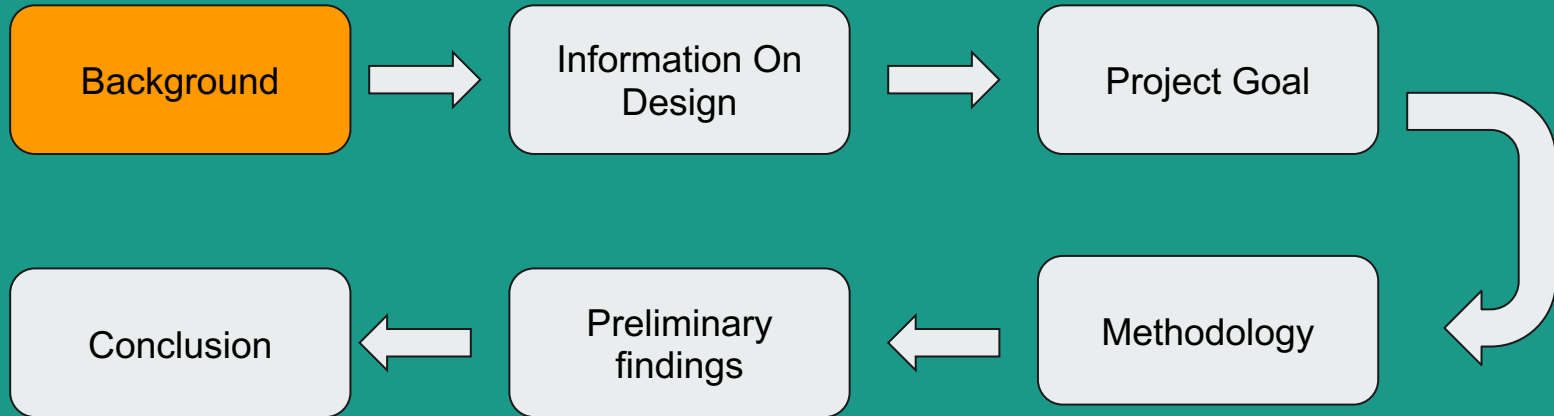# Electrolyte Repletion Patterns of Providers in ICU

Mentor: Dr. Krystoff Laudanski
Presenters: Mousa Ghannam and Parasteh Malihi

Presentation Overview

Background → Information On Design → Project Goal → Methodology → Preliminary findings → Conclusion

Background: Electrolyte Repletion

- Common routine intervention in the ICU
- Electrolytes: K^+, Ca^+, PO_4^{2-}, and Mg^{2+}
  - Regulate nerve and muscle function, hydrate the body, balance blood acidity, etc. [1]
  - Goal: maintain homeostatic range
- Variation in repletion protocol
  - Repletion regimens vary by institution and by individual patient factors [2]
- Adherence to published guidelines is poor [3]

Source:
1. https://www.cedars-sinai.org/blog/electrolytes.html
2. B Phillips. *Electrolyte Replacement: A Review*. The Internet Journal of Internal Medicine. 2003 Volume 5 Number 1.
3. Ament, S. M., de Groot, J. J., Maessen, J. M., Dirksen, C. D., van der Weijden, T., & Kleijnen, J. (2015). Sustainability of professionals' adherence to clinical practice guidelines in medical care: a systematic review. *BMJ open*, *5*(12), e008073. https://doi.org/10.1136/bmjopen-2015-008073
4. Joseph, T. T., DiMeglio, M., Huffenberger, A., & Laudanski, K. (2018). Behavioural patterns of electrolyte repletion in intensive care units: lessons from a large electronic dataset. *Scientific reports*, *8*(1), 1-9.
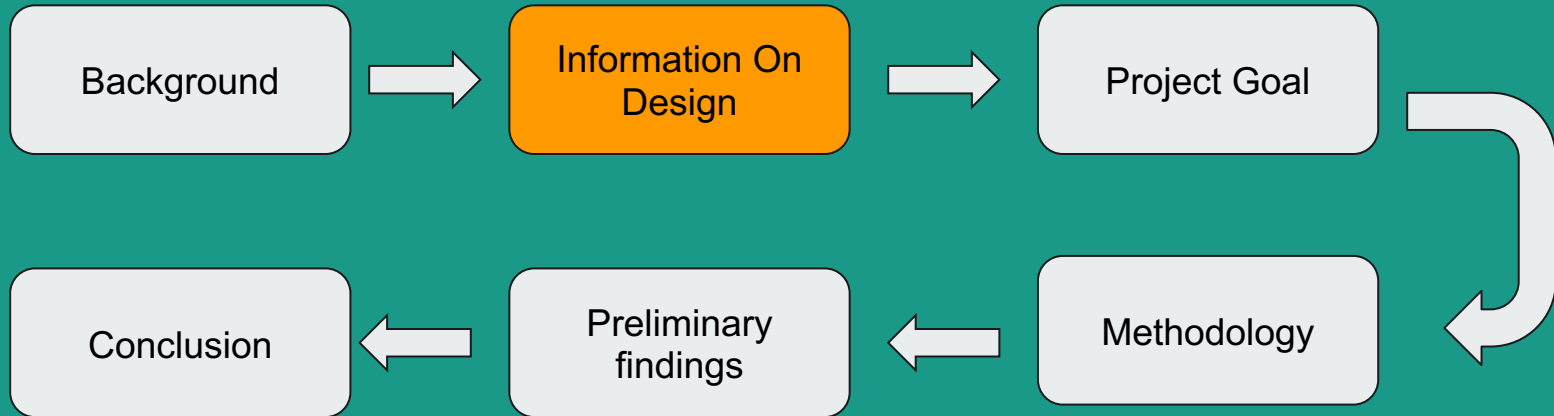
Significance of Study

- All decision making is vulnerable to different forms of cognitive and emotional bias or error [5]

- Heuristics play a role in clinical decision making
  - More than 40 forms of cognitive errors, many are interrelated [5]

- To Err is Human: Building a Safer Health System [6]
  - 44,000-98000 deaths and over a million injuries a year caused by medical errors
  - Need to improve safety by understanding error and how provider bias influences clinical decision making
    - characterizing behaviors in varying clinical settings

Source:
5. Scott, I. A. (2009). Errors in clinical reasoning: causes and remedial strategies. *BMj*, *338*.
6. Kohn L T, Corrigan J M, Donaldson MS (Institute of Medicine) To err is human: building a safer health system. Washington, DC: National Academy Press, 2000

Presentation Overview

Background → Information On Design → Project Goal

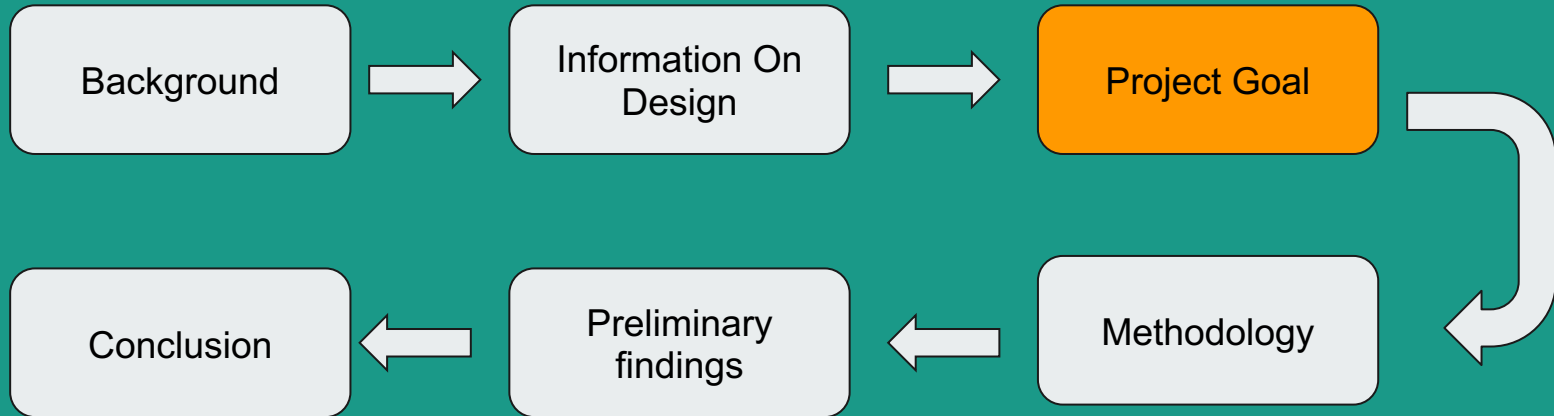Conclusion ← Preliminary findings ← Methodology

Information of Design

- In 2018, Joseph et al. and researchers analyzed ICU data (2010-2015) from 3 major hospitals in the University of Pennsylvania Health System [5]
- Key findings
  - Electrolyte repletions resulted in modest changes in serum levels.
    - Pre-repletion lab value was the more important factor correlating with the amount of increase, rather than the dose administered
  - 67% of replacement happened when the prior potassium level was within the reference limit
    - Deligent repletions do not decrease the risk of adverse events secondary to electrolyte abnormalities [5]
  - $1,254,869.06 in total cost savings and 343 provider-days in total time savings

Source:
5. Joseph, T. T., DiMeglio, M., Huffenberger, A., & Laudanski, K. (2018). Behavioural patterns of electrolyte repletion in intensive care units: lessons from a large electronic dataset. *Scientific reports*, *8*(1), 1-9.

Presentation Overview

Background → Information On Design → **Project Goal**

Conclusion ← Preliminary findings ← Methodology

Goal of Project

1. Cross validate results from the UPHS study using the MIMICs database
   a. Is this pattern unique to UPHS or could this pattern be systemic
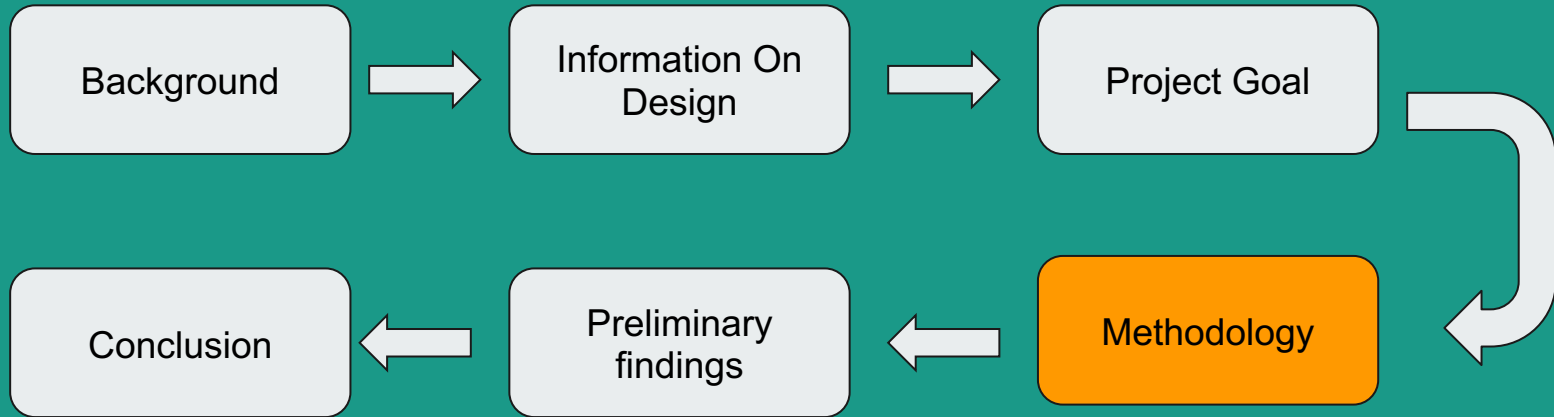2. Testing assumptions behind clinical reasoning

Data
MIMIC-III

- MIMIC-III (**M**edical **I**nformation **M**art for **I**ntensive **C**are III)
  - Freely accessible critical care database
  - Contains over 40,000 patients staying in the critical care units of the Beth Israel Deaconess Medical Center in Boston, MA between 2001-2012
  - Critical Care information systems used:
    - CareVue(**Philips CareVue Clinical Information System)**
      - 2001-2008
    - MetaVision (**iMDsoft MetaVision ICU system)**
      - **2008+**

Presentation Overview

Background → Information On Design → Project Goal

Conclusion ← Preliminary findings ← Methodology

Methodology

1. Exclusion of Confounding Variables
    a. < 18 Y/O
    b. Diseases affecting electrolytes
        i. pRBCs, rhabdomyolysis, parathyroid disease, sarcoid disease, end-stage renal disease (Add amounts excluded for each)
    c. GFR < 30
2. Selection Criteria
    a. All lab-values associated within 24 hours of a repletion
    b. Most recent lab-value prior and after repletion used
    c. Previous study on UPHS had more conservative definition
        i. Needed pre and post lab value
3. Ionized Ca^{2+} only used
    a. Reason for lower n

Presentation Overview

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Conclusion ← Preliminary findings ← Methodology
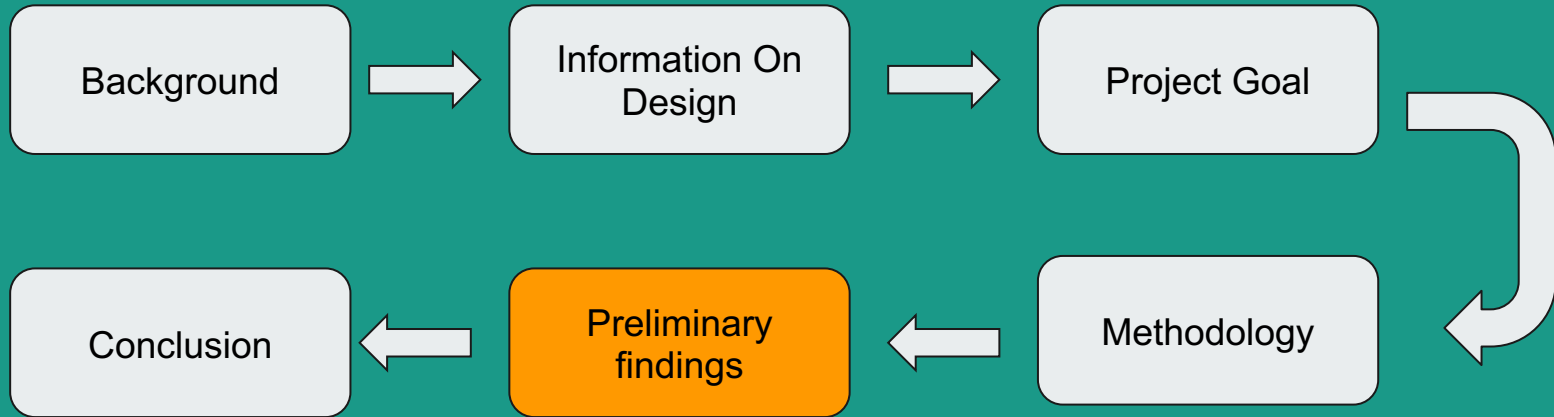
Time of Repletion and Lab Draws

K

UPHS

Mg

Ca

Ph
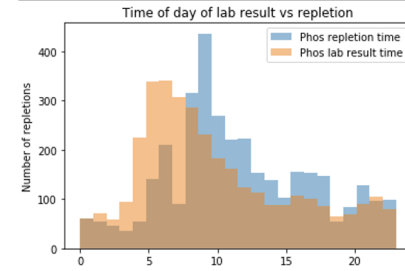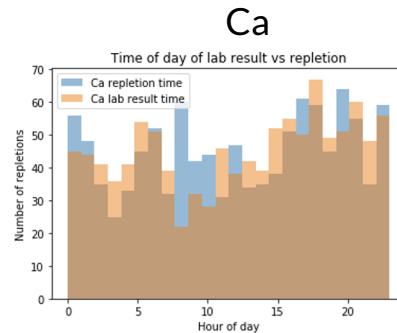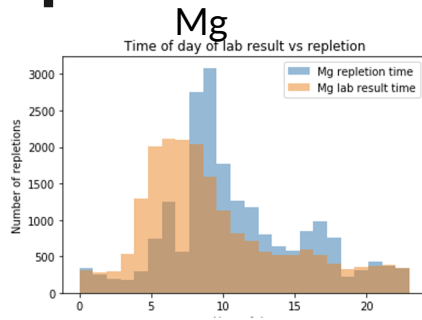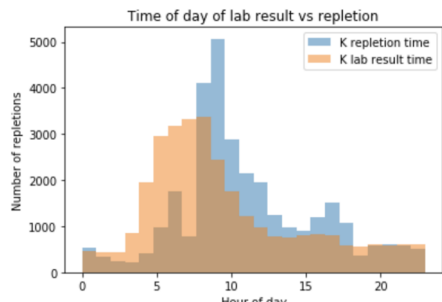
MIMIC
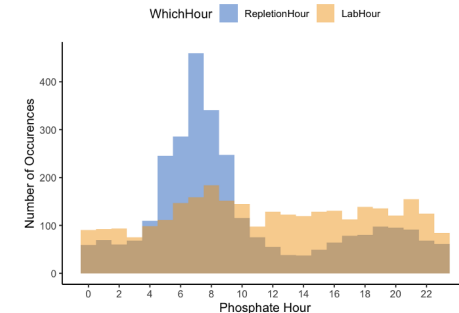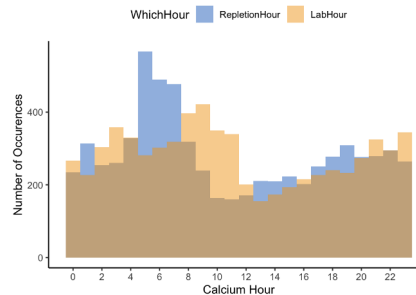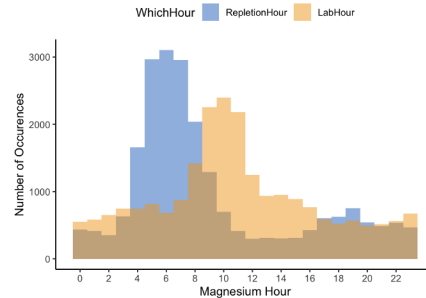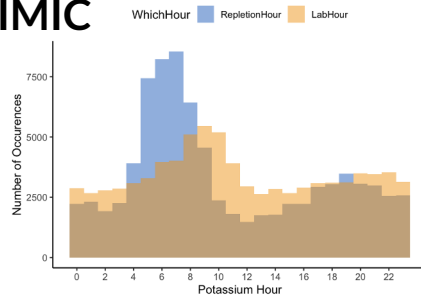
Source:
Joseph, T. T., DiMeglio, M., Huffenberger, A., & Laudanski, K. (2018). Behavioural patterns of electrolyte repletion in intensive care units: lessons from a large electronic dataset. *Scientific reports*, *8*(1), 1-9.
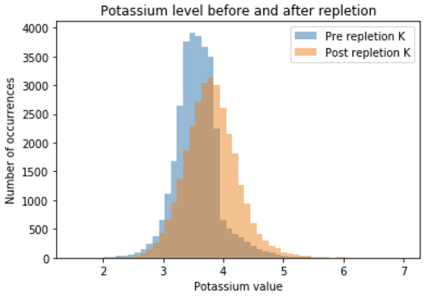
Pre Electrolyte Thresholds
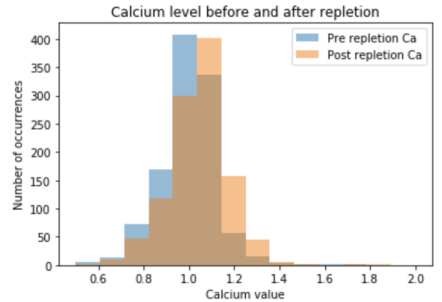
UPHS
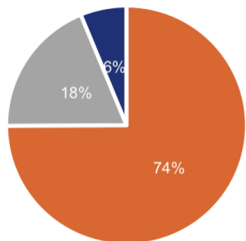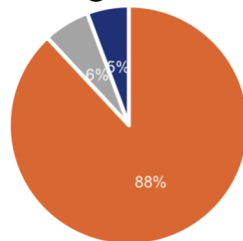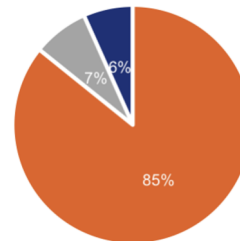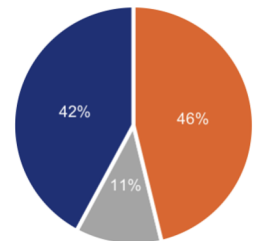
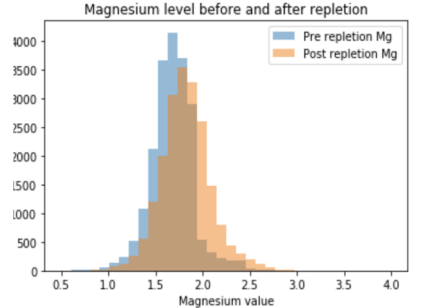**MIMIC**

Pre & Post Repletions for Electrolytes
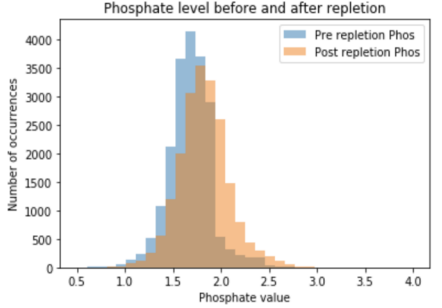
UPHS

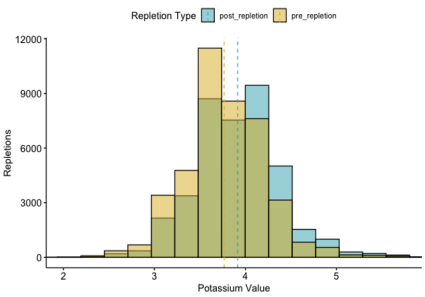K Mean Threshold: 3.66 ± 0.36

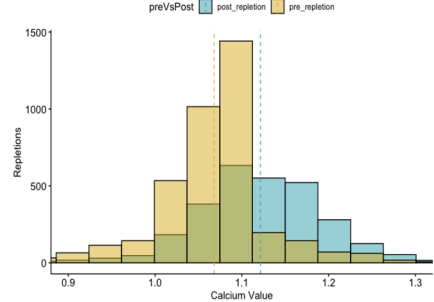Ca Mean Threshold 1.05 ± 0.10

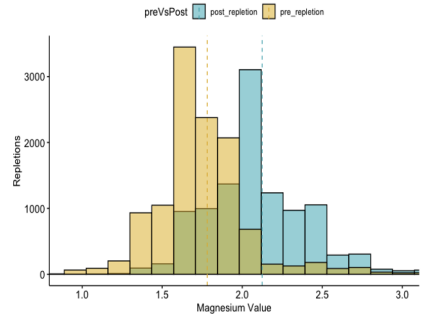Mg Mean Threshold: 1.77 ± 0.20

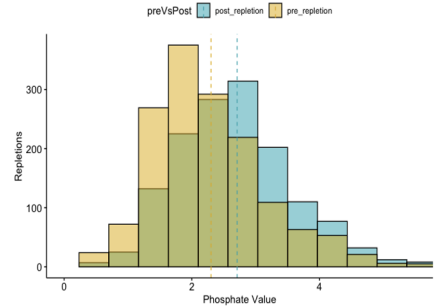Phos Mean = 1.95 ± 0.58

MIMIC

K Mean Threshold 3.77 ± 0.36
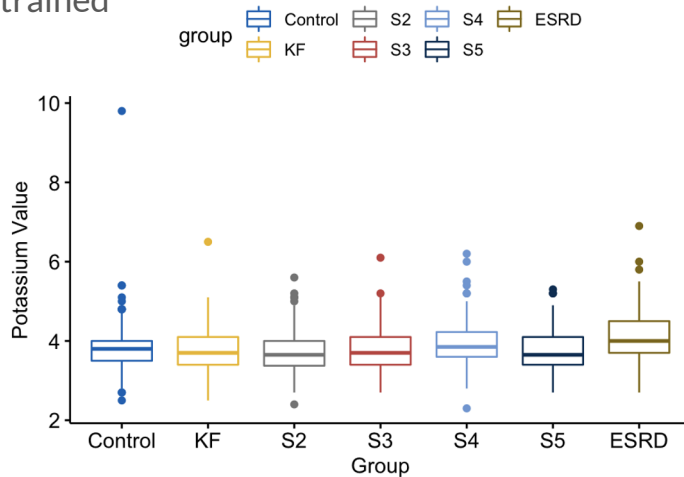
Ca Mean Threshold: 1.07 ± 0.07

Mg Mean Threshold: 1.78 ± 0.59

Phos Mean Threshold: 2.30 ± 0.95

Pre-Repletion Thresholds: Kidney disease

- Kidney failure disrupts potassium metabolism [6]
    - Hypothesis: Since hyperkalemia commonly occurs, we assume that threshold for potassium repletion would be lower in the stages of CKD than the control
- S1 excluded (n=15)
- Sample size constrained

group	observations	mean	std_dev
Control	208	3.79	0.62
KF	208	3.75	0.55
S2	208	3.68	0.49
S3	208	3.78	0.53
S4	208	3.96	0.54
S5	208	3.77	0.54
ESRD	208	4.08	0.59

Source:
6. Lehnhardt, A., & Kemper, M. J. (2011). Pathogenesis, diagnosis and management of hyperkalemia. *Pediatric nephrology (Berlin, Germany)*, *26*(3), 377–384. https://doi.org/10.1007/s00467-010-1699-3

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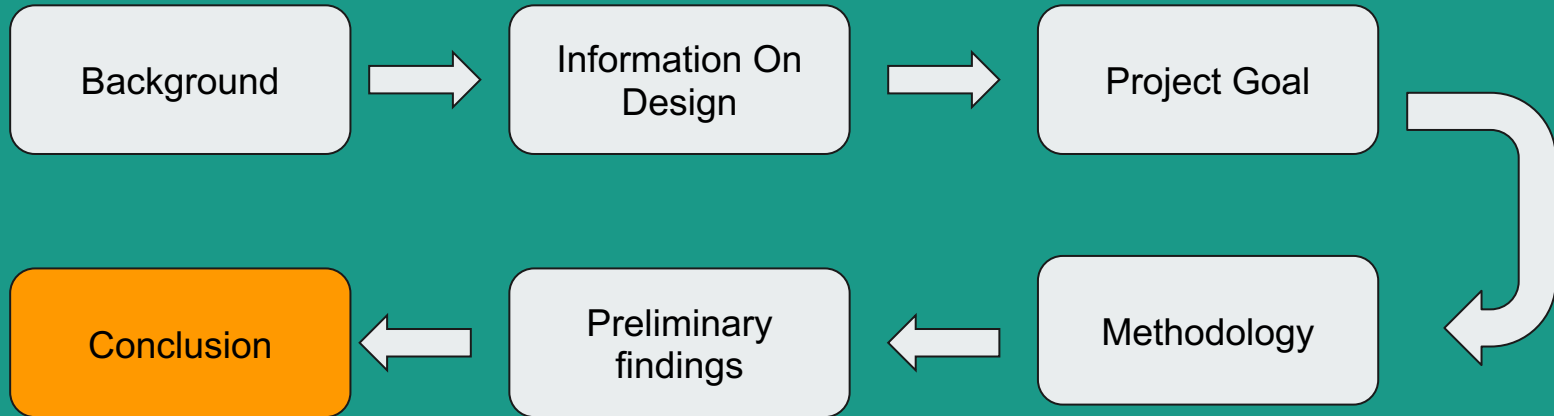
Challenges

- Two different critical care information systems
    - Many different item-ids to sort through
    - Different formats for each database
        - Defining a "beginning" of a repletion was difficult between both
- MIMICs and UPHs data were different
    - MIMICs lacked provider IDs!
        - Provider IDs limited to people that validated a given repletion, not who ordered it

Concluding Remarks

Mousa
- Responsibilities
  - Led majority of data analysis, Data visualization, project methodology, statistical knowledge acquisition
- Lessons Learned
  - Strengthened coding skills, knowledge in the methodology and design process, statistical knowledge acquisition

Parasteh
- Responsibilities
  - Assisted in data analysis, background research , will assist in writing manuscript
- Lessons Learned
  - coding , knowledge in the research design process, statistical knowledge acquisition

Thank you!

Dr. Kryztoff Laudansk

Joanne Levy

Ann Fischer

Aman Deep

Ken Moon

Evelyn Fabian