



# Deep dive into clinical data

HST.956/6.S897

Feb 12, 2019

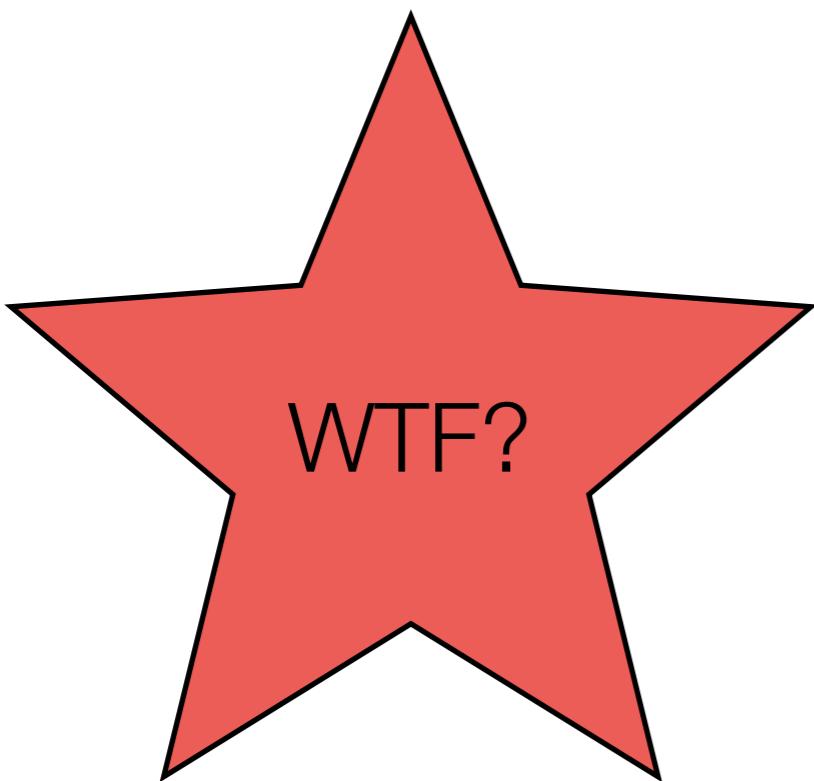


Massachusetts  
Institute of  
Technology

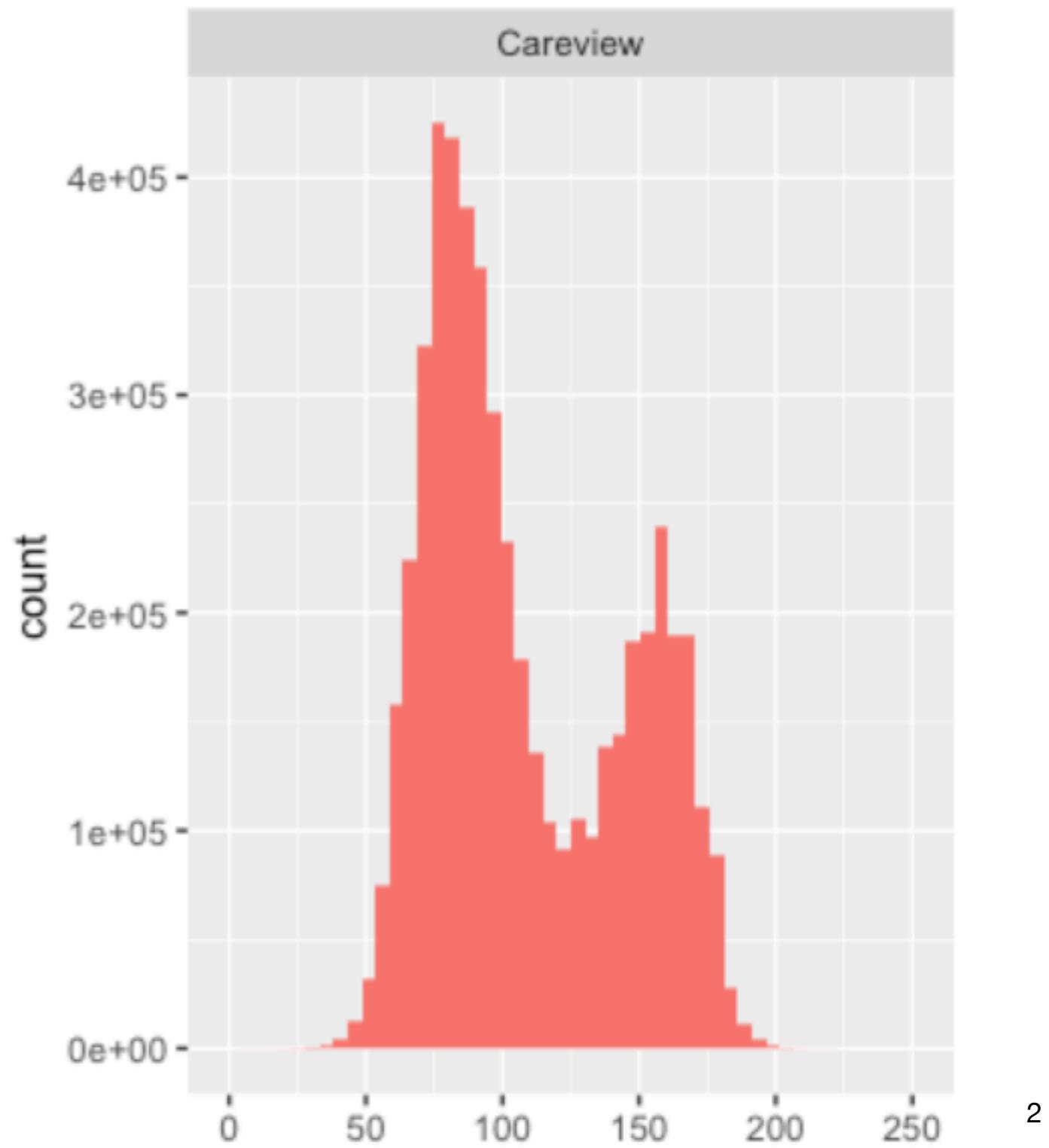
# Understanding clinical data

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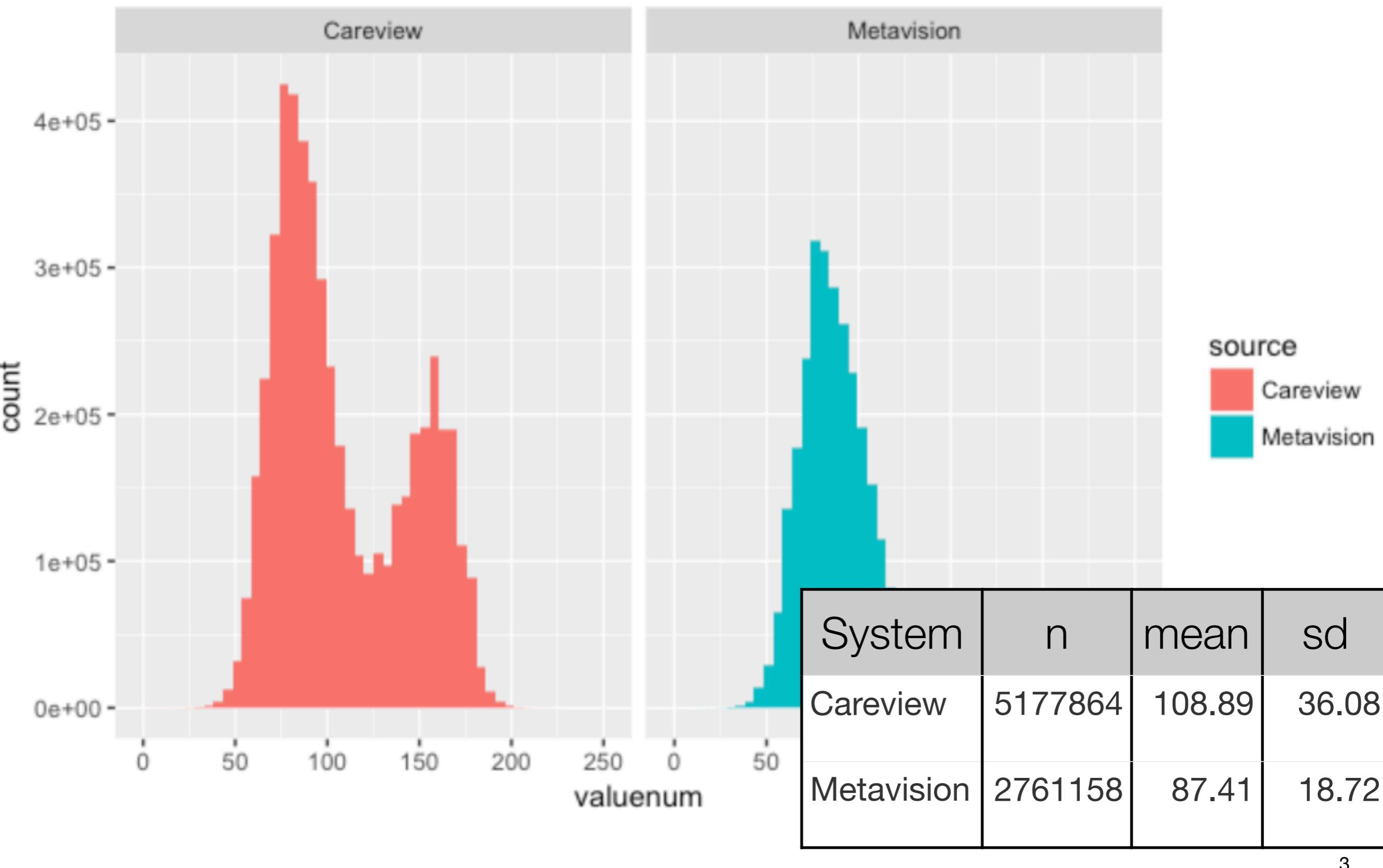
- Consider the distribution of heart rates in the MIMIC-III chart (as recorded in Careview)



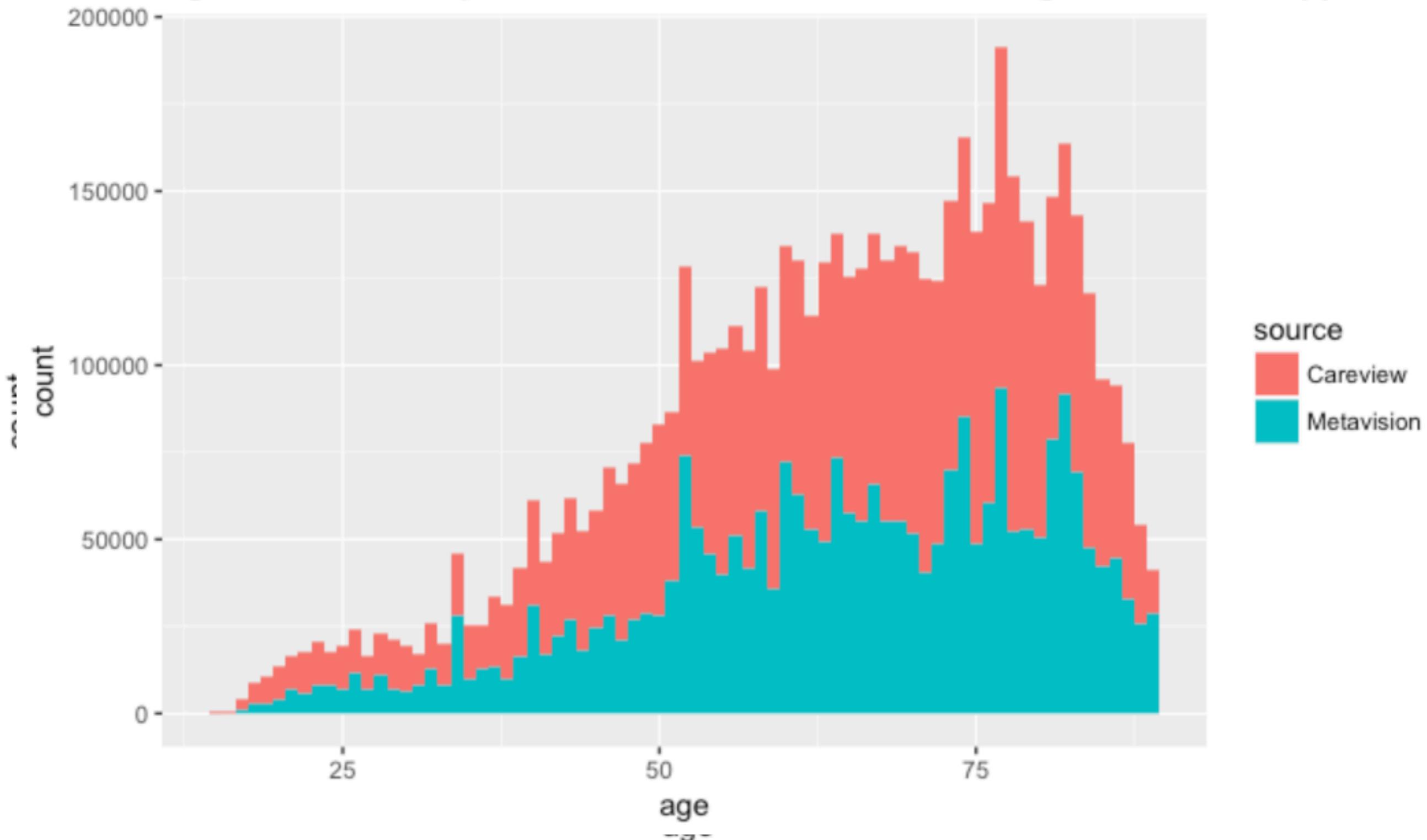
Data from <https://mimic.physionet.org>



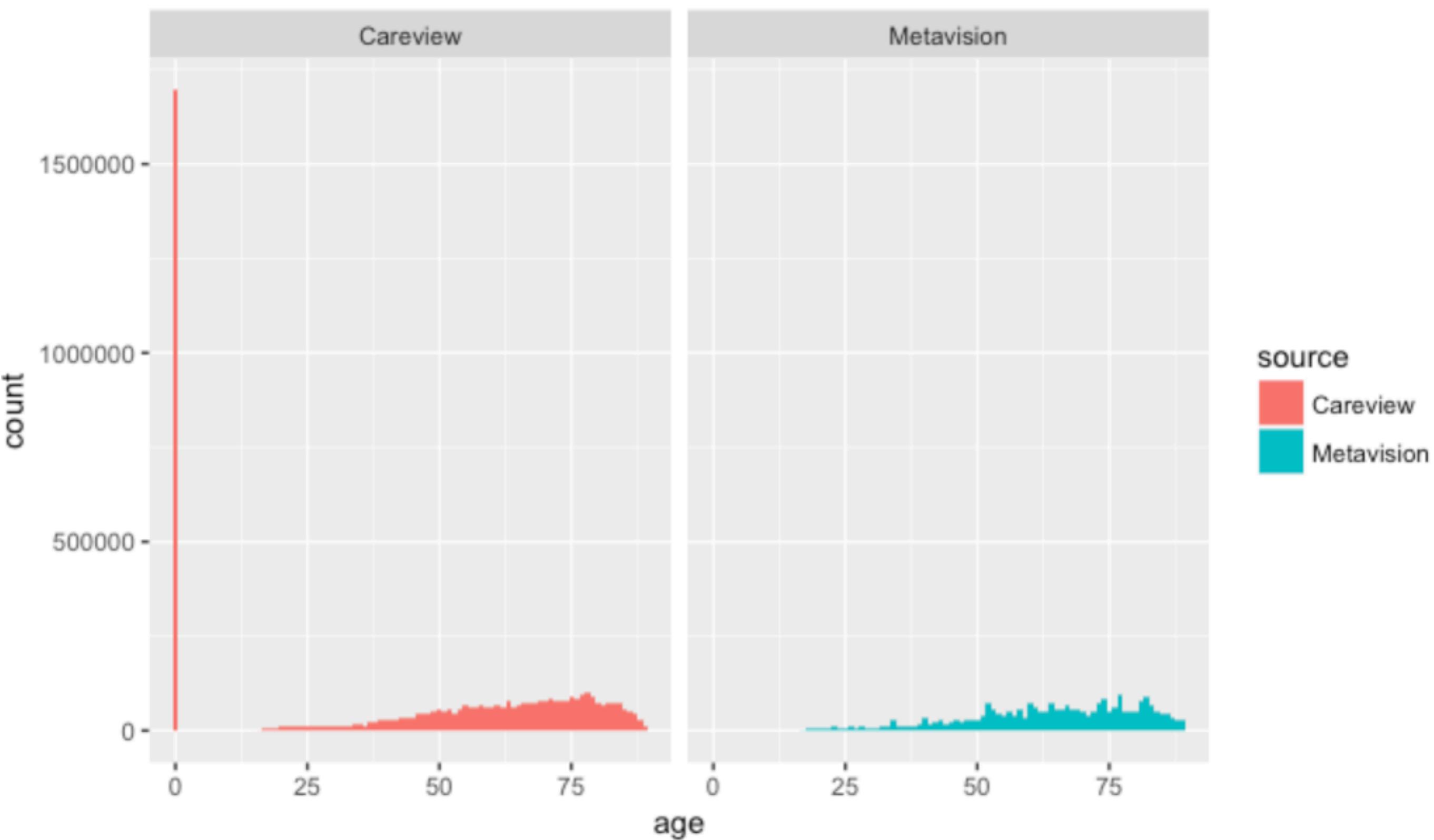
## Comparison of Careview and Metavision heart rates, outliers removed



## Age distribution of patients with recorded heart rates, age $\geq$ 90 or <1 suppressed



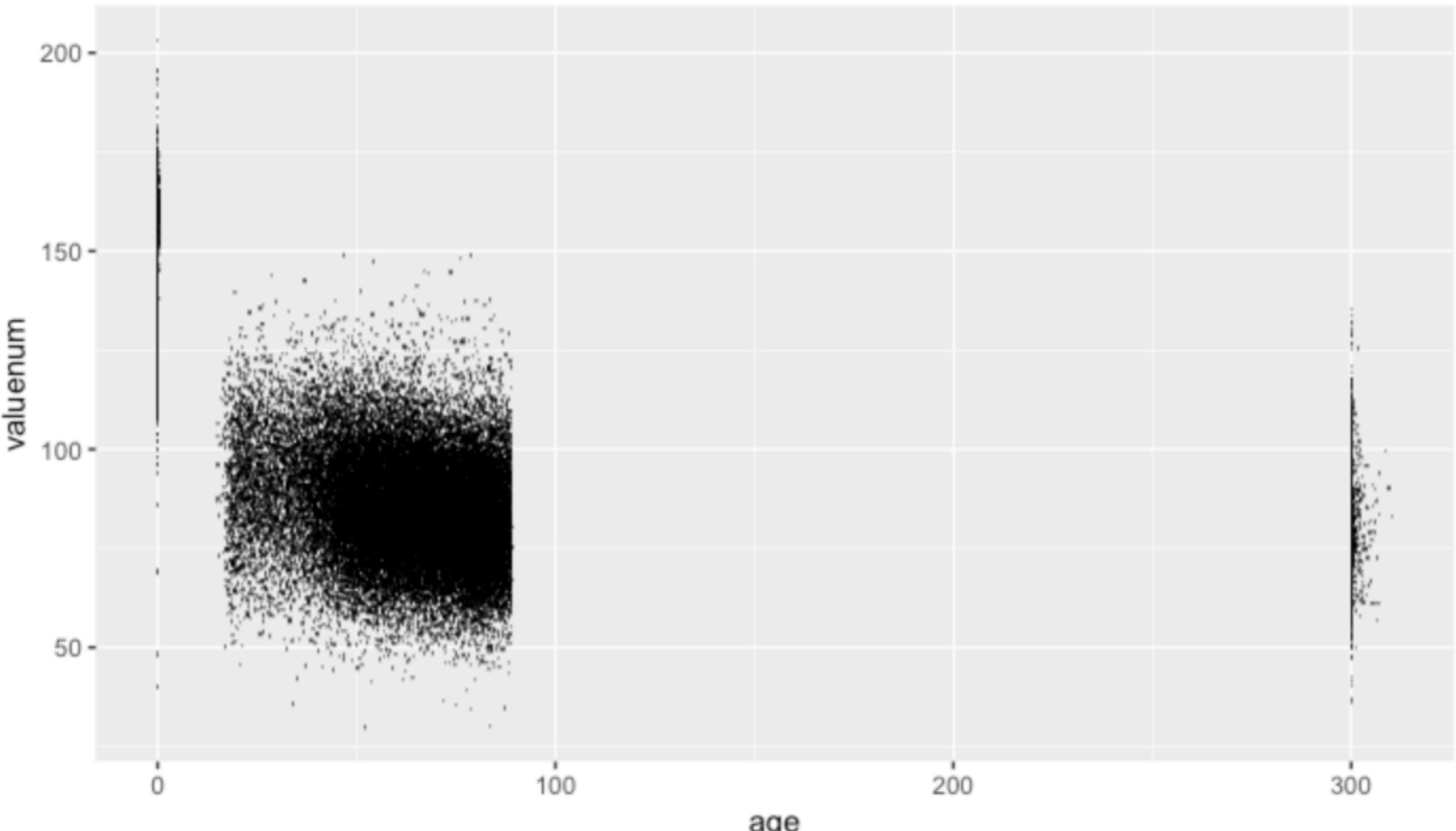
## Age distribution of patients with recorded heart rates, age $\geq 90$ suppressed



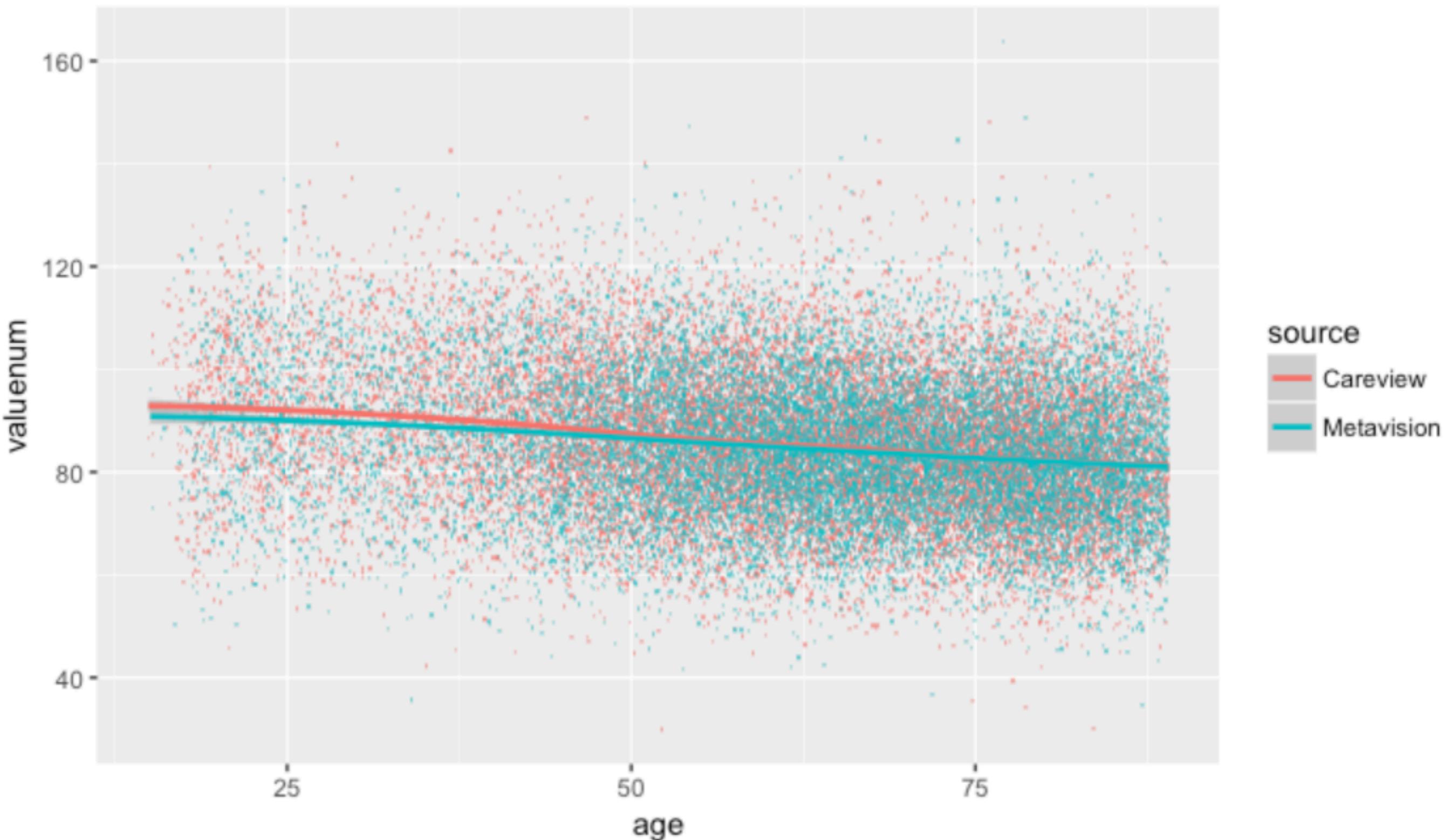
# Is Age a confounder for Heart Rate?

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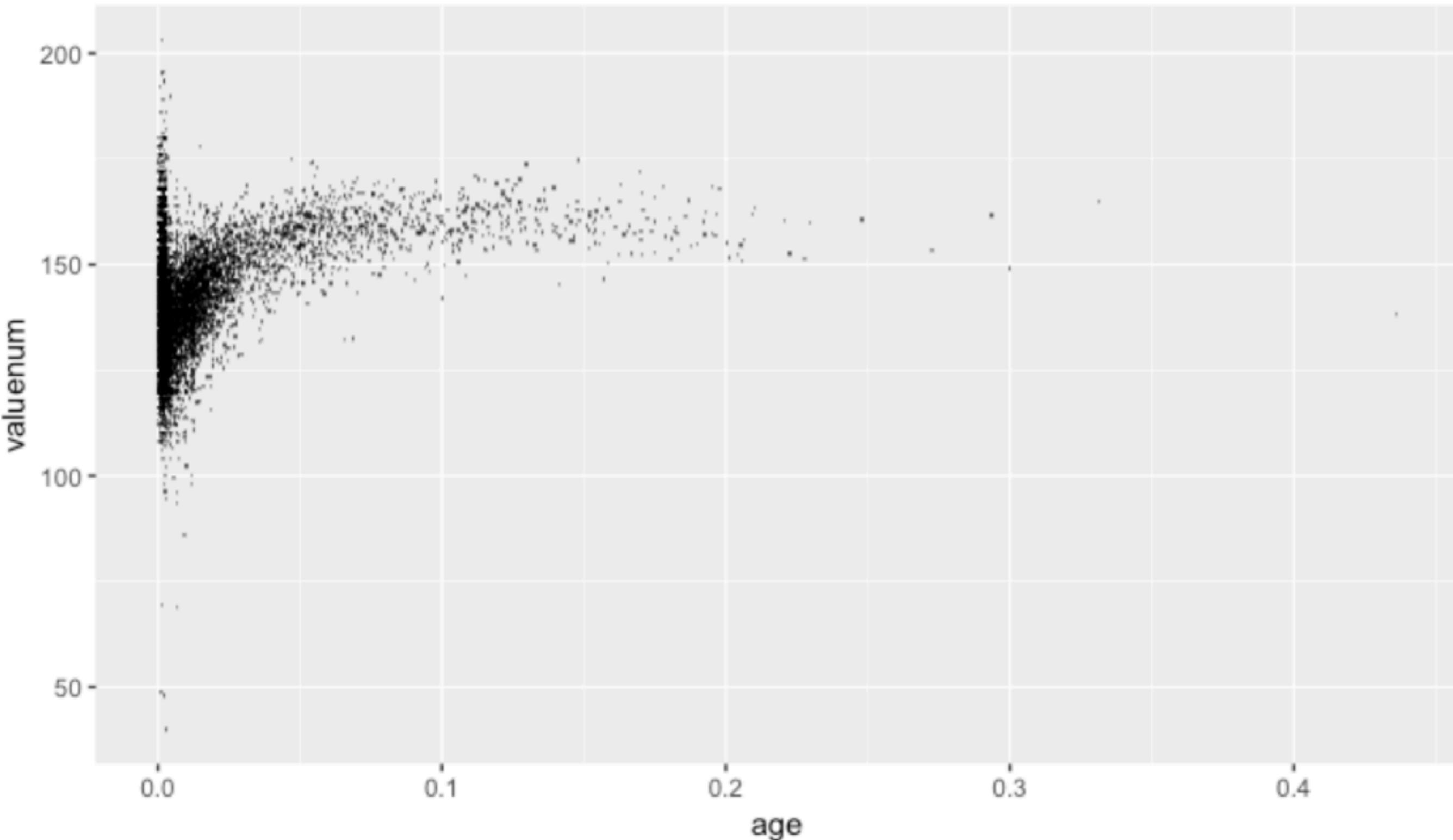
HR vs. Age in entire population



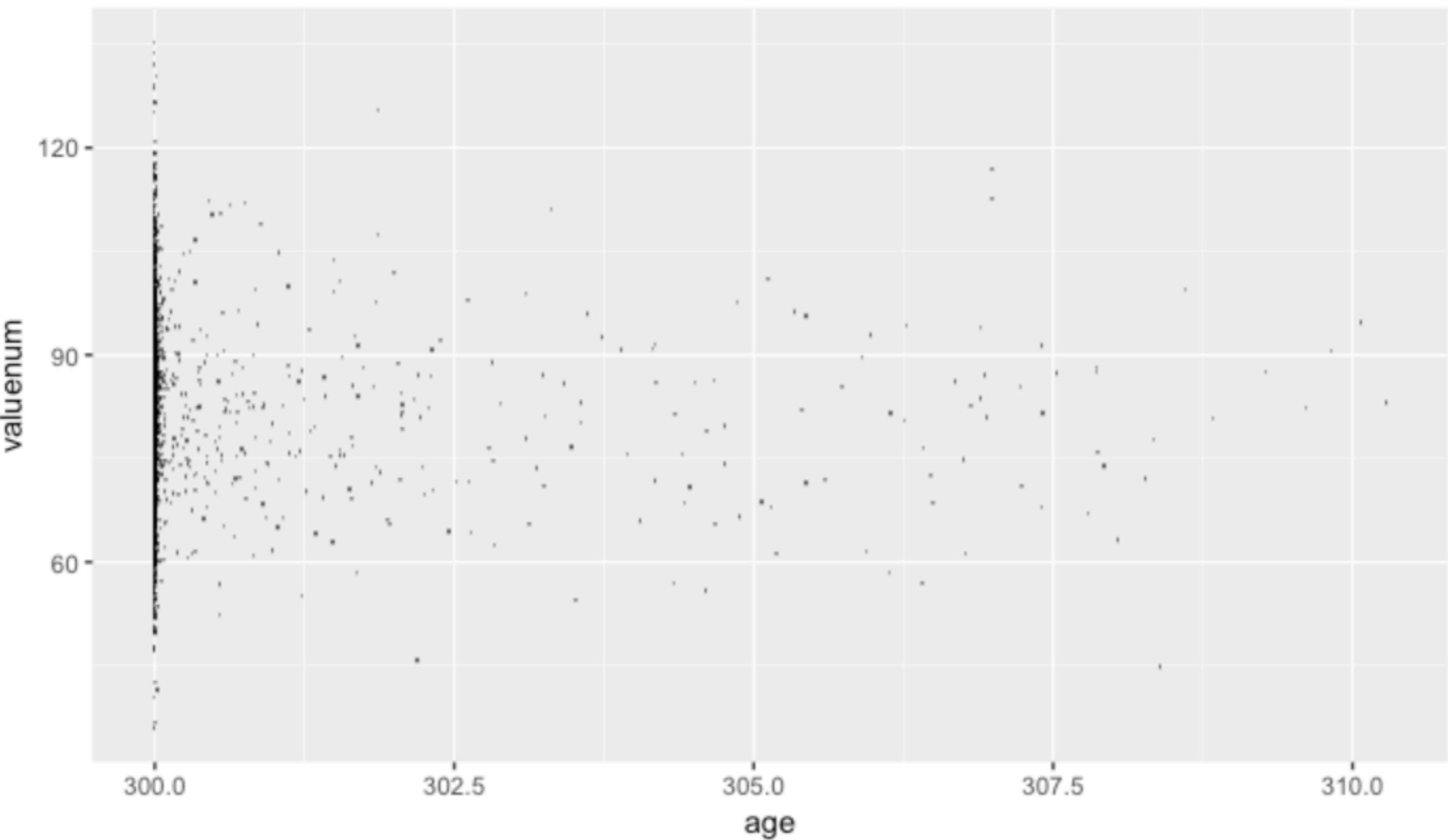
## HR vs. Age in adults, smoothed



## HR vs. Age in neonates



## HR vs. Age in patients over 90



# Types of Data

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- Demographics
  - Age, sex, socio-economic status, insurance type, language, religion, living situation, family structure, location, work, ...
- Vital signs
  - Weight, height, pulse, respiration rate, body temperature, ...
- Medications
  - Prescriptions, over-the-counter drugs, illegal drugs, alcohol, ...
  - Medication reconciliation
- Laboratory
  - Components of blood, urine, stool, saliva, spinal fluid (CSF), ascitic fluid, joint fluid, bone marrow, lung, ...
- Pathology
  - Qualitative and quantitative examination of any body tissue, e.g., biopsy samples, surgical “scraps”
  - Cell-level measurements, e.g., cell-surface antigens

# Types of Data (continued)

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- Microbiology — organisms grown, typically from cultures
  - Testing sensitivity to various antibiotics, at various dilutions
- Notes
  - Discharge summary
  - Attending and/or Resident
  - Nurse
  - Specialist
    - Radiology, Pathology, ECG, Nutrition, Respiratory, Social work, ...
  - Consultant
  - Referring physician
  - Emergency Department

# Types of Data (continued)

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- Billing
  - Diagnoses (ICD-{9, 10})
  - Procedures (CPT and ICD)
  - Diagnosis Related Groups (DRG) [~ abstraction of ICD]
- Administrative
  - Service
  - Transfers

# Types of Data (continued)

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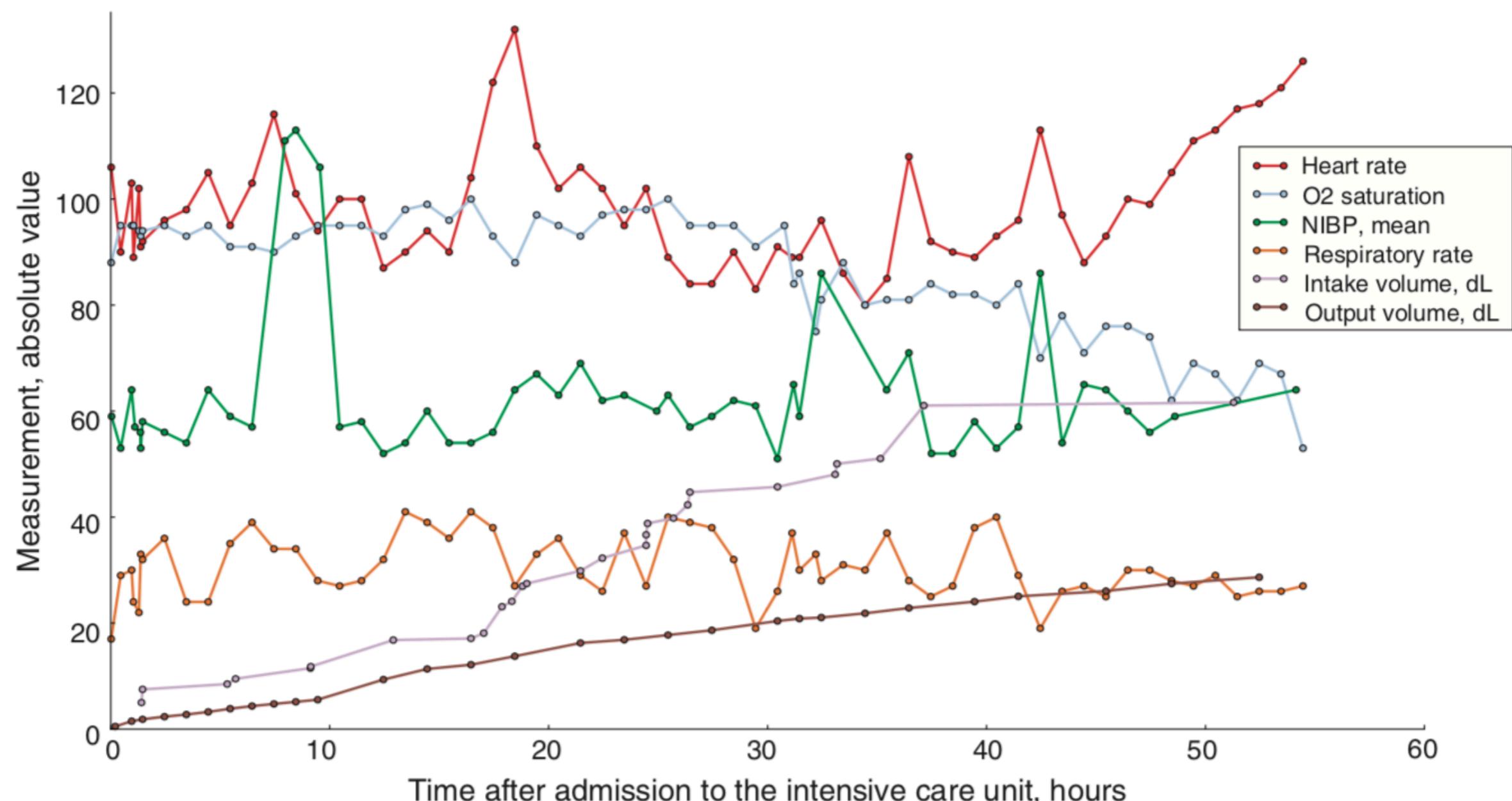
- Imaging
  - X-ray
  - Ultrasound
  - CT
  - MRI
  - PET
  - Retinal
  - Endoscopy
  - Photographs

# Types of Data (continued)

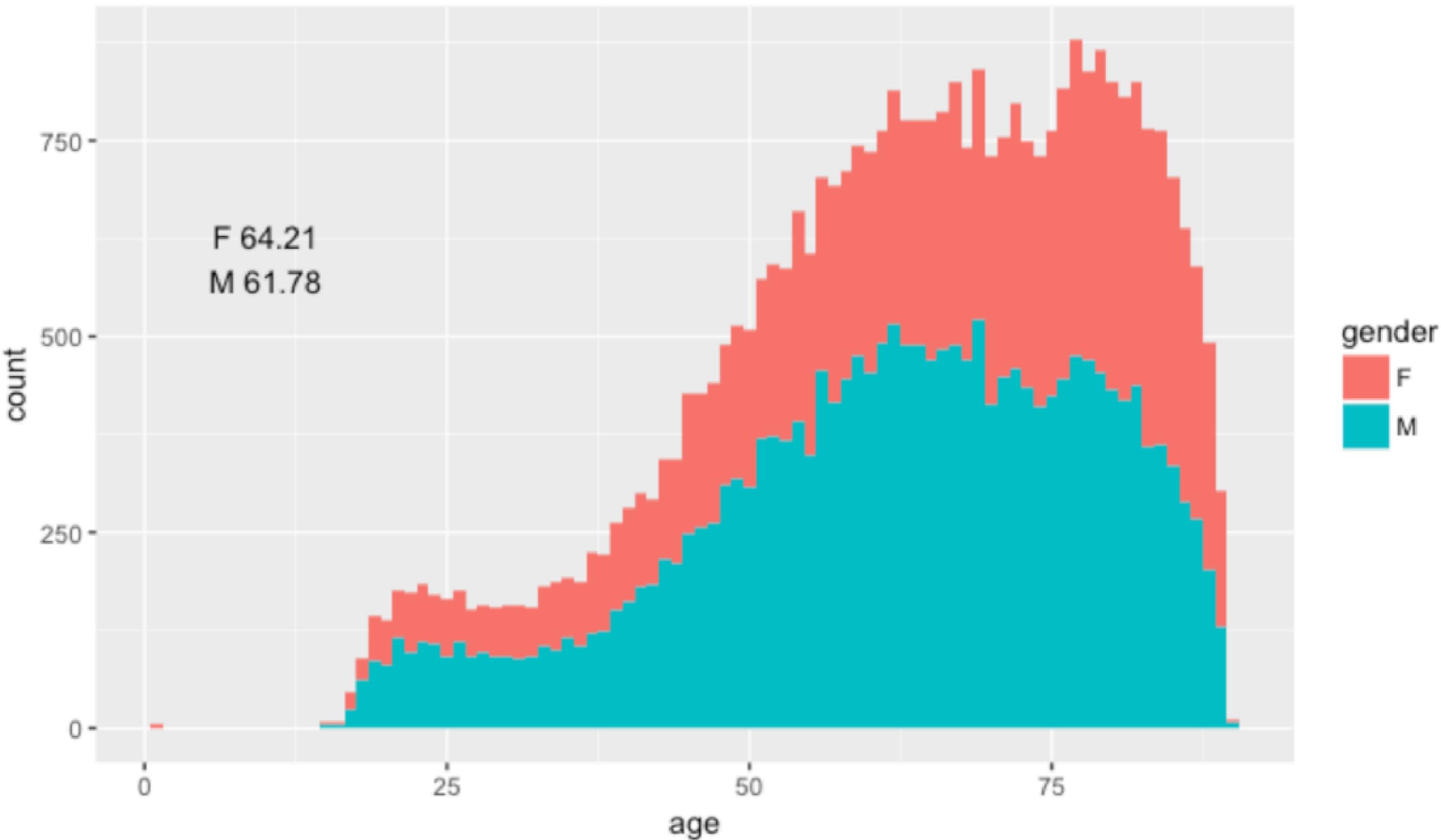
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- Quantified Self
  - Activity
    - Steps
    - Elevation change
    - Workouts
  - Vitals
    - Heart rate
    - Respiration rate
    - Temperature
    - Blood pressure
    - Weight
  - Diet
  - Blood sugar
  - Allergies
- Mindfulness
- Mood
- Sleep
- Pain
- Sex
- “N-of-1 experiments”
- Growing availability of home health measurements

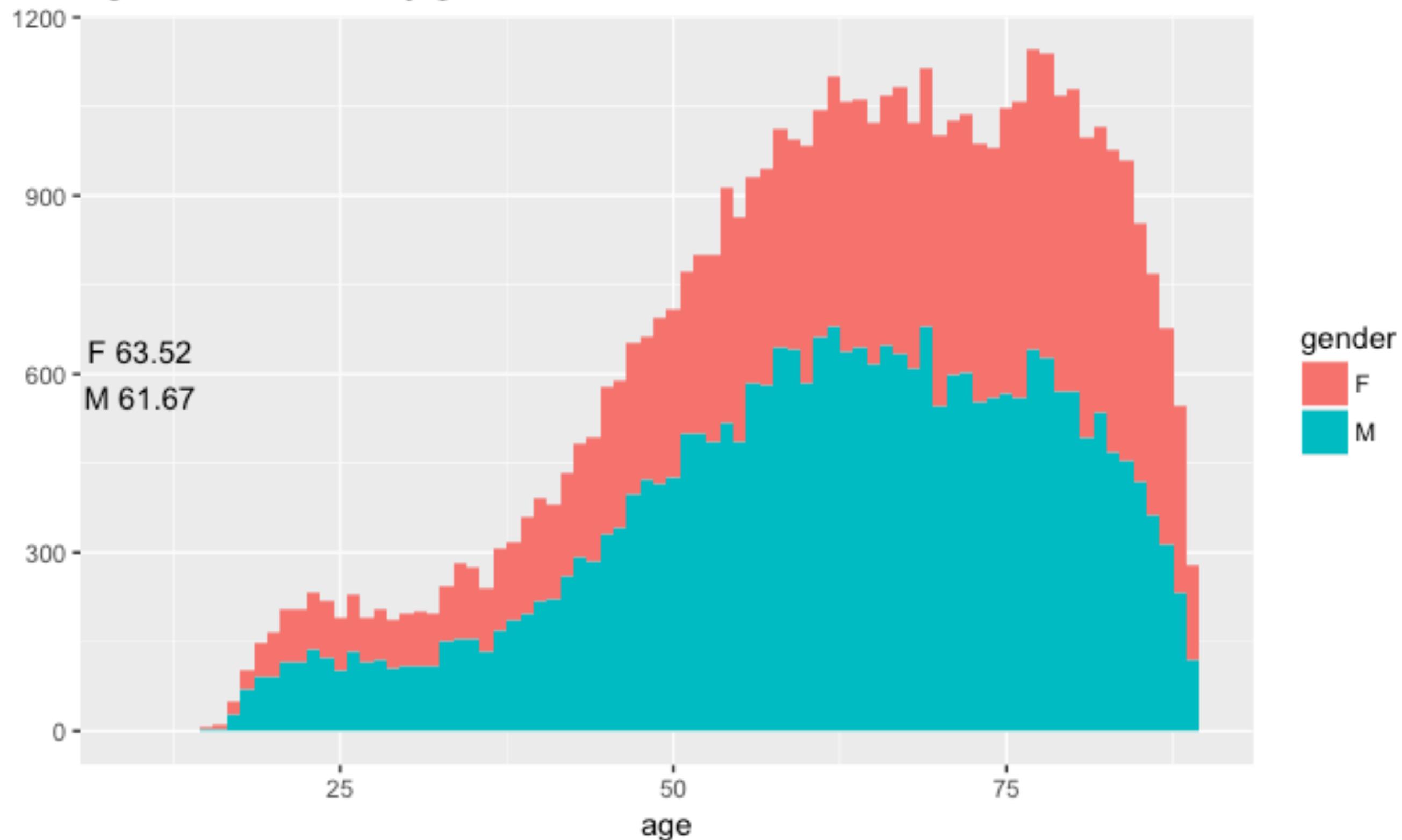
Code status	Full code						Comfort measures
GCS: Verbal	Oriented	Oriented	Oriented	Confused	Confused	Incomprehensible sounds	
GCS: Motor	Obeys commands	Flex-withdraws					
GCS: Eye	Spontaneously	Spontaneously	Spontaneously	To speech	To speech	None	
Platelet, K/uL	48	53	46			45	
Creatinine, mg/dL	0.7		0.7			0.8	
White blood cell, K/uL	9.1	12.4	16.8			23.2	
Neutrophil, %	37						
Morphine Sulfate							
Vancomycin (1 dose)							
Piperacillin (1 dose)							
NaCl 0.9%							
Amiodarone							
Dextrose 5%							



## Ages at time of last lab measurement



## Age at admission, by gender

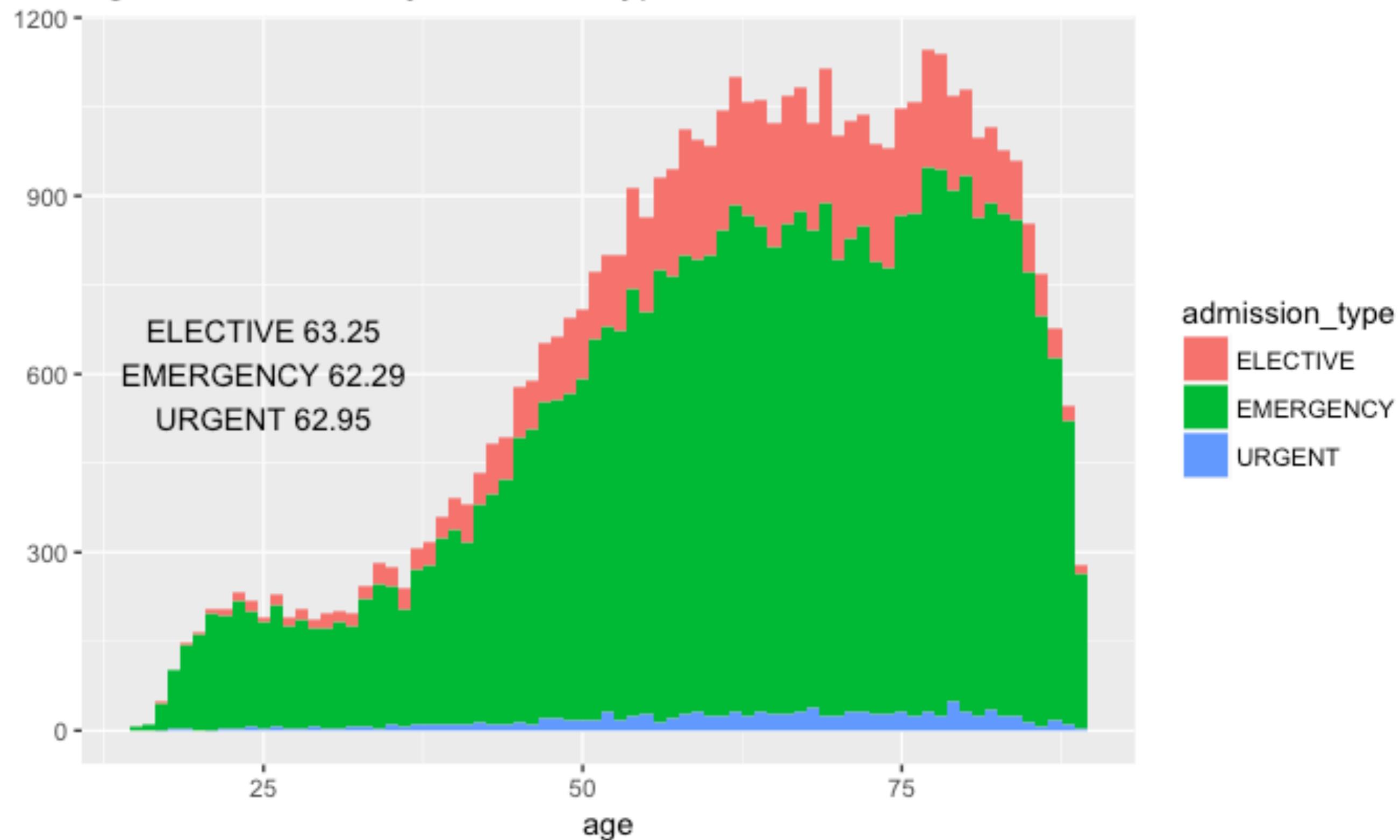


# Demographics

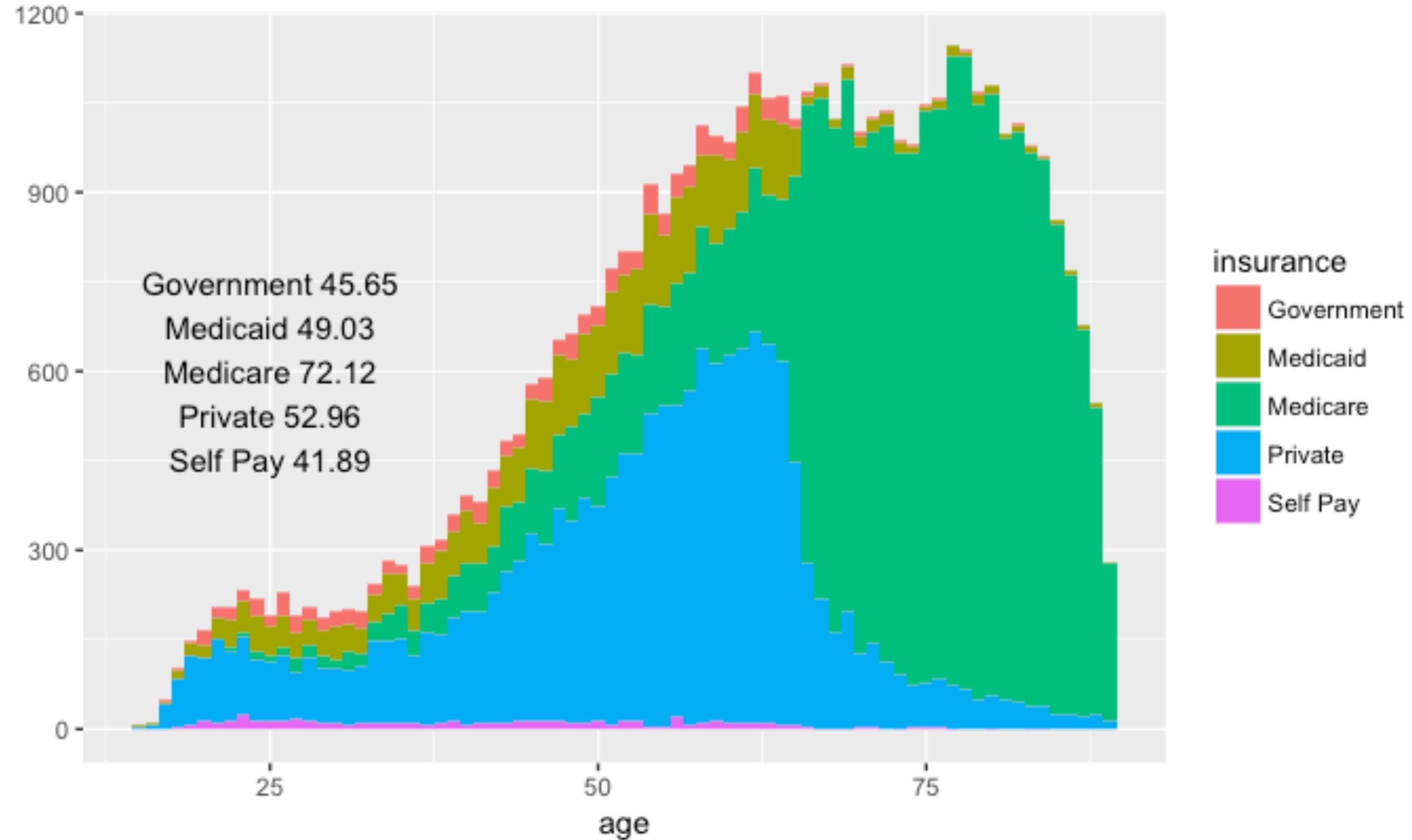
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- Consider how the age distribution changes by
  - gender
  - type of admission
  - type of insurance
  - source of admission
  - whether they die during the admission
  - native language
  - ethnicity
  - marital status

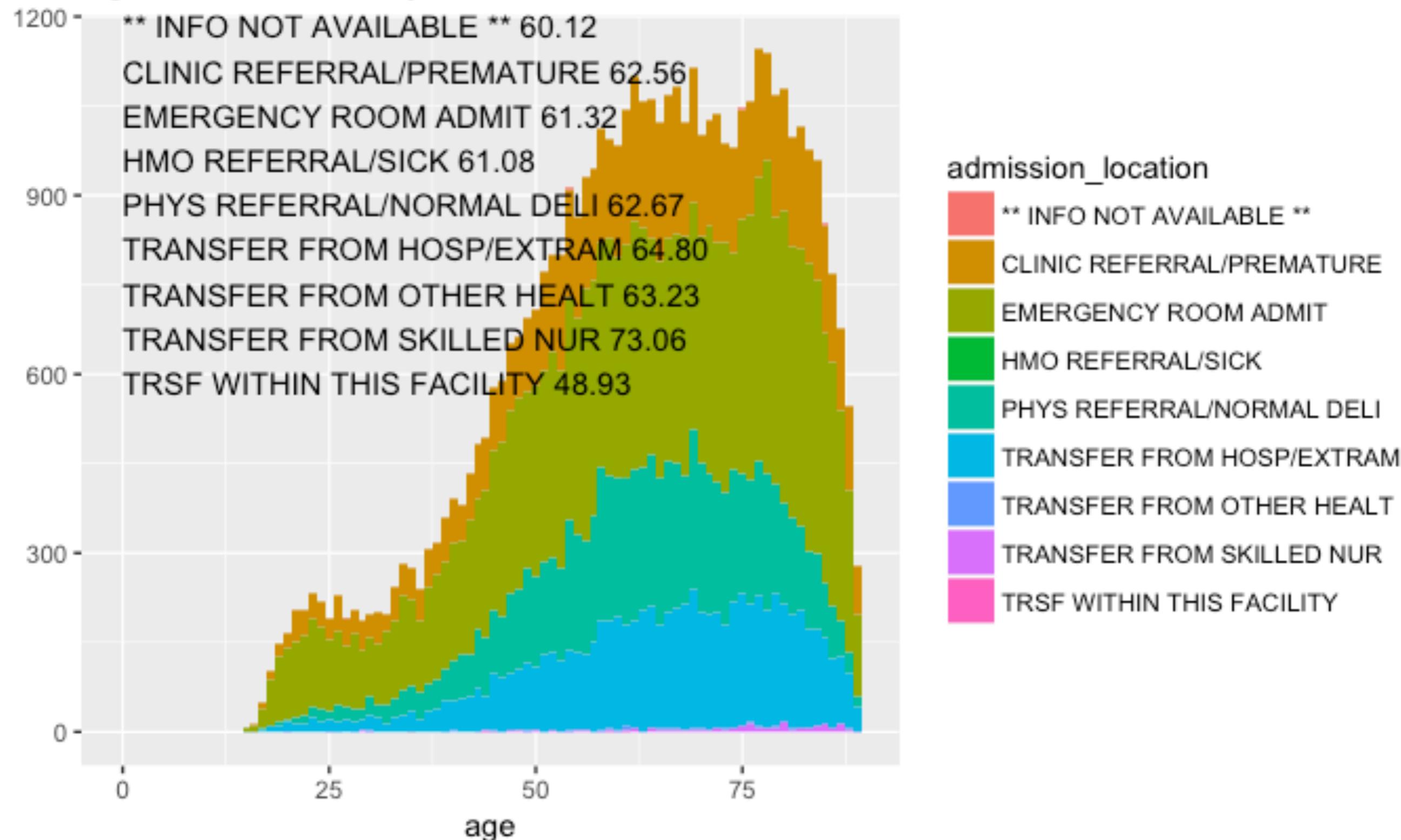
## Age at admission, by admission type



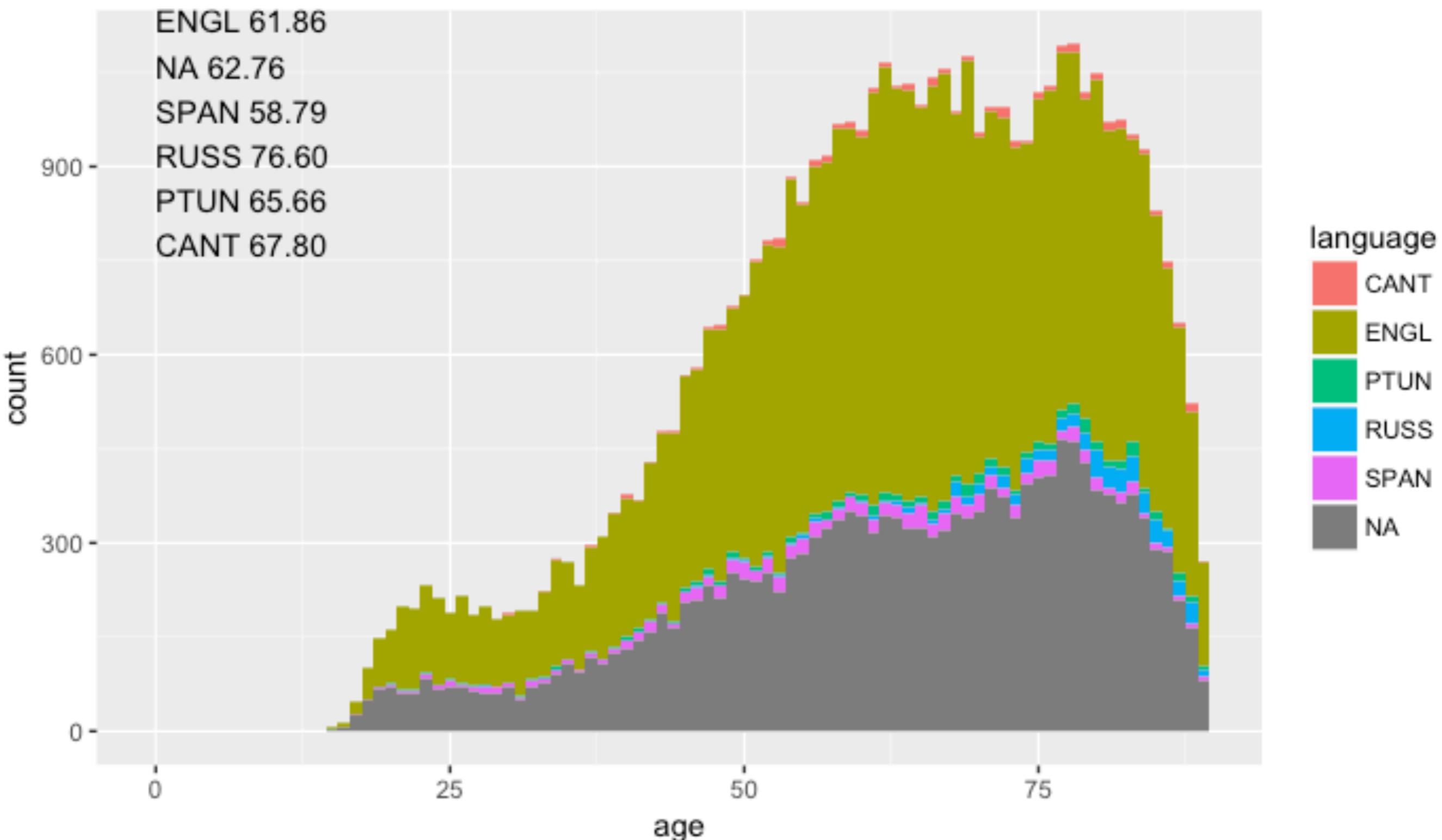
## Age at admission, by insurance type



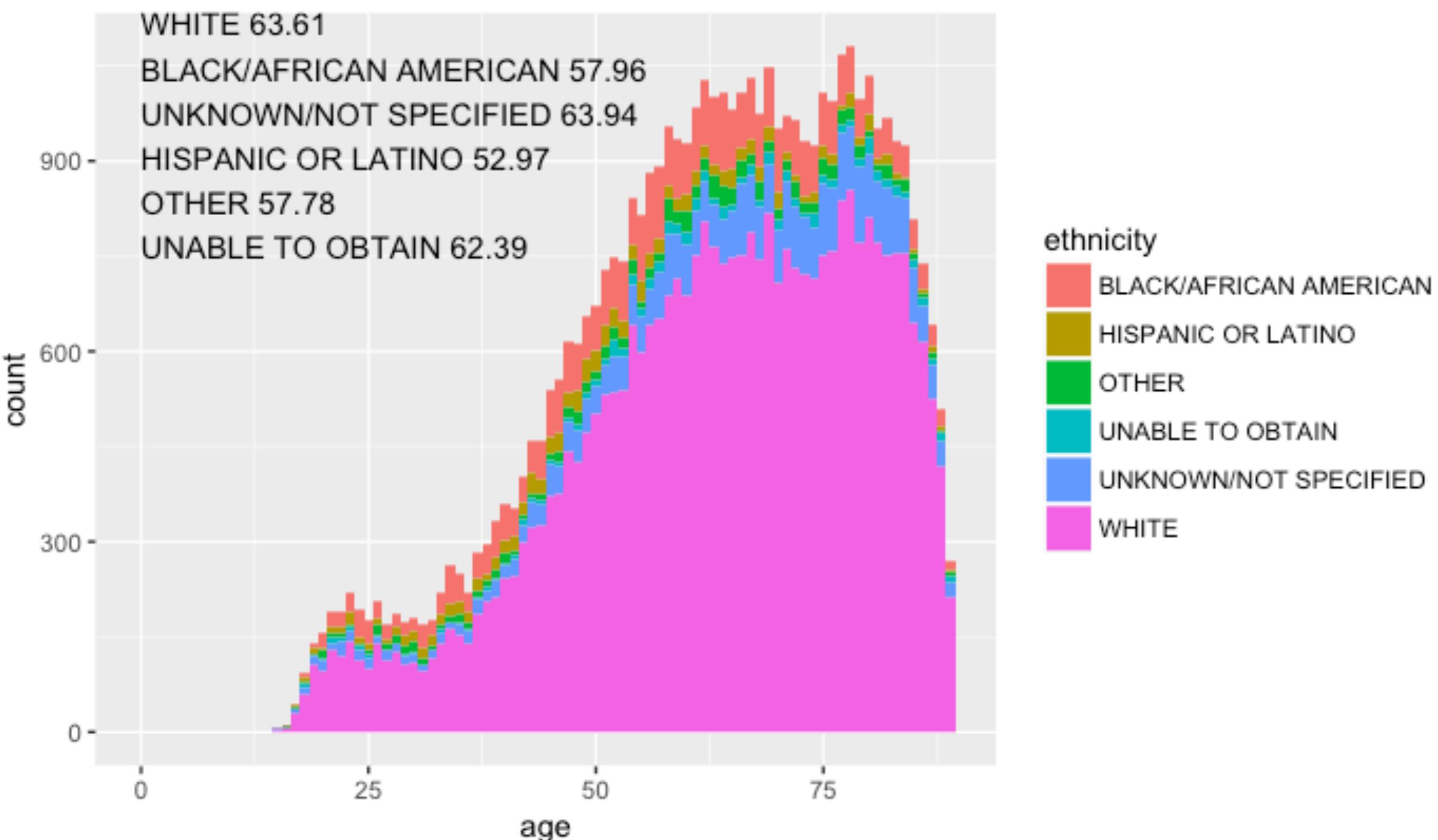
## Age at admission, by source of admission



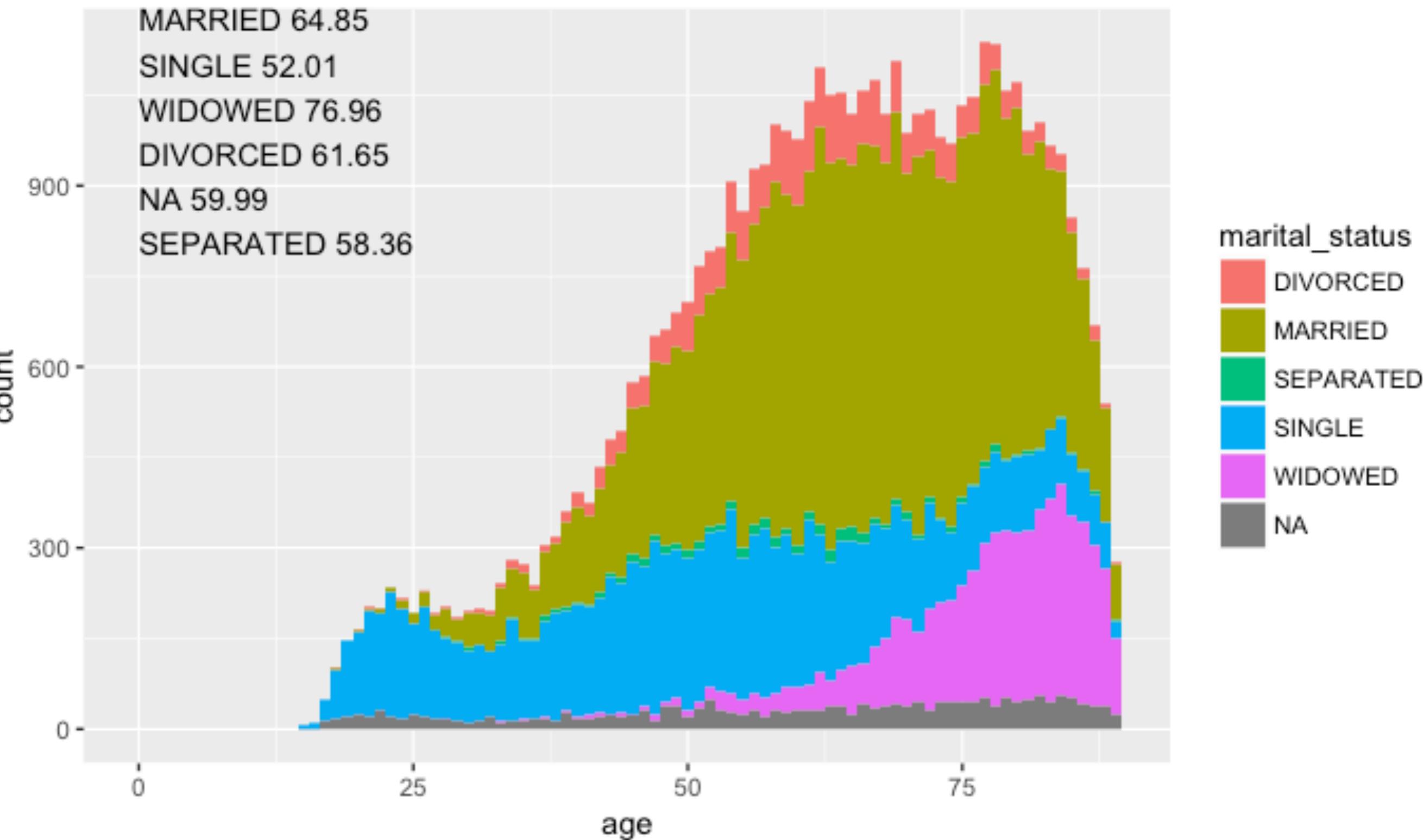
## Age at admission, by language



## Age at admission, by ethnicity



## Age at admission, by marital status



# How do demographics influence in-hospital mortality?

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```
glm(formula = hospital_expire_flag ~ age + ethnicity + marital_status +
language, family = "binomial", data = data)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.1146	-0.4583	-0.3812	-0.3054	2.8384

Coefficients:

	Estimate	Std. Error	z value	Pr(> z )
(Intercept)	-3.107213	0.651502	-4.769	1.85e-06 ***
age	0.031763	0.001774	17.901	< 2e-16 ***
ethnicityHISPANIC OR LATINO	-0.013091	0.196425	-0.067	0.946863
ethnicityOTHER	-0.016074	0.186942	-0.086	0.931477
ethnicityUNABLE TO OBTAIN	0.803709	0.151518	5.304	1.13e-07 ***
ethnicityUNKNOWN/NOT SPECIFIED	0.562160	0.159312	3.529	0.000418 ***
ethnicityWHITE	0.041665	0.079084	0.527	0.598298
marital_statusMARRIED	-0.009904	0.088537	-0.112	0.910929
marital_statusSEPARATED	0.224446	0.213855	1.050	0.293935
marital_statusSINGLE	0.009709	0.094831	0.102	0.918449
marital_statusWIDOWED	-0.113735	0.102765	-1.107	0.268403
languageENGL	-1.487467	0.630198	-2.360	0.018259 *
languagePTUN	-0.754769	0.640661	-1.178	0.238753
languageRUSS	-1.210058	0.642498	-1.883	0.059651 .
languageSPAN	-1.311704	0.657075	-1.996	0.045904 *
---				

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 15330 on 27223 degrees of freedom

Residual deviance: 14792 on 27209 degrees of freedom

(17028 observations deleted due to missingness)

AIC: 14822

# Standards

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- “The wonderful thing about standards is that there are so many to choose from!”
- For example, consider prescriptions in MIMIC

# Two Prescription

SUBJECT_ID	57139	57139
HADM_ID	155470	155470
ICUSTAY_ID	NA	NA
STARTDATE	2185-12-07	2185-12-07
ENDDATE	2185-12-07	2185-12-23
DRUG_TYPE	MAIN	MAIN
DRUG	Acetaminophen	Clobetasol Propionate 0.05%Cream
DRUG_NAME_POE	Acetaminophen	Clobetasol Propionate 0.05%Cream
DRUG_NAME_GENERIC	Acetaminophen	Clobetasol Propionate 0.05%Cream
FORMULARY_DRUG_CD	ACET325	CLOB.05C30
GSN	4489	7634
NDC	182844789	472040030
PROD_STRENGTH	325mg Tablet	30gm Tube
DOSE_VAL_RX	325-650	1
DOSE_UNIT_RX	mg	Appl
FORM_VAL_DISP	1-2	0.01
FORM_UNIT_DISP	TAB	TUBE
ROUTE	PO	TP

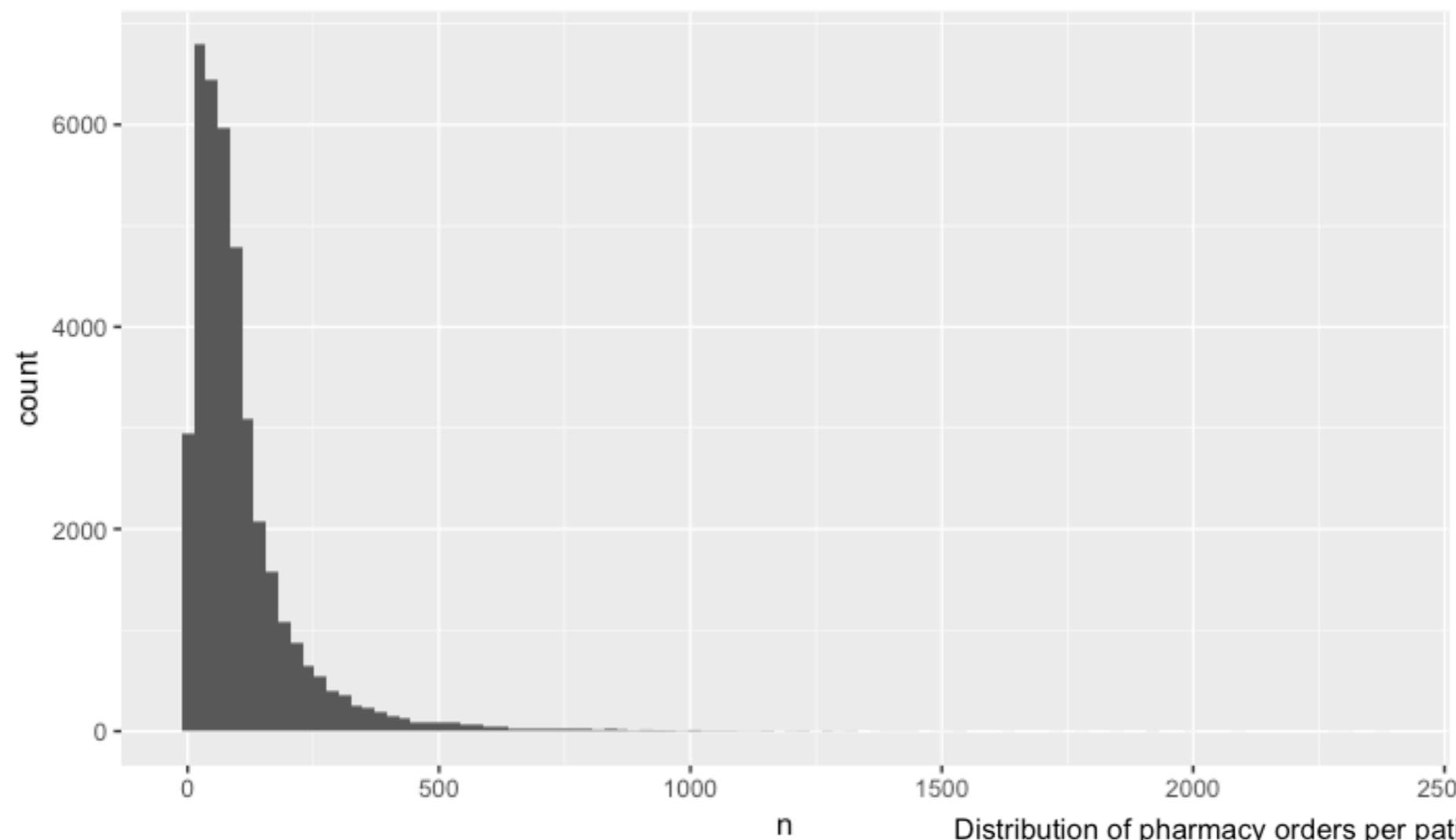
# Most Common Prescriptions

	NDC Code	count
Iso-Osmotic Dextrose	0	86935
Sodium Chloride 0.9% Flush	0	83392
Insulin	0	81356
SW	0	72458
Magnesium Sulfate	409672924	55211
D5W	0	54938
Furosemide	517570425	53073
Potassium Chloride	338070341	47968
D5W	338001702	43038
LR	338011704	35407
Vancomycin	338355248	34741
0.9% Sodium Chloride	338004904	34682
Potassium Chloride	456066270	32533
Heparin	63323026201	31413
NS	338004902	30815

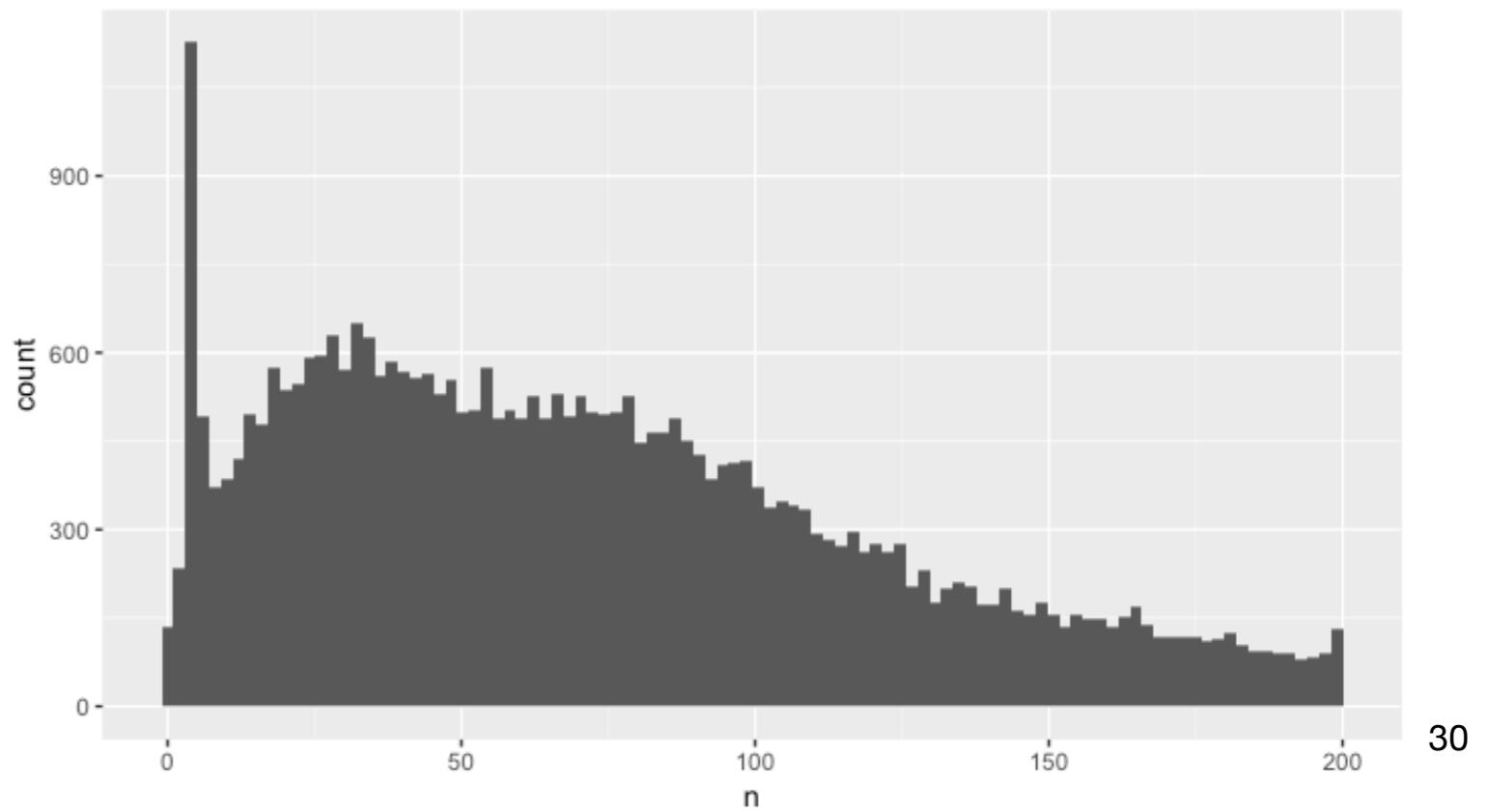
# Next Most Common Prescriptions

	NDC Code	count
NS	338004903	29079
0.9% Sodium Chloride	338004903	28872
Metoprolol Tartrate	51079025520	28781
Insulin	88222033	26431
Pantoprazole	8084199	26379
Bag	0	25745
NS	338004904	25495
Vial	0	24497
Magnesium Sulfate	517260225	24212
5% Dextrose	338001702	24072
Potassium Chloride	58177020211	23881
Furosemide	74610204	23354
NS	338004938	23288
Potassium Chloride	58177000111	22976
Acetaminophen	182844789	22867

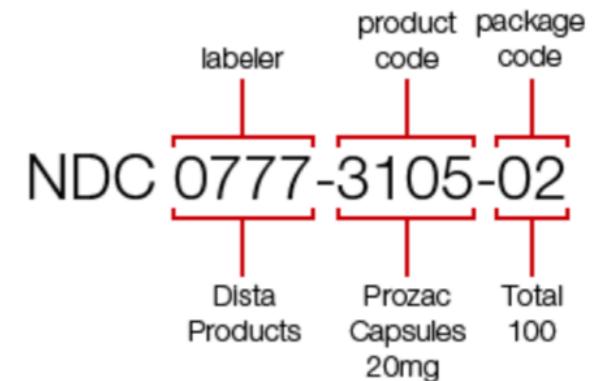
## Distribution of pharmacy orders per admission



## Distribution of pharmacy orders per patient, detail



## Example NDC



# Medications

- NDC
  - “The Drug Listing Act of 1972 requires registered drug establishments to provide the Food and Drug Administration (FDA) with a current list of all drugs manufactured, prepared, propagated, compounded, or processed by it for commercial distribution. ... Drug products are identified and reported using a unique, three-segment number, called the National Drug Code (NDC), which serves as a universal product identifier for drugs. FDA publishes the listed NDC numbers and the information submitted as part of the listing information in the NDC Directory which is updated daily.”
- MedDRA
  - “the late 1990s, the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (ICH) developed MedDRA, a rich and highly specific standardised medical terminology to facilitate sharing of regulatory information internationally for medical products used by humans.”

# Medications (more coding systems)

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- Medicine Services and Procedures CPT Code range 90281- 99607
  - CPT Code range (90281-99607) for medicine contains CPT codes for immune globulins, serum or recombinant prods, immunization administration for vaccines/toxoids, vaccines, toxoids, psychiatry, biofeedback, dialysis, gastroenterology, ophthalmology, special otorhinolaryngologic services, cardiovascular, noninvasive vascular diagnostic studies, pulmonary, allergy and clinical immunology, endocrinology, neurology and neuromuscular procedures, central nervous system assessments/tests (neuro-cognitive, mental status, speech testing), health and behavior assessment/intervention, hydration, therapeutic, prophylactic, diagnostic injections and infusions, and chemotherapy and other highly complex drug or highly complex biologic agent administration, photodynamic therapy, special dermatological procedures, physical medicine and rehabilitation, medical nutrition therapy, acupuncture, osteopathic manipulative treatment, chiropractic manipulative treatment, education and training for patient self-management, non-face-to-face nonphysician services, special services, procedures and reports, other services and procedures, home health procedures/services, medication therapy management services.

# Medications (more coding systems)

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- 2019 Healthcare Common Procedure Coding System
  - HCPCS codes are used for billing Medicare & Medicaid patients
  - HCPCS J-Codes: Drugs administered other than oral method, chemotherapy drugs
  - These codes are used to report injectable drugs that ordinarily cannot be self-administered; chemotherapy, immunosuppressive drugs and inhalation solutions as well as some orally administered drugs.
- Commercial Coding Systems
  - The Generic Product Identifier (GPI) from Medi-Span is 14 characters made up of 7 couplets.
  - FDB [First Data Bank] has the Generic Sequence Number (GSN) also known as the Clinical Formulation ID or formerly as GCN Sequence Number (GCN Seq No), which is 6 digits in length. FDB also has the GCN (Formulation ID) which is 5 digits, ...

## What procedures were performed on the patient?

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- PROCEDURES\_ICD (n=240095)
- CPTEVENTS (n=573146)
- PROCEDUREEVENTS\_MV (n=258066)

# Most Common ICD9 Procedure Codes

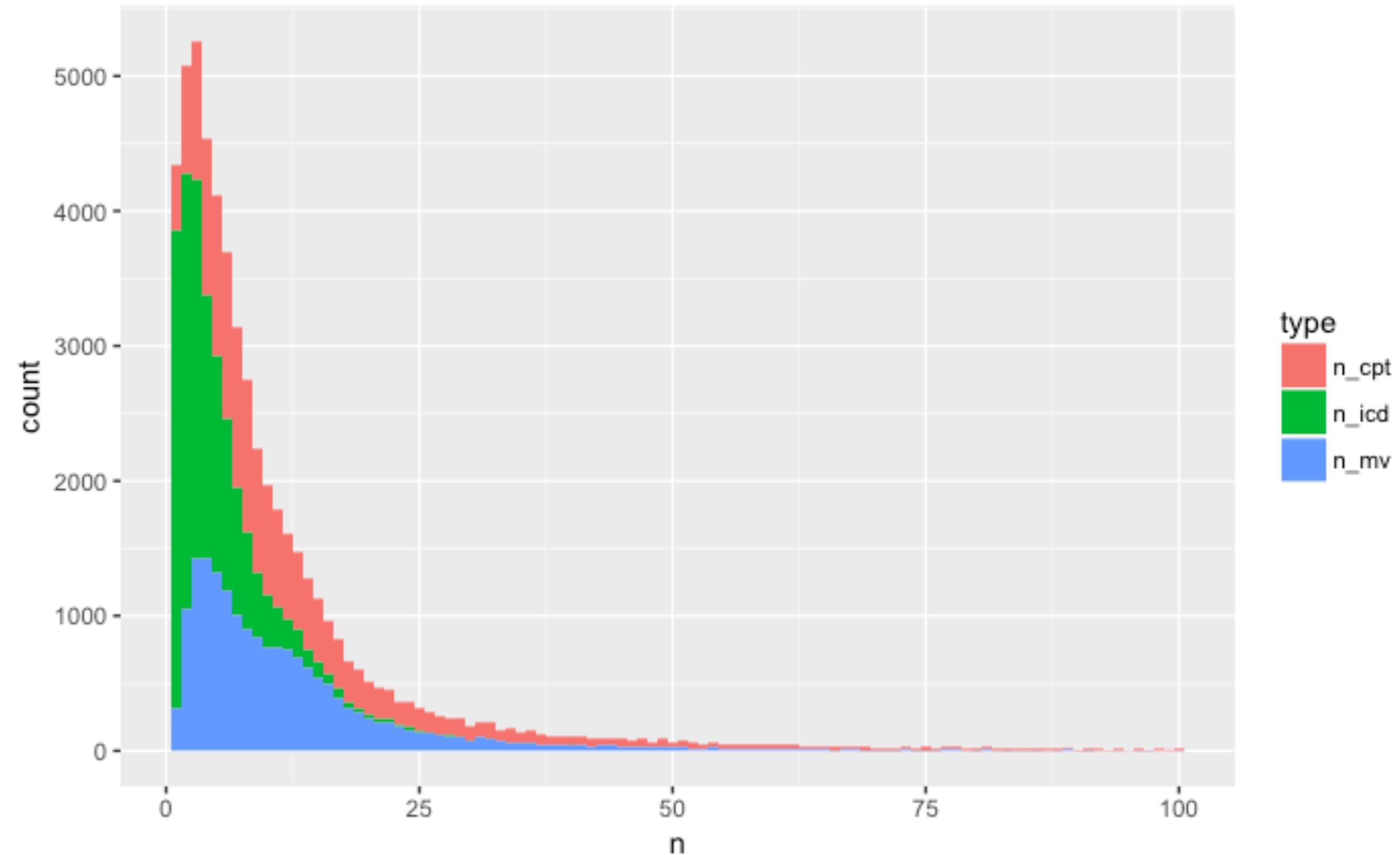
ICD9_code	n	Name
3893	14731	Venous catheterization, not elsewhere classified
9604	10333	Insertion of endotracheal tube
966	9300	Enteral infusion of concentrated nutritional substances
9671	9100	Continuous invasive mechanical ventilation for less than 96 consecutive hours
9904	7244	Transfusion of packed cells
3961	6838	Extracorporeal circulation auxiliary to open heart surgery
9672	6048	Continuous invasive mechanical ventilation for 96 consecutive hours or more
9955	5842	Prophylactic administration of vaccine against other diseases
8856	5337	Coronary arteriography using two catheters
3891	4737	Arterial catheterization
3615	4401	Single internal mammary-coronary artery bypass
9915	4244	Parenteral infusion of concentrated nutritional substances
8872	3548	Diagnostic ultrasound of heart
3722	3311	Left heart cardiac catheterization
3324	3269	Closed [endoscopic] biopsy of bronchus
3995	3254	Hemodialysis

# Procedures (CPT)

Medicine	90281-90399	Immune globulins, serum or recombinant prods
Medicine	90465-90474	Immunization administration for vaccines/toxoids
Medicine	90476-90749	Vaccines, toxoids
Medicine	90801-90899	Psychiatry
Medicine	90901-90911	Biofeedback
Medicine	90918-90925	End-Stage Renal Disease Services (deleted codes)
Medicine	90935-90999	Dialysis
Medicine	91000-91299	Gastroenterology
Medicine	92002-92499	Ophthalmology
Medicine	92502-92700	Special otorhinolaryngologic services
Medicine	92950-93799	Cardiovascular
Medicine	93875-93990	Noninvasive vascular diagnostic studies
Medicine	94002-94799	Pulmonary
Medicine	95004-95199	Allergy and clinical immunology
Medicine	95250-95251	Endocrinology
Medicine	95803-96020	Neurology and neuromuscular procedures
Medicine	96101-96125	Central nervous system assessments/tests (neuro-cogn:
Medicine	96150-96155	Health and behavior assessment/intervention
Medicine	96360-96549	Hydration, therapeutic, prophylactic, diagnostic injec
Medicine	96567-96571	Photodynamic therapy
Medicine	96900-96999	Special dermatological procedures
Medicine	97001-97799	Physical medicine and rehabilitation
Medicine	97802-97804	Medical nutrition therapy
Medicine	97810-97814	Acupuncture
Medicine	98925-98929	Osteopathic manipulative treatment
Medicine	98940-98943	Chiropractic manipulative treatment
Medicine	98960-98962	Education and training for patient self-management
Medicine	98966-98969	Non-face-to-face nonphysician services
Medicine	99000-99091	Special services, procedures and reports
Medicine	99170-99199	Other services and procedures
Medicine	99500-99602	Home health procedures/services
Medicine	99605-99607	Medication therapy management services

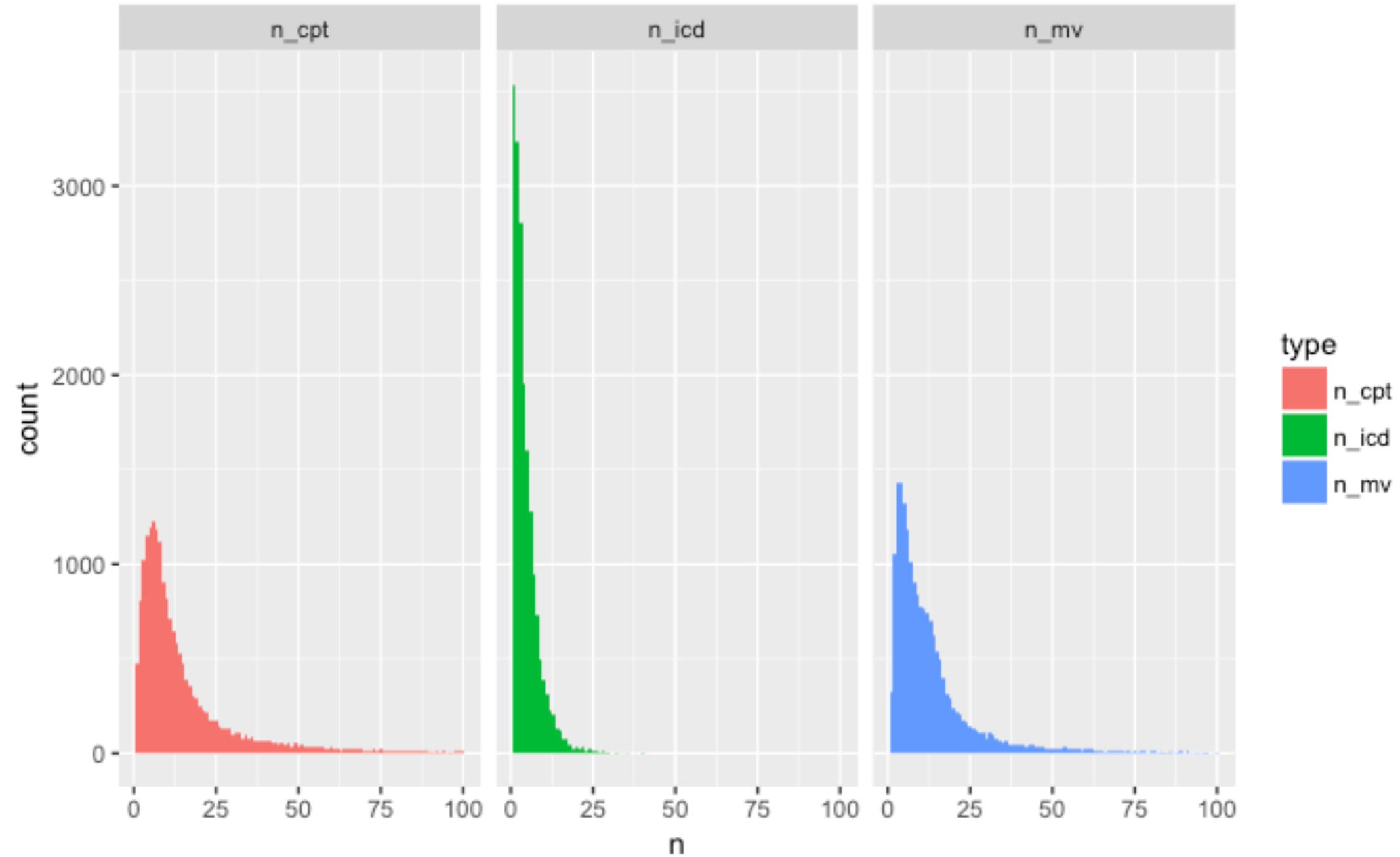
Surgery	10000-10022	General
Surgery	10040-19499	Integumentary system
Surgery	20000-29999	Musculoskeletal system
Surgery	30000-32999	Respiratory system
Surgery	33010-37799	Cardiovascular system
Surgery	38100-38999	Hemic and lymphatic systems
Surgery	39000-39599	Mediastinum and diaphragm
Surgery	40490-49999	Digestive system
Surgery	50010-53899	Urinary system
Surgery	54000-55899	Male genital system
Surgery	55920-55980	Reproductive system and intersex
Surgery	56340-56340	Laparoscopy, Surgical; Cholecystectomy
Surgery	56405-58999	Female genital system
Surgery	59000-59899	Maternity care and delivery
Surgery	60000-60699	Endocrine system
Surgery	61000-64999	Nervous system
Surgery	65091-68899	Eye and ocular adnexa
Surgery	69000-69979	Auditory system
Surgery	69990-69990	Operating microscope (deleted code)
Radiology	70000-76499	Diagnostic imaging
Radiology	76506-76999	Diagnostic ultrasound
Radiology	77001-77032	Radiologic guidance
Radiology	77051-77059	Breast mammography
Radiology	77071-77084	Bone/joint studies
Radiology	77261-77799	Radiation oncology
Radiology	78000-79999	Nuclear medicine

# Procedure Codes per Admission



# Procedure Codes per Admission

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# Lab measurements

itemid	n	label	fluid	category	loinc
51221	881764	Hematocrit	Blood	Hematology	4544-3
50971	845737	Potassium	Blood	Chemistry	2823-3
50983	808401	Sodium	Blood	Chemistry	2951-2
50912	797389	Creatinine	Blood	Chemistry	2160-0
50902	795480	Chloride	Blood	Chemistry	2075-0
51006	791838	Urea Nitrogen	Blood	Chemistry	3094-0
50882	780648	Bicarbonate	Blood	Chemistry	1963-8
51265	778365	Platelet Count	Blood	Hematology	777-3
50868	769810	Anion Gap	Blood	Chemistry	1863-0
51301	753221	White Blood Cells	Blood	Hematology	804-5
51222	752444	Hemoglobin	Blood	Hematology	718-7
50931	748896	Glucose	Blood	Chemistry	2345-7
51249	748147	MCHC	Blood	Hematology	786-4
51279	747999	Red Blood Cells	Blood	Hematology	789-8
51248	747994	MCH	Blood	Hematology	785-6
51250	747977	MCV	Blood	Hematology	787-2

# Labs for patient 2, admission 163353

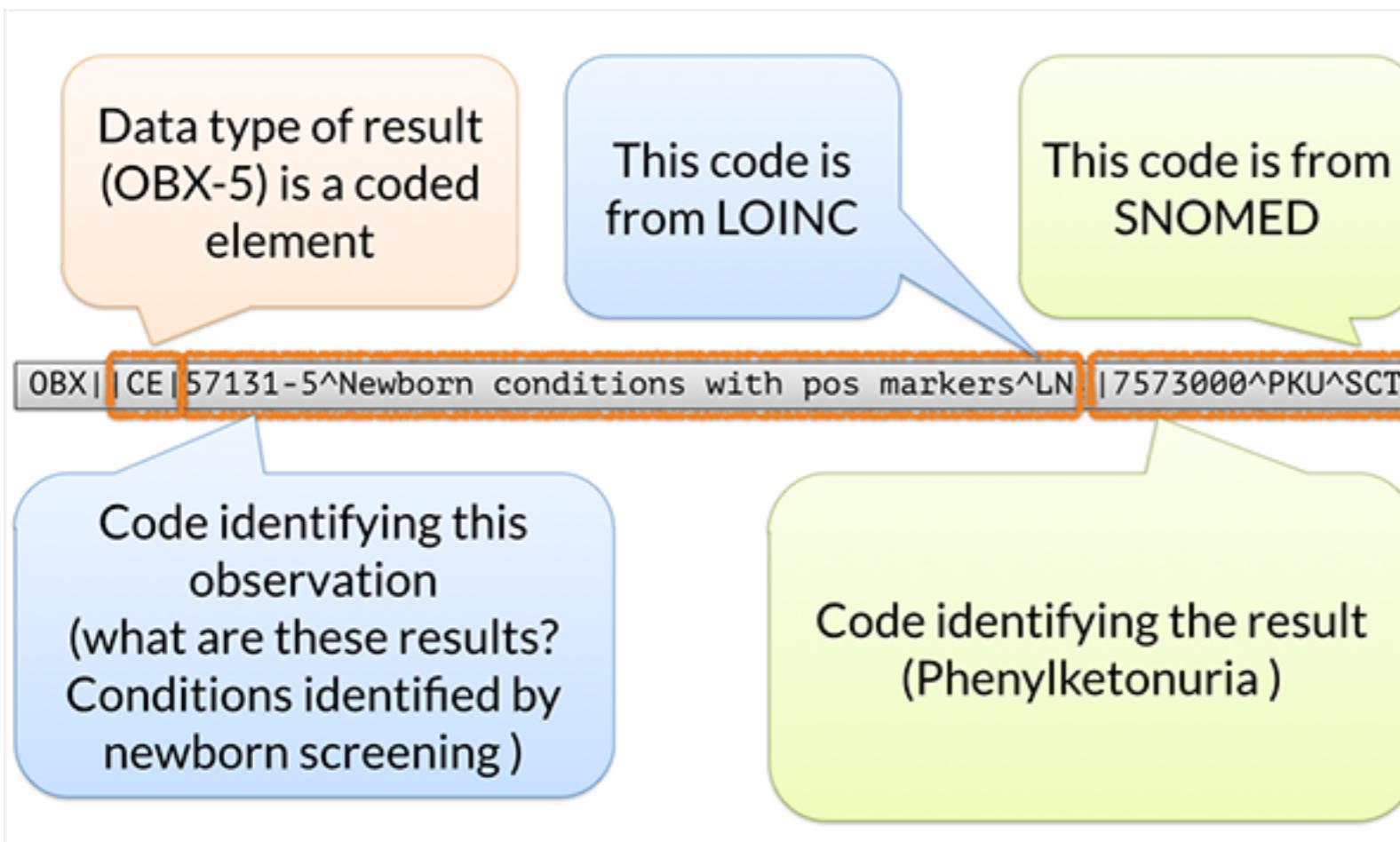
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subj	hadm	item	time	value	units	flag	label	fluid	categ	loinc
2	163353	51143	2138-07-17 20:48:00	0.00	%	NA	Atypical Lymphocytes	Blood	Hem	733-6
2	163353	51144	2138-07-17 20:48:00	0.00	%	NA	Bands	Blood	Hem	763-3
2	163353	51146	2138-07-17 20:48:00	0.00	%	NA	Basophils	Blood	Hem	704-7
2	163353	51200	2138-07-17 20:48:00	0.00	%	NA	Eosinophils	Blood	Hem	711-2
2	163353	51221	2138-07-17 20:48:00	0.00	%	abnormal	Hematocrit	Blood	Hem	4544-3
2	163353	51222	2138-07-17 20:48:00	0.00	g/dL	abnormal	Hemoglobin	Blood	Hem	718-7
2	163353	51244	2138-07-17 20:48:00	0.00	%	NA	Lymphocytes	Blood	Hem	731-0
2	163353	51248	2138-07-17 20:48:00	0.00	pg	abnormal	MCH	Blood	Hem	785-6
2	163353	51249	2138-07-17 20:48:00	0.00	%	abnormal	MCHC	Blood	Hem	786-4
2	163353	51250	2138-07-17 20:48:00	0.00	fL	abnormal	MCV	Blood	Hem	787-2
2	163353	51251	2138-07-17 20:48:00	0.00	%	NA	Metamyelocytes	Blood	Hem	28541-1
2	163353	51254	2138-07-17 20:48:00	0.00	%	NA	Monocytes	Blood	Hem	742-7
2	163353	51255	2138-07-17 20:48:00	0.00	%	NA	Myelocytes	Blood	Hem	26498-6
2	163353	51256	2138-07-17 20:48:00	100.00	%	NA	Neutrophils	Blood	Hem	761-7
2	163353	51265	2138-07-17 20:48:00	5.00	K/uL	abnormal	Platelet Count	Blood	Hem	777-3

# Reporting lab results

## Logical Observation Identifiers Names and Codes

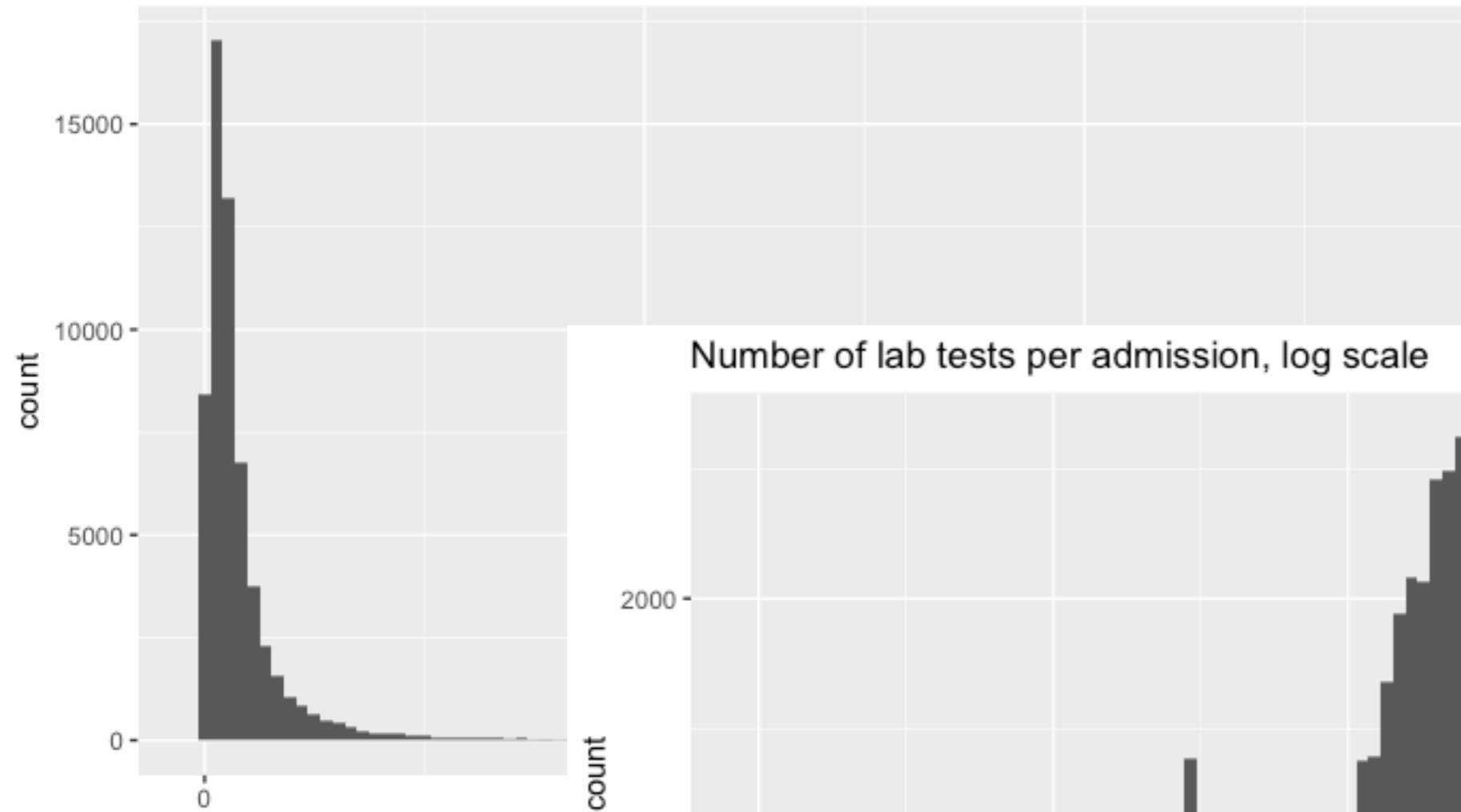
Most laboratory and clinical systems today are sending data out using the HL7 version 2 messaging standard. Looking at an example of the place in the HL7 message where the test results go, you can see how a LOINC code identifies the question and a SNOMED CT code represents the answer:



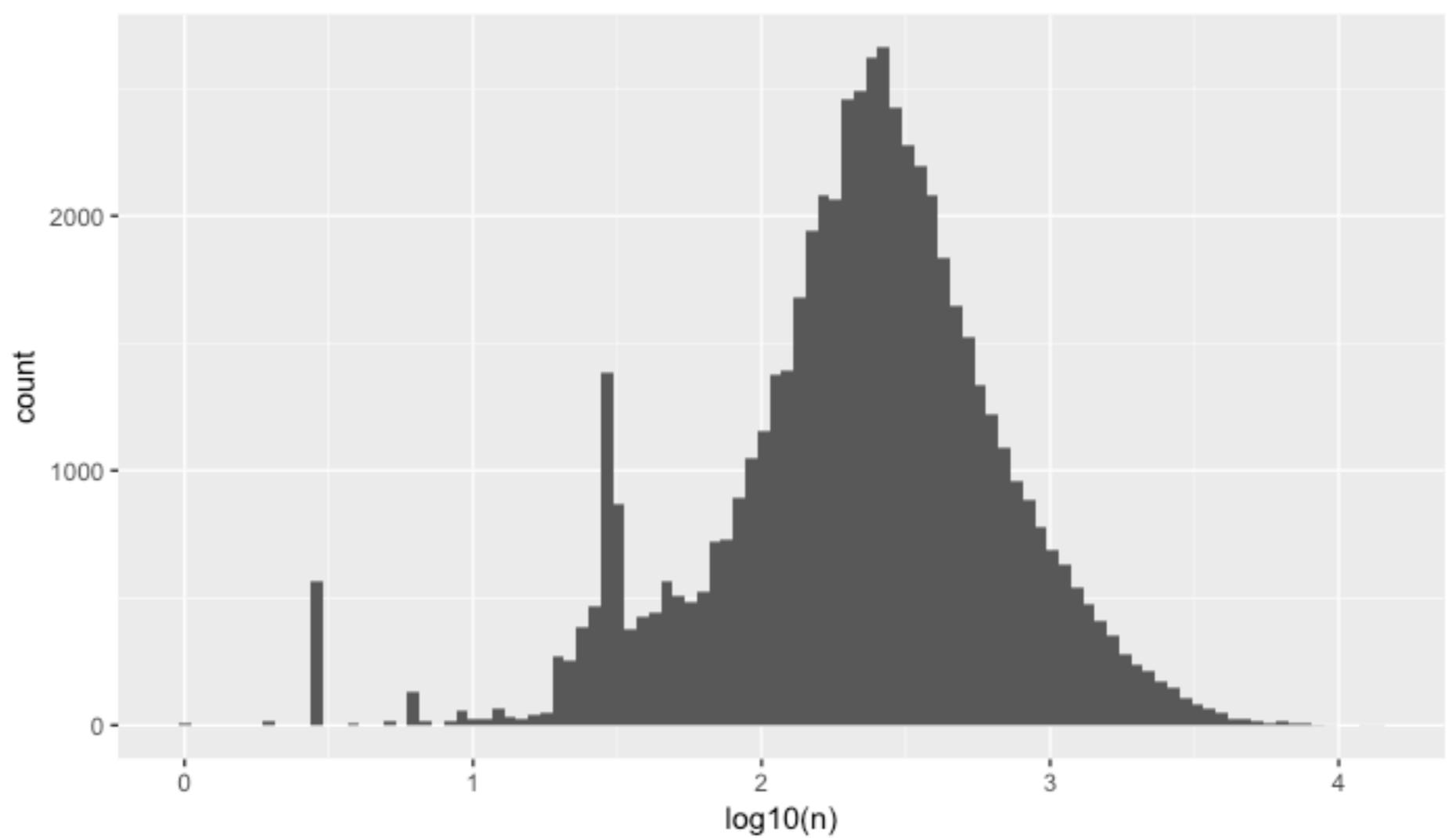
- Component (Analyte)
- Property
- Time
- System (Specimen)
- Scale
- Method

# Lab tests per admission

Number of lab tests per admission



Number of lab tests per admission, log scale

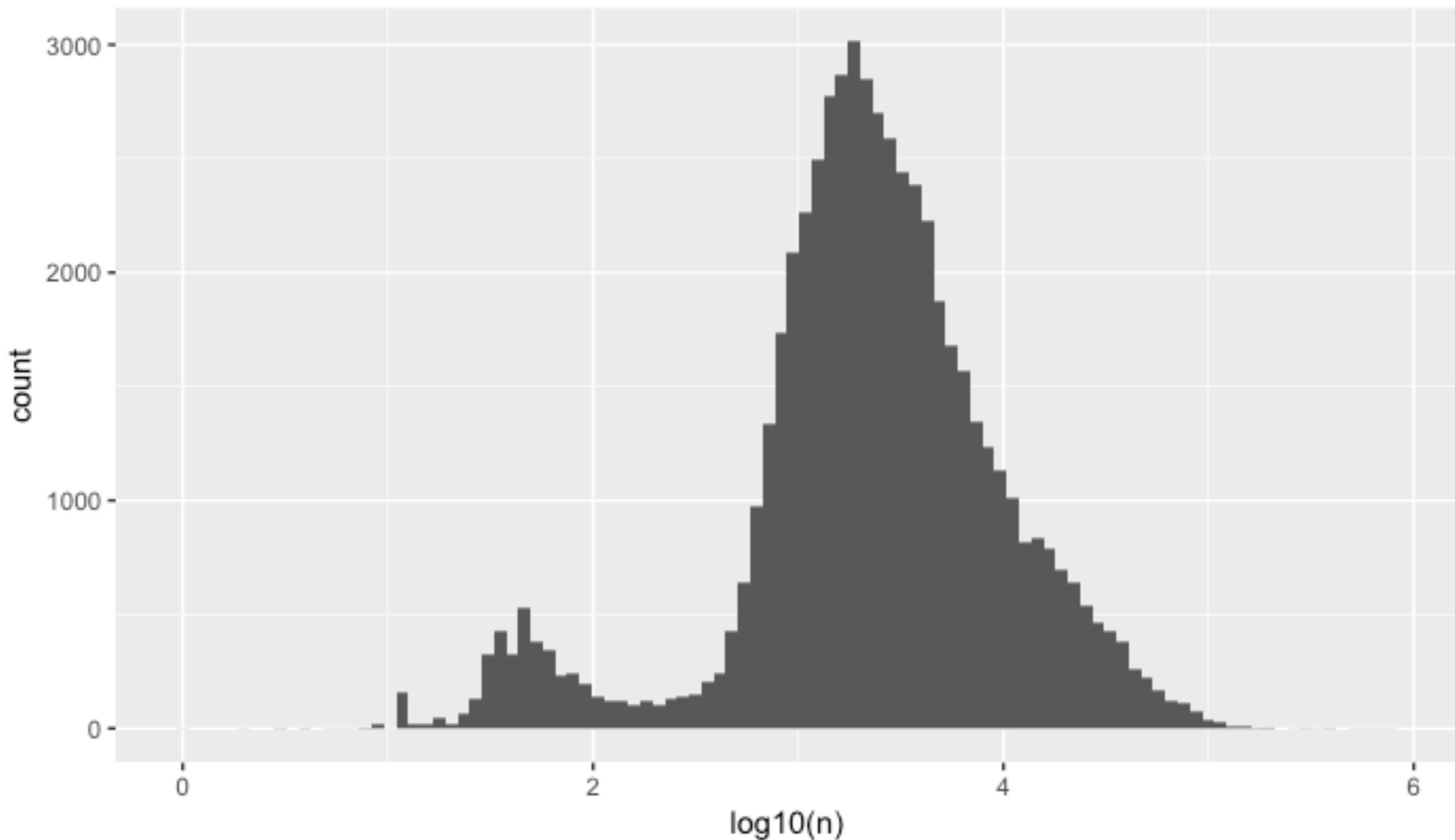


# Chart Events

itemid	n	label	category	units	param_type
211	5180809	Heart Rate	NA	NA	NA
742	3464326	calprevflg	NA	NA	NA
646	3418917	SpO2	NA	NA	NA
618	3386719	Respiratory Rate	NA	NA	NA
212	3303151	Heart Rhythm	NA	NA	NA
161	3236350	Ectopy Type	NA	NA	NA
128	3216866	Code Status	NA	NA	NA
550	3205052	Precautions	NA	NA	NA
1125	2955851	Service Type	NA	NA	NA
220045	2762225	Heart Rate	Routine Vital Signs	bpm	Numeric
220210	2737105	Respiratory Rate	Respiratory	insp/min	Numeric
220277	2671816	O2 saturation pulseoxymetry	Respiratory	%	Numeric
159	2544519	Ectopy Frequency	NA	NA	NA
1484	2261065	Risk for Falls	NA	NA	NA
51	2096678	Arterial BP [Systolic]	NA	NA	NA
8368	2085994	Arterial BP [Diastolic]	NA	NA	NA

# Chart entries

Number of chart entries (log) per admission

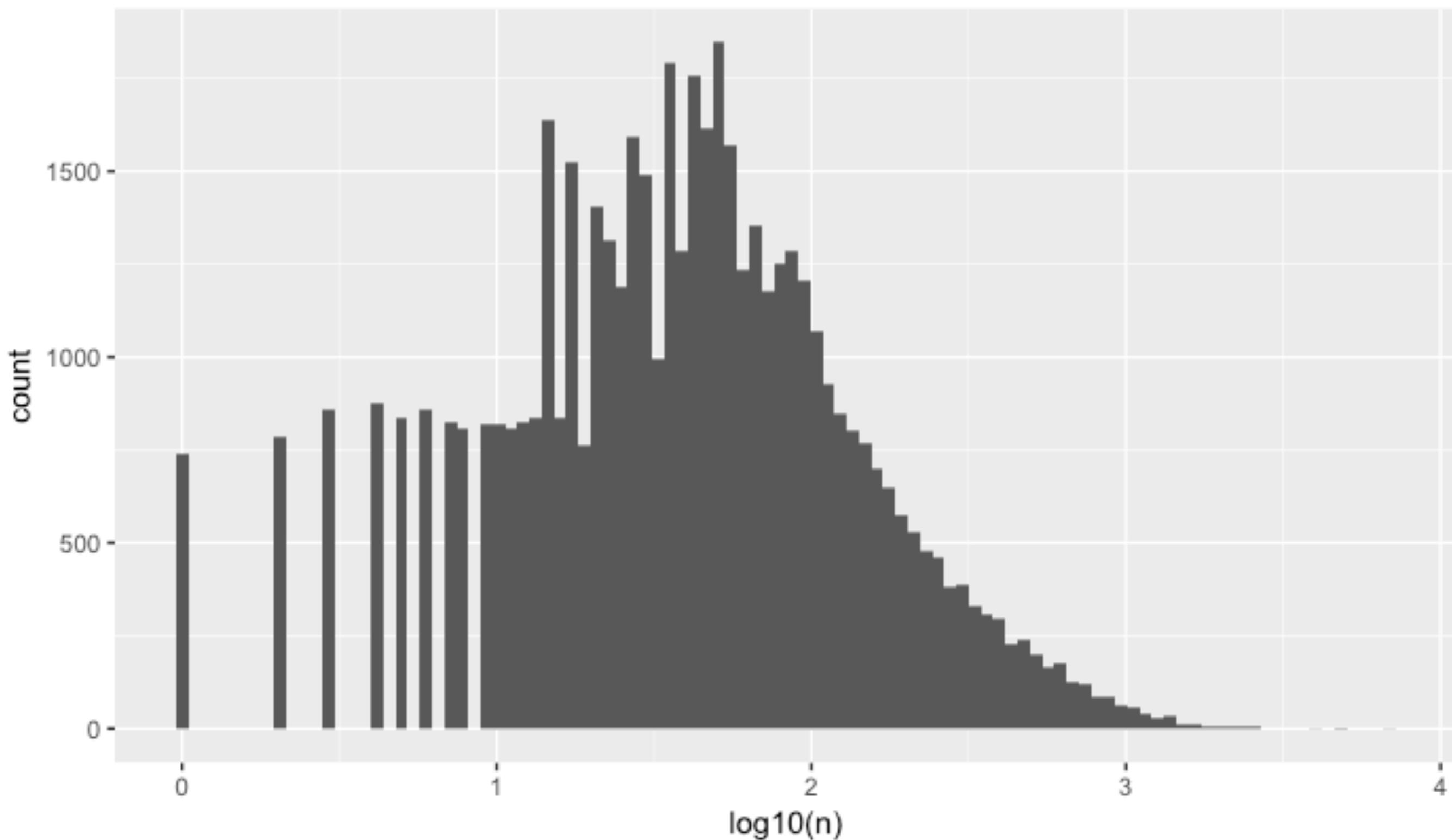


# Outputs

---

itemid	n	label	category	units
40055	1917421	Urine Out Foley	NA	NA
226559	1186717	Foley	Output	mL
40076	152716	Chest Tubes CTICU CT 1	NA	NA
43175	108982	Urine .	NA	NA
40054	81828	Stool Out Stool	NA	NA
226588	81128	Chest Tube #1	Output	mL
40069	69467	Urine Out Void	NA	NA

## Number of outputs (log) per admission



# Inputs (CareVue)

---

itemid	n	label
30013	2557507	D5W
30018	2392372	.9% Normal Saline
30131	924614	Propofol
30045	825758	Insulin
30025	813242	Heparin
30118	780555	Fentanyl
30128	554582	Neosynephrine-k
30124	505509	Midazolam
30120	476971	Levophed-k
30140	373023	N/A

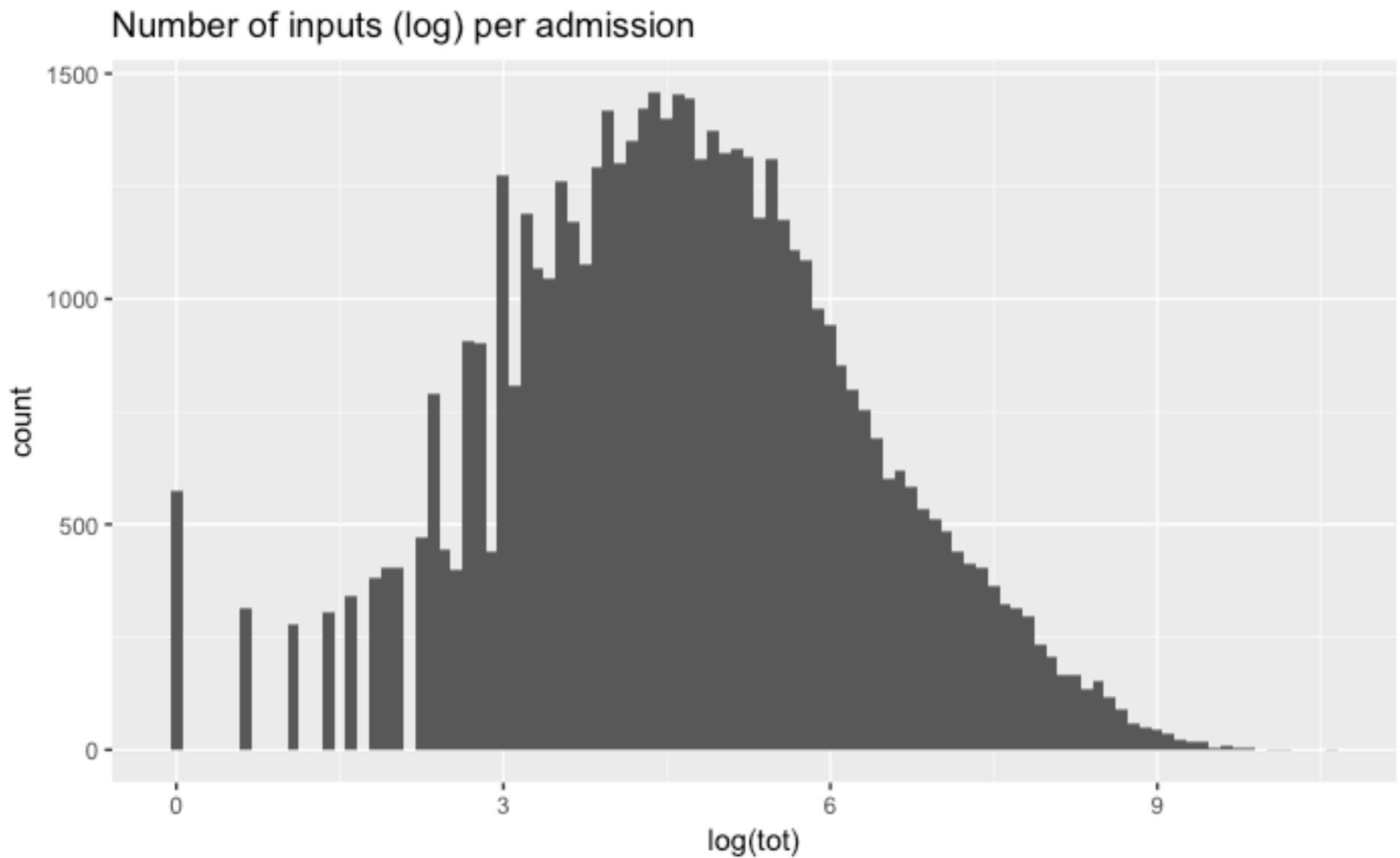
# Inputs (MetaVision)

---

itemid	n	label	category	unit	param_type
225158	527855	NaCl 0.9%	Fluids/Intake	mL	Solution
220949	406345	Dextrose 5%	Fluids/Intake	mL	Solution
225943	246312	Solution	Fluids/Intake	mL	Solution
222168	178819	Propofol	Medications	mg	Solution
226452	135438	PO Intake	Fluids/Intake	mL	Solution
223258	119668	Insulin -	Medications	units	Solution
225799	97629	Gastric Meds	Fluids/Intake	mL	Solution
221749	93571	Phenylephrine	Medications	mg	Solution
221906	89697	Norepinephrine	Medications	mg	Solution
221744	86340	Fentanyl	Medications	mg	Solution

# Inputs (combined MV and CV)

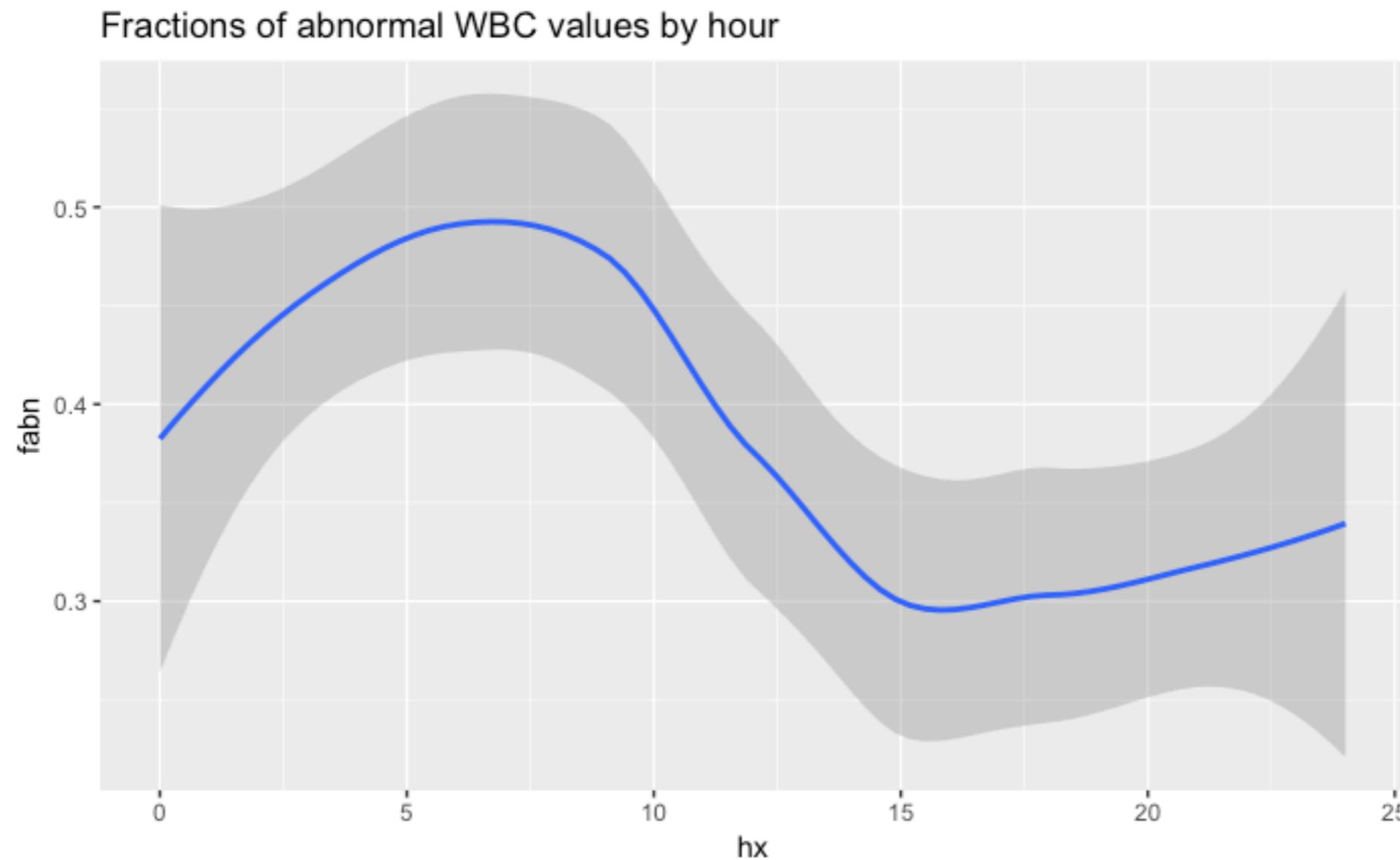
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# Biases in electronic health record data due to processes within the healthcare system: retrospective observational study

Denis Agniel,<sup>1</sup> Isaac S Kohane,<sup>1,2</sup> Griffin M Weber<sup>1,3</sup>

- Showed that for many lab results, “process measures” of the data are more important than actual values in predicting outcomes
  - E.g., White Blood Cell count



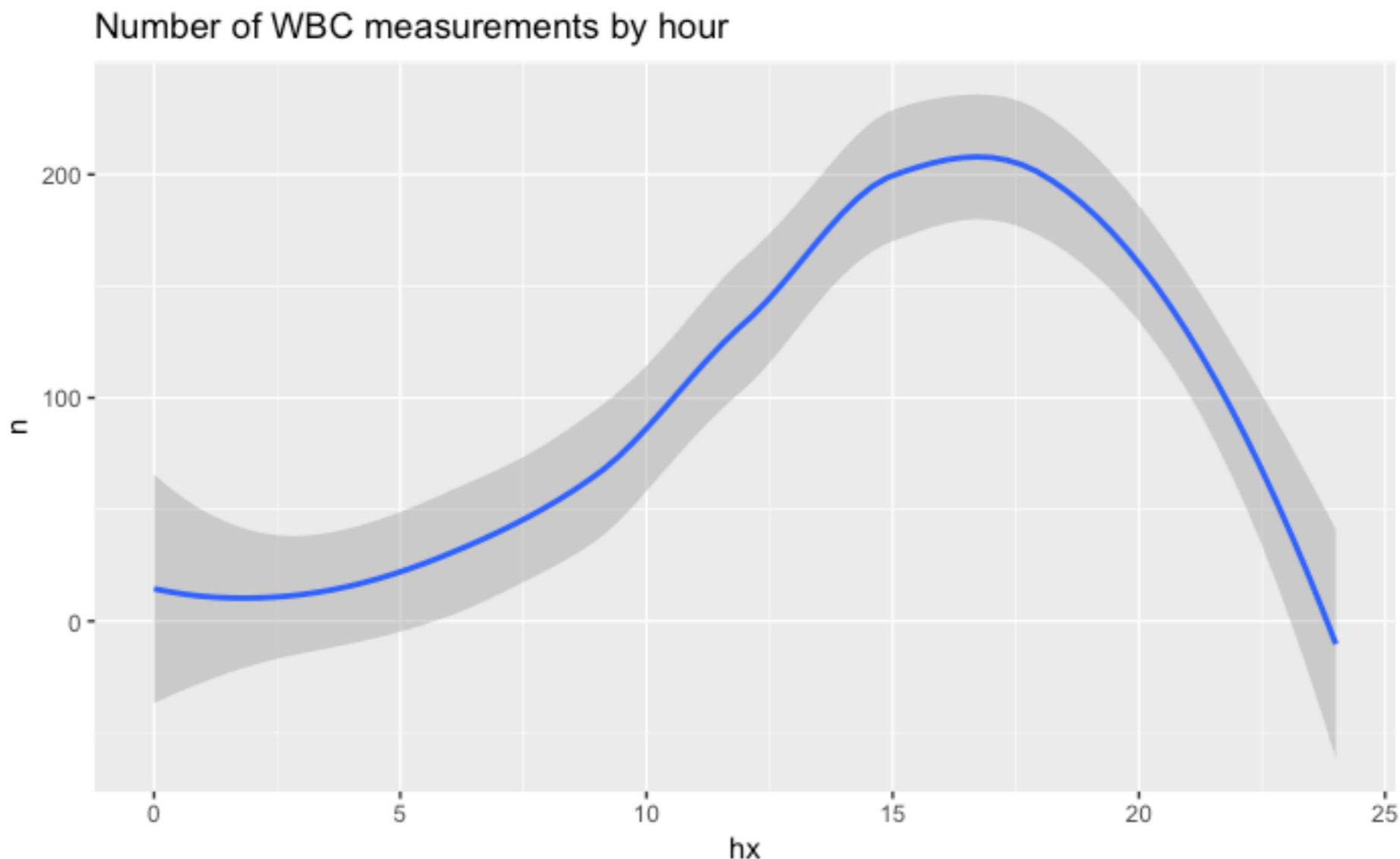
LR model to predict mortality from number of WBC measurements and number abnormal, per hour

Deviance Residuals:						H22	-0.56242	0.36065	-1.559	0.118893
Min	1Q	Median	3Q	Max		H23	-0.45735	0.47557	-0.962	0.336199
-1.8045	-1.0958	-0.5012	1.1245	2.3401		H24	0.08659	0.71026	0.122	0.902962
Coefficients:										
	Estimate	Std. Error	z value	Pr(> z )		HA0	-1.78217	1.32944	-1.341	0.180071
(Intercept)	0.04321	0.11487	0.376	0.706758		HA1	-0.80485	1.28716	-0.625	0.531782
H0	0.75871	0.88579	0.857	0.391700		HA2	-1.39389	1.36913	-1.018	0.308639
H1	0.45657	0.76061	0.600	0.548333		HA3	-15.69112	413.03210	-0.038	0.969696
H2	0.39502	0.65687	0.601	0.547597		HA4	-0.91247	1.21520	-0.751	0.452723
H3	15.46281	413.03082	0.037	0.970136		HA5	-0.32100	1.38380	-0.232	0.816564
H4	0.87956	0.90070	0.977	0.328804		HA6	-1.32274	1.04715	-1.263	0.206524
H5	0.19184	0.92995	0.206	0.836562		HA7	-0.71769	0.93684	-0.766	0.443632
H6	0.43533	0.65352	0.666	0.505330		HA8	-1.71813	0.66992	-2.565	0.010327 *
H7	0.05389	0.40893	0.132	0.895147		HA9	-0.67054	0.51100	-1.312	0.189450
H8	1.36632	0.47436	2.880	0.003972 **		HA10	-0.19831	0.45897	-0.432	0.665693
H9	0.07131	0.24685	0.289	0.772685		HA11	1.72924	0.52482	3.295	0.000984 ***
H10	0.02999	0.16509	0.182	0.855845		HA12	0.03971	0.59225	0.067	0.946540
H11	-1.03418	0.32225	-3.209	0.001331 **		HA13	0.94444	0.62952	1.500	0.133550
H12	0.15791	0.21427	0.737	0.461133		HA14	0.22134	0.45705	0.484	0.628188
H13	-0.39467	0.31470	-1.254	0.209803		HA15	1.25147	0.44487	2.813	0.004906 **
H14	-0.19412	0.18526	-1.048	0.294726		HA16	0.04059	0.39246	0.103	0.917633
H15	-0.42509	0.15821	-2.687	0.007212 **		HA17	0.18535	0.46846	0.396	0.692352
H16	0.24009	0.12191	1.969	0.048900 *		HA18	0.49504	0.44025	1.124	0.260823
H17	-0.10166	0.15254	-0.666	0.505139		HA19	-0.02478	0.45548	-0.054	0.956612
H18	-0.10116	0.18002	-0.562	0.574149		HA20	0.41568	0.53548	0.776	0.437594
H19	-0.23376	0.24193	-0.966	0.333919		HA21	1.60231	0.60935	2.630	0.008550 **
H20	-0.12929	0.18466	-0.700	0.483827		HA22	0.52832	0.56629	0.933	0.350848
H21	-0.79920	0.27154	-2.943	0.003248 **		HA23	0.92591	0.88156	1.050	0.293580
						HA24	0.67132	1.68820	0.398	0.690887
						---				
						Signif. codes:	0 ~***~ <sup>TM</sup> 0.001 ~**~ <sup>TM</sup> 0.01 ~*~ <sup>TM</sup> 0.05			

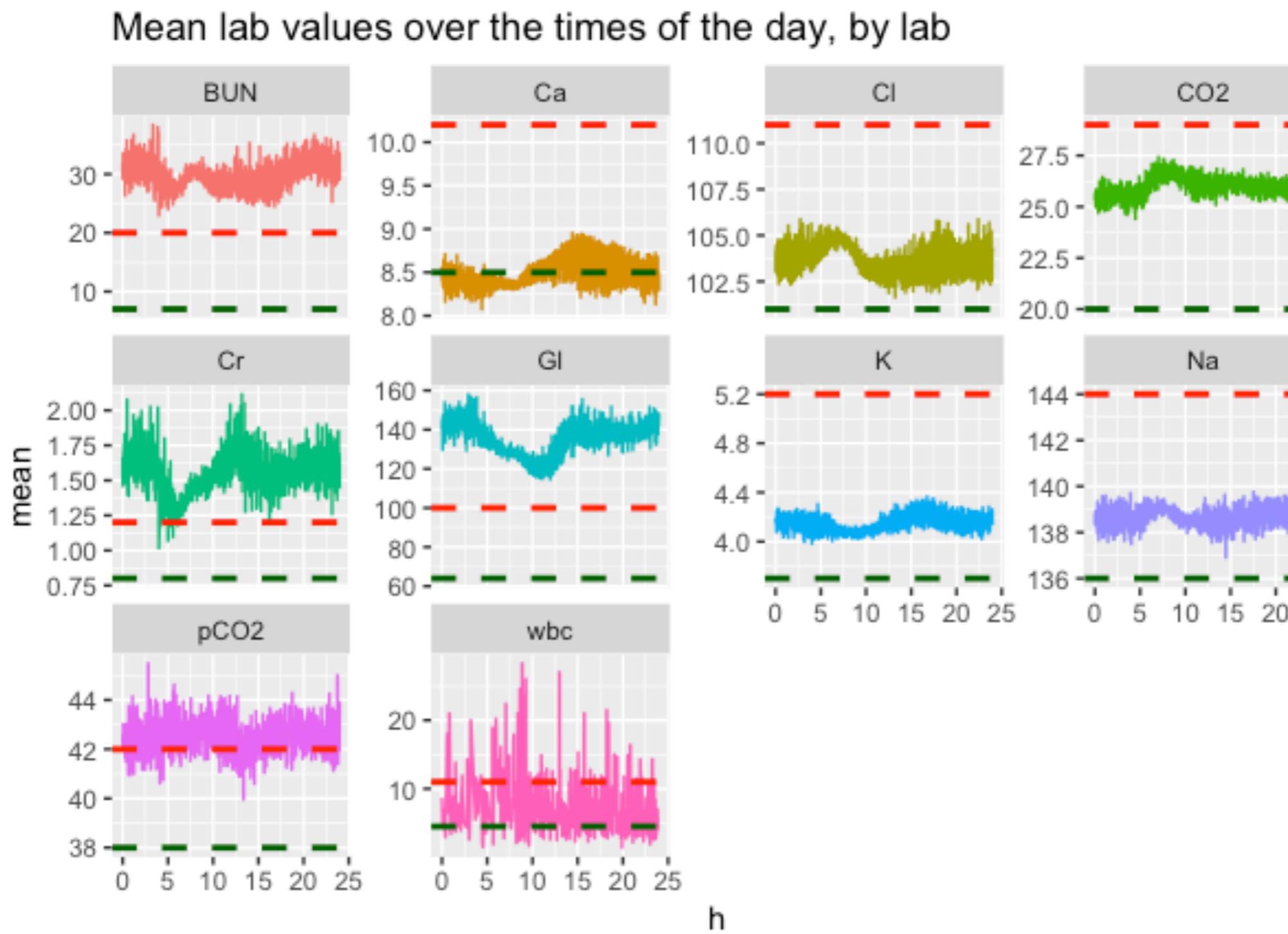
# Relationship of WBC measurements at night to mortality

---

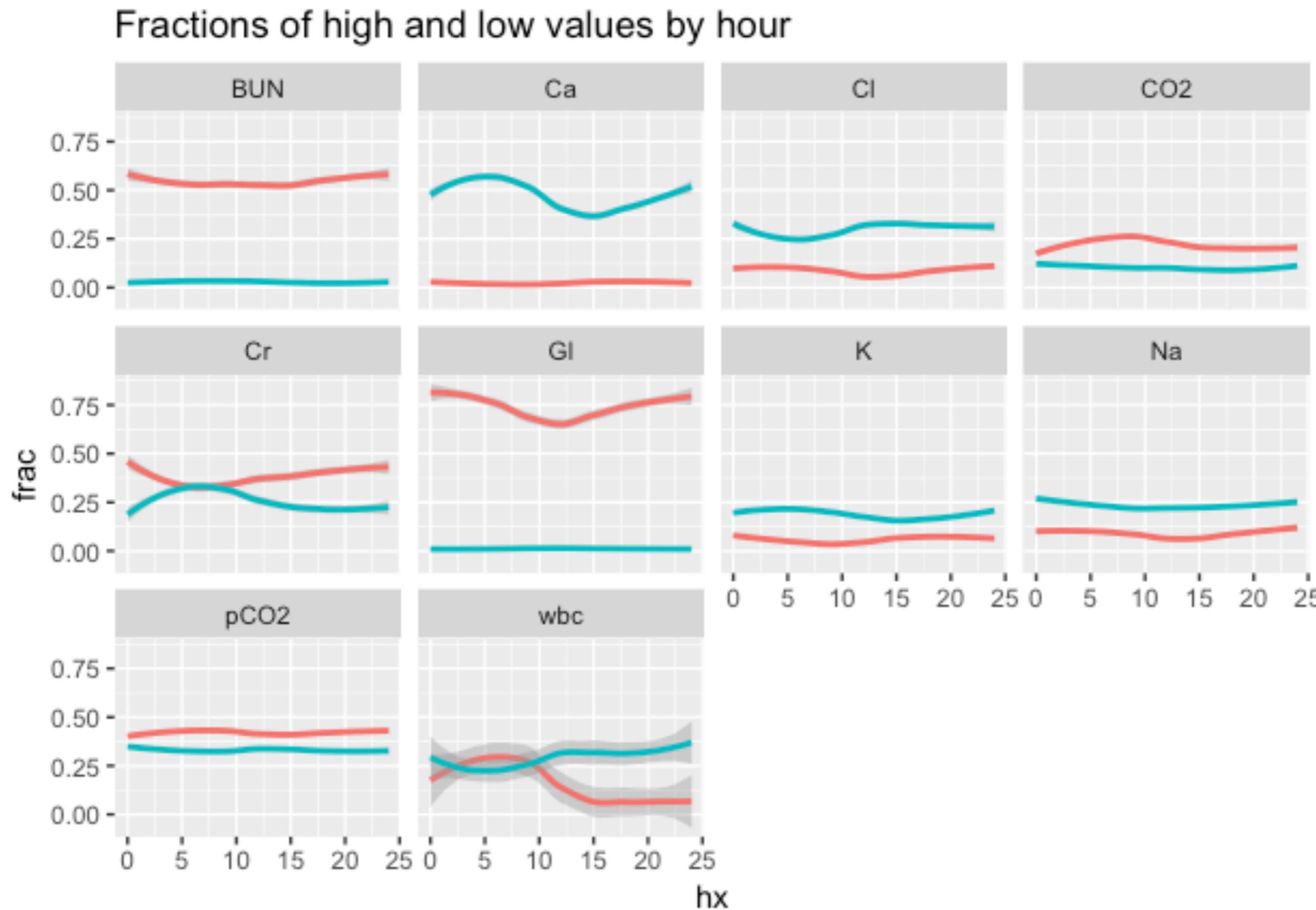
	0	1	2	3	4
FALSE	289	65	8	1	1
TRUE	253	67	3	0	0



# Lab values do vary by time of day

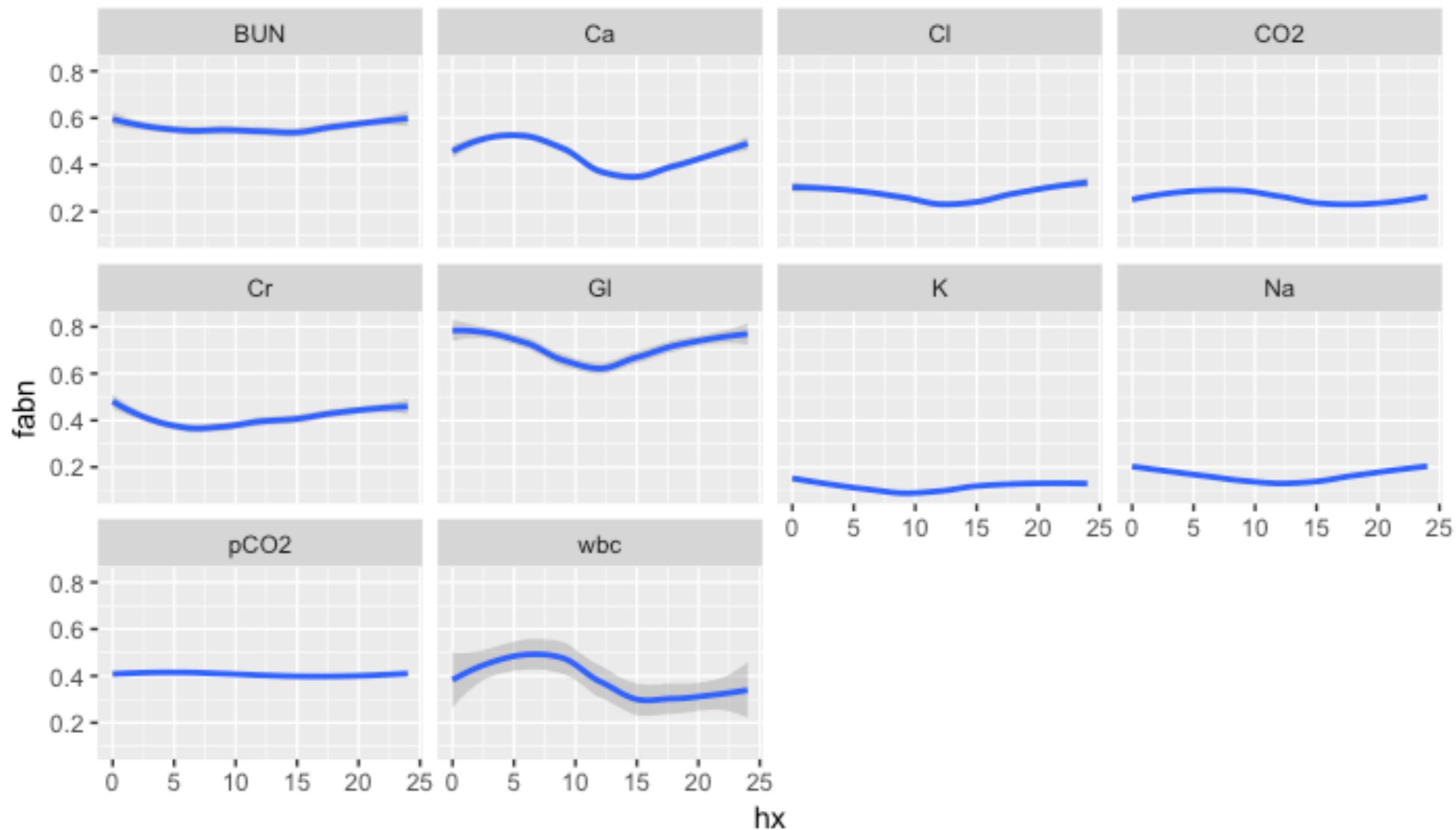


# Fractions of high and low lab values do vary by hour

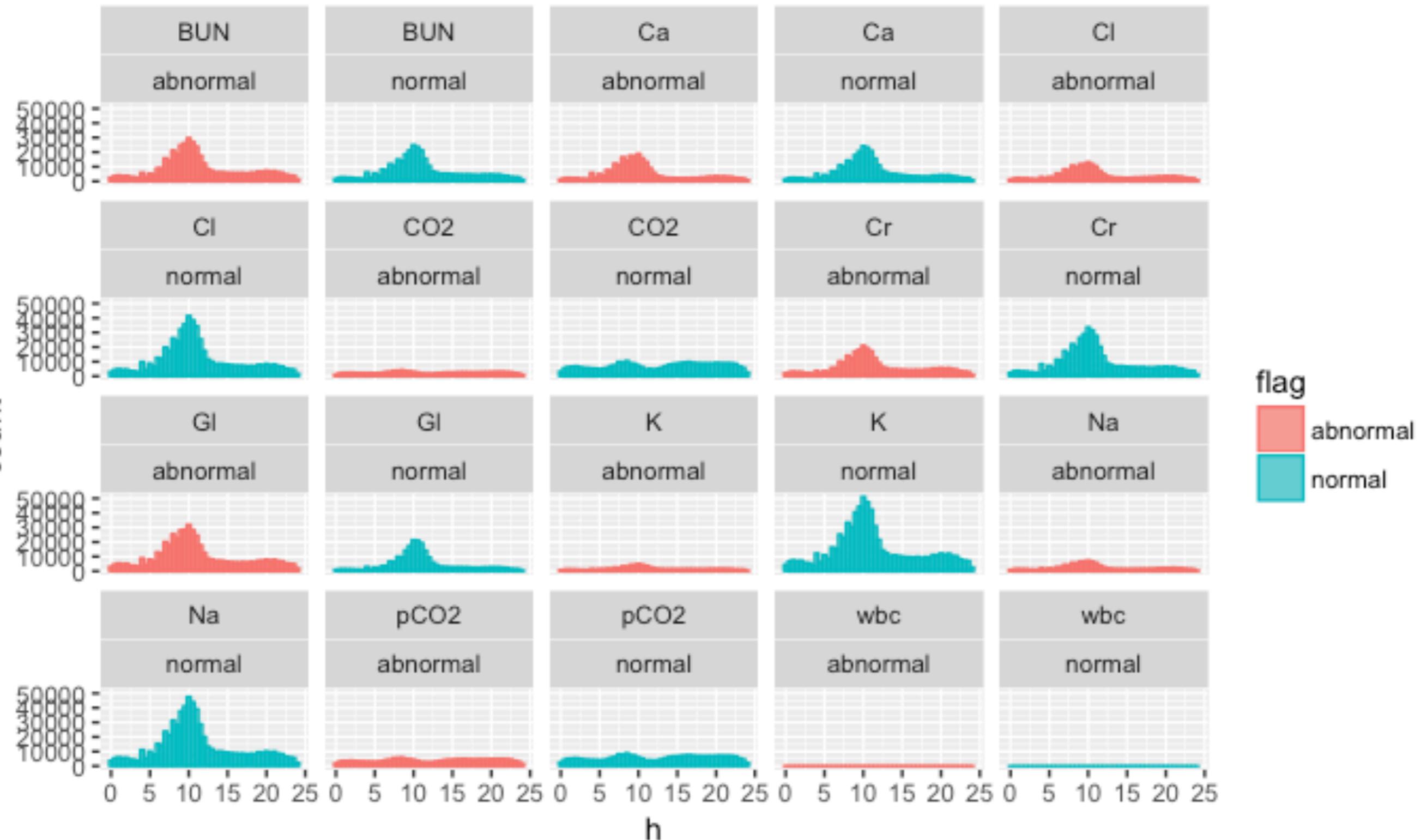


# Fractions of abnormal lab values do vary by hour

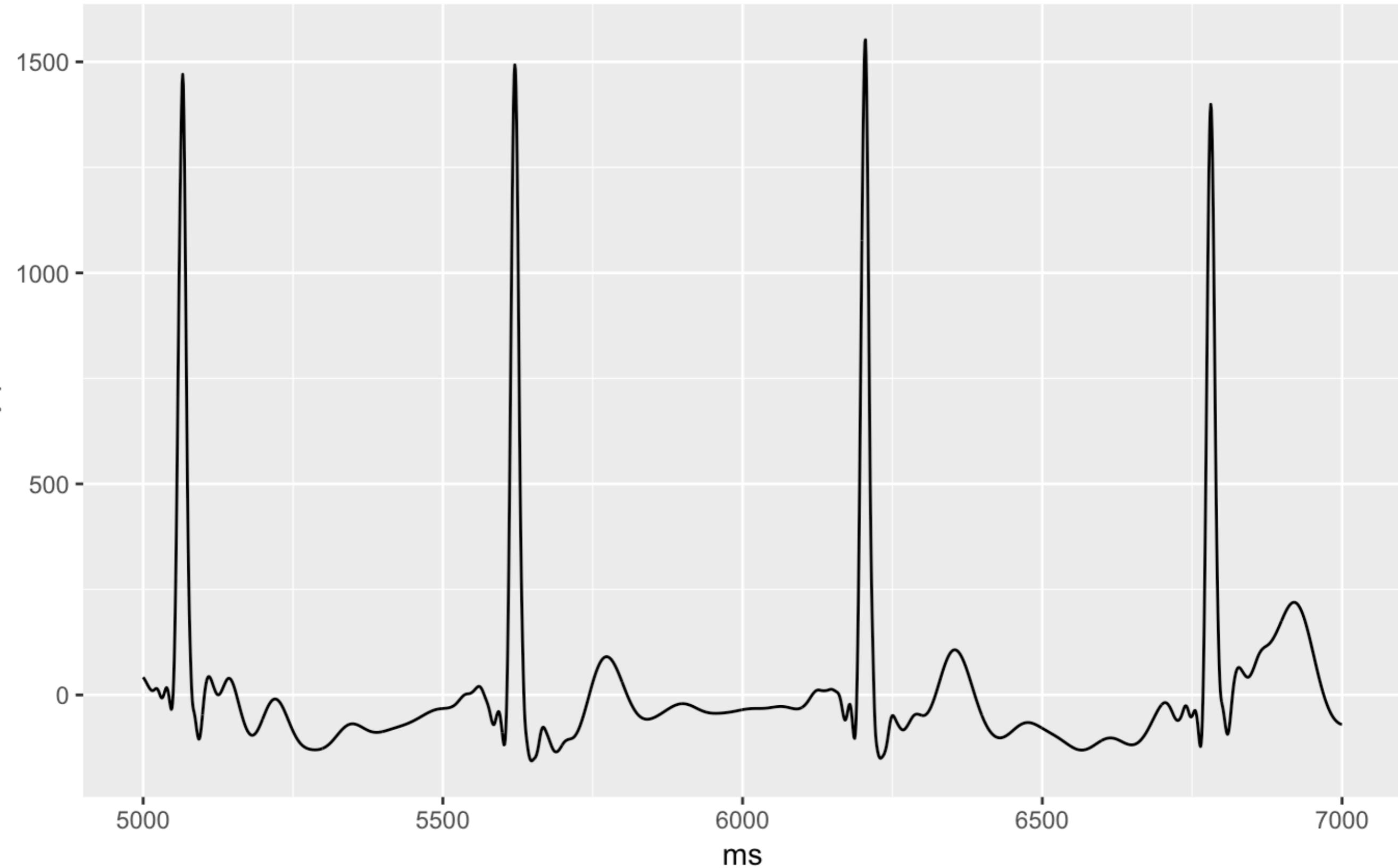
Fractions of abnormal values by hour for common labs



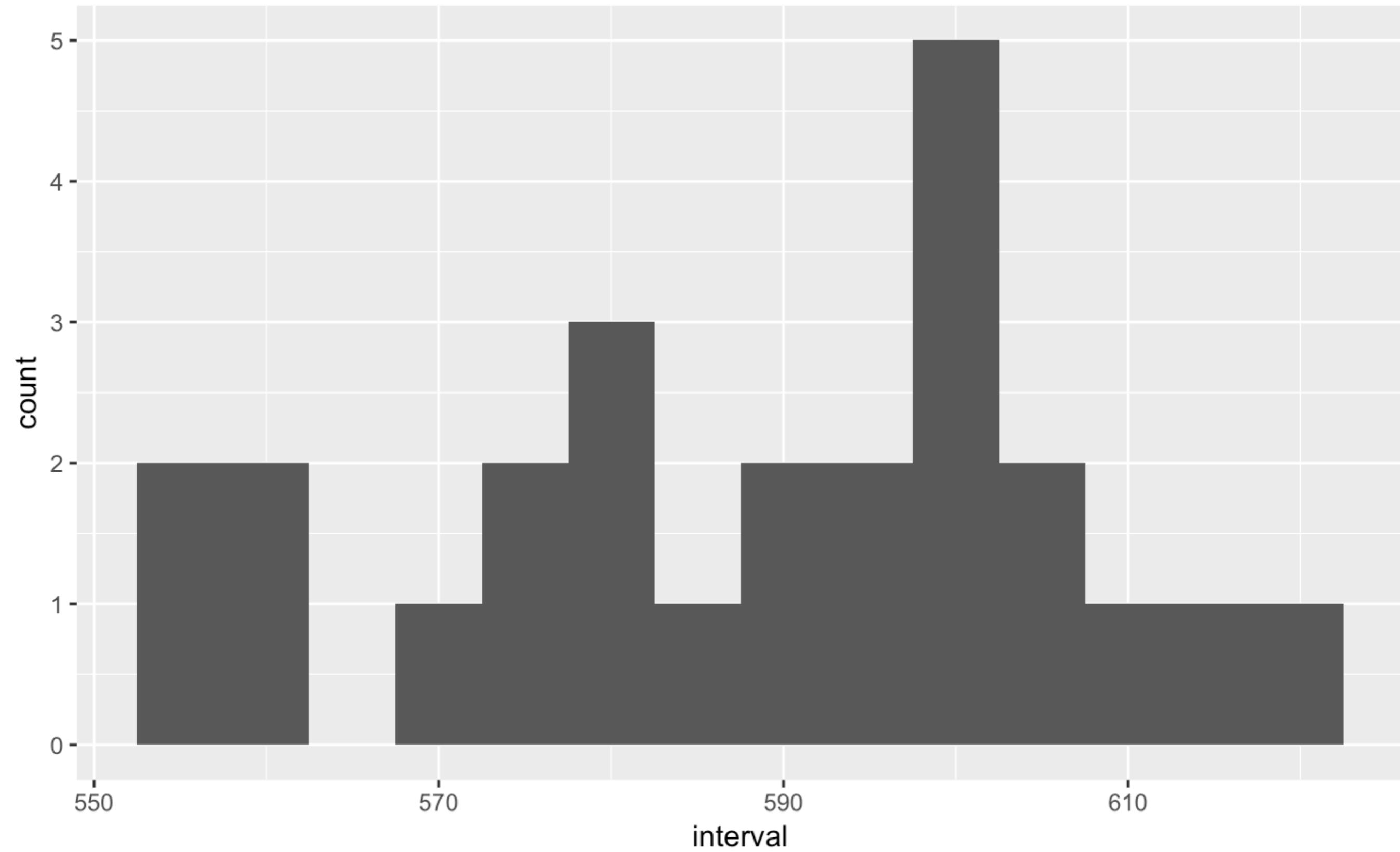
## Times of lab measurements, faceted by type



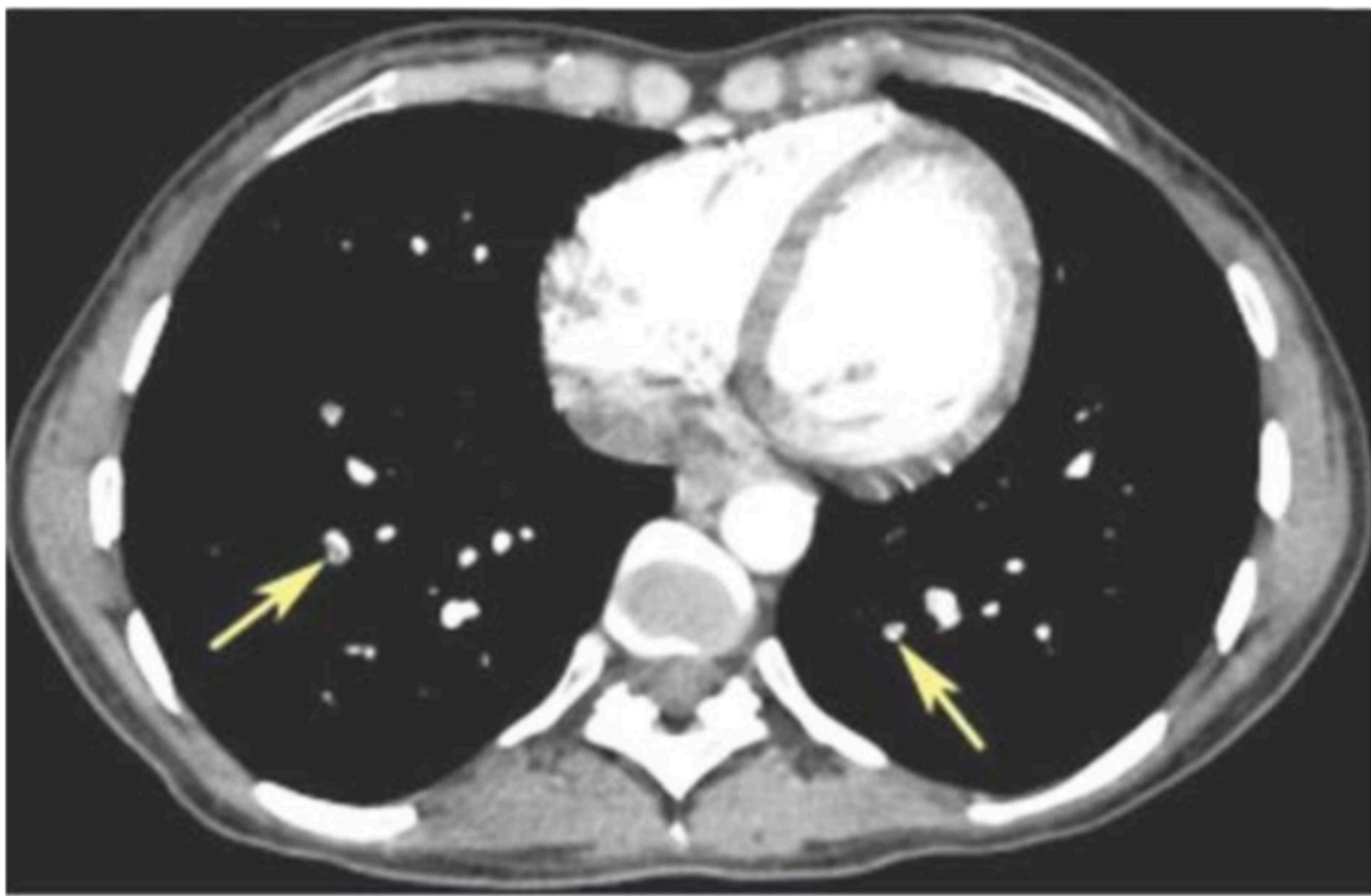
# Data from wearables



# Heart rate variability



# Image Analysis for Pulmonary Emboli



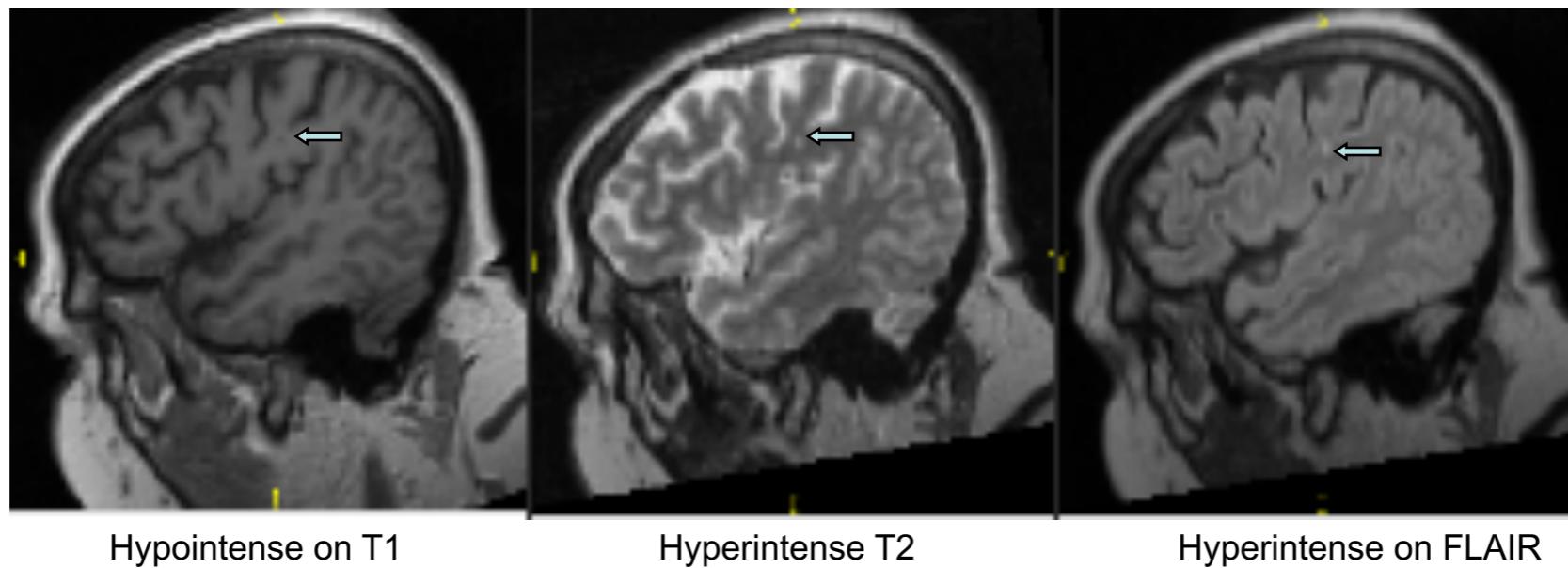
**Figure 2:** Bilateral pulmonary emboli in third and fourth order branch points of the pulmonary arteries. Small emboli distally located can be a diagnostic challenge.



# Lupus Lesions



- Automatic Analysis of White Matter Abnormalities in Neuropsychiatric SLE (Lupus)
- About 1.5 Million Americans with Lupus, Underlying Pathologic Processes Unknown – Possibly Vascular



8

National Alliance for Medical Image Computing  
<http://na-mic.org>

Images: Bockholt et al

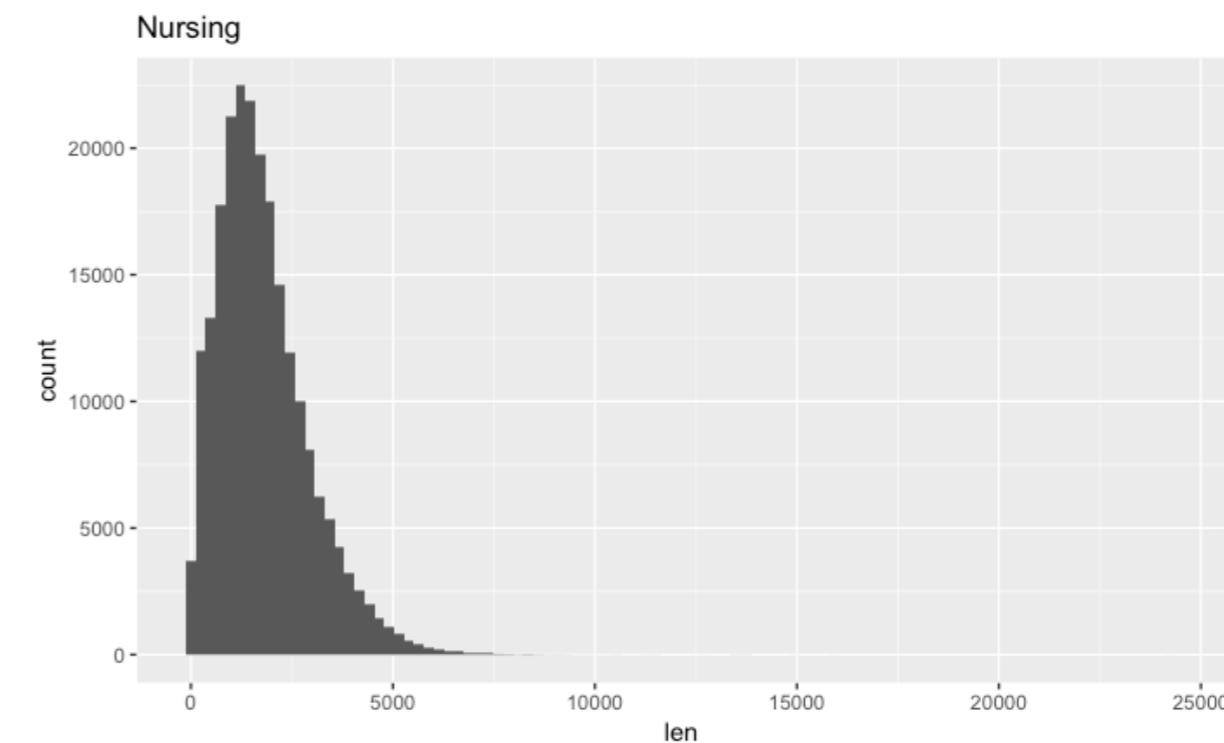
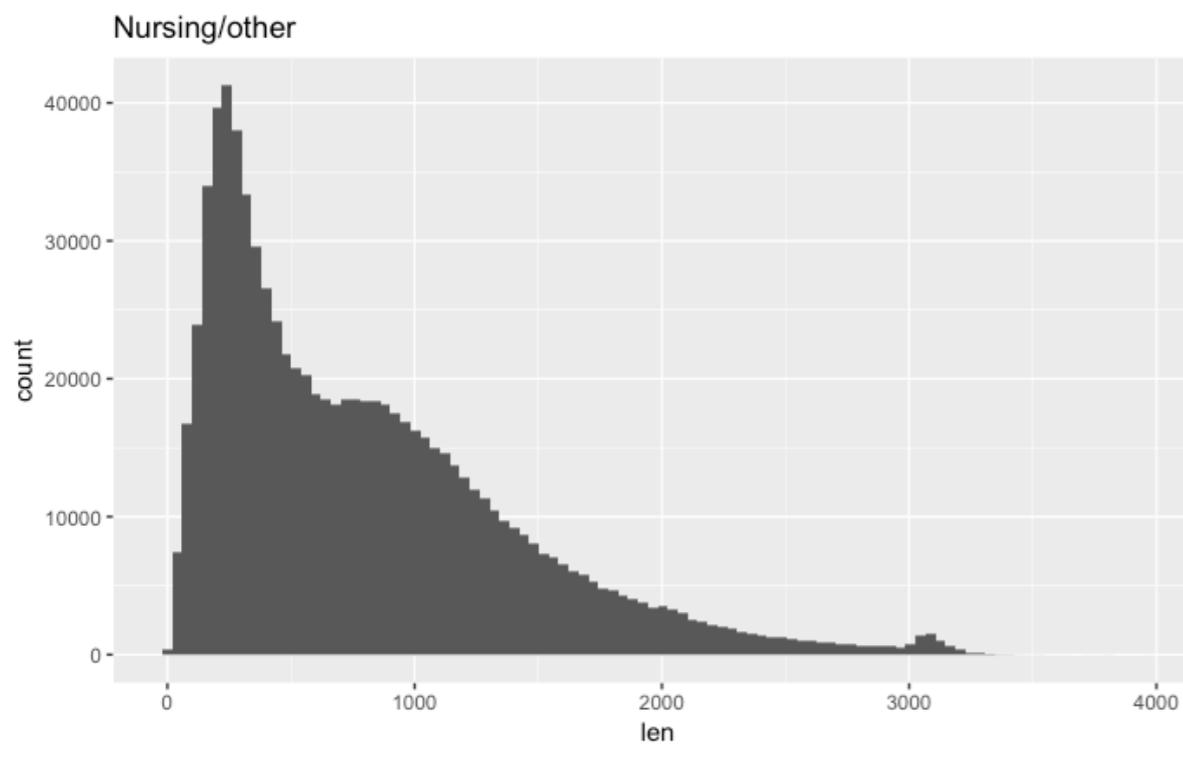
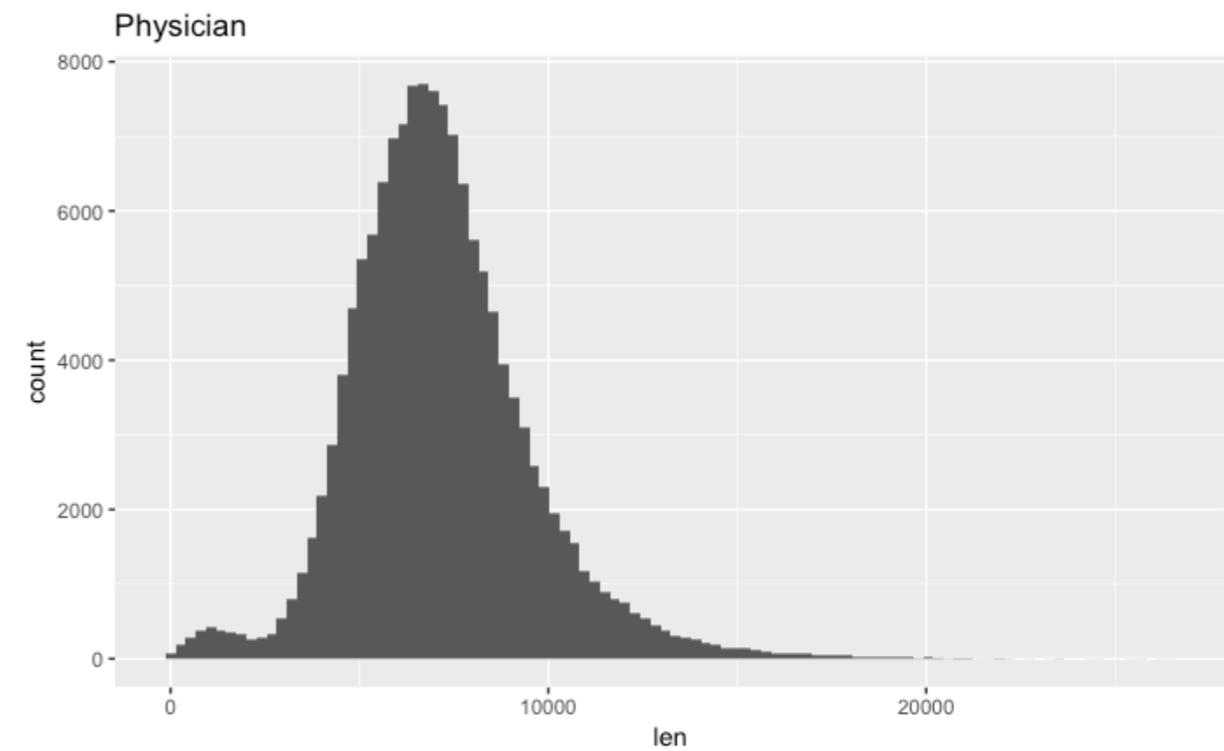
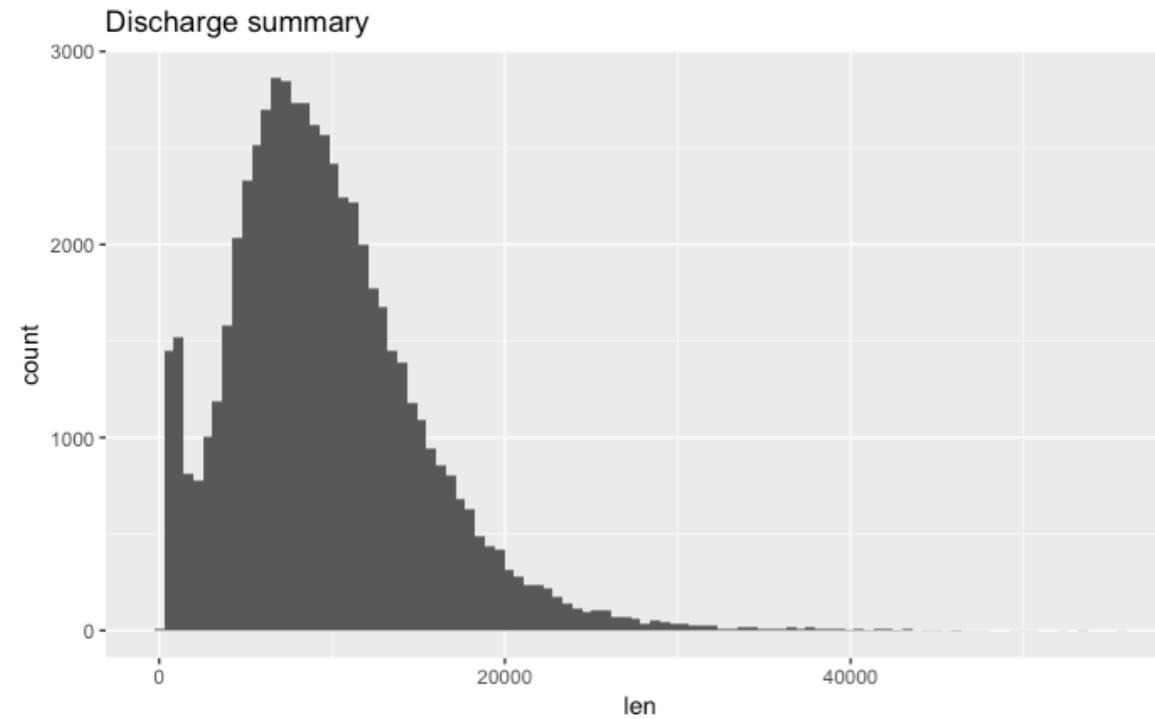
# Clinical Notes in MIMIC

---

Nursing/other	822497
Radiology	522279
Nursing	223556
ECG	209051
Physician	141624
Discharge summary	59652
Echo	45794
Respiratory	31739
Nutrition	9418
General	8301
Rehab Services	5431
Social Work	2670
Case Management	967
Pharmacy	103
Consult	98

# Lengths of different kinds of notes

---



# A brief nursing note

Hypotension (not Shock)

Assessment:

---

Pt remains on phenylephrine drip at 0.75 mcg/kg/min

Action:

No titration needed at this time

Response:

BP stable at > 100, MAP >65

Plan:

Wean Neo if tolerated

Wound infection

Assessment:

Anterior groin area open and oozing mod amts thin pink tinged serous fluid

Pt stooling, with small amts stool on dsg and dangerously close to open wound

Action:

Urology resident in to change dressing

Propofol increased to 100 mcg nad fentanyl 100 mcg given for comfort during dsg change

Flexiseal inserted to help contain bowel movements

Stool sent for c diff.

Response:

Pt comfortable during procedure

Plan:

Continue sedation as needed, increasing Propofol to 100 mcg for sedation during dsg changes.

Keep wound area as clean as possible, check for incontinence of stool as needed

Admission Date: [\*\*2198-7-16\*\*]

Discharge Date: [\*\*2198-7-28\*\*]

Date of Birth: [\*\*2153-5-26\*\*]

Sex: F

Service: SURGERY

Allergies:

No Known Allergies / Adverse Drug Reactions

Attending: [\*\*First Name3 (LF) 1234\*\*]

Chief Complaint:

Leg pain, erythema and swelling secondary to infection of left femoral-popliteal bypass

Major Surgical or Invasive Procedure:

1. Incision and drainage and pulse irrigation of left groin and left above-knee popliteal site incisions with exploration of bypass graft ([\*\*2198-7-16\*\*])
2. Excision of entire left common femoral artery-to-above-knee popliteal artery bypass graft; Repair of common femoral artery and above-knee popliteal artery with harvested left arm cephalic vein ([\*\*2198-7-18\*\*])
3. I and D/washout of left groin with complex wound closure over 2 drains

History of Present Illness:

Ms. [\*\*Known lastname \*\*] is a 45 y/o F who underwent a left fem-AK [\*\*Doctor Last Name \*\*] BPG with PTFE over one month ago on [\*\*2198-6-11\*\*]. She had been doing well postoperatively, and was seen in the clinic 6 days prior to presentation. At this time, she acutely developed nausea/vomiting, fevers, and progressive redness/swelling/pain of her left thigh directly at the surgical incision. She has been unable to keep down food or liquids. At the time, she denied any ischemic-type pain in her lower leg, and denied any chest pain or shortness of breath.

## Discharge Summary

Past Medical History:

PMH: current smoker (1-PPD), cocaine abuse (ceased 6-months prior), asthma, diabetes type 2

PSH: bilateral lower extremity angiograms ([\*\*2198-5-10\*\*]), L knee surgery x2, appendectomy, tonsillectomy, L fem-AK [\*\*Doctor Last Name \*\*] [\*\*2198-6-11\*\*]

Social History:

Moving in with her boyfriend. She has one child. She is unemployed.

Smokes 1.5 ppd

Former cocaine use. (urine tox pos [\*\*2197-11-22\*\*], but pt denied use for 2 years)

Drinks 5-6 drinks on weekends.

Hx of domestic violence.

Family History:

Mother had an abdominal aortic aneurysm status post repair, MI in her mid 50s, carotid stenosis, cervical cancer, coronary artery disease, other vascular lesions which were stented. She died due to complications of a procedure. The patient's father died young. The patient has one cousin with cervical cancer. Her maternal grandmother had an MI in her 60s. Maternal grandfather with MI, hypertension, and hypercholesterolemia.

**Physical Exam:**

Upon presentation,

Vital Signs: Temp: 101.9 RR: 16 Pulse: 98 BP: 114/62

Neuro/Psych: Oriented x3, Affect Normal.

Neck: No masses, Trachea midline, No right carotid bruit, No left carotid bruit.

Nodes: No clavicular/cervical adenopathy, No inguinal adenopathy.

Skin: Abnormal: Cellulitis L thigh.

Heart: Regular rate and rhythm.

Lungs: Clear, Normal respiratory effort.

Gastrointestinal: Non distended, No hepatosplenomegally, No hernia, No AAA.

Rectal: Not Examined.

Extremities: No popliteal aneurysm, No femoral bruit/thrill, No RLE edema, No LLE Edema, No varicosities, abnormal: Tenderness, erythema of L thigh.

Pulse Exam (P=Palpation, D=Dopplerable, N=None)

RUE Radial: P.

LUE Radial: P.

RLE Femoral: P. Popliteal: P. DP: P. PT: P.

LLE Femoral: P. Popliteal: P. DP: P. PT: P. Other: Graft: palp.

**DESCRIPTION OF WOUND:** R thigh incision without breakdown, but tender, erythematous, and swollen especially superiorly. No evidence of drainage or underlying fluctuance. pulses all palpable

Pertinent Results:

[\*\*2198-7-16\*\*] 02:30AM BL00D WBC-7.4 RBC-3.21\*# Hgb-9.6\* Hct-27.6\*  
MCV-86 MCH-29.9 MCHC-34.7 RDW-13.6 Plt Ct-161

[\*\*2198-7-19\*\*] 05:54AM BL00D WBC-5.6 RBC-3.32\* Hgb-10.2\* Hct-28.7\*  
MCV-87 MCH-30.7 MCHC-35.5\* RDW-14.1 Plt Ct-184

[\*\*2198-7-27\*\*] 05:06AM BL00D WBC-7.8 RBC-2.98\* Hgb-9.0\* Hct-26.9\*  
MCV-90 MCH-30.4 MCHC-33.6 RDW-15.8\* Plt Ct-398

[\*\*2198-7-16\*\*] 09:05AM BL00D PT-13.9\* PTT-36.4\* INR(PT)-1.2\*

[\*\*2198-7-19\*\*] 05:54AM BL00D PT-13.1 PTT-29.8 INR(PT)-1.1

[\*\*2198-7-16\*\*] 02:30AM BL00D Glucose-177\* UreaN-20 Creat-1.0 Na-135  
K-3.7 Cl-99 HC03-23 AnGap-17

[\*\*2198-7-27\*\*] 05:06AM BL00D Glucose-72 UreaN-10 Creat-0.6 Na-142  
K-3.5 Cl-108 HC03-27 AnGap-11

[\*\*2198-7-17\*\*] 10:15PM BL00D CK(CPK)-99

[\*\*2198-7-27\*\*] 05:06AM BL00D Calcium-8.3\* Phos-4.6\* Mg-1.9

[\*\*2198-7-16\*\*] 02:30AM URINE Blood-TR Nitrite-NEG Protein-100  
Glucose-NEG Ketone-NEG Bilirub-NEG Urobiln-NEG pH-5.5 Leuks-SM

Blood Culture, Routine (Final [\*\*2198-7-22\*\*]): NO GROWTH.

**Brief Hospital Course:**

The patient was admitted to the surgery service for evaluation and treatment of her lower extremity bypass graft infection.

**Neuro:** The patient received IV pain medications with good effect and adequate pain control. When tolerating oral intake, the patient was transitioned to oral pain medications.

**CV:** The patient was stable from a cardiovascular standpoint; vital signs were routinely monitored.

**Pulmonary:** The patient was stable from a pulmonary standpoint; vital signs were routinely monitored. Good pulmonary toilet, early ambulation and incentive spirometry were encouraged throughout this hospitalization.

**GI/GU/FEN:**

Post operatively, the patient was made NPO with IVF. The patient's diet was advanced when appropriate, which was tolerated well.

The patient's intake and output were closely monitored, and IVF were adjusted when necessary. The patient's electrolytes were routinely followed during this hospitalization, and repleted when necessary.

**ID:** The patient's white blood count and fever curves were closely watched for signs of infection. Final blood cultures were negative.

**Endocrine:** The patient's blood sugar was monitored throughout this stay; insulin dosing was adjusted accordingly and kept within normal range.

**Hematology:** The patient's complete blood count was examined routinely; no transfusions were required during this stay.

**Prophylaxis:** The patient received subcutaneous heparin during this stay, and was encouraged to get up and ambulate as early as possible.

At the time of discharge, the patient was doing well, afebrile with stable vital signs. The patient was tolerating a regular diet, ambulating, voiding without assistance, and pain was well controlled.

**Medications on Admission:**

Albuterol INH PRN

Fexofenadine 60mg 1 tablet [\*\*Hospital1 \*\*]

Fluticasone 50mcg two puffs daily

Percocet PRN

Glargine 35 units

Humalog SS

Lisinopril 40mg qd

Crestor 40mg qd

Metformin 1000mg [\*\*Hospital1 \*\*]

Reglan 5QACHS

Protonix 40mg qd

Tizanidine 4PRN

ASA 81mg qd

**Discharge Medications:**

1. albuterol sulfate 90 mcg/Actuation HFA Aerosol Inhaler Sig:  
Two (2) Puff Inhalation Q4H (every 4 hours) as needed for wheeze.
2. fexofenadine 60 mg Tablet Sig: One (1) Tablet PO BID (2 times a day).
3. fluticasone-salmeterol 100–50 mcg/dose Disk with Device Sig:  
One (1) Disk with Device Inhalation [\*\*Hospital1 \*\*] (2 times a day).
4. rosuvastatin 20 mg Tablet Sig: Two (2) Tablet PO DAILY (Daily).
5. aspirin 81 mg Tablet, Chewable Sig: One (1) Tablet, Chewable PO DAILY (Daily).
6. docusate sodium 100 mg Capsule Sig: One (1) Capsule PO BID (2 times a day).
7. hydromorphone 2 mg Tablet Sig: One (1) Tablet PO Q4H (every 4 hours) as needed for pain.

Disp: \*30 Tablet(s)\* Refills: \*0\*

8. pantoprazole 40 mg Tablet, Delayed Release (E.C.) Sig: One (1) Tablet, Delayed Release (E.C.) PO Q24H (every 24 hours).
9. dicloxacillin 500 mg Capsule Sig: One (1) Capsule PO Q6H (every 6 hours) for 4 weeks: Take 1 tablet every 4 hours for a total 4 week course. First day was [\*\*7-27\*\*].
10. lisinopril 40 mg Tablet Sig: One (1) Tablet PO DAILY (Daily).
11. cilostazol 100 mg Tablet Sig: One (1) Tablet PO BID (2 times a day)
12. Metformin 1000mg [\*\*Hospital1 \*\*]
13. Humalog SS
14. Glargin 35 units (at discretion of patient while monitoring blood sugars, to be followed-up by PCP)

**Discharge Disposition:**

Home With Service

**Facility:**

[\*\*Hospital 119\*\*] Homecare

**Discharge Diagnosis:**  
Infected left femoral-popliteal bypass graft

**Discharge Condition:**  
**Mental Status:** Clear and coherent.  
**Level of Consciousness:** Alert and interactive.  
**Activity Status:** Ambulatory – Independent

**Discharge Instructions:**

What activities you can and cannot do:

?????? When you go home, you may walk and go up and down stairs with an ace-wrap or compression stocking on your left leg.

?????? You may shower (let the soapy water run over groin incision, rinse and pat dry)

?????? Your incision may be left uncovered, unless you have small amounts of drainage from the wound, then place a dry dressing or band aid over the area that is draining, as needed

–Monitor drainage from both JP drains. If either drains less than 20cc in one day, please call Dr. [\*\*Last Name (STitle) 2866\*\*] at his clinic (see number below). Your visiting nurse will teach you how to monitor and care for your drains.

?????? No heavy lifting, pushing or pulling (greater than 5 lbs) for 1 week (to allow groin puncture to heal)

?????? After 1 week, you may resume sexual activity

?????? After 1 week, gradually increase your activities and distance walked as you can tolerate

?????? No driving until you are no longer taking pain medications

?????? Call and schedule an appointment to be seen in [\*\*4-6\*\*] weeks for post procedure check and ultrasound

What to report to office:

?????? Numbness, coldness or pain in lower extremities  
?????? Temperature greater than 101.5F for 24 hours  
?????? New or increased drainage from incision or white, yellow or green drainage from incisions  
?????? Bleeding from groin puncture site

SUDDEN, SEVERE BLEEDING OR SWELLING (Groin puncture site)

?????? Lie down, keep leg straight and have someone apply firm pressure to area for 10 minutes. If bleeding stops, call vascular office [\*\*Telephone/Fax (1) 1237\*\*]. If bleeding does not stop, call 911 for transfer to closest Emergency Room.

Followup Instructions:

Please follow-up with Dr. [\*\*Last Name (STitle) \*\*] on [\*\*8-7\*\*]: call his clinic at ([\*\*Telephone/Fax (1) 2867\*\*] to schedule an appointment.

Please follow-up with Dr. [\*\*Last Name (STitle) 2866\*\*] in two weeks; call his clinic at ([\*\*Telephone/Fax (1) 2868\*\*] to schedule an appointment.

Completed by: [\*\*2198-7-31\*\*]

# Data Standards

- OHDSI
- FHIR (Fast Healthcare Interoperability Resources) — pronounced “fire”
  - HL7

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<Patient xmlns="http://hl7.org/fhir">
  <id value="glossy"/>
  <meta>
    <lastUpdated value="2014-11-13T11:41:00+11:00"/>
  </meta>
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>Henry Levin the 7th</p>
      <p>MRN: 123456. Male, 24-Sept 1932</p>
    </div>
  </text>
  <extension url="http://example.org/StructureDefinition/trials">
    <valueCode value="renal"/>
  </extension>
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      <coding>
        <system value="http://hl7.org/fhir/v2/0203"/>
        <code value="MR"/>
      </coding>
    </type>
    <system value="http://www.goodhealth.org/identifiers/mrn"/>
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  </identifier>
  <active value="true"/>
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    <given value="Henry"/>
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  <gender value="male"/>
  <birthDate value="1932-09-24"/>
  <careProvider>
    <reference value="Organization/2"/>
    <display value="Good Health Clinic"/>
  </careProvider>
</Patient>
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Resource Identity & Metadata

Human Readable Summary

Extension with URL to definition

Standard Data:

- MRN
- Name
- Gender
- Birth Date
- Provider

# Terminology Standards

---

- LOINC
- NDC
- ICD-9, ICD-10
- SNOMED
- DSM-5
- ...
- all gathered in the UMLS Metathesaurus
  - <https://uts.nlm.nih.gov/home.html>

# Take-away lessons

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- Know your data!
- “Harmonization” is difficult and time-consuming
- Standards are often lacking