Author/s:
Bendall, AC;See, EJ;Toussaint, ND;Fazio, T;Tan, SJ

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Bendall Anna Clare (Orcid ID: 0000-0002-9135-9726)

See Emily J (Orcid ID: 0000-0003-4436-4319)

Toussaint Nigel (Orcid ID: 0000-0002-2853-5096)

Title Page

Community acquired versus Hospital acquired acute kidney injury at a large Australian metropolitan quaternary referral centre – incidence, associations, and outcomes

Anna C BENDALL[1], Emily J SEE[1,2,3], Nigel D TOUSSAINT[1,4], Timothy FAZIO[3,5], and Sven-Jean TAN[1,4]
[1]Department of Nephrology, The Royal Melbourne Hospital, Parkville, Victoria, Australia;
[2]Department of Intensive Care, Austin Hospital, Heidelberg, Victoria, Australia;
[3]Department of Critical Care, University of Melbourne, Parkville, Victoria, Australia;
[4]Department of Medicine (RMH), University of Melbourne, Parkville, Victoria, Australia;
[5]Business Intelligence Unit, The Royal Melbourne Hospital, Parkville, Victoria, Australia.

Correspondence: Dr Anna Bendall
Department of Nephrology, The Royal Melbourne Hospital,

Grattan Street, Parkville, Victoria 3052, Australia.

E-mail: annabendall@gmail.com

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Community-acquired versus hospital-acquired acute kidney injury at a large Australian metropolitan quaternary referral centre – incidence, associations, and outcomes

Abstract

Objective: To determine incidence and outcomes of community-acquired (CA-AKI) and hospital-acquired acute kidney injury (HA-AKI) among inpatients in the Australian healthcare setting utilising modern health information systems.

Design: A retrospective cohort study of adult patients admitted to a quaternary hospital in Melbourne, Australia, between 1 January 2018 and 31 December 2019 utilising an electronic data warehouse.

Participants: Adult patients admitted for >24 hours who had more than one serum creatinine level recorded during admission. Kidney transplant and maintenance dialysis patients were excluded.

Main outcome measures: Acute kidney injury (AKI), as classified by the Kidney Disease Improving Global Outcomes (KDIGO) criteria, hospital length of stay (LoS), and 30-day mortality.

Results: 6477 AKI episodes were identified across 43,791 admissions. Of all AKI episodes, 77% (n=5011), 15% (n=947), and 8% (n=519) were KDIGO Stage 1, 2 and 3, respectively. HA-AKI accounted for 55.9% episodes. Patients required Intensive Care Unit admission in 22.7% (n=1100) of CA-AKI and 19.3% (n=935) of HA-AKI, compared to 7.5%. (n=2815) of patients with no AKI (p=0.001). Patients with AKI were older with more co-morbidities, particularly chronic kidney disease (CKD). LoS was longer in CA-AKI (8.8 days) and HA-AKI (11.8 days) compared to admissions without AKI (4.9 days, p<0.001). 30-day mortality was increased with CA-AKI (10.2%) and HA-AKI (12.8%) compared to no AKI (3.7%, p<0.001).

Conclusion: The incidence of AKI detected by the electronic data warehouse was higher than previously reported. Patients who experienced AKI had greater morbidity and mortality. CKD was an important risk factor for AKI in hospitalised patients.

Introduction

There is universal recognition of the rising incidence of acute kidney injury (AKI), its detrimental impacts on short and long-term morbidity and mortality for patients, and considerable cost to healthcare systems[1-4]. One in five adults worldwide experience AKI during hospital admission[5], with rates amongst intensive care unit (ICU) admissions estimated to be as high as 50%[6]. An additional 1% of all hospitalised patients experience a 'subclinical AKI' that does not meet diagnostic criteria but is independently associated with increased hospital mortality[7,8]. A recent systematic review and meta-analysis reported that AKI is associated with significantly increased risk of progressive or new chronic kidney disease (CKD), kidney failure and death, in the magnitude of 2.6, 4.8 and 1.8 times greater respectively[3].

Since the 2012 Kidney Disease: Improving Global Outcomes (KDIGO) report on AKI, there has been an emphasis on differentiating between AKI acquired whilst in hospital (hospital-acquired acute kidney injury, HA-AKI) or in the community (community-acquired acute kidney injury, CA-AKI) on epidemiological and prognostic grounds[9]. The incidence, characteristics and outcome of CA-AKI remain incompletely understood, although research is evolving. A large trial from the United States (US) reported the incidence of non-kidney replacement therapy requiring AKI at 383.1 per 100 000 patient years in the community[10]. The true burden of CA-AKI is likely to be greater, as many patients who experience AKI in the community likely remain undetected. Our understanding of the differences between baseline characteristics and outcomes of CA-AKI versus HA-AKI in the literature is equally limited. A recent meta-analysis revealed only fifteen published studies, of which almost half included small numbers of AKI episodes[11].

Understanding the comparative incidence and outcome of CA-AKI and HA-AKI has major resource implications. The Australian Commission on Safety and Quality in healthcare estimated additional costs of over AUD$55,000 per admission complicated by AKI requiring haemodialysis, largely attributed to an estimated 27-day increase in length of stay (LoS) when compared to an absence of this complication[12]. Associated cost estimates reported by other Western counterparts (including the United Kingdom (UK), US, and Canada) have similarly demonstrated increases in LoS for admissions complicated by AKI[13-15] and an excess in annual inpatient expenditure[13,16,17]. In light of the burden of AKI, and the paucity of local data, a more comprehensive understanding of the incidence of AKI in Australia is warranted to better appreciate the magnitude of this problem, explore prognostic differences between CA-AKI and HA-AKI, and to identify patients most at risk. This retrospective study describes the incidence, patient characteristics and outcome of CA-AKI and HA-AKI at a single Australian metropolitan quaternary referral hospital.

Methods

Study design, data source and description of covariates

A retrospective single-centre cohort study of hospitalised adults (aged ≥18 years) was conducted utilising a data warehouse and International Statistical Classification of Diseases and Related Health problems (ICD) codes. The Royal Melbourne Hospital, a metropolitan quaternary-referral hospital, has a data warehouse containing data from a variety of administrative and clinical information systems. Patient administrative data, clinical coding data and pathology data were identified, linked and extracted from the data warehouse using Structured Query Language. All patients admitted for longer than 24 hours between 1 January 2018 and 31 December 2019 were included if more than one serum creatinine level was recorded during their inpatient stay. Data collected included age, gender, ethnicity, co-morbidities (including history of cardiovascular disease, cerebrovascular disease, peripheral vascular disease, CKD, chronic liver disease, diabetes mellitus, malignancy, hypertension, smoking), principal admission diagnosis, admitting unit (by medical or surgical subspecialty), admission to the ICU or coronary care unit (CCU) (and LoS if applicable), total hospital LoS and discharge disposition (home, rehabilitation, residential aged care facility, transfer to another hospital). In addition to collating 30-day mortality data from hospital records, mortality data also involved indirect integration with the national Births, Deaths and Marriages Registry. Charlson Comorbidity Index (CCI) scores[18] were calculated using co-morbidity data as available.

Pathology data collected included biochemistry (serum creatinine, urea, potassium, sodium, chloride, bicarbonate, albumin), haemoglobin and haemoglobin A1c, if available. The number of serum creatinine values during each admission, and the maximum and minimum serum creatinine values for that admission were collated. Admissions less than 24 hours or with less than two available serum creatinine values were excluded.

Data on the provision of kidney replacement therapy (including haemodialysis, peritoneal dialysis and continuous renal replacement therapy) during admission were also collected. To verify accuracy, patients who received kidney replacement therapy during their admission were cross referenced with a discrete nephrology departmental electronic database. Patients already established on chronic dialysis were excluded, as were known pre-dialysis patients who commenced maintenance dialysis during the admission episode. Kidney transplant recipients and patients specifically admitted for kidney transplantation were also excluded.

Utilising the minimum and maximum serum creatinine obtained during each patient admission, where a calculated serum creatinine increase of 26.5 micromoles/L (0.3mg/dL) within 48 hours or a relative increase by 50% within 7 days or dialysis requirement was present, AKI was diagnosed as per the KDIGO classification system. Data were further divided into severity staging using the KDIGO classification of 1 to 3 (Supplementary Table 1). AKI episodes were segregated into CA-AKI where the calculated elevated serum creatinine was present on admission, and HA-AKI where serum creatinine increased during the hospital stay. CA-AKI was differentiated from CKD when there was an increased serum creatinine on admission and an improvement during the episode satisfying the KDIGO AKI definition. This study was approved by the Melbourne Health Human Research Ethics Committee.

Statistical analysis

Continuous variables were described as mean (± standard deviation) for normally distributed parameters and median (interquartile range) for non-normally distributed variables. Categorical values were summarised using frequency and percentage. Outcomes between CA-AKI, HA-AKI and no AKI cohorts were compared. Chi-square test was used for categorical variables, Kruskal-Wallis analysis was applied to non-normally distributed variables and analysis of variance (ANOVA) was used for normally distributed parameters. A p-value of <0.05 was considered statistically significant and <0.001 statistically highly significant. SPSS Statistics Version 26.0 (IBM Corp., Armonk, NY, USA) was used to analyse the data.

Results

A total of 212,521 admissions were documented across the two-year study period. Episodes of less than 24 hours duration (n=142,027) or with fewer than two serum creatinine values (n=25,231) were excluded, as were episodes involving patients receiving maintenance dialysis or with a history of kidney transplantation (n=1465) (Figure 1). Three episodes involved dialysis for indications other than AKI (i.e. substance overdose) and four episodes were excluded as misclassified. A total of 43,791 episodes in 27,118 patients remained for analysis.

Incidence of acute kidney injury

AKI was detected in 6,477 admission episodes (14.8%, 15.2 episodes per 1000 inpatient-days). Just over half of the AKI episodes were hospital-acquired (n=3,620, 55.9%), therefore, 8.3% of all admissions were complicated by HA-AKI. CA-AKI was evident in 5.5% of all hospital admission episodes in the two-year period. The majority of HA-AKI and CA-AKI episodes were classified as KDIGO stage 1 (n = 3068, 85% in HA-AKI; n=1943, 68% in CA-AKI). More patients with CA-AKI had KDIGO stage 2 or 3 AKI compared to those with HA-AKI (n=914, 32% in CA-AKI; n=552, 15.2% in HA-AKI).

Risk factors for CA-AKI and HA-AKI

Compared to patients without AKI, patients with either HA-AKI and CA-AKI were more likely to be male, older, and to have a history of CKD, diabetes, ischaemic heart disease (IHD), heart failure, hypertension, peripheral vascular disease, and chronic liver disease (CLD) (Tables 1). Patients who developed AKI (HA-AKI or CA-AKI) were more likely to have a history of AKI (23.1% of all HA-AKI episodes and 24.5% of all CA-AKI episodes compared to 3.6% of all no-AKI cases, Table 1). Both AKI groups had higher CCI scores and were more likely to require ICU or CCU admission compared to no-AKI patients. Compared to patients with CA-AKI, patients with HA-AKI were older and more comorbid based on the CCI (1.88 CA-AKI vs 2.16 HA AKI, p=<0.001) (Table 1). Ethnicity did not vary between groups.

Acute kidney injury by admitting unit

AKI was seen to affect all units of the hospital, with the exclusion of patients admitted under anaesthetics for pain management (n=11). Nephrology had the highest percentage of AKI overall, with 40.5% of all admissions affected (HA-AKI 15.6%, CA-AKI 22.9%), which omitted 50% of this unit's admissions with the exclusion of maintenance dialysis patients (n=1225). Cardiothoracic Surgery had the second highest percentage of overall AKI (33.27%) and the highest percentage of HA-AKI, followed by the Haematology and Bone Marrow Transplant units (23.4% and 18.7% respectively) (Figure 2). Following Nephrology, Obstetrics/Gynaecology and Surgical Oncology had the largest percentages of CA-AKI (19.1% and 18.2% respectively). The Mental Health unit experienced the lowest rate of AKI with 1.2% of admissions affected (HA-AKI 0.8%, CA-AKI 0.4%), followed by the Rehabilitation unit (3.1% of all admissions involving AKI).

Outcomes following hospitalisation for CA-AKI and HA-AKI

Median LoS was increased in patients with AKI (CA-AKI 8.8 days, HA-AKI 11.8 days) in comparison to those without (4.9 days, p<0.001). A greater proportion of patients with AKI required admission to the ICU (CA-AKI 22.7%, HA-AKI 19.3% versus 7.5% No AKI, Table 2). More patients with CA-AKI required kidney replacement therapy compared to patients with HA-AKI (n=145, 5.1% versus n= 116, 3.2%, p<0.001) (Table 2).

Acute kidney injury may result in a lower rate of direct discharge home

More patients with CA-AKI and HA-AKI were transferred to another medical facility following acute admission (29.2% and 29.4% respectively) compared to patients without AKI (17.5%, $p<0.001$), where more than 70% of the latter cohort were discharged directly home. (Table 3).

Acute kidney injury is linked to increased mortality

Higher in-hospital mortality was observed in admissions involving HA-AKI and CA-AKI (7.9% and 6.2% respectively) compared to admissions without (1.5%, Table 2). Higher rates of 30-day mortality were also observed in patients with CA-AKI (10.2%) and HA-AKI (12.8%) compared to those with no AKI (3.7%), most pronounced for episodes of stage 3 AKI (17.1%, $p<0.001$, Figure 3).

Discussion

This study analysed over 40,000 adult hospital admissions at a quaternary Australian centre across a two-year period and demonstrated an incidence of AKI of 14.8% for all admissions longer than 24 hours. Preliminary analysis of hospital data from AKI recognised via ICD coding, suggests that potentially up to 40% of episodes detected in our study were not recognised as AKI during admission by standard hospital coding practices. Further analysis of this data is planned in conjunction with a hospital service improvement project**.** The international reported incidence of AKI is highly variable and largely dependent on the population studied and method of detection. Some studies have estimated it to occur in as many as 20% of adult hospital admissions[5], while the Australian Institute of Health and Welfare estimated AKI complicated 1-2% of hospital admissions[19]. The discrepancy between reported incidence with local data seems more likely secondary to under-reporting of the true Australian incidence rather than a distinct geographical variance in AKI. Previous lower Australian estimates could be in part be due to heterogenous classifications for AKI prior to the adoption of the KDIGO 2012 AKI consensus definition[9].

A meta-analysis of fifteen studies (total 46,157 patients; three prospective observational studies and twelve retrospective cohort studies) evaluated differences between CA-AKI and HA-AKI[11]. Notably, ongoing heterogeneity in diagnostic criteria for AKI was evident in earlier studies, though the more recent trials utilised the KDIGO definition[11]. Demographics and baseline characteristics of the two cohorts were not reported as pooled data in the meta-analysis. In the studies included that reported age and gender of patients, majority of patients with AKI were male[11] and the median age of those with HA-AKI was older than those with CA-AKI[11], like our patient distribution.

Outcomes in the meta-analysis revealed a higher mortality, increased need for ICU admission and greater hospital LoS associated with HA-AKI when compared to CA-AKI[11]. The need for kidney replacement therapy and degree of kidney recovery were similar between the cohorts[11]. The reports of higher mortality and increased hospital LoS are congruent with our findings, however in our study, need for ICU admission and kidney replacement therapy were higher in those with CA-AKI compared with HA-AKI. Similar to the largest study (n=14,985 patients across multiple centres) included in the meta-analysis[20]. While there is a globally adopted consensus definition of AKI, approach to diagnosis and definition of CA-AKI and HA-AKI as two distinct entities differ between studies and may contribute to the inconsistency.

The approximate doubling in hospital LoS for patients with AKI compared to those without in our report is consistent with findings from previous Australian and international studies[21,13,15]. Interestingly, despite a more advanced stage of AKI in patients with CA-AKI compared to HA-AKI, with greater rates of kidney replacement therapy and requirement for ICU, the mean LoS was greater in those with HA-AKI. Possible explanations for these findings include more advanced age and CCI scores observed in patients with HA-AKI, with particular comorbidities in some reports more common in HA-AKI such as heart failure, which could complicate admissions and prolong LoS[11].

The greater proportion of stage 1 AKI reported in patients with HA-AKI could relate to earlier detection of AKI due to increased frequency of monitoring whilst hospitalised. AKI episodes were detected across virtually all admitting units. At this quaternary centre, Obstetrics and Gynaecology function through a separate (women's) hospital facility though unwell patients requiring ICU, CCU or those requiring other specialty input are transferred to our hospital and are captured in the data, noting the total number of admissions for a two-year period is less than 50 with a high incidence of AKI demonstrated. Similarly, oncology patients are also treated through a dedicated oncology tertiary facility and medically complicated patients are transferred for co-management. This has likely contributed to a skewed distribution of more ill and higher acuity patients in these units. HA-AKI in the Cardiothoracic Surgery and Haematology/Bone Marrow Transplant units is not unexpected due to the nature of medical and surgical treatments undertaken that may be nephrotoxic including cardiac bypass and administration of antibiotics and/or chemotherapy respectively.

Patient burden following AKI is significant. Several recent meta-analyses demonstrate increased rates of CKD, kidney failure, and overall mortality associated with AKI[1,2]. Mortality is reportedly increased by an additional 5.9 deaths per 100 person years, with patients who experienced AKI 1.8-2 times more likely to die compared to those who did not[1-2]. The high mortality rate observed in both patients with CA-AKI and HA-AKI is in keeping with international estimates of 10-20% mortality in hospitalised patients with AKI[19]. Unsurprisingly, 30-day mortality in our study was greatest for patients with KDIGO stage 3 HA-AKI, and this information may provide an opportunity to facilitate hospital-wide projects targeting earlier detection of AKI to reduce injury progression.

Increased hospital LoS and requirement for ICU admission with AKI demonstrated in our study highlights significant resource implications. It is estimated that 1 in 10 Australian adults have CKD, and CKD as an important risk factor for the development of AKI has been well established[1,4,9,21]. Therefore, a substantial proportion of the population are at increased risk for AKI both in the community and during a hospital admission[21]. Of all hospital admissions in this study, 8.3% admissions were complicated by HA-AKI and 3.2% of these patients required costly kidney replacement therapy, contributing to considerable costs of these episodes of care.

The 2013 Australian Commission on Safety and Quality in Health Care targeted AKI, specifically HA-AKI requiring kidney replacement therapy, as an area of priority in which quality projects are likely to lead to substantial benefits for patients and hospitals alike[16]. In the UK, a national enquiry into AKI in hospitals found significant deficiencies in care and reported less than 50% of cases received best practice recommendations[22]. Management of AKI in Australia may be comparably suboptimal and the frequency of this complication during admissions reported in our study highlights important opportunities for improvement projects within hospitals. In recent years, there have also been global efforts to combat the impact of AKI in response to growing recognition of the chronic impact on patients and burden on healthcare[1,23,24]. What is clear from international experience to date is that any future successful clinical endeavours targeting AKI require a multi-faceted, multi-disciplinary, collaborative approach to support clinicians providing best practice management, with a robust institution-wide AKI education campaign[25].

Estimates of the incidence and characteristics of AKI from observational studies commonly utilise International Classification of Diseases (ICD) coding from discharge summaries due to availability of large and relatively inexpensive data[26]. However, results based on ICD coding alone have limitations with earlier studies estimating markedly reduced sensitivity for AKI[27]. More recently increased clinician awareness, changing practices around AKI, the globally accepted 2012 KDIGO consensus definition (Supplementary Table 1), in addition to improved automated real-time detection of AKI through serum creatinine-based definitions have likely led to improved detection.

Extensive data collected in this study greatly adds to our understanding of AKI in the Australian setting. Our study has several limitations including the retrospective design at a single adult quaternary centre in a large metropolitan city which may restrict generalisability of results. Although 30-day mortality was captured indirectly through integration with hospital records, this study did not directly analyse deaths linked through the national death registry, hence the true 30-day mortality may potentially differ. Changes in serum creatinine levels remain the main tool for detection and classification of AKI[9], however serum creatinine is an insensitive biomarker in detecting subclinical AKI and future improved biomarkers could be helpful in earlier and more sensitive detection of AKI. Given a lack of accurately documented urine output measurements outside the ICU setting, we did not include this parameter into our analysis when determining incidence of AKI, hence possibly underestimating the true incidence as per 2012 KDIGO definition[9]. Use of ICD coding for defining co-morbidities does not account for severity of medical conditions and may potentially overestimate or underestimate the significance of conditions. Similarly, co-morbidities may have been incorrectly omitted or inaccurately documented in medical records and the dataset may be subject to misclassification. Nonetheless the dataset is large and extensive, providing a current snapshot of AKI as well as delineating the entities of CA-AKI and HA-AKI within the Australian healthcare system.

Conclusion

AKI has detrimental effects on patient morbidity and mortality, and is associated with significantly increased healthcare costs, predominantly through increased LoS and need for ICU admission. Findings of this study highlight that the magnitude and impact of AKI within an Australian hospital setting is greater than previously reported and is consistent with global rates. Short and long-term implications of increased morbidity and mortality associated with both community-acquired and hospital-acquired

AKI should not be underestimated, nor the growing economic burden faced by the increasing incidence. Going forward, initiatives targeted at mitigating risks for AKI are needed and consideration should be given for hospital-wide AKI education and projects, such as dedicated AKI services and care bundles to improve early detection and reduce progression of AKI, to improve outcomes.

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Table 1: Characteristics: demographics, co-morbidities and biochemical parameters on admission, comparing patients with community-acquired and hospital-acquired acute kidney injury

	CA-AKI	HA-AKI	No AKI	p-value
Total Episodes	2857	3620	37314	-
Demographic Parameters				
Male Gender, *n (%)*	1749 (61.2%)	2274 (62.8%)	19904 (53.3%)	<0.001
Age, *median (IQR)*	68 (54-80) [d,e]	73 (60-82) [d]	65 (47-79)	<0.001^
First Nation Peoples, *n (%)*	27 (1.0%)	34 (1.0%)	363 (1.0%)	0.978
Received KRT, *n (%)*	145 (5.1%)	116 (3.2%)	3 (0.0%)	<0.001
Required ICU, *n (%)*	1100 (22.7%)	935 (19.3%)	2815 (7.5%)	<0.001
Required CCU, *n (%)*	294 (10.3%)	390 (10.8%)	2045 (5.5%)	<0.001
Total Length of Stay, *days (IQR)*	8.8 (5.1-15.7) [d,e]	11.8 (6.8-21.7) [d]	4.9 (2.8-9.6)	<0.001^
Comorbidities				
Total Episodes	2857	3620	37314	-
Ischaemic Heart Disease, *n (%)*	768 (26.9%)	1152 (31.8%)	6645 (17.8%)	<0.001
Heart Failure, *n (%)*	344 (12.0%)	658 (18.2%)	2286 (6.1%)	<0.001
Hypertension, *n (%)*	1643 (57.5%)	2235 (61.7%)	15261 (40.9%)	<0.001
Peripheral Vascular Disease, *n (%)*	215 (7.5%)	349 (9.6%)	1453 (3.9%)	<0.001
Cerebrovascular Disease, *n (%)*	97 (3.4%)	182 (5.0%)	1658 (4.4%)	0.006
Chronic Liver Disease, *n (%)*	265 (9.3%)	305 (8.4%)	1538 (4.1%)	<0.001
Malignancy, *n (%)*	309 (10.8%)	493 (13.6%)	3467 (9.3%)	<0.001
Metastatic Malignancy, *n (%)*	83 (2.9%)	130 (3.6%)	1341 (3.6%)	0.156
Chronic Kidney Disease, *n (%)*	699 (24.5%)	837 (23.1%)	1328 (3.6%)	<0.001
Diabetes, *n (%)*	942 (33.0%)	1429 (39.5%)	8287 (22.2%)	<0.001
Smoking, *n (%)*	1020 (35.7%)	1347 (37.2%)	12210 (32.7%)	<0.001
Mean Charlson Comorbidity Index*, *n (SD)*	1.88 (± 1.87) [a,b]	2.16 (± 1.97) [a]	0.96 (± 1.45)	<0.001*
Admission Biochemical Parameters				
	CA-AKI	**HA-AKI**	**No AKI**	**p-value**
Serum creatinine, *umol/L (median, IQR)*	130 (97-203) [d,e]	101 (74-152) [d]	71 (62-89)	<0.001^
Sodium, *mmol/L (mean ± SD)*	137.4 ± 4.9 [a,b]	137.9 ± 4.2 [a]	138.2 ± 3.4	<0.001*
Potassium, *mmol/L (mean ± SD)*	4.3 ± 0.8 [a,b]	4.1 ± 0.6 [a]	3.9 ± 0.5	<0.001*

Chloride, *mmol/L (mean ± SD)*	104.9 ± 6.2 [a,b]	104.5 ± 5.2 [c]	104.5 ± 4.4	<0.001*
Bicarbonate, *mmol/L (mean ± SD)*	22.2 ± 4.9 [a,b]	24.2 ± 4.3 [a]	25.0 ± 3.8	<0.001*
Urea, *mmol/L* (*median, IQR*)	11 (7-17) [d,e]	8.8 (5.9-13.8) [d]	5.5 (4-7)	<0.001^
Albumin, g/L *(mean ± SD)*	29.3 ± 5.8 [a,b]	29.5 ± 5.7 [a]	31.6 ± 5.2	<0.001*
Haemoglobin, g/L *(mean ± SD)*	113.8 ± 23.7 [a,b]	111.9 ± 22.9 [a]	121.9 ± 21.5	<0.001*

*One-way ANOVA, [a]p<0.001 compared to No AKI, [b]p<0.001 compared to HA-AKI. [c]NS/not significant compared to No AKI.

^Kruskal-Wallis, [d]p<0.001 compared to No AKI, [e]p<0.001 compared to HA-AKI with Mann-Whitney U.

Categorical variables compared using Chi-square test.

Abbreviations: ATSI, Aboriginal and Torres Strait Islander; CA-AKI, community-acquired acute kidney injury; CCU, coronary care unit; HA-AKI, hospital-acquired acute kidney injury; ICU, intensive care unit; IQR, inter-quartile range; KRT, kidney replacement therapy; No AKI, patients with no acute kidney injury; NS, not significant; SD, standard deviation.

Table 2: Outcomes: community-acquired and hospital acquired acute kidney injury when compared to patients without acute kidney injury, all data and by stage of AKI

	CA-AKI	HA-AKI	No AKI	p-value
Total Episodes	2857	3620	37314	-
Death as inpatient, *n (%)*	177 (6.2%)	286 (7.9%)	543 (1.5%)	<0.001
30-day mortality, *n (%)*	290 (10.2%)	464 (12.8%)	1383 (3.7%)	<0.001
Required KRT, *n (%)*	145 (5.1%)	116 (3.2%)	3 (0.0%)	<0.001
Required ICU, *n (%)*	1100 (22.7%)	935 (19.3%)	2815 (7.5%)	<0.001
Required CCU, *n (%)*	294 (10.3%)	390 (10.8%)	2045 (5.5%)	<0.001
Discharge Home/Private Residence, *n (%)*	1710 (59.9%)	2089 (57.7%)	27472 (73.6%)	<0.001
Discharged to another medical facility, *n (%)*	834 (29.2%)	1063 (29.4%)	6524 (17.5%)	<0.001
Discharged Transition Care, *n (%)*	2 (<0.1%)	13 (<0.1%)	382 (0.9%)	<0.001
Discharged Aged Care Facility, *n (%)*	51 (1.8%)	65 (1.8%)	1158 (3.1%)	<0.001
Left Against Medical Advice, *n (%)*	24 (0.8%)	38 (1.0%)	452 (1.2%)	NS

	No AKI	Stage 1 AKI	Stage 2 AKI	Stage 3 AKI	p-value
Total Episodes	37314	5011	947	519	-
Death as inpatient, *n (%)*	543 (1.5%)	276 (5.5%)	113 (11.9%)	74 (14.3%)	<0.001
30-day mortality, *n (%)*	1383 (3.7%)	516 (10.3%)	149 (15.7%)	89 (17.1%)	<0.001
Discharge Home/Private Residence, *n (%)*	27472 (73.6%)	3083 (61.5%)	464 (49.0%)	252 (48.6%)	<0.001
Discharged to another medical facility, *n (%)*	6524 (17.5%)	1396 (27.9%)	332 (35.1%)	169 (32.6%)	<0.001
Discharged Transition Care, *n (%)*	382 (0.9%)	14 (0.3%)	1 (0.1%)	0 (0%)	<0.001
Discharged Aged Care Facility, *n (%)*	1158 (3.1%)	97 (1.9%)	12 (1.3%)	7 (1.3%)	<0.001
Left Against Medical Advice, *n (%)*	452 (1.2%)	47 (0.9%)	8 (0.8%)	7 (1.3%)	NS

Categorical variables compared using Chi-square test.

Abbreviations: CA-AKI, community-acquired acute kidney injury; HA-AKI, hospital-acquired acute kidney injury; No AKI, patients with no acute kidney injury; KRT, Kidney replacement therapy; ICU, intensive care unit; CCU, Coronary care unit; NS, not significant

Supplementary Table 1: Kidney Disease: Improving Global Outcomes (KDIGO) classification and staging system for acute kidney injury (AKI)[8]

KDIGO 2012 Definition of AKI:

AKI is defined as any of the following (Not Graded):

→ Increase in SCr by ≥0.3 mg/dl (≥26.5 μmol/l) within 48 hours; OR

→ Increase in SCr to ≥1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; OR

→ Urine volume <0.5 ml/kg/h for 6 hours.

KDIGO 2012 Staging of AKI		
Stage	**Serum Creatinine**	**Urine Output**
1	1.5-1.9 times baseline **OR** ≥0.3mg/dl (≥26.5μmol/L) increase	<0.5ml/kg/h for 6-12hours
2	2.0-2.9 times baseline	<0.5ml/kg/h for ≥12hours
3	3.0 times baseline **OR** Increase in serum creatinine to ≥4.0mg/dl (≥353.6μmol/l) **OR** Initiation of renal replacement therapy **OR** In patients <18 years, decrease in eGFR to < 35 ml/min/1.73m^2	<0.3ml/kg/h for ≥24hours **OR** Anuria for ≥12 hours

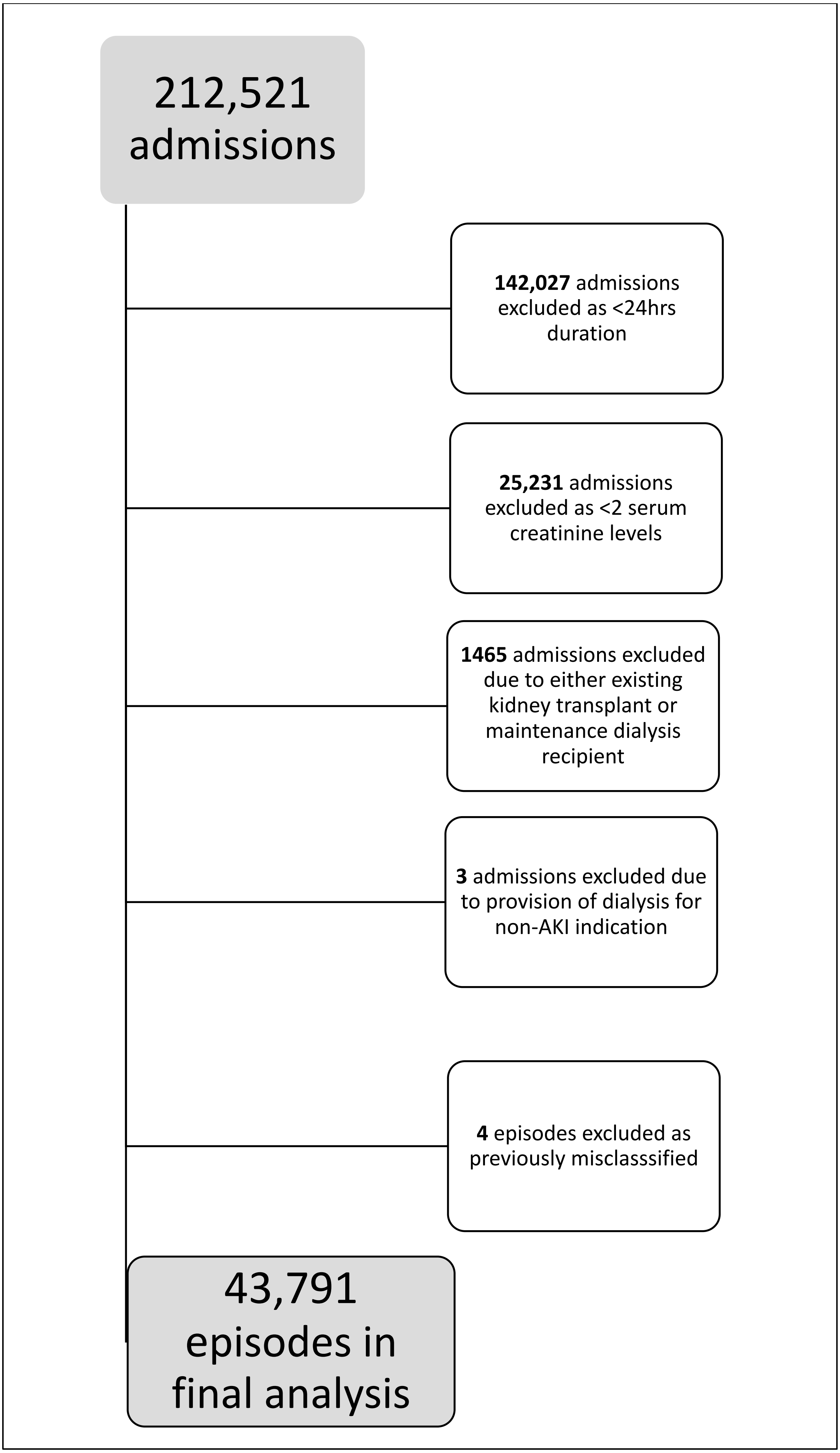
Supplementary Table 2: International Statistical Classification of Diseases and Related Health Problems (ICD)-10 and Australian Classification of Health Interventions (ACHI) codes

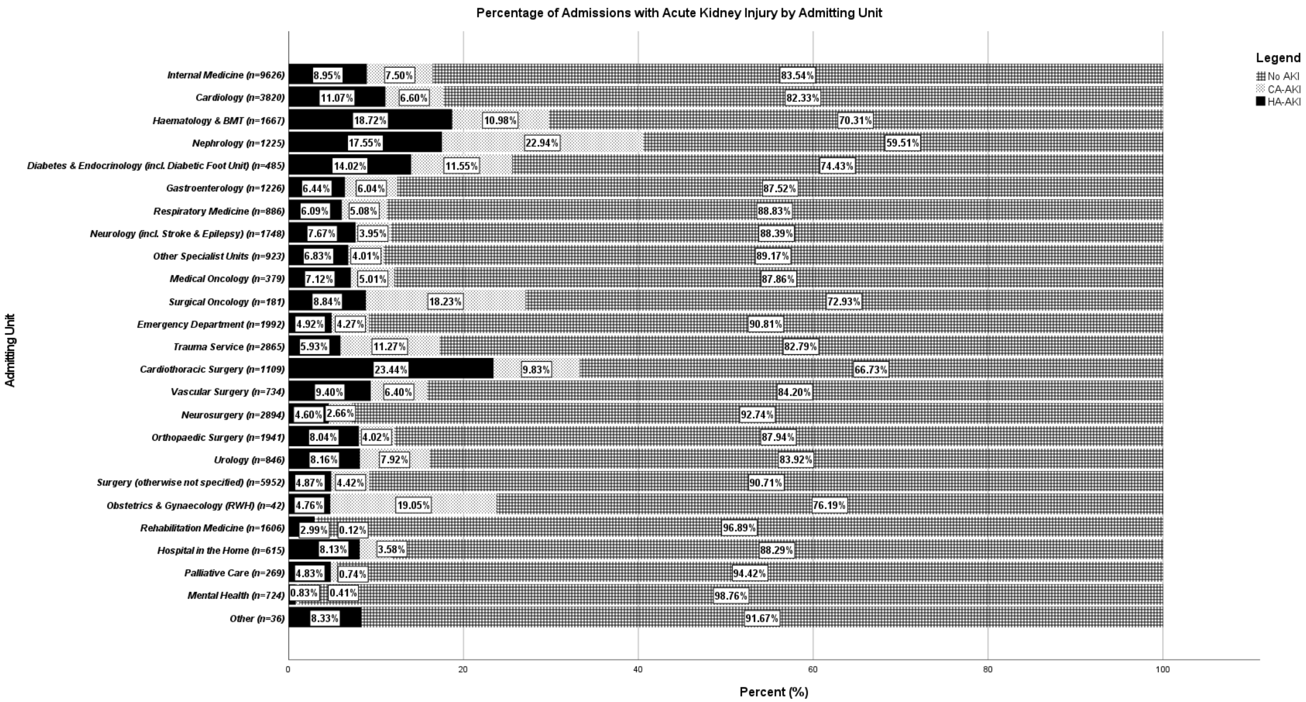
Comorbidity	ICD-10 and ACHI codes
Smoking	F17, T65.2, Z72.0, Z86.43
Diabetes	E10-14, Y42.3, Z92.22 95550-14
Hypertension	I10-15, U82.3
Cerebrovascular disease	G45, G83.81, I63-66, I69 33500
Cardiovascular disease	I20-22, I24-25, U82.1, Z95.5 38215, 38218, 38306, 38312, 38497. 38500, 38503, 38637
Peripheral vascular disease	E11.51-52, I70-71, I73.1, I73.8-9, I74, I77.1, I79.0, I79.2, K55.1, K55.8-9, Z95.8-9 32718, 32742, 32745, 32760, 32763, 32766, 33103, 33112, 33115, 33116, 33118, 33121, 33124, 33145, 33154,33172, 33521, 33539, 33548, 33554, 33806, 33845, 34103, 34106, 35202, 35303, 35309, 35317, 38550, 38553, 38556, 38559, 38562, 38565, 38572, 60000, 60048, 60060, 60072, 60078
Chronic heart failure	E11.53, I09.2, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-9, I43, I50
Arrhythmia	11718, 11721, 11727, 13400, 38256, 38290, 38350, 38353, 38368, 38390, 38393, 90203
Valvular disease	Z95.2 38270, 38475, 38477, 38480, 38488, 38489, 38490, 38493, 38553, 38556, 38559, 38562, 38565
Lung disease	J84.1, J84.8-9, J96.1, U83.1-4 38421, 38424
Liver disease	B18, I85-86, I98, K70-74, K76, T86.4, Z94.4 30409, 30411, 30412, 30414, 30415, 30418, 30421, 30476, 90317, 90319, 90318, 90334
Leukaemia	13706-06, M9801/3, M9805/3, M9823/3, M9835/3, M9836/3, M9837/3, M9861/3, M9866/3, M9867/3, M9871/3, M9872/3, M9891/3, M9895/3, M9896/3, M9920/3, M9945/3
Lymphoma	M9591/3, M9650/3, M9652/3, M9663/3, M9671/3, M9673/3, M9680/3, M9687/3, M9688/3, M9698/3, M9699/3, M9700/3, M9731/3, M9732/3, M9733/3, M9761/3, M9765/1
Non-metastatic malignancy	M8000/3, M8010/3, M8012/3, M8013/3, M8041/3, M8046/3, M8120/3, M8140/3, M8144/3, M8160/3, M8170/3, M8170/9, M8169/3, M8200/3, M8240/3, M8246/3, M8250/3, M8255/3, M8260/3, M8263/3, M8312/3, M8330/3, M8337/3, M8720/3, M8721/3, M8742/3, M8743/3, M8772/3
Metastatic malignancy	C77-80 M8000/6, M8010/6, M8012/6, M8013/6, M8041/6, M8046/6, M8070/6, M8071/6, M8120/6, M8140/6,

	M8144/6, M8160/6, M8170/6, M8169/6, M8240/6, M8246/6, M8255/6, M8260/6, M8263/6, M8312/6, M8330/6, M8337/6, M8720/6, M8721/6, M8742/6, M8743/6, M8772/6

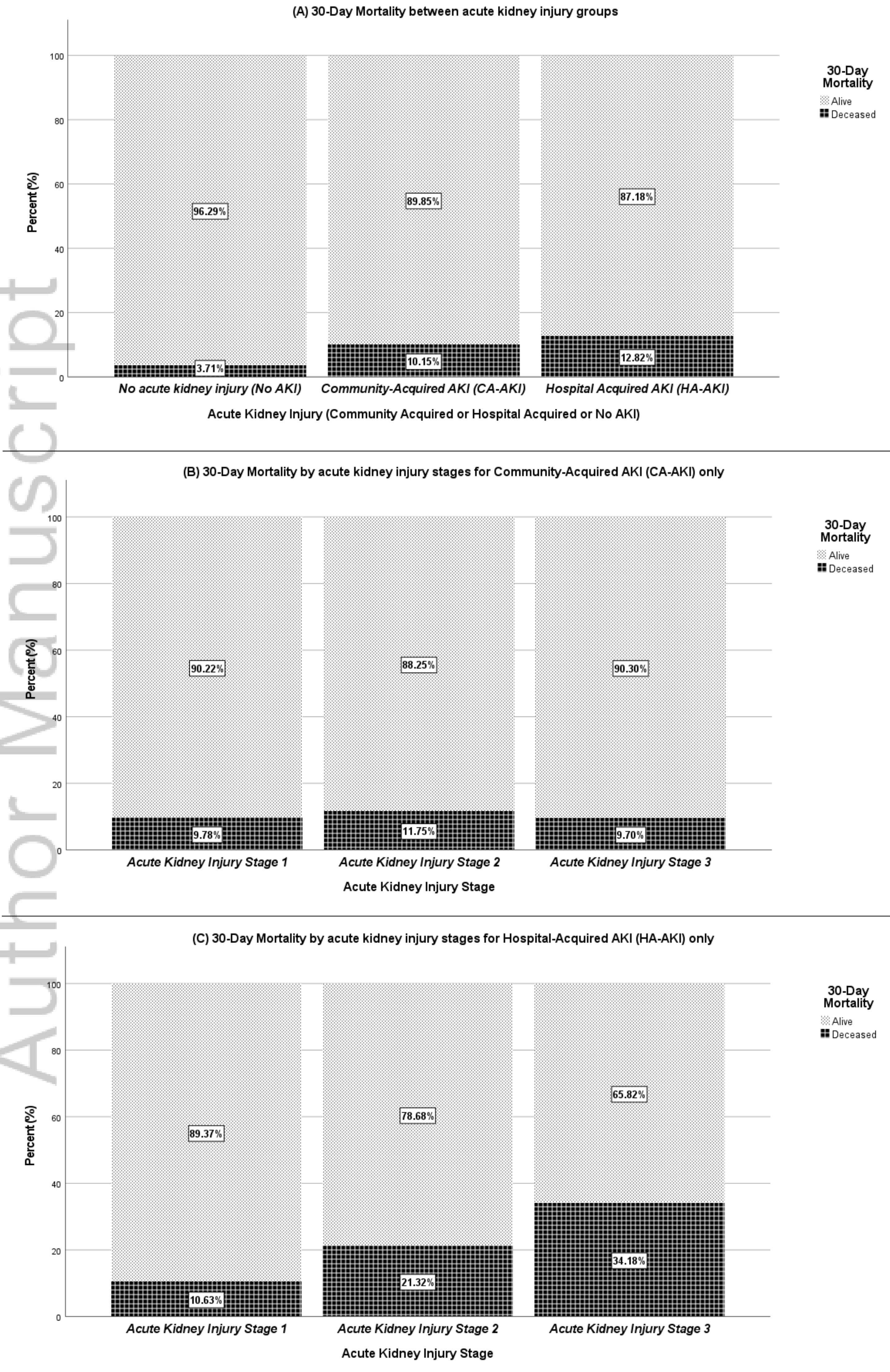
ACHI, Australian Classification of Health Interventions; ICD-10, International Classification of Diseases, 10th Revision.

Figure: 1 Flow diagram of admission episodes analysed in the 2-year study period





Percentage of Admissions with Acute Kidney Injury by Admitting Unit
Admitting Unit
Percent (%)
Legend
No AKI
CA-AKI
HA-AKI
Internal Medicine (n=9626) 8.95% 7.50% 83.54%
Cardiology (n=3820) 11.07% 6.60% 82.33%
Haematology & BMT (n=1667) 18.72% 10.98% 70.31%
Nephrology (n=1225) 17.55% 22.94% 59.51%
Diabetes & Endocrinology (incl. Diabetic Foot Unit) (n=485) 14.02% 11.55% 74.43%
Gastroenterology (n=1226) 6.44% 6.04% 87.52%
Respiratory Medicine (n=886) 6.09% 5.08% 88.83%
Neurology (incl. Stroke & Epilepsy) (n=1748) 7.67% 3.95% 88.39%
Other Specialist Units (n=923) 6.83% 4.01% 89.17%
Medical Oncology (n=379) 7.12% 5.01% 87.86%
Surgical Oncology (n=181) 8.84% 18.23% 72.93%
Emergency Department (n=1992) 4.92% 4.27% 90.81%
Trauma Service (n=2865) 5.93% 11.27% 82.79%
Cardiothoracic Surgery (n=1109) 23.44% 9.83% 66.73%
Vascular Surgery (n=734) 9.40% 6.40% 84.20%
Neurosurgery (n=2894) 4.60% 2.66% 92.74%
Orthopaedic Surgery (n=1941) 8.04% 4.02% 87.94%
Urology (n=846) 8.16% 7.92% 83.92%
Surgery (otherwise not specified) (n=5952) 4.87% 4.42% 90.71%
Obstetrics & Gynaecology (RWH) (n=42) 4.76% 19.05% 76.19%
Rehabilitation Medicine (n=1606) 2.99% 0.12% 96.89%
Hospital in the Home (n=615) 8.13% 3.58% 88.29%
Palliative Care (n=269) 4.83% 0.74% 94.42%
Mental Health (n=724) 0.83% 0.41% 98.76%
Other (n=36) 8.33% 91.67%
0
20
40
60
80
100


(A) 30-Day Mortality between acute kidney injury groups
Percent (%)
0
20
40
60
80
100
96.29%
3.71%
89.85%
10.15%
87.18%
12.82%
No acute kidney injury (No AKI)
Community-Acquired AKI (CA-AKI)
Hospital Acquired AKI (HA-AKI)
Acute Kidney Injury (Community Acquired or Hospital Acquired or No AKI)
30-Day Mortality
Alive
Deceased
(B) 30-Day Mortality by acute kidney injury stages for Community-Acquired AKI (CA-AKI) only
Percent (%)
0
20
40
60
80
100
90.22%
9.78%
88.25%
11.75%
90.30%
9.70%
Acute Kidney Injury Stage 1
Acute Kidney Injury Stage 2
Acute Kidney Injury Stage 3
Acute Kidney Injury Stage
30-Day Mortality
Alive
Deceased
(C) 30-Day Mortality by acute kidney injury stages for Hospital-Acquired AKI (HA-AKI) only
Percent (%)
0
20
40
60
80
100
89.37%
10.63%
78.68%
21.32%
65.82%
34.18%
Acute Kidney Injury Stage 1
Acute Kidney Injury Stage 2
Acute Kidney Injury Stage 3
Acute Kidney Injury Stage
30-Day Mortality
Alive
Deceased