The total costs of AKF, especially the long-term economic impact for patients with AKF who eventually developed chronic kidney disease (CKD), have not been well researched (Lameire et al. 2013). However, it was estimated that approximately one-third of end-stage renal disease (ESRD) was attributable to AKF (Waikar and Winkelmayer 2009). United States Renal Data System estimated that the total healthcare expenditure of ESRD was nearly $33 billion in 2012 (United States Renal Data System 2012). Therefore, prevention of AKF may yield significant savings by reducing the risk of developing CKD and ESRD.

It is known that health insurance coverage has profound impact on people's overall health status (Institute of Medicine of the National Academies 2009). It has been demonstrated that uninsured adults with chronic diseases, especially diabetes and cardiovascular disease, are more likely to delay their diagnosis, have limited access to important preventive care (including low-cost generic medications), and poorly manage their conditions than those with health insurance (Institute of Medicine of the National Academies 2009). Bowker et al. conducted a randomized controlled trial to examine the effect of providing access to self-monitoring supplies on the control of diabetes and found that patients without insurance coverage for those test strips had poorer glycemic control than patients with insurance (Bowker et al. 2004). McWilliams et al. found that compared to insured adults, uninsured adults had a significant higher HbA1c levels, which is a well-known predictor of long-term diabetic complications (McWilliams et al. 2007). Therefore, uninsured people may have a much higher risk of suffering from serious diabetic complications (e.g., kidney failure) due to the delay of care, which needs more advanced medical care services and has significant implications for healthcare resource utilization.

The §3025 of the 2010 Patient Protection and Affordable Care Act aimed at reducing all-cause readmissions (Centers for Medicare & Medicaid Services, 2012). Given AKF inpatients' high rate of readmission (Silver et al, 2017) and the uninsured population's elevated risk of hospital readmission as compared with patients with private insurance (Hasan et al, 2010), empirical evidence linking insurance status to AKF admission and hospital outcome is needed. The rising trend of AKI in recent years (Pavkov et al., 2018) and the elevated burden of Covid-19 among patients with AKF (Hirsh et al., 2020) have made it particularly urgent to address insurance disparity among AKF patients.

A growing body of evidence has shown that besides limited access to medical services for uninsured patients, no health insurance coverage may also affect healthcare providers' behaviors during their daily practices (Volpp et al. 2003; Doyle 2005). Volpp et al. reported that no health insurance was associated with decreased use of cardiac procedures and higher mortality (Volpp et al. 2003). Doyle also found a similar trend among patients with severe injuries (Doyle 2005). Compared to those with health insurance, uninsured patients received 20 percent less treatment, had shorter length of stay in hospitals and a significant higher mortality rate.

To our knowledge, no study has been conducted to assess the relationship between health insurance coverage and AKF-related outcomes during a hospital admission. The aim of this study was to investigate the association between insurance status and the risk of AKF and consequential hospital length of stay and charges.

METHODS

Data

The data used for this study came from the Inpatient component of the South Carolina (SC) Patient Encounter Database (PED) 2012-2013. The PED contained a universe of visits to all licensed healthcare facilities in SC, thus weighting is not considered. Studies that used PED have been published elsewhere (Chen et al., 2020; Charron et al., 2019; Shi et al., 2016). The data was at the episode level with information on patient demographics, diagnoses, procedures performed, and charges incurred. The analytic data included patients age 18-64 but those patients in hospital for the purpose of birth delivery were excluded. We considered two major races of White and African American who have been reported to be significantly at risk of kidney diseases (Chike et al. 2002). While multiple hospitalizations by the same patient were common in the PED, for the purpose of this study, the AKF patients were restricted to the first hospitalization only. Those reported as "self-pay" from the primary payer information were considered as uninsured.

We used *the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* and primary diagnosis code in the data to identify AKF patients. The secondary diagnoses codes were used to identify other comorbidity conditions such as Type 2 Diabetes Mellitus (T2DM), CKD, hypertension and proteinuria. Table 1 describes the ICD-9-CM code for these identifications. To ensure that the hospital charges and length of stay are related to management of renal failure, we restricted the analysis to those with AKF whom subsequently received "renal" treatment by using the All Patient Diagnosis Related Groups (APDRG) for the hospitalization.

Table 1 - ICD 9 CM Diagnose Codes for identifying subjects for the study

Conditions/Comorbidity Description	ICD9CM Diagnose Code
Diabetes Mellitus Type 2	250.00-02, 250.10-12, 250.20-22, 250.30, 250.32,250.40,250.42,250.50,250.52,250.60,250.62,250.70,250.72,250.80, 250.82,250.90,250.92
Acute Kidney Failure	584.9
Hypertension	401.0,401.1,401.9,405.01,405.09,405.11,405.19,405.91,405.99,416.0, 459.30-459.39
Hypertensive heart and chronic kidney disease	404.00-404.03,404.10-404.13,404.90-404.93, 403.00-01, 403.10-11, 403.90-91
Chronic Kidney Diseases	585.1-585.6;585.9
Proteinuria	791.0

Statistical methods

We considered three outcomes, each of them was considered in a separate regression model. The first one was being diagnosed with AKF at hospital admission, constructed as a dichotomous variable. The second one was hospital length of stay, measured as number of days between admission and discharge. The third one was total charges for the hospital visit. Our key explanatory variable was the patient's insurance status: self-pay (reference group) vs. Medicaid vs. private insurance. There other covariates were patient characteristics including age, gender, race, and those risk factors for AKF including T2DM, CKD, hypertension and proteinuria. The variable CKD included all diagnosis codes for single stage CKD, end stage kidney disease, unspecified CKD, hypertensive CKD stages 1 through 4, and hypertensive CKD stage 5 through end stage. All these risk factor variables were constructed dichotomously, taking the value of one with the presence of the condition and zero otherwise.

A multivariate logistic regression was used to estimate the relationship between the risk of AKF (first outcome) and patient's insurance status. A multivariate linear regression model was used to examine length of stay (second outcome) and total charges (third outcome). We used a logarithm transformation for the second and third outcome variables. Given our primary interest in the association between the insurance status and the outcomes, the respective coefficients in the linear regression can be interpreted as percentage change in the dependent variable with respect to a change in the insurance status. The model with total charges as the outcome also included length of hospital stay as an independent variable since this variable was a key determinant of charges.
In the linear models, we studied the changing association of insurance status with the presence of comorbid conditions by interacting the insurance status variable with the comorbidity variables. In the logistic model, we analyzed the interaction by defining a set of dichotomous variables

separately for six groups of insurance status and comorbidities. Our goal was to examine the risk of having AKF facing individuals who were different from one another by either insurance coverage or the presence of comorbidities. The logistic regression coefficient estimates therefore represent the odds ratio of having AKF relative to the reference group, which is self-pay patients without T2DM. Our empirical models were specified as follows:

$$Logit\ (p_i) = \alpha_0 + \alpha_1 G_1 + \alpha_2 G_2 + \alpha_3 G_3 + \alpha_4 G_4 + \alpha_5 G_5 + \alpha_i X_i + e_i$$
$$LnY_j = \beta_0 + \beta_1 I + \beta_2 C + \beta_3 I{*}C + \beta_j X_j + u_j$$

In these equations, p is the probability of having AKF, Y were the outcomes of AKF related hospitalization, G_1 to G_5 represented five groups of insurance status and comorbidities (group 6 is the reference), X represented covariates, I was the variable of insurance status, C represented comorbidity conditions, and $I{*}C$ represented the interaction between insurance and comorbidities. We applied the robust standard errors for the estimates. The statistical analysis was conducted using STATA 14.1.

RESULTS

Table 2 presents the characteristics of patients under study. During the study period, 2,718 patients were diagnosed as having AKF at hospital admission. Compared with non-AKF patients, AKF patients tended to be older, male, and African American. These patients were more likely to be self-pay or covered by Medicaid insurance. AKF patients were more likely to be diagnosed with CKD, especially high among the categories of stage 4, stage 5, and unspecified CKD and hypertensive CKD stage 1 through stage 4. The prevalence of T2DM and proteinuria were also higher among AKF patients.

Table 2 – Characteristics of patients primarily diagnosed with and without AKF

Characteristic	Patients primarily diagnosed with AKF (N=2718)	Patients not primarily diagnosed with AKF (N=246366)	P- value for all comparisons
Mean age at hospitalization (years)	50.3	45.8	0.00
Men %	57.58	43.84	0.00
Race %			
White	49.93	64.41	0.00
African American	50.07	35.59	0.00
Insurance status %			
Self-pay	27.37	21.38	0.00
Medicaid	31.68	28.38	0.00
Private	40.95	50.23	0.00

Diagnosed Chronic Kidney Disease %			
Stage 1	0.04	0.05	0.82
Stage 2	1.80	0.36	0.00
Stage 3	9.82	1.50	0.00
Stage 4	6.29	0.67	0.00
Stage 5	2.43	0.18	0.00
End stage	4.12	1.53	0.00
Unspecified	13.10	2.20	0.00
Hypertensive CKD stage 1 through 4	28.00	3.80	0.00
Hypertensive CKD stage 5 through end stage	6.88	1.32	0.00
Diagnosed Type 2 Diabetic Mellitus %	36.87	19.96	0.00
Diagnosed Proteinuria %	1.43	0.17	0.00
Diagnosed Hypertension %	38.70	39.02	0.73

Note: AKF - Acute Kidney Failure

Table 3 presents the logistic estimation of risk factors for being diagnosed with AKF at hospital admission. The estimation was adjusted for patient's demographics (age, race and gender) and other risk factors which are well known for affecting AKF (T2DM, CKD, proteinuria, and hypertension). The estimates in Column 1 indicated that patient's insurance status alone significantly and independently predicted the risk of diagnosed AKF. Compared with self-pay patients, those with Medicaid or private coverage were predicted to have a lower odds ratio of AKF by about one fourth to one third. Column 2 presents the estimates from the model in which the association with insurance status was allowed to vary by the presence of T2DM. Similar to the previous results, those patients with insurance coverage seemed to have lower odds of having AKF. Furthermore, the risk of AKF seemed to increase among those self-pay patients with T2DM though the coefficient estimate for this group was not statistically significant. Among the patients with T2DM, those with private insurance were likely to have the lowest risk of AKF. The estimates in Column 3 allows for the insurance effect to vary with the presence of CKD condition. While the absence of CKD seemed to help in lowering the odds of having AKF, its presence apparently increased these odds across all insurance statuses. It is also noted that the odds for having AKF with concurrent CKD diagnosed among the self-pay patients (OR 10.00) was about 1.5 times as high as that among the Medicaid (OR 6.40) or private insurance patients (OR 6.91).

Table 3 – Risk factors for Acute Kidney Failure at hospitalization: Results from multivariate logistic regression

	Multivariate OR (p-value, 95% CI)	OR with and without Type 2 Diabetic Mellitus (p-value, 95% CI)	OR with and without chronic kidney disease (p-value, 95% CI)
	(1)	(2)	(3)
Insurance status			
Self-pay	1.00 (Reference)		
Medicaid	0.77 (0.00, 0.70-0.86)		
Private	0.62 (0.00, 0.56-0.68)		
selfpay#no_T2DM		1.00 (Reference)	
selfpay#T2DM		1.10(0.19, 0.95-1.31)	
medicaid#no_T2DM		0.74(0.00, 0.65-0.84)	
medicaid#T2DM		0.94(0.44, 0.81-1.09)	
private#no_T2DM		0.59 (0.00, 0.53-0.66)	
private#T2DM		0.77 (0.00, 0.68-0.89)	
selfpay#no CKD			1.00 (Reference)
selfpay# CKD			10.00 (0.00, 8.37-11.94)
medicaid# no CKD			0.89(0.06, 0.78-1.01)
medicaid# CKD			6.40(0.00, 5.42-7.55)
private# no CKD			0.58(0.00, 0.52-0.66)
private# CKD			6.91(0.00, 5.87-8.13)
Type 2 Diabetic mellitus	1.25 (0.00, 1.14-1.36)		1.24 (0.00, 1.13-1.35)
Chronic Kidney Disease	9.54 (0.00, 8.45-10.78)	9.55(0.00, 8.45-10.79)	
Proteinuria	3.30 (0.00, 2.30-4.78)	3.31(0.00, 2.31-4.74)	3.28 (0.00, 2.29-4.72)
Hypertension	1.86 (0.00, 1.67-2.08)	1.87(0.00, 1.67-2.08)	1.88 (0.00, 1.68-2.09)
Female	0.71(0.00,0.65-0.77)	0.71(0.00,0.66-0.77)	0.71(0.00,0.66-0.77)
African-American	1.34(0.00,1.22-1.46)	1.33(0.00,1.22-1.46)	1.33(0.00,1.21-1.45)
Age	1.01(0.00,1.01-1.02)	1.01(0.00,1.01-1.02)	1.01(0.00,1.01-1.02)

Prob > chi2	0.00	0.00	0.00
N	249084	249084	249084

Note:

- OR : Odds ratio, T2DM: Type 2 Diabetic Mellitus, CKD: Chronic Kidney Disease
- All models use logistic regression method and are adjusted for age group, race and gender

In Table 4, we estimated the linear model of the relation between AKF-related hospitalization outcome (length of stay, total charge) and insurance status. For each outcome we specified the interactive variable of insurance status with the two comorbidities: T2DM and CKD. The estimation was also adjusted for patient's demographics and diagnosed AKF risk factors. In general, those patients without insurance coverage seemed to be charged lower (between 6% and 7% lower) and were discharged earlier (between 22% and 24% shorter stay) than those covered by Medicaid. The similar trend was seen when comparing self-pay patients with the private insurance patients, though these estimate coefficients were not statistically significant. The presence of secondary diagnoses of T2DM (first two columns) seemed to reverse this association. Self-pay AKF patients with T2DM, which served as the reference group for this model, were likely to incur 6% higher charges and stay in the hospital 25% longer than similar patients with Medicaid. Likewise, their charges and hospital stay likely increased by 9% higher than AKF patients with private insurance. These results held true when the presence of CKD was allowed to interact with insurance statuses though the estimates were not statistically significant (last two columns).

Table 4 – Interaction effect between insurance status and comorbidities on AKF related hospital outcomes: Results from Log-Linear regression model

	Insurance x T2DM		Insurance x CKD	
	LoS (1)	Charge (2)	LoS (3)	Charge (4)
Self-pay (ref.)	0	0	0	0
Medicaid	0.24**[0.14,0.33]	0.07+[0.00,0.13]	0.22**[0.12,0.31]	0.06+ [-0.00,0.13]
Private	0.07[-0.02,0.16]	0.04[-0.02,0.10]	0.07+ [-0.01,0.16]	0.00[-0.06,0.06]
w/o T2DM (ref.)	0	0	0	0
w/t T2DM	0.15**[0.04,0.26]	0.11**[0.03,0.19]	0.02[-0.04,0.08]	0.05*[0.01,0.10]
w/o CKD	0 [0.00,0.00]	0[0.00,0.00]	0[0.00,0.00]	0[0.00,0.00]
w/t CKD	0.14**[0.05,0.22]	0.11**[0.05,0.17]	0.24**[0.11,0.36]	0.11*[0.02,0.20]
Self-pay#T2DM	0	0		
Medicaid#T2DM	-0.25**[-0.41,-0.10]	-0.06[-0.16,0.05]		
Private#T2DM	-0.09[-0.23,0.04]	-0.09+[-0.19,0.01]		

Self-pay#CKD (ref.)			0	0
Medicaid#CKD			-0.19* [-0.35,-0.04]	-0.03[-0.14,0.07]
Private#CKD			-0.08[-0.22,0.06]	0.02[-0.08,0.12]
Proteinuria	0.05[-0.17,0.26]	0.05[-0.12,0.23]	0.06[-0.16,0.27]	0.06[-0.12,0.23]
Hypertension	-0.16**[-0.24,-0.08]	-0.03[-0.09,0.02]	-0.16**[-0.24,-0.08]	-0.03[-0.09,0.02]
Female	0.17**[0.11,0.22]	0.07**[0.03,0.11]	0.17**[0.11,0.22]	0.07**[0.03,0.11]
African-American	-0.01[-0.07,0.05]	-0.01[-0.05,0.04]	0[-0.06,0.06]	-0.01[-0.05,0.03]
Expired	0.03[-0.27,0.32]	0.11[-0.07,0.30]	0.01[-0.28,0.31]	0.11[-0.07,0.30]
Patient's age	0.01**[0.00,0.01]	0[-0.00,0.00]	0.01**[0.00,0.01]	0[-0.00,0.00]
Length of stay		0.11**[0.09,0.12]		0.11**[0.09,0.12]
R-squared	0.098	0.525	0.097	0.525
Prob > F	0.00	0.00	0.00	0.00
N	2718	2718	2718	2718

Note:

- AKF : Acute Kidney Failure
- LoS ; Length of stay of each hospitalization
- All models are specified as log linear with the dependent variable being the logarithm of length of stay and charge, respectively. Regressions also include a constant.
- + p<0.10, * p<0.05, ** p<0.01. 95% CI is in square bracket.

DISCUSSION

While having health insurance coverage has been generally recognized as conducive to the improvement of population health outcomes, its role as related to the long-term risk for, as well as the hospitalization outcomes of severe medical conditions is not completely understood (Ayanian et al. 2000; Wilper et al. 2009; Sommers et al. 2012). Of these problems, AKF is one of the most critical renal conditions among hospitalized patients and its incidence has reportedly increased worldwide (Lameire et al. 2005; Li et al. 2013). Adverse financial consequences facing AKF patients is often substantial, especially for those uninsured patients who require dialysis to recover (Chertow et al. 2005).

Previous research in the field of nephrology has documented several leading risk factors of AKF including Chronic Kidney Disease, Type 2 Diabetic Mellitus, proteinuria and hypertension (Hsu et al. 2008; Lafrance et al. 2010; Girman et al. 2012). Even though our analysis only considers the primary diagnoses of AKF at the hospital admission, our results point to the same direction as the previous findings regarding the risk factors for developing AKF. We found that the odds ratio increased more than nine-fold with the coexistence of CKD and more than threefold with the coexistence of proteinuria in both models (without and with interaction between insurance status and T2DM and CKD). T2DM together with its coincident complication of hypertension are well established as important risk factors of CKD through the progression of diabetic nephropathy (Nahas and Bello 2005; Ritz 1999). These studies suggest that appropriate management of T2DM complications may slow down the progression of CKD through blood pressure and glycaemia control (Nahas and Bello 2005; The ADVANCE Collaborative Group Intensive Blood Glucose Control and Vascular Outcomes in Patients with Type 2 Diabetes. *N Engl J Med* 2008; The Action to Control Cardiovascular Risk in Diabetes Study Group. Effects of Intensive Glucose Lowering in Type 2 Diabetes. *N Engl J Med*. 2008; Patel 2007).

As far as the role of health insurance is concerned, many studies have presented evidence on the link between health insurance coverage and the quality of diabetic care. In one study, lack of health insurance is found to prevent patients from having self-monitoring test strips and thus leads to poorer glycemic control (Bowker et al. 2004). Level of deprivation, often correlated with lack of insurance, are found to be negatively associated with glycemic control (Laurent et al. 2005). Nelson et al. found that uninsured adults with diabetes receive fewer preventive services than those with health insurance (Nelson et al. 2005). Providing care to diabetic patients who are not qualified for other public aid has been found to enable the uninsured patients to maintain the same level of hemoglobin A1C or blood pressure as the insured patients (Leither and Ontrop 2012). Thus, the role of health insurance in reducing the risk and in improvement of AKF-related hospital outcomes should necessitate further investigation. Our study is in line with the notion that insurance coverage is helpful in gaining access to preventive care thus conducive to the reduction of consequential prevalence and cost of clinical care (Schoen and DesRoches 2000).

Our study contributes to the better understanding of this research area in some important perspectives. First, using South Carolina Inpatient Encounter Data in which insurance status information is available enables us to directly link the insurance status to AKF, related secondary diagnosed comorbidities, and AKF related hospital outcomes. The considerable sample size also allows us to stratify the analysis by comorbidity condition to substantiate the role of insurance so as to generalize the results in a larger population. Second, by considering the interaction between patient's insurance and risk factors for AKF, our analysis provides an insight into how insurance coverage might act as a modifying factor in determining the long-term risk of critical health conditions.

Our results indicate that the risk of AKF together with the presence of either T2DM or CKD is higher among uninsured patients than privately insured patients and Medicaid patients. This is corroborated by the similar finding that AKF related hospital length of stay and hospital charge for those patients with either T2DM or CKD differ by insurance status. Particularly, self-pay patients are charged higher rates and their hospital stays are extended longer. Provided that T2DM and CKD are primary risk factors for having AKF as well as complicating its treatment procedure, our results indicate the role of insurance coverage in mitigating these risks. Insurance coverage could have provided patients having a history of T2DM and CKD with relatively easier access to renal-protective and cardio-protective treatments prior to hospitalization. This in turn contributes to the delay of the onset of underlying risk factors of CKD. Studies have found the potential positive effect of earlier CKD consultation towards the reduction in mortality and hospital length of stay among AKF patients with the CKD history (Khosla et al. 2009). Lack of insurance could also prevent patients with diabetes from regular and timely adherence to effective medication for controls of blood pressure and glycaemia level, which are crucial to delay the progression of diabetic nephropathy (Gandelman et al. 2004; Piette et al. 2004). Late referral to a nephrologist for renal treatment has been well documented as one major obstacle for optimal renal therapy to prevent the CKD from advancing to higher stages (Jungers 2002; Wavamunno and Harris 2005). Late referral is found to be higher among patients without health insurance (Kinchen et al. 2002; Arora et al. 1999).

Limitations of our studies should be recognized. First, our dependent variable of hospital charge is different from the actual cost that occurred in the hospital, and thus we cannot claim that self-pay AKF inpatients with T2DM incurred more expenses than those insured. However, the fact that self-pay AKF inpatients with T2DM stayed longer in hospital than those with insurance suggests that at least in terms of some inpatient resources (such as beds and room) the former could have consumed more than the latter. Financially this might not be an optimal scenario for hospitals since much of the expenses incurred by the self-pay inpatient could end up uncompensated (Coughlin et al. 2013). Second, our sample excluded non-White and non-African, thus limiting the generalization. Next, socio-economic information on patients was very limited, and thus potentially biasing the estimated relationship due to unobserved or unobservable patient characteristics. For instance, we did not have a measure of patients' education which typically has a positive effect on insurance status and health outcomes. It could very well be lower education level that is an underlying reason for uninsured status and higher chance of having AKF. Last but not least, causal relationship cannot be conferred due to the cross-sectional design.

CONCLUSION

A preventive role of insurance is to help patients gain access to earlier renal-protective treatment and thus potentially reduce the risk of hospitalized AKF as well as improves the consequential hospital outcome. Recent literature shows that that Medicaid expansion had reduced uninsured hospital stay (Nikpay et al. 2016). It might be optimal for hospitals to provide diabetes prevention and treatment to uninsured prediabetes and diabetes patients living in their catchment area, a kind of community service that might serve both the role of accountable care organizations (Clarke et al. 2016) and the purpose of cost savings from reducing uninsured hospital stays of AKF patients with T2DM. Our findings suggest that future research is needed to quantify the protective effect of insurance on reduced hospitalization due to AKF.

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