



Quantifying Bias in Care of Critically Ill Patients

Sarah Walker - UTSG CS 2T5

Supervisors: Dr. Christopher Yarnell & Dr. George Tomlinson
T-CAIREM AI in Medicine Summer Research Project



Objectives

Objectives



Importance

Importance of this
study

Objectives



Importance

Importance of this study



Approach

What data are we using, how are we modeling it?

Objectives



Importance

Importance of this study



Approach

What data are we using, how are we modeling it?



Results

Our preliminary results



In the ICU



In the ICU

- Cardiovascular, respiratory, neurological conditions



In the ICU

- Cardiovascular, respiratory, neurological conditions
- Emergency room, surgical procedures



In the ICU

- Cardiovascular, respiratory, neurological conditions
- Emergency room, surgical procedures
- Constant, close care

Ventilation & Sedation

Ventilation & Sedation



Ventilation & Sedation

- Invasive ventilation can be very uncomfortable



Ventilation & Sedation

- Invasive ventilation can be very uncomfortable
- Sedation can reduce anxiety, improve tolerance of invasive ventilation



Ventilation & Sedation

- Invasive ventilation can be very uncomfortable
- Sedation can reduce anxiety, improve tolerance of invasive ventilation



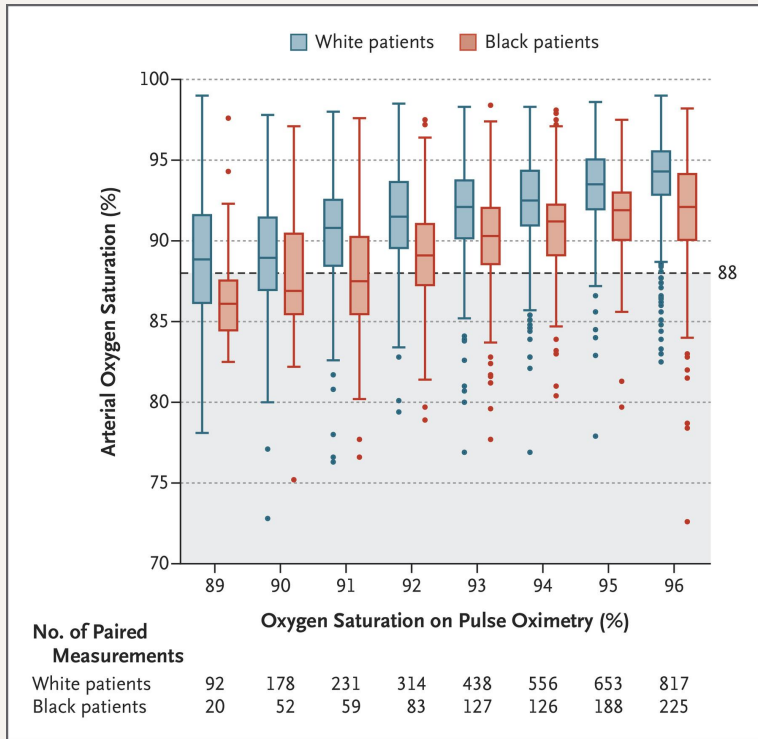
Ventilation & Sedation

- Invasive ventilation can be very uncomfortable
- Sedation can reduce anxiety, improve tolerance of invasive ventilation
- Some choices better than others, too much can be bad



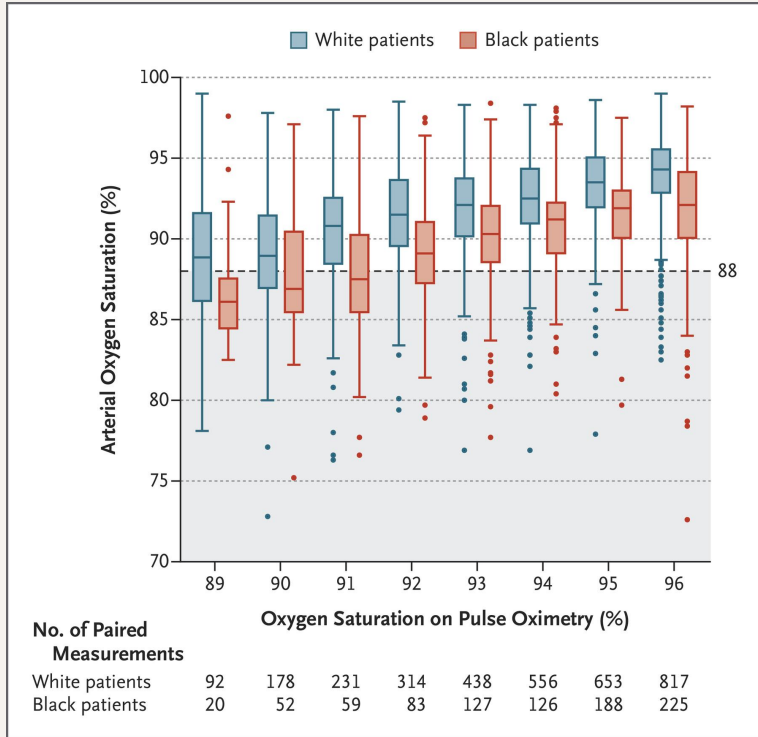
Known Biases

Known Biases

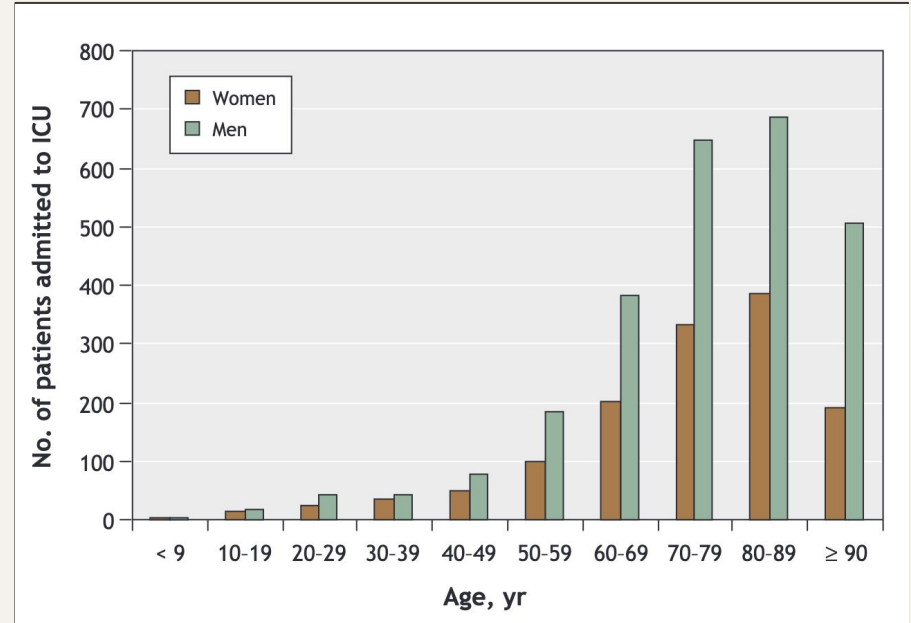


From Sjoding MW et al.

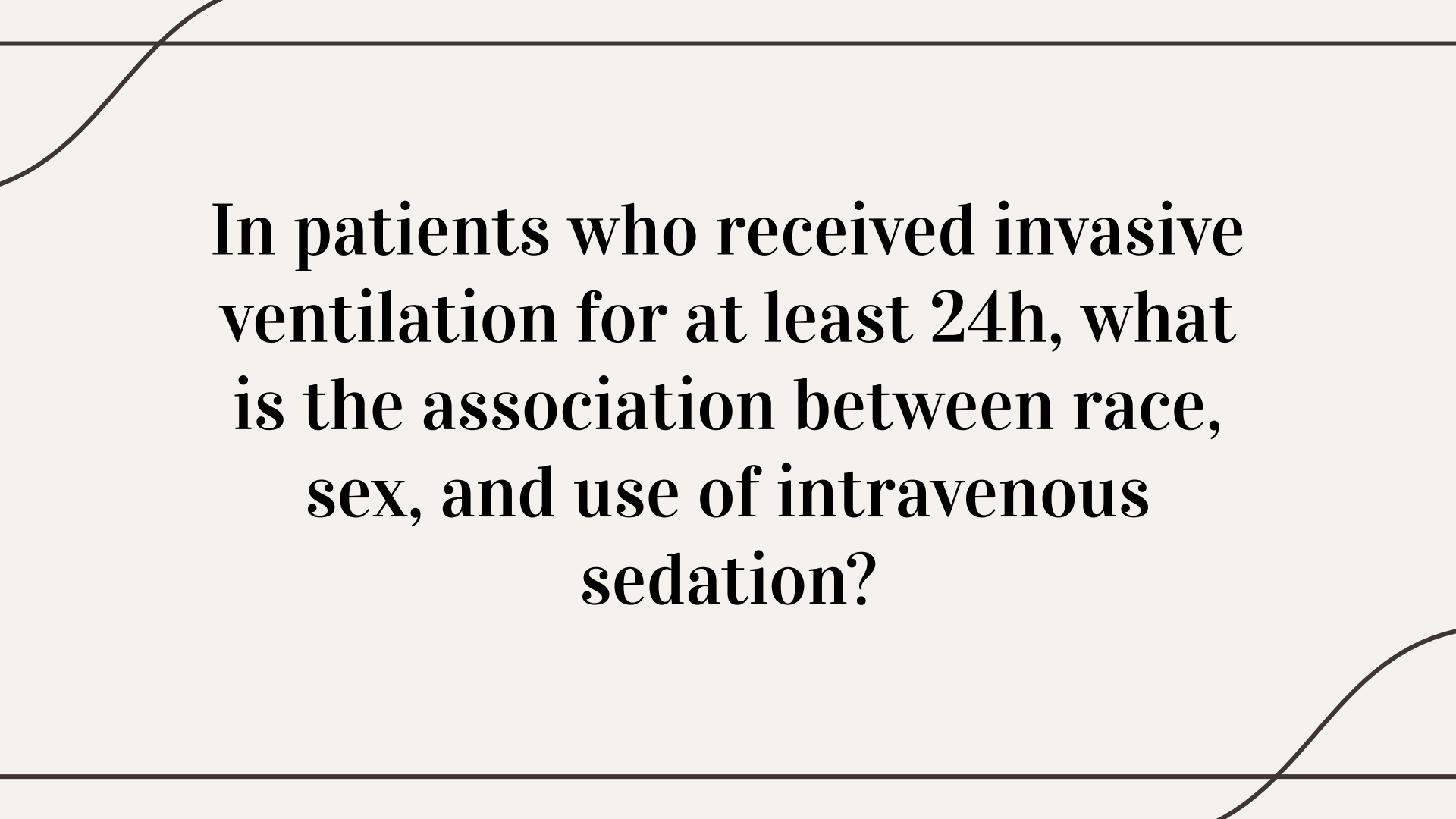
Known Biases



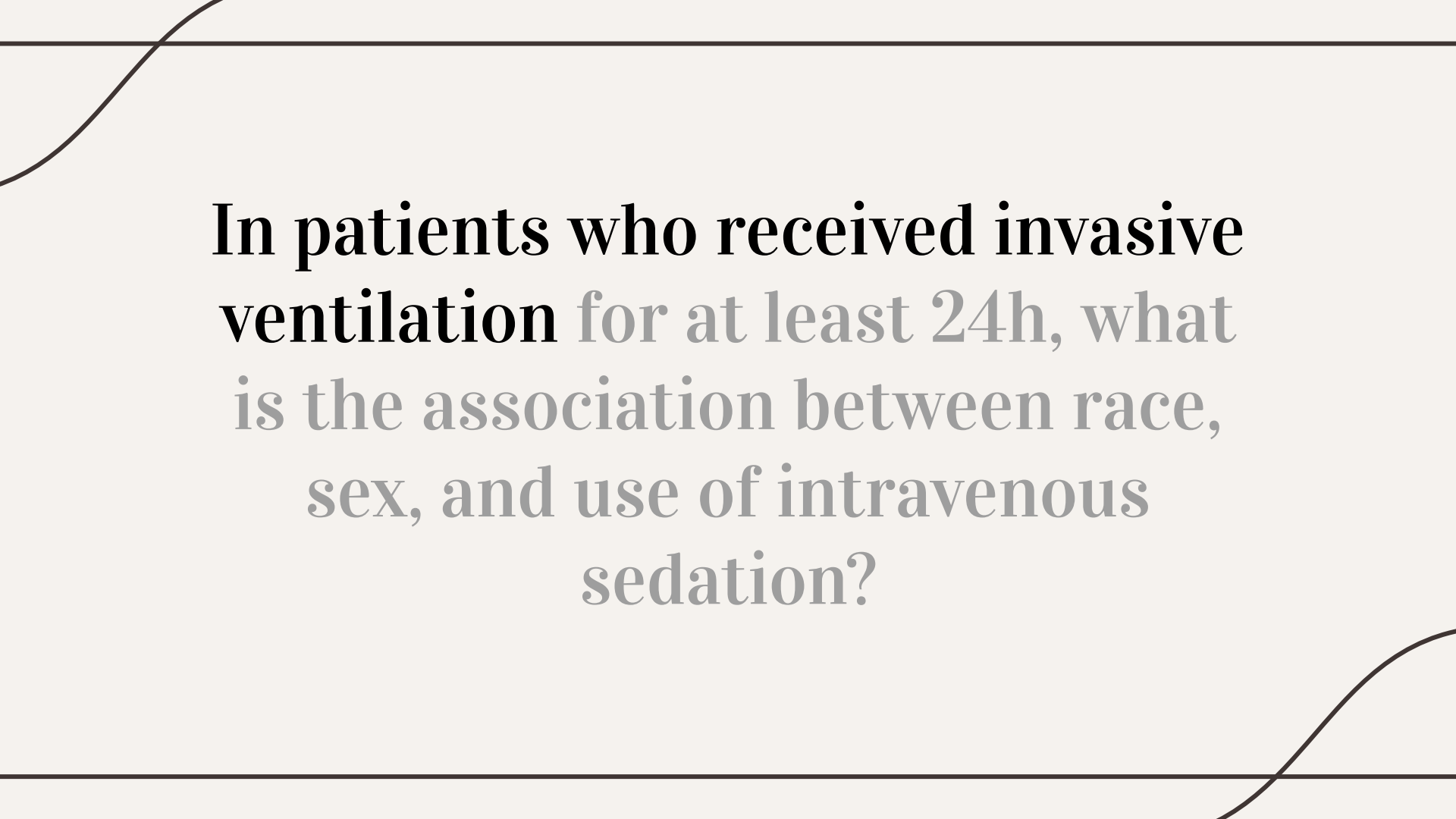
From Sjoding MW et al.



From Fowler RA et al.

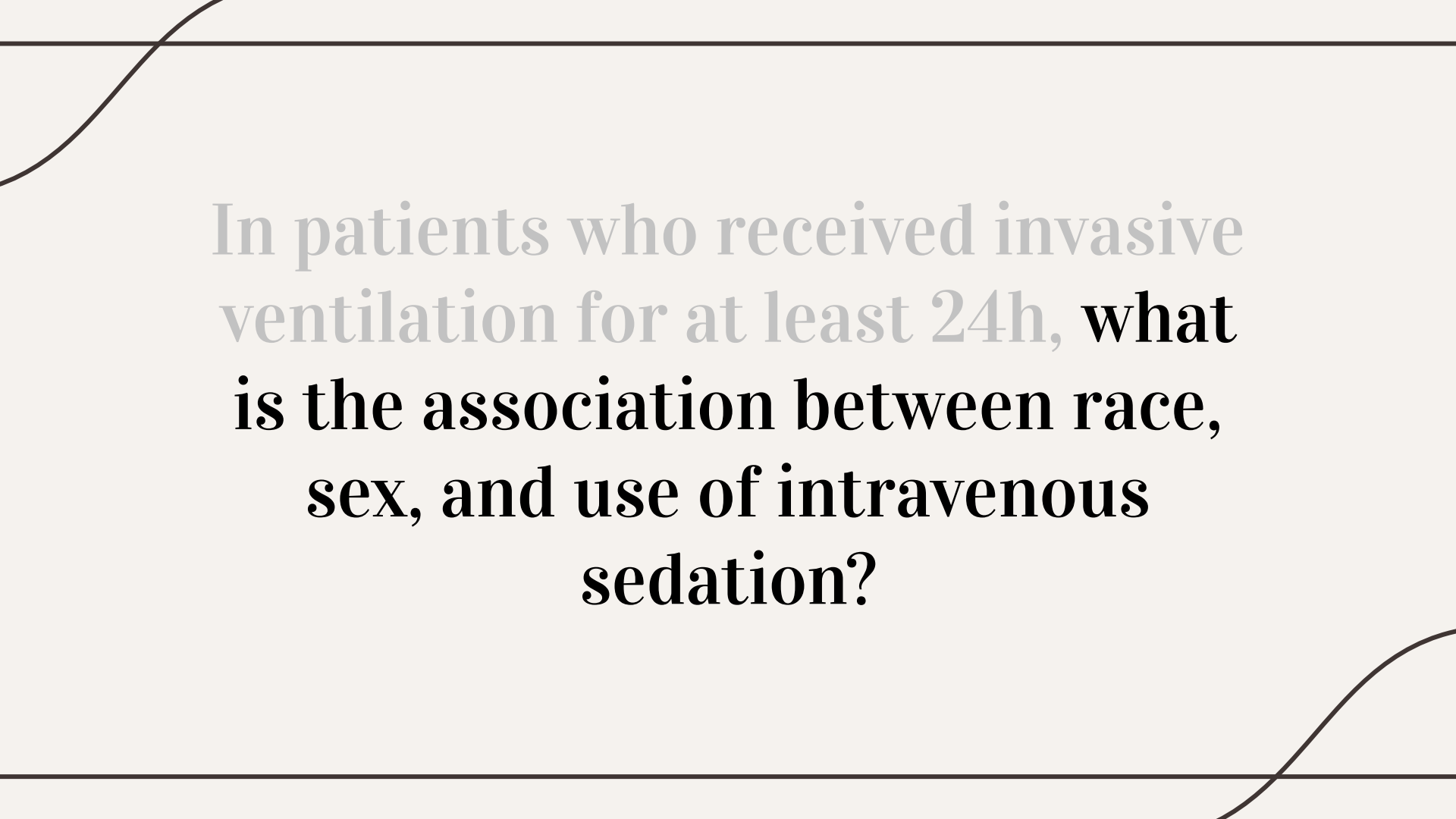


In patients who received invasive ventilation for at least 24h, what is the association between race, sex, and use of intravenous sedation?

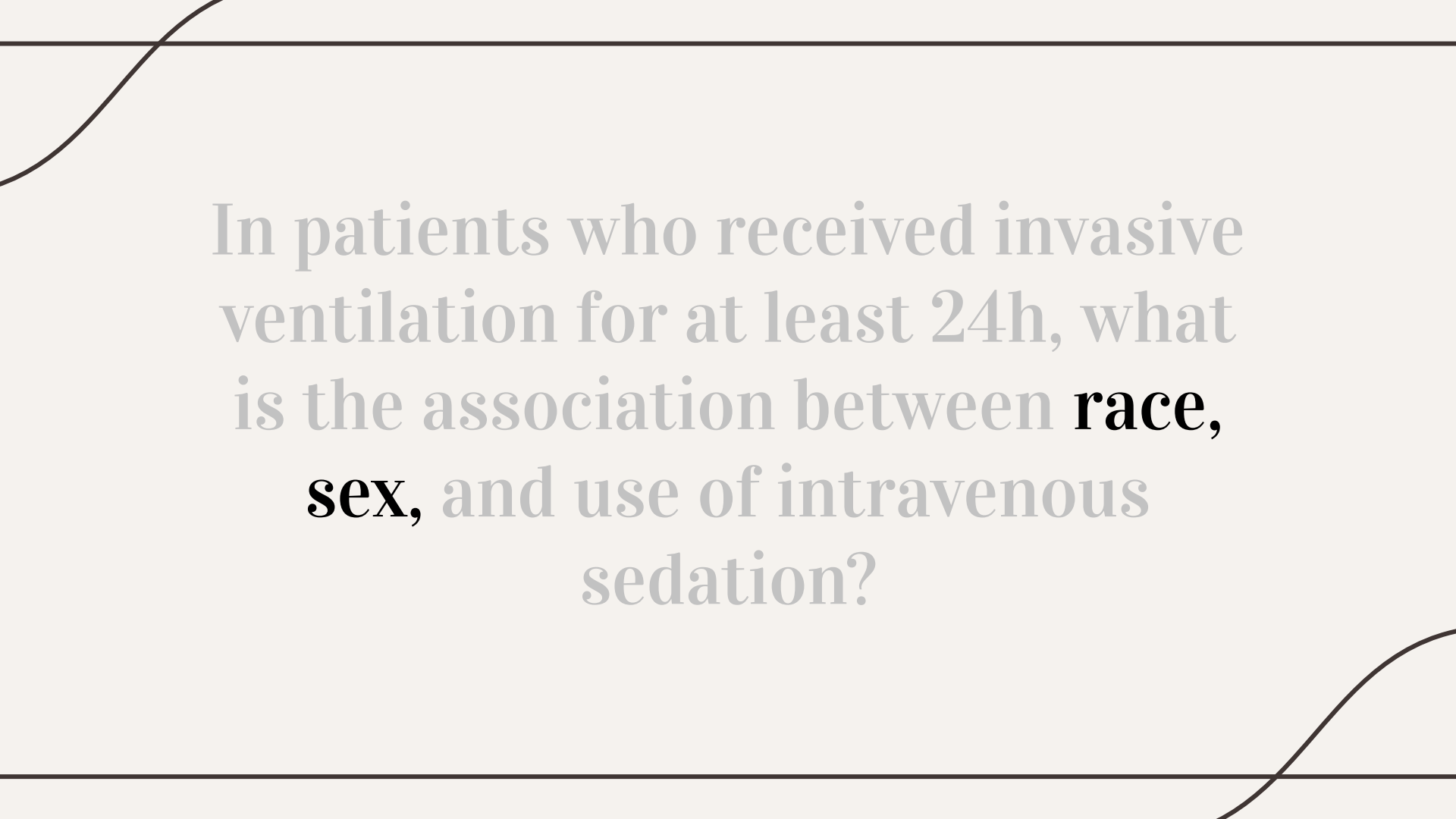


In patients who received invasive ventilation for at least 24h, what is the association between race, sex, and use of intravenous sedation?

In patients who received invasive ventilation for at least 24h, what is the association between race, sex, and use of intravenous sedation?



In patients who received invasive ventilation for at least 24h, **what is the association between race, sex, and use of intravenous sedation?**



In patients who received invasive ventilation for at least 24h, what is the association between **race**, **sex**, and use of intravenous sedation?

In patients who received invasive ventilation for at least 24h, what is the association between race, sex, and **use of intravenous sedation?**

Design



Design

Exposure 1

Race/ethnicity: Asian, Black,
Hispanic, white

Design

Exposure 1

Race/ethnicity: Asian, Black,
Hispanic, white

Exposure 2

Sex: male, female

Design

Exposure 1

Race/ethnicity: Asian, Black,
Hispanic, white

Exposure 2

Sex: male, female

Outcome(s)

Dose of sedation: Propofol,
benzodiazepines

Design

Exposure 1

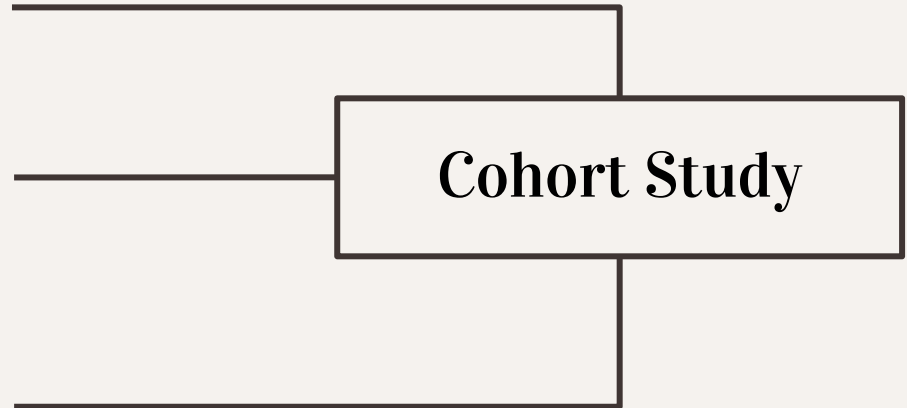
Race/ethnicity: Asian, Black, Hispanic, white

Exposure 2

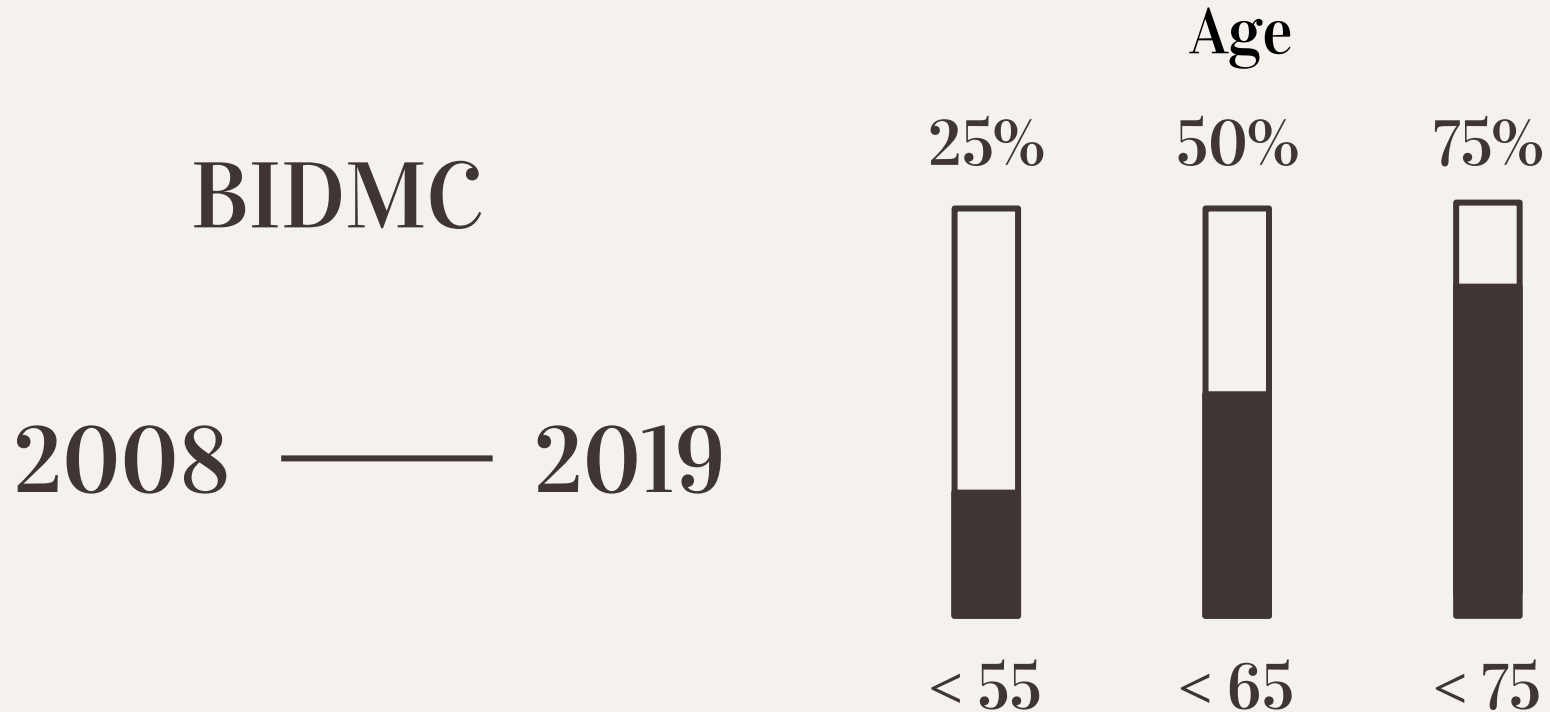
Sex: male, female

Outcome(s)

Dose of sedation: Propofol, benzodiazepines



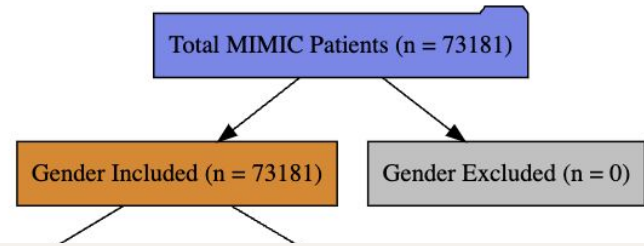
Medical Information Mart for Intensive Care (IV)

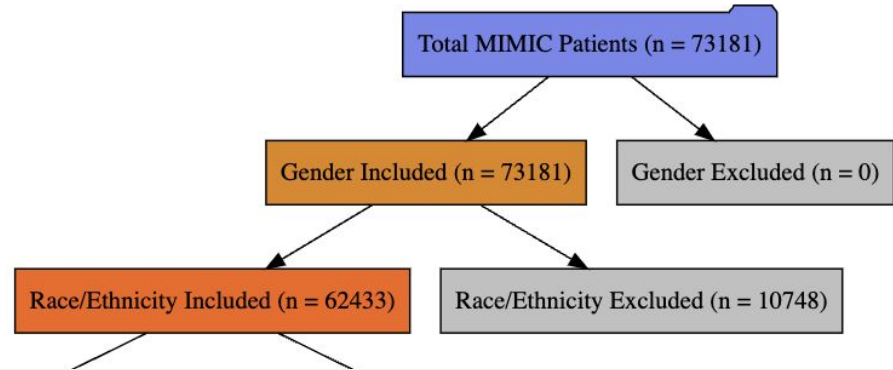


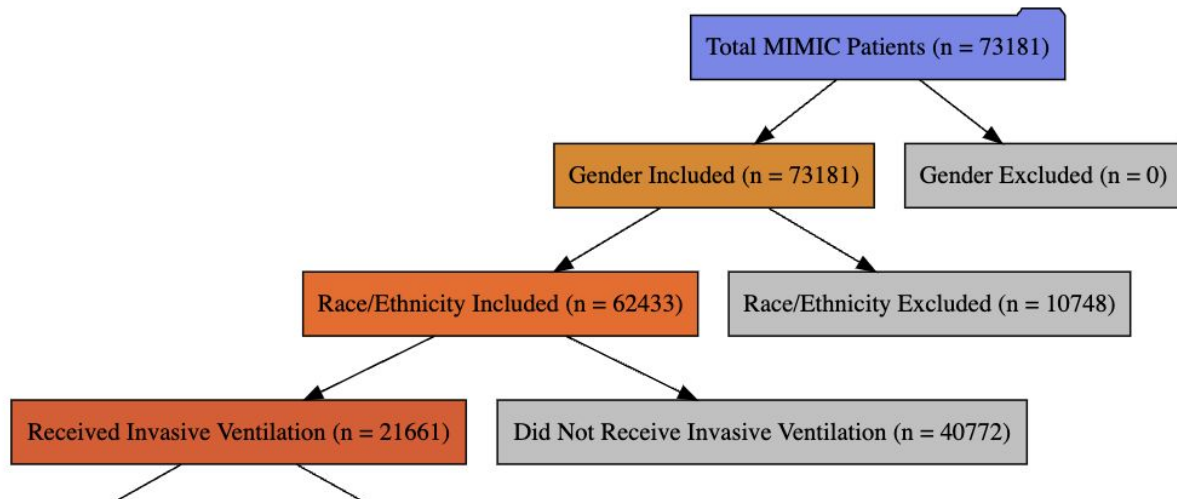
* from eligible patients in our cohort

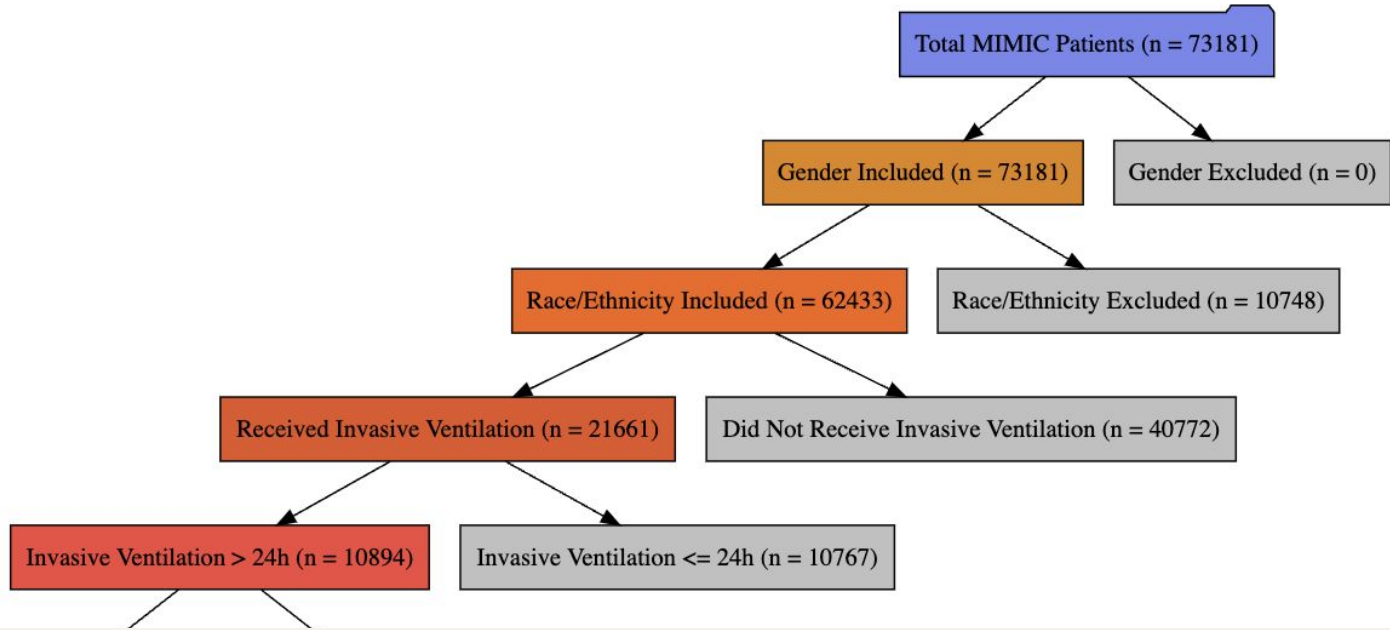
Total MIMIC Patients (n = 73181)

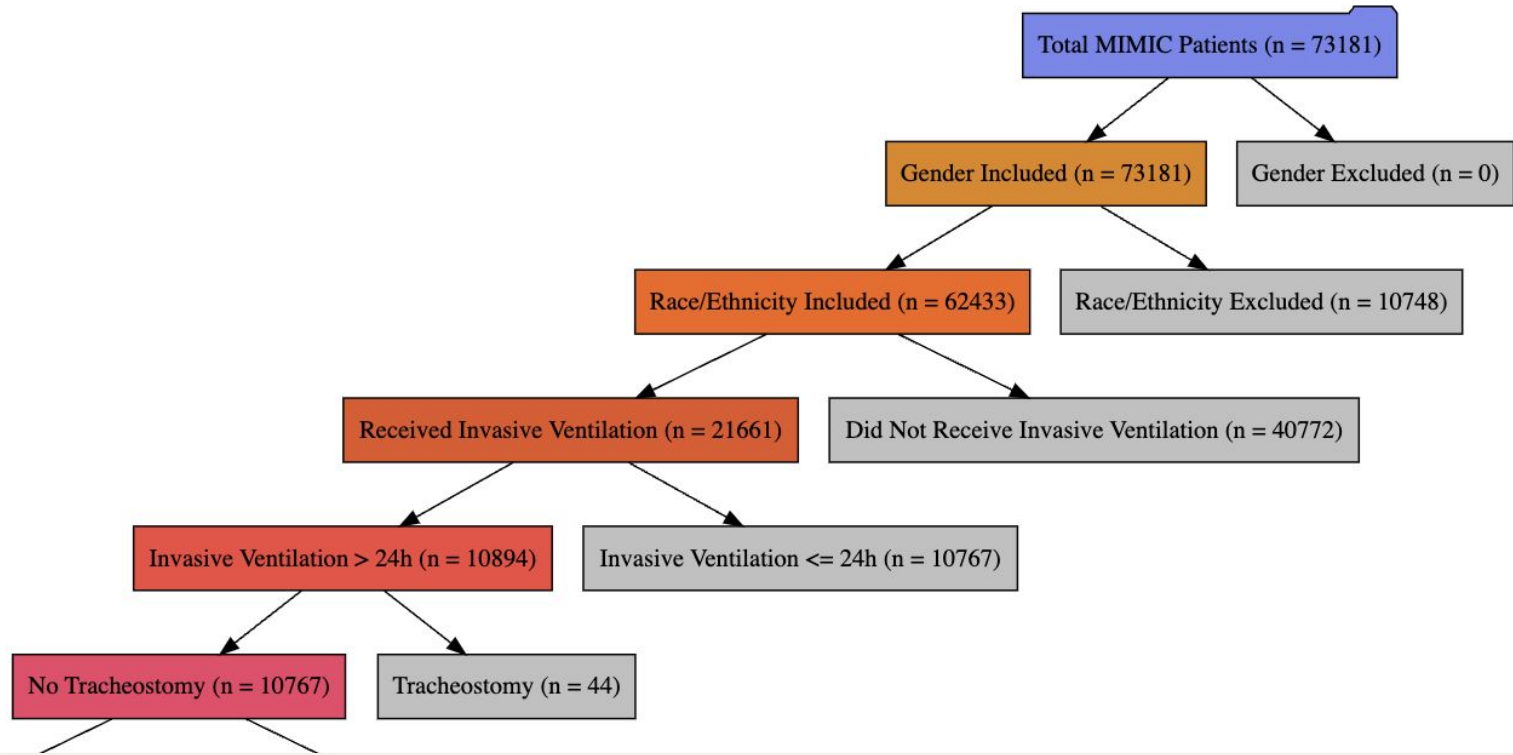


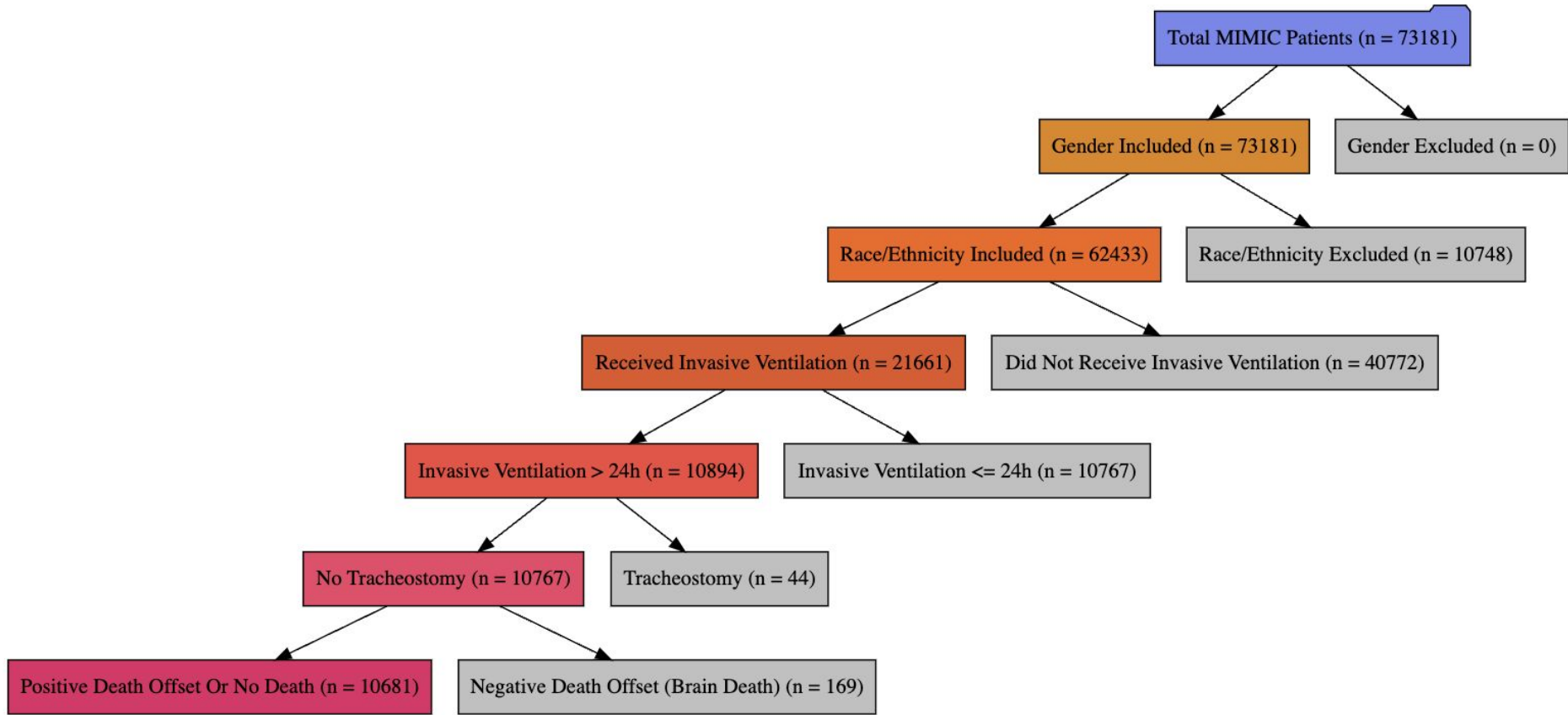












Time Intervals



Time Intervals

admission



Time Intervals

admission

Invasive
ventilation



Time Intervals

admission

Invasive
ventilation

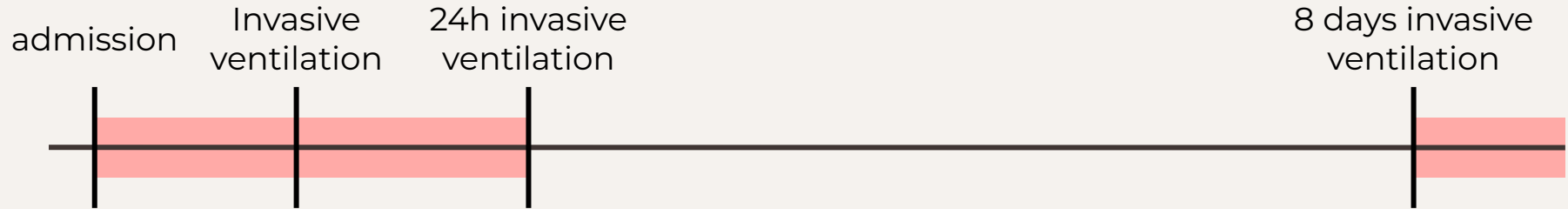
24h invasive
ventilation



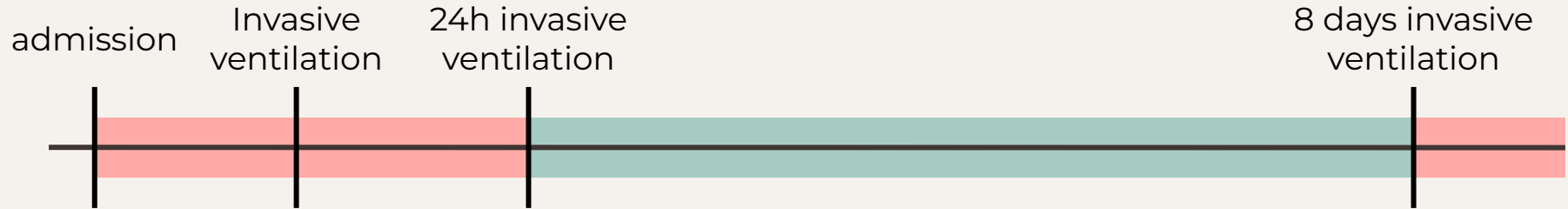
Time Intervals



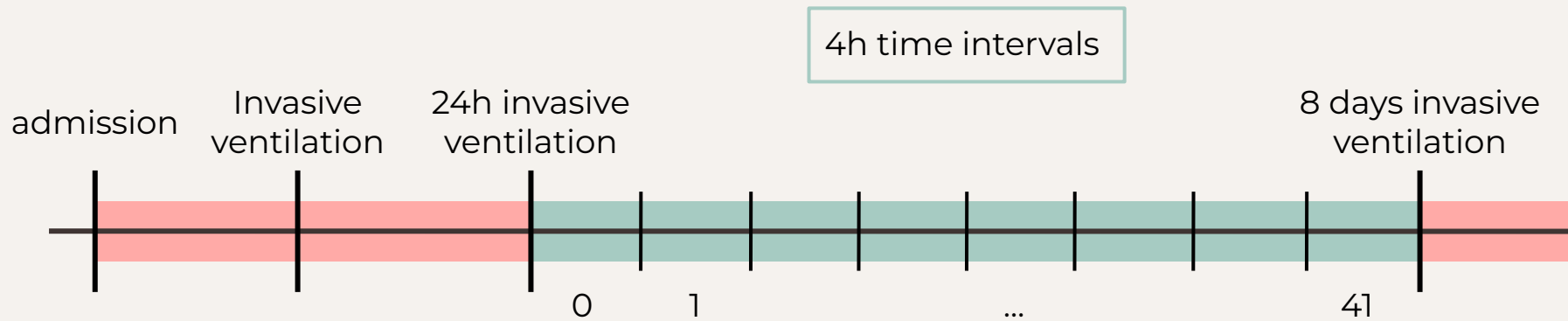
Time Intervals



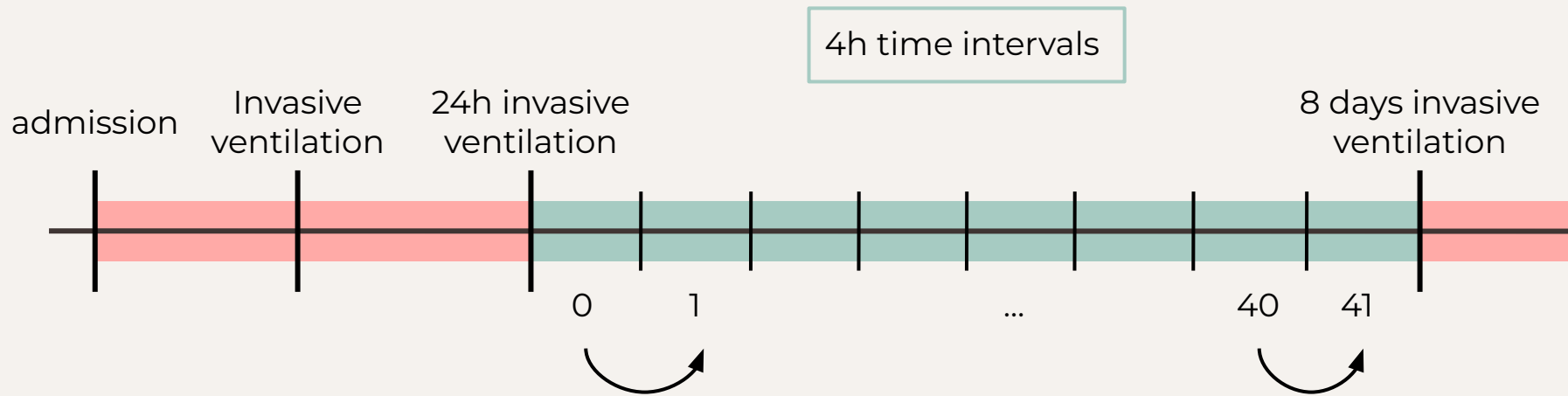
Time Intervals



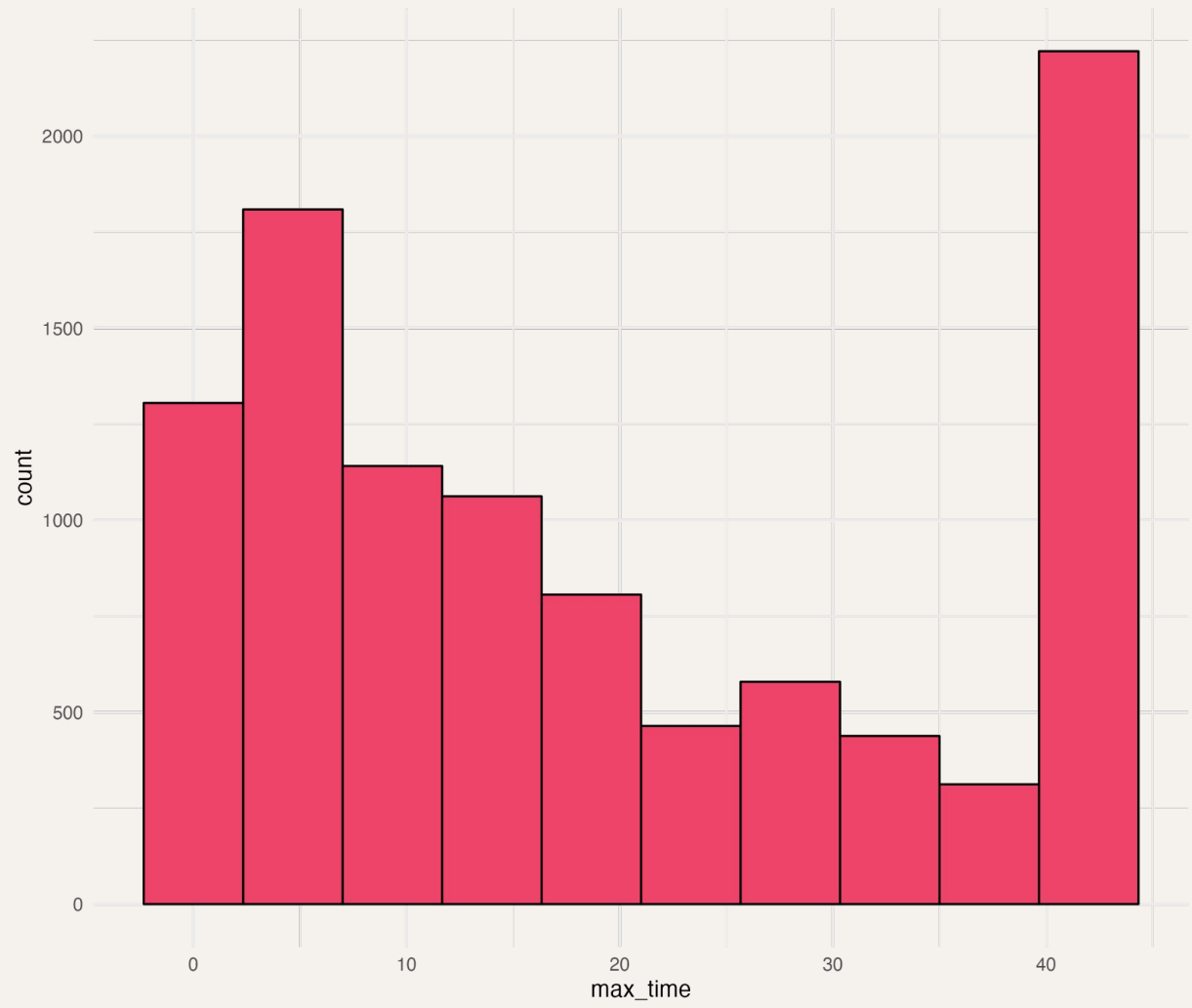
Time Intervals

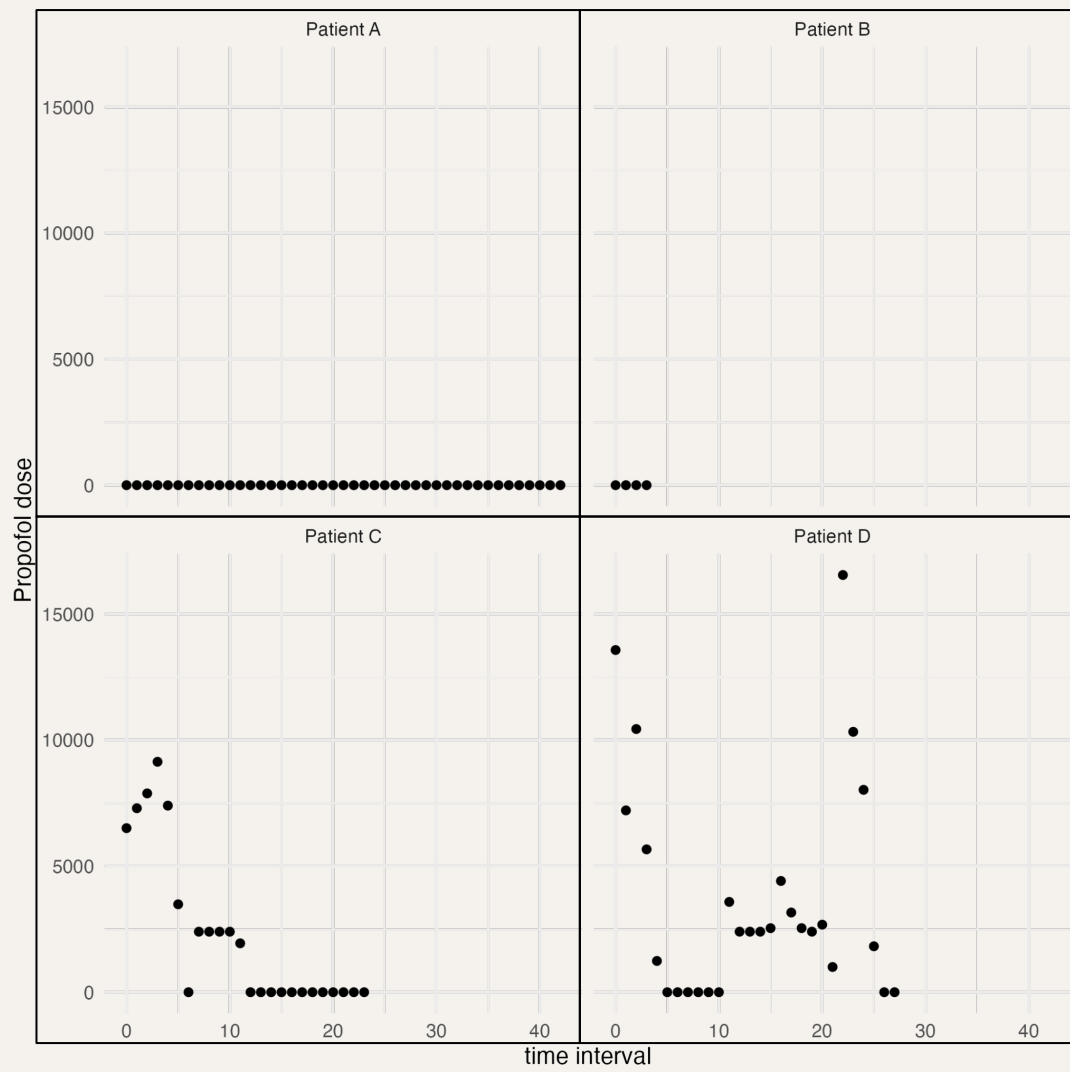


Time Intervals

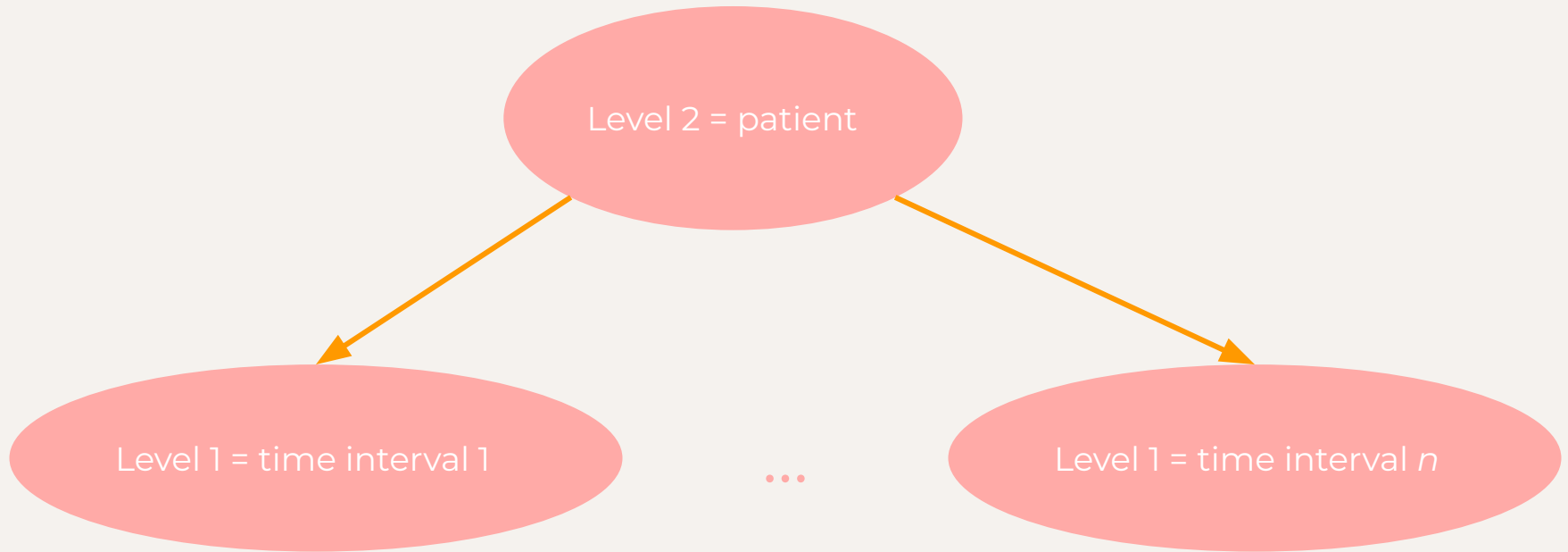


maximum ICU duration





Multilevel modeling



Multilevel modeling

i = level 1 (time)

j = level 2 (patient stay)

$$Y_{ij} = \alpha_j + \beta_j X_{ij} + \varepsilon_{ij}$$

Multilevel modeling

$i = \text{level 1 (time)}$
 $j = \text{level 2 (patient stay)}$

$$Y_{ij} = \alpha_j + \beta_j X_{ij} + \varepsilon_{ij}$$

Outcome (propofol dose)
for time interval i and
patient stay j


Value of predictor
variable for patient stay j
and time interval i

Multilevel modeling

i = level 1 (time)
j = level 2 (patient stay)

$$Y_{ij} = \alpha_j + \beta_j X_{ij} + \varepsilon_{ij}$$

intercept



Multilevel modeling

$i = \text{level 1 (time)}$
 $j = \text{level 2 (patient stay)}$

$$Y_{ij} = (\gamma + v_j) + \beta_j X_{ij} + \varepsilon_{ij}$$

Average intercept
over population

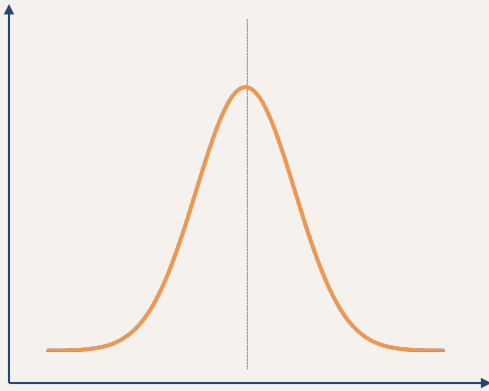
Deviation from intercept to
account for patient stay j

Multilevel modeling

$i = \text{level 1 (time)}$

$j = \text{level 2 (patient stay)}$

$$Y_{ij} = (\tau + v_j) + \beta_j X_{ij} + \varepsilon_{ij}$$

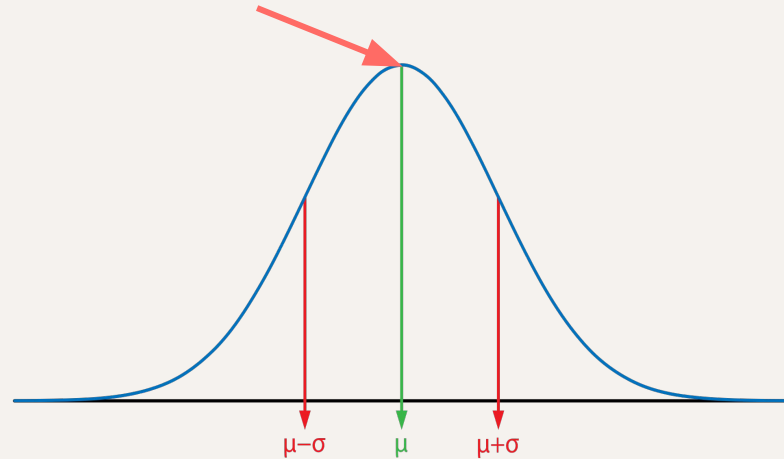
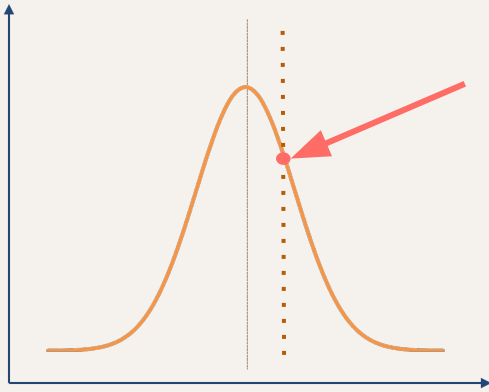


Multilevel modeling

$i = \text{level 1 (time)}$

$j = \text{level 2 (patient stay)}$

$$Y_{ij} = (\tau + v_j) + \beta_j X_{ij} + \varepsilon_{ij}$$



Multilevel modeling

i = level 1 (time)
j = level 2 (patient stay)

$$Y_{ij} = \alpha_i + \beta_j X_{ij} + \varepsilon_{ij}$$

Slope for predictor

Value of predictor
variable for patient stay *j*
and time interval *i*

Multilevel modeling

i = level 1 (time)

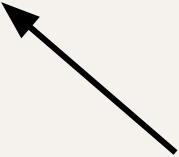
j = level 2 (patient stay)

$$Y_{ij} = \alpha_i + (\gamma + u_j)X_{ij} + \varepsilon_{ij}$$

Average slope over
population



Deviation from average
slope to account for
patient stay *j*




** not actually in our model*

Multilevel modeling

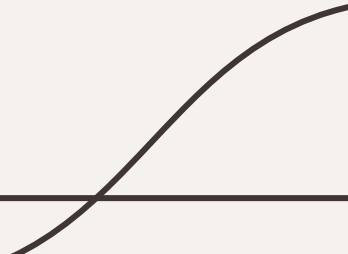
i = level 1 (time)
j = level 2 (patient stay)

$$Y_{ij} = \alpha_j + \beta_j X_{ij} + \varepsilon_{ij}$$



Residual for that
particular data
point

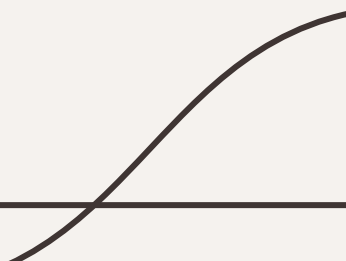
Covariates



Covariates

Baseline

Age
Height
Weight
History of dementia
History of TBI
Substance use disorder
ICU admission type
English fluency
Insurance type
Year of admission



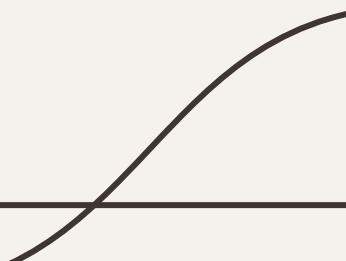
Covariates

Baseline

Age
Height
Weight
History of dementia
History of TBI
Substance use disorder
ICU admission type
English fluency
Insurance type
Year of admission

Time-Varying

Amount of sedative administered
in previous time interval
Blood pressure
FiO2
SpO2
Neuromuscular blocker
PaO2
PaCO2
heart rate
respiratory rate
GCS
intravenous opioids
intravenous vasopressors



	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0	5	64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1	5	64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2	4	64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3	1	64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4	1	64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0	1	56	152	0.19235098	1.40543267	0.50767622
7	30004018	1	1	56	152	0.34555555	0.33605929	1.01649854
8	30004018	2	1	56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3	1	56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4	1	56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5	1	56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6	1	56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7	1	56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8	1	56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9	1	56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10	1	56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11	1	56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12	1	56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13	1	56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14	1	56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15	1	56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16	1	56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17	1	56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18	1	56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19	1	56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20	1	56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21	1	56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22	1	56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23	1	56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24	1	56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25	1	56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26	1	56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27	1	56	152	0.82403817	-0.34734957	0.03011722

	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0 5		64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1 5		64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2 4		64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3 1		64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4 1		64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0 1		56	152	0.19235098	1.40543267	0.50767622
7	30004018	1 1		56	152	0.34555555	0.33605929	1.01649854
8	30004018	2 1		56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3 1		56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4 1		56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5 1		56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6 1		56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7 1		56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8 1		56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9 1		56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10 1		56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11 1		56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12 1		56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13 1		56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14 1		56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15 1		56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16 1		56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17 1		56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18 1		56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19 1		56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20 1		56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21 1		56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22 1		56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23 1		56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24 1		56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25 1		56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26 1		56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27 1		56	152	0.82403817	-0.34734957	0.03011722

	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0 5		64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1 5		64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2 4		64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3 1		64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4 1		64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0 1		56	152	0.19235098	1.40543267	0.50767622
7	30004018	1 1		56	152	0.34555555	0.33605929	1.01649854
8	30004018	2 1		56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3 1		56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4 1		56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5 1		56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6 1		56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7 1		56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8 1		56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9 1		56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10 1		56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11 1		56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12 1		56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13 1		56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14 1		56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15 1		56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16 1		56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17 1		56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18 1		56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19 1		56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20 1		56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21 1		56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22 1		56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23 1		56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24 1		56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25 1		56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26 1		56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27 1		56	152	0.82403817	-0.34734957	0.03011722

	↑	↕	↕	↕	↕	↕	↕	↕	↕	↕
	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2		
1	30003598	0	5	64	183	0.29502026	1.48428383	-0.50962732		
2	30003598	1	5	64	183	0.77824806	1.48428383	-0.50962732		
3	30003598	2	4	64	183	0.68535742	0.41706524	-0.28523835		
4	30003598	3	1	64	183	0.86940232	0.41706524	-0.28523835		
5	30003598	4	1	64	183	1.46381155	0.20934127	-0.17743528		
6	30004018	0	1	56	152	0.19235098	1.40543267	0.50767622		
7	30004018	1	1	56	152	0.34555555	0.33605929	1.01649854		
8	30004018	2	1	56	152	2.16964661	-0.60462390	0.50767622		
9	30004018	3	1	56	152	0.54261715	-0.85822688	0.59693095		
10	30004018	4	1	56	152	0.86940232	-0.85822688	0.59693095		
11	30004018	5	1	56	152	0.19235098	-0.85822688	0.59693095		
12	30004018	6	1	56	152	0.49409325	-0.85822688	0.59693095		
13	30004018	7	1	56	152	0.59066297	-0.85822688	0.59693095		
14	30004018	8	1	56	152	0.19235098	-0.34734957	0.03011722		
15	30004018	9	1	56	152	0.63824004	-0.34734957	0.03011722		
16	30004018	10	1	56	152	0.54261715	-0.34734957	0.03011722		
17	30004018	11	1	56	152	0.34555555	-0.34734957	0.03011722		
18	30004018	12	1	56	152	0.68535742	-0.34734957	0.03011722		
19	30004018	13	1	56	152	1.00301646	-0.34734957	0.03011722		
20	30004018	14	1	56	152	0.91434836	-0.34734957	0.03011722		
21	30004018	15	1	56	152	0.54261715	-0.34734957	0.03011722		
22	30004018	16	1	56	152	0.29502026	-0.34734957	0.03011722		
23	30004018	17	1	56	152	0.29502026	-0.34734957	0.03011722		
24	30004018	18	1	56	152	0.44508167	-0.34734957	0.03011722		
25	30004018	19	1	56	152	0.39557251	-0.34734957	0.03011722		
26	30004018	20	1	56	152	0.44508167	-0.34734957	0.03011722		
27	30004018	21	1	56	152	0.59066297	-0.34734957	0.03011722		
28	30004018	22	1	56	152	0.82403817	-0.34734957	0.03011722		
29	30004018	23	1	56	152	0.86940232	-0.34734957	0.03011722		
30	30004018	24	1	56	152	1.42367461	-0.34734957	0.03011722		
31	30004018	25	1	56	152	1.42367461	-0.34734957	0.03011722		
32	30004018	26	1	56	152	1.09010111	-0.34734957	0.03011722		
33	30004018	27	1	56	152	0.82403817	-0.34734957	0.03011722		

	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0	5	64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1	5	64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2	4	64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3	1	64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4	1	64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0	1	56	152	0.19235098	1.40543267	0.50767622
7	30004018	1	1	56	152	0.34555555	0.33605929	1.01649854
8	30004018	2	1	56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3	1	56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4	1	56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5	1	56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6	1	56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7	1	56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8	1	56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9	1	56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10	1	56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11	1	56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12	1	56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13	1	56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14	1	56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15	1	56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16	1	56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17	1	56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18	1	56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19	1	56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20	1	56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21	1	56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22	1	56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23	1	56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24	1	56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25	1	56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26	1	56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27	1	56	152	0.82403817	-0.34734957	0.03011722

	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0	5	64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1	5	64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2	4	64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3	1	64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4	1	64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0	1	56	152	0.19235098	1.40543267	0.50767622
7	30004018	1	1	56	152	0.34555555	0.33605929	1.01649854
8	30004018	2	1	56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3	1	56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4	1	56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5	1	56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6	1	56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7	1	56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8	1	56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9	1	56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10	1	56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11	1	56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12	1	56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13	1	56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14	1	56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15	1	56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16	1	56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17	1	56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18	1	56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19	1	56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20	1	56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21	1	56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22	1	56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23	1	56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24	1	56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25	1	56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26	1	56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27	1	56	152	0.82403817	-0.34734957	0.03011722

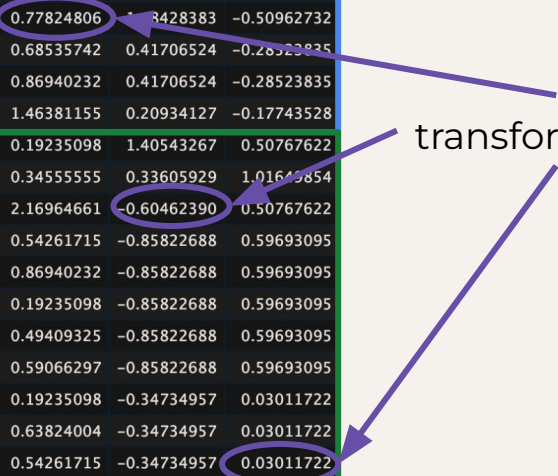
	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0	5	64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1	5	64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2	4	64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3	1	64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4	1	64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0	1	56	152	0.19235098	1.40543267	0.50767622
7	30004018	1	1	56	152	0.34555555	0.33605929	1.01649854
8	30004018	2	1	56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3	1	56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4	1	56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5	1	56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6	1	56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7	1	56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8	1	56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9	1	56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10	1	56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11	1	56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12	1	56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13	1	56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14	1	56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15	1	56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16	1	56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17	1	56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18	1	56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19	1	56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20	1	56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21	1	56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22	1	56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23	1	56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24	1	56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25	1	56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26	1	56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27	1	56	152	0.82403817	-0.34734957	0.03011722

	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0	5	64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1	5	64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2	4	64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3	1	64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4	1	64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0	1	56	152	0.19235098	1.40543267	0.50767622
7	30004018	1	1	56	152	0.34555555	0.33605929	1.01649854
8	30004018	2	1	56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3	1	56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4	1	56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5	1	56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6	1	56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7	1	56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8	1	56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9	1	56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10	1	56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11	1	56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12	1	56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13	1	56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14	1	56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15	1	56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16	1	56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17	1	56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18	1	56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19	1	56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20	1	56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21	1	56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22	1	56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23	1	56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24	1	56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25	1	56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26	1	56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27	1	56	152	0.82403817	-0.34734957	0.03011722

	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0 5		64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1 5		64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2 4		64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3 1		64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4 1		64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0 1		56	152	0.19235098	1.40543267	0.50767622
7	30004018	1 1		56	152	0.34555555	0.33605929	1.01649854
8	30004018	2 1		56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3 1		56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4 1		56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5 1		56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6 1		56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7 1		56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8 1		56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9 1		56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10 1		56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11 1		56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12 1		56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13 1		56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14 1		56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15 1		56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16 1		56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17 1		56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18 1		56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19 1		56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20 1		56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21 1		56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22 1		56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23 1		56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24 1		56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25 1		56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26 1		56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27 1		56	152	0.82403817	-0.34734957	0.03011722

	stay_id	time_interval	propofol_outcome_quantile	age	height	heart_rate	pao2	paco2
1	30003598	0 5		64	183	0.29502026	1.48428383	-0.50962732
2	30003598	1 5		64	183	0.77824806	1.48428383	-0.50962732
3	30003598	2 4		64	183	0.68535742	0.41706524	-0.28523835
4	30003598	3 1		64	183	0.86940232	0.41706524	-0.28523835
5	30003598	4 1		64	183	1.46381155	0.20934127	-0.17743528
6	30004018	0 1		56	152	0.19235098	1.40543267	0.50767622
7	30004018	1 1		56	152	0.34555555	0.33605929	1.01645854
8	30004018	2 1		56	152	2.16964661	-0.60462390	0.50767622
9	30004018	3 1		56	152	0.54261715	-0.85822688	0.59693095
10	30004018	4 1		56	152	0.86940232	-0.85822688	0.59693095
11	30004018	5 1		56	152	0.19235098	-0.85822688	0.59693095
12	30004018	6 1		56	152	0.49409325	-0.85822688	0.59693095
13	30004018	7 1		56	152	0.59066297	-0.85822688	0.59693095
14	30004018	8 1		56	152	0.19235098	-0.34734957	0.03011722
15	30004018	9 1		56	152	0.63824004	-0.34734957	0.03011722
16	30004018	10 1		56	152	0.54261715	-0.34734957	0.03011722
17	30004018	11 1		56	152	0.34555555	-0.34734957	0.03011722
18	30004018	12 1		56	152	0.68535742	-0.34734957	0.03011722
19	30004018	13 1		56	152	1.00301646	-0.34734957	0.03011722
20	30004018	14 1		56	152	0.91434836	-0.34734957	0.03011722
21	30004018	15 1		56	152	0.54261715	-0.34734957	0.03011722
22	30004018	16 1		56	152	0.29502026	-0.34734957	0.03011722
23	30004018	17 1		56	152	0.29502026	-0.34734957	0.03011722
24	30004018	18 1		56	152	0.44508167	-0.34734957	0.03011722
25	30004018	19 1		56	152	0.39557251	-0.34734957	0.03011722
26	30004018	20 1		56	152	0.44508167	-0.34734957	0.03011722
27	30004018	21 1		56	152	0.59066297	-0.34734957	0.03011722
28	30004018	22 1		56	152	0.82403817	-0.34734957	0.03011722
29	30004018	23 1		56	152	0.86940232	-0.34734957	0.03011722
30	30004018	24 1		56	152	1.42367461	-0.34734957	0.03011722
31	30004018	25 1		56	152	1.42367461	-0.34734957	0.03011722
32	30004018	26 1		56	152	1.09010111	-0.34734957	0.03011722
33	30004018	27 1		56	152	0.82403817	-0.34734957	0.03011722

transformation



Age (years)

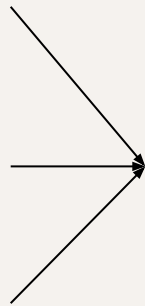
Heart rate_{t-1}

Race

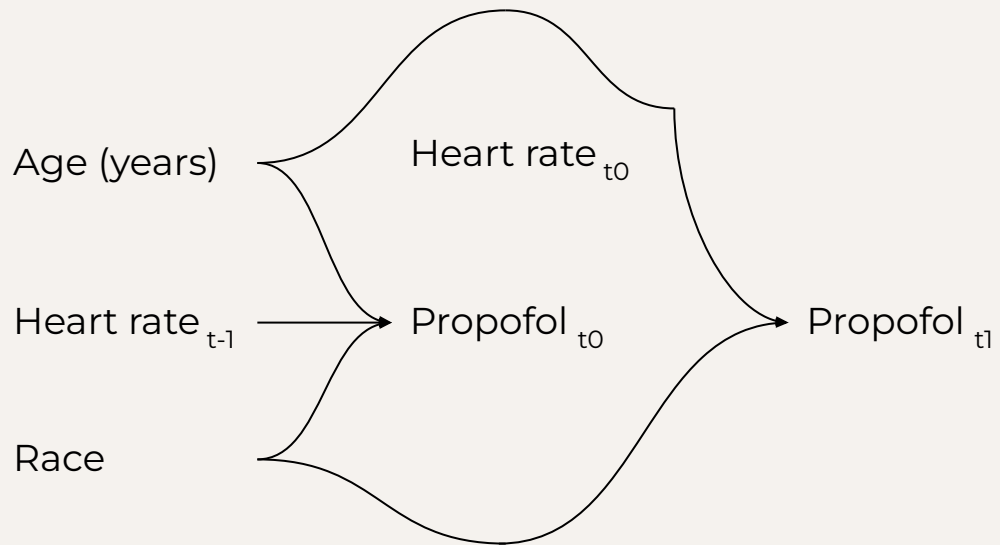
Age (years)

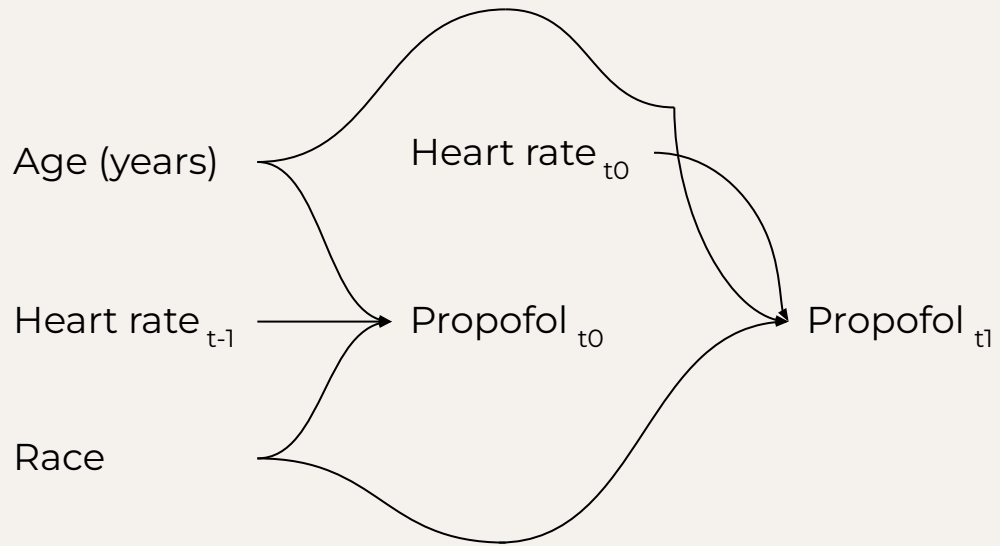
Heart rate_{t-1}

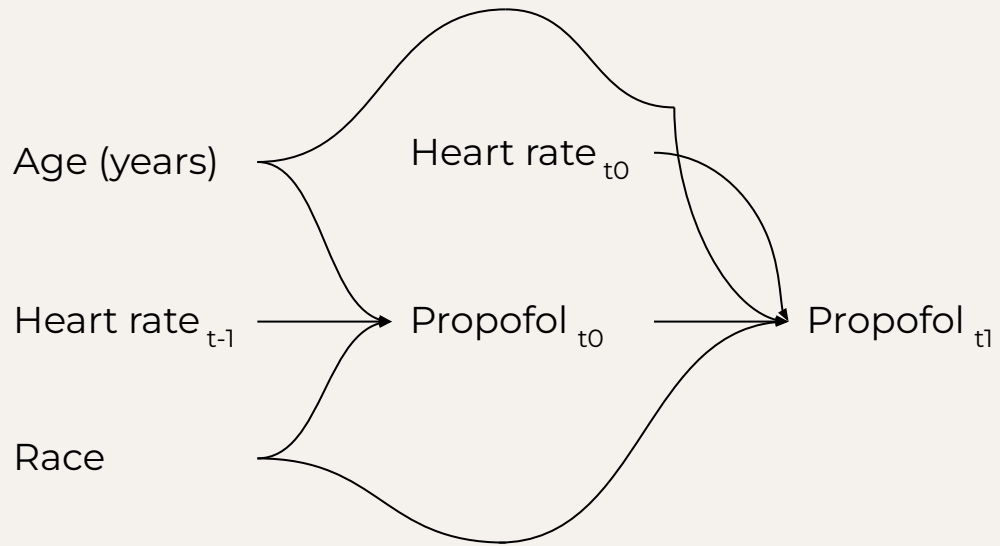
Race



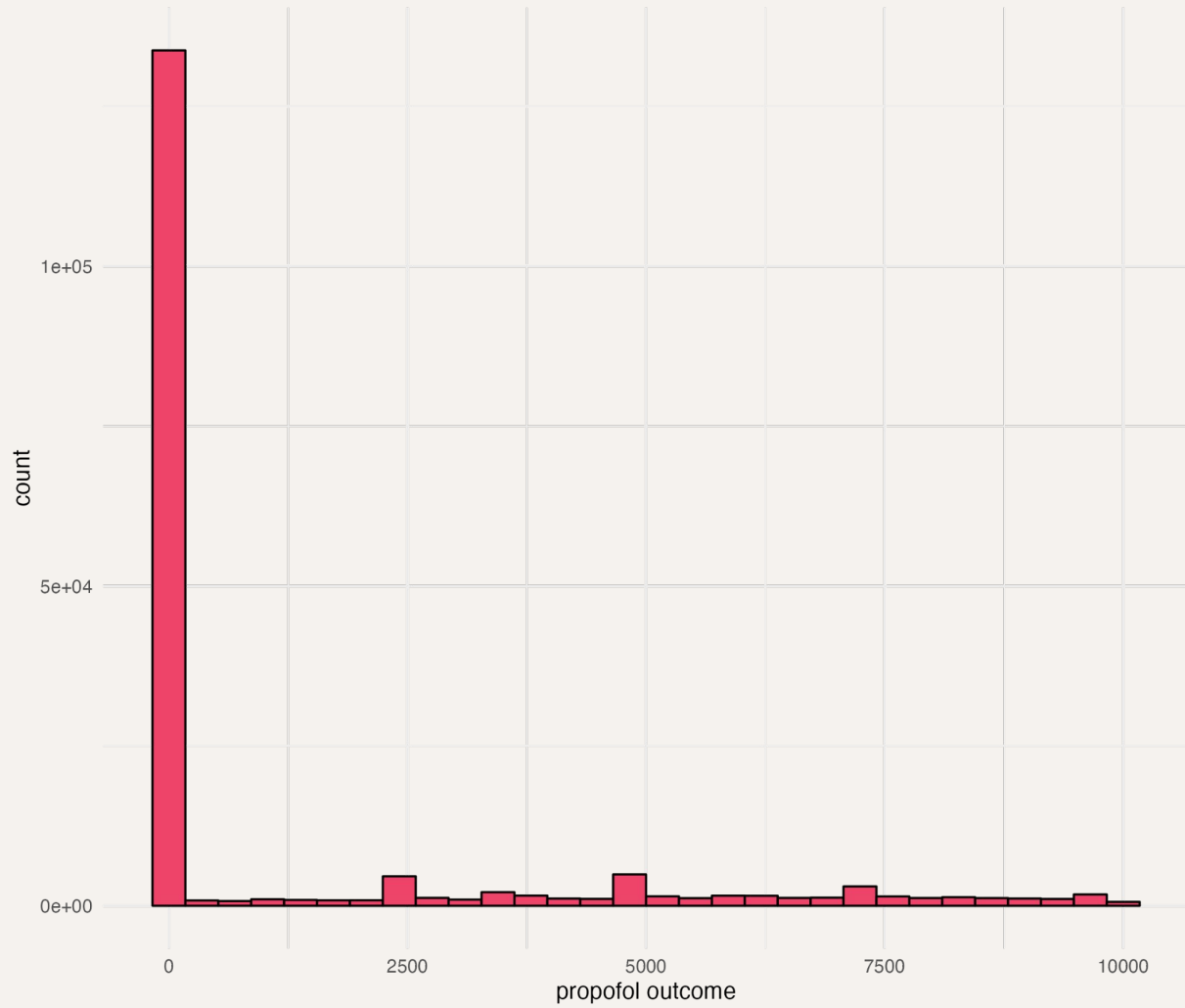
Propofol_{t0}



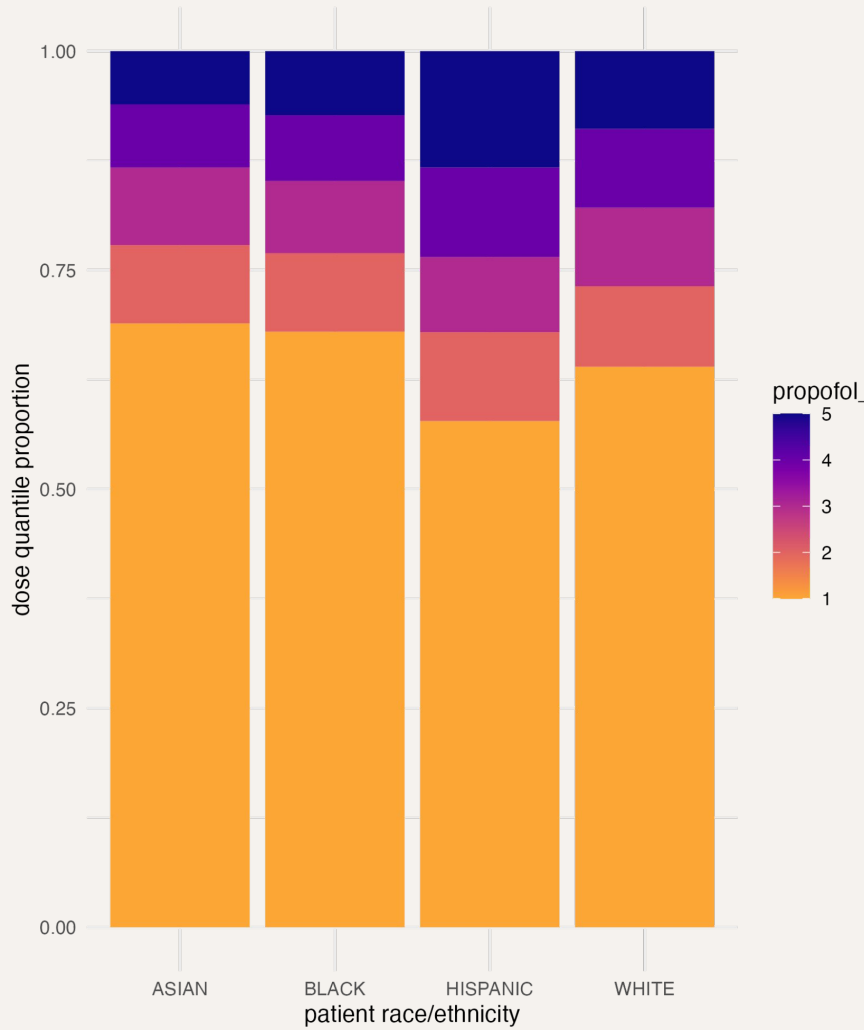




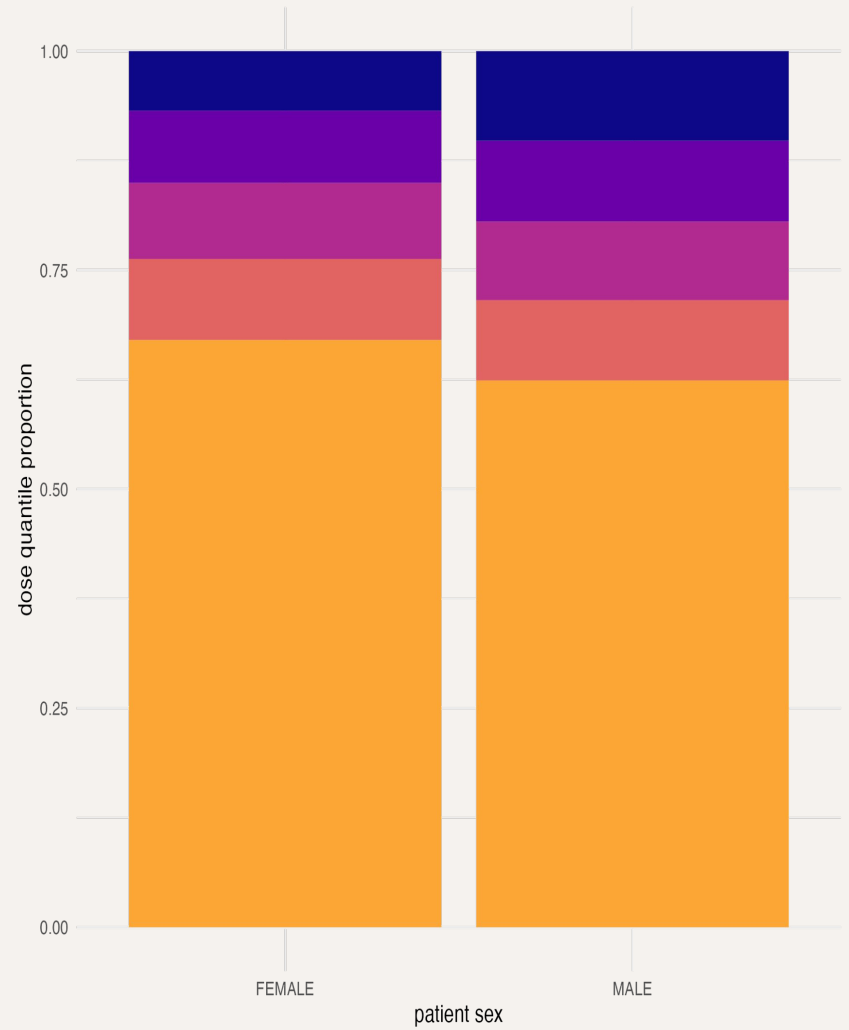
frequency of propofol outcomes



Proportion of propofol dose quantile by race/ethnicity



Proportion of propofol dose quantile by sex



Ordinal logistic regression

Ordinal logistic regression

k=1	No drug
k=2	Drug \leq 25%
k=3	Drug \leq 50%
k=4	Drug \leq 75%
k=5	Drug \leq 100%

Ordinal logistic regression

k=1	No drug
k=2	Drug \leq 25%
k=3	Drug \leq 50%
k=4	Drug \leq 75%
k=5	Drug \leq 100%

$$P(y \leq k | X) = g(\alpha_k - \beta X)$$

Ordinal logistic regression

k=1	No drug
k=2	Drug \leq 25%
k=3	Drug \leq 50%
k=4	Drug \leq 75%
k=5	Drug \leq 100%

$$P(y \leq 1 | X) = g(\alpha_1 - \beta X)$$

$$P(y \leq 2 | X) = g(\alpha_2 - \beta X)$$

$$P(y \leq 3 | X) = g(\alpha_3 - \beta X)$$

$$P(y \leq 4 | X) = g(\alpha_4 - \beta X)$$

Ordinal logistic regression

k=1	No drug
k=2	Drug \leq 25%
k=3	Drug \leq 50%
k=4	Drug \leq 75%
k=5	Drug \leq 100%

$$P(y \leq k | X) = g(\alpha_k - \beta X)$$



Inverse link function

Ordinal logistic regression

k=1	No drug
k=2	Drug \leq 25%
k=3	Drug \leq 50%
k=4	Drug \leq 75%
k=5	Drug \leq 100%

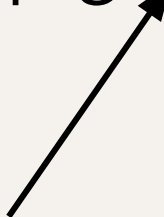
$$P(y \leq k | X) = \frac{1}{1 + e^{-(\alpha_k - \beta X)}}$$

Ordinal logistic regression

k=1	No drug
k=2	Drug \leq 25%
k=3	Drug \leq 50%
k=4	Drug \leq 75%
k=5	Drug \leq 100%

$$P(y \leq k | X) = \frac{1}{1 + e^{-(\alpha_k - \beta X)}}$$

Intercept with respect
to category k



Ordinal logistic regression

k=1	No drug
k=2	Drug \leq 25%
k=3	Drug \leq 50%
k=4	Drug \leq 75%
k=5	Drug \leq 100%

$$P(y \leq k | X) = \frac{1}{1 + e^{-(\alpha_k - \beta X)}}$$

Slopes for each predictor same across equations

Ordinal logistic regression

k=1	No drug
k=2	Drug ≤ 25%
k=3	Drug ≤ 50%
k=4	Drug ≤ 75%
k=5	Drug ≤ 100%

$$P(y \leq k | X) = \frac{1}{1 + e^{-(\alpha_k - \beta X)}}$$

Subtraction!

```
model <- brm_multiple(propofol_outcome_quantile ~ black + asian
  + hispanic + female + age + weight + height + dementia
  + tbi + sud + english + cardiac + med_surg
  + admit_year + medicare + medicaid
  + (1 | stay_id)
  + heart_rate + resp_rate + fio2 + spo2 + sbp + dbp
  + gcs + pao2 + paco2 + time_interval + propofol
  + dexmedetomidine + lorazepam + opioid + vasopressor,
  data=complete_data, family=cumulative(),
```



```
model <- brm_multiple(propofol_outcome_quantile ~ black + asian
  + hispanic + female + age + weight + height + dementia
  + tbi + sud + english + cardiac + med_surg
  + admit_year + medicare + medicaid
  + (1 | stay_id)
  + heart_rate + resp_rate + fio2 + spo2 + sbp + dbp
  + gcs + pao2 + paco2 + time_interval + propofol
  + dexmedetomidine + lorazepam + opioid + vasopressor,
  data=complete_data, family=cumulative(),
```

```
model <- brm_multiple(propofol_outcome_quantile ~ black + asian
  + hispanic + female + age + weight + height + dementia
  + tbi + sud + english + cardiac + med_surg
  + admit_year + medicare + medicaid
  + (1 | stay_id)
  + heart_rate + resp_rate + fio2 + spo2 + sbp + dbp
  + gcs + pao2 + paco2 + time_interval + propofol
  + dexmedetomidine + lorazepam + opioid + vasopressor,
  data=complete_data, family=cumulative(),
```

```
model <- brm_multiple(propofol_outcome_quantile ~ black + asian
  + hispanic + female + age + weight + height + dementia
  + tbi + sud + english + cardiac + med_surg
  + admit_year + medicare + medicaid
  + (1 | stay_id)
  + heart_rate + resp_rate + fio2 + spo2 + sbp + dbp
  + gcs + pao2 + paco2 + time_interval + propofol
  + dexmedetomidine + lorazepam + opioid + vasopressor,
  data=complete_data, family=cumulative(),
```

```
model <- brm_multiple(propofol_outcome_quantile ~ black + asian
  + hispanic + female + age + weight + height + dementia
  + tbi + sud + english + cardiac + med_surg
  + admit_year + medicare + medicaid
  + (1 | stay_id)
  + heart_rate + resp_rate + fio2 + spo2 + sbp + dbp
  + gcs + pao2 + paco2 + time_interval + propofol
  + dexmedetomidine + lorazepam + opioid + vasopressor,
  data=complete_data, family=cumulative(),
```

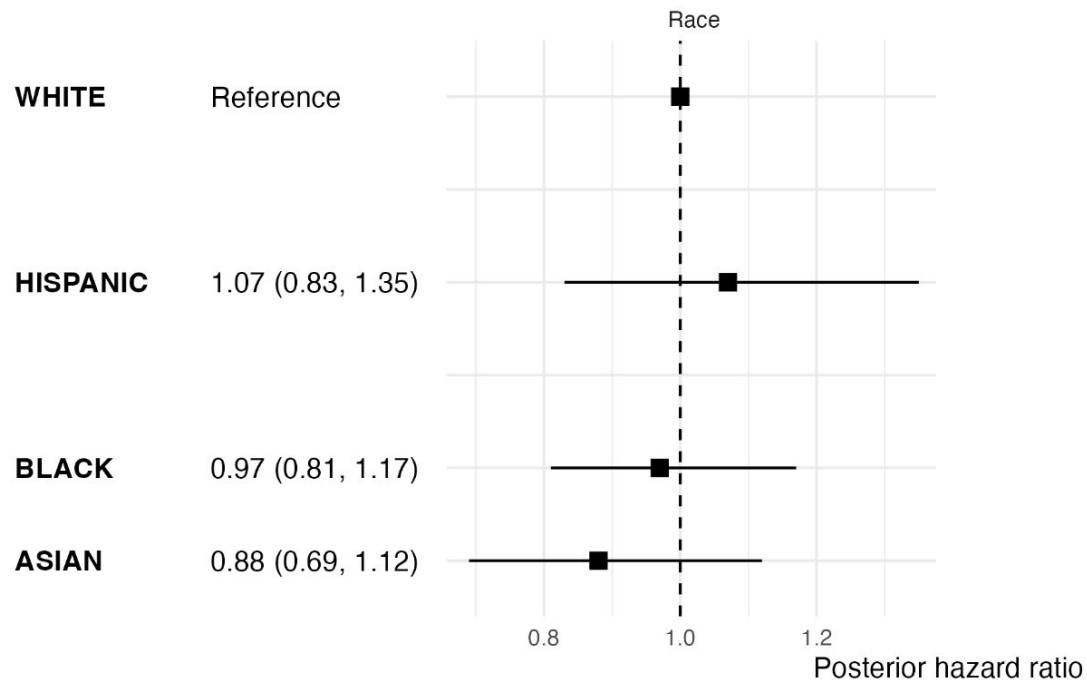
```
model <- brm_multiple(propofol_outcome_quantile ~ black + asian
  + hispanic + female + age + weight + height + dementia
  + tbi + sud + english + cardiac + med_surg
  + admit_year + medicare + medicaid
  + (1 | stay_id)
  + heart_rate + resp_rate + fio2 + spo2 + sbp + dbp
  + gcs + pao2 + paco2 + time_interval + propofol
  + dexmedetomidine + lorazepam + opioid + vasopressor,
  data=complete_data, family=cumulative(),
```

```
model <- brm_multiple(propofol_outcome_quantile ~ black + asian
  + hispanic + female + age + weight + height + dementia
  + tbi + sud + english + cardiac + med_surg
  + admit_year + medicare + medicaid
  + (1 | stay_id)
  + heart_rate + resp_rate + fio2 + spo2 + sbp + dbp
  + gcs + pao2 + paco2 + time_interval + propofol
  + dexmedetomidine + lorazepam + opioid + vasopressor,
  data=complete_data, family=cumulative())
```

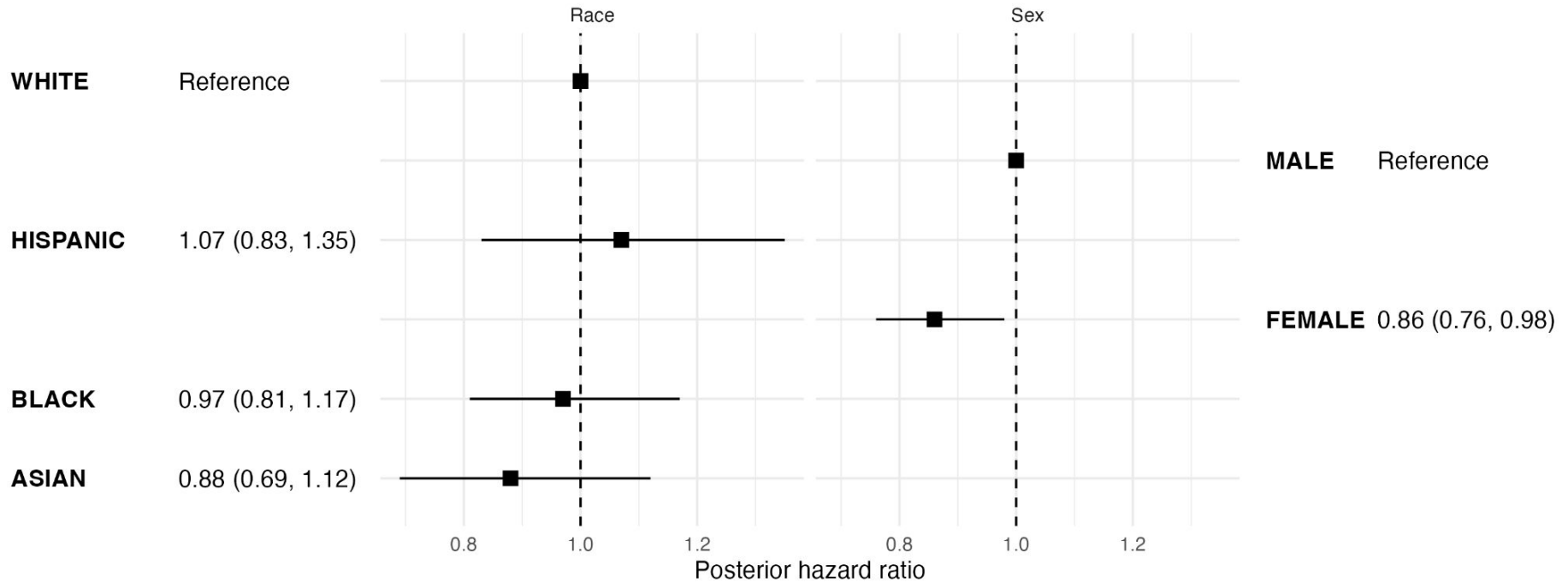
Preliminary Results



Preliminary Results



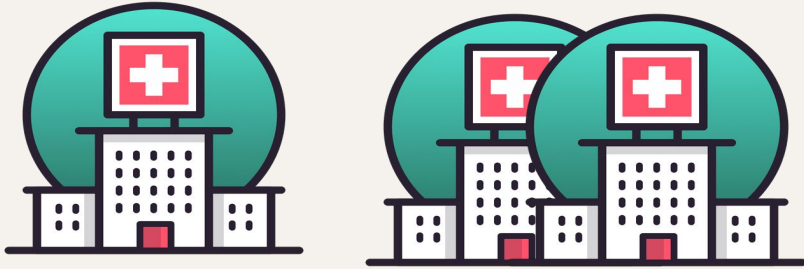
Preliminary Results



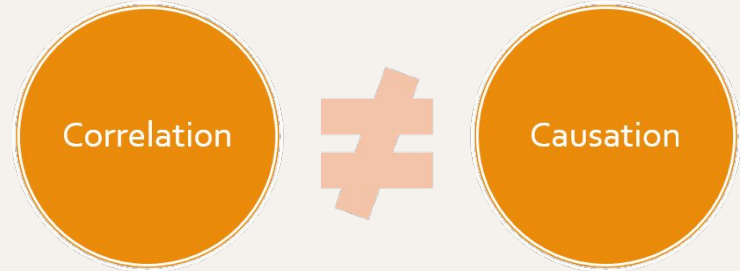
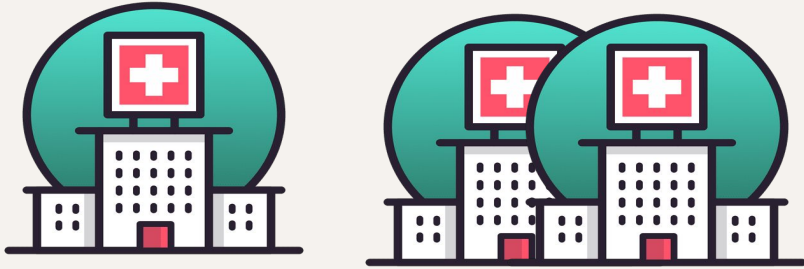
Limitations



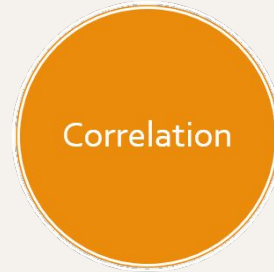
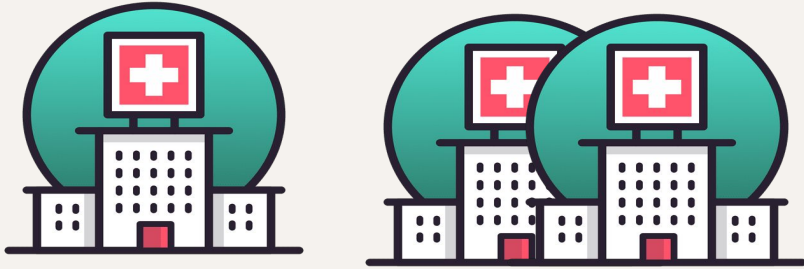
Limitations



Limitations



Limitations



In Conclusion



Importance

Learning where race
and sex biases affect
patient care is
important to improve
healthcare

In Conclusion



Importance

Learning where race and sex biases affect patient care is important to improve healthcare



Approach

Multilevel modeling can be a useful tool in modeling real world data!

In Conclusion



Importance

Learning where race and sex biases affect patient care is important to improve healthcare



Approach

Multilevel modeling can be a useful tool in modeling real world data!



Results

So far it appears that there are associations between race and sex and use of sedation, but further analysis needed!

In Conclusion



Importance

Learning where race and sex biases affect patient care is important to improve healthcare



Approach

Multilevel modeling can be a useful tool in modeling real world data!



Results

So far it appears that there are associations between race and sex and use of sedation, but further analysis needed!

Contact: sarahl.walker@mail.utoronto.ca

References

1. Peitz GJ, Balas MC, Olsen KM, Pun BT, Ely EW. Top 10 myths regarding sedation and delirium in the ICU. *Crit Care Med*. 2013 Sep;41(9 Suppl 1):S46-56. doi: 10.1097/CCM.0b013e3182a168f5. PMID: 23989095
2. Reade MC, Finfer S. Sedation and Delirium in the Intensive Care Unit. *New England Journal of Medicine*. 2014;370(5):444-454. doi:10.1056/NEJMra1208705
3. Lewis K, Alshamsi F, Carayannopoulos KL, et al. Dexmedetomidine vs other sedatives in critically ill mechanically ventilated adults: a systematic review and meta-analysis of randomized trials. *Intensive Care Med*. 2022;48(7):811-840. doi:10.1007/s00134-022-06712-2
4. Ho KM, Ng JY. The use of propofol for medium and long-term sedation in critically ill adult patients: a meta-analysis. *Intensive Care Med*. 2008;34(11):1969-1979. doi:10.1007/s00134-008-1186-5
5. Sjoding MW, Dickson RP, Iwashyna TJ, Gay SE, Valley TS. Racial Bias in Pulse Oximetry Measurement. *N Engl J Med*. 2020;383(25):2477-2478. doi:10.1056/NEJMc2029240
6. Fowler RA, Sabur N, Li P, et al. Sex-and age-based differences in the delivery and outcomes of critical care. *CMAJ*. 2007;177(12):1513-1519. doi:10.1503/cmaj.071112
7. Jia Z, Leiter RE, Sanders JJ, et al. Asian American Medicare Beneficiaries Disproportionately Receive Invasive Mechanical Ventilation When Hospitalized at the End-of-Life. *J GEN INTERN MED*. 2022;37(4):737-744. doi:10.1007/s11606-021-06794-6

References

8. Parcha V, Kalra R, Bhatt SP, Berra L, Arora G, Arora P. Trends and Geographic Variation in Acute Respiratory Failure and ARDS Mortality in the United States. *Chest*. 2021;159(4):1460-1472. doi:10.1016/j.chest.2020.10.042
9. Erickson SE, Shlipak MG, Martin GS, et al. Racial and ethnic disparities in mortality from acute lung injury. *Crit Care Med*. 2009;37(1):1-6. doi:10.1097/CCM.0b013e31819292ea
10. Bime C, Poongkunran C, Borgstrom M, et al. Racial Differences in Mortality from Severe Acute Respiratory Failure in the United States, 2008–2012. *Annals ATS*. 2016;13(12):2184-2189. doi:10.1513/AnnalsATS.201605-359OC
11. Erickson SE, Vasilevskis EE, Kuzniewicz MW, et al. The effect of race and ethnicity on outcomes among patients in the intensive care unit: a comprehensive study involving socioeconomic status and resuscitation preferences. *Crit Care Med*. 2011;39(3):429-435. doi:10.1097/CCM.0b013e318206b3af
12. Chesley CF, Chowdhury M, Small DS, et al. Racial Disparities in Length of Stay Among Severely Ill Patients Presenting With Sepsis and Acute Respiratory Failure. *JAMA Network Open*. 2023;6(5):e239739. doi:10.1001/jamanetworkopen.2023.9739
13. Swart P, Nijbroek SGLH, Paulus F, Neto AS, Schultz MJ. Sex Differences in Use of Low Tidal Volume Ventilation in COVID-19—Insights From the PROVENT–COVID Study. *Frontiers in Medicine*. 2022;8. Accessed June 26, 2023. <https://www.frontiersin.org/articles/10.3389/fmed.2021.780005>

References

14. Johnson, A., Bulgarelli, L., Pollard, T., Horng, S., Celi, L. A., & Mark, R. (2023). MIMIC-IV (version 2.2). *PhysioNet*. <https://doi.org/10.13026/6mm1-ek67>.
15. Johnson, A.E.W., Bulgarelli, L., Shen, L. *et al.* MIMIC-IV, a freely accessible electronic health record dataset. *Sci Data* 10, 1 (2023). <https://doi.org/10.1038/s41597-022-01899-x>