Nephrology In-Reach Services Lead to Improvement in Mortality in Acute Kidney Injury – 3 (AKI-3)

E. Gkekas
Newcastle University Faculty of Medical Sciences
TYT. Tang
Newcastle University Faculty of Medical Sciences
M. Brazell
South Tyneside and Sunderland NHS Foundation Trust
M. Brennan
South Tyneside and Sunderland NHS Foundation Trust
H. Ayub
South Tyneside and Sunderland NHS Foundation Trust
J. Chernick
South Tyneside and Sunderland NHS Foundation Trust
P. Jones
South Tyneside and Sunderland NHS Foundation Trust
A. Robinson
South Tyneside and Sunderland NHS Foundation Trust
G Suthermaraj
South Tyneside and Sunderland NHS Foundation Trust
P. Gaunt
South Tyneside and Sunderland NHS Foundation Trust
S. Ahmed
South Tyneside and Sunderland NHS Foundation Trust
R. Clark
South Tyneside and Sunderland NHS Foundation Trust
Shalabh Srivastava (shalabh.srivastava@newcastle.ac.uk)
South Tyneside and Sunderland NHS Foundation Trust https://orcid.org/0000-0002-3799-4884

Research article

Keywords: AKI, CA-AKI3, A2RB, nephrology

Posted Date: December 3rd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-119034/v1

Abstract

Background: Acute Kidney Injury (AKI) is a sudden decline in kidney function. Early detection and prompt treatment of AKI is vital in improving the outcome of patients. We introduced in-reach nephrology services at South Tyneside District Hospital (STDH) as part of a reconfiguration of local NHS services.

Aims: The principal aim of this study is to analyse patient outcomes relating to service developments and to explore prognostic characteristics among a cohort of AKI-3 patients

Design: This was a single centre retrospective impact evaluation study.

Methods: We studied all patients (n=246) who either presented with or developed AKI-3 during their admission at South Tyneside District Hospital from 2016 to 2018. The inclusion criteria included age 18-95 years and a diagnosis of AKI-3 as per KDIGO classification. Exclusion include those on established dialysis regime or on palliative care.

Results: A total of 246 patients were admitted with AKI-3. There were 64 deaths from AKI-3 over the three-year period. Mortality decreased from 29.5% to 20.7% from 2016 to 2018. In patients with Community Acquired (CA-AKI3) the overall mortality rate was 24.2% (n=182), whereas the overall mortality rate of those with Hospital Acquired (HA-AKI3) was 31.3% (n=64). The pre-AKI use of ACEi, A2RB or diuretics increased from 39.7% in 2016 (n=78), to 59.3% in 2017 (n=86) and 64.6% in 2018 (n=82). Conversely, mortality associated with the use of these medications reduced each consecutive year (32.3%, 25.5%, 18.9%).

Conclusion: Development of nephrology in-reach services, staff education measures and a primary care pathway could reduce AKI-3 mortality among patients in inpatient and community settings.

Background

Acute Kidney Injury (AKI) is a clinical syndrome defined as a sudden decline in kidney function, characterised by a rise in serum creatinine levels, with or without a reduction in urine output. It has evolved as a major health issue affecting numerous patients globally, eventually leading to reduced life expectancy[1]. Kidney Disease: Improving Global Outcomes (KDIGO) Clinical Practice Guideline has recently redefined the criteria for recognising AKI, and implemented a new three-stage classification of severity[2].

The increase of morbidity and mortality among AKI patients has been well established, namely the development of end-stage renal disease and cardiovascular events [3]. According to a review by Coca et al., patients hospitalized with AKI had increased long-term adverse outcomes compared to their counterparts without AKI [4]. Another study by Chertow et al. depicted an increased mortality, length of inpatient stay and hospital cost as a direct result of developing AKI [5]. The incidence of AKI also increases hospital spending, with an estimated £1 billion annual cost of inpatient AKI-related care accounting for 1% of the annual NHS budget [6].

In addition to the wider adverse consequences of AKI on finance and mortality, the patients may present with various compounding factors such as existing co-morbidities and medications that potentially worsen individual outcomes [7]. In the United Kingdom, Think Kidneys has launched a nationwide kidney awareness campaign to equip healthcare professionals with the knowledge and resources required to recognise and prevent the development of AKI. Recent guidance from the National Institute for Health and Care Excellence (NICE) [8] and National Confidential Enquiry into Patient Outcome and Death [9] was issued to improve early recognition and management of AKI. Internationally, there have been quality improvement projects that explore and affirm the need for service improvement, particularly regarding early recognition, specialist outreach support and staff education [10,11,12].

In this study, we aim to analyse the evolution of patient outcomes relating to site-wide service developments over three years. We also aim to explore its effects on a range of variables known to affect clinical outcome among a cohort of AKI patients, such as co-morbidities and medications.

Methods

Study Population

We conducted a cohort study from 2016-2018, between the dates of 1st September and 31st December. This period was chosen as during this period the hospital services traditionally receive multi-morbid patients with complications. This period has been commonly called as the “winter pressure” period. The study took place at South Tyneside district hospital (STDH), belonging to the South Tyneside and Sunderland NHS Foundation Trust (STSFT). STDH serves the population of South Shields and neighbouring boroughs and is situated in the North-East of England. Its population is circa 150,000 (ONS data, 2016), with a larger proportion of people aged 50+ years compared to the rest of the country. We collected data from 1st September to 31st December 2016 to guide our interventions.

We studied all patients (n=246) who either presented with or developed AKI-3 during their admission at STDH within the mentioned timeframe. Data was retrieved using hospital electronic patient record systems. The inclusion criteria included age 18-95 years and a diagnosis of AKI-3 as per KDIGO classification at presentation or during hospital stay. Patients on an established dialysis regime or on palliative care were excluded from the study.

Reflecting the KDIGO diagnostic criteria, AKI was diagnosed as such:

- Increase in SCr by ≥0.3 mg/dl (≥26.5 mmol/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.

AKI was staged into AKI 3 if any one of the following criteria was met:

- Increase in serum creatinine was ≥3.0 times baseline OR
- Increase in serum creatinine to ≥4.0 mg/dl (≥353.6 mmol/l) OR
- Initiation of renal replacement therapy (RRT) OR
- <0.3 ml/kg/h of urine for ≥24 hours OR
- Anuria for ≥12 hours

Service improvement interventions to improve patient outcome

This site did not have any in-reach of renal services prior to December 2016. Due to local NHS service reorganisation and merger of two trusts renal in-reach services were established. Between each year of study, we implemented changes with the aim to improve patient outcomes.

- Educational awareness programme for primary and secondary care teams. This included regular teaching sessions for the clinical teams on the site. The teaching was delivered by a consultant nephrologist in focussed groups including Foundation year 1 trainee teaching, core medical trainees teaching and during weekly clinical meeting attended by all clinical staff members.
- Nephrology in-reach and inpatient service from the local renal centre. This included establishment of two general nephrology clinics on site and two sessions every week for a consultant nephrologist to review patients presenting with AKI or those needing specialist renal input.
- Creation of an AKI Online Health Pathway tool for primary care, in accordance to South Tyneside Clinical Commissioning Group (CCG) protocols.

The primary outcomes of this study were as follows: in-hospital mortality, length of hospital stay and the recovery of renal function. Secondary outcomes included incidence of common co-morbidities (diabetes mellitus, hypertension, left ventricular failure and liver disease); treatment with RRT; incidence of defined medications (ACE-Inhibitors (ACEi), Angiotensin II Receptor Inhibitors (A2RB), Diuretics.

Statistical Analysis

The categorical variables are presented as percentages and rates, while continuous and skewed variables were expressed in terms of the mean value. Statistical analysis was performed using the 26th version of the SPSS software.

Results on analysed individual variables across the three years were presented as percentage values. The overall cohort analysis also includes relative risk of the examined variables against mortality. We used Pearson's Chi-Squared test to evaluate correlations between mortality and a range of different factors. We accepted categorical variables with $p \leq 0.050$ as having a statistically significant correlation. To compare overall mortality between 2016 to 2018, the use of ACEi, A2RB or Diuretics from 2016-2018 and to evaluate significance on any observed trends, we used Independent T-Test analysis.

Results

A total of 246 patients developing AKI-3 during the study period. 182 of these patients developed AKI-3 in the community and were admitted to hospital as compared to the 64 patients who developed their AKI-3 as an inpatient. However, a gradual rise in incidence of hospital acquired AKI (HA-AKI3) was noted as compared to community acquired AKI (CA-AKI3) during the study period **(Table:1).**

The mean age of incidence of AKI was similar over three years, with mean age being between 68 and 71. The average length of hospital stay was shortest in the first year of study; 15.3 days in 2016, compared to 26.5 days in 2017, and 23.6 days in 2018. Of the 246 patients admitted, there were a total of 64 deaths. Most of these deaths were in male patients, comprising of 38 out of the 64 (59.4%). There was an annual decline of overall mortality throughout the study period, from 29.5% (n=78) in 2016 to 20.7% (n=82) in 2018.

Over the three years, there was a decreasing trend in Renal Replacement Therapy (RRT) treatment; dropping from 9.0% of all patients admitted with AKI-3 in 2016, to 7.0% in 2017, and again to 4.9% in 2018. Out of the 17 patients who were treated with RRT, there was only one death recorded, resulting in a statistically significant correlation between the two variables (p=0.050).

Out of the patients with CA-AKI3 the overall mortality from 2016 to 2018 was 24.2% (n=182), whereas the overall mortality of those with HA-AKI3 was 31.3% (n=64). The relative risk of HA-AKI3 and mortality was 1.29, which indicates an increased risk of death among those with HA-AKI3 when compared to the CA-AKI3 cohort. The rate of change for creatinine levels among CA-AKI3 patients on admission compared to baseline increased from 2016 to 2017 and dropped marginally in 2018. Conversely, AKI-3 creatinine on discharge compared to baseline fell from 2016 to 2017 but increased slightly in 2018.

The study examined the prevalence of ACEi, A2RB or diuretics (the defined medications) in patients who developed AKI-3. An upwards trend was observed when examining the annual use of A2RBs and diuretics, whereas no trend was observed in the use of ACEi. Despite the number of patients on diuretics pre-AKI increasing, associated mortality in this patient group dropped from 42.1% in 2016 (n=19) to 25.0% in 2018 (n=36). Similarly, the mortality of patients on A2RB decreased each year, from 42.9% (n=7) in 2016 to 18.8% (n=16) in 2018 **(Table:2; Figure: 1)**. Contrastingly, no change was observed in mortality among patients on ACEi.

The use of any of the three defined medications increased year-on-year. The use of ACEi, A2RB or diuretics pre-AKI increased from 39.7% in 2016 (n=78), to 59.3% in 2017 (n=86) and 64.6% in 2018 (n=82). Patients presenting to hospital with an AKI-3, on pre-existing ACEi, A2RB or diuretics were more prevalent in

number, but upon instigation of treatment tended to have better outcomes. Mortality associated with the use of these medications reduced each year; 32.3% in 2016, 25.5% in 2017 and 18.9% in 2018 **(Table:1; Figure: 1)**.

Data was collected on four co-morbidities commonly associated with AKI-3, the effects of which were analysed. The four co-morbidities under consideration were as follows: hypertension (HTN), Type 1 or Type 2 Diabetes Mellitus (DM), left ventricular failure (LVF), and liver disease (LD). On this analysis, the two more prevalent comorbidities, HTN (47.2%) and DM (31.7%), were also the ones associated with decreased mortality, with relative mortality risk of 0.872 linked with HTN and 0.718 in the diabetic population. Contrastingly, LVF and LD that were the least prevalent co-morbidities (LVF=18.7%, LD=11.4%) was also the ones associated with increased mortality, showing relative risk ratios of 1.33 and 1.44 respectively **(Table:1; Table:3)**.

Discussion

This study aims to analyse the evolution of patient outcomes relating to site-wide service developments over three years. We also aimed to explore a range of factors known to affect clinical outcome among a cohort of AKI patients, such as co-morbidities and medications. Firstly, there was an overall reduction in patient mortality within this study population during the three-year period. Secondly, there was an inverse relationship between percentage of all AKI patients on the defined medications and mortality. Furthermore, overall patient mortality decreased among those treated with RRT, which proved to be statistically significant. Finally, there was a greater incidence of CA-AKI3 and a greater mortality among patients with HA-AKI3.

There was a reduction in incidence of overall mortality among all AKI-3 patients throughout the study period. While this reduction may be attributed to a multitude of factors, it may well also reflect the interventions and service developments made between 2016 and 2018. Similar outcomes have been demonstrated by an epidemiological study on hospitalized patients with AKI in England by Kolhe et al. [15].

Interestingly, our findings demonstrated an inverse trend across the three years between the percentage of patients that developed AKI on the defined medications and percentage mortality in this group. This may be a reflection on the improvements in education among primary and secondary care teams, which promoted wider appropriate use of ACEi, A2RB or diuretics in the context of AKI-3.

Despite the yearly decrease of RRT within this cohort, the patients who were not treated with RRT had a higher overall mortality compared to those treated with RRT. This was moreover statistically significant (p=0.050), indicating a direct correlation between treatment with RRT and improved survival. The relative risk of mortality of those not treated with RRT was 4.677, showing a significant increase in survival rate when RRT was used as part of their treatment. We can explain this result by the presence of significant co-morbidity and frailty in patients not treated with RRT.

Additionally, we found a greater overall rate of mortality among HA-AKI3 patients (31.3%), which supports a previous study by Meran et al. showing increased mortality among patients with HA-AKI3 compared to CA-AKI3 [13]. Contrastingly, the incidence of CA-AKI3 was significantly higher than that of HA-AKI3 in all three years, which was in accordance with previous studies [14]. There was still a relative yearly decrease in mortality among HA-AKI3 patients, which indicated potential improvements the interventions had on AKI management in a secondary care setting.

Our study has several limitations regarding data collection and statistical significance. Firstly, the characteristics of this study are observational and monocentric, which resulted in a lack of a control arm and a smaller study population. The data was gathered retrospectively from an electronic database that was an extension of the hospital's paper-based system. This meant that hospital-based patient information was often inadequate, and quality of clinical notes were often user-dependent. We mediated this through accessing the patient's general practice records for completion. Furthermore, this study was conducted over a brief timeframe of three years, which decreased the number of patients included in the study population and presented an incomplete view of the longitudinal effects of our interventions. Thus, it was anticipated and demonstrated that despite recognizable trends in mortality across the three years, we were unable to find any statistically significant correlations with any of the measured variables. An additional study over a greater number of years with a larger study population will be beneficial to validate the results of this study.

Conclusion

In conclusion, despite the limitations of this study, we can see a benefit from the applied service improvements toward overall patient outcome and survival. This may be a testament to the positive effects of creating an AKI online health pathway tool, educating wider care teams, and providing easier access to specialist physicians. These factors not only enabled early detection of AKI in primary and secondary care, but also promoted improved management through educating on appropriate use of ACEi, A2RB or diuretics. Therefore, this study supports development of in-reach nephrology services to those acute hospital sites where only remote nephrology services can be accessed.

Abbreviations

AKI-3 - Acute Kidney Injury – 3

KDIGO - Kidney Disease: Improving Global Outcomes

STDH - South Tyneside district hospital

STSFT - South Tyneside and Sunderland NHS Foundation Trust

RRT - Renal Replacement Therapy

CCG - Clinical Commissioning Group

DM – Diabetes Mellitus

LVF – Left Ventricular Failure

LD – Liver Disease

HTN – Hypertension

ACE-I – Angiotensin Converting Enzyme – Inhibitor

A2RB – Angiotensinogen 2 Receptor Blocker

HA- AKI-3 – Hospital Acquired AKI -3

CA-AKI-3 – Community Acquired AKI-3

Declarations

Ethics approval and consent to participate

This project was registered with the hospital audit and clinical governance department. Ethical approval was not required for this service improvement evaluation. This is compliant with national guidance: http://www.hra-decisiontools.org.uk/ethics/resultN2.html. All patient-level data are anonymised, and only aggregated patient data are reported in this study.

Consent for publication

Not applicable

Competing interests

None

Funding

None

Authors' contributions

E Gkekas and TYT Tang collected the data, contributed to the writing of the manuscript and did the statistical analysis.

M Brazell, M Brennan, J Chernick, P Jones, A Robinson, G Suthermaraj, P Gaunt, H Ayub – collected the data and contributed to the writing of the manuscript.

R Clark and S Ahmed reviewed and contributed to writing the manuscript

S Srivastava – conceived the project and wrote the manuscript.

Acknowledgements

We would like to thank the Mr. Ian Dunn at the Biochemistry department at Queen Elizabeth Hospital, Gateshead for providing the AKI data.

References

1. Singbartl, K. and J.A. Kellum, AKI in the ICU: definition, epidemiology, risk stratification, and outcomes. Kidney Int, 2012. 81(9): p. 819-25.
2. Khwaja, A., KDIGO Clinical Practice Guidelines for Acute Kidney Injury. Nephron Clinical Practice, 2012. 120(4): p. C179-C184.
3. Odutayo A, Wong CX, Farkouh M, Altman DG, Hopewell S, Emdin CA, Hunn BH. AKI and long-term risk for cardiovascular events and mortality. Journal of the American Society of Nephrology. 2017 Jan 1;28(1):377-87.
4. Coca SG, Yusuf B, Shlipak MG, Garg AX, Parikh CR. Long-term risk of mortality and other adverse outcomes after acute kidney injury: a systematic review and meta-analysis. American journal of kidney diseases. 2009 Jun 1;53(6):961-73.
5. Chertow, G.M., et al., Acute kidney injury, mortality, length of stay, and costs in hospitalized patients. J Am Soc Nephrol, 2005. 16(11): p. 3365-70.
6. Kerr, M., et al., The economic impact of acute kidney injury in England. Nephrol Dial Transplant, 2014. 29(7): p. 1362-8.
7. Finlay S, Bray B, Lewington AJ, Hunter-Rowe CT, Banerjee A, Atkinson JM, Jones MC. Identification of risk factors associated with acute kidney injury in patients admitted to acute medical units. Clinical medicine. 2013 Jun;13(3):233
8. Ftouh, S., M. Thomas, and A.K.I.G. Dev, Acute kidney injury: summary of NICE guidance. Bmj-British Medical Journal, 2013. 347.
9. MacLeod, A., NCEPOD report on acute kidney injury-must do better. Lancet, 2009. 374(9699): p. 1405-6.
10. Park S, Baek SH, Ahn S, Lee KH, Hwang H, Ryu J, Ahn SY, Chin HJ, Na KY, Chae DW, Kim S. Impact of electronic acute kidney injury (AKI) alerts with automated nephrologist consultation on detection and severity of AKI: a quality improvement study. American Journal of Kidney Diseases. 2018 Jan

1;71(1):9-19.

11. Xu G, Baines R, Westacott R, Selby N, Carr S. An educational approach to improve outcomes in acute kidney injury (AKI): report of a quality improvement project. BMJ open. 2014 Mar 1;4(3):e004388.
12. Chandrasekar T, Sharma A, Tennent L, Wong C, Chamberlain P, Abraham KA. A whole system approach to improving mortality associated with acute kidney injury. QJM: An International Journal of Medicine. 2017 Oct 1;110(10):657-66.
13. Meran, S., et al., How good are we at managing acute kidney injury in hospital? Clin Kidney J, 2014. 7(2): p. 144-50.
14. Schissler, M.M., et al., Characteristics and outcomes in community-acquired versus hospital-acquired acute kidney injury. Nephrology (Carlton), 2013. 18(3): p. 183-7.
15. Kolhe, N.V., et al., The epidemiology of hospitalised acute kidney injury not requiring dialysis in England from 1998 to 2013: retrospective analysis of hospital episode statistics. Int J Clin Pract, 2016. 70(4): p. 330-9.

Tables

Table 1: Analysis of individual variables and associated mortality across three years

	2016 (n=78)			2017 (n=86)			2018 (n=82)			Overall (n=246)			
Variable	Patients (%)	Mortality (%)	P Value	Patients (%)	Mortality (%)	P Value	Patients (%)	Mortality (%)	P Value	Patients (%)	Mortality (%)	Relative Risk	P Valu
Sex													
Female	29 (37.2)	11 (37.9)	.208	42 (48.8)	10 (23.8)	.408	33 (40.2)	5 (15.2)	.306	104 (42.3)	26 (25.0)	0.934	.756
Male	49 (62.8)	12 (24.5)	.208	44 (51.2)	14 (31.8)	.408	49 (59.8)	12 (24.5)	.306	142 (57.7)	38 (26.8)	1.07	.756
AKI-3													
CA-AKI3	61 (78.2)	15 (24.6)	.072	64 (74.4)	17 (26.6)	.635	57 (69.5)	12 (21.1)	.914	182 (74.0)	44 (24.2)	0.774	.267
HA-AKI3	17 (21.8)	8 (47.1)	.072	22 (25.6)	7 (31.8)	.635	25 (30.5)	5 (20.0)	.914	64 (26.0)	20 (31.3)	1.29	.267
Medications													
ACEi	19 (24.4)	4 (21.1)	.354	27 (31.4)	5 (18.5)	.189	19 (23.2)	4 (21.1)	.969	65 (26.4)	13 (20.0)	0.710	.197
A2RB	7 (9.0)	3 (42.9)	.416	8 (9.3)	2 (25.0)	.847	16 (19.5)	3 (18.8)	.827	31 (12.6)	8 (25.8)	0.991	.977
Diuretics	19 (24.4)	8 (42.1)	.165	37 (43.0)	11 (29.7)	.743	36 (43.9)	9 (25.0)	.399	92 (37.4)	28 (30.4)	1.30	.222
Any of above	31 (39.7)	10 (32.3)	.663	51 (59.3)	13 (25.5)	.811	53 (64.6)	10 (18.9)	.574	135 (54.9)	33 (24.4)	0.875	.535
Comorbidities													
DM	16 (20.5)	4 (25.0)	.659	28 (32.6)	7 (25.0)	.676	34 (41.5)	5 (14.7)	.257	78 (31.7)	16 (20.5)	0.718	.180
HTN	33 (42.3)	10 (30.3)	.892	41 (47.7)	13 (31.7)	.453	42 (51.2)	5 (11.9)	.043	116 (47.2)	28 (24.1)	0.872	.526
LVF	8 (10.3)	4 (50.0)	.179	14 (16.3)	5 (35.7)	.477	24 (29.3)	6 (25.0)	.540	46 (18.7)	15 (32.6)	1.33	.258
LD	5 (6.4)	3 (60.0)	.122	12 (14.0)	5 (41.7)	.252	11 (13.4)	2 (18.2)	.823	28 (11.4)	10 (35.7)	1.44	.214
RRT													
Yes	7 (9.0)	1 (14.3)	.355	6 (7.0)	0 (0.0)	.114	4 (4.9)	0 (0.0)	.294	17(6.9)	1 (5.9)	0.214	.050
No	71 (91.0)	22 (31.0)	.355	80 (93.0)	24 (30.0)	.114	78 (95.1)	17 (21.8)	.294	229 (93.1)	63 (27.5)	4.677	.050

Table 2: Patient outcomes across three years

Outcome	2016 (n=78)	2017 (n=86)	2018 (n=82)	Overall (n=246)
Discharge or Transfer	55 (70.5)	62 (72.1)	65 (79.3)	182 (74.0)
Death	23 (29.5)	24 (27.9)	17 (20.7)	64 (26.0)

Table 3: Mortality Rate Comparisons between 2016 and 2018

Mortality Rate Comparison - 2016 to 2018			
Variable	2016 (n=78)	2018 (n=82)	Difference
Overall (n=160)	29.5%	20.7%	↓8.8%
CA-AKI3 (n=118)	24.6%	21.1%	↓3.5%
HA-AKI3 (n=42)	47.1%	20.0%	↓27.1%
ACEi (n=38)	21.1%	21.1%	0.0%
A2RB (n=23)	42.9%	18.8%	↓24.1%
Diuretics (n=55)	42.1%	25.0%	↓17.1%
Any of above 3 (n=84)	32.3%	18.9%	↓13.4%
DM (n=50)	25.0%	14.7%	↓10.3%
HTN (n=75)	13.3%	11.9%	↓1.4%
LVF (n=32)	50.0%	25.0%	↓25.0%
LD (n=16)	60.0%	18.2%	↓41.8%

Figures

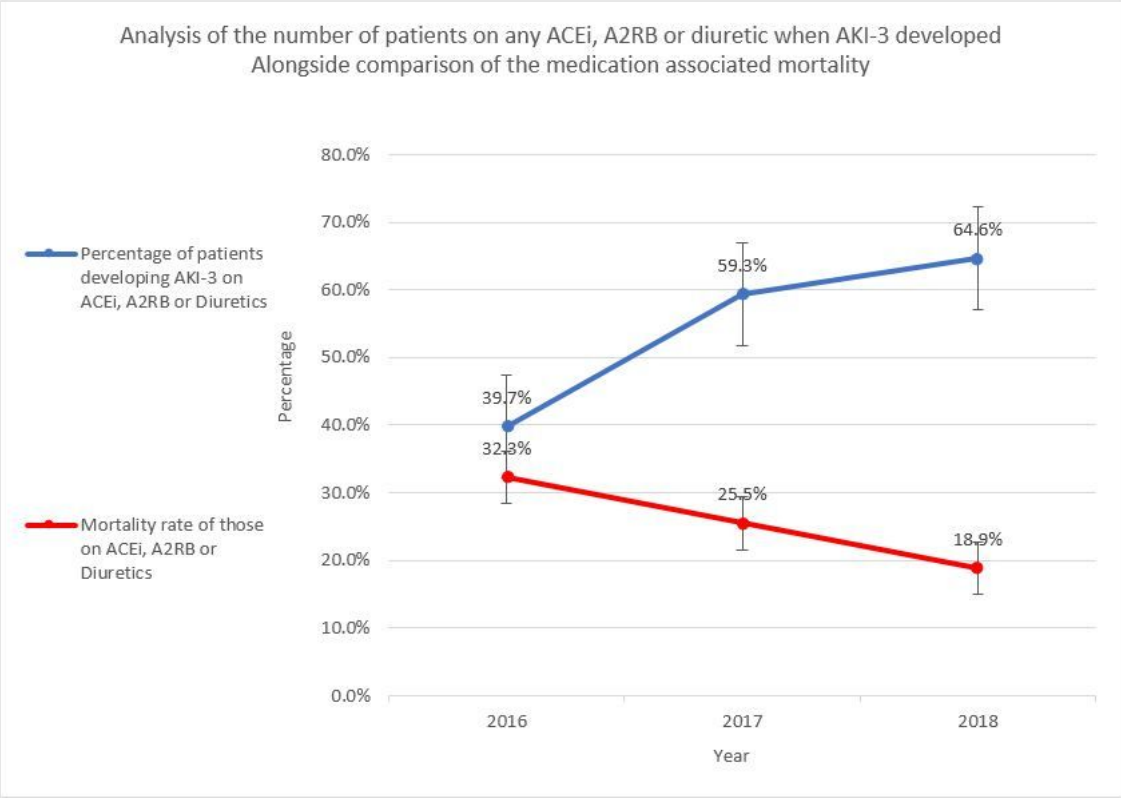

Figure 1

Analysis of the number of patients on any ACEi, A2RB or diuretic when AKI-3 developed. Alongside comparison of the medication associated mortality.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AKIAppendix1.docx
- AKIAppendix2.docx