Epidemiology and Clinical Correlates of AKI in Chinese Hospitalized Adults

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Abstract

Background and objectives Comprehensive epidemiologic data on AKI are particularly lacking in Asian countries. This study sought to assess the epidemiology and clinical correlates of AKI among hospitalized adults in China.

Design, setting, participants, & measurements This was a multicenter retrospective cohort study of 659,945 hospitalized adults from a wide range of clinical settings in nine regional central hospitals across China in 2013. AKI was defined and staged according to Kidney Disease Improving Global Outcomes criteria. The incidence of AKI in the cohort was estimated using a novel two-step approach with adjustment for the frequency of serum creatinine tests and other potential confounders. Risk factor profiles for hospital-acquired (HA) and community-acquired (CA) AKI were examined. The in-hospital outcomes of AKI, including mortality, renal recovery, length of stay, and daily cost, were assessed.

Results The incidence of CA-AKI and HA-AKI was 2.5% and 9.1%, respectively, giving rise to an overall incidence of 11.6%. Although the risk profiles for CA-AKI and HA-AKI differed, preexisting CKD was a major risk factor for both, contributing to 20% of risk in CA-AKI and 12% of risk in HA-AKI. About 40% of AKI cases were possibly drug-related and 16% may have been induced by Chinese traditional medicines or remedies. The in-hospital mortality of AKI was 8.8%. The risk of in-hospital death was higher among patients with more severe AKI. Preexisting CKD and need for intensive care unit admission were associated with higher death risk in patients at any stage of AKI. Transiency of AKI did not modify the risk of in-hospital death. AKI was associated with longer length of stay and higher daily costs, even after adjustment for confounders.

Conclusion AKI is common in hospitalized adults in China and is associated with significantly higher in-hospital mortality and resource utilization.

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Introduction

AKI is a syndrome of abrupt loss of kidney function that is strongly associated with higher mortality and morbidity (1–5). AKI is common in hospitalized patients, occurring in 0.7%–77% of adult patients depending on the definition and the population studied (6,7). The reported mortality rate of AKI in hospitalized adults has ranged from 14% to 60% despite considerable advances in medical care practice and RRT during the past few decades (8–10).

AKI is increasingly prevalent in both developing and developed countries (11). Although many epidemiologic reports on AKI have appeared in the literature, nearly 90% of them are from developed Western countries, which represent only 15% of the world population (12). In particular, the epidemiology and clinical associations of AKI in hospitalized adults have not been extensively assessed in developing Asian countries.

For many years, varying definitions of AKI have been used in the literatures, making comparisons between studies difficult. In 2012, the Kidney Disease Improving Global Outcomes (KDIGO) Work Group developed a consensus-based AKI defining and staging system drawing on consolidating elements of previously proposed criteria (13). The KDIGO definition, as a standardized criterion, has been adopted by professional societies in both developed and developing countries (14–17), making it possible to evaluate and compare the incidence and clinical effect of AKI across countries and populations. More accurate information on the burden of AKI and its consequences will help to optimize prevention and intervention of the syndrome.

This large, retrospective, population-based study on AKI in hospitalized adults from nine regional central hospitals across China encompassed a wide range of clinical settings and both general and critical care populations. We used a novel analytical method to obtain an unbiased estimate of the incidence of AKI according to the KDIGO definition and described the risk profile, cost, and in-hospital outcomes of AKI in China, a large Asian country with 20% of the world population.

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Materials and Methods

Study Design, Setting and Population

The Epidemiology of AKI in Chinese Hospitalized adults (EACH) study is a multicenter retrospective population-based cohort study conducted in nine regional central hospitals that served a combined population of 300 million people across northern, central, and southern China. The study cohort included all patients aged 15–99 years admitted between January 1 and December 31, 2013, excluding those with stages 4–5 CKD and those receiving maintenance dialysis or renal transplantation. We selected from the cohort patients who had at least two serum creatinine (SCr) tests within any 7-day window during their first 30 days of hospitalization as the analysis set (Figure 1). For patients with multiple hospitalizations, we included only the first hospitalization in the analysis set.

Data Sources

We obtained patient-level data from the electronic hospitalization databases and laboratory databases from the participating hospitals. The hospitalization records consisted of patients' age, sex, admission and discharge data, operation procedures and dates, in-hospital death, and total cost. The laboratory data included patients' SCr values and test time. The assays for SCr had been calibrated to be traceable to isotope dilution mass spectrometry. Trained nephrologists also manually reviewed the medical records of the patients with AKI and evaluated their exposure to nephrotoxic drugs and other risk factors prior to AKI. The Medical Ethics Committee of Nanfang Hospital approved the study protocol and waived patient consent.

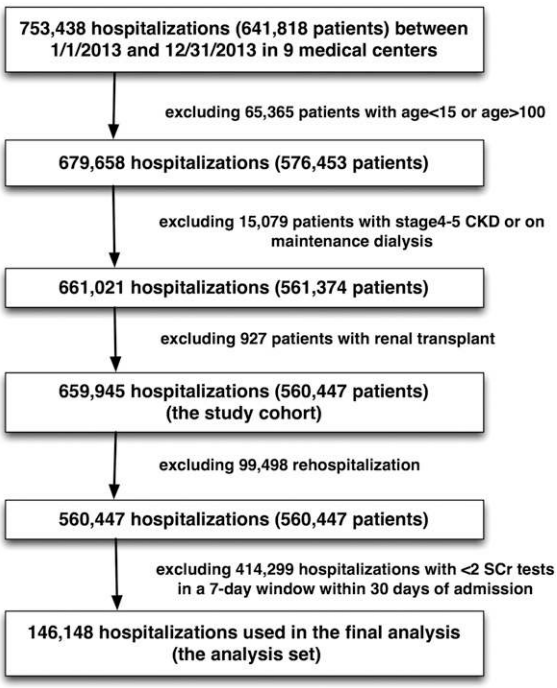

Figure 1. | Flow chart of the study population selection. SCr, serum creatinine.

Identification and Classification of AKI

AKI was defined as an increase in SCr by 0.3 mg/dl within 48 hours or a 50% increase in SCr from the baseline within 7 days according to the KDIGO criteria (13). To screen the patients with AKI in the analysis set, the SCr data during hospitalization were sorted in increasing order according to the test time. At any time point t, a baseline SCr was dynamically defined as the mean of SCr levels within the 7 days before t, and each of the available SCr data within 7 days after t was compared with this baseline. The earliest day that the SCr change met the KDIGO criteria was defined as the date of AKI onset.

Patients who met at least one of the following criteria were classified as having community-acquired (CA) AKI: (*1*) Patient was admitted with AKI according to diagnosis code; (*2*) SCr change on the first day of admission met the KDIGO definition; and (*3*) SCr on admission was ≥1.4 mg/dl in men or ≥1.1 mg/dl in women (corresponding to 1.5-fold of the SCr level in a 60-year-old man or woman with an eGFR of 90 ml/min per 1.73 m^2) and ≥1.5 fold of the minimal SCr level during hospitalization. In these cases, the lowest SCr during hospitalization was used as the baseline.

Patients who developed AKI but did not meet CA-AKI criteria were identified as having hospital-acquired (HA) AKI. The stage of AKI was determined using the peak SCr level after AKI onset (13). We considered an AKI case to be drug-related if the case (*1*) was diagnosed by renal biopsy or (*2*) was associated with a nephrotoxicity exposure within 1 week before AKI and no other obvious causes of AKI.

Definition of Outcomes

The primary outcome of AKI in this study was the time to in-hospital death. Other outcomes included the time to renal recovery, requirement for RRT, length of stay in hospital (LOS), and daily cost of hospitalization. An AKI was considered to be renal recovered if the SCr was decreased to within the non-AKI range and was at least 0.3 mg/dl below the peak level in the absence of RRT. We considered an AKI case to be transient if renal recovery occurred within 3 days of onset (18).

Determination of Comorbidity

Presence of comorbidities was determined by the diagnosis codes at admission and discharge. CKD was identified by the diagnosis codes, a baseline eGFR<60 ml/min per 1.73 m^2 in patients with AKI, or the highest eGFR<60 ml/min per 1.73 m^2 in patients without AKI (19). The burden of comorbidity was determined using the Charlson comorbidity score (20).

Statistical Analyses

Incidence of AKI in the Analysis Set. We calculated the unadjusted incidence of AKI subtypes (CA-AKI or HA-AKI) as follows:

$$\frac{\text{number of AKI subtype}}{\text{size of study population}} \times 100\%.$$

The detection rate of AKI (r) using the KDIGO criteria depended on the frequency of SCr tests (d), which was

Table 1. Demographic and clinical characteristics of the analysis set by AKI strata

Characteristic	Non-AKI (*n*=131,163)	CA-AKI (*n*=4562)	HA-AKI (*n*=10,423)	*P* Value
Age (yr)	53.9±17.2	57.8±18.8	58.0±17.3	<0.001
Age group (%)				<0.001
15–39 yr	20.9	18.6	14.9	
40–59 yr	39.5	31.2	36.2	
60–79 yr	33.5	36.9	38.3	
80–99 yr	6.1	13.3	10.6	
Male patients (%)	54.8	58.8	60.5	<0.001
Geographic location (%)				<0.001
Northern	26.4	30.7	26.4	
Central	32.9	31.7	28.4	
Southern	40.7	37.5	45.2	
Preexisting CKD (%)	6.6	30.7	21.3	<0.001
Charlson comorbidity index	3.3±2.3	4.0±2.6	4.0±2.5	<0.001
No. of SCr tests	3.4±2.5	7.6±9.3	8.1±8.5	<0.001
Frequency of SCr test[a]	0.40±0.24	0.52±0.27	0.49±0.27	<0.001
AKI stage (%)				<0.001
1	–	37.7	66.9	
2	–	26.7	17.0	
3	–	35.6	16.1	
Required intensive care (%)	8.4	24.8	33.8	<0.001
Required dialysis (%)	–	4.5	3.5	<0.001
In-hospital death (%)	0.6	4.7	10.6	<0.001
Length of stay (d)	13 (9, 19)	16 (10, 25)	18 (11, 28)	<0.001
Daily cost (CNY)	1709 (1045, 2992)	1879 (1146, 3537)	2842 (1590, 4730)	<0.001

Length of stay and daily cost are presented in median (25th,75th percentile). Values expressed with a ± sign are presented as mean±SD.
SCr, serum creatinine; CNY, Chinese yuan; CA, community-acquired; HA, hospital-acquired.
[a]Defined as number of days with SCr tests divided by length of stay.

defined as the number of days with SCr data divided by LOS. To obtain the empirical relationship between r and d, we selected 448 HA-AKI cases with complete SCr data during the 7-day window (*i.e.*, having daily SCr data for all 7 days after the baseline) from the analysis set. For each selected case, we derived 128 unique sets of SCr data with all possible permutations of missing data, and we calculated d for each set and its AKI status according to the KDIGO definition. We fitted r using a polynomial function of d, with the following resultant equation (Supplemental Figure 1A):

$$r = 5.77d - 19.7d^2 + 36.2d^3 - 32.4d^4 + 11.1d^5$$

We calculated the adjusted incidence of HA-AKI as follows:

$$\frac{\text{number of HA-AKI}}{\text{number of HA-AKI} + \text{sum of r over Non-AKI}} \times 100\%,$$

where r was the AKI detection rate calculated from the patients' SCr test frequency (d). We also calculated the cumulative incidence of HA-AKI using the weighted Kaplan–Meier method with the weight of r for patients without HA-AKI and 1 for HA-AKI patients. The AKI models have been cross-validated internally (Supplemental Material).

Incidence of AKI in Study Cohort. The incidence calculated for the analysis set may differ from that for the whole cohort because of the difference in the AKI risk factors profiles. To extrapolate the AKI incidence estimated in the analysis set to the whole cohort, we first built a Cox proportional hazard model for HA-AKI and a logistic regression model for CA-AKI in the analysis set, adjusting for all known risk factors, including age, sex, comorbidities, and operation procedures, and then calculated the expected number (or probability) of AKI events for each patient in the whole cohort under the corresponding model given the observed covariates and LOS. We estimated the AKI incidence in the whole cohort as follows:

$$\frac{\text{sum of expected number of AKI over patients}}{\text{number of subjects}} \times 100\%.$$

Risk Factors and Outcomes in the Analysis Set. We used the Cox proportional hazard model to estimate the hazard ratios (HRs) of all possible risk factors for HA-AKI, including age, sex, comorbidities, clinical procedures, and hospital strata in the analysis set. Similarly, we used the logistic regression model to estimate the odds ratios (ORs) of the above risk factors for CA-AKI. We also estimated the population attributable fractions (PAF) of the significant risk factors empirically identified in the study population.

We calculated the cumulative rates of in-hospital death in the subgroups by AKI status using the Kaplan–Meier method and estimated the corresponding HRs using the Cox proportional hazard model with adjustment for age, sex, comorbidities, and clinical procedures. We further performed an analysis with the Cox model to test whether preexisting CKD, need for intensive care, and transient

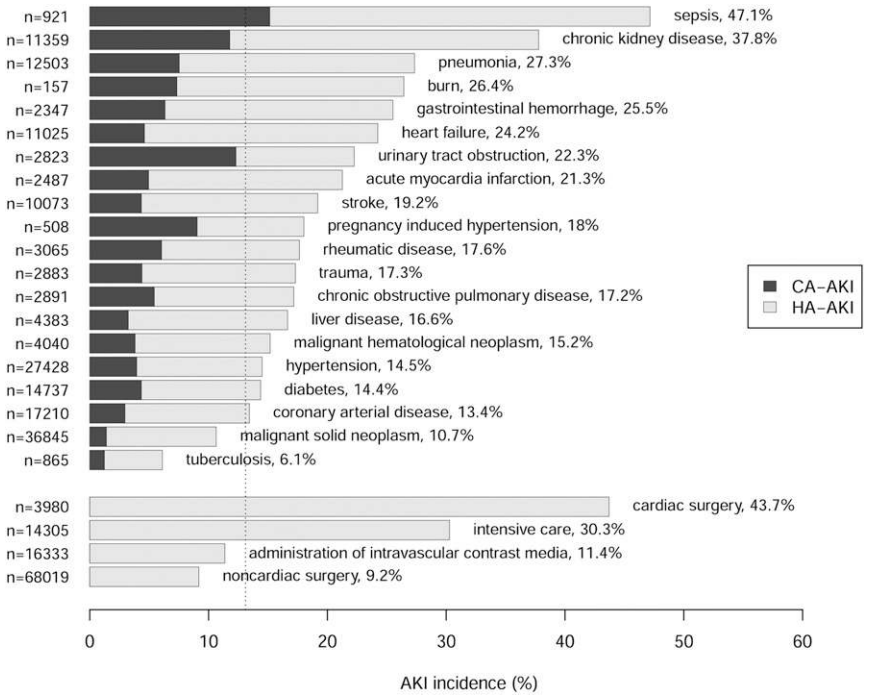

Figure 2. | **Incidence of AKI in various clinical settings**. The number of patients with a clinical setting is indicated by n. The dotted vertical line specifies the overall incidence of AKI in the analysis set. For clinical procedures during hospitalization, only hospital-acquired AKI (HA-AKI) was counted. CA-AKI, community-acquired AKI.

HA-AKI modified the HRs of in-hospital death at different AKI stages. We also compared the effect of AKI on average daily cost during hospitalization and LOS under a linear regression model with log transformation of the response variable and adjustment for age, sex, comorbidities, clinical procedures, and hospital strata.

We performed all statistical analyses using R software, version 3.1.1, and the survival package, version 2.37.

Results

Of 659,945 hospitalizations in the study cohort, 70.2% had none (8.6%) or only one (61.6%) SCr test during hospitalization. A total of 146,148 hospitalizations met our inclusion and exclusion criteria (Figure 1) and constituted the analysis set for risk and outcome analysis. We identified 10,423 HA-AKI cases and 4562 CA-AKI cases from the analysis set. The characteristics of the patients stratified by AKI subtype are summarized in Table 1. Compared with the non-AKI group, the AKI group had a higher percentage of male patients, elderly patients, and patients with preexisting CKD, as well as higher comorbidity scores.

Incidence of AKI

We calculated the raw incidence of AKI at 10.7% (CA-AKI at 3.3% and HA-AKI at 7.4%) in the analysis set. As shown in Supplemental Figure 1A, the frequency of SCr tests had a large effect on the detection rate of HA-AKI. If only one SCr test was performed during the 7-day period, approximately 48% of the HA-AKI cases would have been missed. The mean frequency of SCr tests in the analysis was 0.41 (*i.e.*, SCr data were available for 41% of the days during hospitalization), which corresponded to an AKI detection rate of 76%. Incidence adjusted for the frequency of SCr tests was 13.1% (CA-AKI at 3.3% and HA-AKI at 9.8%). Incidence extrapolated to the study cohort was 11.6% after adjustment for age, sex, comorbidity, and operation procedures. It is also noteworthy that the incidence of HA-AKI increased almost linearly with LOS during the first 30 days of hospitalization (Supplemental Figure 1B), with a weekly incidence of 6.9% in the analysis set.

Risk Factors for AKI

The incidence of CA-AKI and HA-AKI in various clinical settings is depicted in Figure 2. The three clinical settings with the highest incidence of CA-AKI were sepsis (15.2%), urinary tract obstruction (12.3%), and CKD (11.8%). For HA-AKI, the top three settings were cardiac surgery (43.7%), sepsis (32.0%), and intensive care (30.3%). While the incidence of HA-AKI increased with age across the spectrum of age, the association between CA-AKI and age was observed only in patients older than 60 years. Male patients had an approximately 6% higher risk of both CA-AKI and HA-AKI than female patients. We estimated the PAF of the risk factors to assess their contribution to AKI. The top three risk factors, ranked in order of decreasing PAF, were as follows: CKD, pneumonia, and urinary tract obstruction for CA-AKI and intensive care, CKD, and cardiac surgery for HA-AKI (Table 2). CKD was a major contributor to both HA-AKI and CA-AKI.

More than 40% of AKI cases were possibly drug induced (39.2% in patients with CA-AKI and 42.9% in patients with HA-AKI) (Table 3). Contrast media–induced AKI was found in 9.1% of patients with HA-AKI. It is noteworthy

Table 2. Major risk factors for community- and hospital-acquired AKI

Risk Factors	Frequency (%)	CA-AKI		HA-AKI	
		OR (95% CI)[a]	PAF (%)	HR (95% CI)[a]	PAF (%)
Age					
15–39 yr	20.5	Reference		Reference	
40–59 yr	38.9	0.98 (0.89 to 1.08)		1.17 (1.10 to 1.25)	
60–79 yr	33.9	1.13 (1.02 to 1.25)		1.25 (1.17 to 1.34)	
80–99 yr	6.8	1.57 (1.36 to 1.79)		1.30 (1.18 to 1.43)	
Sex					
Female	44.6	Reference		Reference	
Male	55.4	1.06 (0.99 to 1.14)		1.06 (1.02 to 1.11)	
Clinical settings					
Preexisting CKD	7.6	4.10 (3.78 to 4.44)	20.1	3.00 (2.84 to 3.18)	12.1
Pneumonia	9.2	2.05 (1.88 to 2.23)	10.1	1.10 (1.03 to 1.16)	1.5
Shock	1.1	4.62 (3.97 to 5.37)	5.0	2.25 (2.05 to 2.48)	2.6
Urinary tract obstruction	2.1	4.10 (3.60 to 4.66)	5.8	1.17 (1.01 to 1.36)	0.3
Sepsis	0.7	2.86 (2.31 to 3.54)	1.8	1.19 (1.03 to 1.38)	0.3
Gastrointestinal bleeding	1.7	1.47 (1.22 to 1.78)	1.0	1.42 (1.27 to 1.59)	1.0
Pregnancy-induced hypertension	0.4	3.39 (2.45 to 4.68)	0.8	2.35 (1.66 to 3.32)	0.2
Intensive care	10.7	–		2.35 (2.23 to 2.48)	17.7
Cardiac surgery	3.0	–		1.81 (1.66 to 1.97)	5.7
Noncardiac surgery	50.9	–		1.07 (1.02 to 1.12)	3.1
Heart failure	8.3	1.07 (0.96 to 1.20)		1.30 (1.22 to 1.39)	3.8
Liver disease	3.3	1.04 (0.86 to 1.25)		1.28 (1.16 to 1.42)	1.0
Stroke	7.5	1.01 (0.90 to 1.14)		1.19 (1.11 to 1.27)	1.8
Acute myocardial infarction	1.9	1.05 (0.85 to 1.28)		1.42 (1.26 to 1.59)	0.9
Diabetes	11.1	1.16 (1.05 to 1.28)	1.8	0.86 (0.80 to 0.92)	
Rheumatic disease	2.3	1.64 (1.39 to 1.94)	1.5	1.07 (0.94 to 1.22)	
Hematologic malignancy	3.0	1.29 (1.08 to 1.54)	0.8	0.97 (0.87 to 1.10)	
Trauma	2.2	1.22 (1.01 to 1.49)	0.5	0.97 (0.86 to 1.10)	
Burn	0.1	2.22 (1.14 to 4.31)	0.1	1.16 (0.75 to 1.78)	

CA-AKI, community-acquired AKI; OR, odds ratio; 95% CI, 95% confidence interval; PAF, population attributable fraction; HA-AKI, hospital-acquired AKI.
[a]Adjusted for age, sex, comorbidities, and clinical procedures.

that Chinese traditional medicine/remedies were the most common drug exposure before the occurrence of AKI, although their causal effects could not be established. Because of the lack of prescription data in the non-AKI patients, we could not assess the risk of nephrotoxicity in AKI in this study.

In-Hospital Outcomes

Mortality. The incidence of in-hospital death was 0.6% in the non-AKI group and 8.8% in the AKI group. The mortality among patients with HA-AKI (10.6%) was higher than that among patients with CA-AKI (4.7%) (Table 1). The mortality increased steadily with the severity of AKI (Figure 3). The HRs (95% confidence intervals) of in-hospital death adjusted for age, sex, comorbidities, and operation procedures were 4.1 (3.6 to 4.6), 6.2 (5.4 to 7.2), 7.9 (6.8 to 9.0), and 8.8 (7.0 to 10.9), respectively, for stage 1, stage 2, stage 3 without RRT, and stage 3 with RRT. We also compared the HRs for mortality among patients with different stages of AKI in the presence or absence of preexisting

Table 3. Percentage of AKI cases that were possibly drug induced

Drug	CA-AKI (%)	HA-AKI (%)	*P* Value
Nephrotoxic drugs	39.2	42.9	0.02
Antibiotics	5.3	8.6	<0.001
Anticancer drugs	1.4	2.9	0.004
Chinese traditional medicine/herbs	15.3	16.2	0.44
NSAIDs	8.7	13.2	<0.001
Contrast media	–	9.1	

NSAIDs, nonsteroidal anti-inflammatory drugs; CA-AKI, community-acquired AKI; HA-AKI, hospital-acquired AKI.

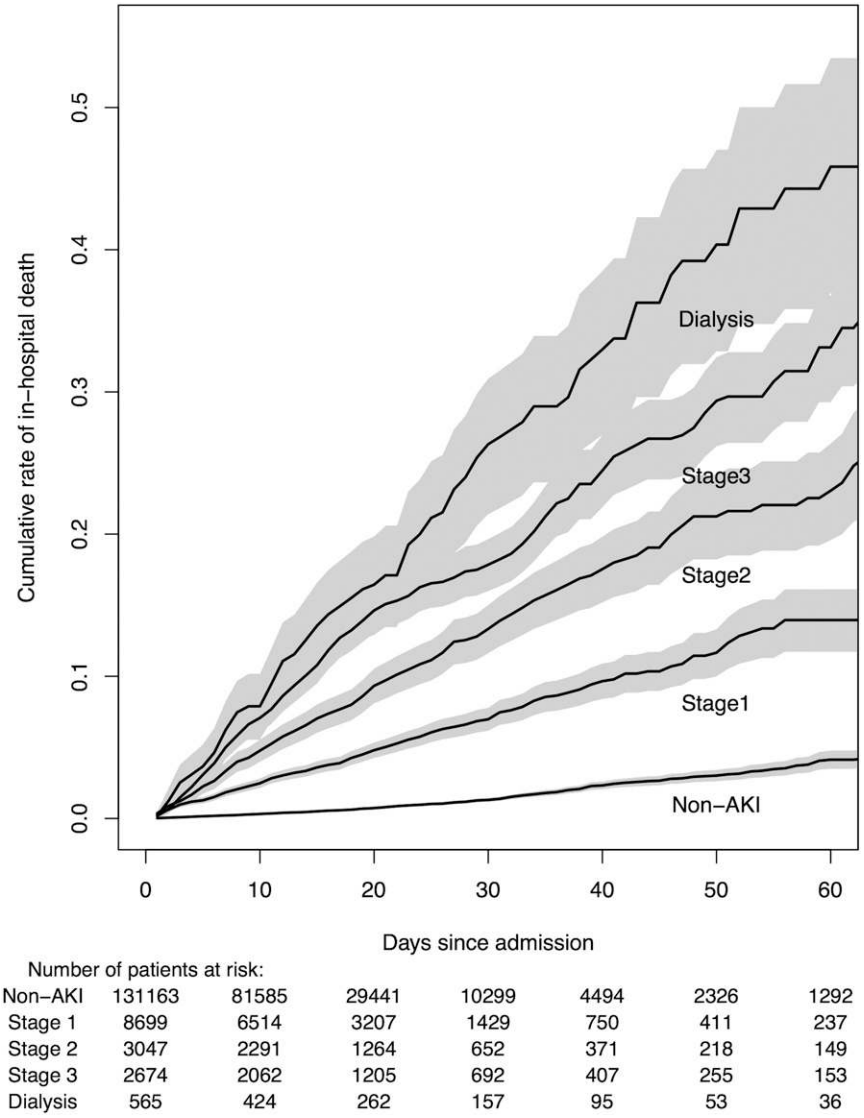

Figure 3. | **Kaplan–Meier plot of cumulative rates of in-hospital death by AKI stage.** Gray zones indicate the 95% confidence intervals of the corresponding estimates.

CKD, need for intensive care, and transient HA-AKI (Figure 4). Preexisting CKD was associated with higher risk of in-hospital death in all stages of AKI, although the magnitude of increase in stage 3 was smaller than that in stages 1 and 2. A similar trend was seen in patients who needed intensive care. There were no significant differences in the risk of in-hospital death between persistent and transient AKI (HR, 0.99; P=0.97) across all stages.

LOS and Daily Cost. AKI was associated with longer LOS and higher daily cost during hospitalization (Table 1). After adjustment for age, sex, comorbidities, and operation procedures, stage 1, stage 2, and stage 3 AKI were associated with 22%, 25%, and 32% longer LOS and 6%, 15%, and 33% higher daily cost, respectively, compared with those without AKI (P<0.001 for all).

Renal Outcome. About 4.5% of patients with CA-AKI and 3.5% of those with HA-AKI required dialysis during hospitalization. Forty percent of patients with HA-AKI had fully recovered renal function at discharge (the median LOS in the analysis set was 18 days). The median time to recovery was 7 days (Supplemental Figure 2).

Discussion

This study represents the largest and the most extensive analysis of AKI among hospitalized adults in China. We estimated the incidence of AKI at 11.6% among 659,945 hospitalizations from nine regional central hospitals encompassing a wide range of clinical settings and including both critical care patients and non–critical care patients. We also illustrated differences in the incidence and in-hospital outcomes between CA-AKI and HA-AKI and highlighted major risk factors for AKI.

The detection rate of AKI based on SCr change depends on the frequency of SCr testing. However, most hospitalized patients do not undergo enough SCr testing. The proportion of patients with two or more SCr tests during hospitalization was 30% in this study and ranged from 25%

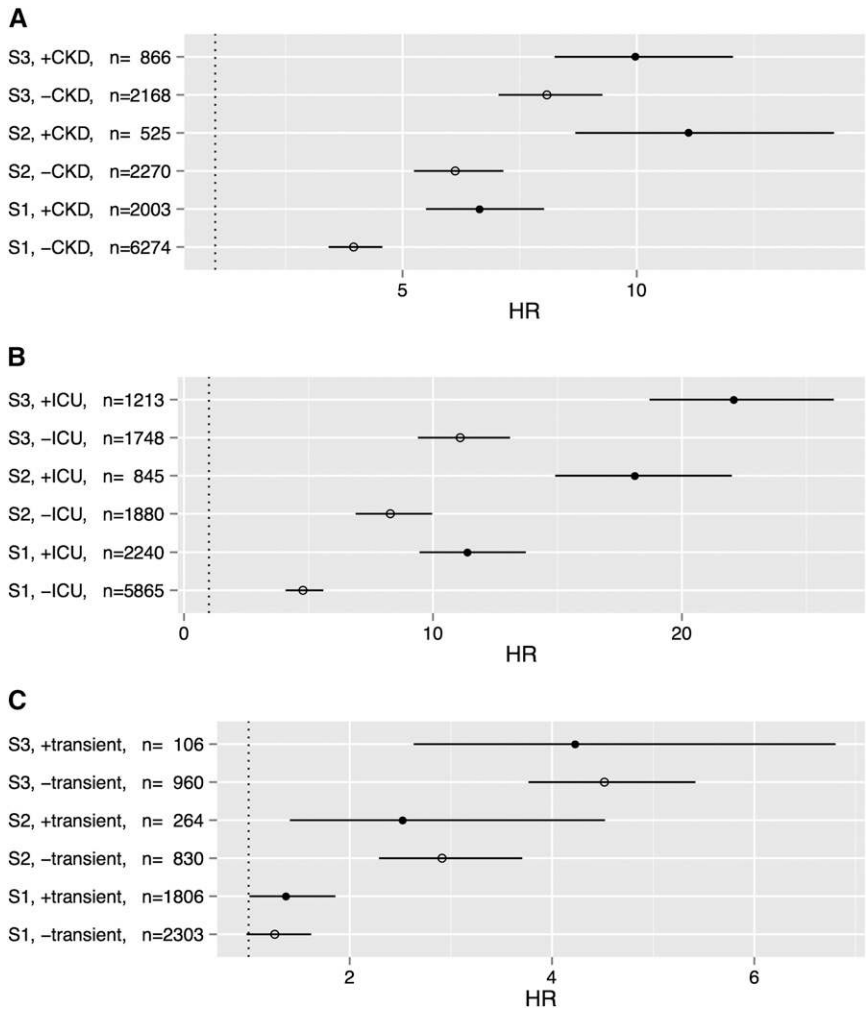

Figure 4. | **The hazard ratios of in-hospital death among patients at different stages of AKI in three special settings.** The settings are in the presence or absence of preexisting CKD (A), intensive care (B), and transient hospital-acquired AKI (C). S1–S3 in the labels denotes AKI stages 1–3, respectively. Dots and lines indicate the hazard ratio (HR) estimates and the corresponding 95% confidence intervals, respectively. All HRs were calculated using non-AKI without indicated setting as the reference and adjusted for age, sex, comorbidities, and clinical procedures. ICU, intensive care unit.

to 46% in previous reports (21–23). Even for patients with two SCr tests in 7 days, AKI would be missed in 48% of the patients (Supplemental Figure 1A). In this study, we used a novel two-step approach to estimate the incidence of AKI in the study cohort. This method provided a more robust estimate of the AKI incidence through adjustment for the frequency of SCr tests and the risk factor profiles. By using this method, we estimated an AKI incidence of 11.6% in the hospitalized adults. Our estimate was much higher than the range of 0.3%–3.2% reported in several single-center studies conducted in Chinese hospitalized adults (23–25). In these studies, patients lacking SCr data were categorized as non-AKI, which may lead to significant underestimation of the incidence. Our estimate is similar to the reports from the United Kingdom and the United States (4,26,27). Two other studies have described a higher incidence of 18%–23% using the KDIGO definition (28,29), although the percentage of patients needing intensive care was much higher than that in our study (22% versus 10%).

Preexisting CKD contributed to about 20% of the risk in CA-AKI and 12% of the risk in HA-AKI in our study population. This is consistent with a previous report showing that the incidence and the severity of AKI increased substantially with lower levels of baseline eGFR (30). Besides CKD, severe infection and obstructive nephropathy were the major contributors to CA-AKI, while intensive care and cardiac surgery were the major contributors to HA-AKI. Drug-induced nephrotoxicity contributes to up to 26% of HA-AKI and 18% of CA-AKI cases globally (9,31–33). In our study, 39.2% of CA-AKI and 42.9% of HA-AKI cases were possibly drug related (Table 3), although we were not able to calculate the PAF of nephrotoxicity because of the lack of prescription data in patients without AKI. In particular, the use of traditional Chinese medicines or remedies, which is common in Asian countries (34), was linked to 15.3% of CA-AKI and 16.2% of HA-AKI cases in our study cohort. The implications for the role of traditional medicine in the development of AKI warrant more attention and closer scrutiny from physicians and researchers.

Consistent with previous reports (21,22,30,35–39), we found that the severity of AKI was associated with increased in-hospital mortality and resource utilization, including LOS, need for RRT, and daily cost. After adjustment for other potential confounders, patients with stage 3 AKI had an LOS that was 8 days longer and 33% higher daily cost compared with those without AKI.

The large scale of the study allowed us to assess the prognostic value of the KDIGO staging system in several specific situations that have not yet been recognized by the current definitions. The KDIGO staging criteria performed well in predicting in-hospital mortality generally, but their value was reduced in critically ill patients or those with preexisting CKD (40–42). Although both preexisting CKD and the need for intensive care unit support were associated with higher risk of in-hospital death in patients with any stage of AKI, the prognosis of patients at AKI stage 2 who had preexisting CKD or the need for intensive care unit support was even worse than that of patients at AKI stage 3. This finding suggests that patients with acute-on-chronic kidney injury or critically ill AKI should be considered at the highest risk.

Transient AKI, defined as recovery within 3 days of onset, is a rapidly reversible form of AKI and closely related to prerenal azotemia (18,43–45). It has been postulated that transient AKI may be a benign form of AKI that does not increase mortality (18). In our study, 21% of HA-AKI cases were transient. Transiency did not reduce the risk of mortality in patients across all stages of AKI (HR, 0.99; P=0.97), suggesting that transient AKI is not benign.

A major strength of the study is that we used a novel analytical method to more accurately estimate the incidence of AKI with adjustment for frequency of SCr tests and known risk factors. Another key strength is the availability of patient-level data with time stamps, which permitted a detailed examination of risk profiles for both CA-AKI and HA-AKI and statistical adjustment for data censoring and important confounders, such as comorbidity or severity of AKI, when interpreting the associations between AKI and outcomes. The third strength is our strict adherence to the KDIGO's SCr criteria in defining and staging AKI.

Our study has several limitations. First, because the study cohort was from tertiary hospitals, the generalizability of the results to patients in the lower-level hospitals remains to be confirmed. Second, the lack of follow-up data limited our analysis to in-hospital outcomes. Third, prescription data in patients without AKI was not available, preventing us from a more vigorous analysis of drug-related AKI. Fourth, like most retrospective studies on AKI, this study did not use urine output to identify AKI because urinary data were not available for most patients. Finally, direct measurement of AKI incidence in all hospitalizations was not possible because most of the patients did not have multiple SCr tests. The true AKI incidence in all hospitalizations is still not known.

In summary, our study found an 11.6% incidence of AKI among hospitalized adults in China and described the profiles of risk factors and in-hospital outcomes of AKI. Results from this study may help to clarify the epidemiologic characteristics and burden of AKI in China; increase the awareness of AKI among the public, policy makers, and health care professionals; and develop health policies to improve AKI-related care.

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Disclosures

None.

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