A Trial of a “Kidney Action Team” for Hospitalized Patients with Acute Kidney Injury

F. Perry Wilson, MD MSCE

Associate Professor of Medicine and Public Health

Director, Clinical and Translational Research Accelerator

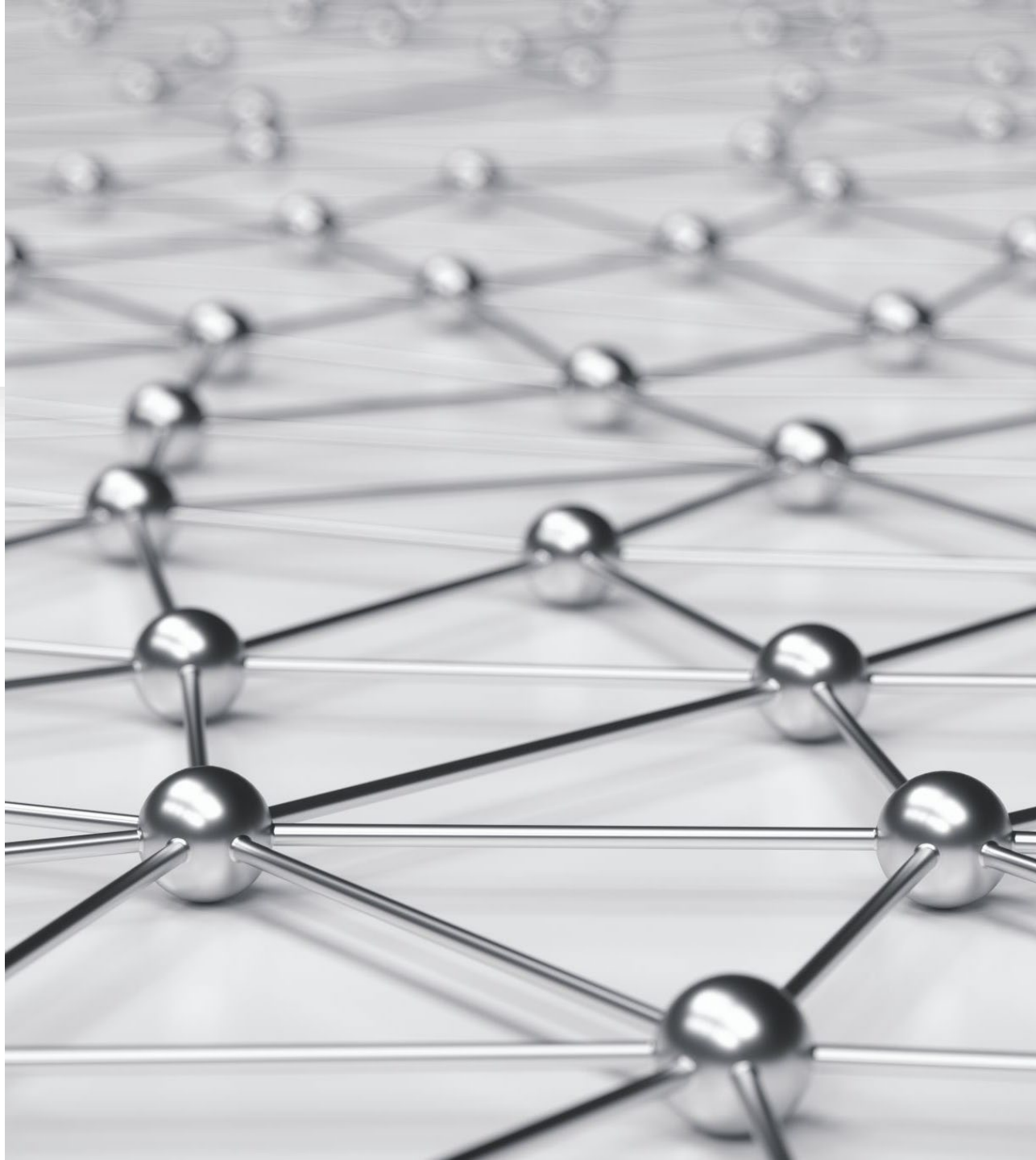
Yale University, New Haven CT USA

Disclosures

- Research support: NIDDK, AHRQ, DOD, Amgen, AstraZeneca, Whoop
- Consulting: WndrHLTH
- Ownership: Efference, LLC

Learning Objectives

- Describe the four critical elements for alerts to be successful in theory
- Describe the elements alerts require to be successful in practice
- Describe how human-supervised recommendations may lead to better alert automation



Grand Unified Theory of Electronic Alerts

Alerts can not work if…

- The provider already *knows* what is wrong with the patient
- They don't *care* about what is wrong with the patient
- They have no specific *action* to take in response
- The action does not *matter* - i.e it doesn't change outcomes

AKI is a Problem!

- Acute Kidney Injury is common in hospitalized patients (~15%).

- A hospitalized patient with AKI has an inpatient mortality rate of 10% (vs. 1.5% for a hospitalized patient without AKI)

- Early recognition and nephrologist involvement may improve clinical outcomes

AKI Definition

- Abrupt decline in kidney function.
- Based on serum creatinine levels:
  - Increase by 0.3mg/dL over 48 hours.
  - Relative increase by 50% over 7 days.

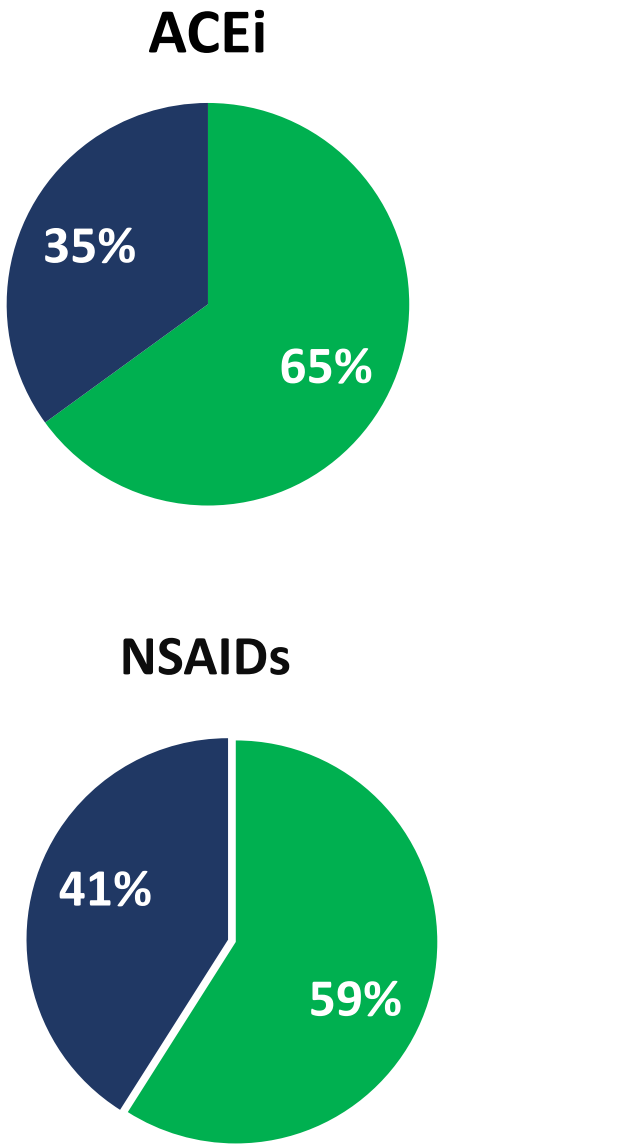
THE PROBLEM - ACTIONS

Nephrotoxic agents are continued after AKI.

Best Practice	Current Rate
AKI Documentation	34.2%
Urinalysis	16.4%
Creatinine Monitoring	65.2%
Urine output monitoring	77.5%
Avoidance of Nephrotoxins	92.6%

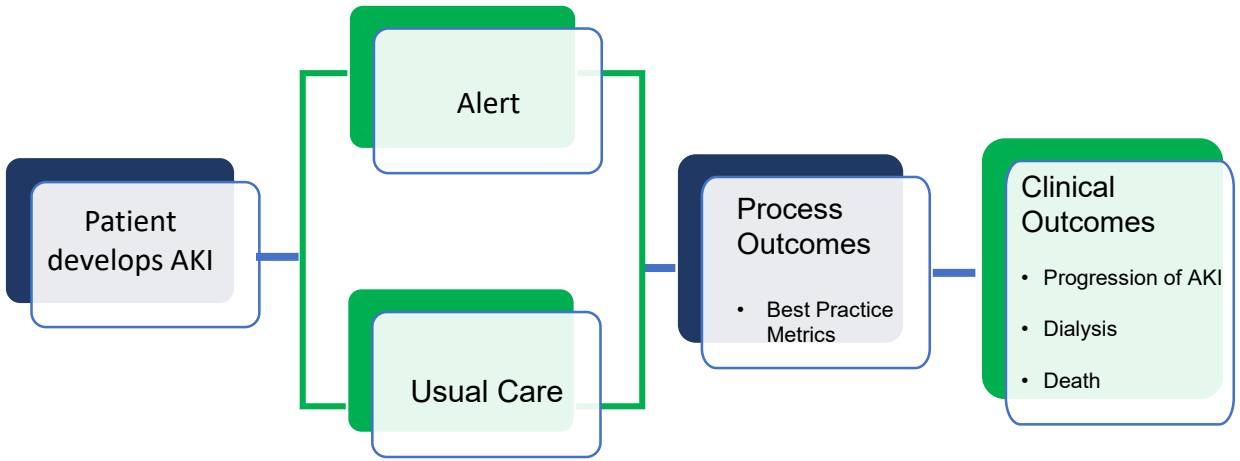
AKI best practices occurring within 24 hours of AKI among 9,534 individuals with AKI at 3 study hospitals. Nephrotoxins defined as receipt of iodinated contrast, aminoglycoside, or NSAID.

Moledina et al. AJKD 2020



ARE ALERTS A SOLUTION? A RANDOMIZED TRIAL

ELAIA-1 was a multicenter, randomized, parallel-group clinical trial of an electronic alert system for acute kidney injury.



Best Practice Alert for AKI

BestPractice Advisory

Patient Safety (Advisory: 1)

AKI Alert:

Your patient has been identified as having acute kidney injury. Relevant creatinine values over the last seven days are listed below:

Most recent: 0.93 mg/dl

Lowest in past 7 days: 0.5 mg/dl

Highest in past 7 days: 0.93 mg/dl

THIS ALERT DOES NOT FIRE FOR ALL PATIENTS. This patient is part of a randomized trial. For more information click here: www.akistudy.org. For AKI best practices, click here: www.akistudy.org/aki-best-practices.

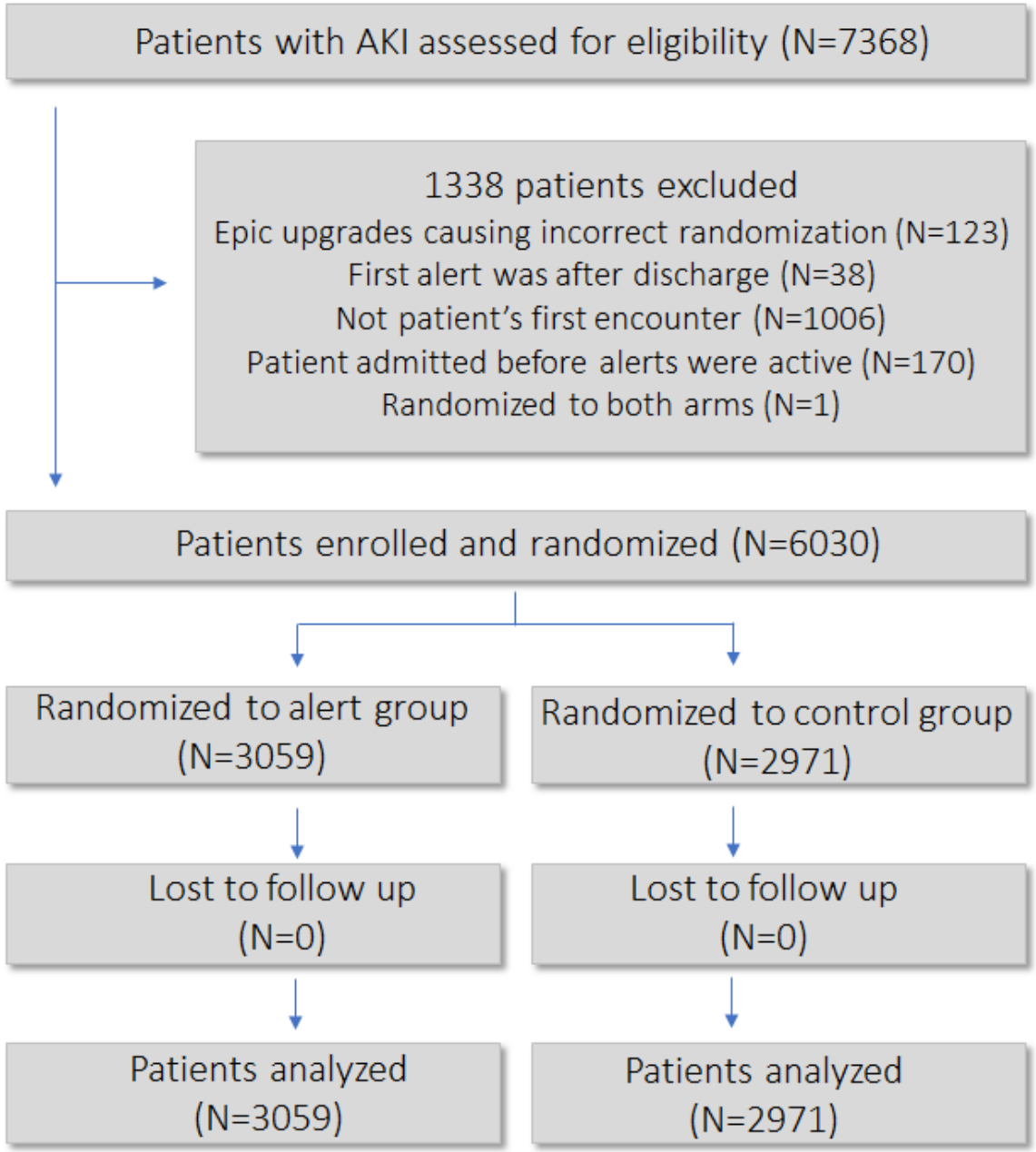
Open Order Set	Do Not Open	AKI ORDER SET preview
Add Problem	Do Not Add	Acute kidney injury > Edit details (Hospital problem, Share with patient)

Acknowledge Reason

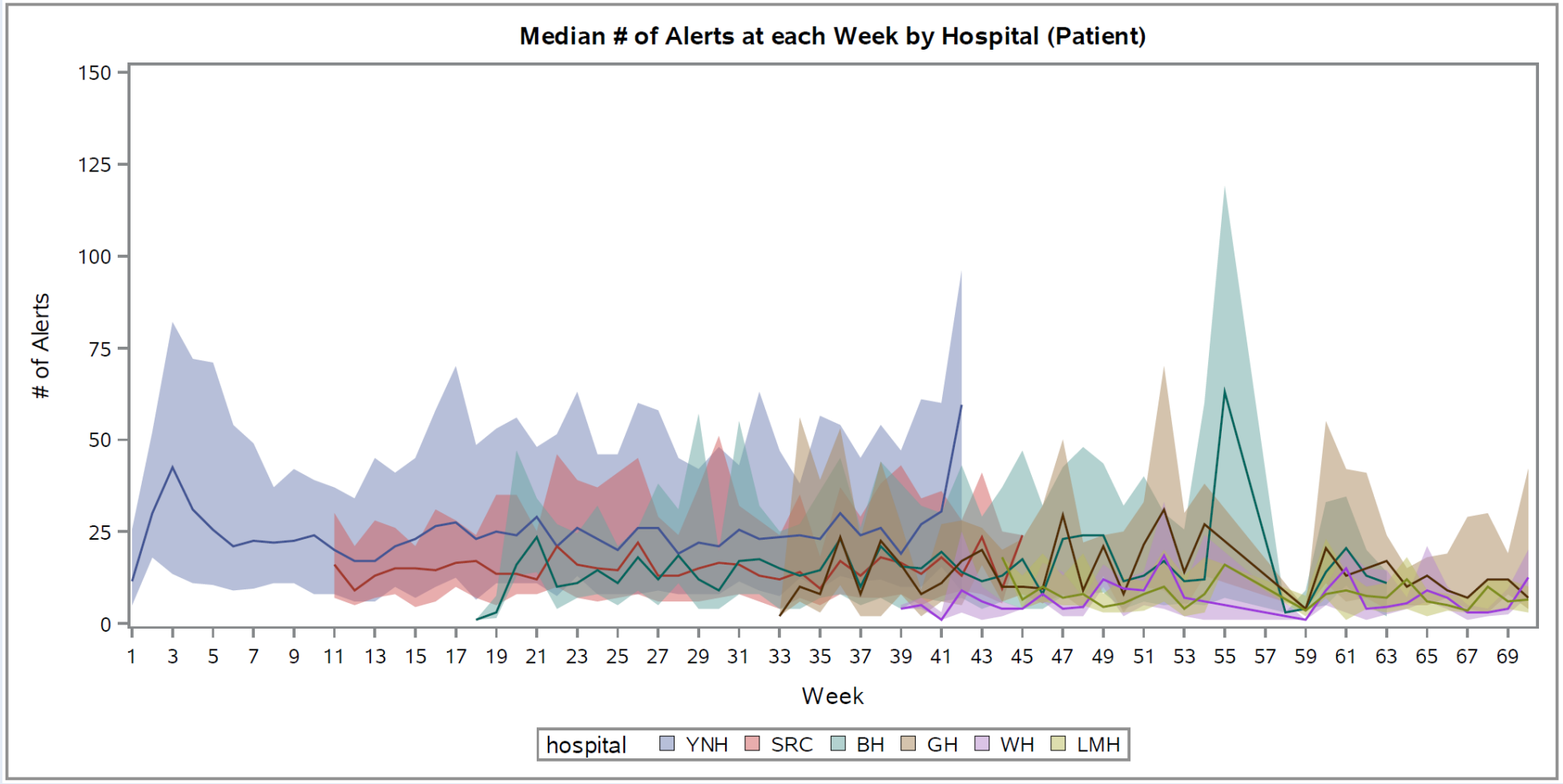
Agree - Do not alert me for 48 hours | Disagree with alert because...

Accept | Dismiss

CONSORT Diagram



THE PRICE OF REAL-TIME RESEARCH IS ETERNAL VIGILANCE



Weekly Metrics *We* Follow…

Variables "Break"

HOSPITAL	PT_DEPT_AT_TIME_ALERT_FIRED	LAG	ACTION_INSTANT	TRIGGERING_LAB_RESULT_TIME
YNH	YNH EP 65 SURGERY	-2:09	2018-06-22T06:00:00	2018-06-22T08:09:00
YNH	YNH EP 75 MEDICINE	-1:40	2018-06-22T06:34:00	2018-06-22T08:14:00
YNH	YNH NP 10 MICU SD	-1:26	2018-06-22T06:13:00	2018-06-22T07:39:00
YNH	YNH SP 51 CORONARY CARE UNIT	-2:34	2018-06-22T06:00:00	2018-06-22T08:34:00
YNH	YNH NP 11 HEME ONCOLOGY	-1:47	2018-06-22T06:04:00	2018-06-22T07:51:00
YNH	YNH SP 54 SURGERY	-1:58	2018-06-22T05:55:00	2018-06-22T07:53:00
YNH	YNH NP 9 MICU	-1:13	2018-06-22T06:33:00	2018-06-22T07:46:00

Negative time values all happening on the same day

Hi Perry

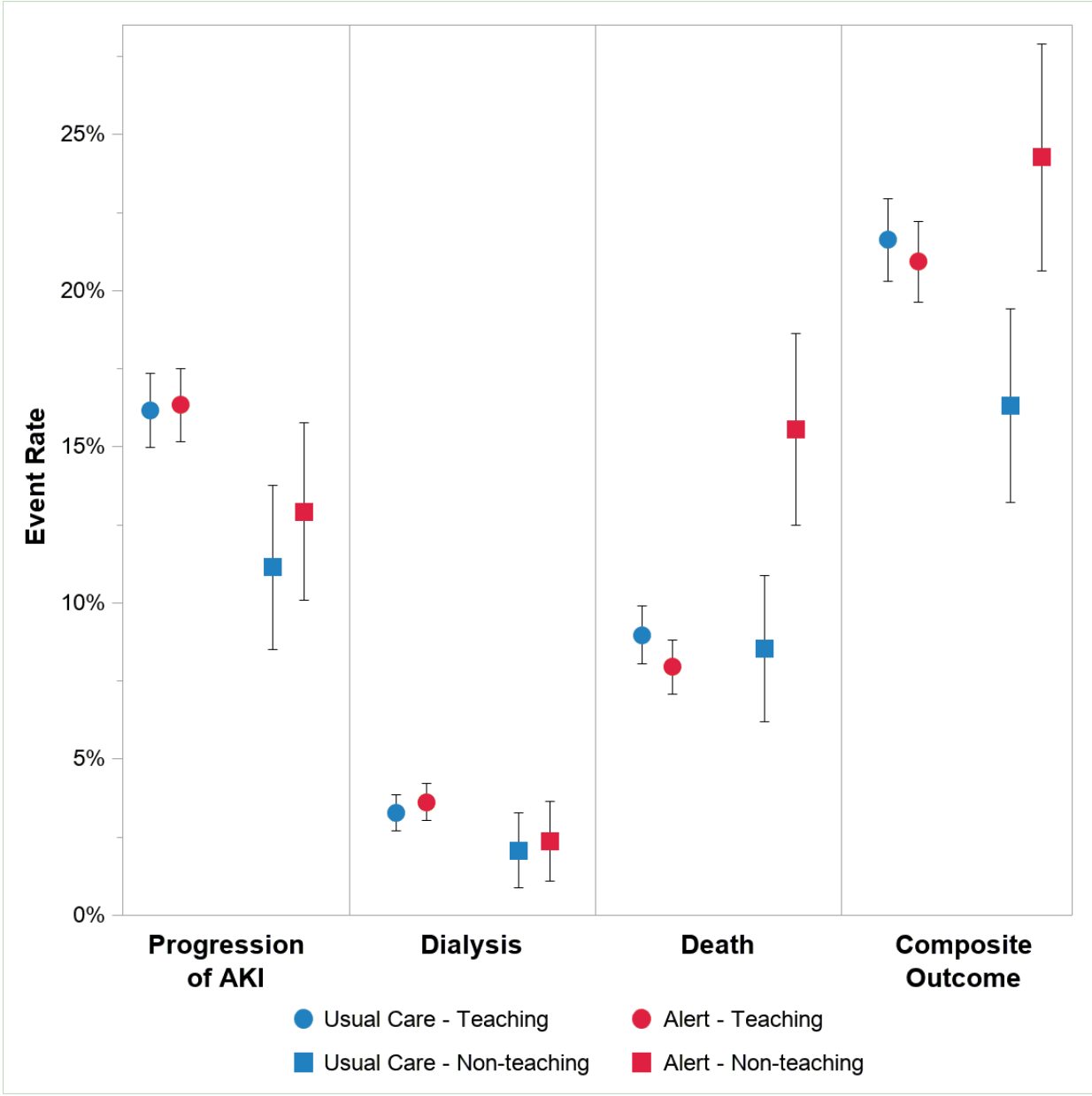
Yes. We did have some corections made that day for creatinine. The regent volume was incorrect/unupdated, but all patients that were affected during that period were repeated and corrected. Corrective action has already been taken to prevent this from happening in the future.

I hope this clarifies your question. I apologize for any inconvenience this has caused you.

Julie

Julie Diakonikolas, MLS (ASCP)^{CM}
Autochemistrty Section Coordinator

ELAIA-1: Unexpected Results



Wilson et al. BMJ. 2021

Explaining a Surprise?

	Adjusted Relative Risk of Death	Percent of Effect Mediated
Baseline adjusted Relative Risk	**1.58 (1.08 - 2.31)**	**n/a**
Markers of Fluid Overload		
IV fluid administration (binary)	1.59 (1.09 - 2.31)	-3.1
NS administration (binary)	1.58 (1.08 - 2.31)	-1.6
LR administration (binary)	1.61 (1.10 - 2.35)	-0.4
IV Fluid Administration (Total in 24h)	1.58 (1.08 - 2.31)	-0.6
O2 Sat (24 h)	1.60 (1.08 - 2.37)	-1.4
O2 Sat (48 h)	1.58 (1.07 - 2.33)	-0.5
Change in O2 sat	1.51 (1.01 - 2.24)	-0.4
Respiratory rate	1.52 (1.03 - 2.24)	-1.6
Change in Respiratory rate	1.52 (1.03 - 2.24)	-1.6
Medications		
IV Contrast	1.58 (1.08 - 2.33)	0.8
Diuretic use	1.54 (1.05 - 2.25)	-0.1
Loop Diuretic use	1.58 (1.08 - 2.31)	-0.6
Process Factors		
Other alert burden	1.58 (1.08 - 2.31)	0
Percent of Alerts to Attending Physicians	1.57 (1.07 - 2.30)	2.8
Renal Consult	1.58 (1.07 - 2.31)	-0.3

ELAIA-1 TAKE HOME POINTS

Real-time clinical research is highly efficient and cost effective.

These studies are pragmatic and give practical, actionable information for a health system.

Randomized trials are key to detect unexpected effects

AKI Bundles May Improve Outcomes

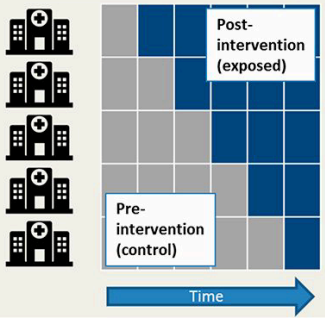
Tackling AKI Study: Organisational Level Interventions for Acute Kidney Injury

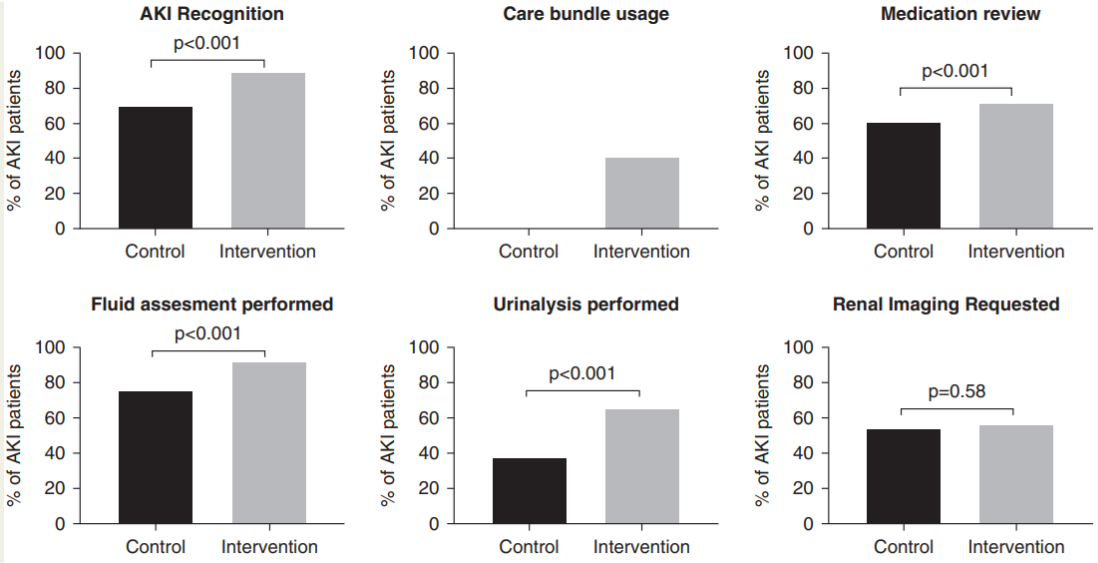
METHODS:

Multicentre stepped-wedge cluster randomised trial.

Intervention: hospital-wide AKI e-alerts, care bundle and education.

24,059 AKI episodes
5 hospitals





OUTCOMES:

- **30-day mortality** (Primary outcome)
- **AKI progression**

UNCHANGED

- **Hospital length of stay** (in those with longer LoS)

REDUCED

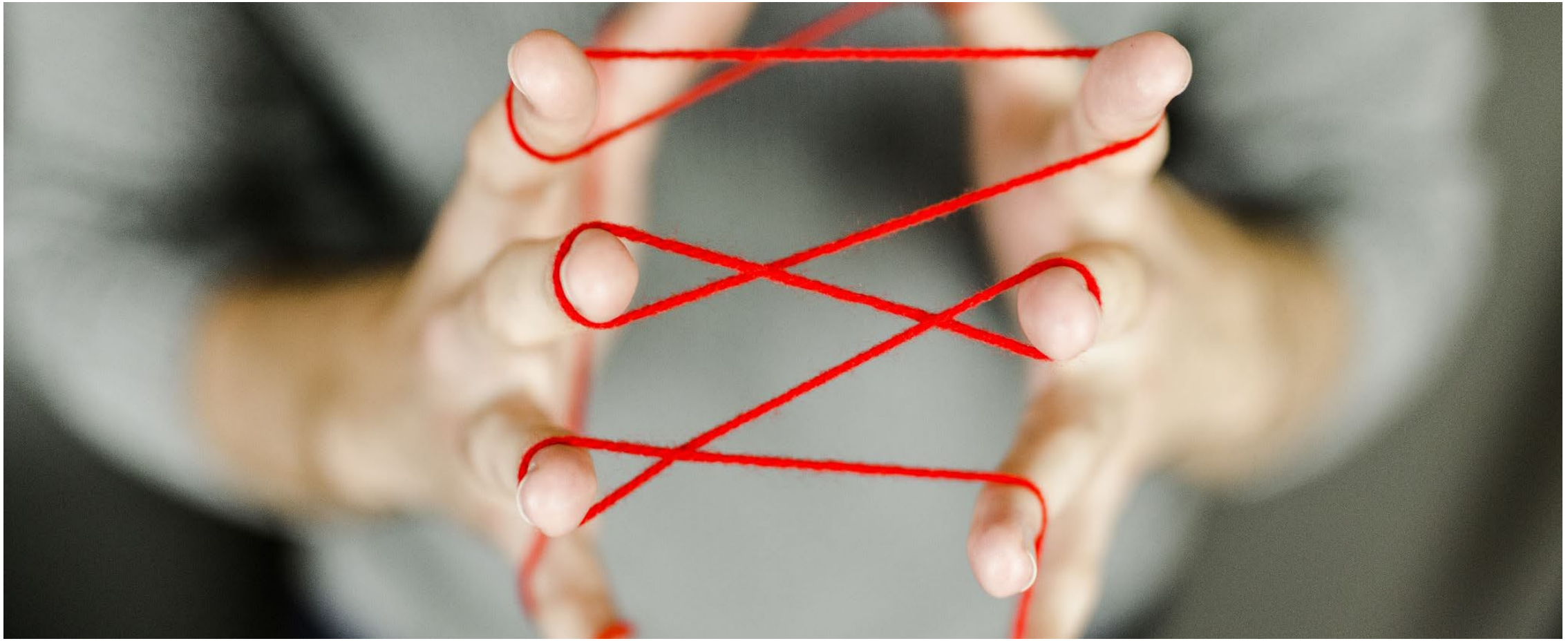
- **AKI incidence** (improved detection)
- **Delivery of AKI care**

INCREASED

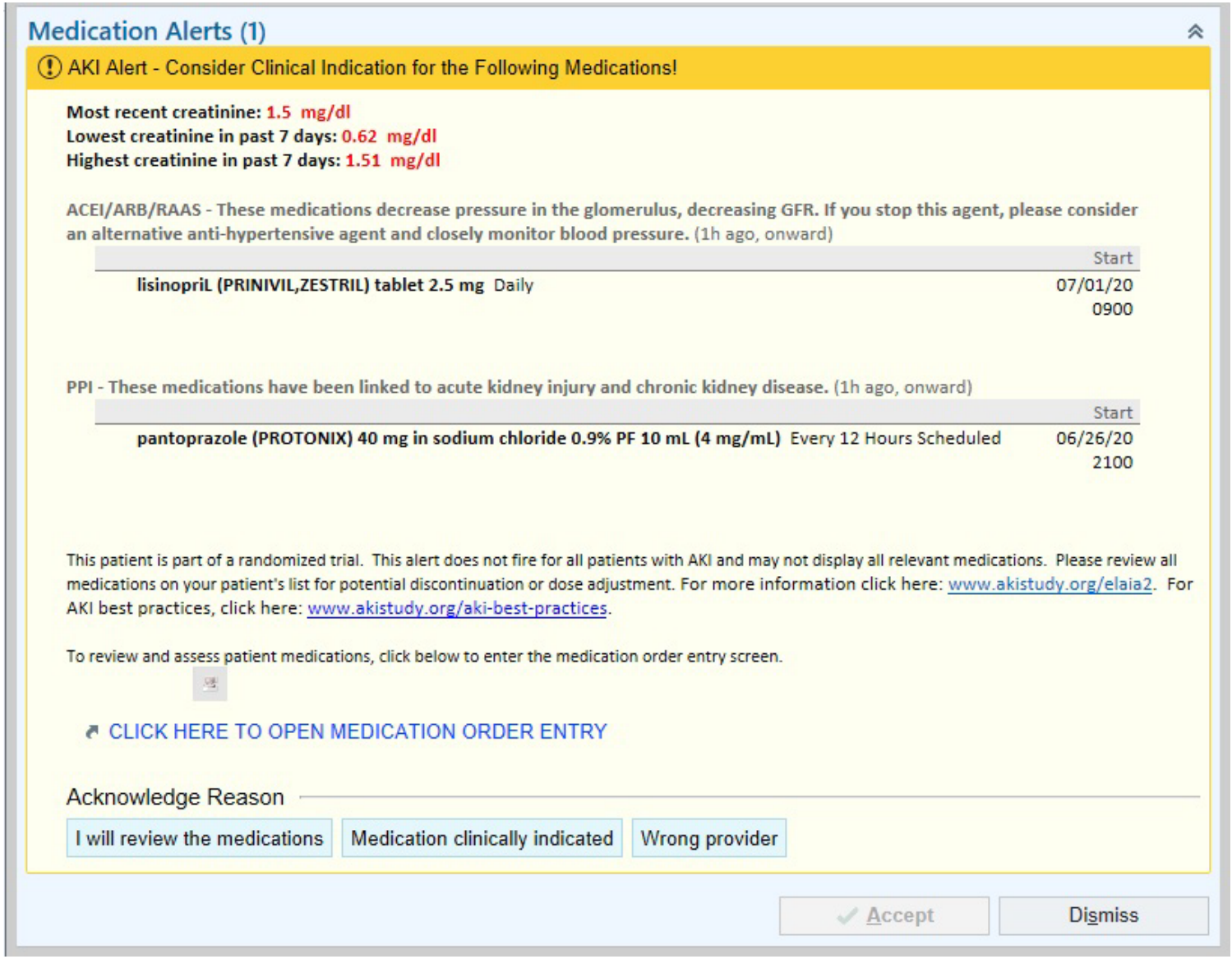
CONCLUSION: A complex, hospital-wide intervention for AKI did not alter mortality but reduced hospital length of stay, whilst improving quality of care and AKI recognition.

Selby et al. JASN 2019.

Hypothesis: Alerts Should Be Tied To Actions



ELAIA-2: Drug-Targeted AKI Alerts



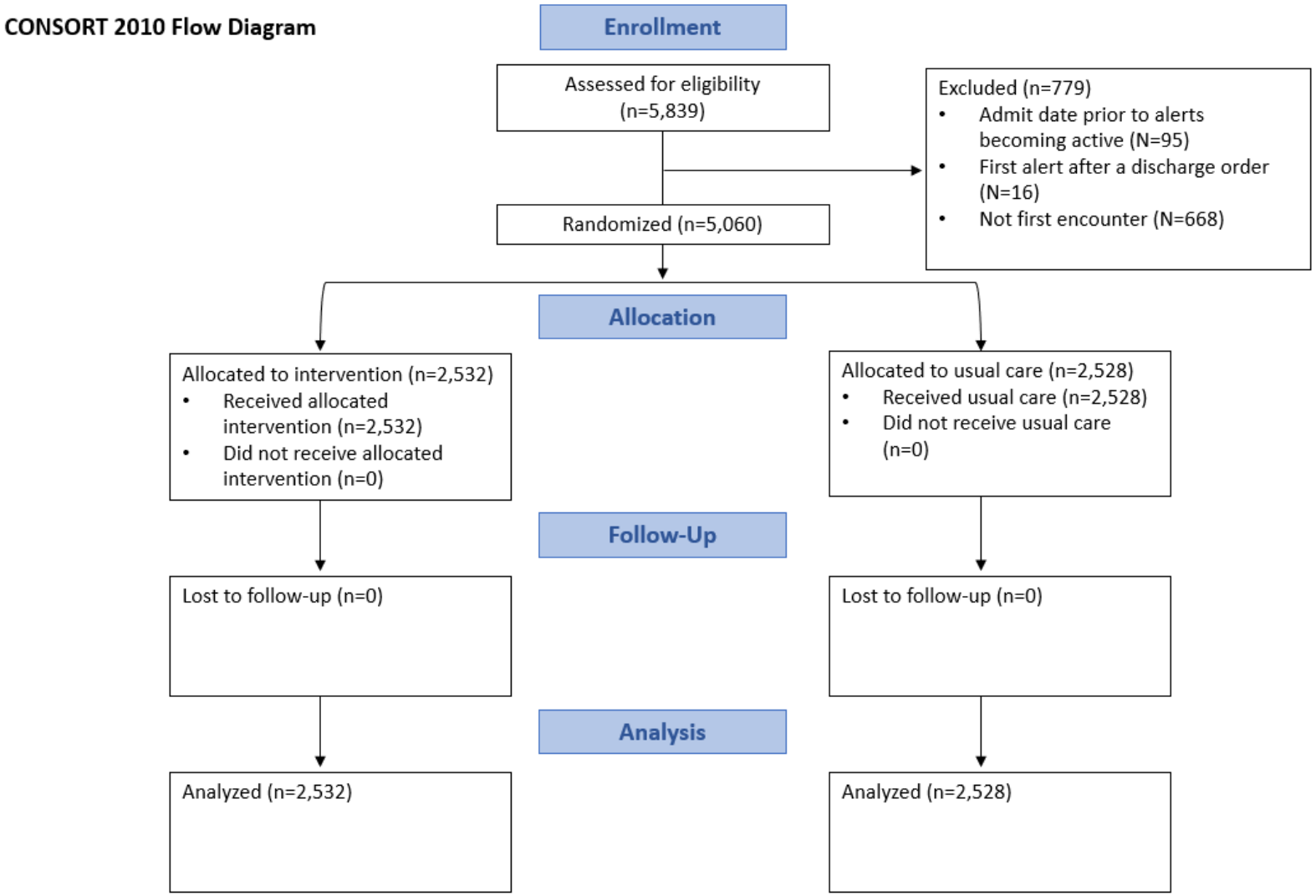
Selection of Medications of Interest

	NSAID	RAASi	PPI
Mechanism	Decreased kidney perfusion	Decreased kidney perfusion	Interstitial inflammation
Guideline Recommendation	Discontinue in appropriate clinical scenario		
Empiric evidence	Frequently discontinued	Sometimes discontinued	Rarely discontinued

KDIGO Clinical Practice Guideline for Acute Kidney Injury, KI, 2012

Design

- Open-label, paralle group randomized controlled trial



Inclusion / Exclusion Criteria

Inclusion

- Adults >=18 years of age
- Inpatient
- KDIGO Stage 1 AKI
- Active order for medication of interest

Exclusion

- Initial hospital creatinine >= 4.0 mg/dL
- Dialysis within a year prior to AKI
- Hospice or “comfort measures only”
- ICD-10 with ESKD
- Kidney transplant
- Previously enrolled

Primary and Secondary Outcomes

Primary:

- Process Outcome: Cessation of at least one medication of interest within 24 hours
- Clinical Outcome: Progression of AKI, dialysis, or death within 14 days of randomization or until discharge (whichever came first)

Secondary outcomes:

- Individual components of primary
- Duration of AKI
- 30-day readmission

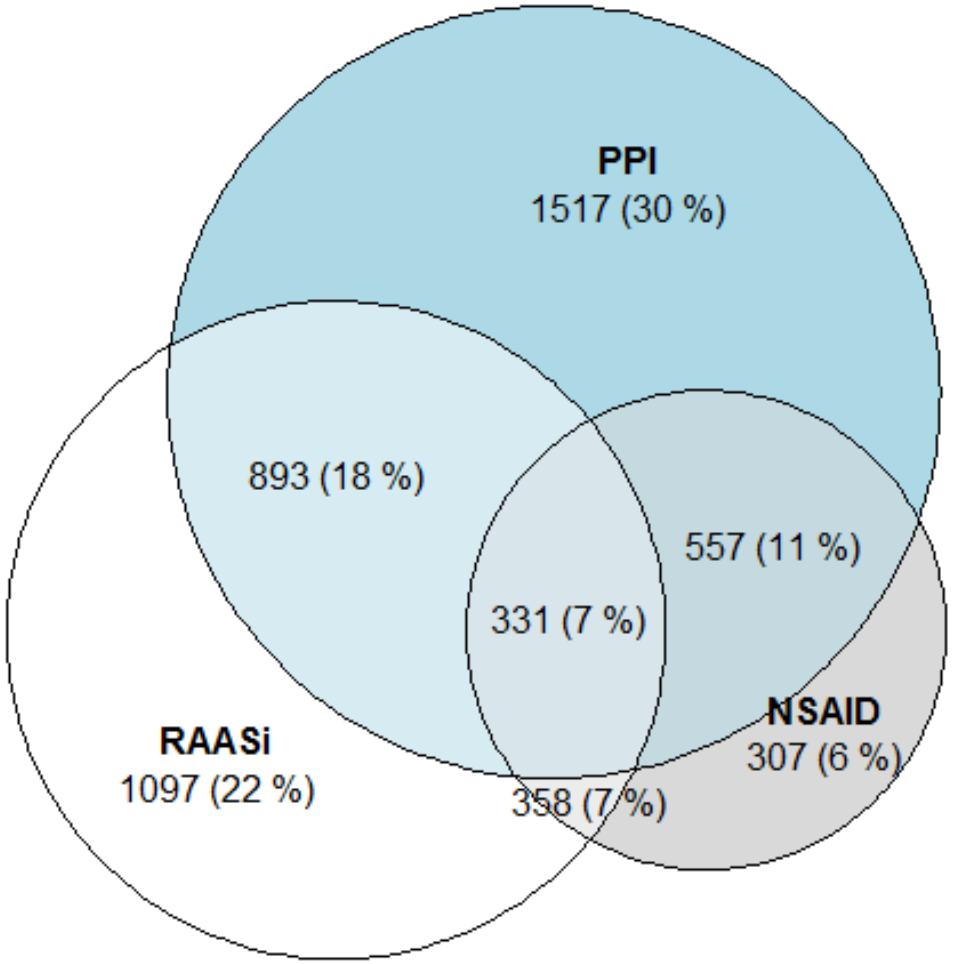
Safety outcomes:

- NSAIDs: Pain scores, opioid use
- RAASi: Hypertension, mechanical ventilation
- PPI: Pain scores, hemoglobin levels, blood transfusion

Participant Characteristics

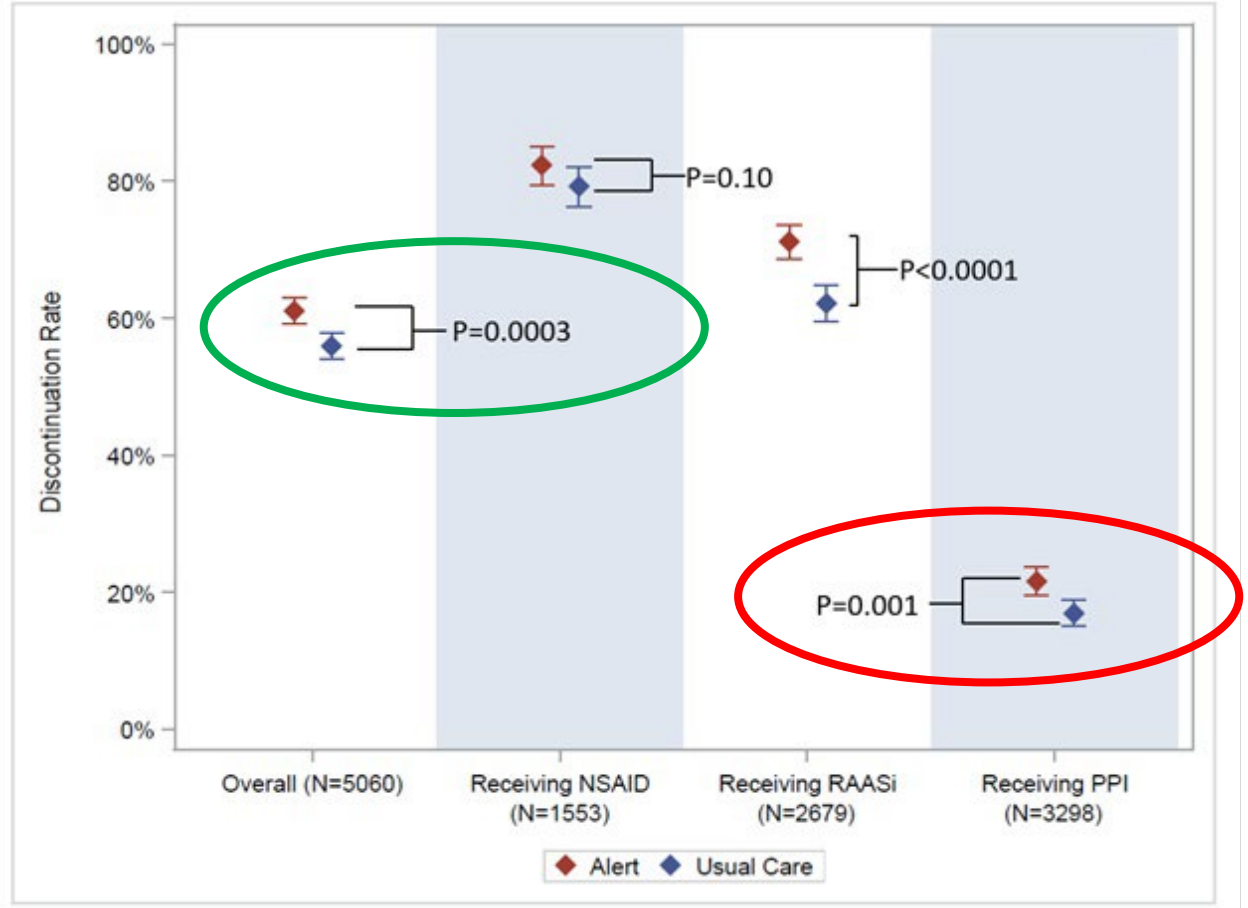
	Alert (N=2,532)	Usual Care (n=2,528)
Age	70 (59, 81)	70 (59, 80)
Female	1231 (49%)	1222 (48%)
Black	498 (20%)	470 (19%)
Medical admission	1937 (77%)	1924 (76%)
ICU at randomization	560 (22%)	598 (24%)
CHF	827 (33%)	784 (31%)
Diabetes mellitus	967 (38%)	928 (37%)
Creatinine (admission), mg/dL	1.2 (0.9, 1.7)	1.2 (0.8, 1.6)
Creatinine (randomization), mg/dL	1.5 (1.2, 2.0)	1.5 (1.1, 2.0)
Modified SOFA	2 (1 ,4)	3 (1, 5)

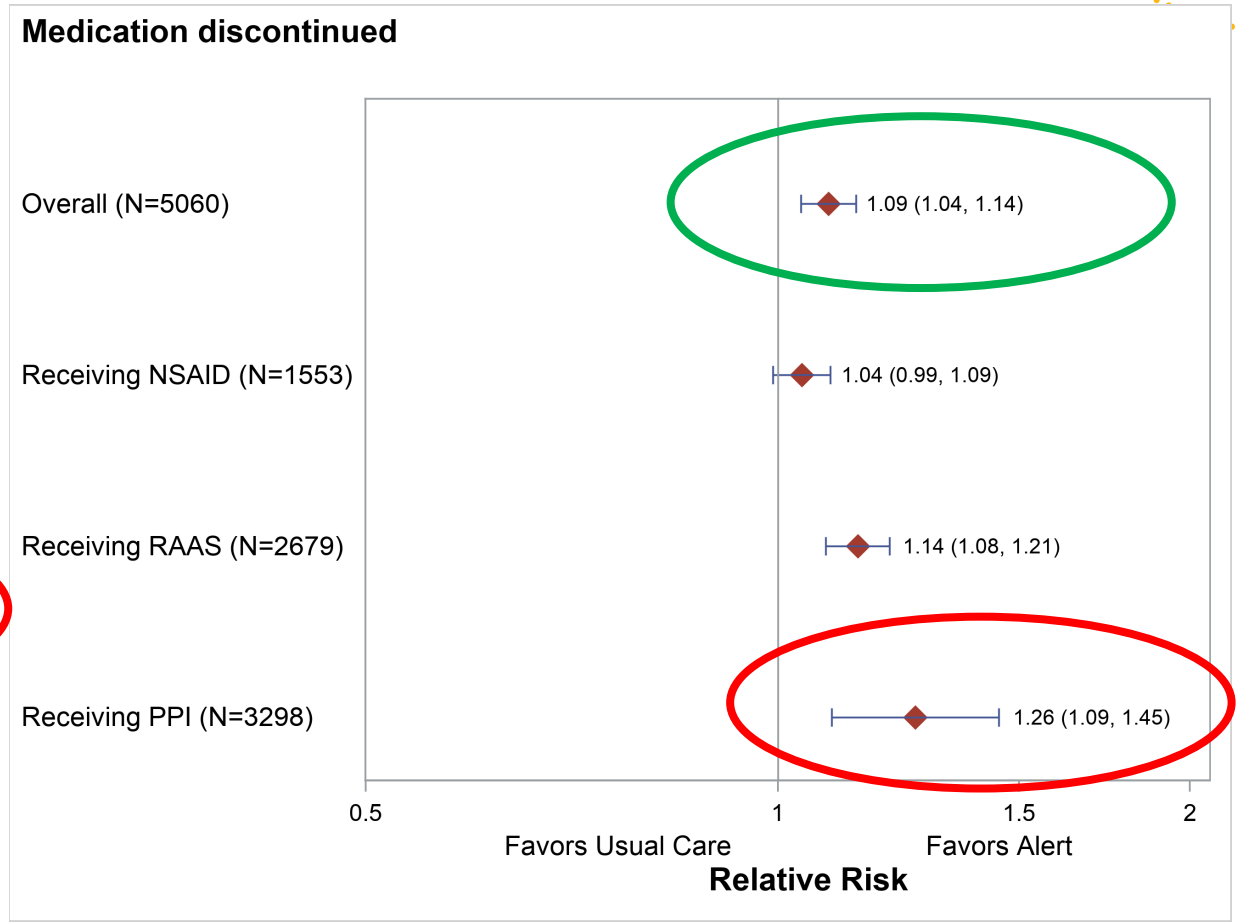
Medications of Interest



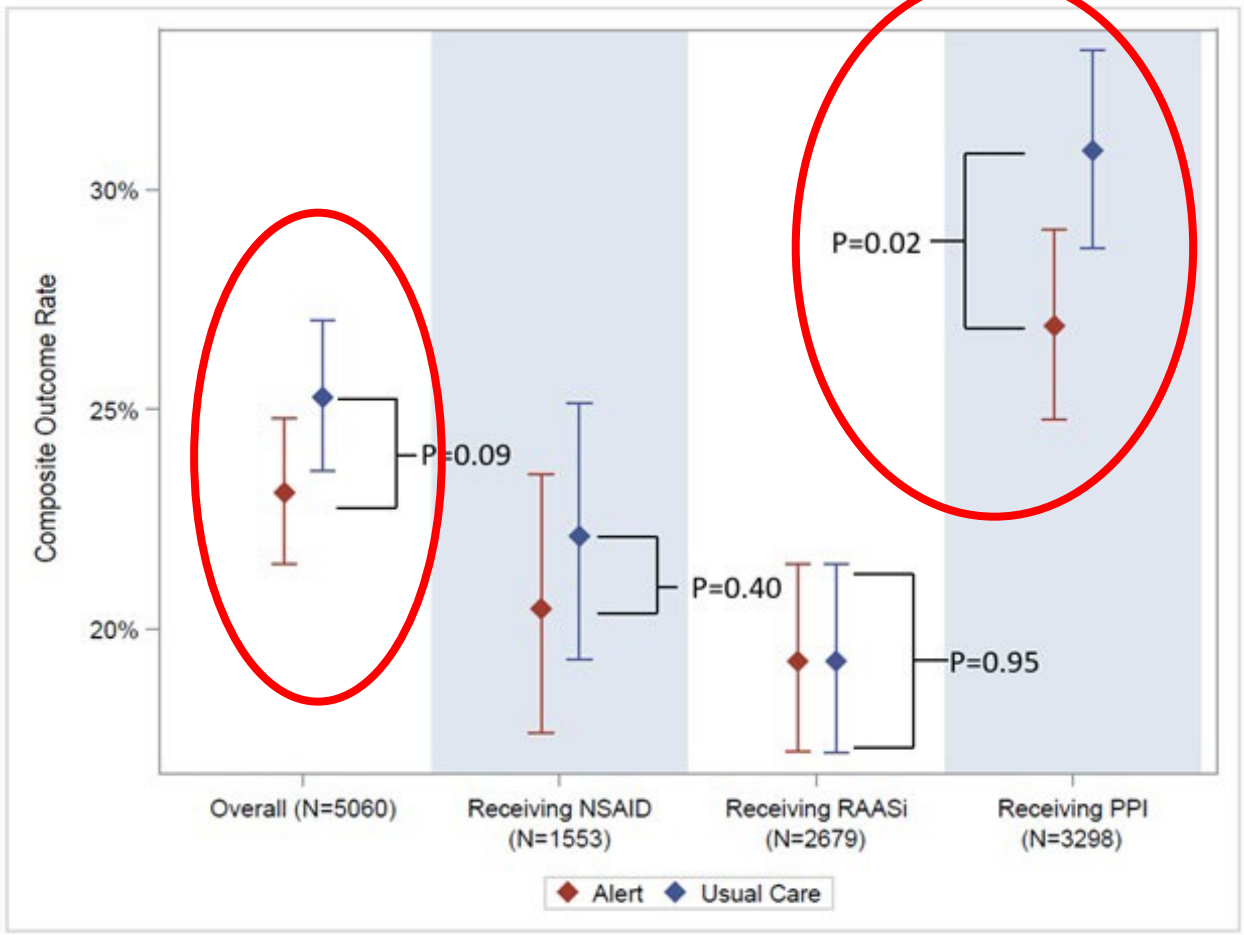
	Alert (N=2,532)	Usual Care (N=2,528)
NSAID	748 (30%)	805 (32%)
RAASi	1350 (53%)	1329 (53%)
PPI	1654 (65%)	1644 (65%)
1 MOI	1470 (58%)	1451 (57%)
2 MOIs	904 (36%)	904 (36%)
3 MOIs	158 (6%)	173 (7%)

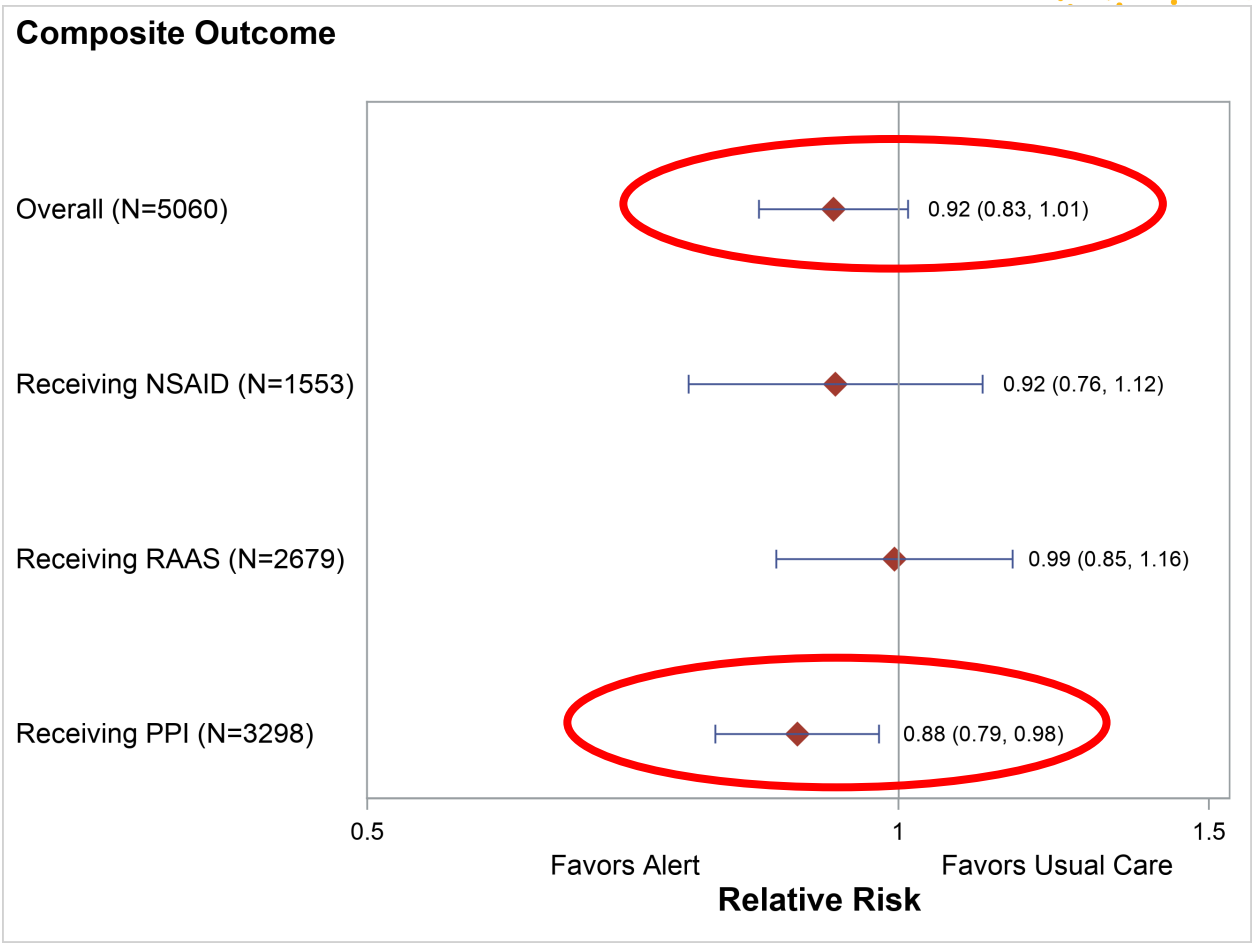
Process Outcome





Clinical Outcome





Key Secondary Outcomes

Outcome	Alert (N=2,532)	Usual Care (N=2,528)	Relative Risk (95% CI)
Progression of AKI	475 (18.8%)	505 (20.0%)	0.95 (0.85 to 1.06)
Dialysis	123 (4.9%)	127 (5.0%)	0.98 (0.77 to 1.25)
Death	253 (10.0%)	282 (11.2%)	0.90 (0.77 to 1.06)
Progression to stage 2 AKI	242 (9.6%)	248 (9.8%)	0.98 (0.83 to 1.16)
Progression to stage 3 AKI	231 (9.1%)	256 (10.1%)	0.91 (0.77 to 1.08)
30-day readmission	322 (12.7%)	354 (14.0%)	0.91 (0.79 to 1.05)
Inpatient kidney consult	367 (14.5%)	366 (14.5%)	1.01 (0.88 to 1.15)
Duration of AKI (median days, IQR)	1 (0.8,2.1)	1.1 (0.8,2.2)	0.14
Length of stay (post randomization) (median days, IQR)	5.3 (2.3 – 11.8)	5.2 (2.2 – 11.2)	0.38

Safety Outcomes

Outcome	Alert	Usual Care	Difference, 95% CI
NSAID Subgroup	N=748	N=805	
Opioid prescription	509 (68.0%)	557 (69.2%)	0.6 (-4 - 5.2)
Max pain score	8 (5,10)	8 (5,10)	0 (-0.1,0.1)
RAASi Subgroup	N=1350	N=1329	
Max SBP	162 (145,179)	161 (145,179)	1 (-1.2,3.2)
Max DBP	89 (80,99)	89 (81,100)	0.5 (-1.1,2.1)
Mechanical Ventilation	181 (13.4%)	177 (13.3%)	0 (-2.5, 2.6)
PPI Subgroup	N=1654	N=1644	
PRBC transfusion	433 (26.2%)	448 (27.3%)	0.5 (-2.5, 3.5)
Minimum hemoglobin	8.6 (7.2,10.5)	8.6 (7.1,10.4)	0 (-0.2,0.2)
Max pain score	7 (4,9)	7 (3,9)	0 (-0.5,0.5)

Why Might Alerts Benefit Those on PPI?

- Effect of alert on discontinuation was highest with PPI
- PPIs an under-recognized contributor to AKI in hospitalized patients
- Possibility of alpha error
- Patients receiving PPI have unique characteristics / phenotype

Wilson et al. Nat Commun 2023.

PPI-users are different

	PPI (N=3,298)	No PPI (N=1,762)	P-value
Age	70 (59 , 80)	70 (58, 80)	0.04
Female	1575 (48%)	878 (50%)	0.29
Black	574 (17%)	394 (22%)	<0.0001
Medical admission	2568 (78%)	1293 (73%)	<0.0001
ICU at randomization	908 (28%)	250 (14%)	<0.0001
CHF	1104 (33%)	507 (29%)	0.0002
Diabetes mellitus	1197 (36%)	698 (40%)	0.03
Creatinine (admission), mg/dL	1.2 (0.9, 1.7)	1.1 (0.8, 1.5)	<0.0001
Creatinine (randomization), mg/dL	1.5 (1.2, 2.0)	1.4 (1.1, 1.8)	<0.0001
Modified SOFA	3 (1 , 4)	2 (1, 3)	<0.0001

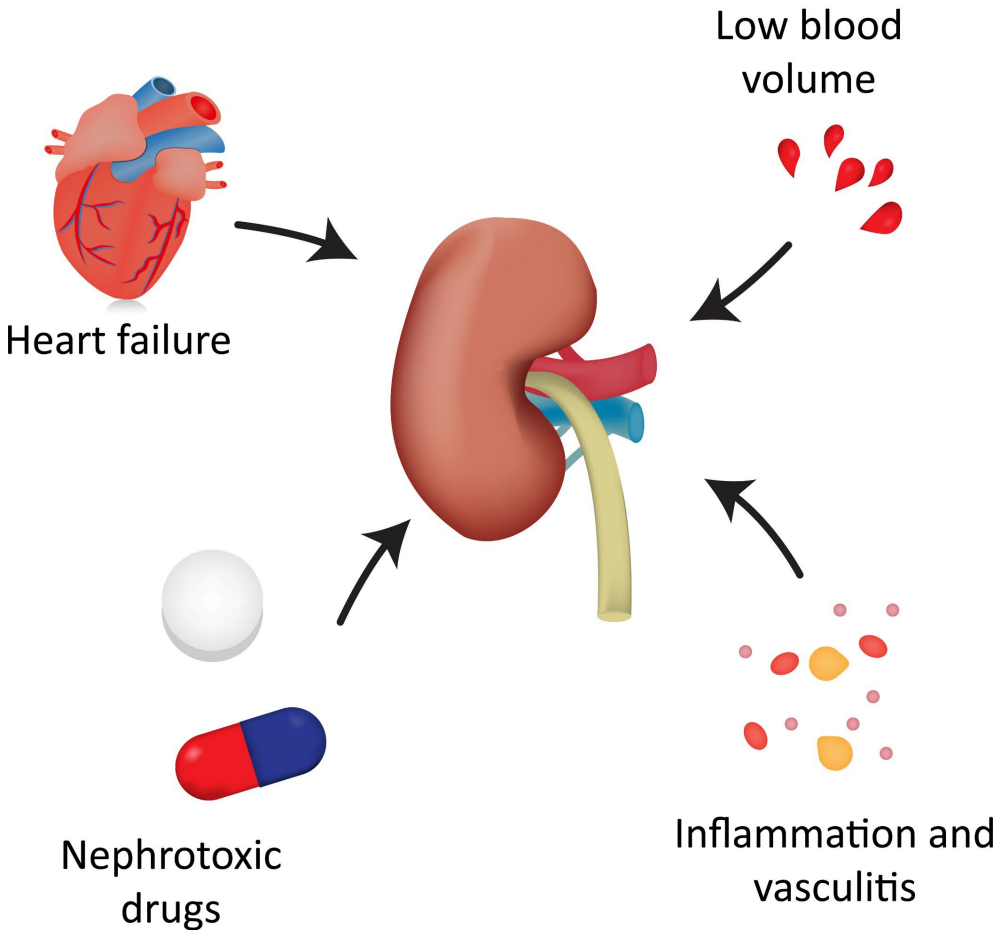
ELAIA-2 TAKE HOME POINTS

Automated alerts for AKI can increase the rate of cessation of potentially nephrotoxic medications without endangering patients

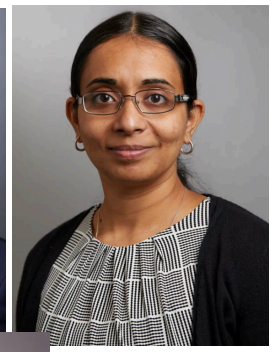
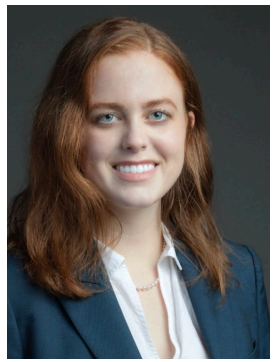
There is limited evidence that these alerts change clinical outcomes

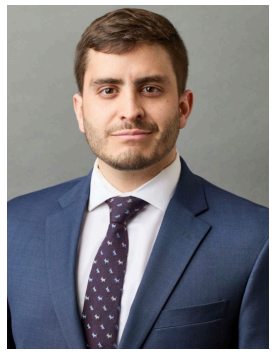
There may be clinical benefit of alerts among patients who are receiving PPIs

NEW HYPOTHESIS: AKI IS HETEROGENOUS. WE NEED TO CUSTOMIZE ACTIONS





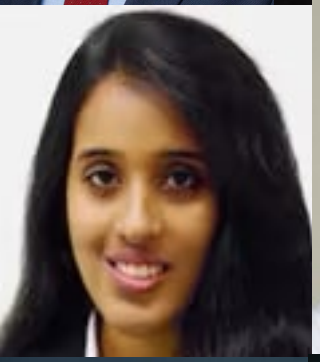
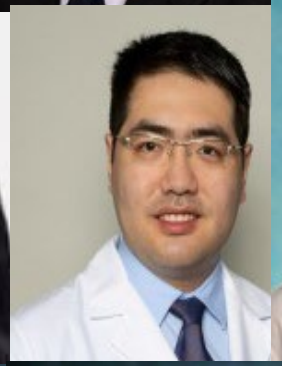





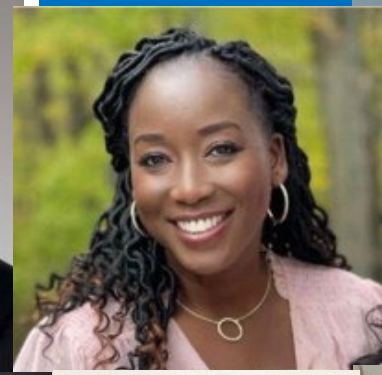



KIDNEY ACTION TEAM
11/1/21 – 2/8/24

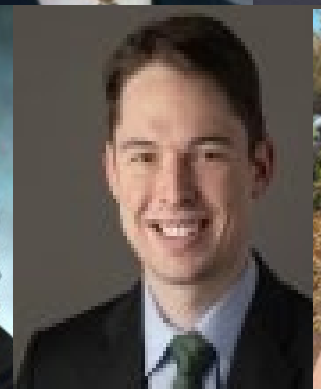
Kristina Shvets



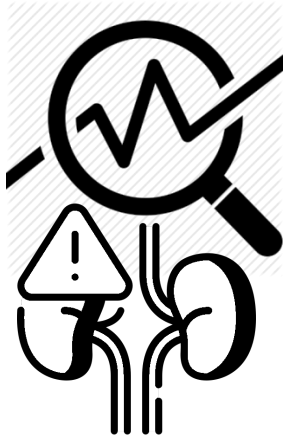







KAT-AKI: TRIAL OBJECTIVE



Kidney Action Team

Physician

Pharmacist

Recommendations

- General Diagnostics
- Volume
- Potassium
- Acid-Base
- Medication

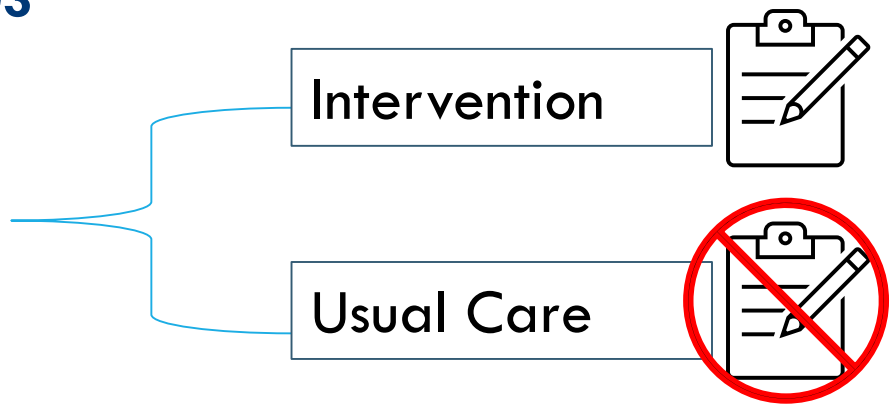
?

Improvement in in-hospital mortality and AKI progression

KAT-AKI TRIAL DESIGN

Multicenter RCT, n = 4003

1:1 randomized



Two hospital systems: Yale & Johns Hopkins

- 7 hospitals in the US (Connecticut, Maryland, Rhode Island)

10/2021 – 2/2024

ENROLLMENT AND RANDOMIZATION

Age ≥ 18

KDIGO Stage ≥1 AKI Criteria

Alert sent to **KAT**

KAT reviews chart

Excluded

- *ESKD or CKD 5*
- *Comfort measures only*
- *Solid organ transplant*
- *Urgent renal consult criteria*
- *Nephrology following*

KAT creates recommendations

Randomization

INTERVENTION

KAT Note

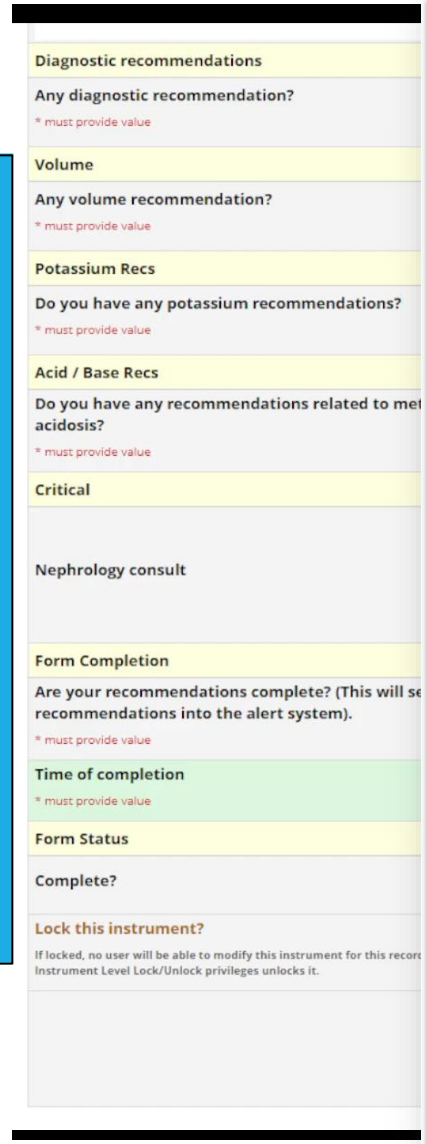
USUAL CARE

No KAT Note

Goal time from AKI to randomization: 1-2 h

A NOVEL RAPID RECOMMENDATION ENTRY SYSTEM

- General Diagnostics
- Volume
- Potassium
- Acid-Base
- Renal consult
- Medication



Kidney Action Team Recommendation Alert

MRN: _____

Date: __/__/__ **Time:** __/__

THIS IS NOT A CONSULT

The Kidney Action Team is a group of physicians and pharmacists designed to provide personalized recommendations for the diagnosis and treatment of patients with Acute Kidney Injury (AKI).

We have received an alert within the past hour that this patient has developed AKI. We have reviewed the patient's chart and based on the patient's current status and medical history, make the specific recommendations listed below.

KIDNEY ACTION TEAM PERSONALIZED RECOMMENDATIONS FOR YOUR PATIENT WITH AKI:

1. Diagnostic Recommendations:

- ❑ Check a spot urinalysis
- ❑ Ensure strict INs and OUTs are being recorded
- ❑ Consider a bladder scan/post-void residual measurement
- ❑ Check orthostatic vitals

2. Volume Recommendations

- ❑ Daily Weights (standing if able)
- ❑ Consider volume challenge if evidence of volume depletion
- ❑ Reassess volume status prior to volume rechallenge

3. Potassium Management Recommendations:

- ❑ There are no specific recommendations regarding potassium for this patient

4. Acid/Base Management Recommendations:

- ❑ There are no specific recommendations regarding Acid/Base management for this patient.

5. Please Consider Discontinuing the Following Medications:

- ❑ Discontinue ibuprofen
- ❑ Discontinue enoxaparin and consider switching to subQ Heparin for DVT prophylaxis

6. Medication Dose Adjustment Recommendations:

- ❑ Recommend dose adjustment of piperacillin-tazobactam to 3.375 grams every 6 hours

*****For all patients with AKI, we recommend continued follow-up of serum creatinine and avoiding nephrotoxic exposures.*****

Covering Provider: please click here to help us track the time it takes for this note to be seen by a provider and for any feedback. Thank you!

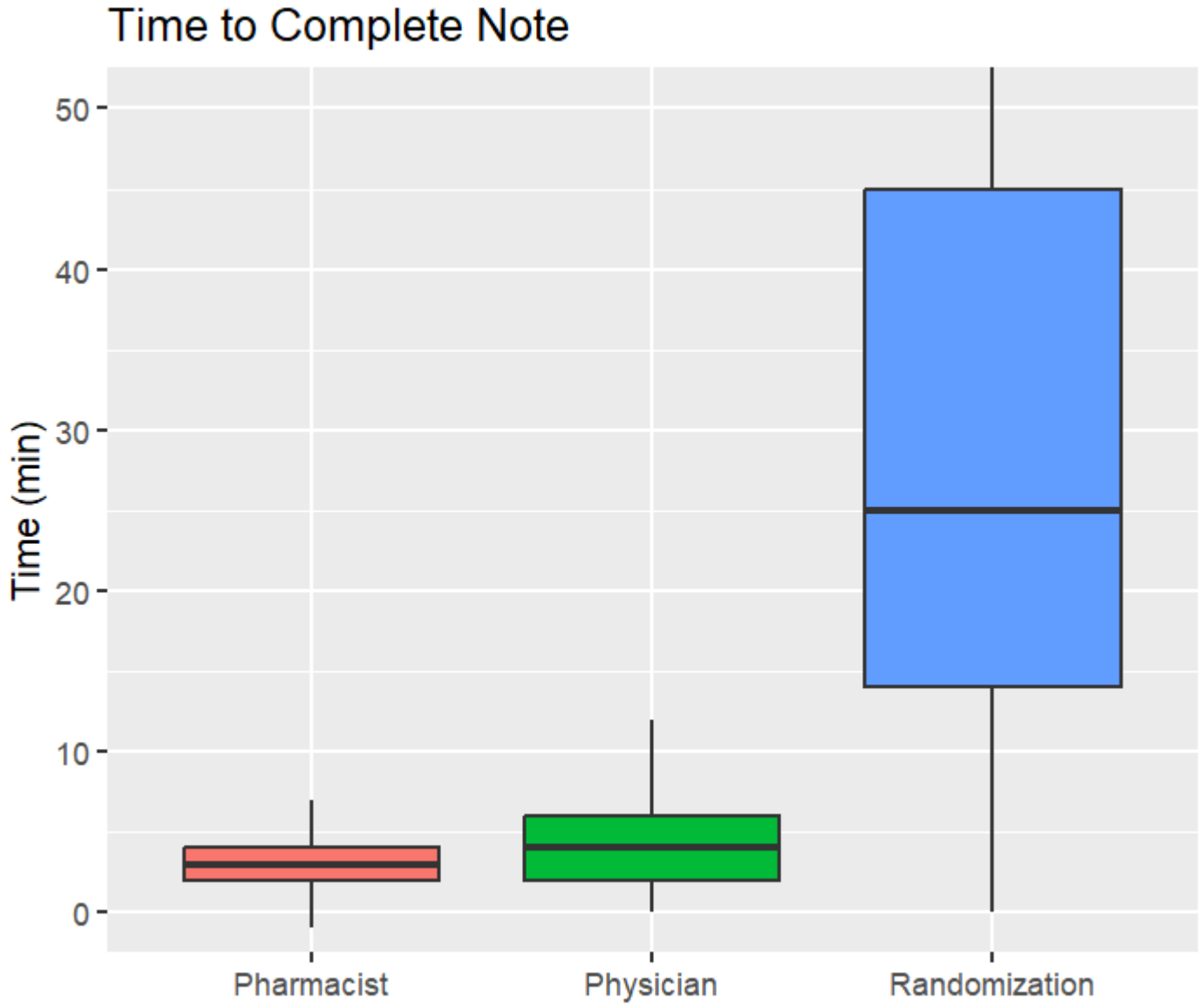
Please note: This patient is part of a randomized clinical trial designed to test the efficacy of personalized recommendations for the diagnosis and treatment of Acute Kidney Injury. You will NOT receive this recommendation note for all patients who develop AKI.

The Kidney Action Team has not seen or examined this patient. Our recommendations are based on chart review only. ***It is your choice to follow these recommendations using your own clinical judgement and your examination of the patient and his/her medical history.*** *Note, the Kidney Action Team will* ***not*** *follow up on further test results or provide any further recommendations. If you need assistance with AKI management, please consider a formal kidney consult. Medication recommendations are based on currently prescribed medications. Please reach out to your floor pharmacist if any further questions about starting renally cleared medications.*

Covering Provider - Please cosign to acknowledge receipt of the recommendations.

Time to KAT action

- Note completion
  - Physician: 4 (2 – 6) min
  - Pharmacist: 3 (2 – 4) min
- Time to randomization
  - 25 (14 – 45) min



OUTCOMES

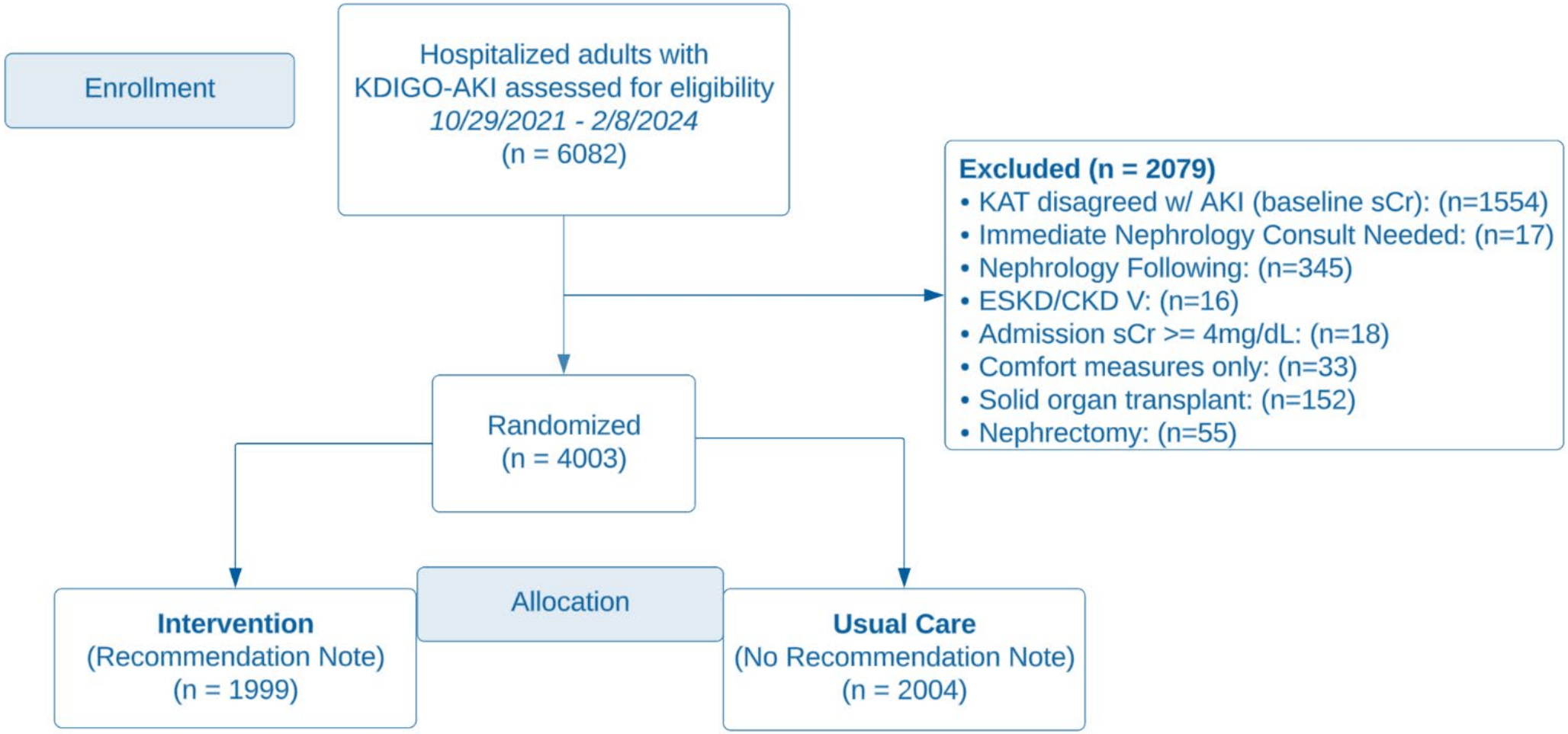
Primary clinical outcome

- Composite (in 14 days)
  - Death
  - Dialysis
  - AKI progression

Process outcome

- Proportion of recommendations implemented in 24 hours

- **Pre-Specified Secondary outcomes**
  - AKI progression (14 d)
  - Dialysis (14 d)
  - Death (14 d)
  - Nephrology consult (14 d)


Enrollment
Hospitalized adults with KDIGO-AKI assessed for eligibility
10/29/2021 - 2/8/2024
(n = 6082)
Excluded (n = 2079)
• KAT disagreed w/ AKI (baseline sCr): (n=1554)
• Immediate Nephrology Consult Needed: (n=17)
• Nephrology Following: (n=345)
• ESKD/CKD V: (n=16)
• Admission sCr >= 4mg/dL: (n=18)
• Comfort measures only: (n=33)
• Solid organ transplant: (n=152)
• Nephrectomy: (n=55)
Randomized
(n = 4003)
Allocation
Intervention
(Recommendation Note)
(n = 1999)
Usual Care
(No Recommendation Note)
(n = 2004)

BASELINE CHARACTERISTICS

Characteristic	ENROLLED n = 4003
Age, median (IQR), years	72 [61, 81]
Female sex	47%
Hypertension	81%
Diabetes mellitus	46%
Heart failure	44%
Chronic kidney disease	42%
Cirrhosis	7%
Elix comorbidity score	7 [4, 12]
sCr, median (IQR), mg/dL *	1.5 [1.2, 2.0]
Hospital	
Yale	80%
Hopkins	20%

at randomization

Hospital service*	
General medical floor	50%
Hospitalist	36 %
Teaching team	14 %
ICU/SDU units	20 %
Surgical floor	17%
Specialist medical floor	14%

Recommendation count, median (IQR)	**Time AKI to recommendations,** median (IQR)
3 (2, 5)	56 (34-83) min

MOST PATIENTS HAD AT LEAST ONE RECOMMENDATION

14539 recommendations made

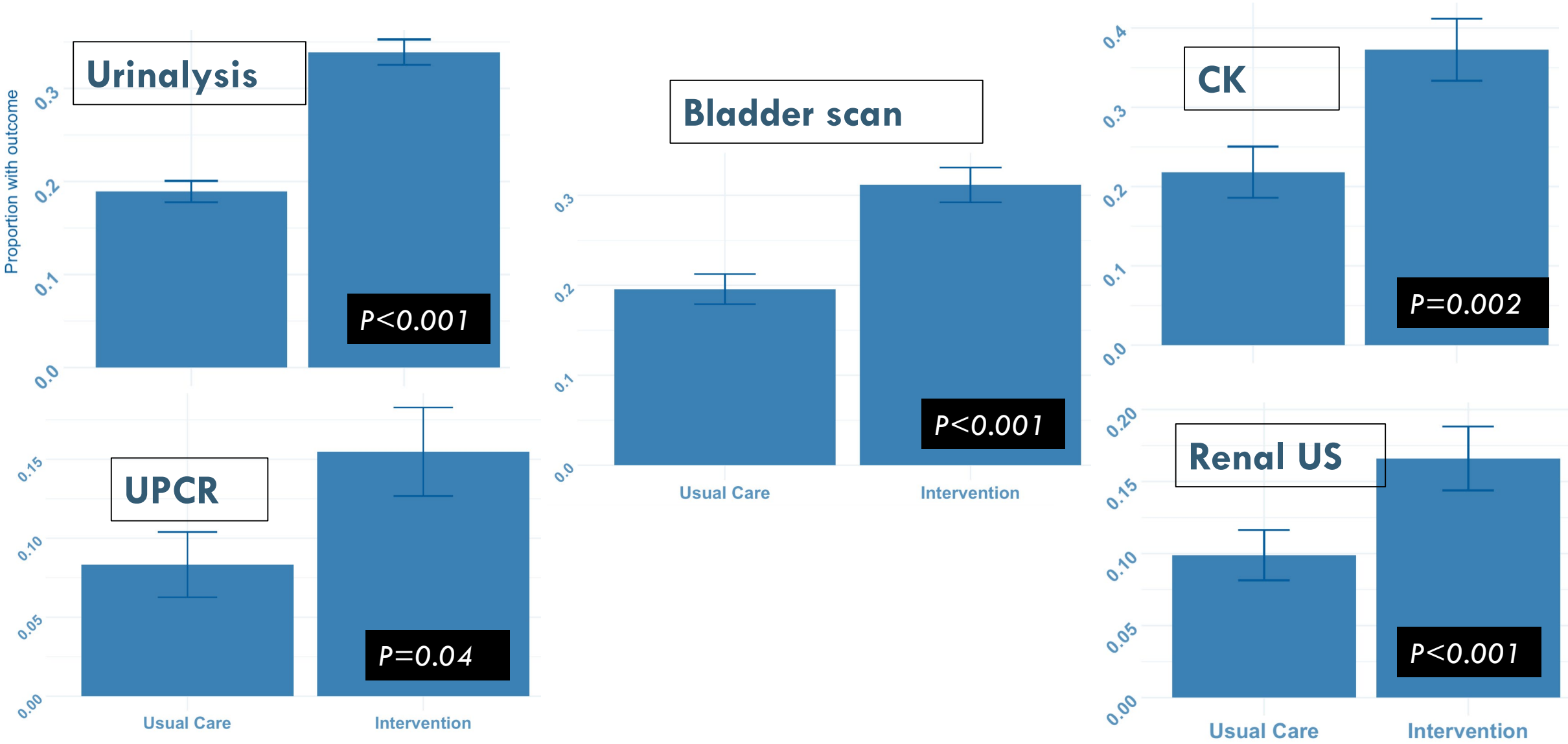
Broad Recommendation Categories	
General *(diagnosis & monitoring)*	96 %
Volume	80 %
Potassium	16 %
Acid-base	10 %
Renal consult	2 %
Medication	55 %

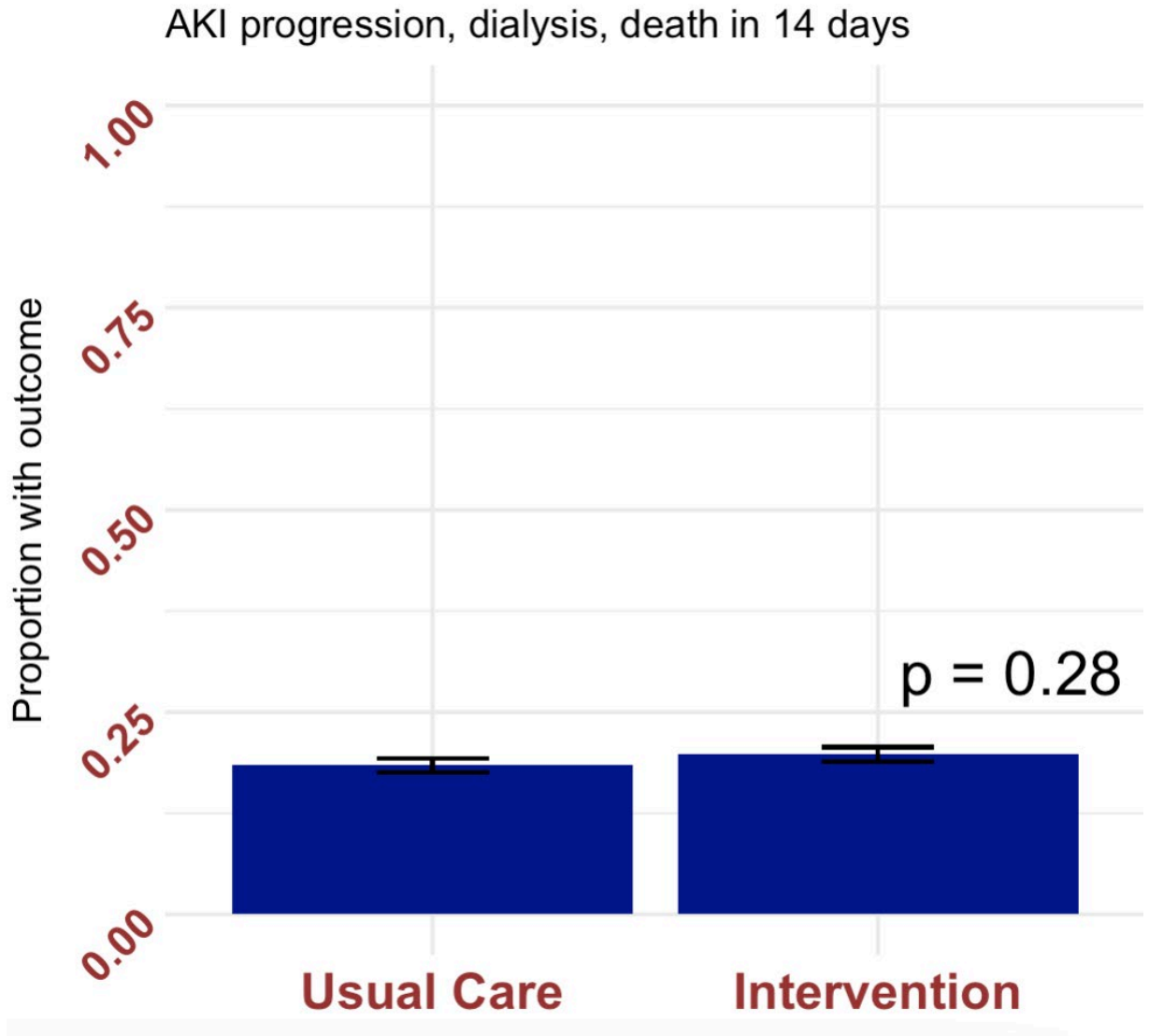
e.g., UA, renal US, pigment nephropathy, proteinuria, …

PROCESS OUTCOMES
(KAT RECOMMENDATIONS COMPLETED WITHIN 24 HOURS)

	INTERVENTION *n = 1999*	**USUAL CARE** *n = 2004*	**Mean difference (95% CI)**	**p-value**
KAT recommendations completed in 24h				
General diagnosis & monitoring				
Volume				
Potassium				
Acid-base				
Medications				

24-HOUR IMPLEMENTATION OF RECOMMENDATIONS

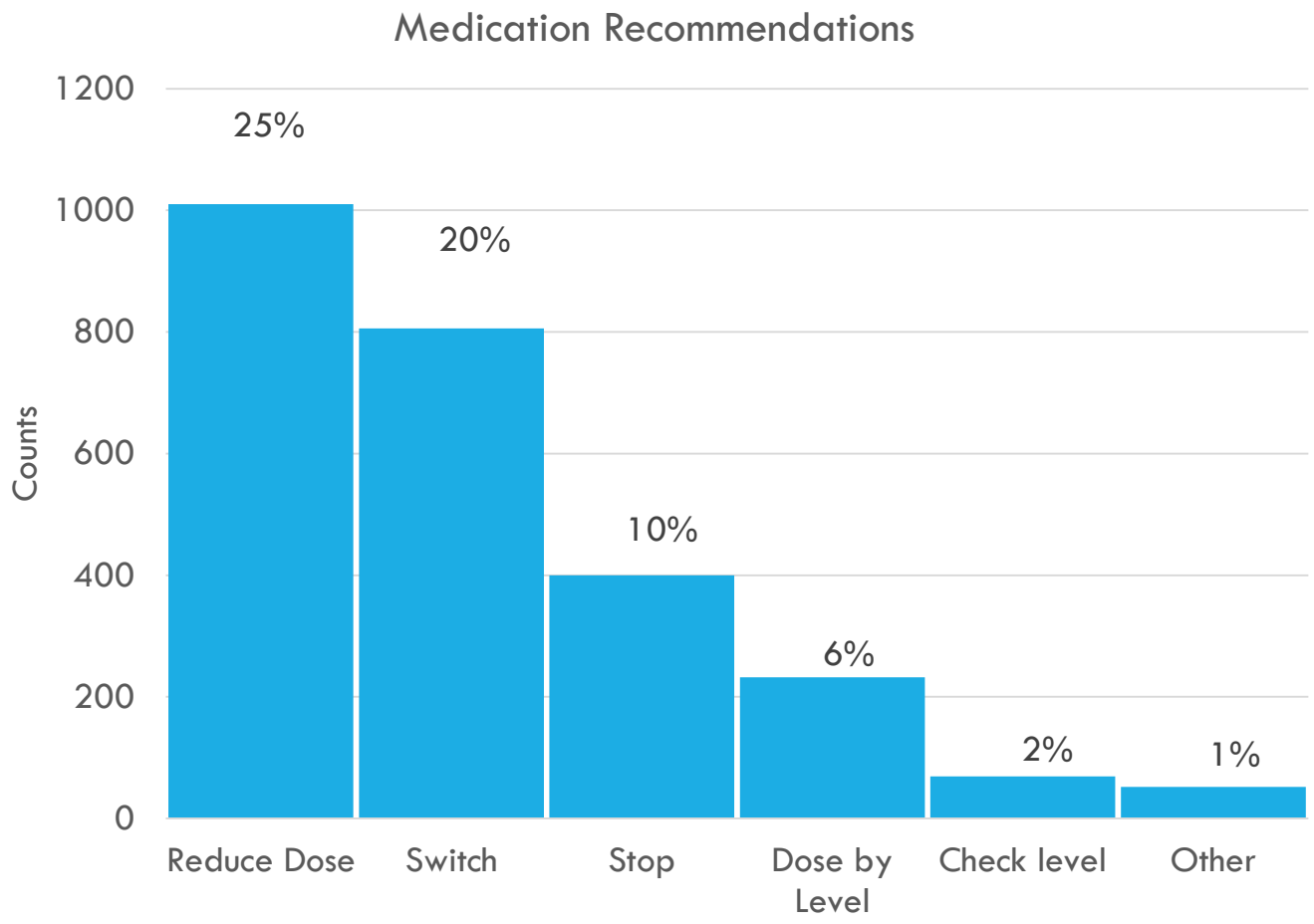



AKI progression, dialysis, death in 14 days
Proportion with outcome
1.00
0.75
0.50
0.25
0.00
p = 0.28
Usual Care
Intervention

SECONDARY OUTCOMES

Outcome	INTERVENTION *n = 1999*	USUAL CARE *n = 2004*	% Difference (95% CI)	p-value
AKI progression	13.5%	13.0%	0.5 (-1.6, 2.6)	0.65
Mortality	9.6%	9.2%	0.4 (-1.5, 2.1)	0.72
Dialysis	1.6 %	1.5%	0.1 (-0.7, 0.8)	0.89
Nephrology consult	16.1 %	14.2%	1.9 (-0.3, 4.1)	0.09

SPECIFIC RECOMMENDATIONS

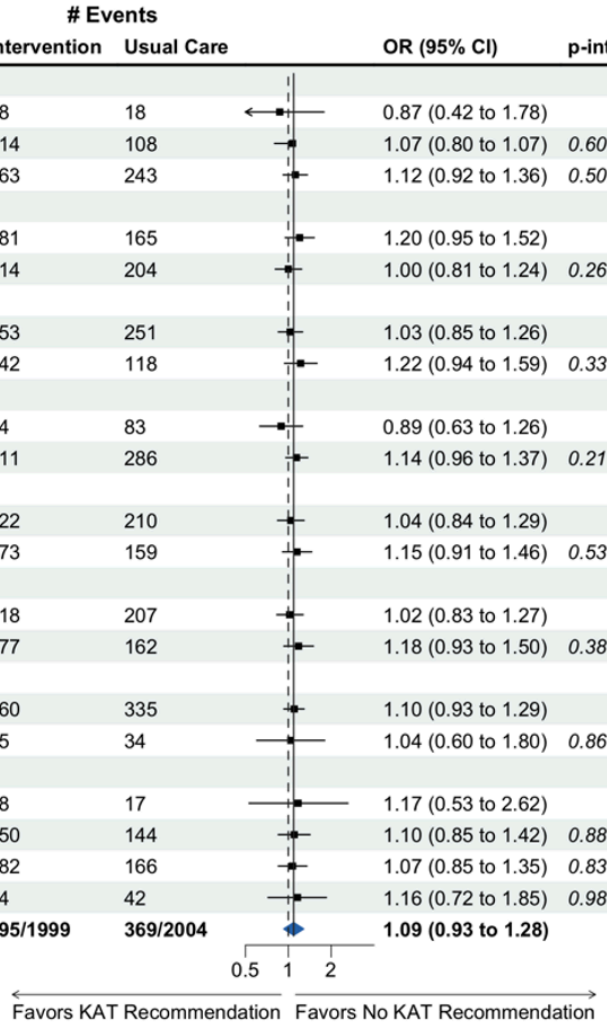


	Intervention n = 1999	Usual Care n = 2004
Potential nephrotoxin*	26.1%	26.0%
Other medications	27.6%	29.6%

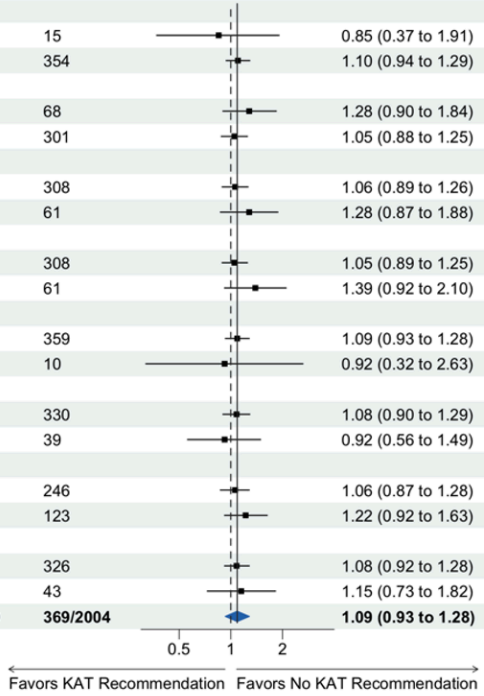
NSAIDs, antimicrobials, antihypertensives, diuretics, PPI, MTX, CNI, lithium.

SUBGROUP ANALYSES

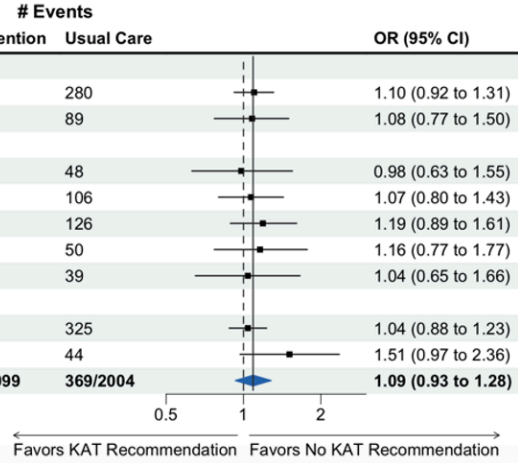
Subgroup	# Events Intervention	# Events Usual Care	OR (95% CI)	p-interaction
Age				
18-39 years	18	18	0.87 (0.42 to 1.78)	
40-65 years	114	108	1.07 (0.80 to 1.07)	*0.60.*
≥65 years	263	243	1.12 (0.92 to 1.36)	*0.50.*
Sex				
Female	181	165	1.20 (0.95 to 1.52)	
Male	214	204	1.00 (0.81 to 1.24)	*0.26*
CKD History				
No	253	251	1.03 (0.85 to 1.26)	
Yes	142	118	1.22 (0.94 to 1.59)	*0.33*
HTN History				
No	84	83	0.89 (0.63 to 1.26)	
Yes	311	286	1.14 (0.96 to 1.37)	*0.21*
DM History				
No	222	210	1.04 (0.84 to 1.29)	
Yes	173	159	1.15 (0.91 to 1.46)	*0.53*
HF History				
No	218	207	1.02 (0.83 to 1.27)	
Yes	177	162	1.18 (0.93 to 1.50)	*0.38*
Cirrhosis				
No	360	335	1.10 (0.93 to 1.29)	
Yes	35	34	1.04 (0.60 to 1.80)	*0.86*
Baseline sCr				
<0.5	18	17	1.17 (0.53 to 2.62)	
0.5-1	150	144	1.10 (0.85 to 1.42)	*0.88*
1.0-2.0	182	166	1.07 (0.85 to 1.35)	*0.83*
≥2.0	44	42	1.16 (0.72 to 1.85)	*0.98*
Overall	**395/1999**	**369/2004**	**1.09 (0.93 to 1.28)**	



Subgroup	# Events Intervention	# Events Usual Care	OR (95% CI)	p-interaction
General				
No	14	15	0.85 (0.37 to 1.91)	
Yes	381	354	1.10 (0.94 to 1.29)	*0.53*
Volume				
No	79	68	1.28 (0.90 to 1.84)	
Yes	316	301	1.05 (0.88 to 1.25)	*0.32*
Potassium				
No	323	308	1.06 (0.89 to 1.26)	
Yes	72	61	1.28 (0.87 to 1.88)	*0.38*
Acidosis				
No	322	308	1.05 (0.89 to 1.25)	
Yes	73	61	1.39 (0.92 to 2.10)	*0.23*
Nephrology Consult				
No	385	359	1.09 (0.93 to 1.28)	
Yes	10	10	0.92 (0.32 to 2.63)	*0.75*
Discontinue Med				
No	354	330	1.08 (0.90 to 1.29)	
Yes	41	39	0.92 (0.56 to 1.49)	*0.54*
Adjust/Monitor Med				
No	269	246	1.06 (0.87 to 1.28)	
Yes	126	123	1.22 (0.92 to 1.63)	*0.42*
Discontinue and Adjust				
No	345	326	1.08 (0.92 to 1.28)	
Yes	50	43	1.15 (0.73 to 1.82)	*0.81*
Overall	**395/1999**	**369/2004**	**1.09 (0.93 to 1.28)**	

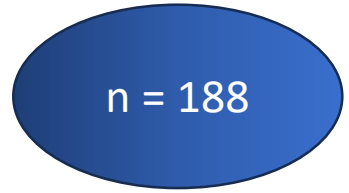


Subgroup	# Events Intervention	# Events Usual Care	OR (95% CI)	p-interaction
Hospital				
Yale	301	280	1.10 (0.92 to 1.31)	
Hopkins	94	89	1.08 (0.77 to 1.50)	*0.93*
Primary Team				
Teaching Gen Med	43	48	0.98 (0.63 to 1.55)	
Hospitalist	112	106	1.07 (0.80 to 1.43)	*0.76*
ICU	134	126	1.19 (0.89 to 1.61)	*0.49*
Specialist Med	64	50	1.16 (0.77 to 1.77)	*0.59*
Surgery	42	39	1.04 (0.65 to 1.66)	*0.87*
Hospital Type				
Teaching	335	325	1.04 (0.88 to 1.23)	
Non-teaching	60	44	1.51 (0.97 to 2.36)	*0.13*
Overall	**395/1999**	**369/2004**	**1.09 (0.93 to 1.28)**	

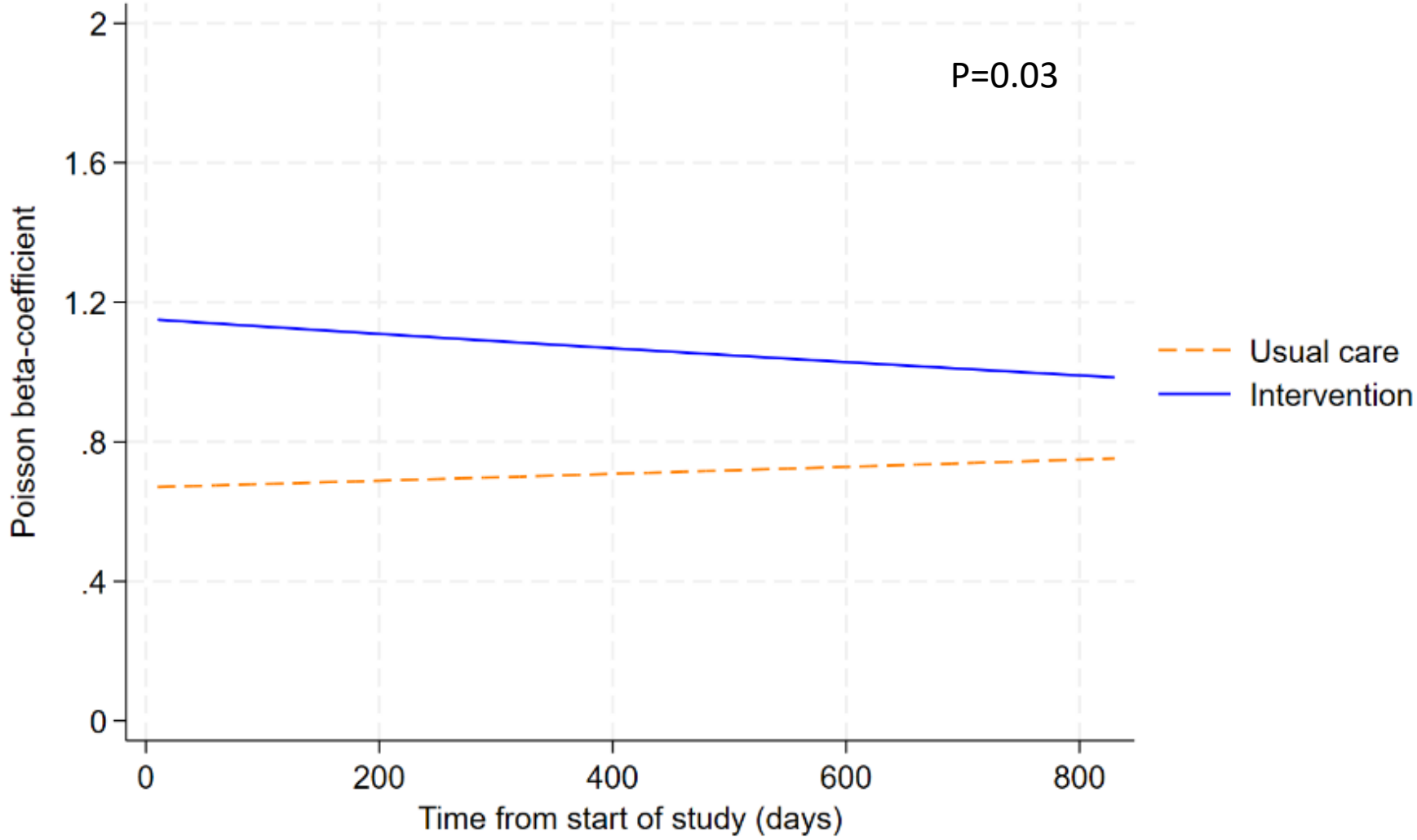


Survey results

Question	Response	Count (%)
Did you find the recommendation helpful?	Yes	147 (77.8)
	No	37 (19.6)
	No response	4 (2.1)
What did you find helpful?	Helped me recognize AKI early.	48 (25)
	Helpful medication recommendations.	42 (22)
	Helpful diagnostic recommendations.	41 (22)
	Saved me time.	33 (17)
	Helpful volume recommendations.	19 (10)
	Other	6 (3)
Why did you not find the recommendations helpful?	Already aware/thought of doing this.	15 (7.9)
	Other - Saw it late.	12 (6.3)
	I do not agree with AKI diagnosis.	9 (4.8)
	Disruptive.	4 (2.1)
	I do not like the format	1 (0.5)



Contamination?



Can a computer do this?

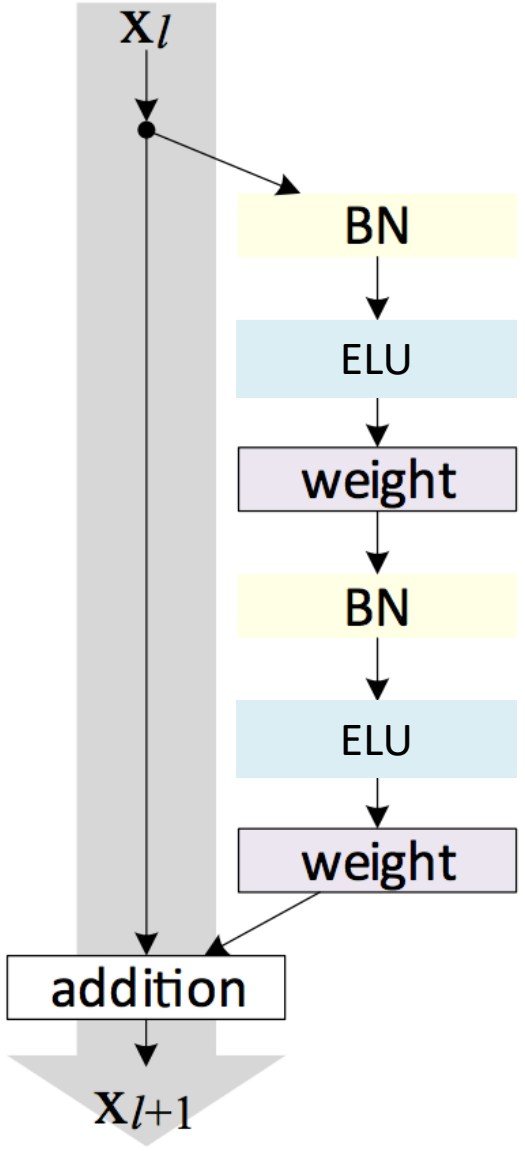
With 1/2 of the data, trained a neural network to predict all 43 possible recommendations

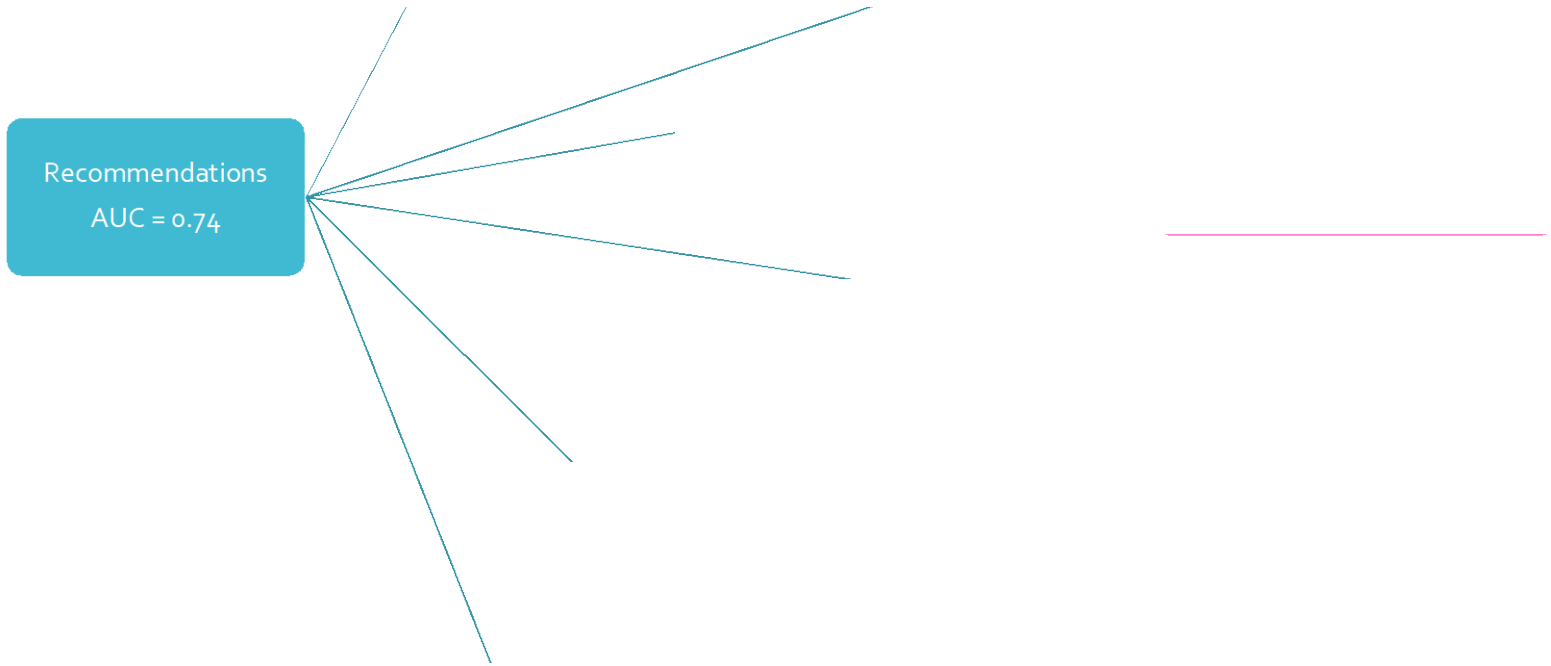
Architecture:

- Network width of 12 neurons
- Two Fully-Connected Residual Layers

Controlling overfitting:

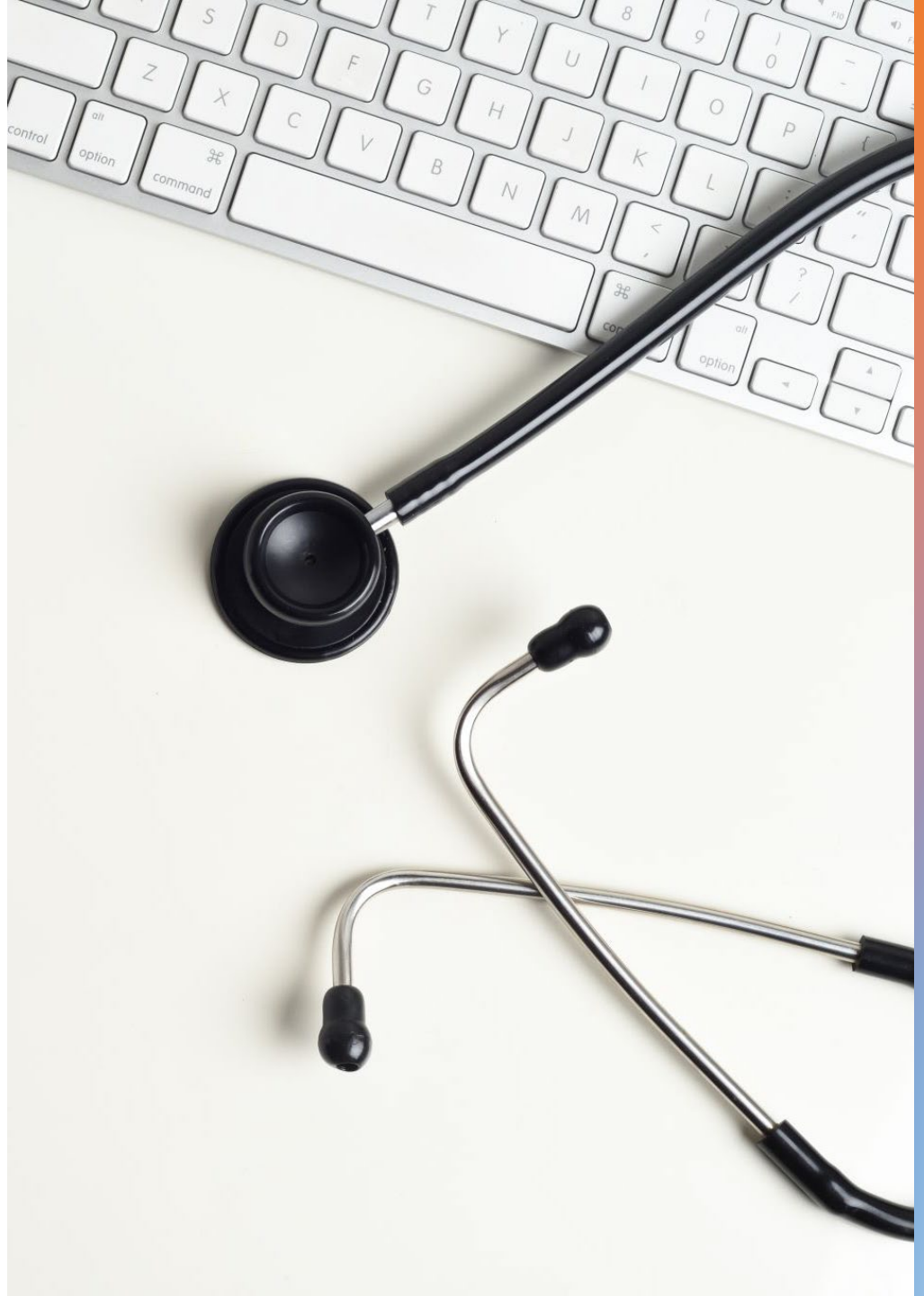
- Joint training across recommendations
- Batch Normalization without trainable parameters paired with L2 regularization of weights
- Early Stopping using 1/6 of data as a validation set




Recommendations
AUC = 0.74

Kidney Action Team: Summary

- Rapid evaluation of new-onset AKI is feasible
- There are diagnostic or therapeutic interventions possible for virtually all patients
  - Whether they would be done in the absence of a notification is a key question of this trial
  - Marginal differences in action rates across study arms might allow us to identify high-yield interventions (instrumental variable analysis)
- Next step: Automating recommendations using a neural network-based approach



Aklilu et al. JAMA 2024.

Conclusions

- AKI alerts, like all alerts, have to pass the know, care, act, matter test to work
- Many providers do not know their patient has AKI
- Most providers care their patient has AKI
- The big barriers appear to be in the “act” and “matter” domains
- Perhaps greater personalization can lead to better outcomes

CTRA
Clinical and Translational Research Accelerator

Dedicated to facilitating clinical research at Yale through novel methodologies, robust data infrastructure, collaboration, and support

Leadership

F. Perry Wilson, MD MSCE – Director
Monique Hinchcliff, MD MS – Assistant Director
Dennis Moledina, MD PhD – Director of Biobanking

Faculty and Team Members

Tariq Ahmad, MD MPH
Jameel Alausa
Tanima Arora, MBBS
Aditya Biswas
Christine Bakhoum
Frida Calderon
Nihar Desai, MD MPH
Lama Ghazi, MD PHD
Jason Greenberg, MD
Deborah Kearns
Sherry Mansour, MD
Melissa Martin, MS
Jim Nugent
Christina Price, MD
Ishan Saran
Melissa Shaw
Labeebah Subair
Yu Yamamoto, MS
William Zhang

Additional Thanks

Yale University

- ❑ Bob Souffer
- ❑ Gary Desir
- ❑ Stephen Latham
- ❑ Wade Schulz

Extramural Support

- ❑NIH R01-DK113191
- ❑NIH P30-DK079310
- ❑ DOD W81XWH-17-1-0663
- ❑AHRQ R01-HS027626

External Collaborators

- ❑ Chirag Parikh
- ❑ Amit Garg
- ❑ Paul Palevsky
- ❑ Christopher Laing

Yale New Haven Health System

- ❑ Allen Hsiao
- ❑ Nitu Kashyap
- ❑ Prem Thomas
- ❑ Richard Hintz
- ❑ Erica Moreira
- ❑ Caitlyn Partridge

Cheshire, CT

- ❑ Niamey Wilson