# National trends in acute kidney injury requiring dialysis in England between 1998 and 2013

Nitin V. Kolhe[1], Andrew W. Muirhead[2], Sally R. Wilkes[3], Richard J. Fluck[1] and Maarten W. Taal[1,4]

[1]Department of Renal Medicine, Royal Derby Hospital, Derby, UK; [2]Department of Public Health, Derby City Council, Derby, UK; [3]Division of Rheumatology, Orthopaedics and Dermatology, School of Medicine, University of Nottingham, Nottingham, UK and [4]Division of Medical Sciences and Graduate Entry Medicine, University of Nottingham, Derby, UK

**Acute kidney injury (AKI) severe enough to require dialysis is increasing and associated with high mortality, yet robust information about temporal epidemiology of AKI requiring dialysis in England is lacking. In this retrospective observational study of the Hospital Episode Statistics (HES) data set covering the entire English National Health Service, we identified all patients with a diagnosis of AKI requiring dialysis between 1998 and 2013. This incidence increased from 774 cases (15.9 per million people) in 1998–1999 to 11,164 cases (208.7 per million people) in 2012–2013. The unadjusted in-hospital case-fatality was 30.3% in 1998–2003 and 30.2% in 2003–2008, but significantly increased to 41.1% in 2008–2013. Compared with 2003–2008, the multivariable adjusted odds ratio for death was higher in 1998–2003 at 1.20 (95% CI: 1.10–1.30) and in 2008–2013 at 1.13 (1.07–1.18). Charlson comorbidity scores of more than five (odds ratio 2.35; 95% CI: 2.20–2.51) and emergency admissions (2.46 (2.32-2.61) had higher odds for death. The odds for death decreased in patients over 85 years from 4.83 (3.04–7.67) in 1998–2003 to 2.19 (1.99–2.41) in 2008–2013. AKI in secondary diagnosis and in other diagnoses codes had higher odds for death compared with AKI in primary diagnosis code in all three periods. Thus, the incidence of AKI requiring dialysis has increased progressively over 15 years in England. Improvement in case-fatality in 2003–2008 has not been sustained in the last 5 years.**

*Kidney International* advance online publication, 29 July 2015; doi:10.1038/ki.2015.234

KEYWORDS: acute kidney injury; dialysis; epidemiology; outcome

**Correspondence:** *Nitin V. Kolhe, Department of Renal Medicine, Royal Derby Hospital, Uttoxeter Road, Derby DE22 3NE, UK. E-mail: Nitin.kolhe@nhs.net*

**Received 16 April 2015; revised 16 May 2015; accepted 4 June 2015**

Acute kidney injury (AKI) has been identified by the International Society of Nephrology (ISN) as an important, preventable cause of death globally and the ISN has set itself the goal of 'eliminating preventable and treatable deaths from AKI worldwide by 2025'.[1] When severe enough to require dialysis, the morbidity and in-hospital case-fatality associated with AKI are rarely exceeded by any other disease process, with reported mortality between 44 and 80%.[2–5] Despite this, there have been few studies describing the epidemiology of AKI on a national level. Moreover, there is increasing evidence from various studies that the incidence of AKI requiring dialysis (AKI-D) is increasing because of increasing age and comorbidities of hospitalized patients and increasing prevalence of risk factors for AKI, especially chronic kidney disease (CKD) and diabetes mellitus.[6–8] The worldwide incidence of AKI-D is poorly known because of underreporting, regional disparities, and differences in definition and case-mix. In addition, some studies have reported incidence of AKI-D per hospitalization, whereas others have quoted the person-time incident rate, which makes it difficult to compare the incidence in different regions and over a period of time.[3,9–11] Most epidemiological studies describing AKI-D have either been single center studies or have been described it in the context of intensive care or specific conditions like cardiac surgery.[12–14] This is further complicated by regional variation in requirement for dialysis and physician threshold for commencing dialysis in AKI.[15] In addition, after publication of RIFLE criteria for AKI in 2003 and AKIN in 2008, there was a paradigm shift in global awareness of AKI but there are few recent epidemiological studies describing the incidence and outcome of AKI-D on a national level.[16,17]

The objectives of this study were to investigate temporal trends in the incidence and outcomes of AKI-D and to examine the relative contribution of age, gender, ethnicity, admission type, and comorbidities to the changes in the incidence and outcomes in England between April 1998 and March 2013.

## RESULTS

### Incidence

There were 194,157,726 discharges from hospitals in England between 1998 and 2013. Of these, we identified 65,937 patients with AKI who required dialysis (Figure 1). Data were incomplete in a small number of patients with AKI, which

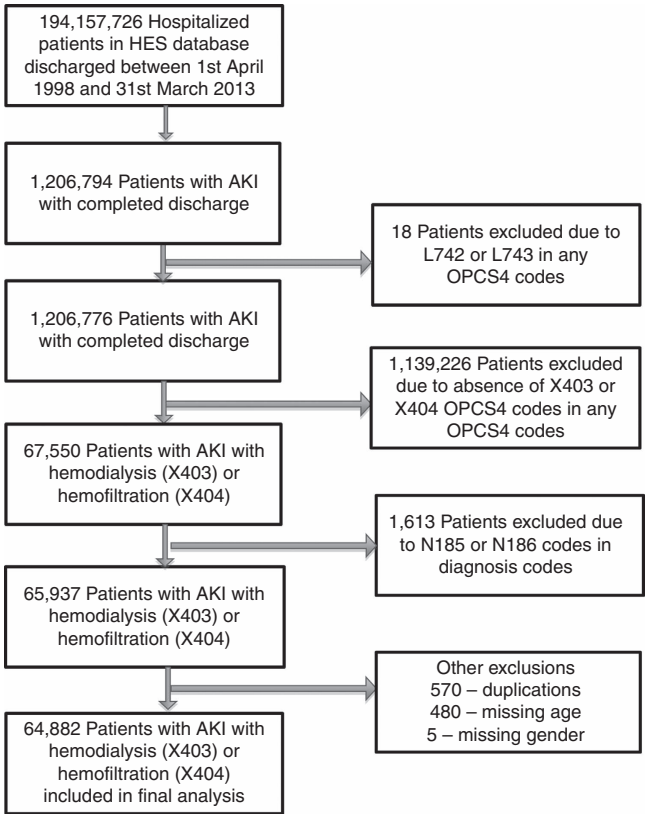


**Figure 1 | Flow chart illustrating the development of the study population.**

were excluded from the analysis, leaving 64,882 for final analysis: age missing in 480 patients, gender missing in 5 patients, length of stay (LOS) in 60 patients, and admission method were not documented in 41 patients. The incidence of AKI-D increased from 774 cases in 1998–1999 to 11,164 cases in 2012–2013. In the same period, the population incidence of AKI-D increased from 15.9 per million people (pmp) to 208.7 pmp (Figure 2). The distribution of AKI patients requiring dialysis changed during the observation period, decreasing in medical specialties from 88.4% in 1998–1999 to 64.6% in 2012–2013, but increasing in intensive care (3.7–14.6%), surgical specialties (5.7–13.2%) and cardiothoracic surgery (2.1–7.4%) (Figure 3).

### Trends in patient characteristics

The demographic and clinical characteristics of these patients in each of the 5-year period are shown in Table 1. There was a consistent increase in the proportion of patients undergoing dialysis for AKI in the age group of >85 years over the three 5-year periods (2.8% in 1998–2003, 3.8% in 2003–2008 and 5.5% in 2008–13; $P<0.001$). The proportion of patients with AKI-D under the age of 65 years decreased from 45.1% in 1998–2003 to 39.5% in 2003–2008 and remained at same proportion in the later period. The mean age increased from 59.7 (95% confidence interval (CI): 58.4–61·0) years in 1998–1999 to 65.1 (95% CI: 64.8–65.4) years in 2012–2013 (Figure 4). The average LOS decreased significantly from 21.8 days (95% CI: 21.1–22.4) to 19.4 days (95% CI: 19.0–19.8) from 1998–2003 to 2003–08 ($P<0.001$), but then remained relatively unchanged to 19.2 days (95% CI: 19.0–19.4) in 2008–2013 ($P<0.001$).

Overall, men accounted for >60% of AKI-D in all three 5-year periods ($P<0.001$). The proportion of AKI-D patients in all ethnic groups and emergency admissions increased from 1998 to 2013. The proportion of patients, who were transferred from non-dialysis providing centers decreased from 29.1% in 1998–2003 to 12.6% in 2008–2013 ($P<0.001$). There was statistically significant increase in all comorbidities from 1998–2003 to 2012–2013. In 59.9% of cases, AKI was coded in primary diagnosis code in 1998–2003 but this decreased to 55.5% in 2003–2008 and 38.8% in 2008–2013. There was a significant increase in AKI coded in other diagnosis codes from 24.1% in 1998–2003 to 30.5% in 2003–2008 and 45.7% in 2008–2013, $P<0.001$.

### Trends in case-fatality

In-hospital case-fatality was 30.3% in 1998–2003, remained unchanged at 30.2% in 2003–2008 and increased to 41.1% in 2008–2013 ($P<0.001$). During the 15-year period, case-fatality was lowest in 2005–2006 at 24.5% but since then it has steadily increased, peaking at 46.8% in 2012–2013 (Figure 5). Throughout the observation period, case-fatality was lowest for AKI coded in primary diagnosis codes. Case-fatality was incrementally higher when AKI was coded in secondary or other diagnoses codes. Case-fatality was greatest when AKI was coded in diagnoses codes from 3 to 20 and this increased over the three 5-year period from 48.3% in 1998–2003, 51.4% in 2003–2008 to 57.6% in 2008–2013, $P<0.001$ (Table 2). Compared with 1998–2003, the unadjusted odds for death in 2003–2008 were 1.01 (95% CI: 0.93–1.08) and in 2008–2013 were 1.61 (95% CI: 1.54–1.68).

### Determinants of case-fatality trend

A logistic regression was performed to ascertain the effects of age, gender, ethnicity, admission method, Charlson's comorbidity score (CCS), place of AKI in diagnoses codes, and 5-year period when AKI occurred on the likelihood of case-fatality. In multivariable analysis, the odds for death for patients aged over 85 in 1998–2003 were almost five times higher than for patients who were less than 65 years of age (Table 3). In comparison, for the diagnosis period 2008–2013 the odds for death for patients aged over 85 were just over two times higher than for patients who were less than 65 years of age. Patients with non-white ethnicities had lower odds for death as compared with white. Among all ethnicities, black ethnicity had lowest odds for death as compared with white race (odds ratio (OR) 0.67; 95% CI: 0.60–0.75). The OR increased with increasing CCS with a score more than five having OR 2.35 (95% CI: 2.20–2.51) compared with a CCS of zero. Emergency admissions and transfers had significantly higher odds for death (OR 2.46; 95% CI: 2.32–2.61 and OR