Biostat 203B Homework 3

Due Feb 23 @ 11:59PM

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Table of contents

#clear workspace, only keep 'icu_cohort' tibble: rm(list = setdiff(ls(), "icu_cohort"))

#if you want to interactive plot: library(plotly) p <- icu |> … ggplotly(p)

Display machine information for reproducibility:

```
sessionInfo()
```

```
R version 4.4.2 (2024-10-31)
Platform: aarch64-apple-darwin20
Running under: macOS Sonoma 14.7.3

Matrix products: default
BLAS:   /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRblas.0.dylib
LAPACK: /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRlapack.dylib;  l

locale:
[1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8

time zone: America/Los_Angeles
```

```
tzcode source: internal

attached base packages:
[1] stats     graphics  grDevices utils     datasets  methods   base

loaded via a namespace (and not attached):
 [1] compiler_4.4.2    fastmap_1.2.0     cli_3.6.3         tools_4.4.2
 [5] htmltools_0.5.8.1 rstudioapi_0.17.1 yaml_2.3.10       rmarkdown_2.29
 [9] knitr_1.49        jsonlite_1.8.9    xfun_0.50         digest_0.6.37
[13] rlang_1.1.5       evaluate_1.0.3
```

Load necessary libraries (you can add more as needed).

```
library(arrow)
```

```
Attaching package: 'arrow'

The following object is masked from 'package:utils':

    timestamp
```

```
library(gtsummary)
library(memuse)
library(pryr)
```

```
Attaching package: 'pryr'

The following object is masked from 'package:gtsummary':

    where
```

```
library(R.utils)
```

```
Loading required package: R.oo

Loading required package: R.methodsS3
```

```
R.methodsS3 v1.8.2 (2022-06-13 22:00:14 UTC) successfully loaded. See ?R.methodsS3 for help.

R.oo v1.27.0 (2024-11-01 18:00:02 UTC) successfully loaded. See ?R.oo for help.


Attaching package: 'R.oo'

The following object is masked from 'package:R.methodsS3':

    throw

The following objects are masked from 'package:methods':

    getClasses, getMethods

The following objects are masked from 'package:base':

    attach, detach, load, save

R.utils v2.12.3 (2023-11-18 01:00:02 UTC) successfully loaded. See ?R.utils for help.


Attaching package: 'R.utils'

The following object is masked from 'package:arrow':

    timestamp

The following object is masked from 'package:utils':

    timestamp

The following objects are masked from 'package:base':

    cat, commandArgs, getOption, isOpen, nullfile, parse, use, warnings
```

```r
library(tidyverse)
```

```
-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v dplyr     1.1.4     v readr     2.1.5
v forcats   1.0.0     v stringr   1.5.1
v ggplot2   3.5.1     v tibble    3.2.1
v lubridate 1.9.4     v tidyr     1.3.1
v purrr     1.0.4

-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x purrr::compose()      masks pryr::compose()
x lubridate::duration() masks arrow::duration()
x tidyr::extract()      masks R.utils::extract()
x dplyr::filter()       masks stats::filter()
x dplyr::lag()          masks stats::lag()
x purrr::partial()      masks pryr::partial()
x dplyr::where()        masks pryr::where(), gtsummary::where()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becor
```

```
library(ggplot2)
library(lubridate)
```

Display your machine memory.

```
memuse::Sys.meminfo()
```

```
Totalram:  16.000 GiB
Freeram:    8.236 GiB
```

In this exercise, we use tidyverse (ggplot2, dplyr, etc) to explore the MIMIC-IV data introduced in homework 1 and to build a cohort of ICU stays.

Q1. Visualizing patient trajectory

Visualizing a patient's encounters in a health care system is a common task in clinical data analysis. In this question, we will visualize a patient's ADT (admission-discharge-transfer) history and ICU vitals in the MIMIC-IV data.

Q1.1 ADT history

A patient's ADT history records the time of admission, discharge, and transfer in the hospital. This figure shows the ADT history of the patient with `subject_id` 10001217 in the MIMIC-IV data. The x-axis is the calendar time, and the y-axis is the type of event (ADT, lab, procedure). The color of the line segment represents the care unit. The size of the line segment represents whether the care unit is an ICU/CCU. The crosses represent lab events, and the shape of the dots represents the type of procedure. The title of the figure shows the patient's demographic information and the subtitle shows top 3 diagnoses.

Hint: We need to pull information from data files `patients.csv.gz`, `admissions.csv.gz`, `transfers.csv.gz`, `labevents.csv.gz`, `procedures_icd.csv.gz`, `diagnoses_icd.csv.gz`, `d_icd_procedures.csv.gz`, and `d_icd_diagnoses.csv.gz`. For the big file `labevents.csv.gz`, use the Parquet format you generated in Homework 2. For reproducibility, make the Parquet folder `labevents_pq` available at the current working directory `hw3`, for example, by a symbolic link. Make your code reproducible.

```
patients_tble <- read_csv("~/mimic/hosp/patients.csv.gz") |>
  print(width = Inf)
```

```
Rows: 364627 Columns: 6
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (2): gender, anchor_year_group
dbl  (3): subject_id, anchor_age, anchor_year
date (1): dod

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# A tibble: 364,627 x 6
   subject_id gender anchor_age anchor_year anchor_year_group dod
        <dbl> <chr>       <dbl>       <dbl> <chr>             <date>
 1   10000032 F              52        2180 2014 - 2016       2180-09-09
 2   10000048 F              23        2126 2008 - 2010       NA
 3   10000058 F              33        2168 2020 - 2022       NA
 4   10000068 F              19        2160 2008 - 2010       NA
 5   10000084 M              72        2160 2017 - 2019       2161-02-13
 6   10000102 F              27        2136 2008 - 2010       NA
 7   10000108 M              25        2163 2014 - 2016       NA
 8   10000115 M              24        2154 2017 - 2019       NA
 9   10000117 F              48        2174 2008 - 2010       NA
```

```
10   10000161 M             60        2163 2020 - 2022       NA
# i 364,617 more rows
```

```
admissions_tble <- read_csv("~/mimic/hosp/admissions.csv.gz") |>
  print(width = Inf)
```

```
Rows: 546028 Columns: 16
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (8): admission_type, admit_provider_id, admission_location, discharge_l...
dbl  (3): subject_id, hadm_id, hospital_expire_flag
dttm (5): admittime, dischtime, deathtime, edregtime, edouttime

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.

# A tibble: 546,028 x 16
   subject_id  hadm_id admittime           dischtime           deathtime
        <dbl>    <dbl> <dttm>              <dttm>              <dttm>
 1   10000032 22595853 2180-05-06 22:23:00 2180-05-07 17:15:00 NA
 2   10000032 22841357 2180-06-26 18:27:00 2180-06-27 18:49:00 NA
 3   10000032 25742920 2180-08-05 23:44:00 2180-08-07 17:50:00 NA
 4   10000032 29079034 2180-07-23 12:35:00 2180-07-25 17:55:00 NA
 5   10000068 25022803 2160-03-03 23:16:00 2160-03-04 06:26:00 NA
 6   10000084 23052089 2160-11-21 01:56:00 2160-11-25 14:52:00 NA
 7   10000084 29888819 2160-12-28 05:11:00 2160-12-28 16:07:00 NA
 8   10000108 27250926 2163-09-27 23:17:00 2163-09-28 09:04:00 NA
 9   10000117 22927623 2181-11-15 02:05:00 2181-11-15 14:52:00 NA
10   10000117 27988844 2183-09-18 18:10:00 2183-09-21 16:30:00 NA
   admission_type    admit_provider_id admission_location     discharge_location
   <chr>             <chr>             <chr>                  <chr>
 1 URGENT            P49AFC            TRANSFER FROM HOSPITAL HOME
 2 EW EMER.          P784FA            EMERGENCY ROOM         HOME
 3 EW EMER.          P19UTS            EMERGENCY ROOM         HOSPICE
 4 EW EMER.          P06OTX            EMERGENCY ROOM         HOME
 5 EU OBSERVATION    P39NWO            EMERGENCY ROOM         <NA>
 6 EW EMER.          P42H7G            WALK-IN/SELF REFERRAL  HOME HEALTH CARE
 7 EU OBSERVATION    P35NE4            PHYSICIAN REFERRAL     <NA>
 8 EU OBSERVATION    P40JML            EMERGENCY ROOM         <NA>
 9 EU OBSERVATION    P47EY8            EMERGENCY ROOM         <NA>
10 OBSERVATION ADMIT P13ACE            WALK-IN/SELF REFERRAL  HOME HEALTH CARE
   insurance language marital_status race  edregtime
```

```
   <chr>     <chr>    <chr>          <chr> <dttm>
 1 Medicaid  English  WIDOWED        WHITE 2180-05-06 19:17:00
 2 Medicaid  English  WIDOWED        WHITE 2180-06-26 15:54:00
 3 Medicaid  English  WIDOWED        WHITE 2180-08-05 20:58:00
 4 Medicaid  English  WIDOWED        WHITE 2180-07-23 05:54:00
 5 <NA>      English  SINGLE         WHITE 2160-03-03 21:55:00
 6 Medicare  English  MARRIED        WHITE 2160-11-20 20:36:00
 7 Medicare  English  MARRIED        WHITE 2160-12-27 18:32:00
 8 <NA>      English  SINGLE         WHITE 2163-09-27 16:18:00
 9 Medicaid  English  DIVORCED       WHITE 2181-11-14 21:51:00
10 Medicaid  English  DIVORCED       WHITE 2183-09-18 08:41:00
   edouttime           hospital_expire_flag
   <dttm>                             <dbl>
 1 2180-05-06 23:30:00                    0
 2 2180-06-26 21:31:00                    0
 3 2180-08-06 01:44:00                    0
 4 2180-07-23 14:00:00                    0
 5 2160-03-04 06:26:00                    0
 6 2160-11-21 03:20:00                    0
 7 2160-12-28 16:07:00                    0
 8 2163-09-28 09:04:00                    0
 9 2181-11-15 09:57:00                    0
10 2183-09-18 20:20:00                    0
# i 546,018 more rows
```

```
transfers_tble <- read_csv("~/mimic/hosp/transfers.csv.gz") |>
  print(width = Inf)
```

```
Rows: 2413581 Columns: 7
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (2): eventtype, careunit
dbl  (3): subject_id, hadm_id, transfer_id
dttm (2): intime, outtime

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.

# A tibble: 2,413,581 x 7
   subject_id  hadm_id transfer_id eventtype careunit
        <dbl>    <dbl>       <dbl> <chr>     <chr>
 1   10000032 22595853    33258284 ED        Emergency Department
```

```
 2   10000032 22595853    35223874 admit     Transplant
 3   10000032 22595853    36904543 discharge UNKNOWN
 4   10000032 22841357    34100253 discharge UNKNOWN
 5   10000032 22841357    34703856 admit     Transplant
 6   10000032 22841357    38112554 ED        Emergency Department
 7   10000032 25742920    35509340 admit     Transplant
 8   10000032 25742920    35968195 ED        Emergency Department
 9   10000032 25742920    38883756 discharge UNKNOWN
10   10000032 29079034    32952584 ED        Emergency Department
   intime              outtime
   <dttm>              <dttm>
 1 2180-05-06 19:17:00 2180-05-06 23:30:00
 2 2180-05-06 23:30:00 2180-05-07 17:21:27
 3 2180-05-07 17:21:27 NA
 4 2180-06-27 18:49:12 NA
 5 2180-06-26 21:31:00 2180-06-27 18:49:12
 6 2180-06-26 15:54:00 2180-06-26 21:31:00
 7 2180-08-06 01:44:00 2180-08-07 17:50:44
 8 2180-08-05 20:58:00 2180-08-06 01:44:00
 9 2180-08-07 17:50:44 NA
10 2180-07-22 16:24:00 2180-07-23 05:54:00
# i 2,413,571 more rows
```

```
procedures_icd_tble <- read_csv("~/mimic/hosp/procedures_icd.csv.gz") |>
  print(width = Inf)
```

```
Rows: 859655 Columns: 6
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (1): icd_code
dbl  (4): subject_id, hadm_id, seq_num, icd_version
date (1): chartdate

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.

# A tibble: 859,655 x 6
   subject_id  hadm_id seq_num chartdate  icd_code icd_version
        <dbl>    <dbl>   <dbl> <date>     <chr>          <dbl>
 1   10000032 22595853       1 2180-05-07 5491               9
 2   10000032 22841357       1 2180-06-27 5491               9
 3   10000032 25742920       1 2180-08-06 5491               9
```

```
 4   10000068 25022803       1 2160-03-03 8938              9
 5   10000117 27988844       1 2183-09-19 0QS734Z          10
 6   10000280 25852320       1 2151-03-18 8938              9
 7   10000560 28979390       1 2189-10-16 5551              9
 8   10000635 26134563       1 2136-06-19 3734              9
 9   10000635 26134563       2 2136-06-19 3728              9
10   10000635 26134563       3 2136-06-19 3727              9
# i 859,645 more rows
```

```
diagnoses_icd_tble <- read_csv("~/mimic/hosp/diagnoses_icd.csv.gz") |>
  print(width = Inf)
```

```
Rows: 6364488 Columns: 5
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (1): icd_code
dbl (4): subject_id, hadm_id, seq_num, icd_version

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.

# A tibble: 6,364,488 x 5
   subject_id  hadm_id seq_num icd_code icd_version
        <dbl>    <dbl>   <dbl> <chr>          <dbl>
 1   10000032 22595853       1 5723               9
 2   10000032 22595853       2 78959              9
 3   10000032 22595853       3 5715               9
 4   10000032 22595853       4 07070              9
 5   10000032 22595853       5 496                9
 6   10000032 22595853       6 29680              9
 7   10000032 22595853       7 30981              9
 8   10000032 22595853       8 V1582              9
 9   10000032 22841357       1 07071              9
10   10000032 22841357       2 78959              9
# i 6,364,478 more rows
```

```
d_icd_procedures_tble <- read_csv("~/mimic/hosp/d_icd_procedures.csv.gz") |>
  print(width = Inf)
```

```
Rows: 86423 Columns: 3
-- Column specification --------------------------------------------------------
```

```
Delimiter: ","
chr (2): icd_code, long_title
dbl (1): icd_version

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.

# A tibble: 86,423 x 3
   icd_code icd_version
   <chr>          <dbl>
 1 0001               9
 2 0002               9
 3 0003               9
 4 0009               9
 5 001               10
 6 0010               9
 7 0011               9
 8 0012               9
 9 0013               9
10 0014               9
   long_title
   <chr>
 1 Therapeutic ultrasound of vessels of head and neck
 2 Therapeutic ultrasound of heart
 3 Therapeutic ultrasound of peripheral vascular vessels
 4 Other therapeutic ultrasound
 5 Central Nervous System and Cranial Nerves, Bypass
 6 Implantation of chemotherapeutic agent
 7 Infusion of drotrecogin alfa (activated)
 8 Administration of inhaled nitric oxide
 9 Injection or infusion of nesiritide
10 Injection or infusion of oxazolidinone class of antibiotics
# i 86,413 more rows
```

```
d_icd_diagnoses_tble <- read_csv("~/mimic/hosp/d_icd_diagnoses.csv.gz") |>
  print(width = Inf)
```

```
Rows: 112107 Columns: 3
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (2): icd_code, long_title
dbl (1): icd_version
```

```
i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# A tibble: 112,107 x 3
   icd_code icd_version long_title
   <chr>          <dbl> <chr>
 1 0010               9 Cholera due to vibrio cholerae
 2 0011               9 Cholera due to vibrio cholerae el tor
 3 0019               9 Cholera, unspecified
 4 0020               9 Typhoid fever
 5 0021               9 Paratyphoid fever A
 6 0022               9 Paratyphoid fever B
 7 0023               9 Paratyphoid fever C
 8 0029               9 Paratyphoid fever, unspecified
 9 0030               9 Salmonella gastroenteritis
10 0031               9 Salmonella septicemia
# i 112,097 more rows
```

```
lab_events <- open_dataset("~/203b/hw/hw3/labevents_pq",
                           format = "parquet") %>%
  select(subject_id, charttime, itemid, storetime, valuenum) %>%
  collect()
print(lab_events, width = Inf)
```

```
# A tibble: 158,374,764 x 5
   subject_id charttime           itemid storetime           valuenum
        <int> <dttm>               <int> <dttm>                 <dbl>
 1   10000032 2180-03-23 04:51:00  50931 2180-03-23 08:56:00       95
 2   10000032 2180-03-23 04:51:00  51071 2180-03-23 09:00:00       NA
 3   10000032 2180-03-23 04:51:00  51074 2180-03-23 09:00:00       NA
 4   10000032 2180-03-23 04:51:00  51075 2180-03-23 09:00:00       NA
 5   10000032 2180-03-23 04:51:00  51079 2180-03-23 09:00:00       NA
 6   10000032 2180-03-23 04:51:00  51087 NA                        NA
 7   10000032 2180-03-23 04:51:00  51089 2180-03-23 09:15:00       NA
 8   10000032 2180-03-23 04:51:00  51090 2180-03-23 09:00:00       NA
 9   10000032 2180-03-23 04:51:00  51092 2180-03-23 09:00:00       NA
10   10000032 2180-03-23 04:51:00  50853 2180-03-25 04:06:00       15
# i 158,374,754 more rows
```

```r
subject_id <- 10063848

adt_data <- transfers_tble %>%
  filter(subject_id == !!subject_id & !is.na(intime) & !is.na(outtime)) %>%
  mutate(intime = as.POSIXct(intime,
                             format="%Y-%m-%d %H:%M:%S",
                             tz="UTC"),
         outtime = as.POSIXct(outtime,
                              format="%Y-%m-%d %H:%M:%S",
                              tz="UTC"))

lab_data <- lab_events %>%
  filter(subject_id == !!subject_id) %>%
  distinct(subject_id, charttime, itemid, .keep_all = TRUE) %>%
  mutate(charttime = as.POSIXct(charttime, tz="UTC"))

patient_info <- admissions_tble %>%
  filter(subject_id == !!subject_id) %>%
  select(subject_id, race) %>%
  distinct() %>%
  left_join(patients_tble %>% select(subject_id, gender, anchor_age),
            by = "subject_id")

diagnoses_icd <- diagnoses_icd_tble %>%
  mutate(icd_code = str_remove(icd_code, "^0+"),
         icd_version = as.character(icd_version))

d_icd_diagnoses <- d_icd_diagnoses_tble %>%
  mutate(icd_code = str_remove(icd_code, "^0+"),
         icd_version = as.character(icd_version))

diagnosis_data <- diagnoses_icd_tble %>%
  filter(subject_id == !!subject_id) %>%
  left_join(d_icd_diagnoses_tble, by = c("icd_code", "icd_version")) %>%
  left_join(admissions_tble %>% select(subject_id, admittime),
            by = "subject_id") %>%
  arrange(admittime) %>%
  slice(1:3)
```

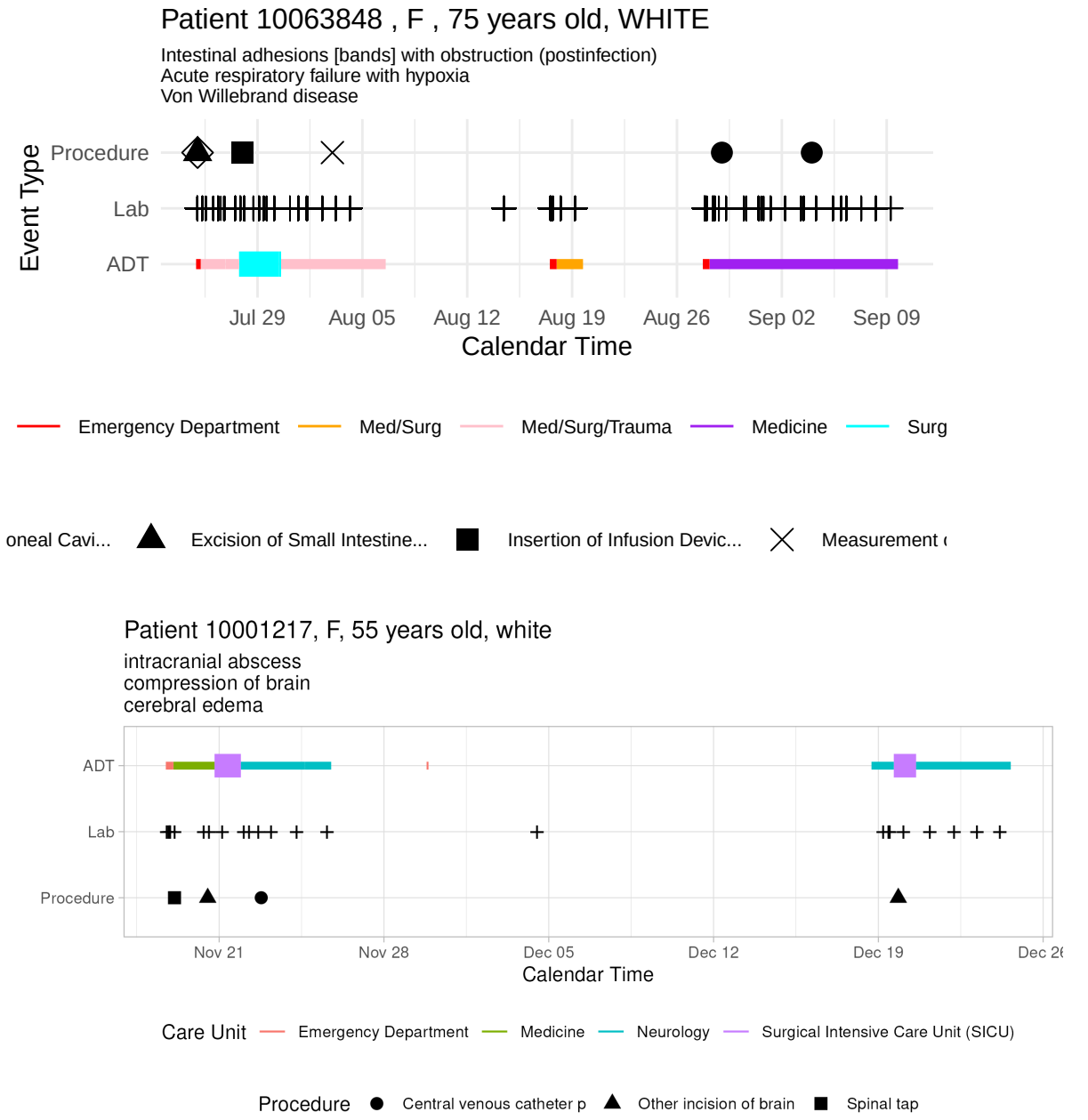
```
Warning in left_join(., admissions_tble %>% select(subject_id, admittime), : Detected an unex
i Row 1 of `x` matches multiple rows in `y`.
i Row 3309 of `y` matches multiple rows in `x`.
```

```
i If a many-to-many relationship is expected, set `relationship =
  "many-to-many"` to silence this warning.
```

```
procedure_data <- procedures_icd_tble %>%
  filter(subject_id == !!subject_id & !is.na(chartdate)) %>%
  left_join(d_icd_procedures_tble, by = "icd_code") %>%
  mutate(chartdate = as.POSIXct(chartdate,
                                format="%Y-%m-%d",
                                tz="UTC"),
         procedure_label = ifelse(is.na(long_title),
                                  "Unknown Procedure",
                                  str_trunc(long_title, 30,
                                            side = "right")))
```

```
title_text <- paste("Patient", subject_id, ",",
                    patient_info$gender, ",",
                    patient_info$anchor_age, "years old,",
                    patient_info$race)

subtitle_text <- diagnosis_data %>%
  filter(!is.na(long_title)) %>%
  pull(long_title) %>%
  paste(collapse = "\n")

procedure_data <- procedure_data %>%
  mutate(procedure_label = str_trunc(long_title, 30, side = "right"))

ggplot() +

  geom_point(data = procedure_data,
             aes(x = chartdate, y = "Procedure",
                 shape = factor(procedure_label)),
             size = 4) +

  # ADT
  geom_segment(data = adt_data,
               aes(x = intime, xend = outtime, y = "ADT",
                   color = careunit,
                   linewidth = ifelse(str_detect(careunit,
                                                 "ICU|CCU|SICU"), 5, 2))
               ) +
  scale_linewidth_identity() +
```

```r
# Lab
geom_point(data = lab_data,
           aes(x = charttime, y = "Lab"),
           shape = 3, size = 3, color = "black") +

scale_x_datetime(date_labels = "%b %d", date_breaks = "7 days") +

theme_minimal() +
labs(title = title_text,
     subtitle = subtitle_text,
     x = "Calendar Time",
     y = "Event Type",
     color = "Care Unit",
     shape = "Procedure") +

# Care Unit
scale_color_manual(values = c("red",
                              "orange",
                              "pink",
                              "purple",
                              "cyan")) +

# Procedure
scale_shape_manual(values = c(16, 17, 15, 4, 5)) +

guides(
  color = guide_legend(title = "Care Unit", nrow = 1),
  shape = guide_legend(title = "Procedure", nrow = 1)
) +

theme(
  legend.position = "bottom",
  legend.box = "vertical",
  legend.spacing.y = unit(0.5, "cm"),
  legend.text = element_text(size = 8),
  plot.title = element_text(size = 12, hjust = 0),
  plot.subtitle = element_text(size = 8, hjust = 0),
  legend.key.size = unit(0.8, "cm")
)
```



Do a similar visualization for the patient with `subject_id` 10063848 using ggplot.

Q1.2 ICU stays

ICU stays are a subset of ADT history. This figure shows the vitals of the patient `10001217` during ICU stays. The x-axis is the calendar time, and the y-axis is the value of the vital.

The color of the line represents the type of vital. The facet grid shows the abbreviation of the vital and the stay ID.

```
icu_stays_tble <- read_csv("~/mimic/icu/icustays.csv.gz") |>
  print(width = Inf)
```

```
Rows: 94458 Columns: 8
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (2): first_careunit, last_careunit
dbl  (4): subject_id, hadm_id, stay_id, los
dttm (2): intime, outtime

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# A tibble: 94,458 x 8
   subject_id  hadm_id  stay_id first_careunit
        <dbl>    <dbl>    <dbl> <chr>
 1   10000032 29079034 39553978 Medical Intensive Care Unit (MICU)
 2   10000690 25860671 37081114 Medical Intensive Care Unit (MICU)
 3   10000980 26913865 39765666 Medical Intensive Care Unit (MICU)
 4   10001217 24597018 37067082 Surgical Intensive Care Unit (SICU)
 5   10001217 27703517 34592300 Surgical Intensive Care Unit (SICU)
 6   10001725 25563031 31205490 Medical/Surgical Intensive Care Unit (MICU/SICU)
 7   10001843 26133978 39698942 Medical/Surgical Intensive Care Unit (MICU/SICU)
 8   10001884 26184834 37510196 Medical Intensive Care Unit (MICU)
 9   10002013 23581541 39060235 Cardiac Vascular Intensive Care Unit (CVICU)
10   10002114 27793700 34672098 Coronary Care Unit (CCU)
   last_careunit                                     intime
   <chr>                                             <dttm>
 1 Medical Intensive Care Unit (MICU)                2180-07-23 14:00:00
 2 Medical Intensive Care Unit (MICU)                2150-11-02 19:37:00
 3 Medical Intensive Care Unit (MICU)                2189-06-27 08:42:00
 4 Surgical Intensive Care Unit (SICU)               2157-11-20 19:18:02
 5 Surgical Intensive Care Unit (SICU)               2157-12-19 15:42:24
 6 Medical/Surgical Intensive Care Unit (MICU/SICU) 2110-04-11 15:52:22
 7 Medical/Surgical Intensive Care Unit (MICU/SICU) 2134-12-05 18:50:03
 8 Medical Intensive Care Unit (MICU)                2131-01-11 04:20:05
 9 Cardiac Vascular Intensive Care Unit (CVICU)      2160-05-18 10:00:53
10 Coronary Care Unit (CCU)                          2162-02-17 23:30:00
   outtime              los
```

```
   <dttm>              <dbl>
 1 2180-07-23 23:50:47 0.410
 2 2150-11-06 17:03:17 3.89
 3 2189-06-27 20:38:27 0.498
 4 2157-11-21 22:08:00 1.12
 5 2157-12-20 14:27:41 0.948
 6 2110-04-12 23:59:56 1.34
 7 2134-12-06 14:38:26 0.825
 8 2131-01-20 08:27:30 9.17
 9 2160-05-19 17:33:33 1.31
10 2162-02-20 21:16:27 2.91
# i 94,448 more rows
```

```
chartevents <- read_csv("~/203b/hw/hw3/chartevents_filtered.csv") |>
  print(width = Inf)
```

```
Rows: 5069858 Columns: 11
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (1): valueuom
dbl  (8): subject_id, hadm_id, stay_id, caregiver_id, itemid, value, valuenu...
dttm (2): charttime, storetime

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# A tibble: 5,069,858 x 11
   subject_id  hadm_id  stay_id caregiver_id charttime
        <dbl>    <dbl>    <dbl>        <dbl> <dttm>
 1   10000032 29079034 39553978        18704 2180-07-23 14:00:00
 2   10000032 29079034 39553978        18704 2180-07-23 14:11:00
 3   10000032 29079034 39553978        18704 2180-07-23 14:11:00
 4   10000032 29079034 39553978        18704 2180-07-23 14:12:00
 5   10000032 29079034 39553978        18704 2180-07-23 14:12:00
 6   10000032 29079034 39553978        18704 2180-07-23 14:30:00
 7   10000032 29079034 39553978        18704 2180-07-23 14:30:00
 8   10000032 29079034 39553978        18704 2180-07-23 14:30:00
 9   10000032 29079034 39553978        18704 2180-07-23 14:30:00
10   10000032 29079034 39553978        18704 2180-07-23 15:00:00
   storetime           itemid value valuenum valueuom warning
   <dttm>               <dbl> <dbl>    <dbl> <chr>      <dbl>
 1 2180-07-23 14:20:00 223761  98.7     98.7 °F             0
```

```
 2 2180-07-23 14:17:00 220179  84       84   mmHg           0
 3 2180-07-23 14:17:00 220181  56       56   mmHg           0
 4 2180-07-23 14:17:00 220045  91       91   bpm            0
 5 2180-07-23 14:17:00 220210  24       24   insp/min       0
 6 2180-07-23 14:43:00 220045  93       93   bpm            0
 7 2180-07-23 14:43:00 220179  95       95   mmHg           0
 8 2180-07-23 14:43:00 220181  67       67   mmHg           0
 9 2180-07-23 14:43:00 220210  21       21   insp/min       0
10 2180-07-23 15:34:00 220045  94       94   bpm            0
# i 5,069,848 more rows
```

```r
icu_stays <- icu_stays_tble %>%
  filter(subject_id == 10001217) %>%
  mutate(intime = as.POSIXct(intime, tz = "UTC"),
         outtime = as.POSIXct(outtime, tz = "UTC")) %>%
  select(subject_id, stay_id, intime, outtime)

vitals_data <- chartevents %>%
  filter(subject_id == 10001217, !is.na(valuenum)) %>%
  select(subject_id, stay_id, charttime, itemid, valuenum) %>%
  mutate(
    stay_id = as.double(stay_id),
    charttime = as.POSIXct(charttime, tz = "UTC")
  ) %>%
  inner_join(icu_stays, by = "stay_id") %>%
  filter(charttime >= intime & charttime <= outtime)

print(vitals_data)
```

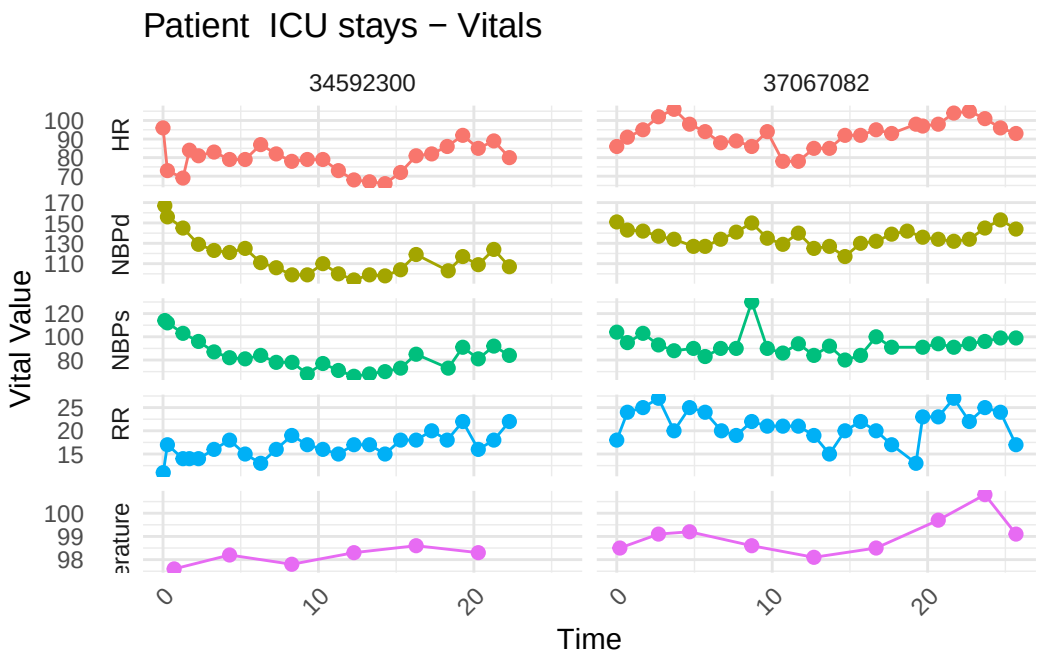
```
# A tibble: 218 x 8
   subject_id.x  stay_id charttime           itemid valuenum subject_id.y
          <dbl>    <dbl> <dttm>               <dbl>    <dbl>        <dbl>
 1     10001217 37067082 2157-11-20 19:19:00 220045     86       10001217
 2     10001217 37067082 2157-11-20 19:19:00 220179    151       10001217
 3     10001217 37067082 2157-11-20 19:19:00 220181    104       10001217
 4     10001217 37067082 2157-11-20 19:19:00 220210     18       10001217
 5     10001217 37067082 2157-11-20 19:31:00 223761     98.5     10001217
 6     10001217 37067082 2157-11-20 20:00:00 220045     91       10001217
 7     10001217 37067082 2157-11-20 20:00:00 220179    143       10001217
 8     10001217 37067082 2157-11-20 20:00:00 220181     95       10001217
 9     10001217 37067082 2157-11-20 20:00:00 220210     24       10001217
10     10001217 37067082 2157-11-20 21:00:00 220045     95       10001217
```

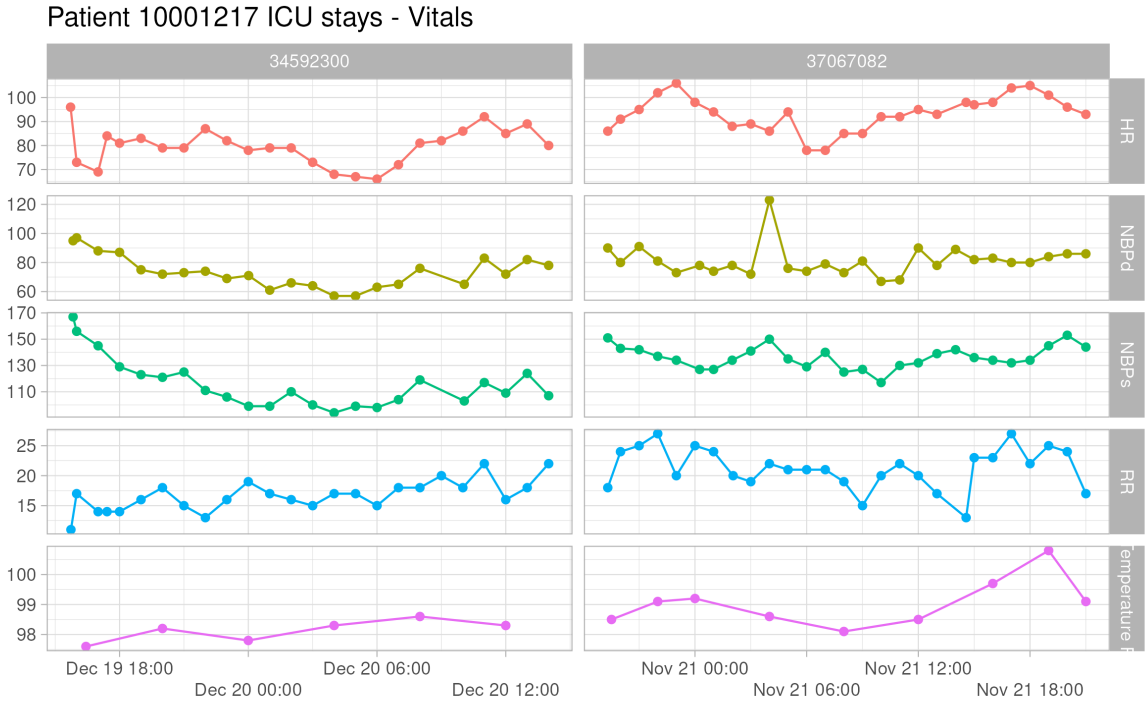
```
# i 208 more rows
# i 2 more variables: intime <dttm>, outtime <dttm>
```

```
vitals_data <- vitals_data %>%
  mutate(vital_label = case_when(
    itemid %in% c(220045) ~ "HR",
    itemid %in% c(220179) ~ "NBPd",
    itemid %in% c(220181) ~ "NBPs",
    itemid %in% c(220210) ~ "RR",
    itemid %in% c(223761) ~ "Temperature",
    TRUE ~ NA_character_
  )) %>%
  filter(!is.na(vital_label)) %>%
  group_by(stay_id) %>%
  mutate(relative_charttime = as.numeric(difftime(charttime,
                                                  min(charttime),
                                                  units = "hours"))
         ) %>%
  ungroup()
```

```
ggplot(vitals_data, aes(x = relative_charttime,
                        y = valuenum,
                        color = vital_label)) +
  geom_line() +
  geom_point(size = 2) +
  facet_grid(vital_label ~ stay_id, scales = "free_y", switch = "y") +
  theme_minimal() +
  labs(
    title = paste("Patient", unique(vitals_data$subject_id), "ICU stays - Vitals"),
    x = "Time",
    y = "Vital Value"
  ) +
  theme(
    axis.text.x = element_text(angle = 45, hjust = 1),
    strip.text.y = element_text(angle = 0, hjust = 1),
    legend.position = "none",
    panel.grid.major = element_line(color = "grey90")
  )
```

```
Warning: Unknown or uninitialised column: `subject_id`.
```





Do a similar visualization for the patient 10063848.

Q2. ICU stays

`icustays.csv.gz` (https://mimic.mit.edu/docs/iv/modules/icu/icustays/) contains data about Intensive Care Units (ICU) stays. The first 10 lines are

```
zcat < ~/mimic/icu/icustays.csv.gz | head
```

```
subject_id,hadm_id,stay_id,first_careunit,last_careunit,intime,outtime,los
10000032,29079034,39553978,Medical Intensive Care Unit (MICU),Medical Intensive Care Unit (MI
10000690,25860671,37081114,Medical Intensive Care Unit (MICU),Medical Intensive Care Unit (MI
10000980,26913865,39765666,Medical Intensive Care Unit (MICU),Medical Intensive Care Unit (MI
10001217,24597018,37067082,Surgical Intensive Care Unit (SICU),Surgical Intensive Care Unit
10001217,27703517,34592300,Surgical Intensive Care Unit (SICU),Surgical Intensive Care Unit
10001725,25563031,31205490,Medical/Surgical Intensive Care Unit (MICU/SICU),Medical/Surgical
10001843,26133978,39698942,Medical/Surgical Intensive Care Unit (MICU/SICU),Medical/Surgical
10001884,26184834,37510196,Medical Intensive Care Unit (MICU),Medical Intensive Care Unit (MI
10002013,23581541,39060235,Cardiac Vascular Intensive Care Unit (CVICU),Cardiac Vascular Inte
```

Q2.1 Ingestion

Import `icustays.csv.gz` as a tibble `icustays_tble`.

```
icustays_tble <- read_csv("~/mimic/icu/icustays.csv.gz") |>
  print(width = Inf)
```

```
Rows: 94458 Columns: 8
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (2): first_careunit, last_careunit
dbl  (4): subject_id, hadm_id, stay_id, los
dttm (2): intime, outtime

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# A tibble: 94,458 x 8
   subject_id  hadm_id  stay_id first_careunit
        <dbl>    <dbl>    <dbl> <chr>
 1   10000032 29079034 39553978 Medical Intensive Care Unit (MICU)
 2   10000690 25860671 37081114 Medical Intensive Care Unit (MICU)
```

```
 3   10000980 26913865 39765666 Medical Intensive Care Unit (MICU)
 4   10001217 24597018 37067082 Surgical Intensive Care Unit (SICU)
 5   10001217 27703517 34592300 Surgical Intensive Care Unit (SICU)
 6   10001725 25563031 31205490 Medical/Surgical Intensive Care Unit (MICU/SICU)
 7   10001843 26133978 39698942 Medical/Surgical Intensive Care Unit (MICU/SICU)
 8   10001884 26184834 37510196 Medical Intensive Care Unit (MICU)
 9   10002013 23581541 39060235 Cardiac Vascular Intensive Care Unit (CVICU)
10   10002114 27793700 34672098 Coronary Care Unit (CCU)
   last_careunit                                       intime
   <chr>                                               <dttm>
 1 Medical Intensive Care Unit (MICU)                  2180-07-23 14:00:00
 2 Medical Intensive Care Unit (MICU)                  2150-11-02 19:37:00
 3 Medical Intensive Care Unit (MICU)                  2189-06-27 08:42:00
 4 Surgical Intensive Care Unit (SICU)                 2157-11-20 19:18:02
 5 Surgical Intensive Care Unit (SICU)                 2157-12-19 15:42:24
 6 Medical/Surgical Intensive Care Unit (MICU/SICU)    2110-04-11 15:52:22
 7 Medical/Surgical Intensive Care Unit (MICU/SICU)    2134-12-05 18:50:03
 8 Medical Intensive Care Unit (MICU)                  2131-01-11 04:20:05
 9 Cardiac Vascular Intensive Care Unit (CVICU)        2160-05-18 10:00:53
10 Coronary Care Unit (CCU)                            2162-02-17 23:30:00
   outtime               los
   <dttm>              <dbl>
 1 2180-07-23 23:50:47 0.410
 2 2150-11-06 17:03:17 3.89
 3 2189-06-27 20:38:27 0.498
 4 2157-11-21 22:08:00 1.12
 5 2157-12-20 14:27:41 0.948
 6 2110-04-12 23:59:56 1.34
 7 2134-12-06 14:38:26 0.825
 8 2131-01-20 08:27:30 9.17
 9 2160-05-19 17:33:33 1.31
10 2162-02-20 21:16:27 2.91
# i 94,448 more rows
```

Q2.2 Summary and visualization

How many unique `subject_id`? Can a `subject_id` have multiple ICU stays? Summarize the number of ICU stays per `subject_id` by graphs.

```
unique_subjects <- icustays_tble %>%
  distinct(subject_id) %>%
```

```
  nrow()
print(unique_subjects)
```

```
[1] 65366
```

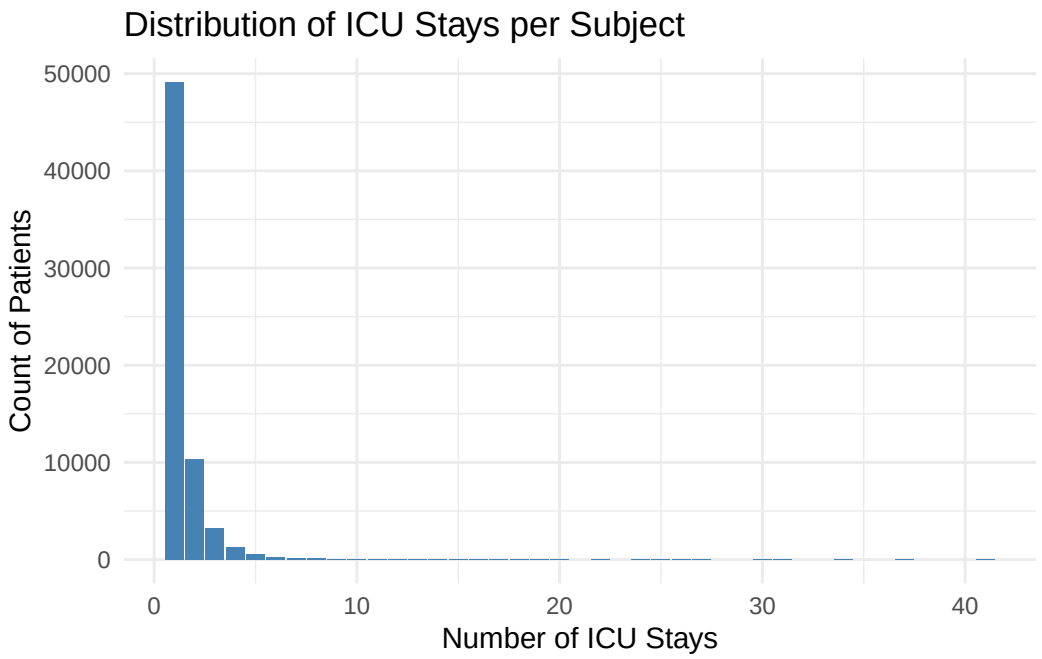
```
icu_stay_counts <- icustays_tble %>%
  count(subject_id) %>%
  arrange(desc(n))

print(icu_stay_counts)
```

```
# A tibble: 65,366 x 2
   subject_id     n
        <dbl> <int>
 1   12468016    41
 2   18358138    37
 3   17585185    34
 4   17295976    31
 5   13269859    30
 6   18676703    27
 7   12517625    26
 8   11281568    25
 9   15229355    25
10   15455517    25
# i 65,356 more rows
```

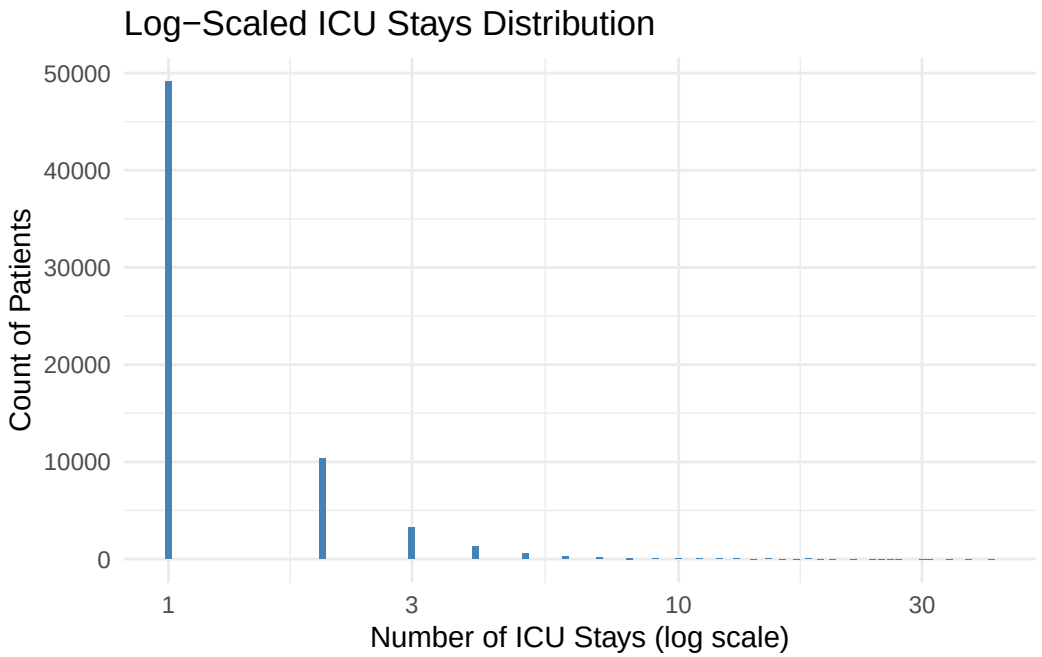
```
icu_summary <- icu_stay_counts %>%
  summarize(
    mean_stays = mean(n),
    median_stays = median(n),
    min_stays = min(n),
    max_stays = max(n)
  )
print(icu_summary)
```

```
# A tibble: 1 x 4
  mean_stays median_stays min_stays max_stays
       <dbl>        <dbl>     <int>     <int>
1       1.45            1         1        41
```

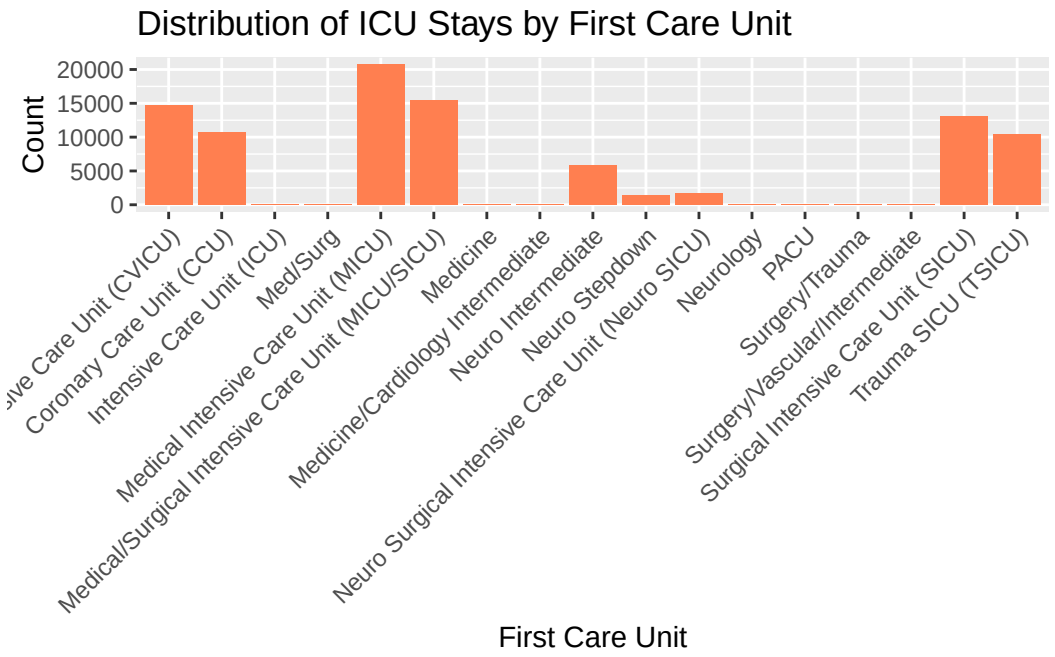
```r
ggplot(icu_stay_counts, aes(x = n)) +
  geom_bar(fill = "steelblue") +
  labs(title = "Distribution of ICU Stays per Subject",
       x = "Number of ICU Stays",
       y = "Count of Patients") +
  theme_minimal()
```




```r
ggplot(icu_stay_counts, aes(x = n)) +
  geom_bar(fill = "steelblue") +
  scale_x_log10() +
  labs(title = "Log-Scaled ICU Stays Distribution",
       x = "Number of ICU Stays (log scale)",
       y = "Count of Patients") +
  theme_minimal()
```




```
ggplot(icustays_tble, aes(x = first_careunit)) +
  geom_bar(fill = "coral") +
  labs(title = "Distribution of ICU Stays by First Care Unit",
       x = "First Care Unit",
       y = "Count") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



Q3. `admissions` data

Information of the patients admitted into hospital is available in `admissions.csv.gz`. See https://mimic.mit.edu/docs/iv/modules/hosp/admissions/ for details of each field in this file. The first 10 lines are

```
zcat < ~/mimic/hosp/admissions.csv.gz | head
```

```
subject_id,hadm_id,admittime,dischtime,deathtime,admission_type,admit_provider_id,admission_l
10000032,22595853,2180-05-06 22:23:00,2180-05-07 17:15:00,,URGENT,P49AFC,TRANSFER FROM HOSPIT
10000032,22841357,2180-06-26 18:27:00,2180-06-27 18:49:00,,EW EMER.,P784FA,EMERGENCY ROOM,HOM
10000032,25742920,2180-08-05 23:44:00,2180-08-07 17:50:00,,EW EMER.,P19UTS,EMERGENCY ROOM,HOS
10000032,29079034,2180-07-23 12:35:00,2180-07-25 17:55:00,,EW EMER.,P06OTX,EMERGENCY ROOM,HOM
10000068,25022803,2160-03-03 23:16:00,2160-03-04 06:26:00,,EU OBSERVATION,P39NWO,EMERGENCY RO
10000084,23052089,2160-11-21 01:56:00,2160-11-25 14:52:00,,EW EMER.,P42H7G,WALK-IN/SELF REFER
10000084,29888819,2160-12-28 05:11:00,2160-12-28 16:07:00,,EU OBSERVATION,P35NE4,PHYSICIAN RE
10000108,27250926,2163-09-27 23:17:00,2163-09-28 09:04:00,,EU OBSERVATION,P40JML,EMERGENCY RO
10000117,22927623,2181-11-15 02:05:00,2181-11-15 14:52:00,,EU OBSERVATION,P47EY8,EMERGENCY RO
```

Q3.1 Ingestion

Import `admissions.csv.gz` as a tibble `admissions_tble`.

```
admissions_tble <- read_csv("~/mimic/hosp/admissions.csv.gz")
```

```
Rows: 546028 Columns: 16
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (8): admission_type, admit_provider_id, admission_location, discharge_l...
dbl  (3): subject_id, hadm_id, hospital_expire_flag
dttm (5): admittime, dischtime, deathtime, edregtime, edouttime

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Q3.2 Summary and visualization

Summarize the following information by graphics and explain any patterns you see.

- number of admissions per patient
- admission hour (anything unusual?)
- admission minute (anything unusual?)
- length of hospital stay (from admission to discharge) (anything unusual?)

According to the MIMIC-IV documentation,

> All dates in the database have been shifted to protect patient confidentiality. Dates will be internally consistent for the same patient, but randomly distributed in the future. Dates of birth which occur in the present time are not true dates of birth. Furthermore, dates of birth which occur before the year 1900 occur if the patient is older than 89. In these cases, the patient's age at their first admission has been fixed to 300.

```
unique_hadm <- admissions_tble %>% distinct(hadm_id) %>% nrow()
unique_subjects <- admissions_tble %>% distinct(subject_id) %>% nrow()

cat("Unique hospital admissions (hadm_id):", unique_hadm, "\n")
```

```
Unique hospital admissions (hadm_id): 546028
```

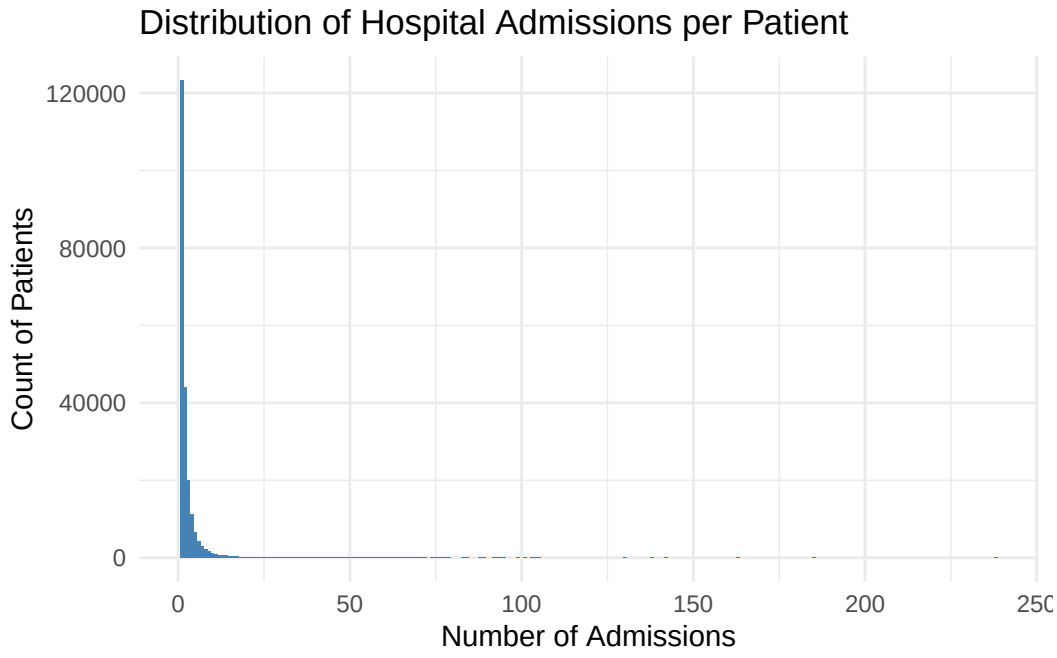
```r
cat("Unique patients (subject_id):", unique_subjects, "\n")
```

```
Unique patients (subject_id): 223452
```

```r
admissions_tble <- admissions_tble %>%
  mutate(los = difftime(dischtime, admittime, units = "days"))

summary(admissions_tble$los)
```

```
   Length     Class      Mode
   546028 difftime   numeric
```

```r
admission_counts <- admissions_tble %>%
  count(subject_id) %>%
  arrange(desc(n))

ggplot(admission_counts, aes(x = n)) +
  geom_bar(fill = "steelblue") +
  labs(title = "Distribution of Hospital Admissions per Patient",
       x = "Number of Admissions",
       y = "Count of Patients") +
  theme_minimal()
```



Most patients have only one hospital admission,

but a small subset has an extremely high number of admissions (e.g., 50+ times).

Patients with excessive admissions might represent chronic disease cases or

special cases requiring frequent hospital visits.

Further investigation is needed to check for potential data entry errors

among patients with more than 50 admissions.

```
admissions_tble %>%
  count(subject_id) %>%
  filter(n > 50)
```

```
# A tibble: 119 x 2
   subject_id     n
        <dbl> <int>
 1   10108435    53
 2   10123949    56
 3   10264646    94
 4   10312715    51
 5   10427568    63
 6   10577647    89
 7   10578325    74
 8   10580201    66
 9   10714009   163
10   10913302    78
# i 109 more rows
```

The number of admissions at midnight (00:00) is unusually high,

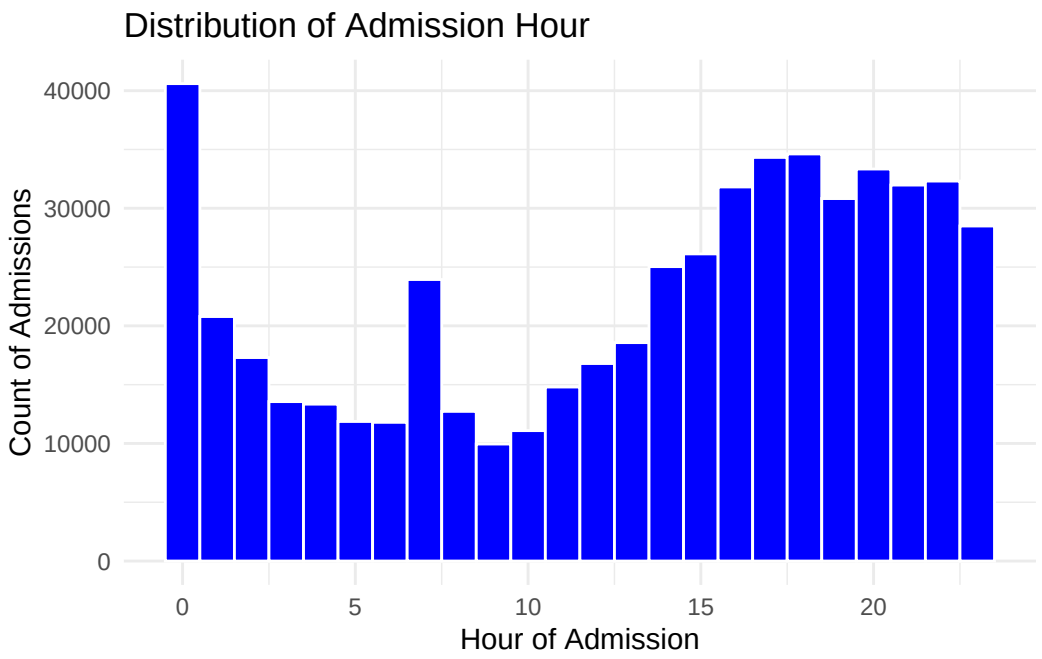
possibly due to a default system value (e.g., missing times being recorded as 00:00).

The peak in admissions from 3 PM to 9 PM may reflect normal hospital admission patterns.

The spike at midnight is likely a system default; we will check whether admittime = "00:00:00"

corresponds to missing data being automatically filled.

```
admissions_tble %>%
  mutate(admit_hour = hour(admittime)) %>%
  ggplot(aes(x = admit_hour)) +
  geom_histogram(binwidth = 1, fill = "blue", color = "white") +
  labs(title = "Distribution of Admission Hour",
       x = "Hour of Admission",
       y = "Count of Admissions") +
  theme_minimal()
```

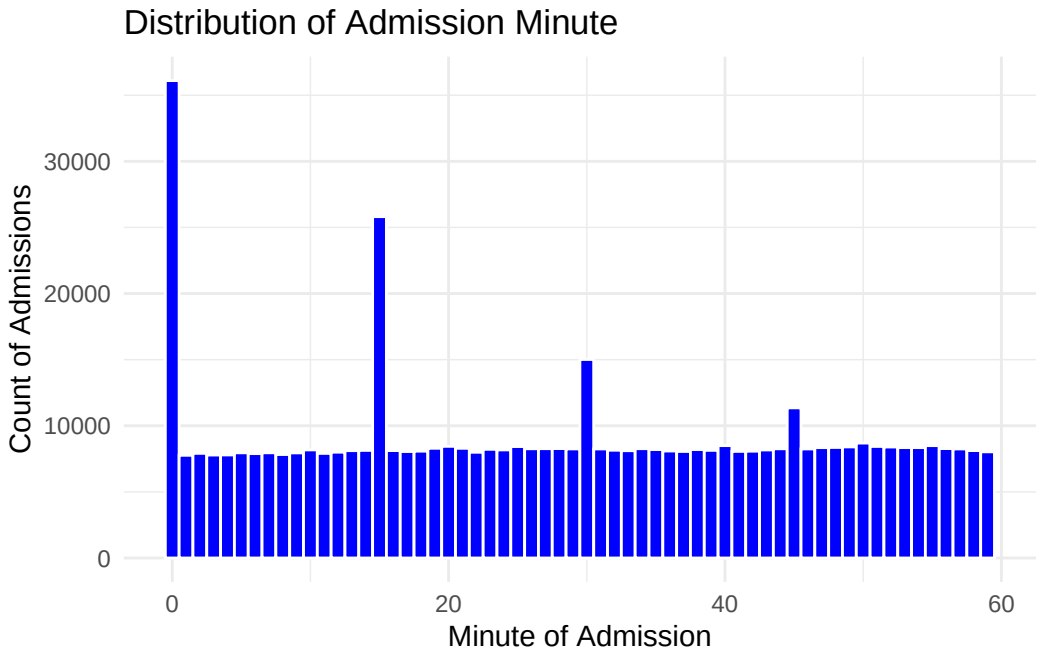



```
admissions_tble %>%
  filter(hour(admittime) == 0) %>%
  count(admittime)
```

```
# A tibble: 36,153 x 2
   admittime               n
   <dttm>              <int>
 1 2110-01-12 00:00:00     1
 2 2110-01-12 00:34:00     1
 3 2110-01-13 00:00:00     1
 4 2110-01-23 00:00:00     1
 5 2110-01-27 00:10:00     1
 6 2110-01-27 00:32:00     1
 7 2110-01-28 00:00:00     1
 8 2110-01-28 00:12:00     1
 9 2110-01-31 00:00:00     1
10 2110-02-03 00:00:00     1
# i 36,143 more rows
```

```
admissions_tble %>%
  mutate(admit_minute = minute(admittime)) %>%
  ggplot(aes(x = admit_minute)) +
```

```
  geom_histogram(binwidth = 1, fill = "blue", color = "white") +
  labs(title = "Distribution of Admission Minute",
       x = "Minute of Admission",
       y = "Count of Admissions") +
  theme_minimal()
```



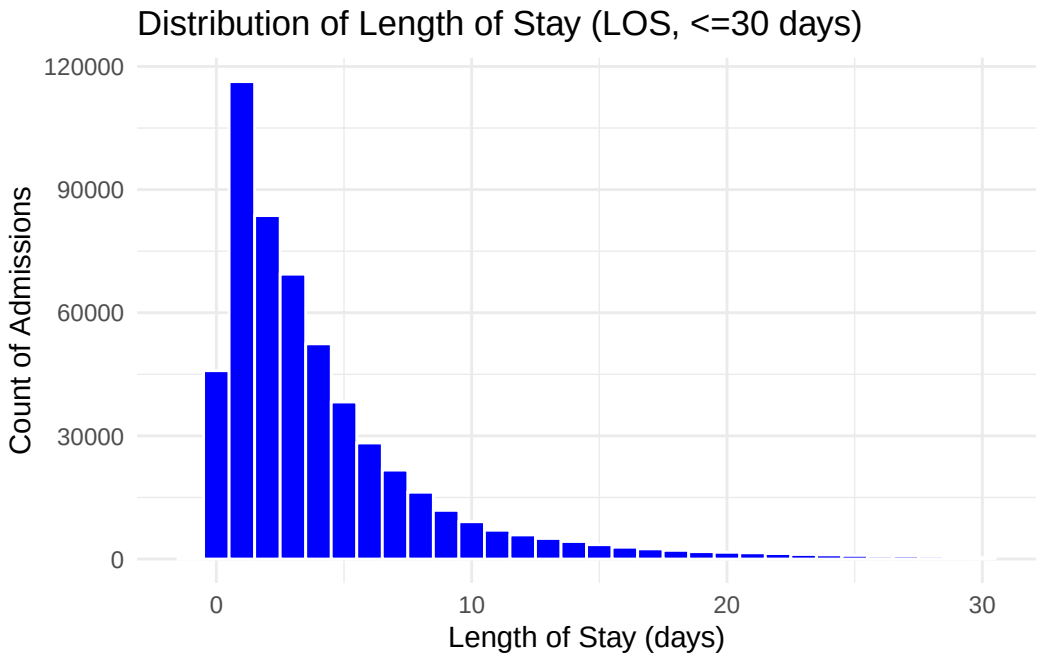
Admission counts at 0, 15, 30, and 45 minutes are unusually high, # suggesting that round-minute timestamps are overused. # This could indicate that hospital systems tend to round admission times # rather than recording them at a precise second level. # # The following code calculates the proportion of admissions at exact # versus non-exact minutes. The results confirm excessive rounding, # indicating that admission time precision is limited.

```
admissions_tble %>%
  mutate(admit_minute = minute(admittime)) %>%
  count(admit_minute) %>%
  arrange(desc(n))
```

```
# A tibble: 60 x 2
   admit_minute     n
          <int> <int>
 1            0 36108
 2           15 25818
 3           30 15015
 4           45 11357
 5           50  8692
 6           40  8501
 7           55  8499
 8           20  8447
 9           51  8438
10           25  8431
# i 50 more rows
```

```r
ggplot(admissions_tble %>% filter(los <= 30), aes(x = los)) +
  geom_histogram(binwidth = 1, fill = "blue", color = "white") +
  labs(title = "Distribution of Length of Stay (LOS,  30 days)",
       x = "Length of Stay (days)",
       y = "Count of Admissions") +
  theme_minimal()
```

```
Don't know how to automatically pick scale for object of type <difftime>.
Defaulting to continuous.
```



The majority of hospital stays (Length of Stay, LOS) are concentrated between 1-7 days, # but extreme values (>30 days) are not fully represented in the plot. # A small subset of patients has exceptionally long hospital stays (e.g., 100+ days), # which could indicate long-term hospitalization or potential data anomalies.

```
admissions_tble %>%
  filter(los > 100) %>%
  select(subject_id, hadm_id, admittime, dischtime, los)
```

```
# A tibble: 242 x 5
   subject_id  hadm_id admittime           dischtime           los
        <dbl>    <dbl> <dttm>              <dttm>              <drtn>
 1   10164344 22658293 2194-07-08 15:14:00 2194-11-30 11:00:00 144.8236 days
 2   10186976 20911819 2120-12-20 19:41:00 2121-06-24 01:30:00 185.2424 days
 3   10201645 24687711 2131-08-07 17:58:00 2132-01-10 11:30:00 155.7306 days
 4   10253349 24426241 2189-11-24 08:43:00 2190-05-13 16:08:00 170.3090 days
 5   10253349 26415640 2190-05-23 01:00:00 2191-10-20 14:30:00 515.5625 days
 6   10337961 26061931 2118-07-26 16:13:00 2118-11-04 16:00:00 100.9910 days
```

```
 7   10416715 24843066 2181-04-19 14:55:00 2181-08-19 14:05:00 121.9653 days
 8   10519706 29552796 2184-08-26 00:19:00 2185-07-13 14:13:00 321.5792 days
 9   10636904 22554647 2112-02-11 15:08:00 2112-07-09 19:25:00 149.1785 days
10   10636904 29894505 2113-05-07 00:19:00 2113-09-19 16:18:00 135.6660 days
# i 232 more rows
```

Q4. `patients` data

Patient information is available in `patients.csv.gz`. See https://mimic.mit.edu/docs/iv/modules/hosp/patients/ for details of each field in this file. The first 10 lines are

```
zcat < ~/mimic/hosp/patients.csv.gz | head
```

```
subject_id,gender,anchor_age,anchor_year,anchor_year_group,dod
10000032,F,52,2180,2014 - 2016,2180-09-09
10000048,F,23,2126,2008 - 2010,
10000058,F,33,2168,2020 - 2022,
10000068,F,19,2160,2008 - 2010,
10000084,M,72,2160,2017 - 2019,2161-02-13
10000102,F,27,2136,2008 - 2010,
10000108,M,25,2163,2014 - 2016,
10000115,M,24,2154,2017 - 2019,
10000117,F,48,2174,2008 - 2010,
```

Q4.1 Ingestion

Import `patients.csv.gz` (https://mimic.mit.edu/docs/iv/modules/hosp/patients/) as a tibble `patients_tble`.

```
patients_tble <- read_csv("~/mimic/hosp/patients.csv.gz")
```

```
Rows: 364627 Columns: 6
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (2): gender, anchor_year_group
dbl  (3): subject_id, anchor_age, anchor_year
date (1): dod

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Q4.2 Summary and visualization

Summarize variables `gender` and `anchor_age` by graphics, and explain any patterns you see.

```
gender_summary <- patients_tble %>%
  count(gender) %>%
  mutate(percentage = n / sum(n) * 100)

print(gender_summary)
```

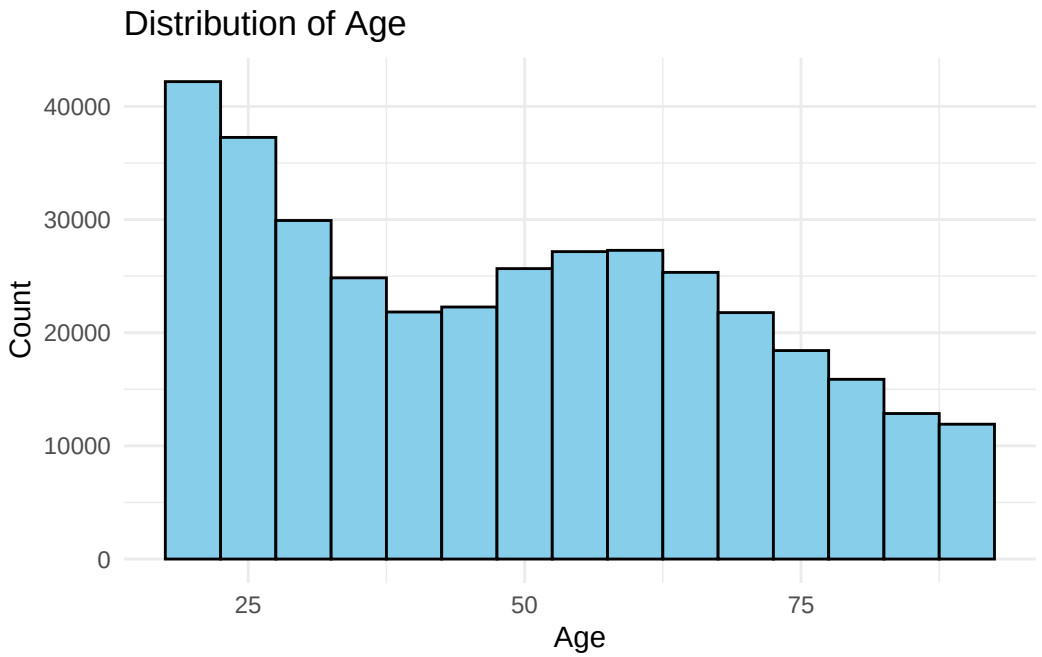
```
# A tibble: 2 x 3
  gender      n percentage
  <chr>   <int>      <dbl>
1 F      191984       52.7
2 M      172643       47.3
```

```
age_summary <- patients_tble %>%
  summarise(
    mean_age = mean(anchor_age, na.rm = TRUE),
    median_age = median(anchor_age, na.rm = TRUE),
    min_age = min(anchor_age, na.rm = TRUE),
    max_age = max(anchor_age, na.rm = TRUE)
  )

print(age_summary)
```

```
# A tibble: 1 x 4
  mean_age median_age min_age max_age
     <dbl>      <dbl>   <dbl>   <dbl>
1     48.9         48      18      91
```

```
gender_plot <- ggplot(patients_tble, aes(x = gender, fill = gender)) +
  geom_bar() +
  labs(
    title = "Distribution of Gender",
    x = "Gender",
    y = "Count"
  ) +
  theme_minimal()

print(gender_plot)
```


```
age_plot <- ggplot(patients_tble, aes(x = anchor_age)) +
  geom_histogram(binwidth = 5, fill = "skyblue", color = "black") +
  labs(
    title = "Distribution of Age",
    x = "Age",
    y = "Count"
  ) +
  theme_minimal()

print(age_plot)
```



Q5. Lab results

`labevents.csv.gz` (https://mimic.mit.edu/docs/iv/modules/hosp/labevents/) contains all laboratory measurements for patients. The first 10 lines are

```
zcat < ~/mimic/hosp/labevents.csv.gz | head
```

```
labevent_id,subject_id,hadm_id,specimen_id,itemid,order_provider_id,charttime,storetime,valu
1,10000032,,2704548,50931,P69FQC,2180-03-23 11:51:00,2180-03-23 15:56:00,___,95,mg/dL,70,100
2,10000032,,36092842,51071,P69FQC,2180-03-23 11:51:00,2180-03-23 16:00:00,NEG,,,,,ROUTINE,
3,10000032,,36092842,51074,P69FQC,2180-03-23 11:51:00,2180-03-23 16:00:00,NEG,,,,,ROUTINE,
4,10000032,,36092842,51075,P69FQC,2180-03-23 11:51:00,2180-03-23 16:00:00,NEG,,,,,ROUTINE,"
5,10000032,,36092842,51079,P69FQC,2180-03-23 11:51:00,2180-03-23 16:00:00,NEG,,,,,ROUTINE,
6,10000032,,36092842,51087,P69FQC,2180-03-23 11:51:00,,,,,,,ROUTINE,RANDOM.
7,10000032,,36092842,51089,P69FQC,2180-03-23 11:51:00,2180-03-23 16:15:00,,,,,,ROUTINE,PRESU
8,10000032,,36092842,51090,P69FQC,2180-03-23 11:51:00,2180-03-23 16:00:00,NEG,,,,,ROUTINE,MI
9,10000032,,36092842,51092,P69FQC,2180-03-23 11:51:00,2180-03-23 16:00:00,NEG,,,,,ROUTINE,"(
```

`d_labitems.csv.gz` (https://mimic.mit.edu/docs/iv/modules/hosp/d_labitems/) is the dictionary of lab measurements.

```
zcat < ~/mimic/hosp/d_labitems.csv.gz | head
```

```
itemid,label,fluid,category
50801,Alveolar-arterial Gradient,Blood,Blood Gas
50802,Base Excess,Blood,Blood Gas
50803,"Calculated Bicarbonate, Whole Blood",Blood,Blood Gas
50804,Calculated Total CO2,Blood,Blood Gas
50805,Carboxyhemoglobin,Blood,Blood Gas
50806,"Chloride, Whole Blood",Blood,Blood Gas
50808,Free Calcium,Blood,Blood Gas
50809,Glucose,Blood,Blood Gas
50810,"Hematocrit, Calculated",Blood,Blood Gas
```

We are interested in the lab measurements of creatinine (50912), potassium (50971), sodium (50983), chloride (50902), bicarbonate (50882), hematocrit (51221), white blood cell count (51301), and glucose (50931). Retrieve a subset of `labevents.csv.gz` that only containing these items for the patients in `icustays_tble`. Further restrict to the last available measurement (by `storetime`) before the ICU stay. The final `labevents_tble` should have one row per ICU stay and columns for each lab measurement.

```
> labevents_tble
# A tibble: 88,086 × 10
   subject_id  stay_id bicarbonate chloride creatinine glucose potassium sodium hematocrit   wbc
        <dbl>    <dbl>       <dbl>    <dbl>      <dbl>   <dbl>     <dbl>  <dbl>       <dbl> <dbl>
 1   10000032 39553978          25       95        0.7     102       6.7    126        41.1   6.9
 2   10000690 37081114          26      100        1        85       4.8    137        36.1   7.1
 3   10000980 39765666          21      109        2.3      89       3.9    144        27.3   5.3
 4   10001217 34592300          30      104        0.5      87       4.1    142        37.4   5.4
 5   10001217 37067082          22      108        0.6     112       4.2    142        38.1  15.7
 6   10001725 31205490          NA       98       NA        NA       4.1    139        NA    NA
 7   10001843 39698942          28       97        1.3     131       3.9    138        31.4  10.4
 8   10001884 37510196          30       88        1.1     141       4.5    130        39.7  12.2
 9   10002013 39060235          24      102        0.9     288       3.5    137        34.9   7.2
10   10002114 34672098          18       NA        3.1      95       6.5    125        34.3  16.8
# ℹ 88,076 more rows
# ℹ Use `print(n = ...)` to see more rows
```

Hint: Use the Parquet format you generated in Homework 2. For reproducibility, make `labevents_pq` folder available at the current working directory `hw3`, for example, by a symbolic link.

```
dlabitems_tble <- read_csv("~/mimic/hosp/d_labitems.csv.gz") %>%
  mutate(itemid = as.character(itemid)) %>%
  select(itemid, label) %>%
  collect()
```

```
Rows: 1650 Columns: 4
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (3): label, fluid, category
dbl (1): itemid

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```r
labevents_tble <- open_dataset("labevents_pq", format = "parquet") |>
  to_duckdb() |>
  select(subject_id, itemid, storetime, valuenum) |>
  filter(itemid %in% c("50912", "50971", "50983", "50902", "50882", "51221", "51301", "50931
  left_join(
    select(icustays_tble, subject_id, stay_id, intime),
    by = c("subject_id"),
    copy = TRUE
  ) |>
  filter(storetime < intime) |>
  group_by(subject_id, stay_id, itemid) |>
  slice_max(storetime, n = 1) |>
  select(-storetime, -intime) |>
  ungroup() |>
  left_join(dlabitems_tble, by = "itemid", copy = TRUE) |>
  select(-itemid) |>
  pivot_wider(names_from = label, values_from = valuenum) |>
  rename_with(~ str_to_lower(.)) |>
  rename(wbc = 'white blood cells') |>
  arrange(subject_id, stay_id) |>
  show_query() |>
  collect()
```

```
<SQL>
SELECT
  subject_id,
  stay_id,
  MAX(CASE WHEN ("label" = 'Chloride') THEN valuenum END) AS chloride,
  MAX(CASE WHEN ("label" = 'Glucose') THEN valuenum END) AS glucose,
  MAX(CASE WHEN ("label" = 'Potassium') THEN valuenum END) AS potassium,
  MAX(CASE WHEN ("label" = 'Bicarbonate') THEN valuenum END) AS bicarbonate,
  MAX(CASE WHEN ("label" = 'Hematocrit') THEN valuenum END) AS hematocrit,
  MAX(CASE WHEN ("label" = 'Creatinine') THEN valuenum END) AS creatinine,
```

```
  MAX(CASE WHEN ("label" = 'Sodium') THEN valuenum END) AS sodium,
  MAX(CASE WHEN ("label" = 'White Blood Cells') THEN valuenum END) AS wbc
FROM (
  SELECT subject_id, valuenum, stay_id, "label"
  FROM (
    SELECT subject_id, itemid, valuenum, stay_id
    FROM (
      SELECT
        q01.*,
        RANK() OVER (PARTITION BY subject_id, stay_id, itemid ORDER BY storetime DESC) AS col
      FROM (
        SELECT LHS.*, stay_id, intime
        FROM (
          SELECT subject_id, itemid, storetime, valuenum
          FROM arrow_001
          WHERE (itemid IN ('50912', '50971', '50983', '50902', '50882', '51221', '51301', '5
        ) LHS
        LEFT JOIN dbplyr_HZfAkhDGDZ
          ON (LHS.subject_id = dbplyr_HZfAkhDGDZ.subject_id)
      ) q01
      WHERE (storetime < intime)
    ) q01
    WHERE (col01 <= 1)
  ) LHS
  LEFT JOIN dbplyr_oihE0WLYT4
    ON (LHS.itemid = dbplyr_oihE0WLYT4.itemid)
) q01
GROUP BY subject_id, stay_id
ORDER BY subject_id, stay_id
```

```
print(labevents_tble)
```

```
# A tibble: 88,086 x 10
   subject_id  stay_id chloride glucose potassium bicarbonate hematocrit
        <dbl>    <dbl>    <dbl>   <dbl>     <dbl>       <dbl>      <dbl>
 1   10000032 39553978       95     102       6.7          25       41.1
 2   10000690 37081114      100      85       4.8          26       36.1
 3   10000980 39765666      109      89       3.9          21       27.3
 4   10001217 34592300      104      87       4.1          30       37.4
 5   10001217 37067082      108     112       4.2          22       38.1
 6   10001725 31205490       98      NA       4.1          NA       NA
 7   10001843 39698942       97     131       3.9          28       31.4
```

```
 8   10001884 37510196       88     141       4.5          30       39.7
 9   10002013 39060235      102     288       3.5          24       34.9
10   10002114 34672098       NA      95       6.5          18       34.3
# i 88,076 more rows
# i 3 more variables: creatinine <dbl>, sodium <dbl>, wbc <dbl>
```

Q6. Vitals from charted events

`chartevents.csv.gz` (https://mimic.mit.edu/docs/iv/modules/icu/chartevents/) contains all the charted data available for a patient. During their ICU stay, the primary repository of a patient's information is their electronic chart. The `itemid` variable indicates a single measurement type in the database. The `value` variable is the value measured for `itemid`. The first 10 lines of `chartevents.csv.gz` are

```
zcat < ~/mimic/icu/chartevents.csv.gz | head
```

```
subject_id,hadm_id,stay_id,caregiver_id,charttime,storetime,itemid,value,valuenum,valueuom,wa
10000032,29079034,39553978,18704,2180-07-23 12:36:00,2180-07-23 14:45:00,226512,39.4,39.4,kg
10000032,29079034,39553978,18704,2180-07-23 12:36:00,2180-07-23 14:45:00,226707,60,60,Inch,0
10000032,29079034,39553978,18704,2180-07-23 12:36:00,2180-07-23 14:45:00,226730,152,152,cm,0
10000032,29079034,39553978,18704,2180-07-23 14:00:00,2180-07-23 14:18:00,220048,SR (Sinus Rhy
10000032,29079034,39553978,18704,2180-07-23 14:00:00,2180-07-23 14:18:00,224642,Oral,,,0
10000032,29079034,39553978,18704,2180-07-23 14:00:00,2180-07-23 14:18:00,224650,None,,,0
10000032,29079034,39553978,18704,2180-07-23 14:00:00,2180-07-23 14:20:00,223761,98.7,98.7,°F
10000032,29079034,39553978,18704,2180-07-23 14:11:00,2180-07-23 14:17:00,220179,84,84,mmHg,0
10000032,29079034,39553978,18704,2180-07-23 14:11:00,2180-07-23 14:17:00,220180,48,48,mmHg,0
```

`d_items.csv.gz` (https://mimic.mit.edu/docs/iv/modules/icu/d_items/) is the dictionary for the `itemid` in `chartevents.csv.gz`.

```
zcat < ~/mimic/icu/d_items.csv.gz | head
```

```
itemid,label,abbreviation,linksto,category,unitname,param_type,lownormalvalue,highnormalvalue
220001,Problem List,Problem List,chartevents,General,,Text,,
220003,ICU Admission date,ICU Admission date,datetimeevents,ADT,,Date and time,,
220045,Heart Rate,HR,chartevents,Routine Vital Signs,bpm,Numeric,,
220046,Heart rate Alarm - High,HR Alarm - High,chartevents,Alarms,bpm,Numeric,,
220047,Heart Rate Alarm - Low,HR Alarm - Low,chartevents,Alarms,bpm,Numeric,,
220048,Heart Rhythm,Heart Rhythm,chartevents,Routine Vital Signs,,Text,,
220050,Arterial Blood Pressure systolic,ABPs,chartevents,Routine Vital Signs,mmHg,Numeric,90
220051,Arterial Blood Pressure diastolic,ABPd,chartevents,Routine Vital Signs,mmHg,Numeric,60
220052,Arterial Blood Pressure mean,ABPm,chartevents,Routine Vital Signs,mmHg,Numeric,,
```

We are interested in the vitals for ICU patients: heart rate (220045), systolic non-invasive blood pressure (220179), diastolic non-invasive blood pressure (220180), body temperature in Fahrenheit (223761), and respiratory rate (220210). Retrieve a subset of `chartevents.csv.gz` only containing these items for the patients in `icustays_tble`. Further restrict to the first vital measurement within the ICU stay. The final `chartevents_tble` should have one row per ICU stay and columns for each vital measurement.

```
> chartevents_tble
# A tibble: 94,424 × 7
   subject_id  stay_id heart_rate non_invasive_blood_pressure_systolic non_invasive_blood_pressure_diastolic respiratory_rate temperature_fahrenheit
        <int>    <dbl>      <dbl>                                <dbl>                                 <dbl>           <dbl>                 <dbl>
 1   10000032 39553978         91                                   84                                    48              24                  98.7
 2   10000690 37081114         79                                  107                                    63              23                  97.7
 3   10000980 39765666         77                                  150                                    77              23                  98
 4   10001217 34592300         96                                  167                                    95              11                  97.6
 5   10001217 37067082         86                                  151                                    90              18                  98.5
 6   10001725 31205490         55                                   73                                    56              19                  97.7
 7   10001843 39698942        118                                  112                                    71              17                  97.9
 8   10001884 37510196         38                                  180                                    12              10                  98.1
 9   10002013 39060235         80                                  104                                    70              14                  97.2
10   10002114 34672098        105                                  104                                    81              22                  97.9
# ℹ 94,414 more rows
# ℹ Use `print(n = ...)` to see more rows
```

Hint: Use the Parquet format you generated in Homework 2. For reproducibility, make `chartevents_pq` folder available at the current working directory, for example, by a symbolic link.

```
d_items_tble <- read_csv("~/mimic/icu/d_items.csv.gz") %>%
  mutate(itemid = as.character(itemid)) %>%
  select(itemid, label) %>%
  collect()
```

```
Rows: 4095 Columns: 9
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (6): label, abbreviation, linksto, category, unitname, param_type
dbl (3): itemid, lownormalvalue, highnormalvalue

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
chartevents_tble <- open_dataset("chartevents_pq", format = "parquet") |>
  to_duckdb() |>
  select(subject_id, stay_id, charttime, itemid, valuenum) |>
  filter(itemid %in% c("220045", "220179", "220180", "223761", "220210")) |>
  left_join(
    select(icustays_tble, subject_id, stay_id, intime, outtime),
    by = c("subject_id", "stay_id"),
    copy = TRUE
```

```
  ) |>
  filter(charttime >= intime & charttime <= outtime) |>
  group_by(subject_id, stay_id, itemid) |>
  slice_min(charttime, n = 1) |>
  select(-charttime, -intime, -outtime) |>
  ungroup() |>
  left_join(d_items_tble, by = "itemid", copy = TRUE) |>
  select(-itemid) |>
  pivot_wider(names_from = label, values_from = valuenum) |>
  rename_with(~ str_to_lower(.)) |>
  rename(
    heart_rate = 'heart rate',
    systolic_bp = 'non invasive blood pressure systolic',
    diastolic_bp = 'non invasive blood pressure diastolic',
    temperature_f = 'temperature fahrenheit',
    respiratory_rate = 'respiratory rate'
  ) |>
  arrange(subject_id, stay_id) |>
  show_query() |>
  collect()
```

```
<SQL>
SELECT
  subject_id,
  stay_id,
  MAX(CASE WHEN ("label" = 'Heart Rate') THEN valuenum END) AS heart_rate,
  MAX(CASE WHEN ("label" = 'Temperature Fahrenheit') THEN valuenum END) AS temperature_f,
  MAX(CASE WHEN ("label" = 'Respiratory Rate') THEN valuenum END) AS respiratory_rate,
  MAX(CASE WHEN ("label" = 'Non Invasive Blood Pressure diastolic') THEN valuenum END) AS dia
  MAX(CASE WHEN ("label" = 'Non Invasive Blood Pressure systolic') THEN valuenum END) AS syst
FROM (
  SELECT subject_id, stay_id, valuenum, "label"
  FROM (
    SELECT subject_id, stay_id, itemid, valuenum
    FROM (
      SELECT
        q01.*,
        RANK() OVER (PARTITION BY subject_id, stay_id, itemid ORDER BY charttime) AS col01
      FROM (
        SELECT LHS.*, intime, outtime
        FROM (
          SELECT subject_id, stay_id, charttime, itemid, valuenum
```

```
          FROM arrow_002
          WHERE (itemid IN ('220045', '220179', '220180', '223761', '220210'))
        ) LHS
        LEFT JOIN dbplyr_JtFyHsTb9b
          ON (
            LHS.subject_id = dbplyr_JtFyHsTb9b.subject_id AND
            LHS.stay_id = dbplyr_JtFyHsTb9b.stay_id
          )
      ) q01
      WHERE (charttime >= intime AND charttime <= outtime)
    ) q01
    WHERE (col01 <= 1)
  ) LHS
  LEFT JOIN dbplyr_VKr9yelozx
    ON (LHS.itemid = dbplyr_VKr9yelozx.itemid)
) q01
GROUP BY subject_id, stay_id
ORDER BY subject_id, stay_id
```

```
print(chartevents_tble)
```

```
# A tibble: 94,424 x 7
   subject_id  stay_id heart_rate temperature_f respiratory_rate diastolic_bp
        <dbl>    <dbl>      <dbl>         <dbl>             <dbl>        <dbl>
 1   10000032 39553978         91          98.7                24           48
 2   10000690 37081114         79          97.7                23           63
 3   10000980 39765666         77          98                  23           77
 4   10001217 34592300         96          97.6                11           95
 5   10001217 37067082         86          98.5                18           90
 6   10001725 31205490         55          97.7                19           56
 7   10001843 39698942        118          97.9                17           71
 8   10001884 37510196         38          98.1                10           12
 9   10002013 39060235         80          97.2                14           70
10   10002114 34672098        105          97.9                22           81
# i 94,414 more rows
# i 1 more variable: systolic_bp <dbl>
```

Q7. Putting things together

Let us create a tibble `mimic_icu_cohort` for all ICU stays, where rows are all ICU stays of adults (age at `intime` >= 18) and columns contain at least following variables

- all variables in `icustays_tble`

- all variables in `admissions_tble`

- all variables in `patients_tble`
- the last lab measurements before the ICU stay in `labevents_tble`
- the first vital measurements during the ICU stay in `chartevents_tble`

The final `mimic_icu_cohort` should have one row per ICU stay and columns for each variable.

```
> mimic_icu_cohort
# A tibble: 94,458 × 41
   subject_id  hadm_id  stay_id first_careunit        last_careunit intime              outtime              los admittime           dischtime           deathtime
        <dbl>    <dbl>    <dbl> <chr>                 <chr>         <dttm>              <dttm>             <dbl> <dttm>              <dttm>              <dttm>
 1   10000032 29079034 39553978 Medical Intensive Car… Medical Inte… 2180-07-23 14:00:00 2180-07-23 23:50:47 0.410 2180-07-23 12:35:00 2180-07-25 17:55:00 NA
 2   10000690 25860671 37081114 Medical Intensive Car… Medical Inte… 2150-11-02 19:37:00 2150-11-06 17:03:17 3.89  2150-11-02 18:02:00 2150-11-12 13:45:00 NA
 3   10000980 26913865 39765666 Medical Intensive Car… Medical Inte… 2189-06-27 08:42:00 2189-06-27 20:38:27 0.498 2189-06-27 07:38:00 2189-07-03 03:00:00 NA
 4   10001217 24597018 37067082 Surgical Intensive Ca… Surgical Int… 2157-11-20 19:18:02 2157-11-21 22:08:00 1.12  2157-11-18 22:56:00 2157-11-25 18:00:00 NA
 5   10001217 27703517 34592300 Surgical Intensive Ca… Surgical Int… 2157-12-19 15:42:24 2157-12-20 14:27:41 0.948 2157-12-18 16:58:00 2157-12-24 14:55:00 NA
 6   10001725 25563031 31205490 Medical/Surgical Inte… Medical/Surg… 2110-04-11 15:52:22 2110-04-12 23:59:56 1.34  2110-04-11 15:08:00 2110-04-14 15:00:00 NA
 7   10001843 26133978 39698942 Medical/Surgical Inte… Medical/Surg… 2134-12-05 18:50:03 2134-12-06 14:38:26 0.825 2134-12-05 00:10:00 2134-12-06 12:54:00 2134-12-06 12:54:00
 8   10001884 26184834 37510196 Medical Intensive Car… Medical Inte… 2131-01-11 04:20:05 2131-01-20 08:27:30 9.17  2131-01-07 20:39:00 2131-01-20 05:15:00 2131-01-20 05:15:00
 9   10002013 23581541 39060235 Cardiac Vascular Inte… Cardiac Vasc… 2160-05-18 10:00:53 2160-05-19 17:33:33 1.31  2160-05-18 07:45:00 2160-05-23 13:30:00 NA
10   10002114 27793700 34672098 Coronary Care Unit (C… Coronary Car… 2162-02-17 23:30:00 2162-02-20 21:16:27 2.91  2162-02-17 22:32:00 2162-03-04 15:16:00 NA
# ℹ 94,448 more rows
# ℹ 30 more variables: admission_type <chr>, admit_provider_id <chr>, admission_location <chr>, discharge_location <chr>, insurance <chr>, language <chr>,
#   marital_status <chr>, race <chr>, edregtime <dttm>, edouttime <dttm>, hospital_expire_flag <dbl>, gender <chr>, anchor_age <dbl>, anchor_year <dbl>,
#   anchor_year_group <chr>, dod <date>, bicarbonate <dbl>, chloride <dbl>, creatinine <dbl>, glucose <dbl>, potassium <dbl>, sodium <dbl>, hematocrit <dbl>, wbc <dbl>,
#   heart_rate <dbl>, non_invasive_blood_pressure_systolic <dbl>, non_invasive_blood_pressure_diastolic <dbl>, respiratory_rate <dbl>, temperature_fahrenheit <dbl>,
#   age_intime <dbl>
# ℹ Use `print(n = ...)` to see more rows
```

```r
icustays_tble <- collect(icustays_tble)
admissions_tble <- collect(admissions_tble)
patients_tble <- collect(patients_tble)
labevents_tble <- collect(labevents_tble)
chartevents_tble <- collect(chartevents_tble)

mimic_icu_cohort <- icustays_tble |>
  left_join(admissions_tble, by = c("subject_id", "hadm_id")) |>
  left_join(patients_tble, by = "subject_id") |>
  filter(anchor_age + (year(intime) - anchor_year) >= 18) |>
  left_join(labevents_tble, by = c("subject_id", "stay_id")) |>
  left_join(chartevents_tble, by = c("subject_id", "stay_id")) |>
  arrange(subject_id, hadm_id)
print(mimic_icu_cohort)
```

```
# A tibble: 94,458 x 41
   subject_id  hadm_id  stay_id first_careunit last_careunit intime
        <dbl>    <dbl>    <dbl> <chr>          <chr>         <dttm>
 1   10000032 29079034 39553978 Medical Inten~ Medical Inte~ 2180-07-23 14:00:00
 2   10000690 25860671 37081114 Medical Inten~ Medical Inte~ 2150-11-02 19:37:00
 3   10000980 26913865 39765666 Medical Inten~ Medical Inte~ 2189-06-27 08:42:00
```

```
 4   10001217 24597018 37067082 Surgical Inte~ Surgical Int~ 2157-11-20 19:18:02
 5   10001217 27703517 34592300 Surgical Inte~ Surgical Int~ 2157-12-19 15:42:24
 6   10001725 25563031 31205490 Medical/Surgi~ Medical/Surg~ 2110-04-11 15:52:22
 7   10001843 26133978 39698942 Medical/Surgi~ Medical/Surg~ 2134-12-05 18:50:03
 8   10001884 26184834 37510196 Medical Inten~ Medical Inte~ 2131-01-11 04:20:05
 9   10002013 23581541 39060235 Cardiac Vascu~ Cardiac Vasc~ 2160-05-18 10:00:53
10   10002114 27793700 34672098 Coronary Care~ Coronary Car~ 2162-02-17 23:30:00
# i 94,448 more rows
# i 35 more variables: outtime <dttm>, los.x <dbl>, admittime <dttm>,
#   dischtime <dttm>, deathtime <dttm>, admission_type <chr>,
#   admit_provider_id <chr>, admission_location <chr>,
#   discharge_location <chr>, insurance <chr>, language <chr>,
#   marital_status <chr>, race <chr>, edregtime <dttm>, edouttime <dttm>,
#   hospital_expire_flag <dbl>, los.y <drtn>, gender <chr>, ...
```

Q8. Exploratory data analysis (EDA)

Summarize the following information about the ICU stay cohort `mimic_icu_cohort` using appropriate numerics or graphs:

- Length of ICU stay `los` vs demographic variables (race, insurance, marital_status, gender, age at intime)
- Length of ICU stay `los` vs the last available lab measurements before ICU stay
- Length of ICU stay `los` vs the first vital measurements within the ICU stay
- Length of ICU stay `los` vs first ICU unit

```
mimic_icu_cohort_df <- mimic_icu_cohort |> collect()

print(mimic_icu_cohort_df)
```

```
# A tibble: 94,458 x 41
   subject_id  hadm_id  stay_id first_careunit last_careunit intime
        <dbl>    <dbl>    <dbl> <chr>          <chr>         <dttm>
 1   10000032 29079034 39553978 Medical Inten~ Medical Inte~ 2180-07-23 14:00:00
 2   10000690 25860671 37081114 Medical Inten~ Medical Inte~ 2150-11-02 19:37:00
 3   10000980 26913865 39765666 Medical Inten~ Medical Inte~ 2189-06-27 08:42:00
 4   10001217 24597018 37067082 Surgical Inte~ Surgical Int~ 2157-11-20 19:18:02
 5   10001217 27703517 34592300 Surgical Inte~ Surgical Int~ 2157-12-19 15:42:24
 6   10001725 25563031 31205490 Medical/Surgi~ Medical/Surg~ 2110-04-11 15:52:22
 7   10001843 26133978 39698942 Medical/Surgi~ Medical/Surg~ 2134-12-05 18:50:03
```

```
 8   10001884 26184834 37510196 Medical Inten~ Medical Inte~ 2131-01-11 04:20:05
 9   10002013 23581541 39060235 Cardiac Vascu~ Cardiac Vasc~ 2160-05-18 10:00:53
10   10002114 27793700 34672098 Coronary Care~ Coronary Car~ 2162-02-17 23:30:00
# i 94,448 more rows
# i 35 more variables: outtime <dttm>, los.x <dbl>, admittime <dttm>,
#   dischtime <dttm>, deathtime <dttm>, admission_type <chr>,
#   admit_provider_id <chr>, admission_location <chr>,
#   discharge_location <chr>, insurance <chr>, language <chr>,
#   marital_status <chr>, race <chr>, edregtime <dttm>, edouttime <dttm>,
#   hospital_expire_flag <dbl>, los.y <drtn>, gender <chr>, ...
```

```
summary(mimic_icu_cohort_df)
```

```
   subject_id          hadm_id            stay_id         first_careunit
 Min.   :10000032   Min.   :20000094   Min.   :30000153   Length:94458
 1st Qu.:12514630   1st Qu.:22482122   1st Qu.:32506785   Class :character
 Median :15005544   Median :24982475   Median :34999442   Mode  :character
 Mean   :15004217   Mean   :24981846   Mean   :34998318
 3rd Qu.:17517575   3rd Qu.:27465060   3rd Qu.:37490986
 Max.   :19999987   Max.   :29999828   Max.   :39999858

 last_careunit          intime
 Length:94458       Min.   :2110-01-11 10:16:06.0
 Class :character   1st Qu.:2133-11-20 18:31:35.5
 Mode  :character   Median :2153-09-27 20:32:30.0
                    Mean   :2153-10-25 12:54:18.1
                    3rd Qu.:2173-11-22 06:48:00.0
                    Max.   :2214-07-22 17:05:53.0

    outtime                          los.x
 Min.   :2110-01-12 17:17:47.00   Min.   :  0.00125
 1st Qu.:2133-11-23 07:15:37.75   1st Qu.:  1.09621
 Median :2153-10-01 12:22:23.00   Median :  1.96565
 Mean   :2153-10-28 15:34:24.78   Mean   :  3.63002
 3rd Qu.:2173-11-26 18:02:40.25   3rd Qu.:  3.86258
 Max.   :2214-07-26 17:13:57.00   Max.   :226.40308
 NA's   :14                       NA's   :14
   admittime                        dischtime
 Min.   :2110-01-11 10:14:00.00   Min.   :2110-01-15 17:31:00.0
 1st Qu.:2133-11-18 08:52:15.00   1st Qu.:2133-11-27 17:55:00.0
 Median :2153-09-25 21:37:00.00   Median :2153-10-06 06:12:30.0
 Mean   :2153-10-23 06:08:41.18   Mean   :2153-11-04 01:29:54.3
```

```
3rd Qu.:2173-11-21 19:10:15.00   3rd Qu.:2173-11-30 06:30:15.0
Max.   :2214-07-18 14:05:00.00   Max.   :2214-08-11 16:08:00.0

  deathtime                      admission_type     admit_provider_id
Min.   :2110-01-25 09:40:00.00   Length:94458       Length:94458
1st Qu.:2133-09-27 14:15:00.00   Class :character   Class :character
Median :2153-12-10 14:21:00.00   Mode  :character   Mode  :character
Mean   :2153-11-13 05:18:05.85
3rd Qu.:2174-01-21 07:10:00.00
Max.   :2211-01-17 12:34:00.00
NA's   :83117
admission_location discharge_location  insurance          language
Length:94458       Length:94458       Length:94458       Length:94458
Class :character   Class :character   Class :character   Class :character
Mode  :character   Mode  :character   Mode  :character   Mode  :character



marital_status         race              edregtime
Length:94458       Length:94458       Min.   :2110-01-11 21:42:00.0
Class :character   Class :character   1st Qu.:2134-12-18 08:36:00.0
Mode  :character   Mode  :character   Median :2154-08-02 19:39:00.0
                                      Mean   :2154-09-25 03:55:09.6
                                      3rd Qu.:2174-09-30 01:02:30.0
                                      Max.   :2214-07-17 21:17:00.0
                                      NA's   :32331
  edouttime                      hospital_expire_flag    los.y
Min.   :2110-01-12 00:54:00.00   Min.   :0.0000       Length:94458
1st Qu.:2134-12-18 22:42:00.00   1st Qu.:0.0000       Class :difftime
Median :2154-08-02 23:10:00.00   Median :0.0000       Mode  :numeric
Mean   :2154-09-25 10:17:42.23   Mean   :0.1202
3rd Qu.:2174-09-30 08:39:30.00   3rd Qu.:0.0000
Max.   :2214-07-18 16:21:00.00   Max.   :1.0000
NA's   :32331
   gender            anchor_age     anchor_year   anchor_year_group
Length:94458       Min.   :18.00   Min.   :2110   Length:94458
Class :character   1st Qu.:53.00   1st Qu.:2132   Class :character
Mode  :character   Median :65.00   Median :2151   Mode  :character
                   Mean   :63.04   Mean   :2152
                   3rd Qu.:76.00   3rd Qu.:2172
                   Max.   :91.00   Max.   :2207
```

```
      dod                chloride        glucose         potassium
 Min.   :2110-01-25   Min.   : 45.0   Min.   :   4.0   Min.   : 1.300
 1st Qu.:2135-11-10   1st Qu.: 98.0   1st Qu.:  99.0   1st Qu.: 3.900
 Median :2155-10-22   Median :102.0   Median : 120.0   Median : 4.200
 Mean   :2155-12-09   Mean   :101.2   Mean   : 144.6   Mean   : 4.339
 3rd Qu.:2176-01-25   3rd Qu.:105.0   3rd Qu.: 156.0   3rd Qu.: 4.600
 Max.   :2214-10-12   Max.   :144.0   Max.   :2340.0   Max.   :10.000
 NA's   :56491        NA's   :11360   NA's   :11663    NA's   :11396
  bicarbonate      hematocrit      creatinine         sodium
 Min.   : 2.00   Min.   : 6.50   Min.   : 0.000   Min.   : 74.0
 1st Qu.:21.00   1st Qu.:29.60   1st Qu.: 0.800   1st Qu.:135.0
 Median :24.00   Median :35.30   Median : 1.000   Median :138.0
 Mean   :24.02   Mean   :34.89   Mean   : 1.508   Mean   :137.9
 3rd Qu.:27.00   3rd Qu.:40.20   3rd Qu.: 1.500   3rd Qu.:141.0
 Max.   :50.00   Max.   :69.70   Max.   :62.500   Max.   :180.0
 NA's   :11558   NA's   :6759    NA's   :8036     NA's   :11339
      wbc           heart_rate      temperature_f    respiratory_rate
 Min.   :  0.10   Min.   :   0.00   Min.   :  0.00   Min.   :  0.0
 1st Qu.:  6.80   1st Qu.:  74.00   1st Qu.: 97.70   1st Qu.: 15.0
 Median :  9.30   Median :  86.00   Median : 98.20   Median : 18.0
 Mean   : 11.08   Mean   :  88.69   Mean   : 98.11   Mean   : 19.2
 3rd Qu.: 13.20   3rd Qu.: 101.00   3rd Qu.: 98.70   3rd Qu.: 22.0
 Max.   :513.40   Max.   :8400.00   Max.   :998.90   Max.   :180.0
 NA's   :6858     NA's   :35        NA's   :1774     NA's   :160
  diastolic_bp       systolic_bp
 Min.   :    0.00   Min.   :    0
 1st Qu.:   57.00   1st Qu.:  105
 Median :   68.00   Median :  121
 Mean   :   73.06   Mean   :  123
 3rd Qu.:   80.00   3rd Qu.:  138
 Max.   :82127.00   Max.   :12262
 NA's   :1373       NA's   :1367
```

```r
mimic_icu_cohort_df <- mimic_icu_cohort_df |> drop_na()
```

```r
# 1. Relationship Between ICU Length of Stay (LOS) and Demographic Variables
# 1.1 LOS vs Race
ggplot(mimic_icu_cohort_df, aes(x = race, y = los, fill = race)) +
  geom_boxplot(na.rm = TRUE) +
  labs(title = "Length of ICU Stay vs Race", x = "Race",
       y = "Length of Stay (days)") +
  theme_minimal()
```

```r
# 1.2 LOS vs Insurance
ggplot(mimic_icu_cohort_df, aes(x = insurance, y = los, fill = insurance)) +
  geom_boxplot() +
  labs(title = "Length of ICU Stay vs Insurance",
       x = "Insurance", y = "Length of Stay (days)") +
  theme_minimal()

# 1.3 LOS vs Marital Status
ggplot(mimic_icu_cohort_df, aes(x = marital_status, y = los,
                                fill = marital_status)) +
  geom_boxplot() +
  labs(title = "Length of ICU Stay vs Marital Status",
       x = "Marital Status", y = "Length of Stay (days)") +
  theme_minimal()

# 1.4 LOS vs Gender
ggplot(mimic_icu_cohort_df, aes(x = gender, y = los, fill = gender)) +
  geom_boxplot() +
  labs(title = "Length of ICU Stay vs Gender",
       x = "Gender", y = "Length of Stay (days)") +
  theme_minimal()

# 1.5 LOS vs Age at ICU Admission
ggplot(mimic_icu_cohort_df, aes(x = anchor_age +
                                  (year(intime) - anchor_year), y = los)) +
  geom_point(alpha = 0.5) +
  labs(title = "Length of ICU Stay vs Age at Admission",
       x = "Age at Admission",
       y = "Length of Stay (days)") +
  theme_minimal()

# 2. Relationship Between ICU Length of Stay (LOS) and Last Pre-ICU
# 2.1 LOS vs Creatinine
ggplot(mimic_icu_cohort_df, aes(x = creatinine, y = los)) +
  geom_point(alpha = 0.5) +
  labs(title = "Length of ICU Stay vs Creatinine",
       x = "Creatinine", y = "Length of Stay (days)") +
  theme_minimal()

# 2.2 LOS vs Sodium
ggplot(mimic_icu_cohort_df, aes(x = sodium, y = los)) +
  geom_point(alpha = 0.5) +
```

```
  labs(title = "Length of ICU Stay vs Sodium", x = "Sodium",
       y = "Length of Stay (days)") +
  theme_minimal()

# 3. Relationship Between ICU Length of Stay (LOS) and First Vital Signs
# 3.1 LOS vs Heart Rate
ggplot(mimic_icu_cohort_df, aes(x = heart_rate, y = los)) +
  geom_point(alpha = 0.5) +
  labs(title = "Length of ICU Stay vs Heart Rate",
       x = "Heart Rate", y = "Length of Stay (days)") +
  theme_minimal()

# 3.2 LOS vs Systolic Blood Pressure
ggplot(mimic_icu_cohort_df, aes(x = systolic_bp, y = los)) +
  geom_point(alpha = 0.5) +
  labs(title = "Length of ICU Stay vs Systolic BP",
       x = "Systolic BP", y = "Length of Stay (days)") +
  theme_minimal()

# 4. Relationship Between ICU Length of Stay (LOS) and First ICU Unit
ggplot(mimic_icu_cohort_df, aes(x = first_careunit, y = los)) +
  geom_boxplot() +
  labs(title = "Length of ICU Stay vs First ICU Unit",
       x = "First ICU Unit", y = "Length of Stay (days)") +
  theme_minimal()
```