



Deep dive into clinical data

HST.956/6.S897

Feb 12, 2019



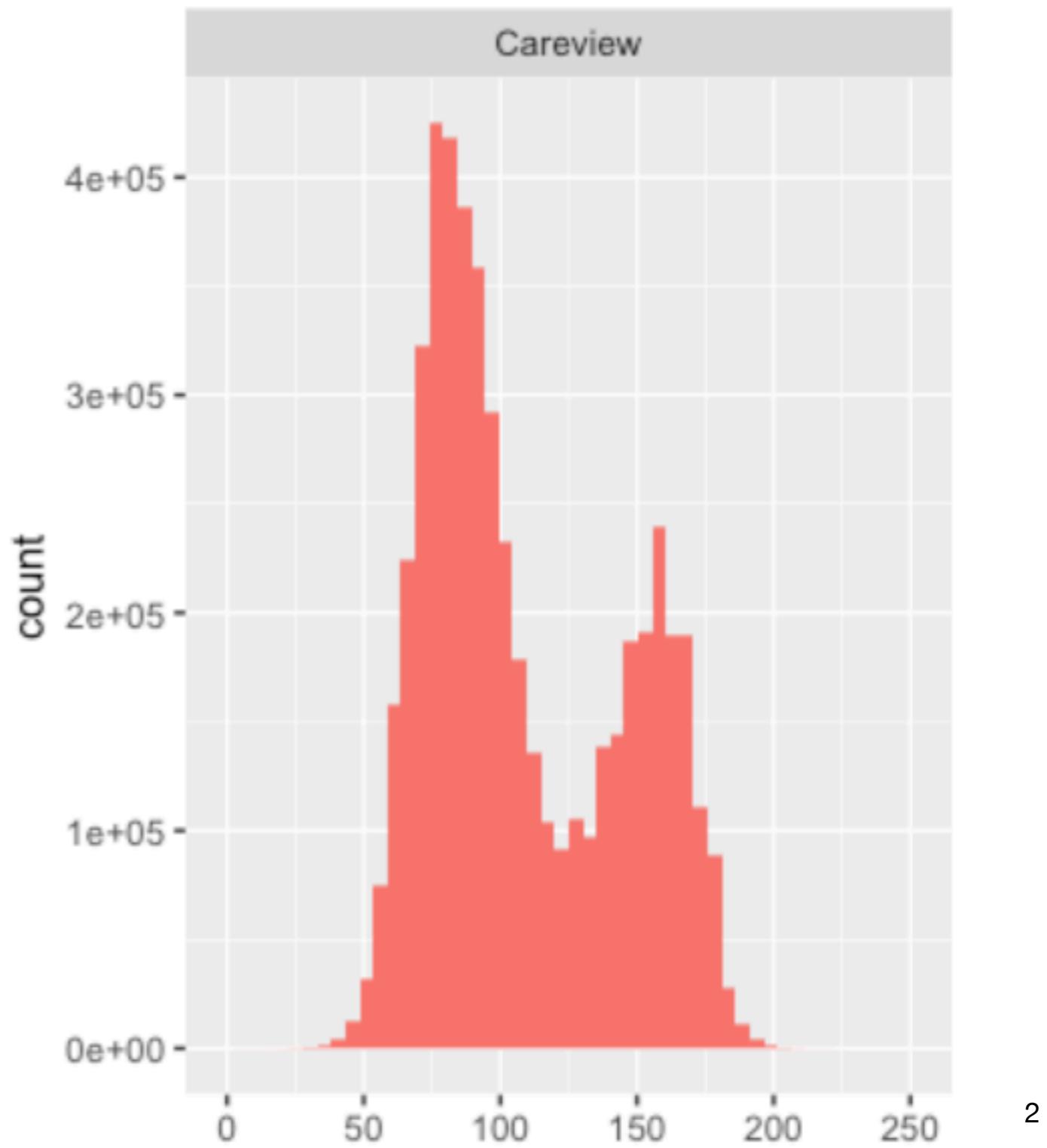
Massachusetts
Institute of
Technology

Understanding clinical data

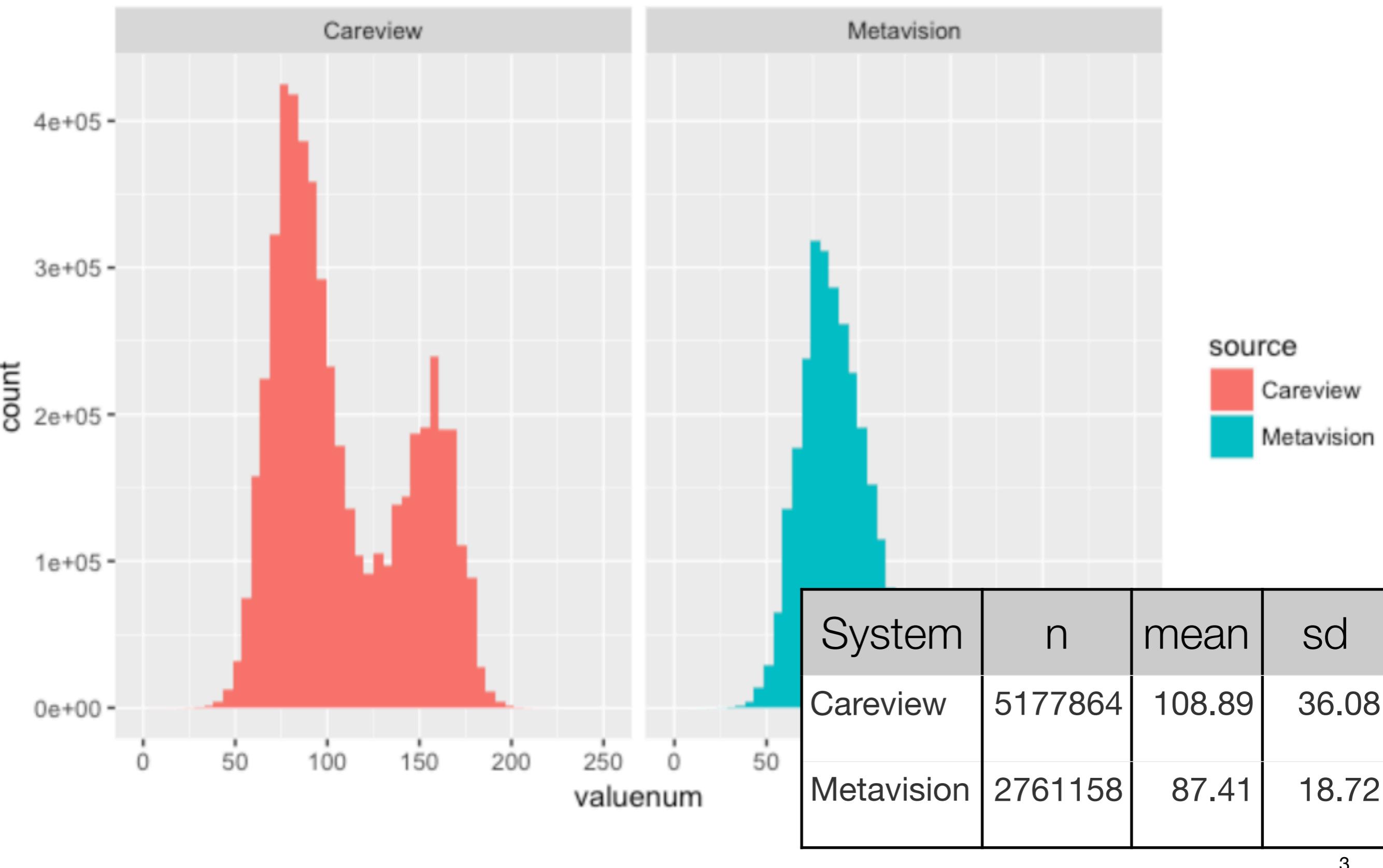
- Consider the distribution of heart rates in the MIMIC-III chart (as recorded in Careview)



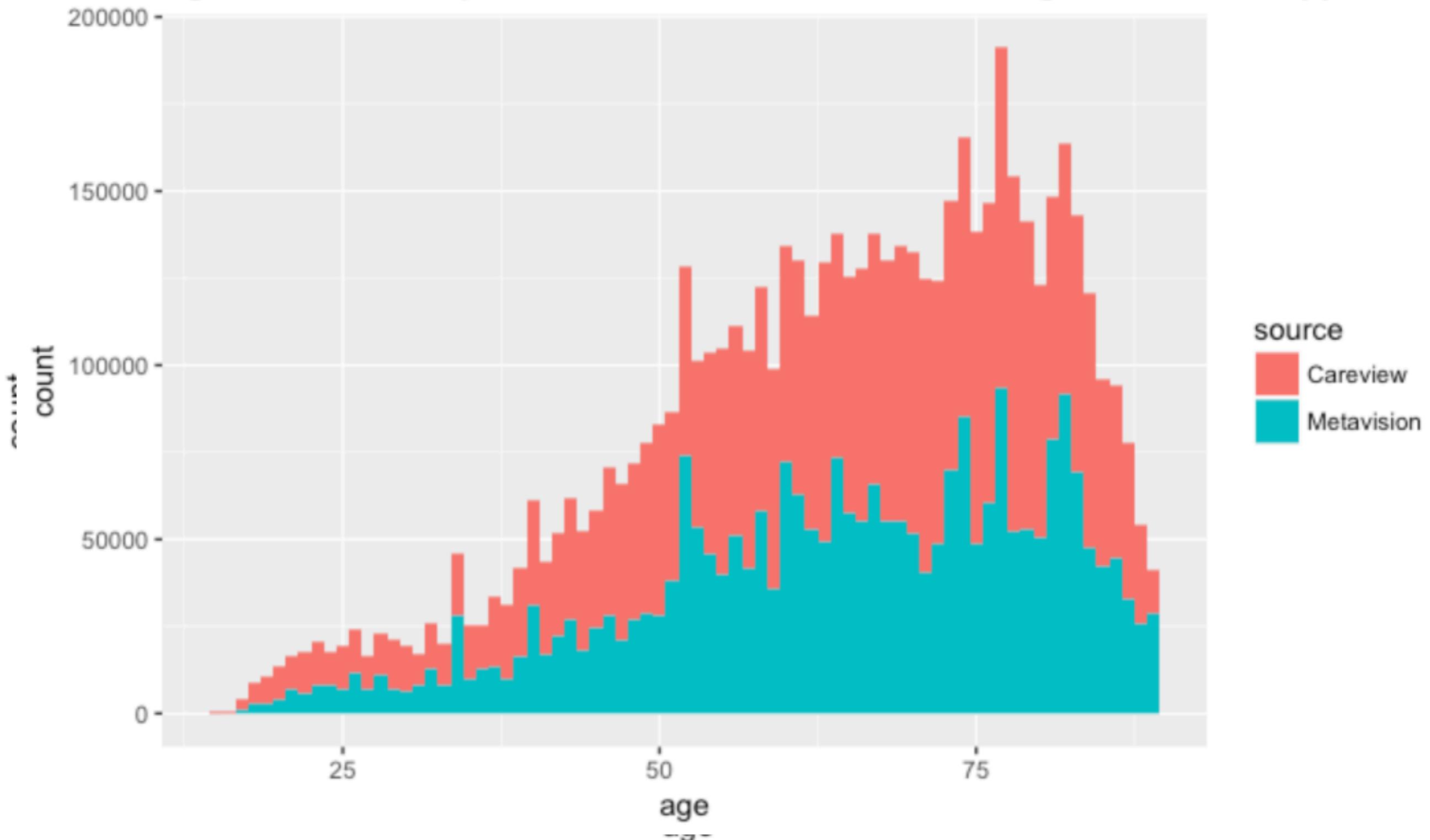
Data from <https://mimic.physionet.org>



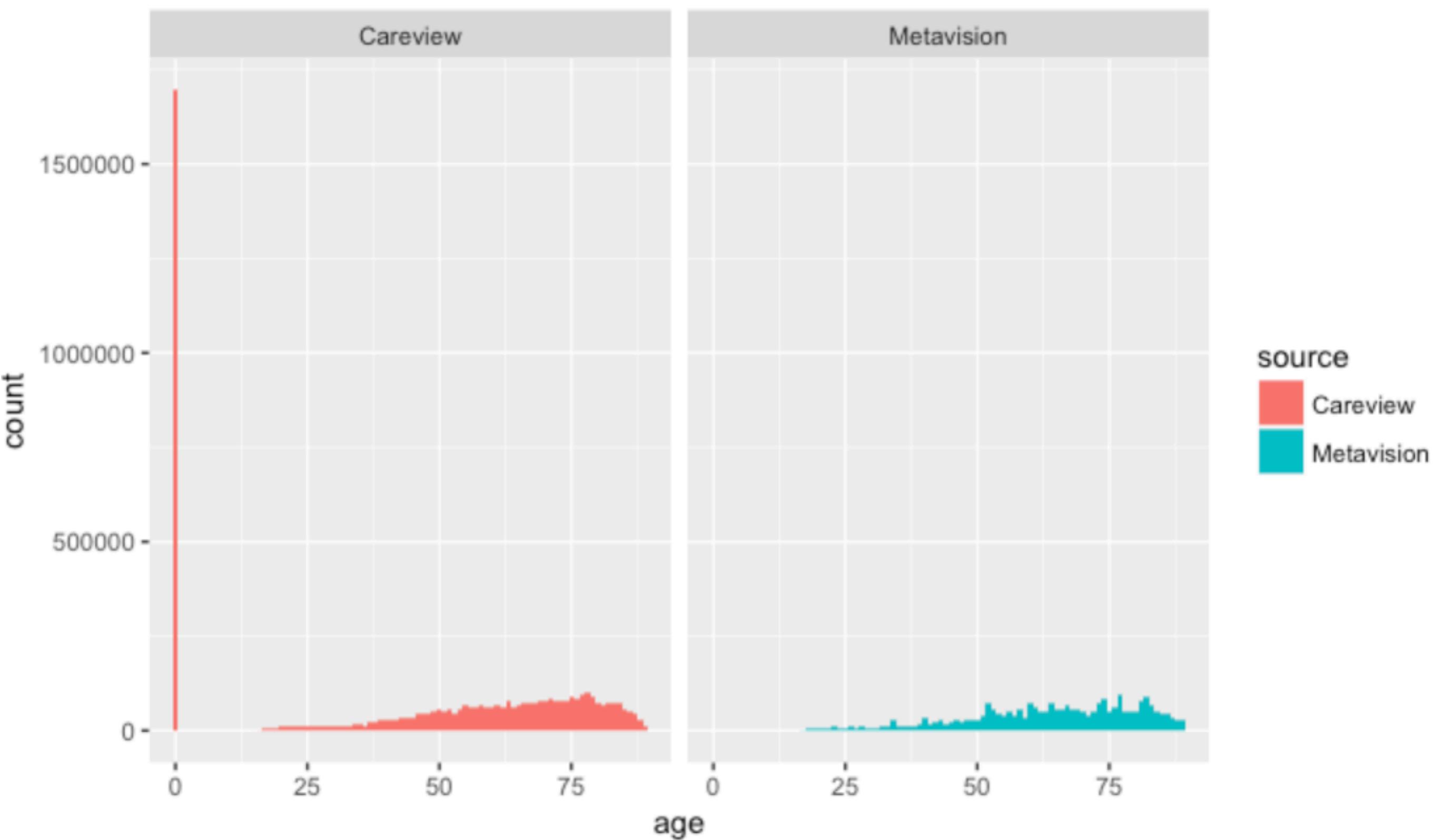
Comparison of Careview and Metavision heart rates, outliers removed



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

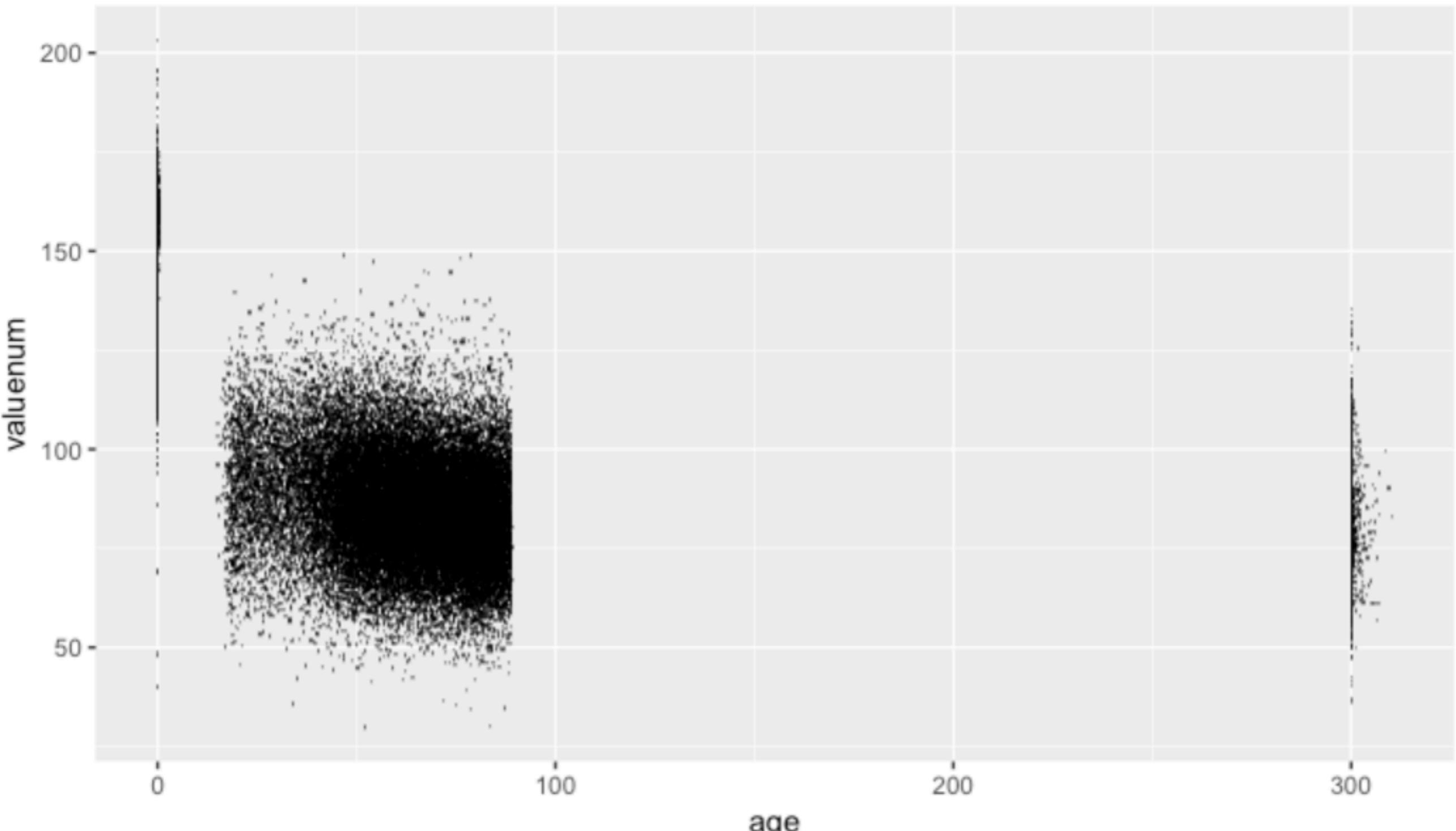


Age distribution of patients with recorded heart rates, age ≥ 90 suppressed

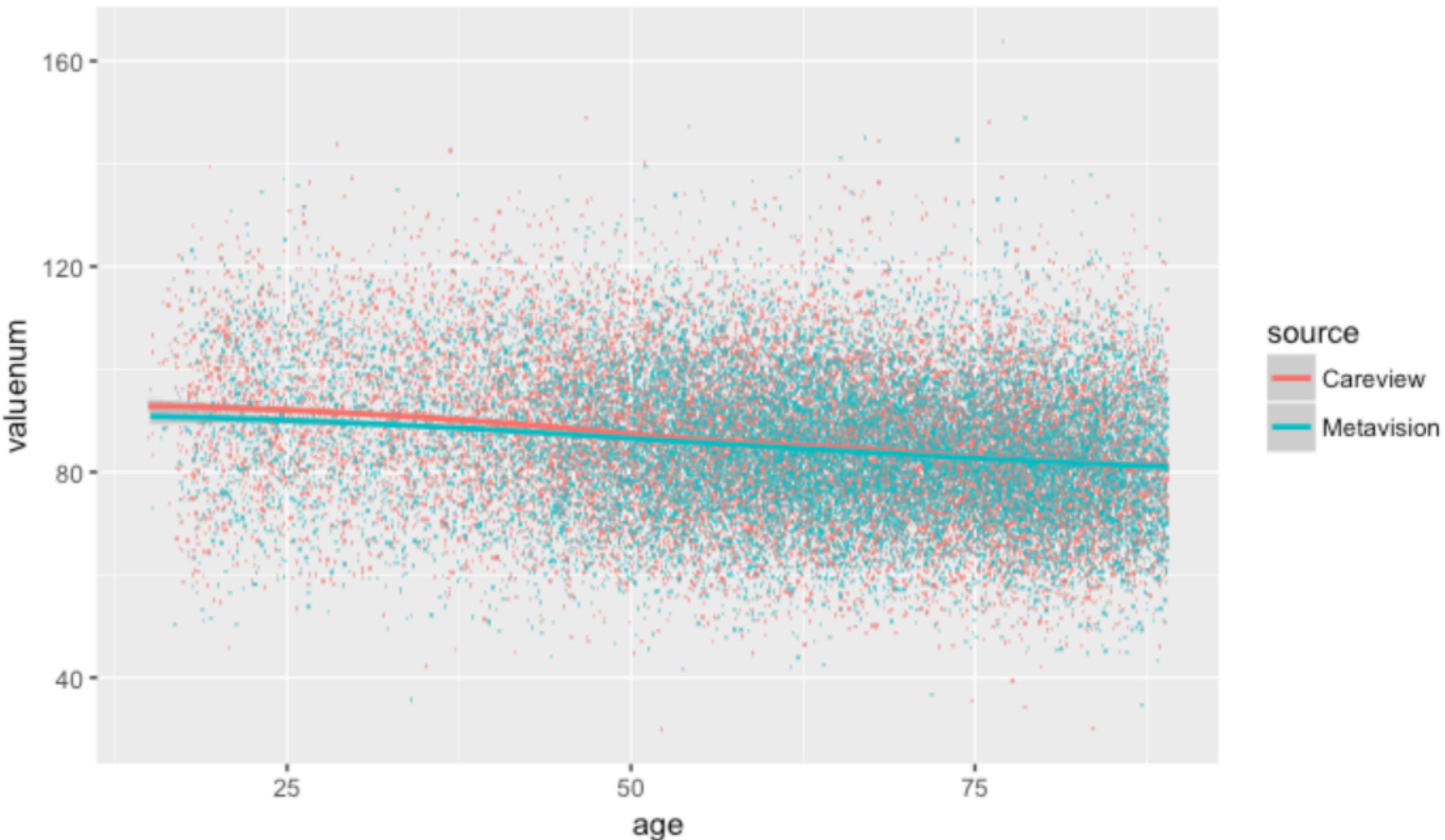


Is Age a confounder for Heart Rate?

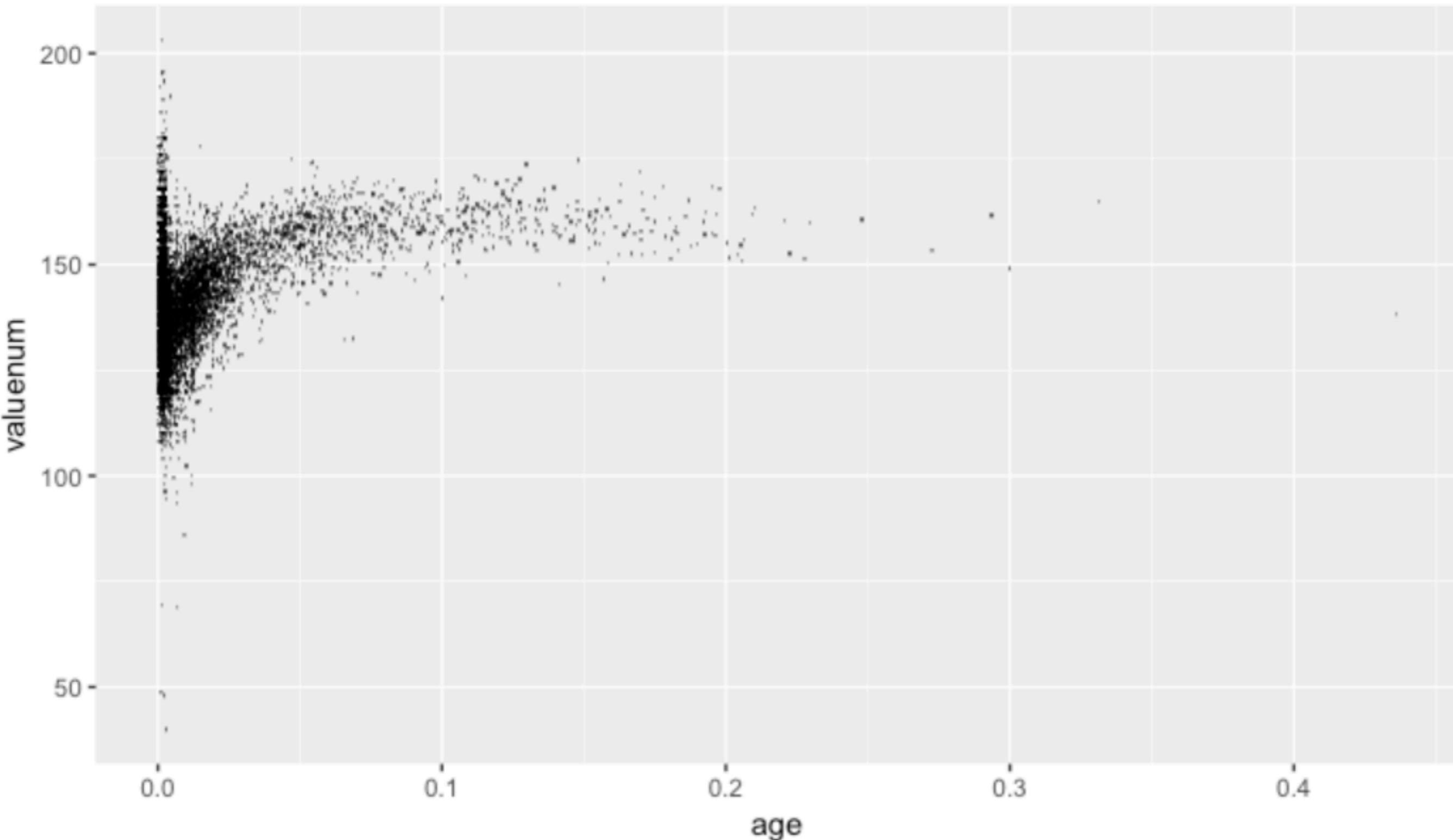
HR vs. Age in entire population



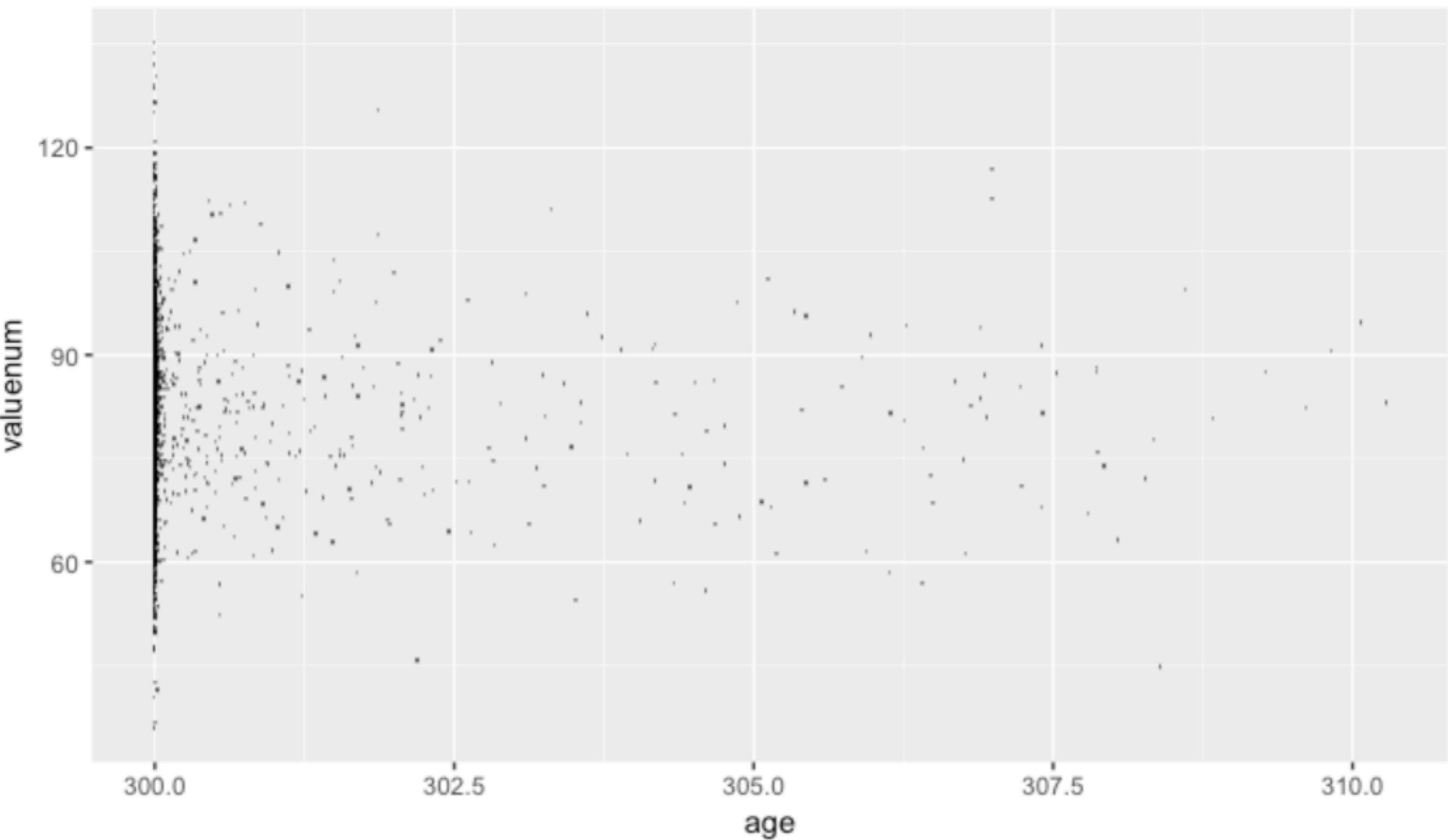
HR vs. Age in adults, smoothed



HR vs. Age in neonates



HR vs. Age in patients over 90



Types of Data

- 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)

- 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)

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

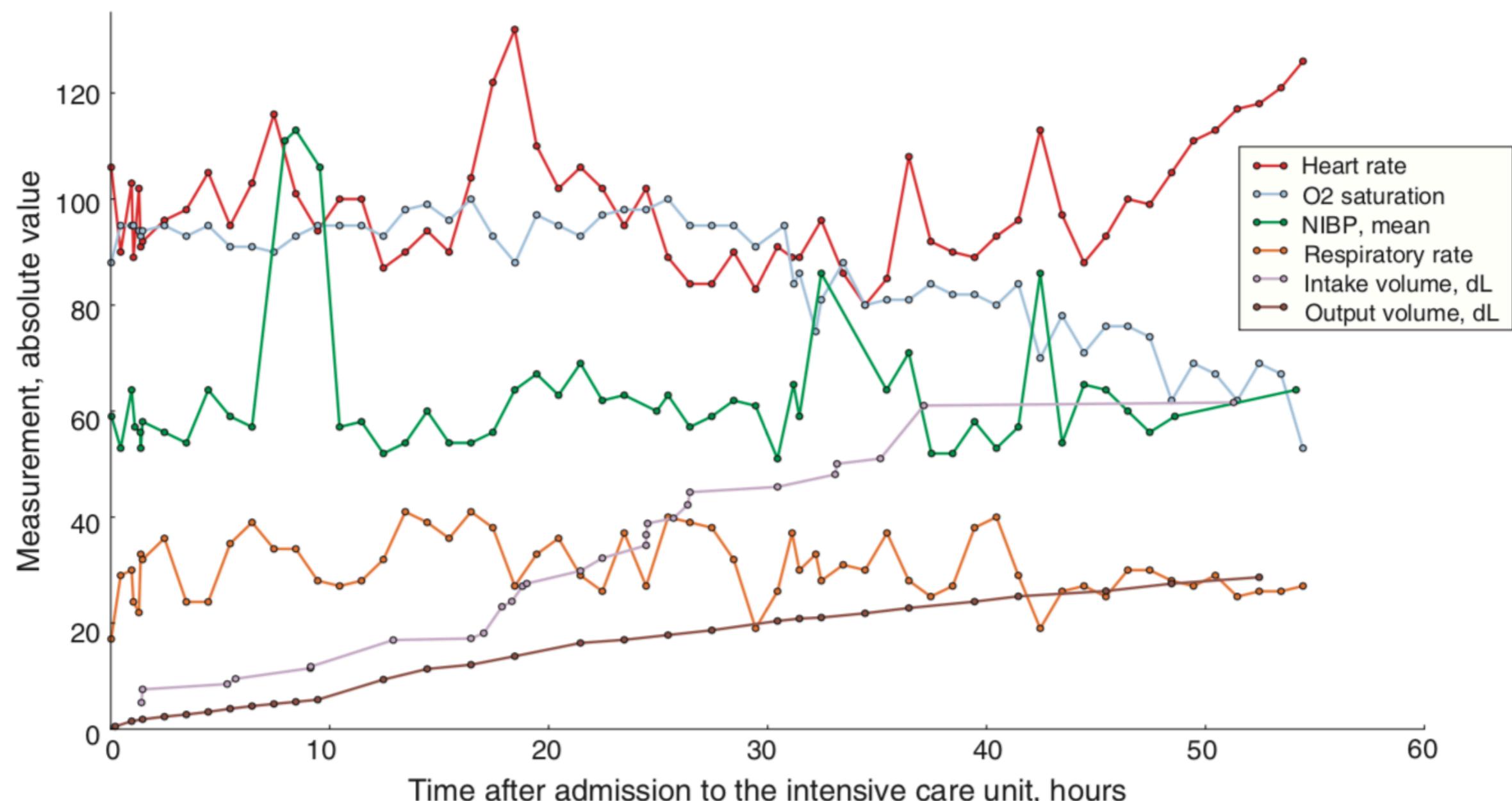
Types of Data (continued)

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

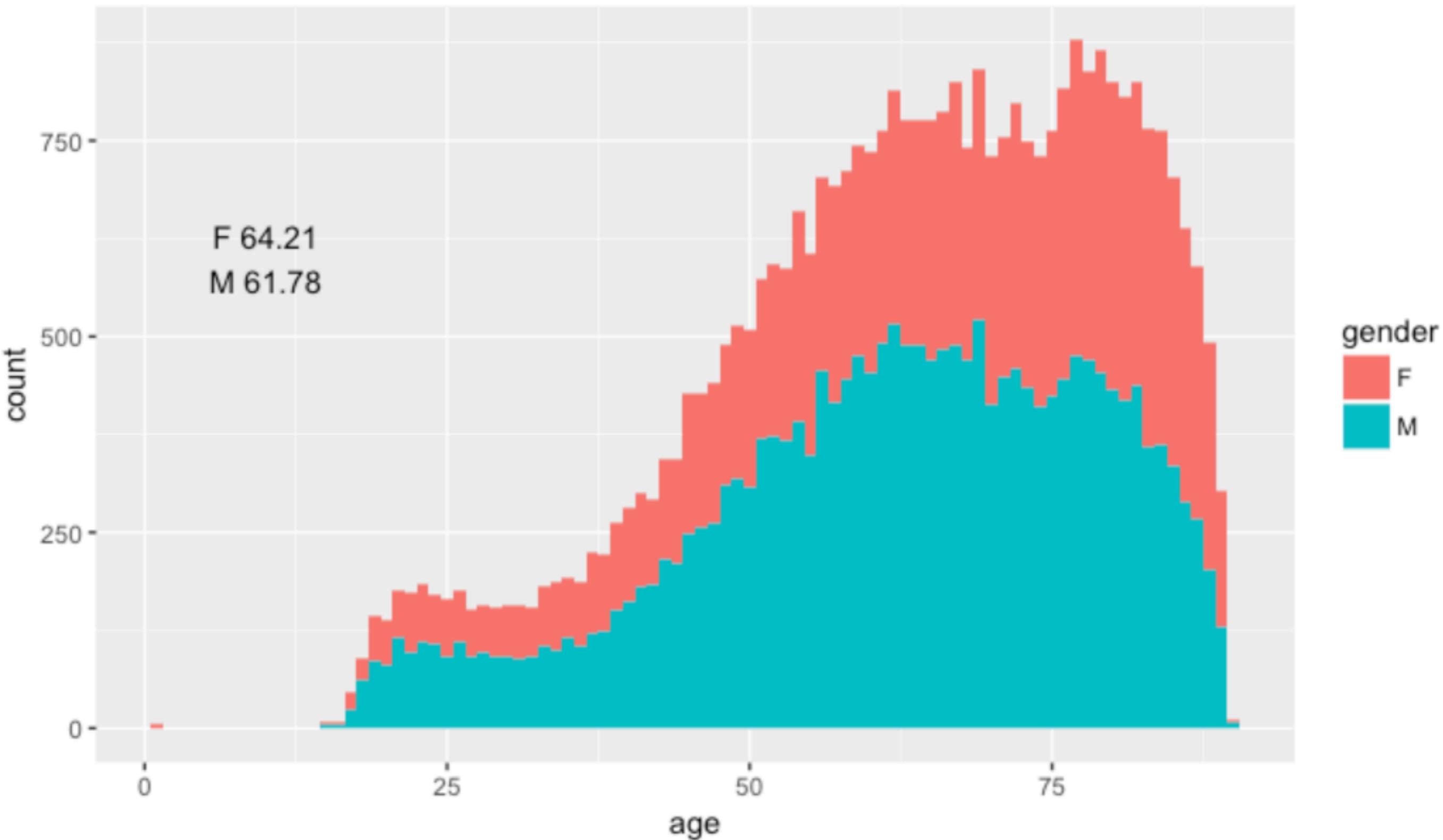
Types of Data (continued)

- 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

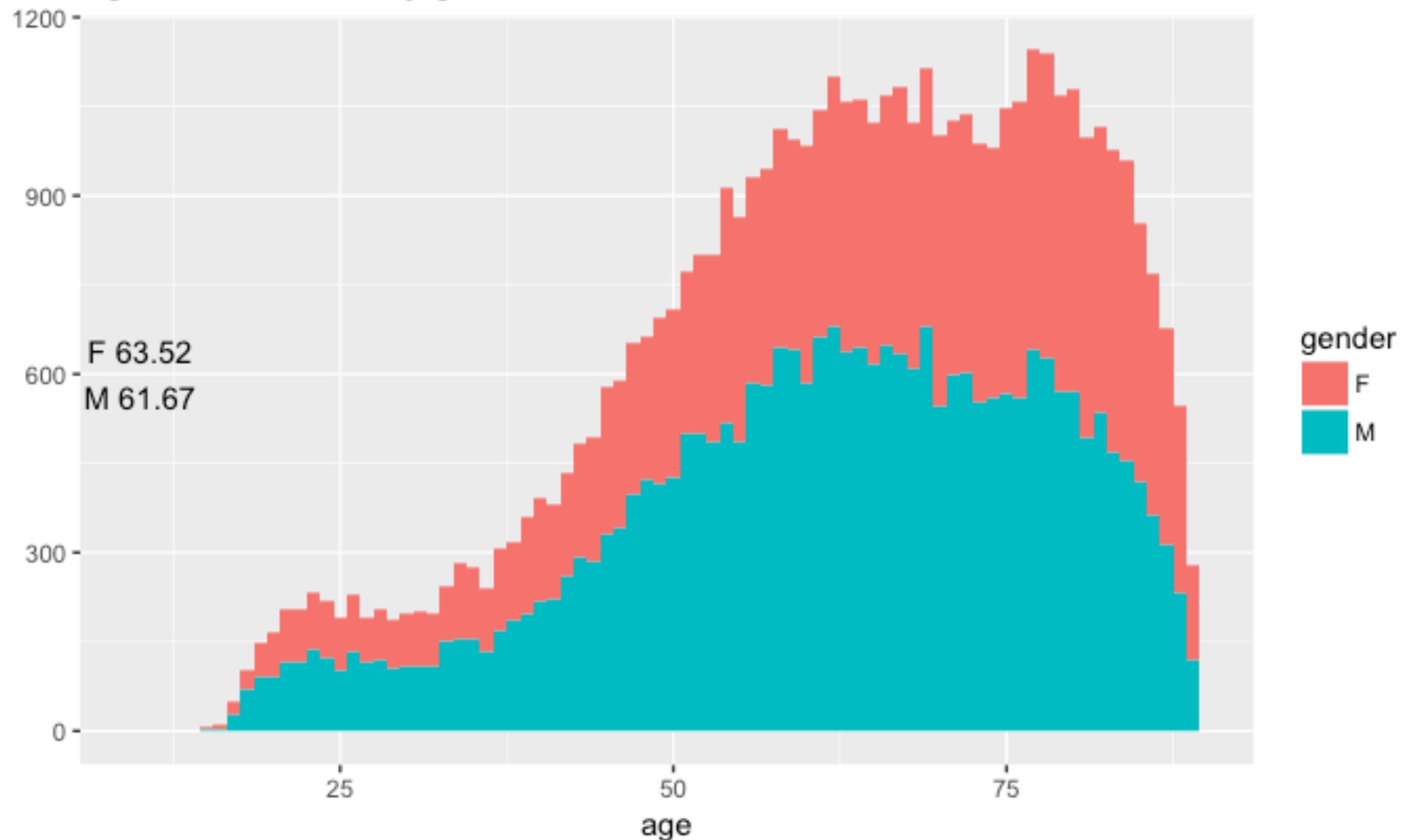
Code status	Full code						Comfort measures
GCS: Verbal	Oriented	Oriented	Oriented	Confused	Confused	Incomprehensible sounds	
GCS: Motor	Obeys commands	Flex-withdraws					
GCS: Eye	Spontaneously	Spontaneously	Spontaneously	To speech	To speech	None	
Platelet, K/uL	48	53	46			45	
Creatinine, mg/dL	0.7		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



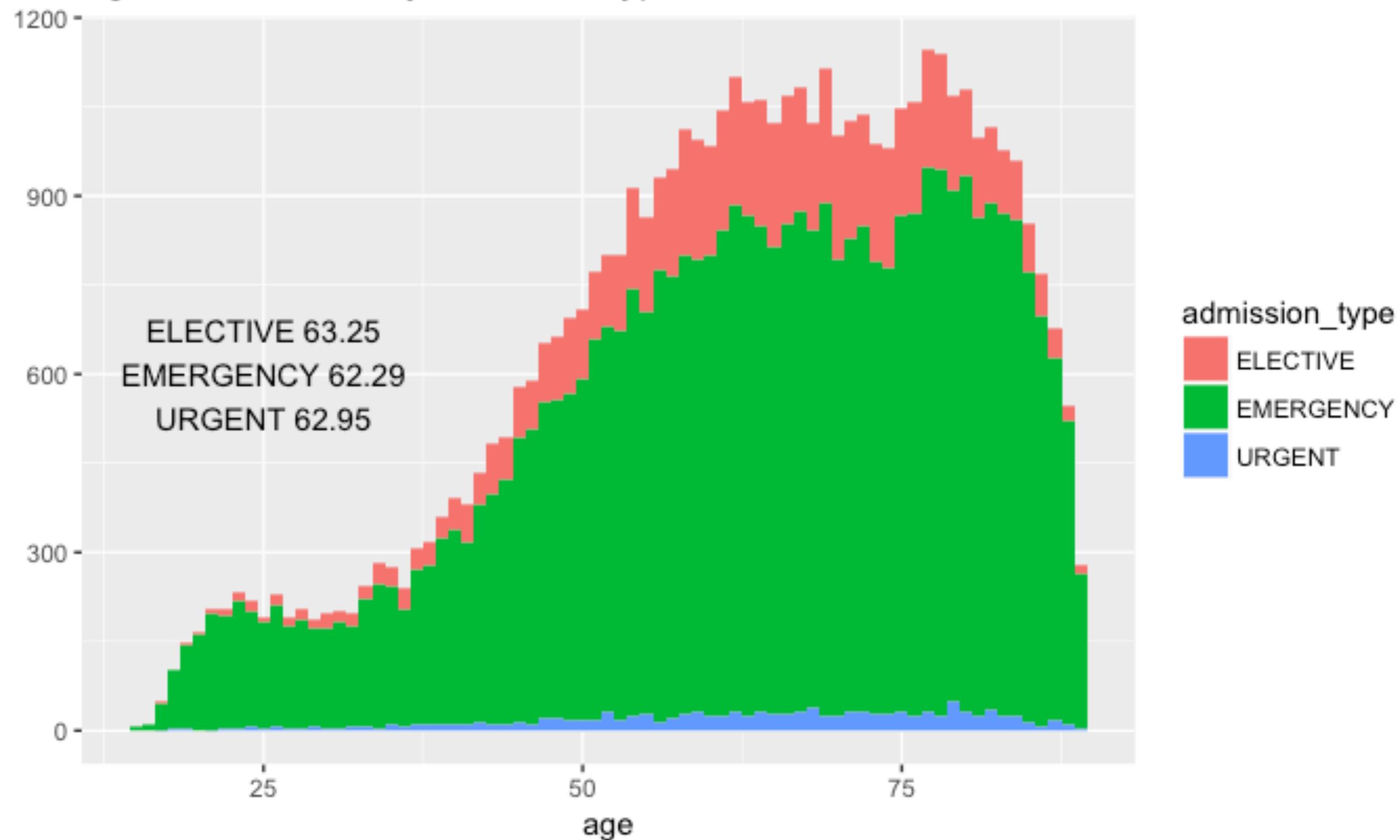
Age at admission, by gender



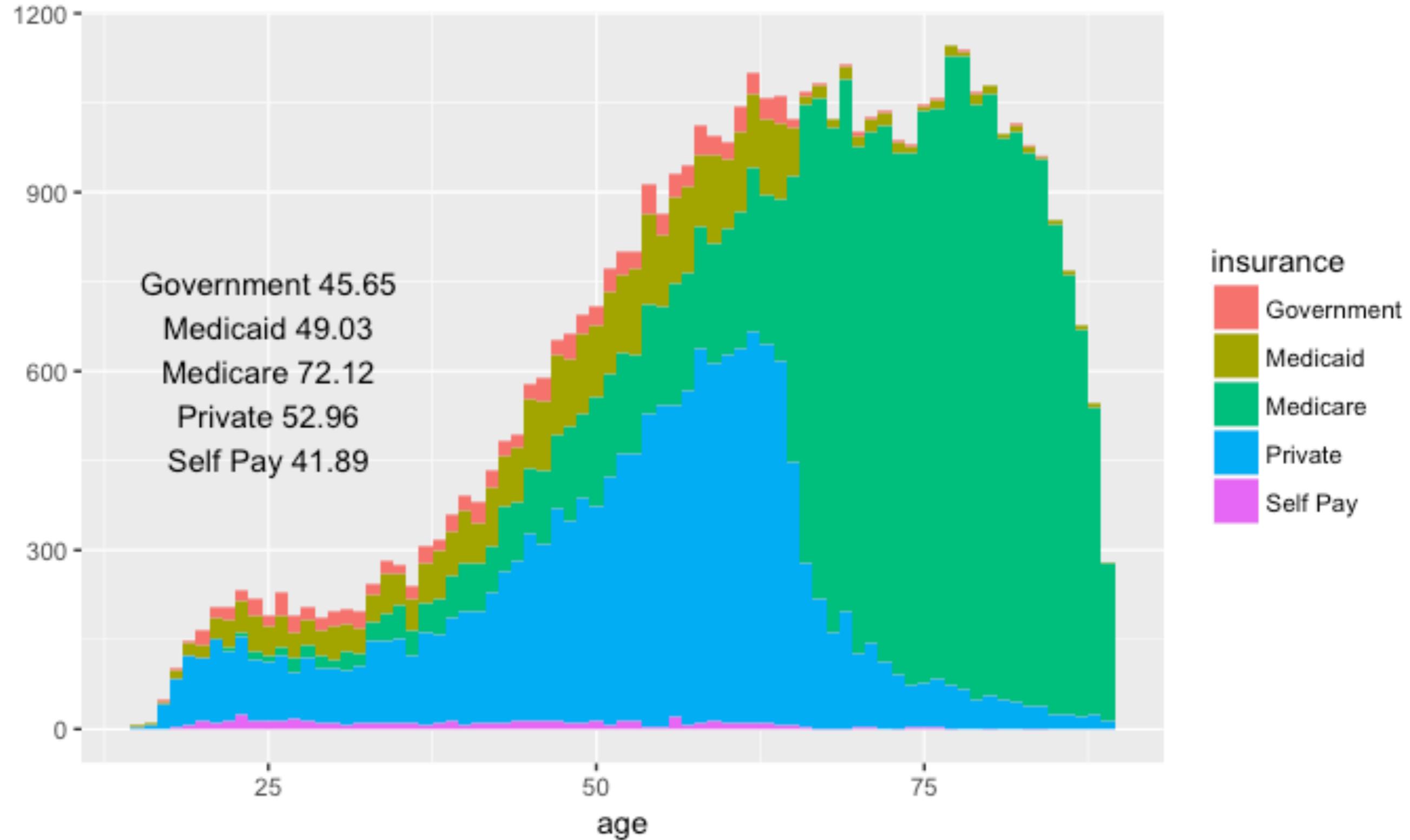
Demographics

- 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

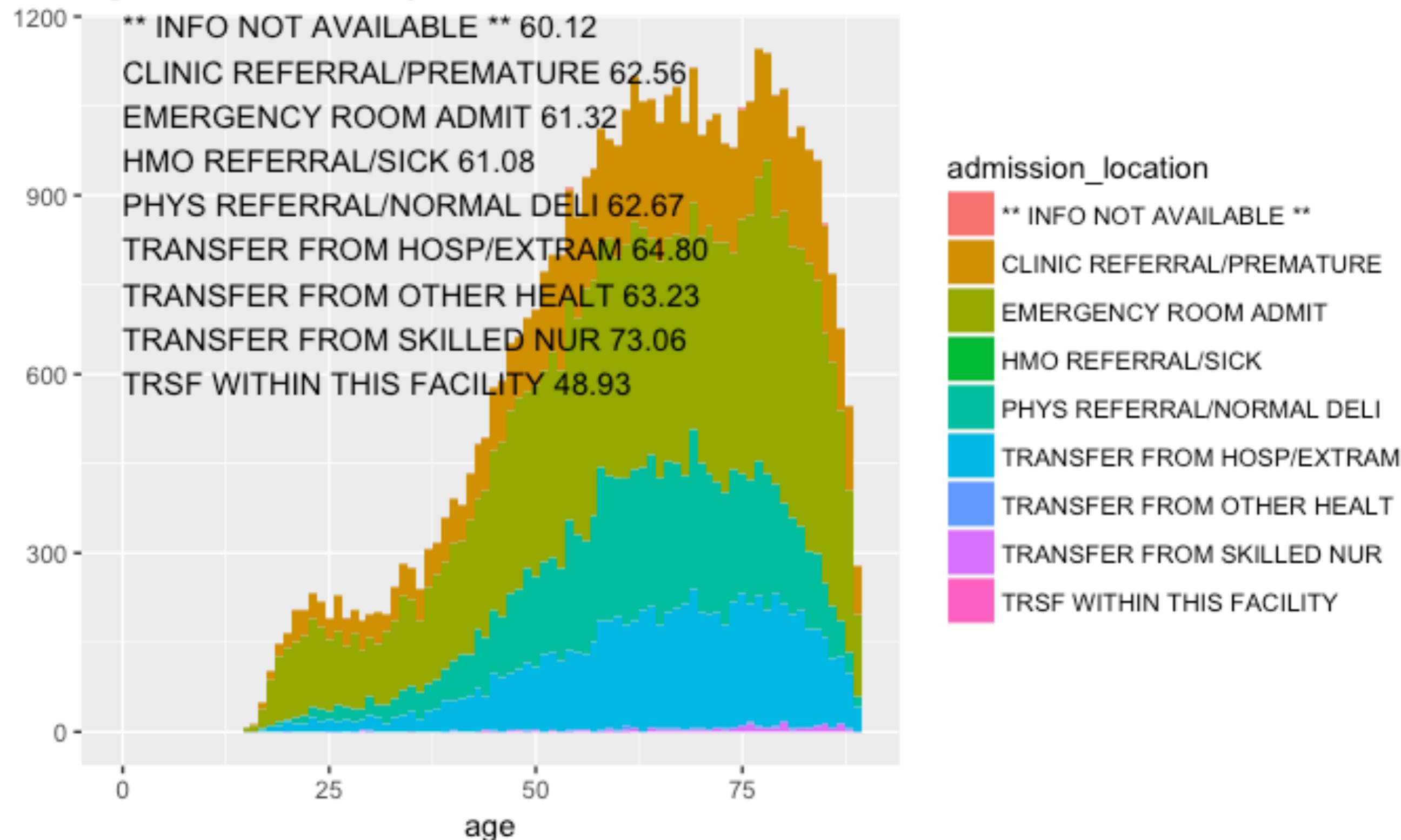
Age at admission, by admission type



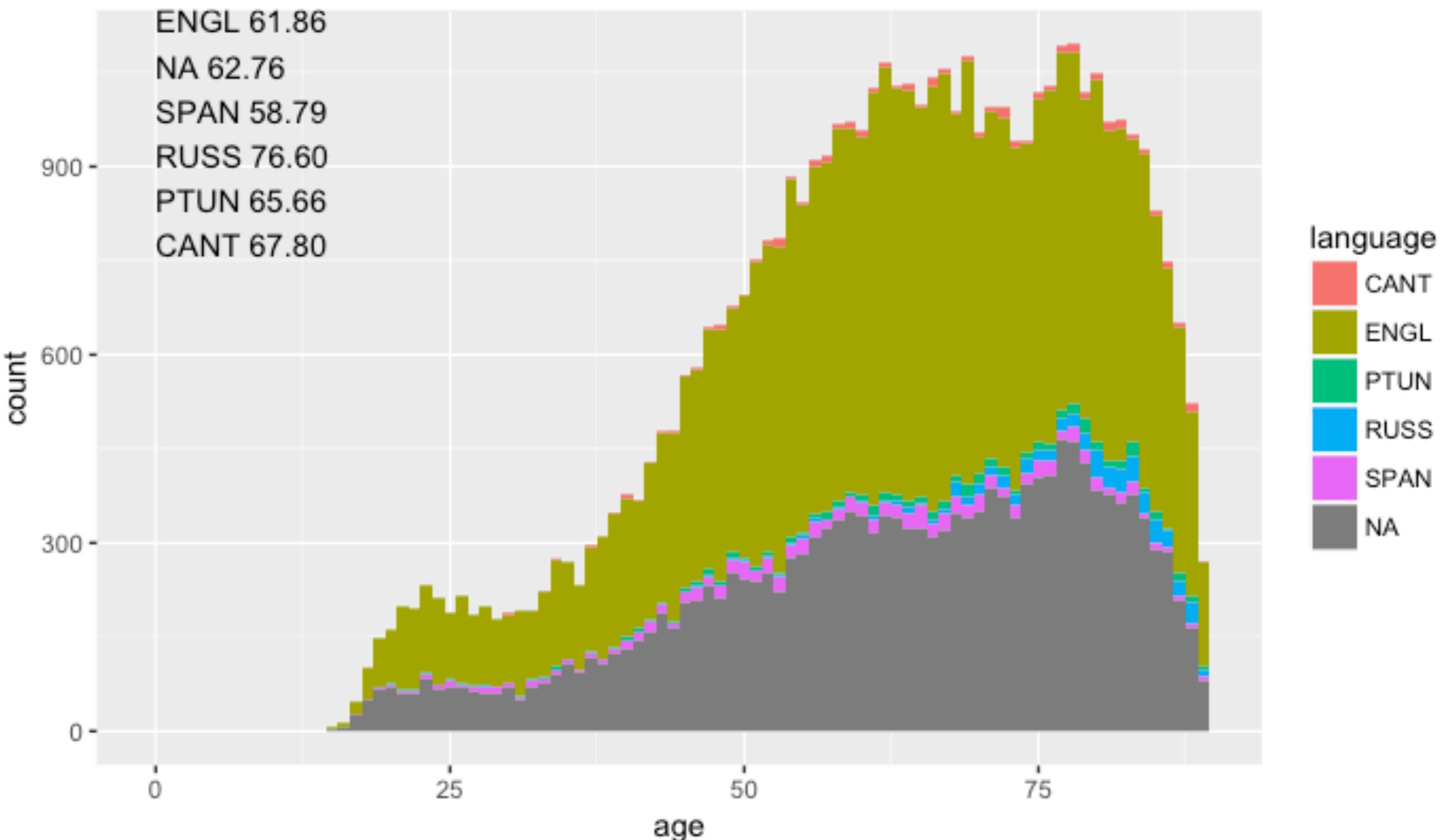
Age at admission, by insurance type



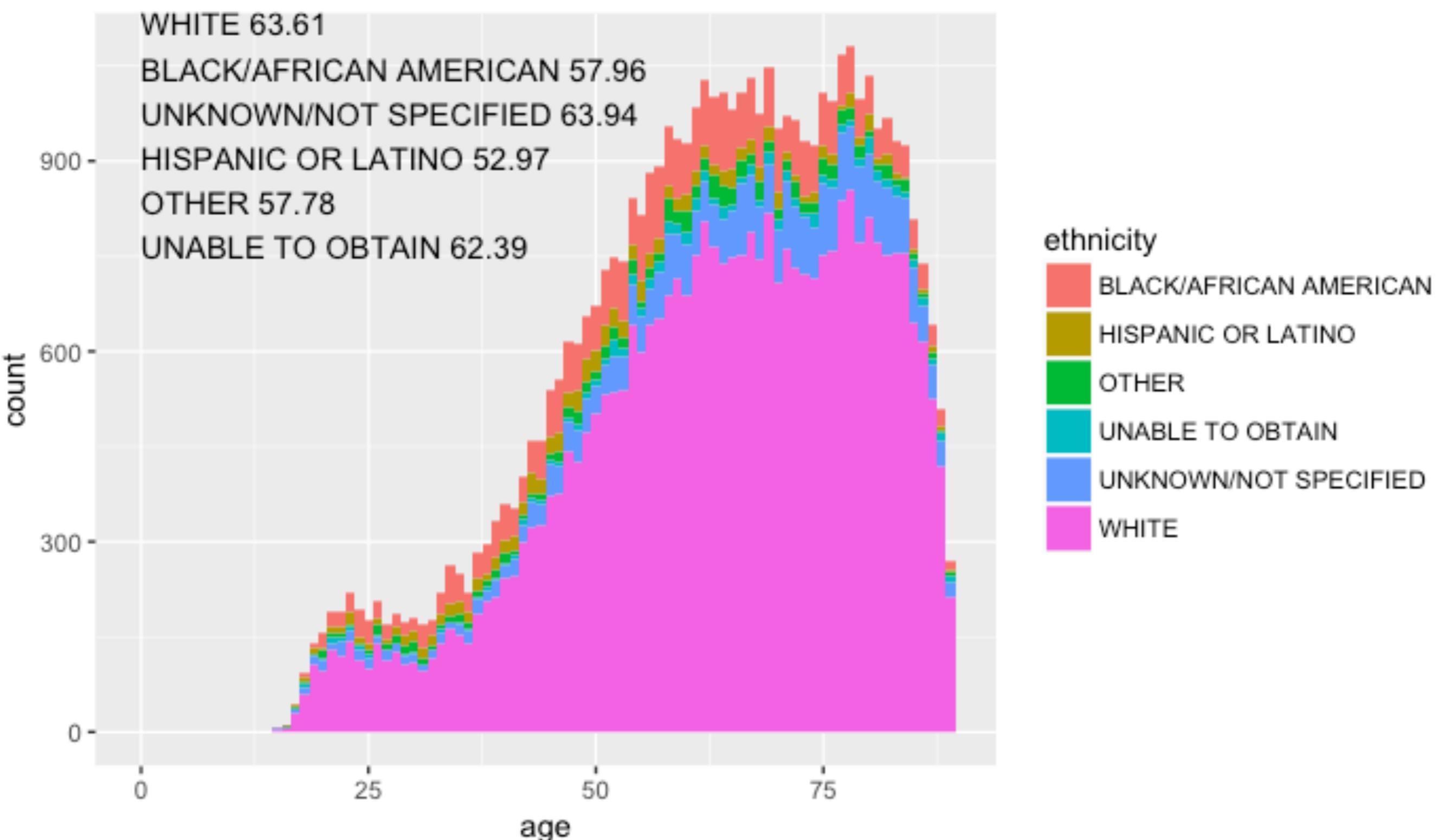
Age at admission, by source of admission



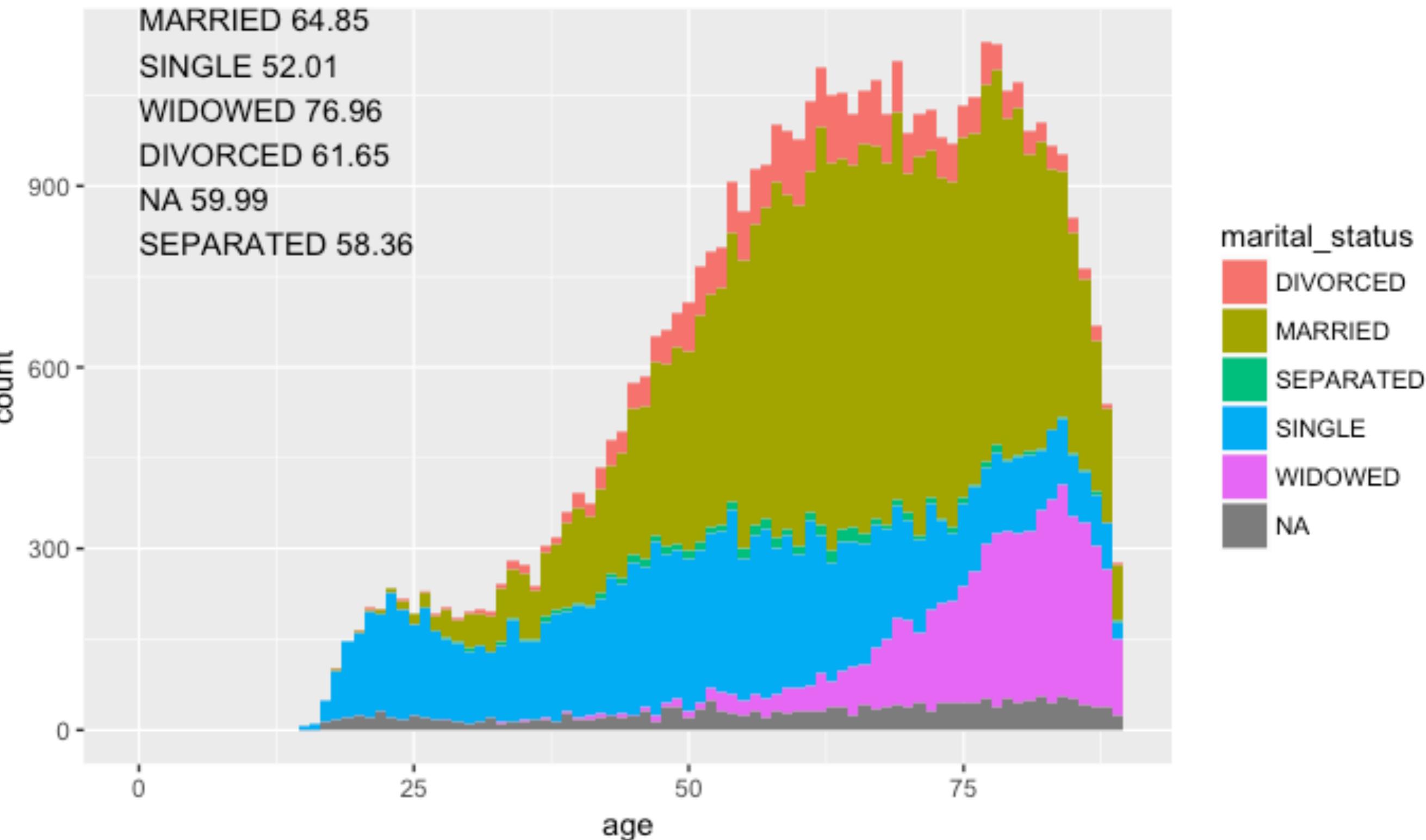
Age at admission, by language



Age at admission, by ethnicity



Age at admission, by marital status



How do demographics influence in-hospital mortality?

```
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

- “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

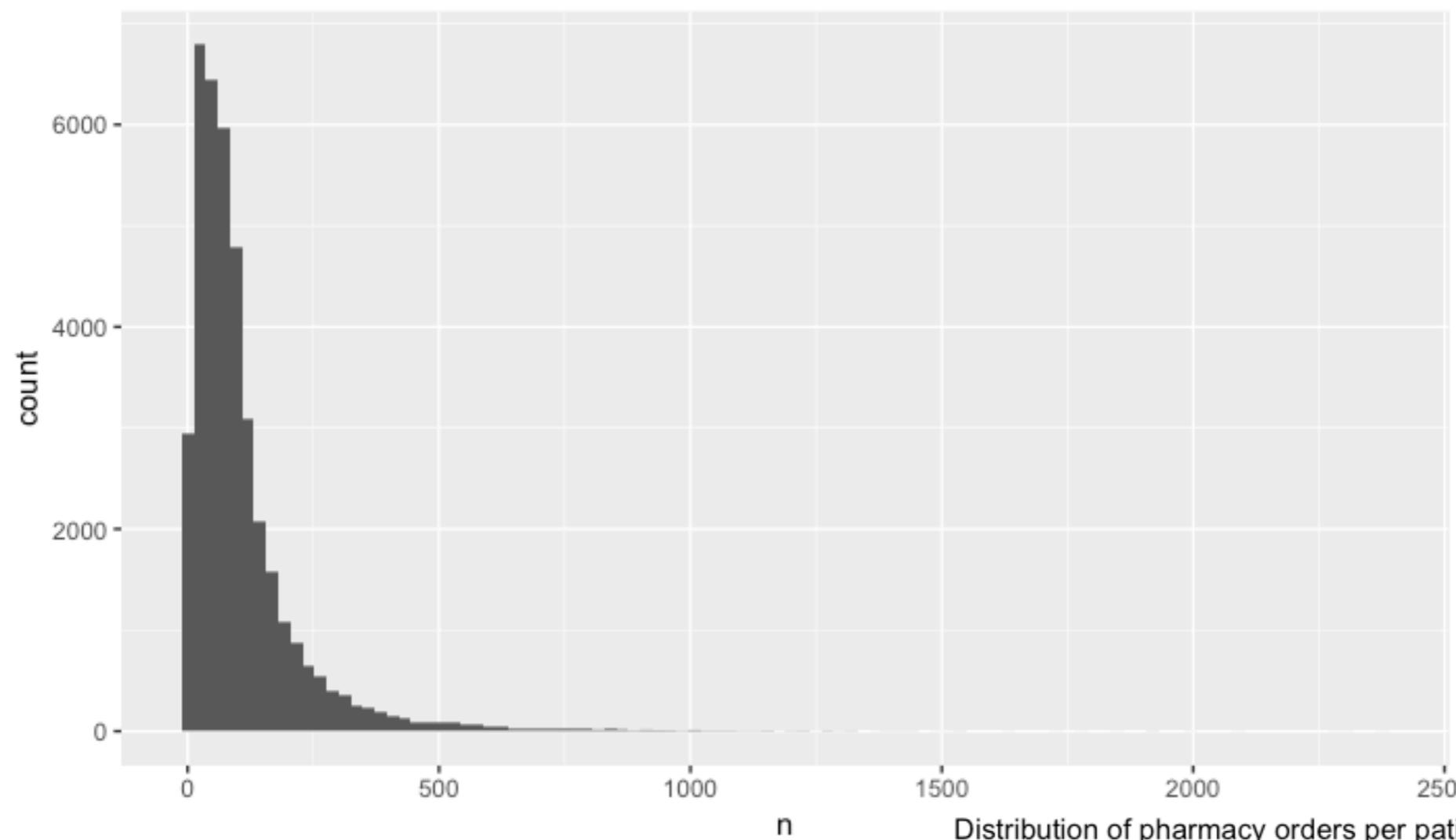
Most Common Prescriptions

	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

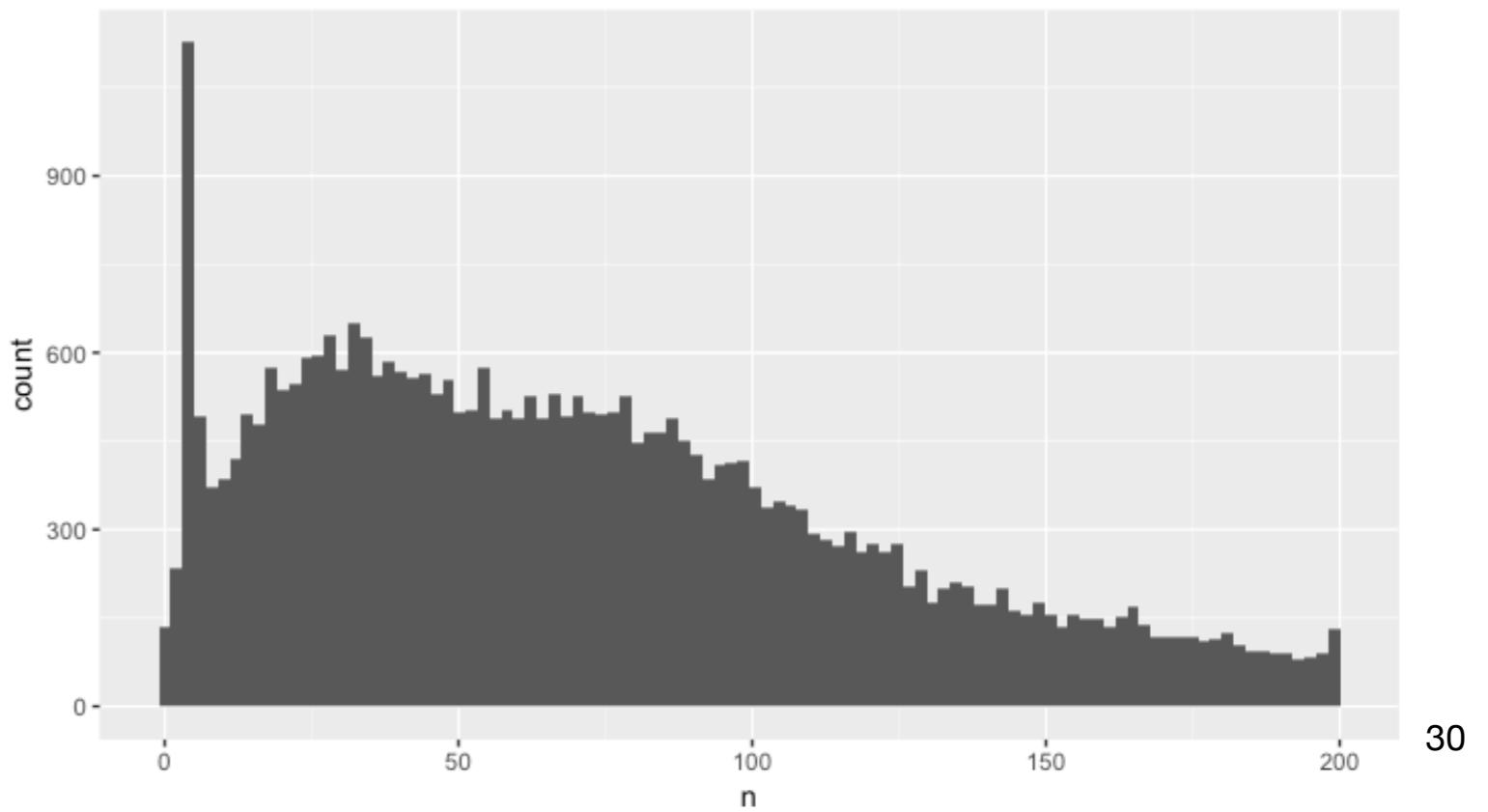
Next Most Common Prescriptions

	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

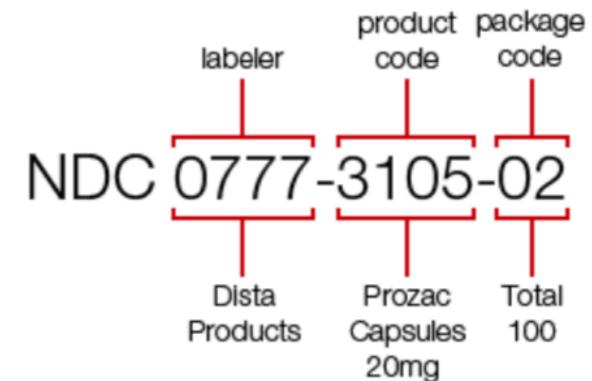
Distribution of pharmacy orders per admission



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)

- 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)

- 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?

- PROCEDURES_ICD (n=240095)
- CPTEVENTS (n=573146)
- PROCEDUREEVENTS_MV (n=258066)

Most Common ICD9 Procedure Codes

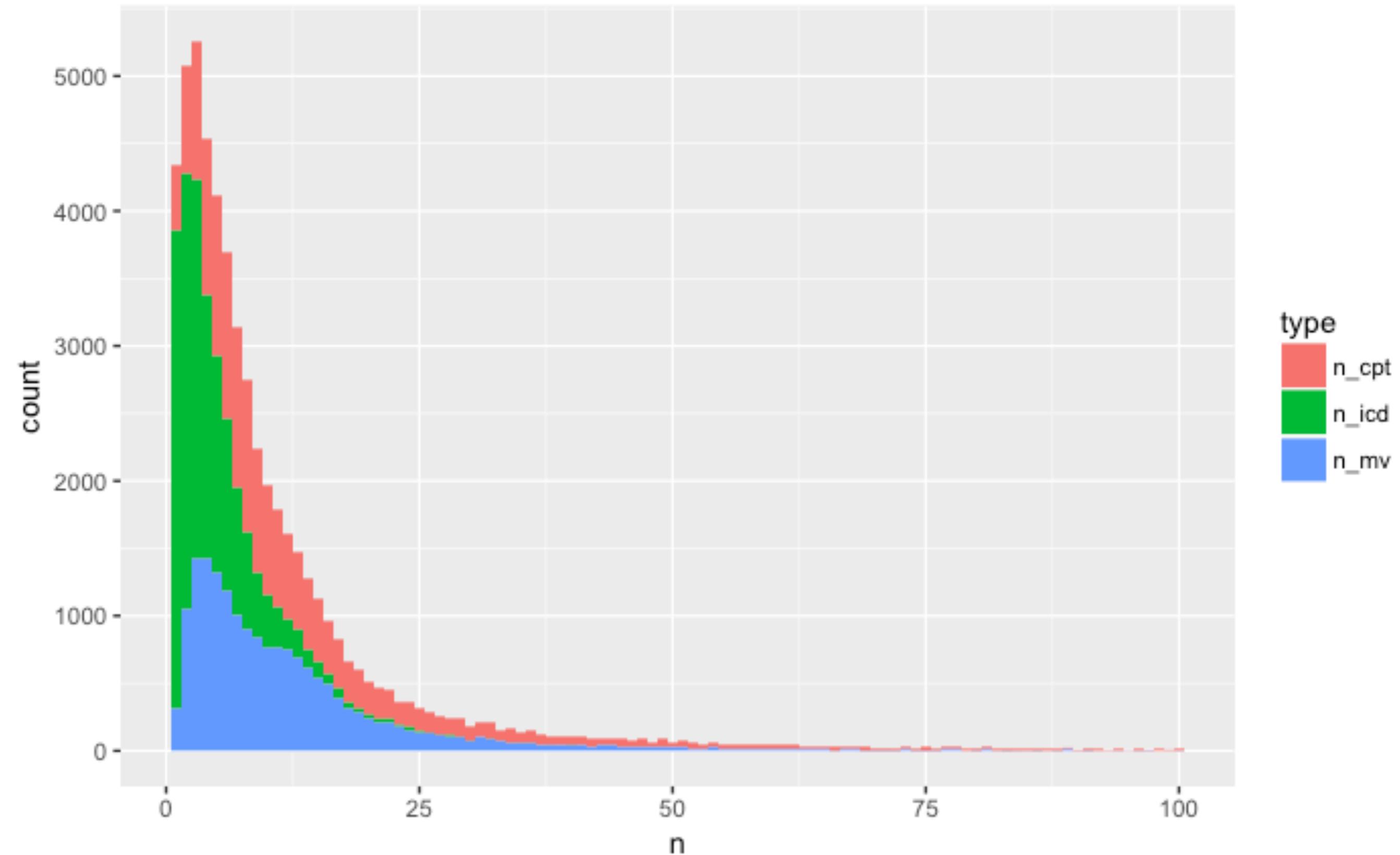
ICD9_code	n	Name
3893	14731	Venous catheterization, not elsewhere classified
9604	10333	Insertion of endotracheal tube
966	9300	Enteral infusion of concentrated nutritional substances
9671	9100	Continuous invasive mechanical ventilation for less than 96 consecutive hours
9904	7244	Transfusion of packed 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)

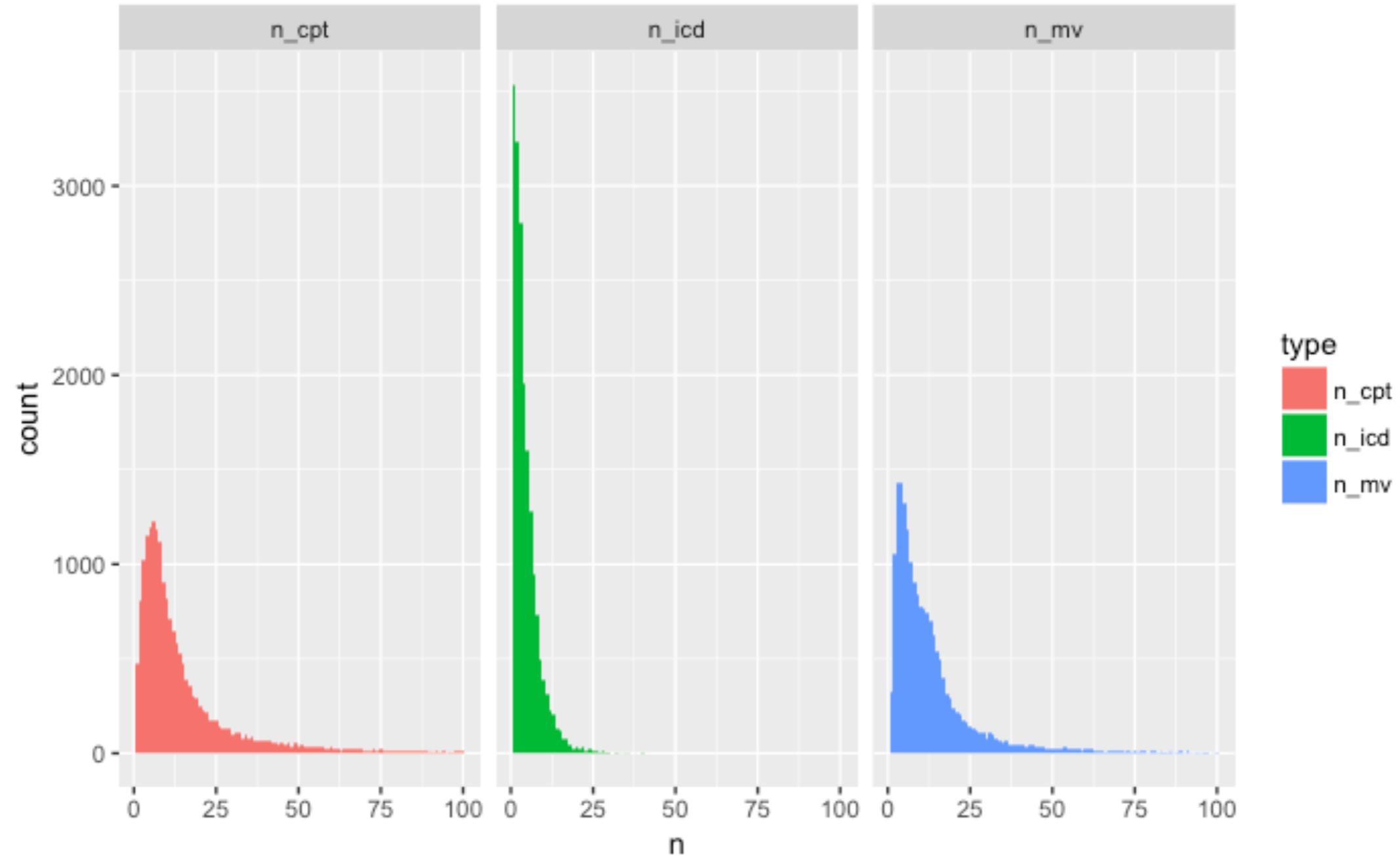
Medicine	90281-90399	Immune globulins, serum or recombinant prods
Medicine	90465-90474	Immunization administration for vaccines/toxoids
Medicine	90476-90749	Vaccines, toxoids
Medicine	90801-90899	Psychiatry
Medicine	90901-90911	Biofeedback
Medicine	90918-90925	End-Stage Renal Disease Services (deleted 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



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

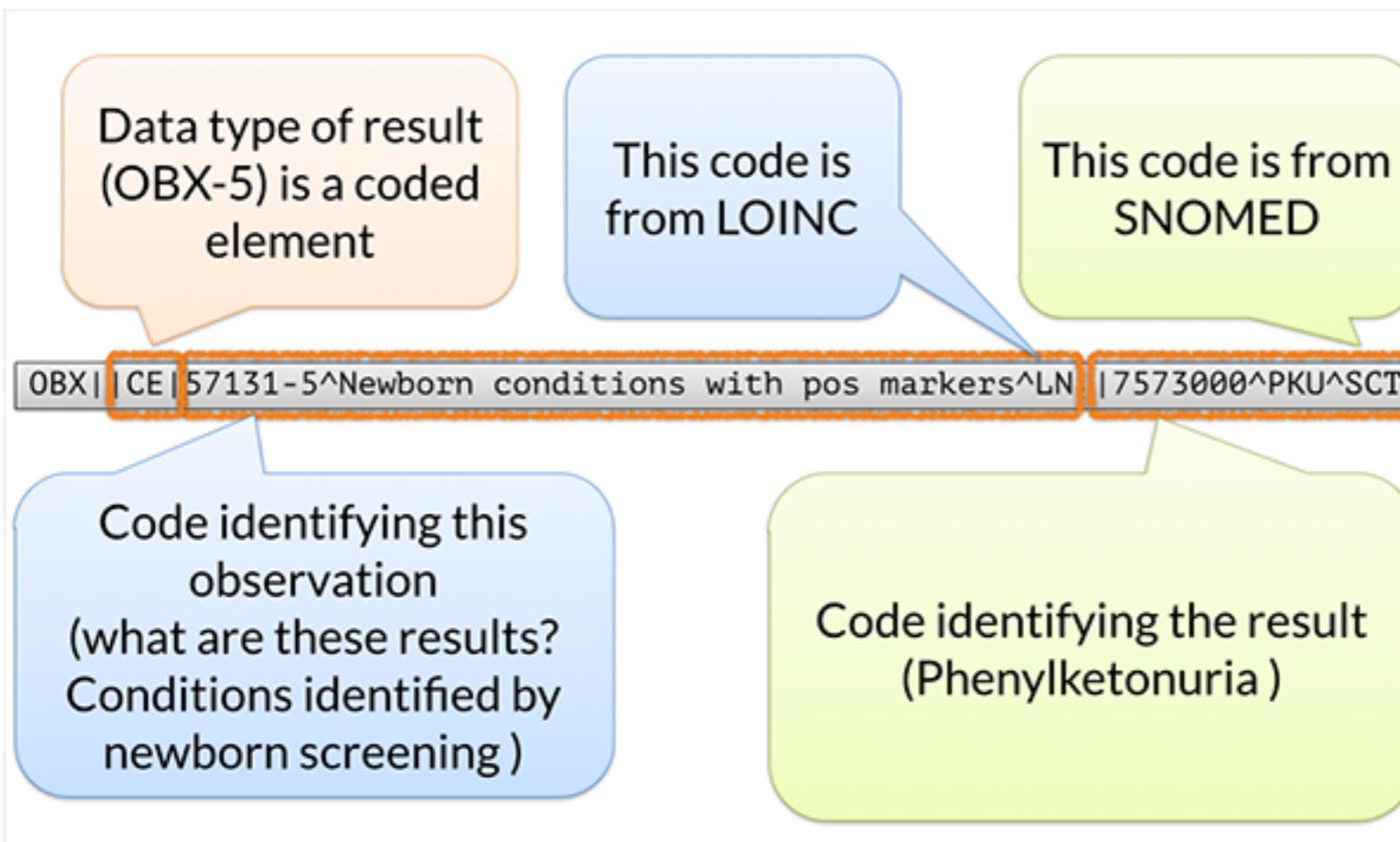
Labs for patient 2, admission 163353

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

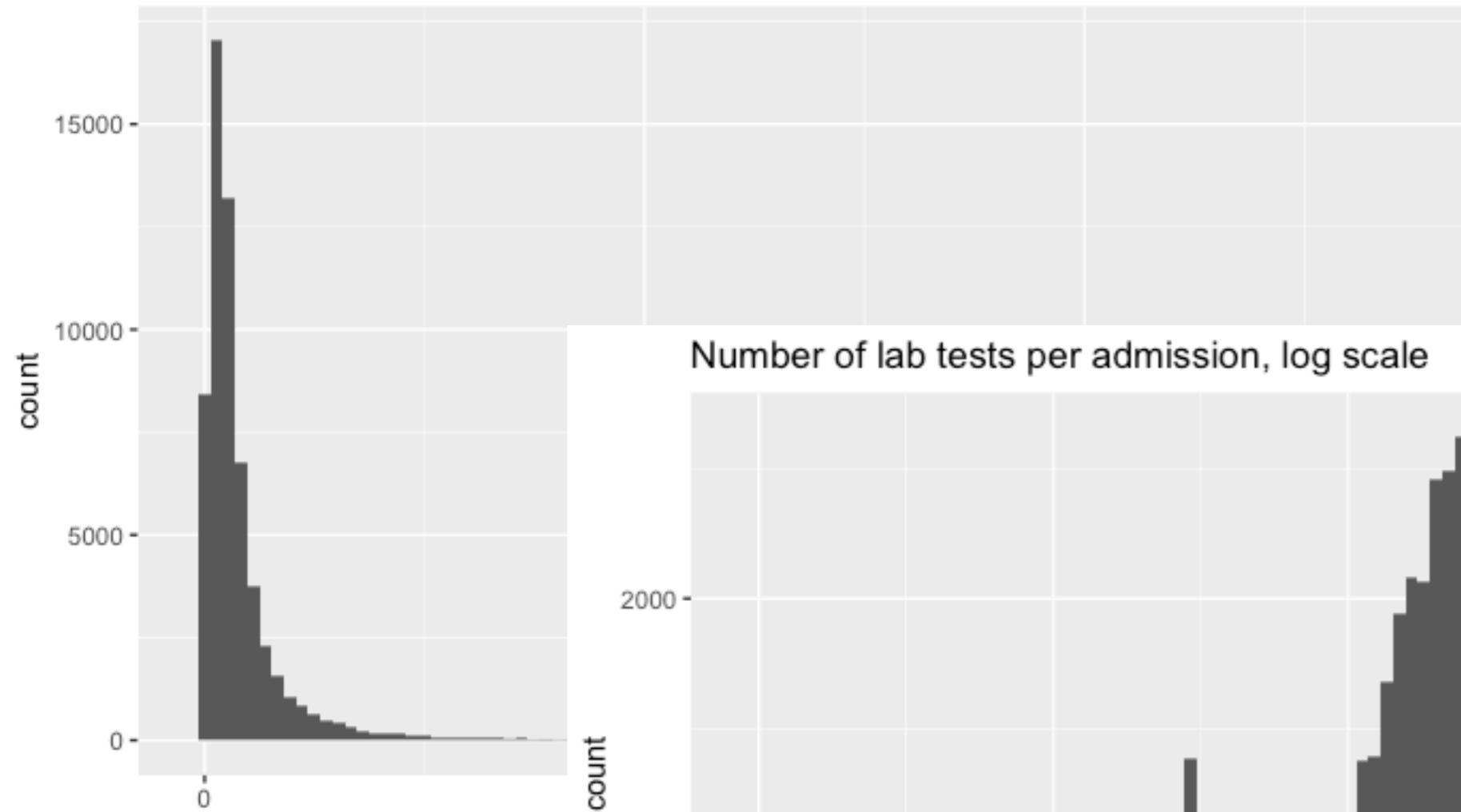
Most laboratory and clinical systems today are sending data out using the HL7 version 2 messaging standard. Looking at an example of the place in the HL7 message where the test results go, you can see how a LOINC code identifies the question and a SNOMED CT code represents the answer:



- 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

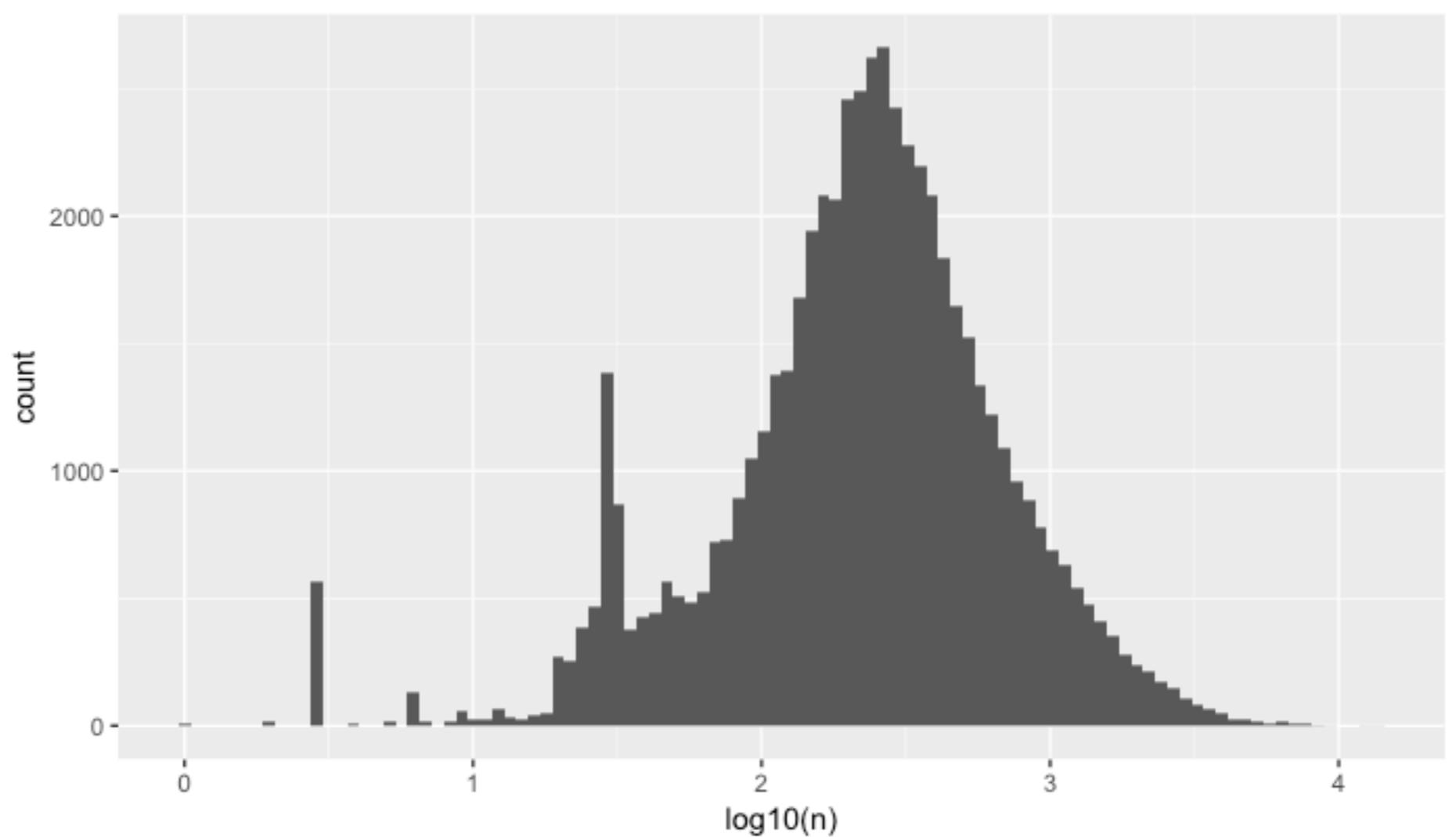
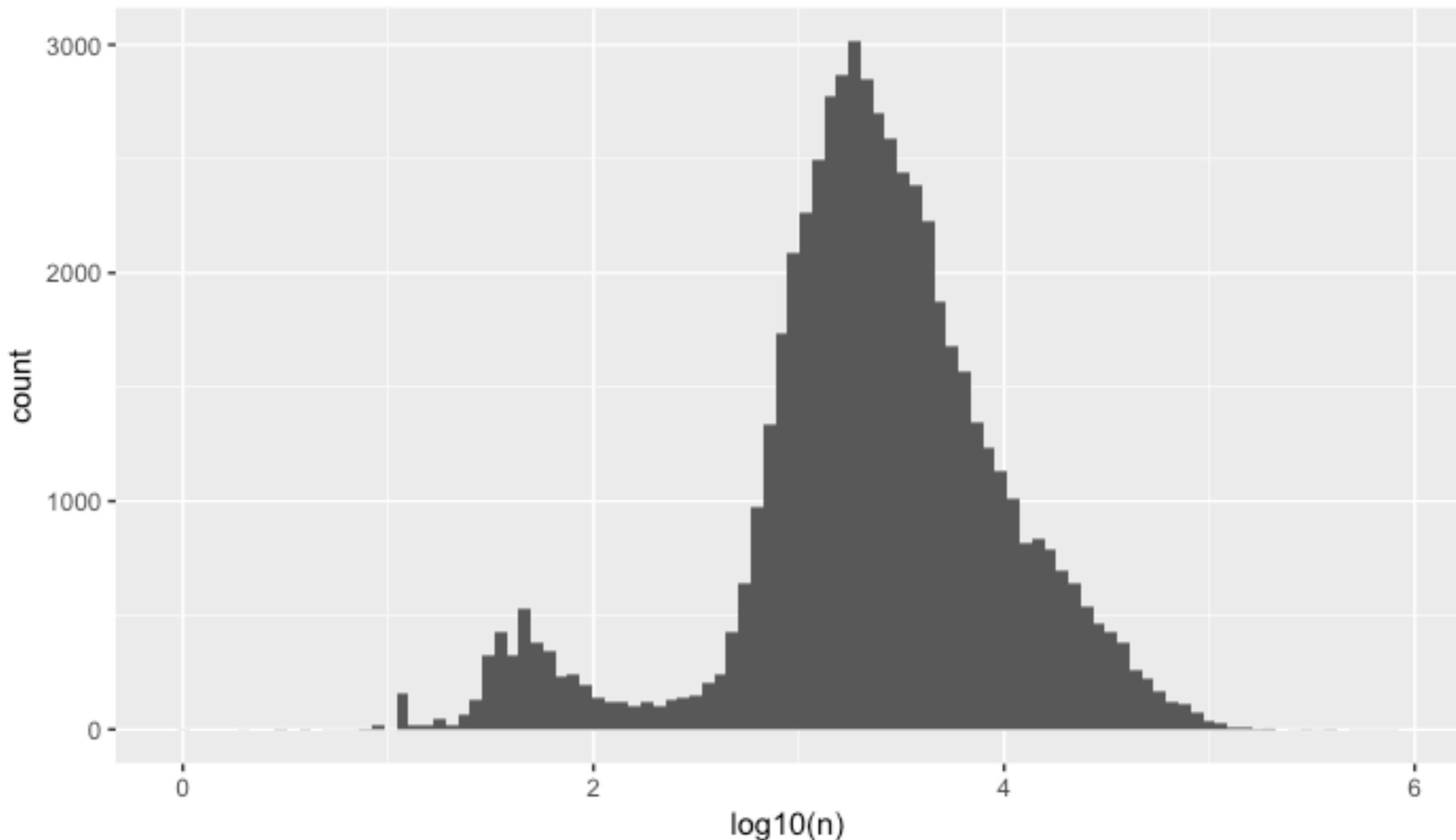


Chart Events

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

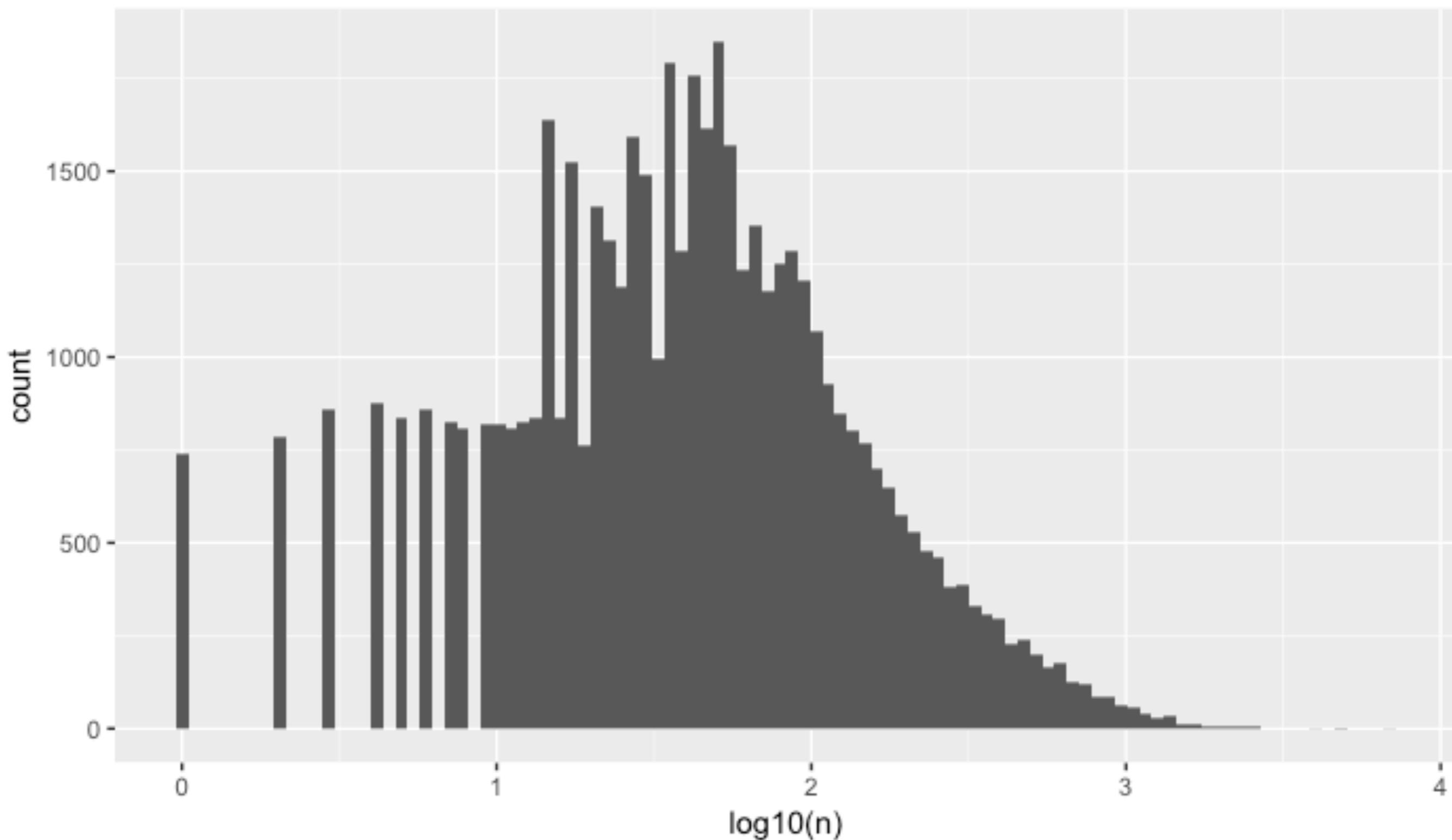
Number of chart entries (log) per admission



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



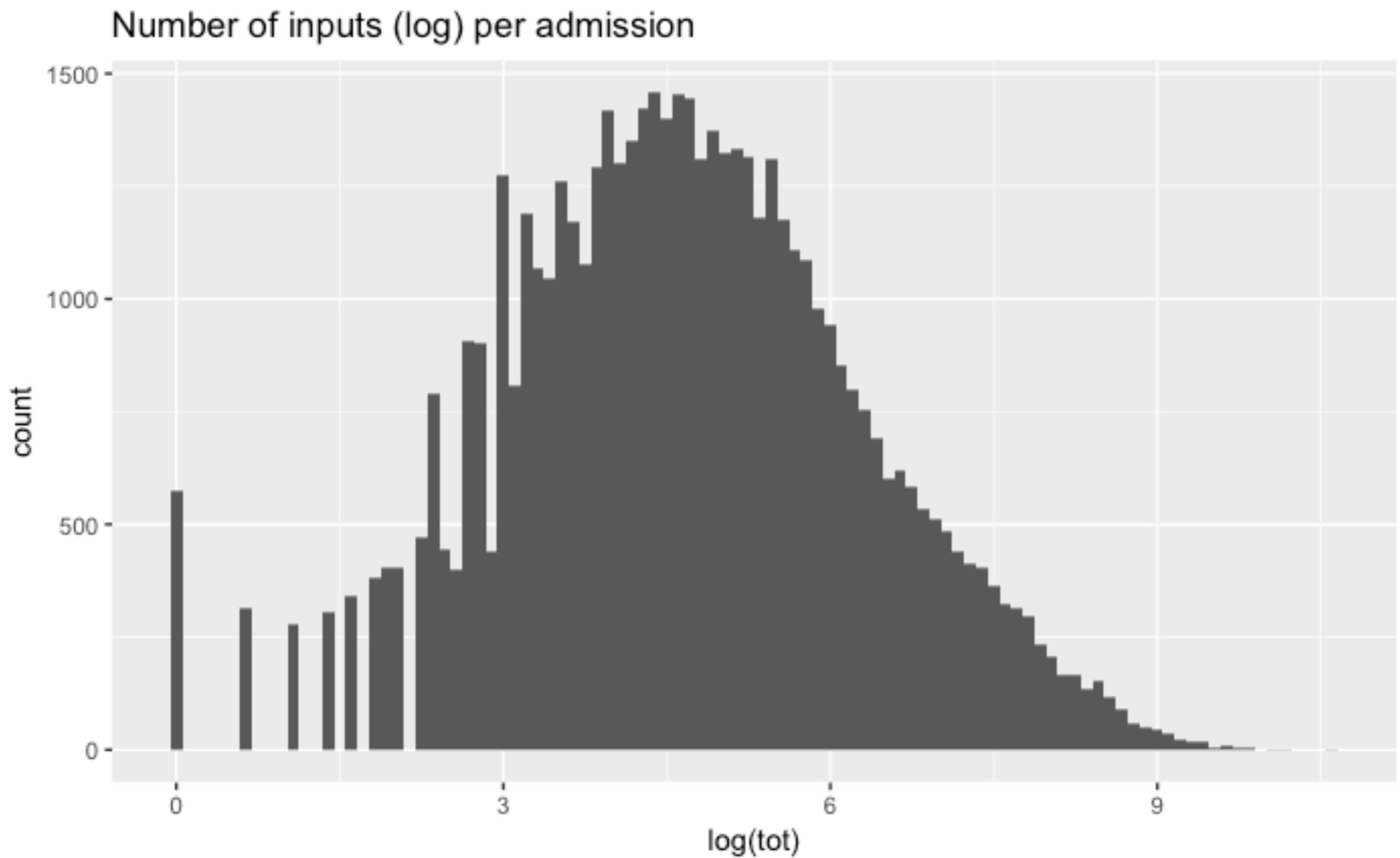
Inputs (CareVue)

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 - Regular	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

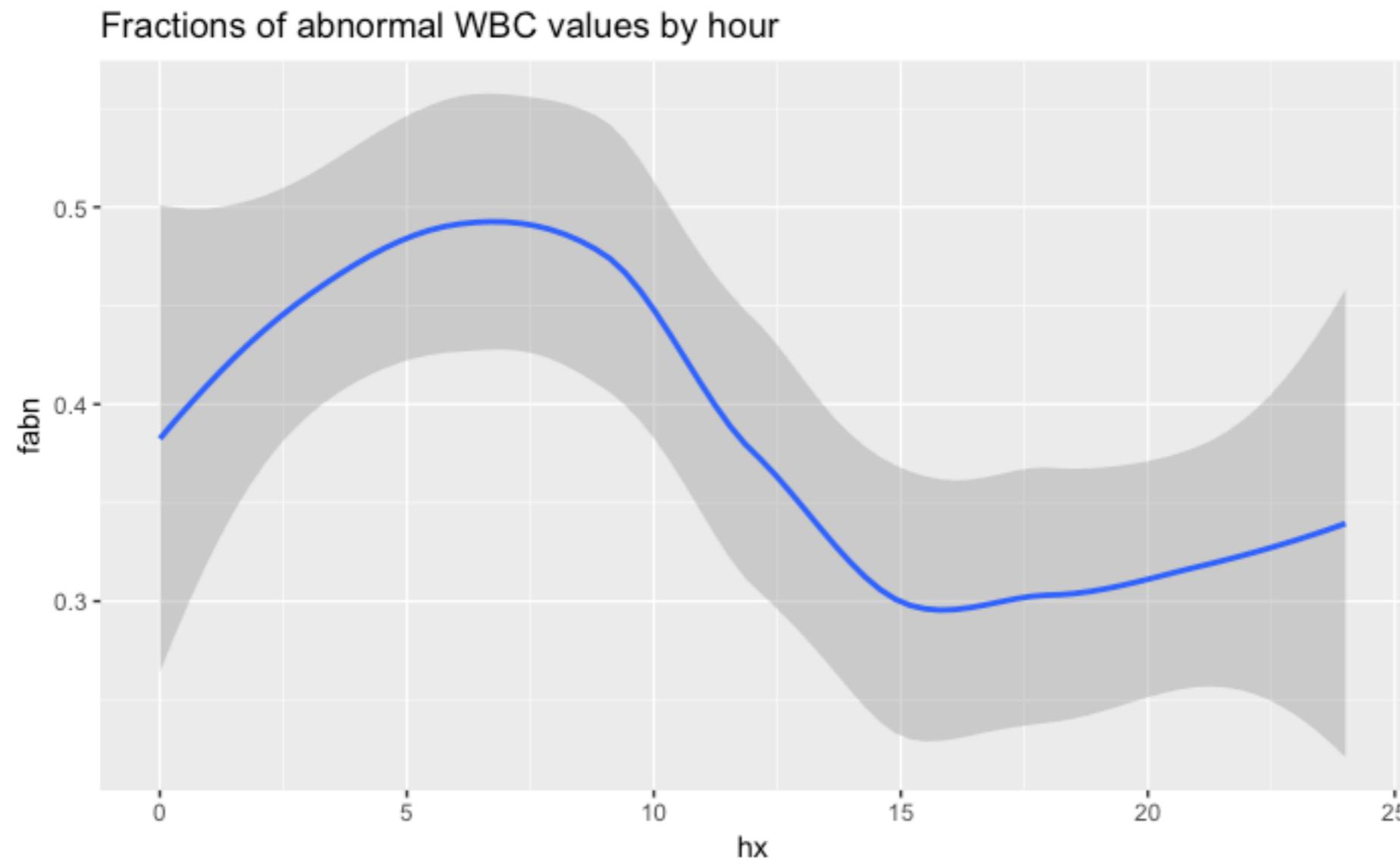
Inputs (combined MV and CV)



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

Denis Agniel,¹ Isaac S Kohane,^{1,2} Griffin M Weber^{1,3}

- 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



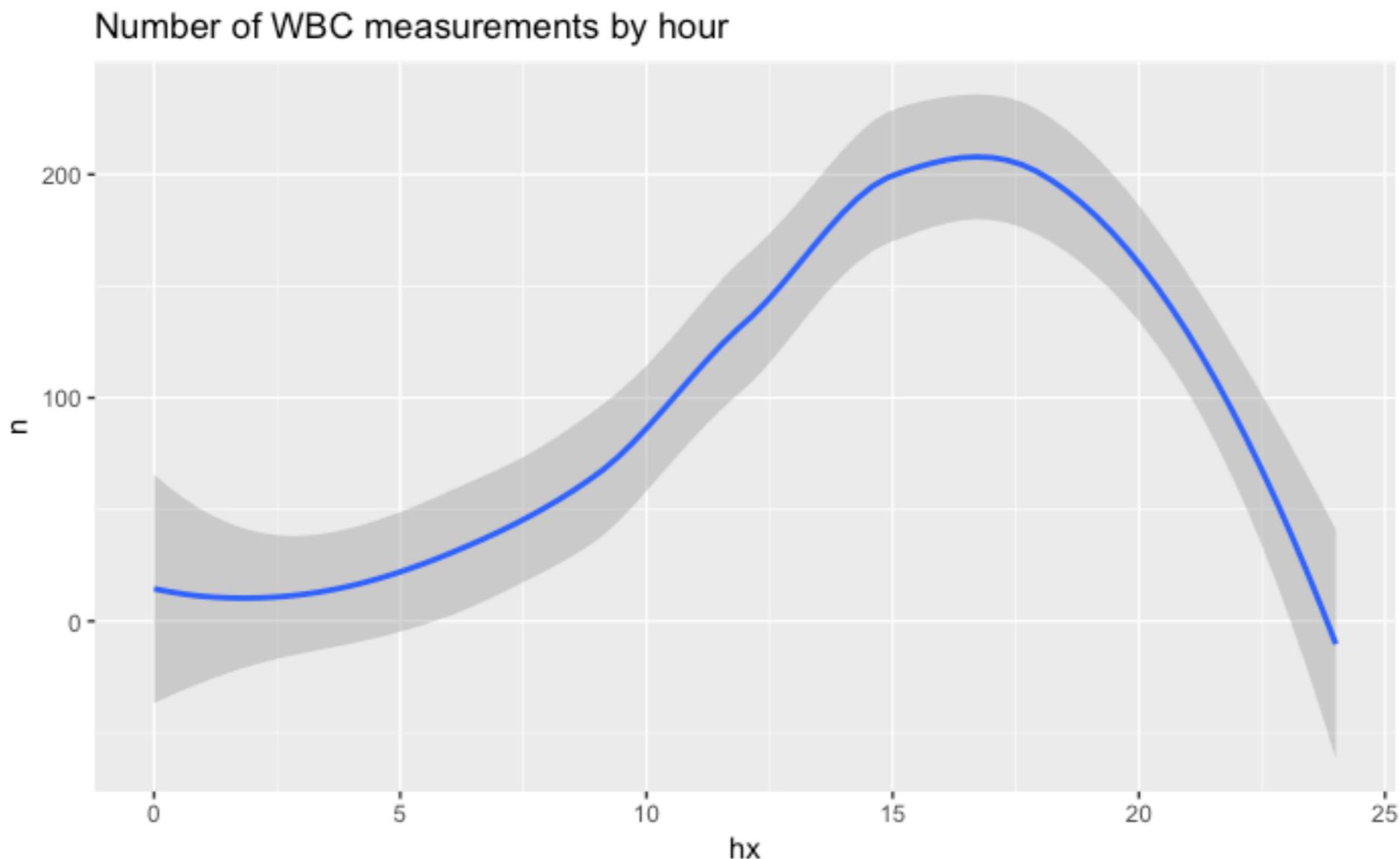
LR model to predict mortality from number of WBC measurements and number abnormal, per hour

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

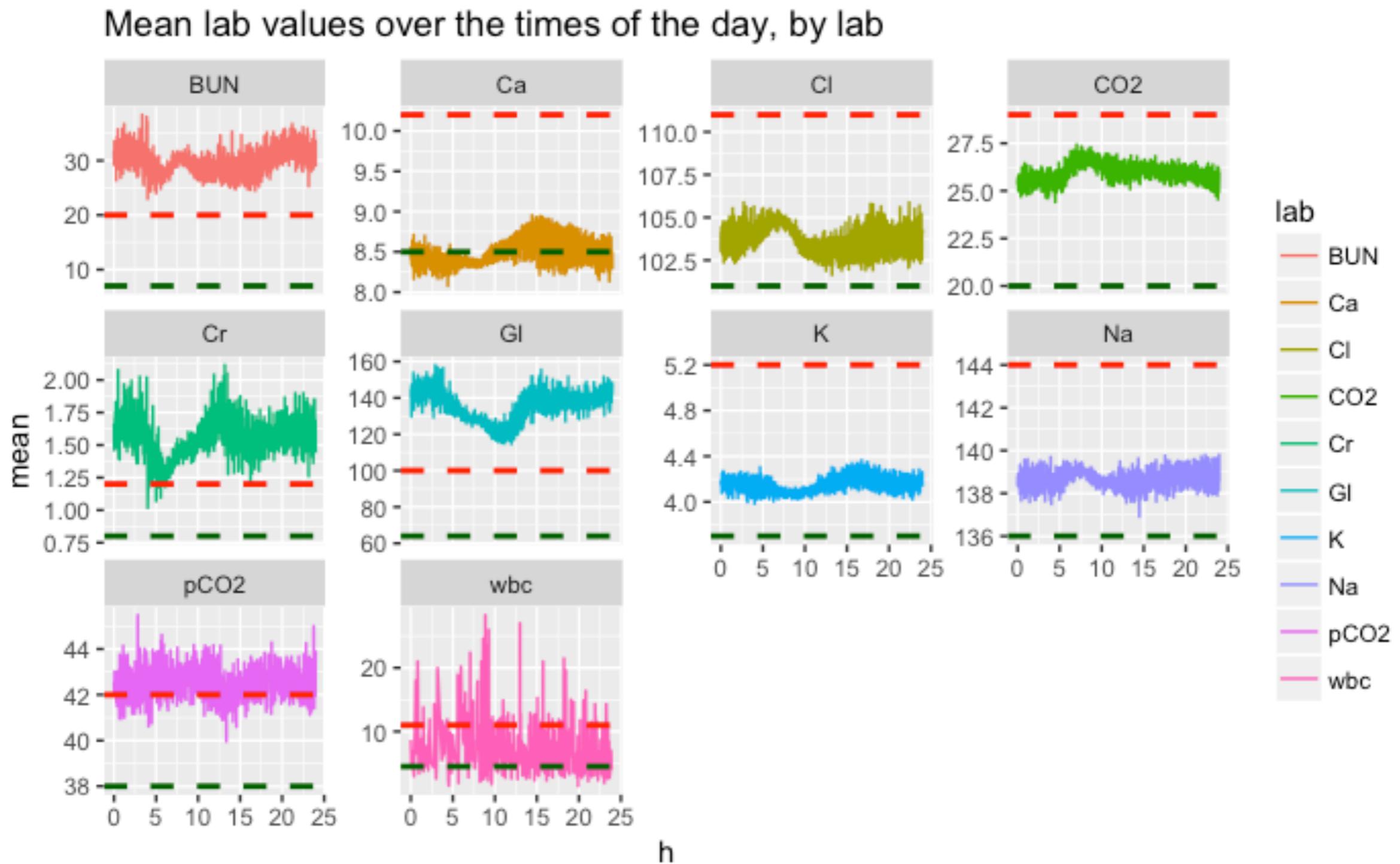
						Signif. codes:	0 ~***~ TM 0.001 ~**~ TM 0.01 ~*~ TM 0.05			

Relationship of WBC measurements at night to mortality

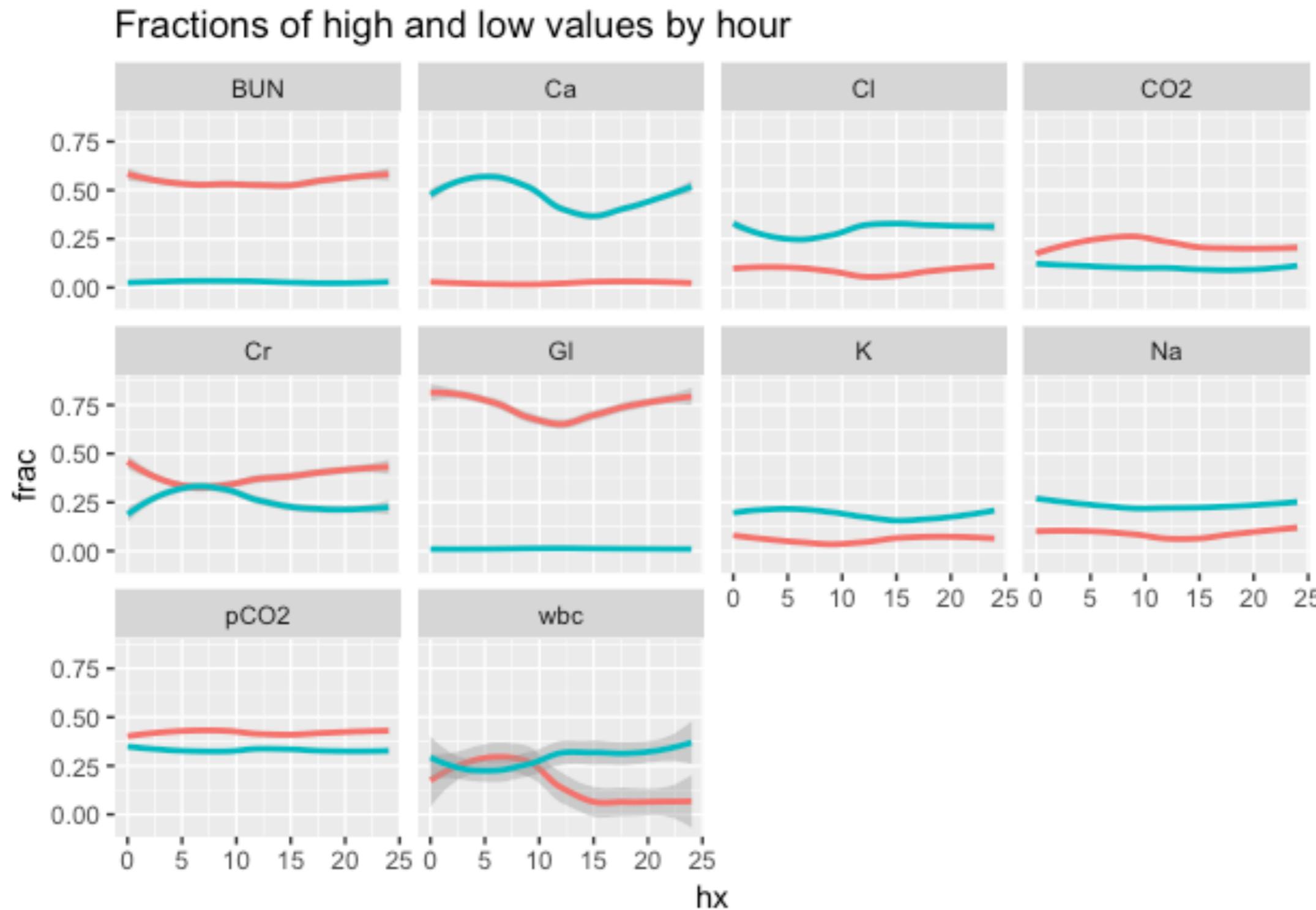
	0	1	2	3	4
FALSE	289	65	8	1	1
TRUE	253	67	3	0	0



Lab values do vary by time of day

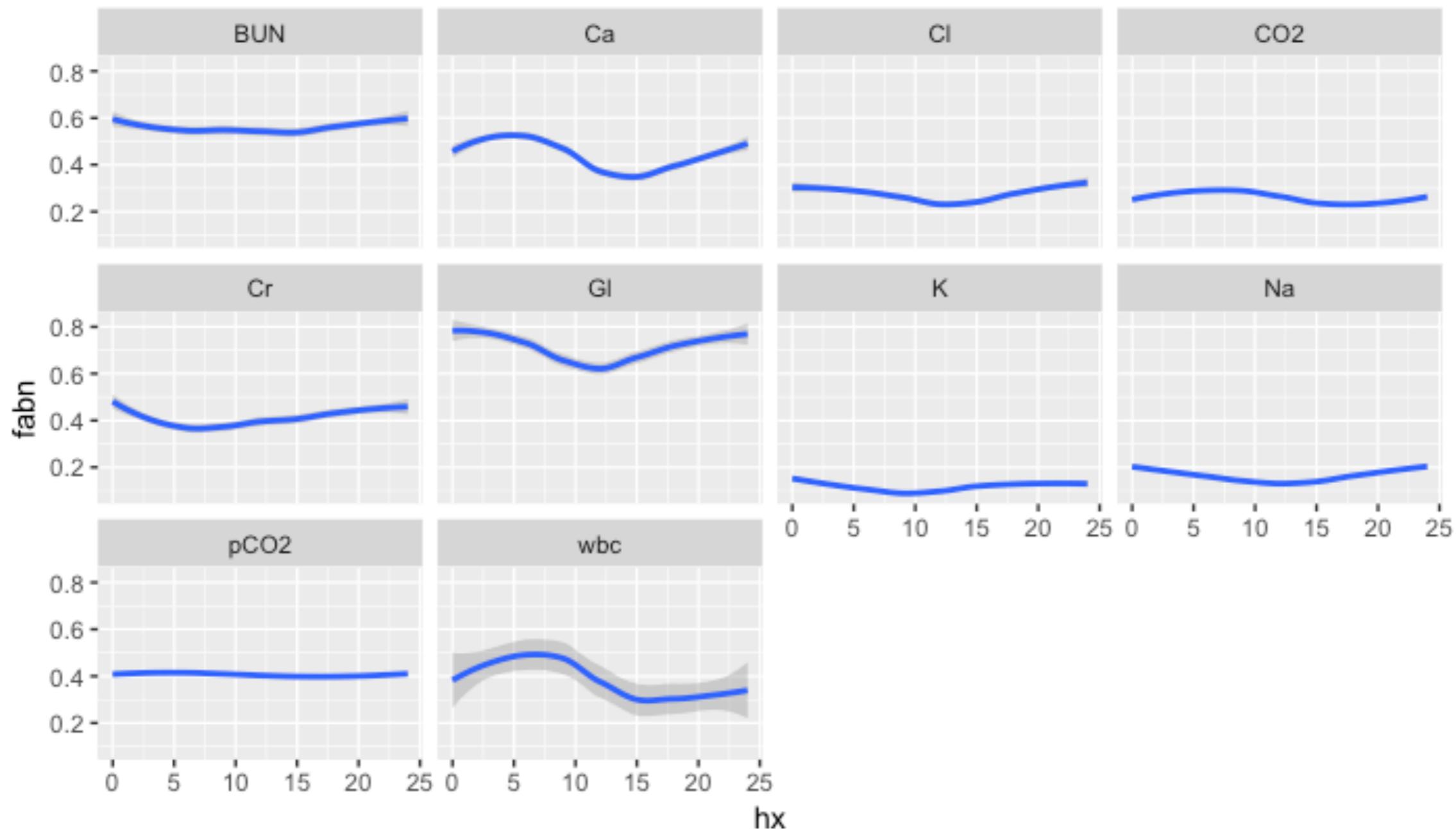


Fractions of high and low lab values do vary by hour

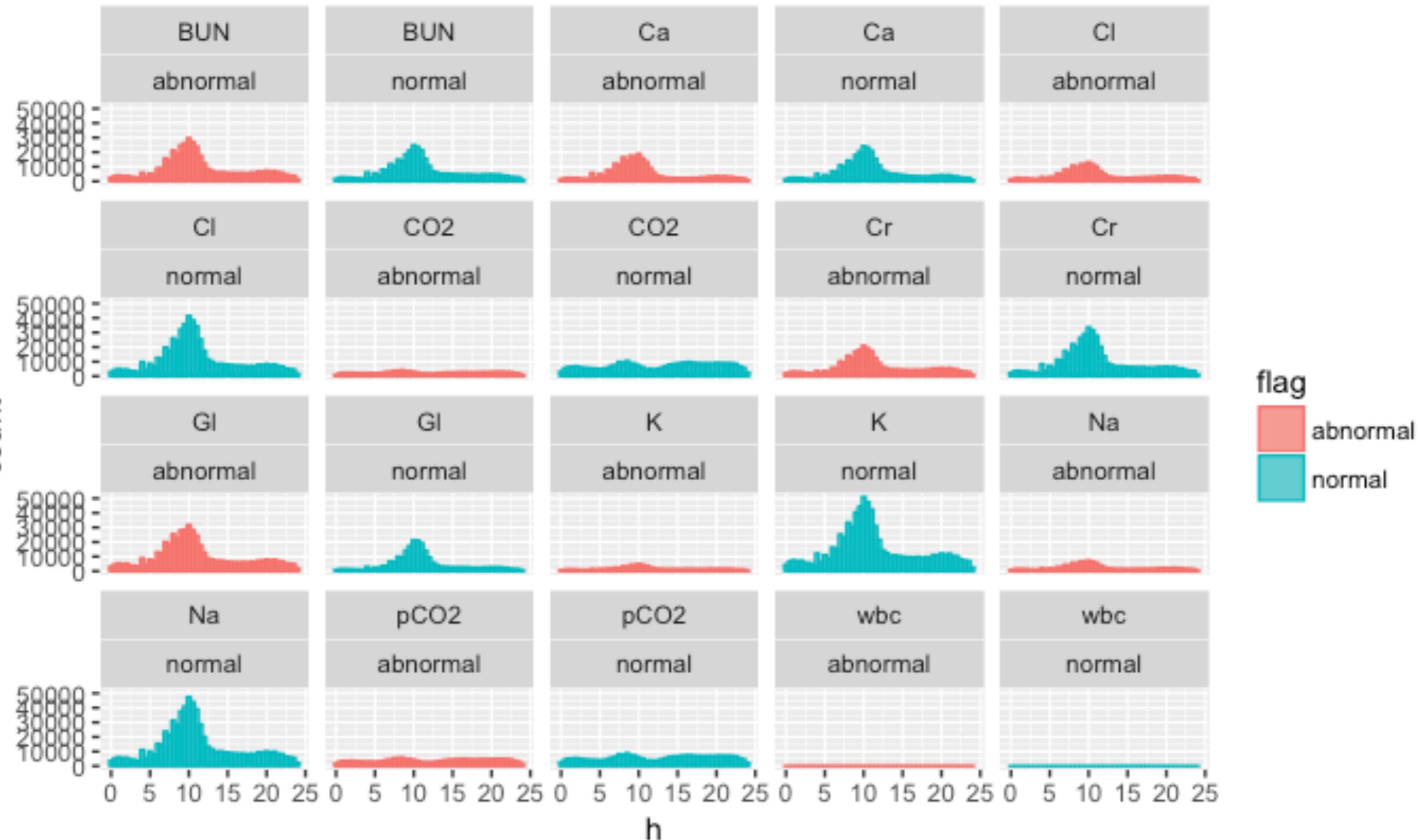


Fractions of abnormal lab values do vary by hour

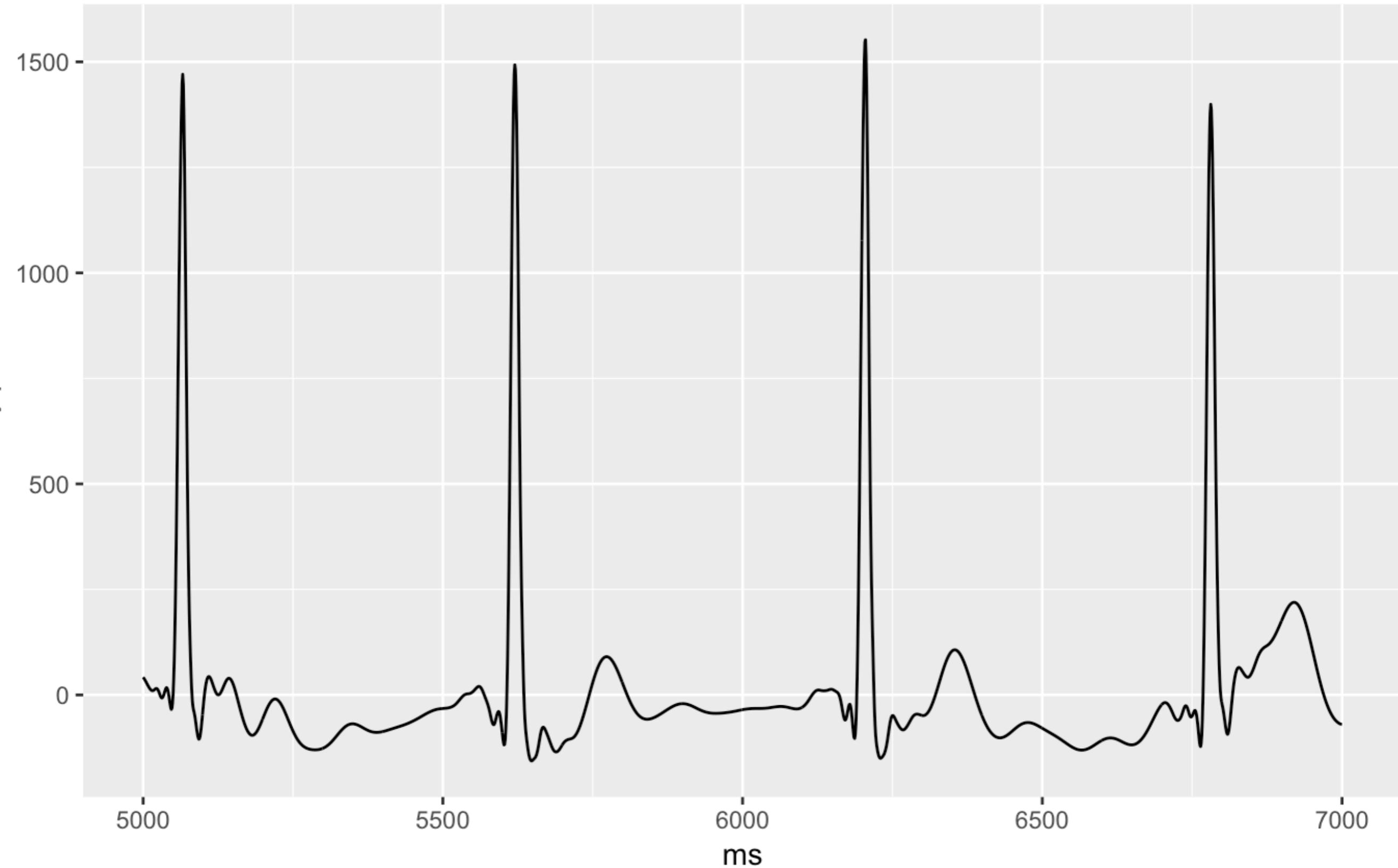
Fractions of abnormal values by hour for common labs



Times of lab measurements, faceted by type



Data from wearables



Heart rate variability

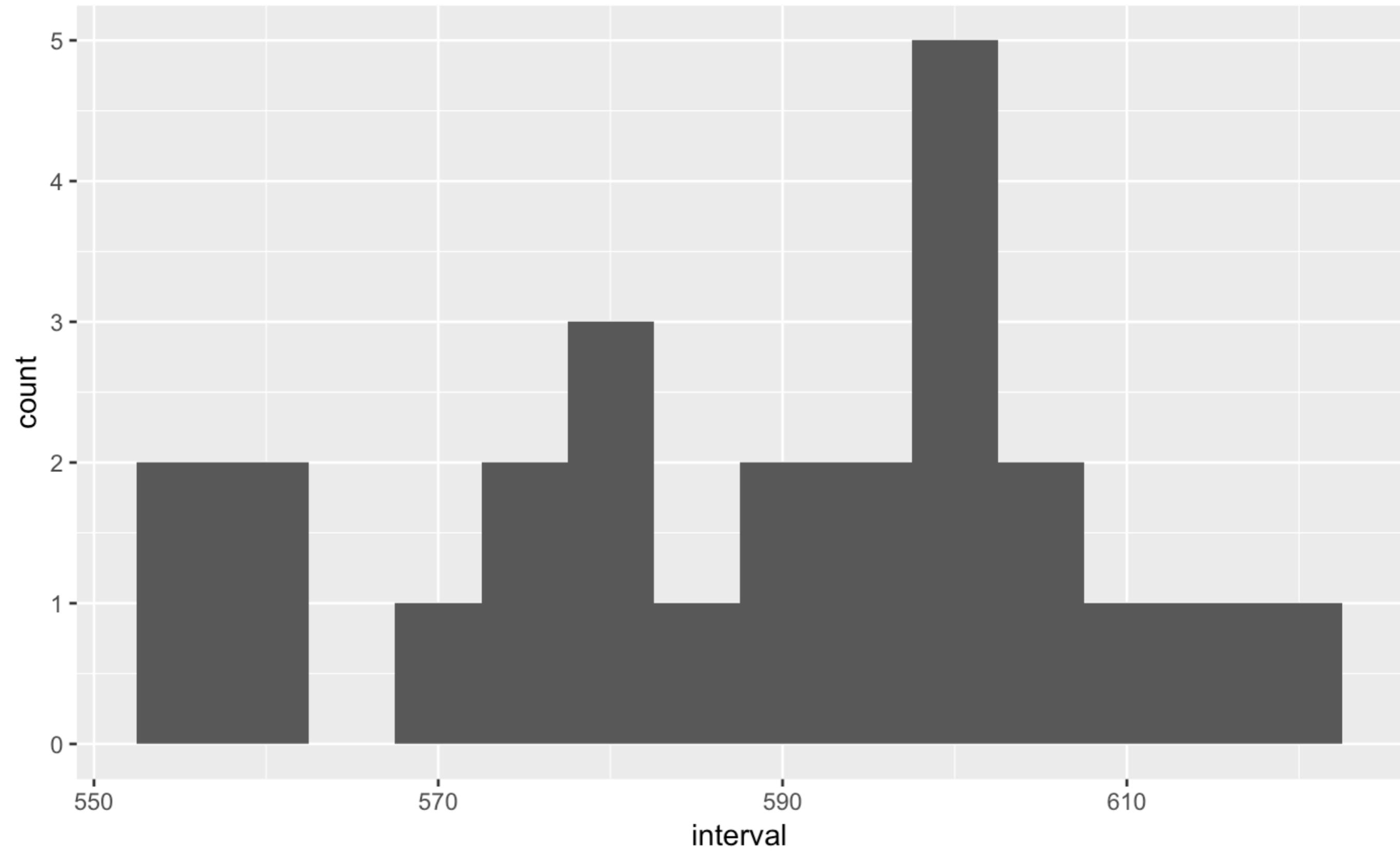


Image Analysis for Pulmonary Emboli

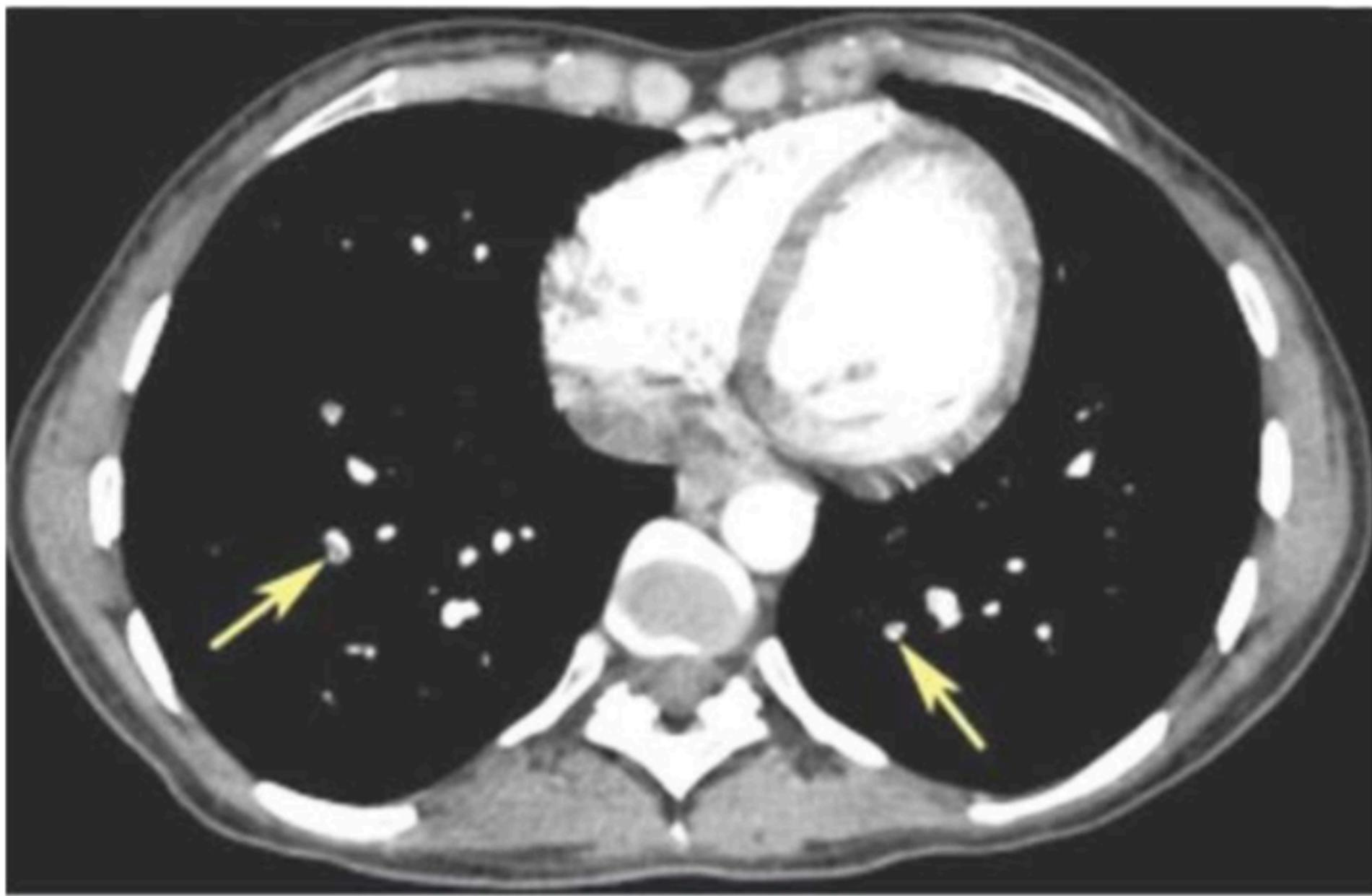


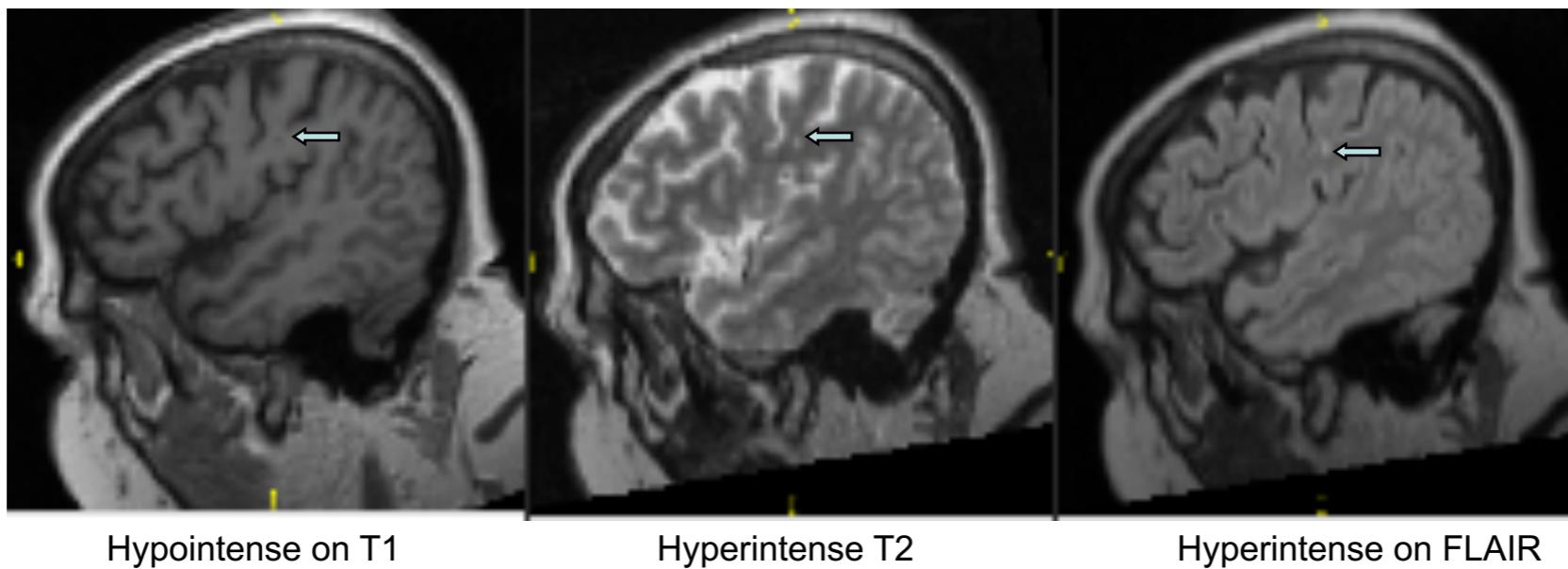
Figure 2: Bilateral pulmonary emboli in third and fourth order branch points of the pulmonary arteries. Small emboli distally located can be a diagnostic challenge.



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

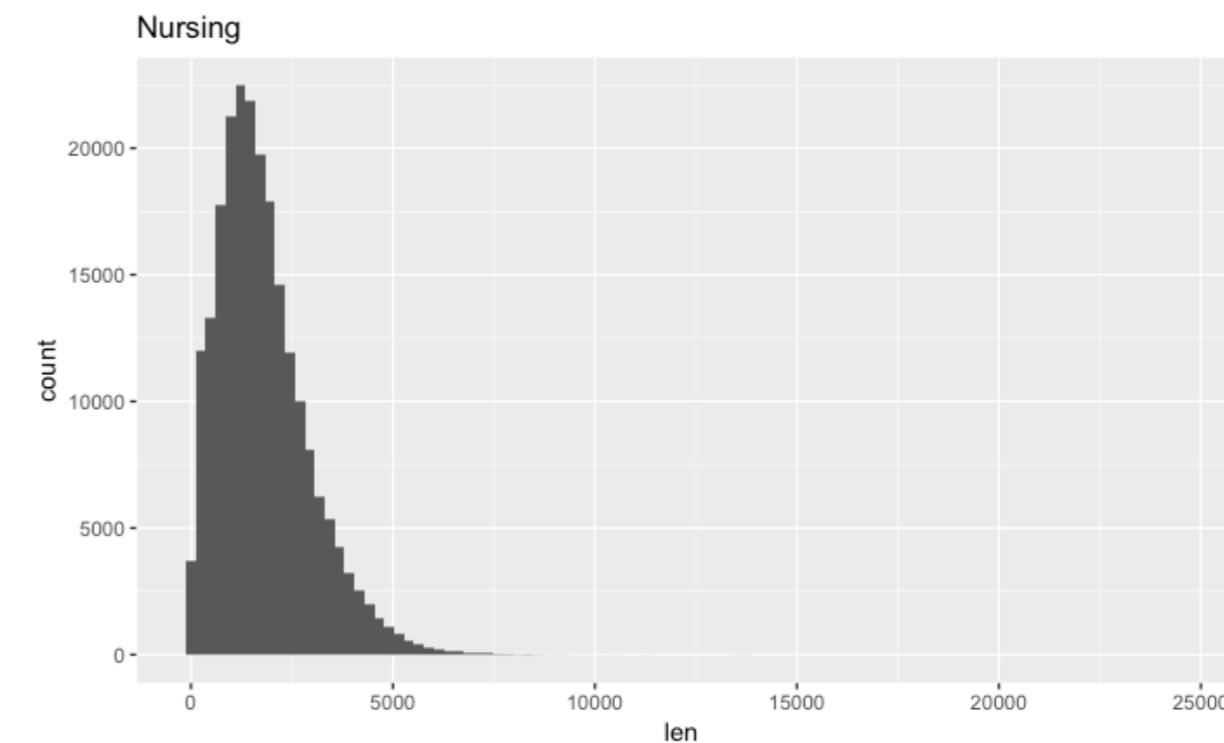
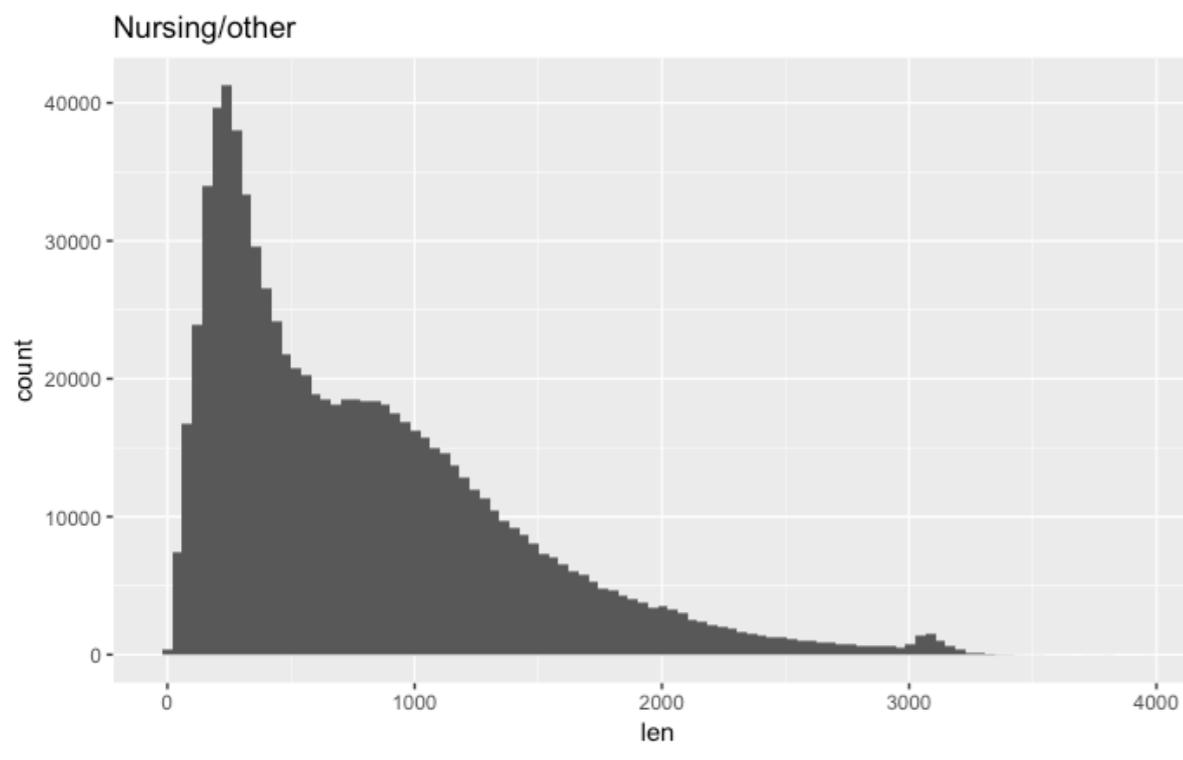
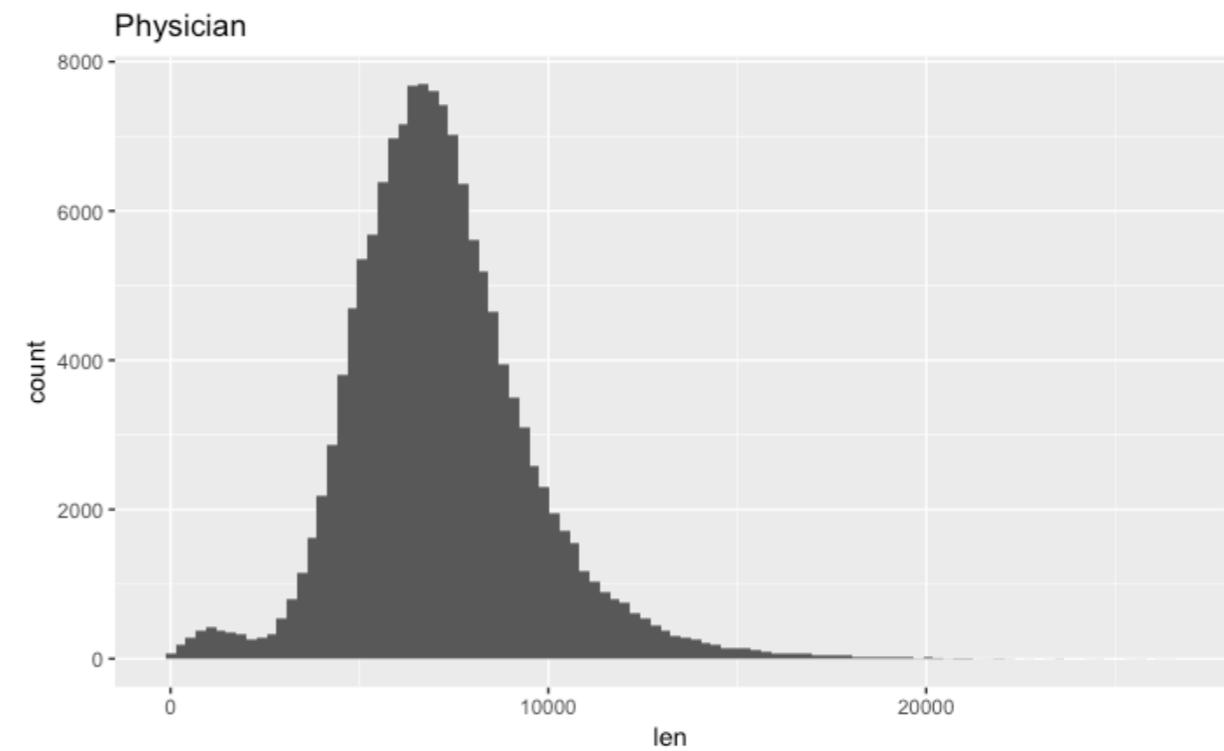
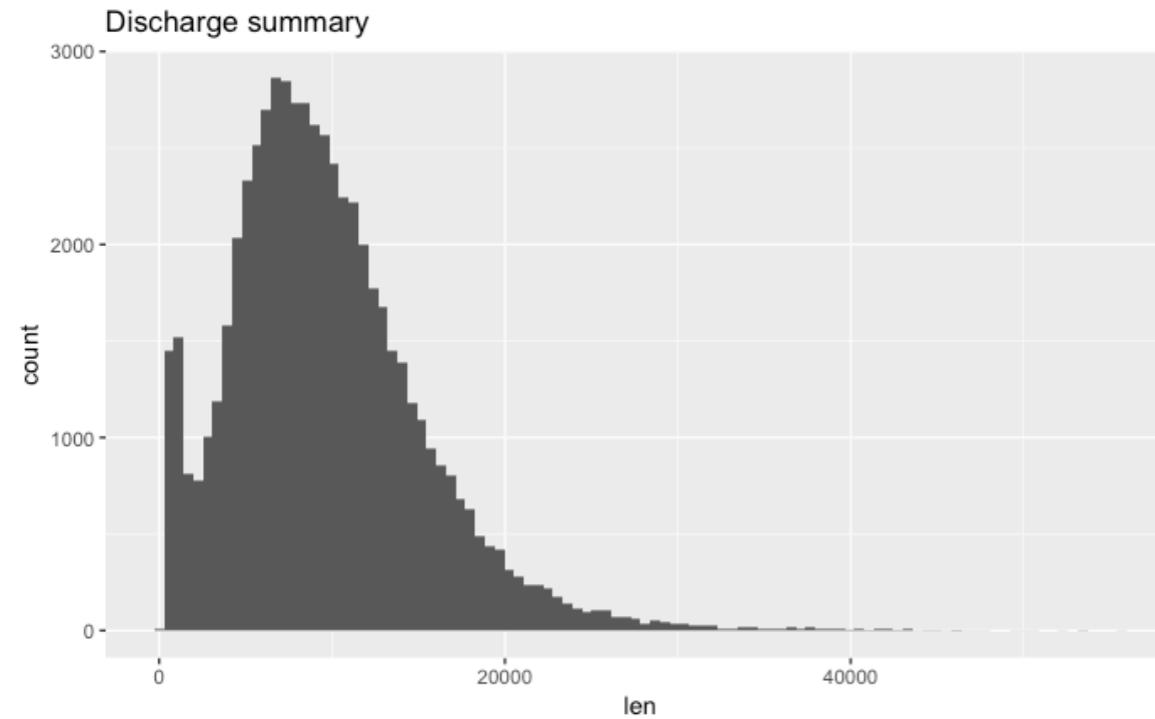
National Alliance for Medical Image Computing
<http://na-mic.org>

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

Data Standards

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

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  <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>
  <identifier>
    <use value="usual"/>
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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"/>
    <value value="123456"/>
  </identifier>
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    <given value="Henry"/>
    <suffix value="The 7th"/>
  </name>
  <gender value="male"/>
  <birthDate value="1932-09-24"/>
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    <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

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