Exploring MIMIC-III Critical Care Data Using Postgres/tidyverse/dbplyr/dplyr

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Files on GitHub

https://github.com/EarlGlynn/MIMIC-III-Getting-Started

000-Download-Files	
010-Count-Characters	Quality Checks
020-Count-Lines-Fields-Records	count.fields
040-Load-MIMIC-into-PostgreSQL	Loading databse
050-Querying-MIMIC-III	SQL / dplyr example
060-Nature-Scientific-Data	Jupyter notebook example

https://github.com/EarlGlynn/MIMIC-III-Exploration

admissions	Database tables
chartevents	
diagnoses_icd	
patients	

Others to be added

Future: MIMIC-III-Predictive-Analytics

MIMIC-III Critical Care Data Outline

- Getting Started with MIMIC-III
  - Background / Motivation
  - Training Requirements
  - Loading Postgres Database
  - Querying MIMIC-III with SQL or dplyr
- MIMIC-III Exploration with tidyverse/dplyr
  - Patients Table
  - Admissions Table
  - Diagnoses Tables
- Take Home

Getting Started with MIMIC-III Background / Motivation

- https://mimic.physionet.org/

- https://www.nature.com/articles/sdata201635

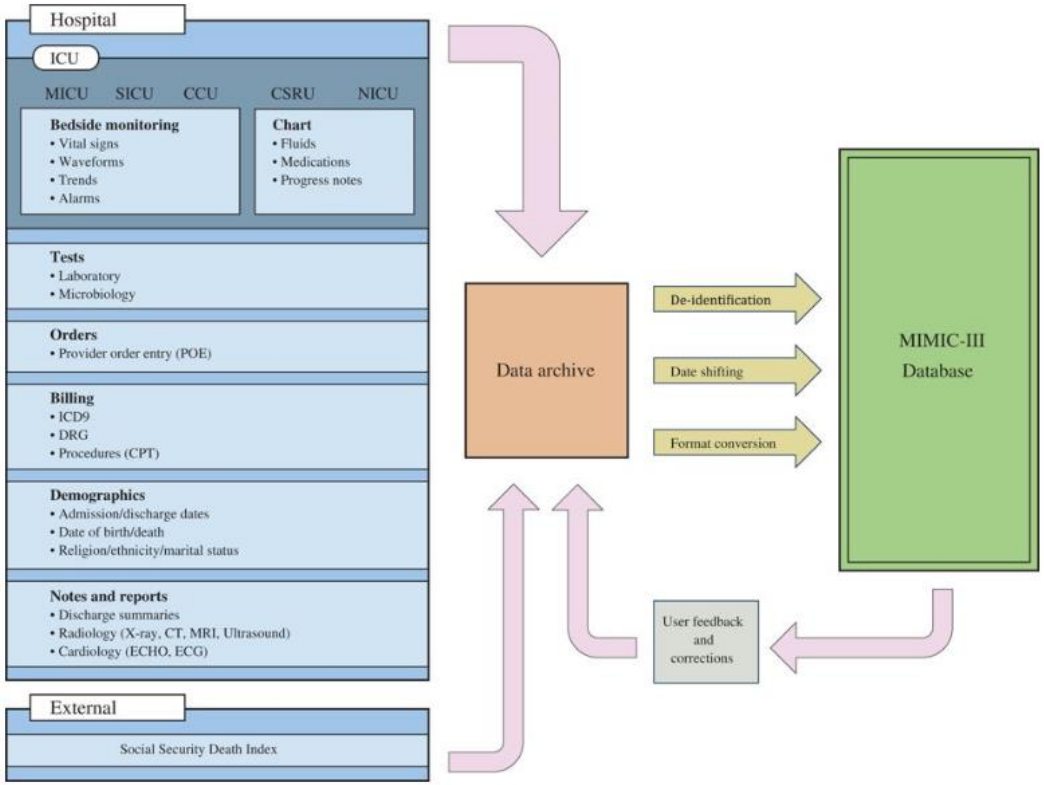
- MIMIC-III supports applications including academic and industrial research, quality improvement initiatives, and higher education coursework.
- MIMIC-III is great source for data science experiments, including predictive analytics.

Getting Started with MIMIC-III Background / Motivation

- https://www.nature.com/articles/sdata201635

Figure 1 : Overview of the MIMIC-III critical care database.

From: MIMIC-III, a freely accessible critical care database



Getting Started with MIMIC-III Training Requirements

- https://mimic.physionet.org/gettingstarted/access/

Complete the required training course

Prior to requesting access to MIMIC, you will need to complete the CITI "Data or Specimens Only Research" course:

- First register on the CITI program website, selecting "Massachusetts Institute of Technology Affiliates" as your organization affiliation (***not*** *"independent learner"*): https://www.citiprogram.org/index.cfm?pageID=154&icat=0&ac=0
- Follow the links to add a Massachusetts Institute of Technology Affiliates course. In the Human Subjects training category, select the "Data or Specimens Only Research" course
- Complete the course and save a copy of your completion report. The completion report lists all modules completed, with dates and scores.

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

REQUIRED AND ELECTIVE MODULES ONLY

History and Ethics of Human Subjects Research (ID: 498)
Basic Institutional Review Board (IRB) Regulations and Review Process (ID: 2)
Records-Based Research (ID: 5)
Genetic Research in Human Populations (ID: 6)
Populations in Research Requiring Additional Considerations and/or Protections (ID: 16680)
Research and HIPAA Privacy Protections (ID: 14)
Conflicts of Interest in Human Subjects Research (ID: 17464)
Massachusetts Institute of Technology (ID: 1290)

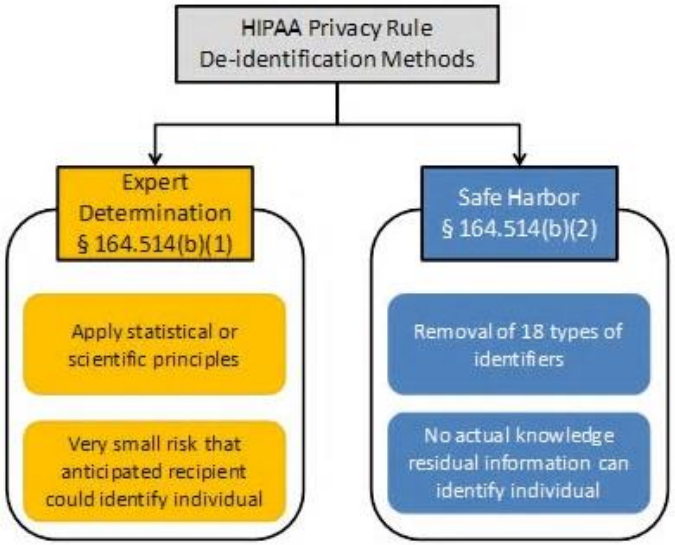
3 to 7
quiz questions
per module

Getting Started with MIMIC-III Training Requirements

Purpose of Training: Protected Health Information (PHI)

https://www.hhs.gov/hipaa/for-professionals/privacy/special-topics/de-identification/index.html

Guidance Regarding Methods for De-identification of Protected Health Information in Accordance with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule



Getting Started with MIMIC-III Loading Postgres Database

- https://mimic.physionet.org/gettingstarted/dbsetup/
- 000-Download-Files/DownloadMIMIC-III.nb.html

Download MIMIC-III Files

efg | 2018-07-03

Start at PhysioNet web page and select MIMIC-III Database.

Select **Data** and complete all the requirements to access MIMIC-III.

Once you have a username and password, run this script ...

- Quality checks
  - 010-Count-Characters (see problems in MIMIC-III-character-counts.xlsx)
  - 020-Count-Lines-Fields-Records/MIMIC-III-Will-Files-Parse.nb.html
  - 030-Files-Fields-MetaStats

Getting Started with MIMIC-III Loading Postgres Database

MIMIC-III-Will-Files-Parse.nb.html

Filename	Lines	Records	Fields
ADMISSIONS.csv	58,977	58,977	19
CALLOUT.csv	34,500	34,500	24
CAREGIVERS.csv	7,568	7,568	4
CHARTEVENTS.csv	330,712,484	330,712,484	15
CPTEVENTS.csv	573,147	573,147	12
D_CPT.csv	135	135	9
D_ICD_DIAGNOSES.csv	14,568	14,568	4
D_ICD_PROCEDURES.csv	3,883	3,883	4
D_ITEMS.csv	12,488	12,488	10
D_LABITEMS.csv	754	754	6
DATETIMEEVENTS.csv	4,485,938	4,485,938	14
DIAGNOSES_ICD.csv	651,048	651,048	5
DRGCODES.csv	125,558	125,558	8

Filename	Lines	Records	Fields
ICUSTAYS.csv	61,533	61,533	12
INPUTEVENTS_CV.csv	17,527,936	17,527,936	22
INPUTEVENTS_MV.csv	3,618,992	3,618,992	31
LABEVENTS.csv	27,854,056	27,854,056	9
MICROBIOLOGYEVENTS.csv	631,727	631,727	16
NOTEEVENTS.csv	91,692,309	2,083,181	11
OUTPUTEVENTS.csv	4,349,219	4,349,219	13
PATIENTS.csv	46,521	46,521	8
PRESCRIPTIONS.csv	4,156,451	4,156,451	19
PROCEDUREEVENTS_MV.csv	258,067	258,067	25
PROCEDURES_ICD.csv	240,096	240,096	5
SERVICES.csv	73,344	73,344	6
TRANSFERS.csv	261,898	261,898	13

020-Count-Lines-Fields-Records

Getting Started with MIMIC-III Loading Postgres Database

040-Load-MIMIC-into-PostgreSQL

Installing-PostgreSQL-on-Windows-for-MIMIC-III.docx

Download and use BigSQL graphical installer to install Postgres on Windows in directory D:\PostgreSQL.

To use the odbc R package below, be sure to install the Windows Postgres ODBC Driver discussed in Section 4.

Loading-MIMIC-III-into-PostgreSQL.docx

Run psql shell to …

- create mimic database,
- load tables with data,
- build indexes for faster access,
- test the build.

The final section shows a link to online MIMIC-III database schema documentation.

MIMIC-Install-on-Postgres.html

Additional details about running SQL command in psql from previous step.

Getting Started with MIMIC-III
R Database Driver Packages

2 Open database with RPostgres

```
MimicDB <- dbConnect(RPostgres::Postgres(),
                     host     = "localhost",
                     dbname   = "mimic",
                     user     = Sys.getenv("MIMIC_User"),
                     password = Sys.getenv("MIMIC_Password"),
                     bigint   = "integer",
                     options  = "-c search_path=mimiciii")
```

Hadley Wickham
@hadleywickham
Follow

If you currently use RPostgreSQL or RMySQL, check out RPostgres (github.com/r-dbi/RPostgres) & RMariaDB (github.com/r-dbi/RMariaDB). These have many tests + modern C++ backends + active maintainer + much polishing. Thanks to @krlmlr + @RConsortium! #rstats

r-dbi/RMariaDB
An R interface to MariaDB. Contribute to r-dbi/RMariaDB development by creating an account on GitHub.
github.com

6:46 AM - 8 Jan 2018

"Hide" in file .Renviron

```
> Sys.getenv("R_USER")
[1] "C:/Users/efg/Documents"
```

This PC › OS (C:) › Users › efg › Documents

Name
.Renviron

```
MIMIC_User = postgres
MIMIC_Password = NotSoSecure
```

date/time problem (discussed later)

krlmlr

Confirmed that this is a bug in *RPostgres*. Should be fixed with the next update, planned end of February.

040-Load-MIMIC-into-PostgreSQL/MIMIC-III-First-Look*.html

Getting Started with MIMIC-III
R Database Driver Packages

2 Open database with RPostgres

```
MimicDB <- dbConnect(RPostgres::Postgres(),
                     host     = "localhost",
                     dbname   = "mimic",
                     user     = Sys.getenv("MIMIC_User"),
                     password = Sys.getenv("MIMIC_Password"),
                     bigint   = "integer",
                     options  = "-c search_path=mimiciii")
```

Alternative DB Drivers

2 Open database with RPostgreSQL

```
MimicDB <- dbConnect(PostgreSQL(),
                     dbname="mimic",
                     user     = Sys.getenv("MIMIC_User"),
                     password = Sys.getenv("MIMIC_Password"))
```

2 Open database with odbc

```
MimicDB <- dbConnect(odbc::odbc(),
                     driver   = "PostgreSQL Unicode(x64)",
                     database = "mimic",
                     user     = Sys.getenv("MIMIC_User"),
                     password = Sys.getenv("MIMIC_Password"),
                     bigint   = "integer")
```

040-Load-MIMIC-into-PostgreSQL/MIMIC-III-First-Look*.html

Getting Started with MIMIC-III
Querying MIMIC-III with SQL or dplyr

050-Querying-MIMIC-III

Reproduce online SQL Examples with dplyr in Rstudio Notebooks

- https://mimic.physionet.org/tutorials/intro-to-mimic-iii/
- Online examples numbered 3 – 7,
  plus a tutorial problem in 8 steps
- Examples using SQL code chunks
  - Querying-MIMIC-III-SQL.html
  - Querying-MIMIC-III-Tutorial-Problem-SQL.html
- Equivalent examples with R dplyr code chunks
  - Querying-MIMIC-III-dplyr.html
  - Querying-MIMIC-III-Tutorial-Problem-Tidyverse-dplyr.html
- These sets of notebooks should help understand equivalent SQL and dplyr solutions

Getting Started with MIMIC-III
Querying MIMIC-III with SQL or dplyr

Example 3. Patient Numbers

SQL Chunk

```
```{sql, connection=MimicDB}
SELECT   gender, COUNT(*)
FROM     patients
GROUP BY gender
```
```

```
SELECT   gender, COUNT(*)
FROM     patients
GROUP BY gender
```

2 records

gender	count
M	26121
F	20399

050-Querying-MIMIC-III/Querying-MIMIC-III-SQL.html
050-Querying-MIMIC-III/Querying-MIMIC-III-dplyr.html

R Chunk

```
```{r}
patients              %>%
  group_by(gender)    %>%
  count()             %>%
  Show()
```
```

```
library(tidyverse)
```

```
patients   <- tbl(MimicDB, in_schema("mimiciii", "patients"))
```

```
patients            %>%
  group_by(gender) %>%
  count()           %>%
  Show()
```

gender	n
M	26121
F	20399

Getting Started with MIMIC-III

Experimental "kable" function to `Show` results

```
library(kableExtra)
```

Helper function: Common formatting mostly for data.frames/tibbles below

```
Show <- function(data, caption="", bigMark="", ...)
{
  data                                          %>%
  kable("html", caption=caption,
        format.args=list(big.mark=bigMark))  %>%
  kable_styling(bootstrap_options=c("striped", "bordered", "condensed"),
                position="left",
                full_width=FALSE, ...)
}
```

"Pass the dots".
You do not need rlang.

See "Lazy evaluation" and nonstandard evaluation (NSE) by Jenny Bryan at RStudioConf::2019 ~15:00 in video

```
patients   %>%
  head(5)  %>%
  Show(font_size = 10)
```

row_id	subject_id	gender	dob	dod	dod_hosp	dod_ssn	expire_flag
234	249	F	2075-03-13	NA	NA	NA	0

Also see: Create Awesome HTML Table with knitr::kable and kableExtra

050-Querying-MIMIC-III/Querying-MIMIC-III-dplyr.html

Getting Started with MIMIC-III
Querying MIMIC-III with SQL or dplyr

dbplyr "magic" automatically creates SQL

`show_query` reveals generated SQL

```
```{r}
patients                  %>%
  group_by(gender)        %>%
  count()                 %>%
show_query()
```
```

```
<SQL>
SELECT "gender", COUNT(*) AS "n"
FROM mimiciii.patients
GROUP BY "gender"
```

```
```{r}
dobByYearMonth <-
  patients                                        %>%
  mutate(Year  = date_part("year",  dob),
         Month = date_part("month", dob))         %>%
  select(Year, Month)                             %>%
  group_by(Year, Month)                           %>%
  count()                                         %>%
  ungroup()                                       %>%
  show_query()
```
```

```
<SQL>
SELECT "Year", "Month", COUNT(*) AS "n"
FROM (SELECT "Year", "Month"
FROM (SELECT "row_id", "subject_id", "gender", "dob", "dod", "dod_hosp",
"dod_ssn", "expire_flag", DATE_PART('year', "dob") AS "Year",
DATE_PART('month', "dob") AS "Month"
FROM mimiciii.patients) "ityyvyejfh") "spjpupahrs"
GROUP BY "Year", "Month"
```

Functions not recognized by dbplyr are passed to database server for evaluation, e.g., `date_part` is passed to Postgres. (`COUNT_BIG` can be passed to MS SQL.) Some R functions are translated to SQL (`str_flatten` but not `paste`).

Getting Started with MIMIC-III
Querying MIMIC-III with SQL or dplyr
Tutorial. Step 2

SQL

```{sql, connection=MimicDB, output.var="SQLresults"}
```

Step 2

Using the patients table retrieve the calculated age of patients.

```
SELECT
  ie.subject_id,
  ie.hadm_id,
  ie.icustay_id,
  ie.intime,
  ie.outtime,
  ROUND((cast(ie.intime as date) - cast(pat.dob as date))/365.242, 2) AS age_years
FROM
  icustays ie

  INNER JOIN patients pat
  ON ie.subject_id = pat.subject_id;
```

```
dim(SQLresults)
```

```
[1] 61532     6
```

dplyr

```
icustays   <- tbl(MimicDB, in_schema("mimiciii", "icustays"))
patients   <- tbl(MimicDB, in_schema("mimiciii", "patients"))
```

Step 2

Using the patients table retrieve the calculated age of patients.

DB

R

```
results2 <-
  icustays                                                          %>%
  inner_join(patients, by="subject_id")                             %>%
  select(subject_id, hadm_id, icustay_id, intime, outtime, dob)     %>%
  collect()                                                         %>%
  mutate(ageYears = (as.numeric(floor_date(intime, unit="day") -
                                floor_date(dob,    unit="day"),
                                units="days")  /  365.242)  %>%  round(2))  %>%
  select(-dob)
```

```
dim(results2)
```

```
[1] 61532     6
```

Calculated ages

subject_id	hadm_id	icustay_id	intime	outtime	ageYears
268	110404	280836	2198-02-14	2198-02-18	65.98
269	106296	206613	2170-11-05	2170-11-08	40.10
270	188028	220345	2128-06-24	2128-06-27	80.08

dbplyr uses "lazy evaluation." `collect` forces computation of database query.

050-Querying-MIMIC-III/Querying-MIMIC-III-Tutorial-Problem-SQL.html
050-Querying-MIMIC-III/Querying-MIMIC-III-Tutorial-Problem-Tidyverse-dplyr.html

Getting Started with MIMIC-III
Querying MIMIC-III with SQL or dplyr
Tutorial. Step 5

SQL

Step 5

Next find the date of the patient's death if applicable.

```
SELECT
  ie.subject_id,
  ie.hadm_id,
  ie.icustay_id,
  ie.intime,
  ie.outtime,
  adm.deathtime,

  ROUND((cast(ie.intime as date) - cast(pat.dob as date))      /365.242, 2) as age_years,
        (cast(ie.intime as date) - cast(adm.admittime as date))             as preiculos_days,

  CASE
    WHEN ROUND((cast(ie.intime as date) - cast(pat.dob as date))/365.242, 2) <= 1
    THEN 'neonate'

    WHEN ROUND((cast(ie.intime as date) - cast(pat.dob as date))/365.242, 2) <= 14
    THEN 'middle'

    -- all ages > 89 in the database were replaced with 300
    WHEN ROUND((cast(ie.intime as date) - cast(pat.dob as date))/365.242, 2) > 100
    THEN '>89'

    ELSE 'adult'
  END AS ICUSTAY_AGE_GROUP

FROM
  icustays ie

  INNER JOIN patients pat
  ON ie.subject_id = pat.subject_id

  INNER JOIN admissions adm
  ON ie.hadm_id = adm.hadm_id
```

```
dim(SQLresults)
```

```
[1] 61532     9
```

dplyr

```
icustays   <- tbl(MimicDB, in_schema("mimiciii", "icustays"))
patients   <- tbl(MimicDB, in_schema("mimiciii", "patients"))
admissions <- tbl(MimicDB, in_schema("mimiciii", "admissions"))
```

Step 5

Next find the date of the patient's death if applicable.

DB

R

```
results5 <-
  icustays                                                          %>%
  inner_join(patients,   by = "subject_id")                         %>%
  inner_join(admissions, by = c("subject_id", "hadm_id"))           %>%
  select(subject_id, hadm_id, icustay_id, intime, outtime,
         deathtime, dob, admittime)                                 %>%
  collect()                                                         %>%
  mutate(ageYears      = (as.numeric(floor_date(intime,    unit="day") -
                                     floor_date(dob,       unit="day"),
                                     units="days")  / 365.242)  %>%  round(2),

         preiculosDays = (as.numeric(floor_date(intime,    unit="day") -
                                     floor_date(admittime, unit="day"),
                                     units="days"))

        )                                                           %>%
  select(-dob, -admittime)                                          %>%
  mutate(icuStayAgeGroup =
           case_when
           (
             ageYears <=  1 ~ "neonate",
             ageYears <= 14 ~ "middle",
             ageYears > 100 ~ ">89",
             TRUE           ~ "adult"
           )
         )
```

```
dim(results5)
```

```
[1] 61532     9
```

MIMIC-III Critical Care Data Outline

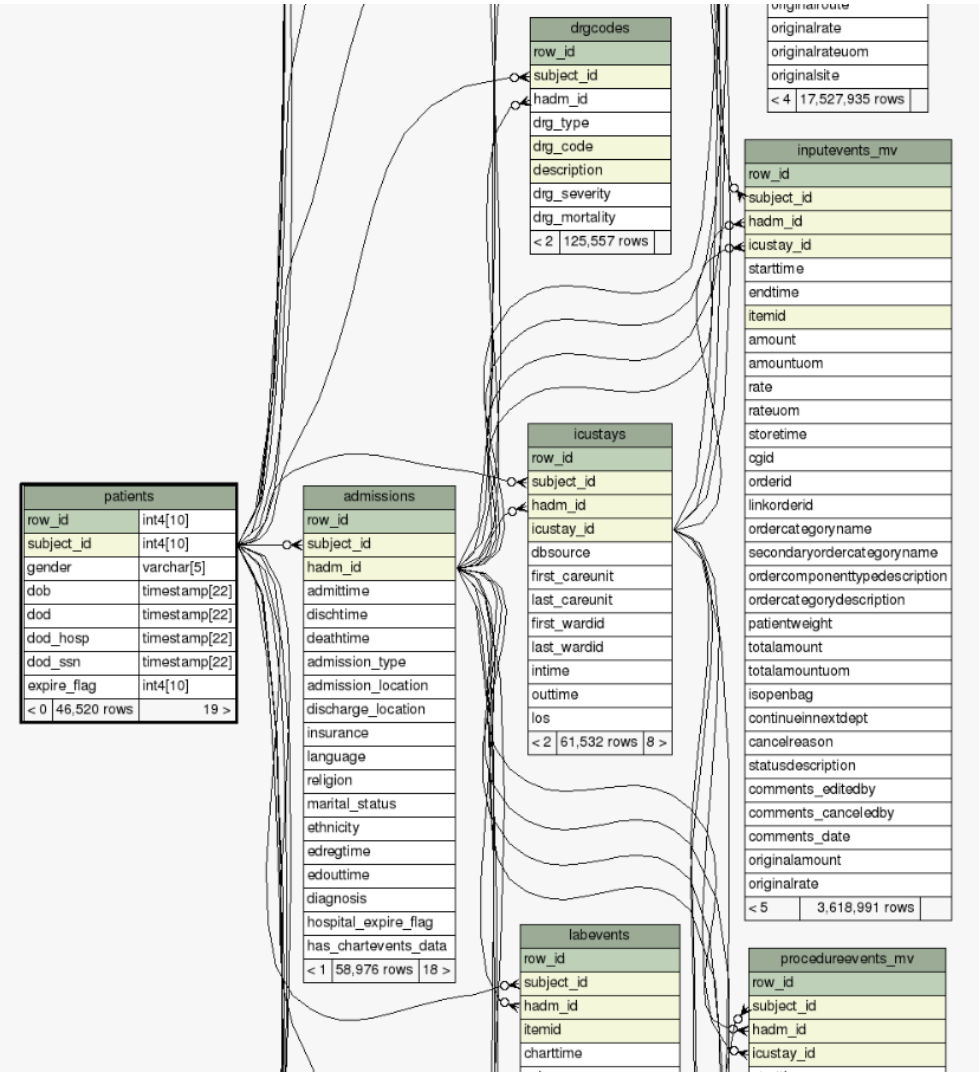
- Getting Started with MIMIC-III
  - Background / Motivation
  - Training Requirements
  - Loading Postgres Database
  - Querying MIMIC-III with SQL or dplyr
- MIMIC-III Exploration with tidyverse/dplyr
  - Patients Table
  - Admissions Table
  - Diagnoses Tables
- Take Home

MIMIC-III Exploration

- Important to understand data fields before using in analysis projects.
- Avoid “garbage in, garbage out.”
- A data dictionary or code book can be helpful but often can be inadequate or out-of-date.
- Database schema can help with relationships among tables, but provides little information about data fields.
- Want a “statistical abstract” of table and fields as a starting point.
- Goal is “clean” and understandable data to build predictive models.

MIMIC-III Exploration

Online Schema Shows Complicated Relationships



MIMIC-III Exploration

Online Schema Shows Terse Field Information

Table mimic.mimiciii.patients

Patients associated with an admission to the ICU.

☐ Related columns ☐ Constraints ☑ Comments ☑ Legend

Column	Type	Size	Nulls	Auto	Default	Children	Parents	Comments
row_id	int4	10						Unique row identifier.
subject_id	int4	10				admissions callout chartevents cptevents datetimeevents diagnoses_icd drgcodes icustays inputevents_cv inputevents_mv labevents microbiologyevents noteevents outputevents prescriptions procedureevents_mv procedures_icd services transfers		Primary key. Identifies the patient.
gender	varchar	5						Gender.
dob	timestamp	22						Date of birth.
dod	timestamp	22	√		null			Date of death. Null if the patient was alive at least 90 days post hospital discharge.
dod_hosp	timestamp	22	√		null			Date of death recorded in the hospital records.
dod_ssn	timestamp	22	√		null			Date of death recorded in the social security records.
expire_flag	int4	10						Flag indicating that the patient has died.

Table contained 46,520 rows at Thu Oct 12 12:29 EDT 2017

https://mit-lcp.github.io/mimic-schema-spy/tables/patients.html

MIMIC-III Exploration

Online info about patients table

https://mimic.physionet.org/mimictables/patients/

PATIENTS

MIMIC The latest version of MIMIC-III is v1.4

About

Getting started

Tables in MIMIC

- ADMISSIONS
- CALLOUT
- CAREGIVERS
- CHARTEVENTS
- CPTEVENTS
- D_CPT
- D_ICD_DIAGNOSES
- D_ICD_PROCEDURES
- D_ITEMS
- D_LABITEMS
- DATETIMEEVENTS
- DIAGNOSES_ICD

The patients table

Table source: CareVue and Metavision ICU databases.

Table purpose: Contains all charted data for all patients.

Number of rows: 46,520

Links to:

- ADMISSIONS on SUBJECT_ID
- ICUSTAYS on SUBJECT_ID

Important considerations

- DOB has been shifted for patients older than 89. The median age for the patients whose date of birth was shifted is 91.4.

DOB ranges from 1800 to 2201!

https://mimic.physionet.org/mimictables/patients/

MIMIC-III Exploration
Patients Table

MIMIC-III Patients Table

RStudio Notebook
YAML Markdown Header

```
---
title: "MIMIC-III Patients Table"
output:
  html_document:
    toc: yes
    number_sections: yes
  html_notebook:
    toc: yes
---

<style type="text/css">
div#TOC li {
    list-style:none;
    background-image:none;
    background-repeat:none;
    background-position:0;
}
</style>
```

patients/Patients.html

MIMIC-III Exploration Patients Table

1.3 Open database

```
MimicDB <- dbConnect(RPostgres::Postgres(),
                     dbname   = "mimic",
                     user     = Sys.getenv("MIMIC_User"),
                     password = Sys.getenv("MIMIC_Password"),
                     bigint   = "integer",
                     options  = "-c search_path=mimiciii")

plotCaptionLeft  <- "MIMIC-III v1.4"
plotCaptionRight <- paste("efg", format(Sys.time(), "%Y-%m-%d"))
```

3 Sample patients

```
patients <- tbl(MimicDB, in_schema("mimiciii", "patients"))

patients          %>%
  head(10)        %>%
  Show()
```

row_id	subject_id	gender	dob	dod	dod_hosp	dod_ssn	expire_flag
234	249	F	2075-03-13	NA	NA	NA	0
235	250	F	2164-12-27	2188-11-22	2188-11-22	NA	1

4 Record count

```
patients              %>%
  summarize(n = n())  %>%
  Show()
```

n
46520

patients/Patients.html

MIMIC-III Exploration
Patients Table

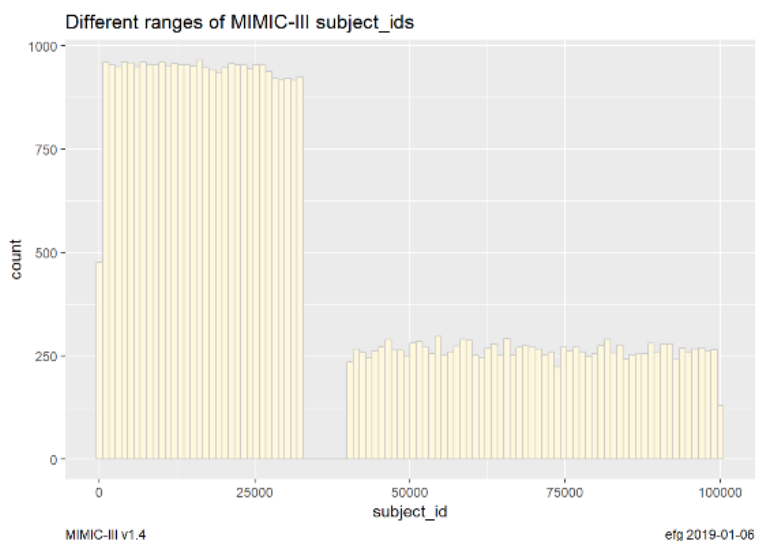
5.2 subject_id

```
patients                                                  %>%
  summarize(minSubjectID = min(subject_id, na.rm=TRUE),
            maxSubjectID = max(subject_id, na.rm=TRUE))  %>%
  Show()
```

minSubjectID	maxSubjectID
2	99999

There are two groups of `subject _id` ranges.

```
patients                 %>%
  select(subject_id)     %>%
  collect                %>%
  ggplot(aes(x=subject_id))                                  +
  geom_histogram(fill="cornsilk", color="grey80", bins=100) +
  labs(title = "Different ranges of MIMIC-III subject_ids",
       caption=c(plotCaptionLeft, plotCaptionRight))         +
  theme(plot.caption = element_text(hjust=c(0.0,1.0)))
```



What explains this? `dbsource` in `icustays` table?

patients/Patients.html

MIMIC-III Exploration
Patients Table

5.4 dob (date of birth) counts

DB

R

```
dobByYearMonth <-
  patients                                  %>%
  mutate(Year  = date_part("year",  dob),
         Month = date_part("month", dob))   %>%
  select(Year, Month)                       %>%
  group_by(Year, Month)                     %>%
  count()  %>%
  ungroup()                                 %>%
  collect()                                 %>%
  arrange(Year, Month)                      %>%
  spread(Month, n, fill=0)
```

Counts of MIMIC-III dates of birth (dob) by year and month

```
dobByYearMonth                        %>%
  Show()                              %>%
  scroll_box(height = "500px")
```

Year	1	2	3	4	5	6	7	8	9	10	11	12
1800	0	0	0	0	0	0	4	2	3	2	1	1
1801	1	4	2	0	1	0	3	3	2	3	0	1
1802	5	2	4	3	0	3	3	3	1	2	4	3
1803	1	3	5	1	2	0	3	0	2	4	0	1
1804	2	5	1	3	3	3	1	0	4	0	2	2

To de-identify patients, dates have been shifted over a 400 year range. [Unusual convention]

Date-of-birth values range from 1800 to 1901 and 2012 to 2201.

Date-of-death values range from 2100 to 2211.

Year-over-year trends will be impossible to observe, which is often a good self-consistency check.

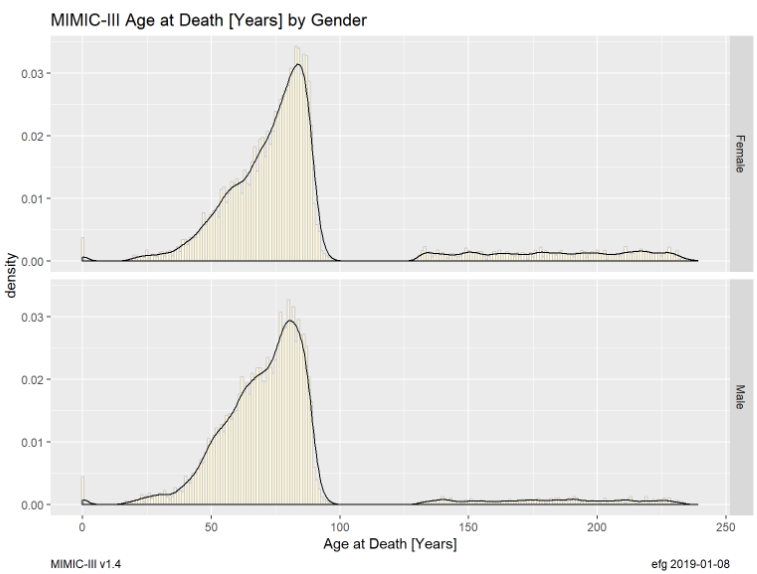
patients/Patients.html

MIMIC-III Exploration
Patients Table

5.8 Computed: Age at Death [INCORRECT results with RPostgres]

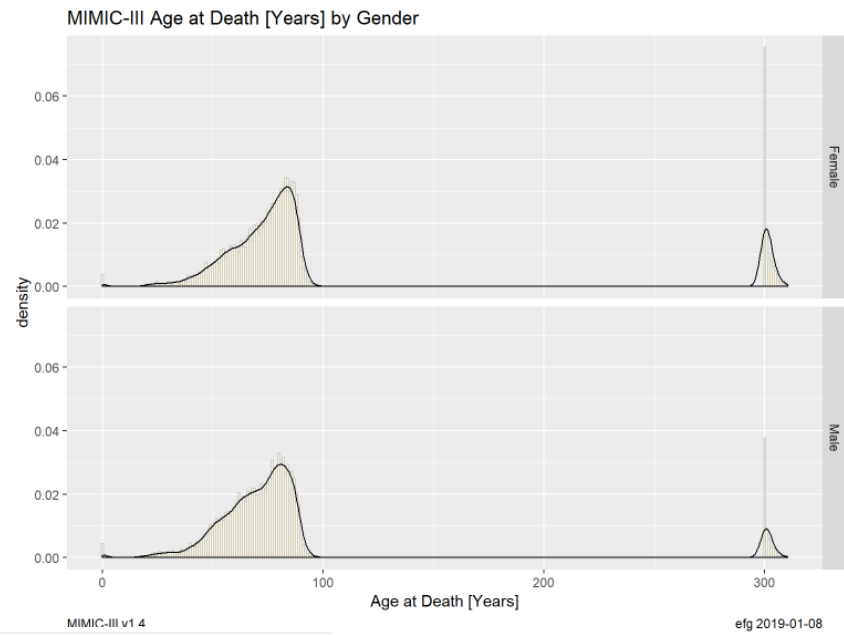
```
facetLabels <- c(`F` = "Female",
                 `M` = "Male")
```

```
patients                                        %>%
  filter(expire_flag == 1)                      %>%
  select(-dod_hosp, -dod_ssn, -expire_flag)     %>%
  collect()                                     %>%
  mutate(AgeAtDeathYears = as.double(dod - dob)/ (86400 * 365.25) )  %>%

  ggplot(aes(x = AgeAtDeathYears, y = ..density..))              +
    geom_histogram(fill="cornsilk", color="grey80", binwidth=1) +
    geom_density()                                               +
    facet_grid(gender ~ ., labeller = as_labeller(facetLabels)) +
    labs(title="MIMIC-III Age at Death [Years] by Gender",
         x = "Age at Death [Years]",
         caption=c(plotCaptionLeft, plotCaptionRight))           +
    theme(plot.caption = element_text(hjust=c(0.0,1.0)))
```



7.1 Computed: Age at Death [CORRECT results with RPostgreSQL]

```
patients                                        %>%
  filter(expire_flag == 1)                      %>%
  select(-dod_hosp, -dod_ssn, -expire_flag)     %>%
  collect()                                     %>%
  mutate(AgeAtDeathYears = as.double(dod - dob)/ (86400 * 365.25) )  %>%

  ggplot(aes(x = AgeAtDeathYears, y = ..density..))              +
    geom_histogram(fill="cornsilk", color="grey80", binwidth=1) +
    geom_density()                                               +
    facet_grid(gender ~ ., labeller = as_labeller(facetLabels)) +
    labs(title="MIMIC-III Age at Death [Years] by Gender",
         x = "Age at Death [Years]",
         caption=c(plotCaptionLeft, plotCaptionRight))           +
    theme(plot.caption = element_text(hjust=c(0.0,1.0)))
```



patients/Patients.html

krimir

Confirmed that this is a bug in *RPostgres*. Should be fixed with the next update, planned end of February.

MIMIC-III Exploration Admissions Table

MIMIC-III Admissions Table

admissions/Admissions.html

MIMIC-III Exploration Admissions Table

2 List tables in database

This works with RPostgres but not RPostgreSQL.

```
dbListTables(MimicDB)
```

```
 [1] "admissions"         "callout"            "caregivers"
 [4] "chartevents_1"      "chartevents_2"      "chartevents_3"
 [7] "chartevents_4"      "chartevents_5"      "chartevents_6"
[10] "chartevents_7"      "chartevents_8"      "chartevents_9"
[13] "chartevents_10"     "chartevents_11"     "chartevents_12"
[16] "chartevents_13"     "chartevents_14"     "chartevents_15"
[19] "chartevents_16"     "chartevents_17"     "chartevents"
[22] "cptevents"          "datetimeevents"     "diagnoses_icd"
[25] "drgcodes"           "d_cpt"              "d_icd_diagnoses"
[28] "d_icd_procedures"   "d_items"             "d_labitems"
[31] "icustays"           "inputevents_cv"     "inputevents_mv"
[34] "labevents"          "microbiologyevents" "noteevents"
[37] "outputevents"       "patients"           "prescriptions"
[40] "procedureevents_mv" "procedures_icd"     "services"
[43] "transfers"
```

3 List of fields in admissions table

```
dbListFields(MimicDB, "admissions")
```

```
 [1] "row_id"               "subject_id"           "hadm_id"
 [4] "admittime"            "dischtime"            "deathtime"
 [7] "admission_type"       "admission_location"   "discharge_location"
[10] "insurance"            "language"             "religion"
[13] "marital_status"       "ethnicity"            "edregtime"
[16] "edouttime"            "diagnosis"            "hospital_expire_flag"
[19] "has_chartevents_data"
```

admissions/Admissions.html

MIMIC-III Exploration Admissions Table

5 Sample admissions records

```
admissions   %>%
  head(5)    %>%
  Show()
```

row_id	subject_id	hadm_id	admittime	dischtime	deathtime	admission_type	admission_location	discharge_location	insurance	language	religion
21	22	165315	2196-04-09 12:26:00	2196-04-10 15:54:00	NA	EMERGENCY	EMERGENCY ROOM ADMIT	DISC-TRAN CANCER/CHLDRN H	Private	NA	UNOBTAINABLE
22	23	152223	2153-09-03 07:15:00	2153-09-08 19:10:00	NA	ELECTIVE	PHYS REFERRAL/NORMAL DELI	HOME HEALTH CARE	Medicare	NA	CATHOLIC

marital_status	ethnicity	edregtime	edouttime	diagnosis	hospital_expire_flag	has_chartevents_data
MARRIED	WHITE	2196-04-09 10:06:00	2196-04-09 13:24:00	BENZODIAZEPINE OVERDOSE	0	1
MARRIED	WHITE	NA	NA	CORONARY ARTERY DISEASEARTERY BYPASS GRAFT/SDA	0	1

admissions/Admissions.html

MIMIC-III Exploration Admissions Table

6.4 admittime, dischtime, deathtime

- Time of admission to the hospital.
- Time of discharge from the hospital.
- Time of death.

sample values

Unclear why time differences are in minutes here.

```
admissions                                                    %>%
  select(admittime, dischtime, deathtime)                     %>%
  collect()                                                   %>%
  mutate(StayDays = as.double(dischtime - admittime) /1440)   %>%
  head(10)  %>%
  Show()
```

admittime	dischtime	deathtime	StayDays
2196-04-09 12:26:00	2196-04-10 15:54:00	NA	1.144444
2153-09-03 07:15:00	2153-09-08 19:10:00	NA	5.496528

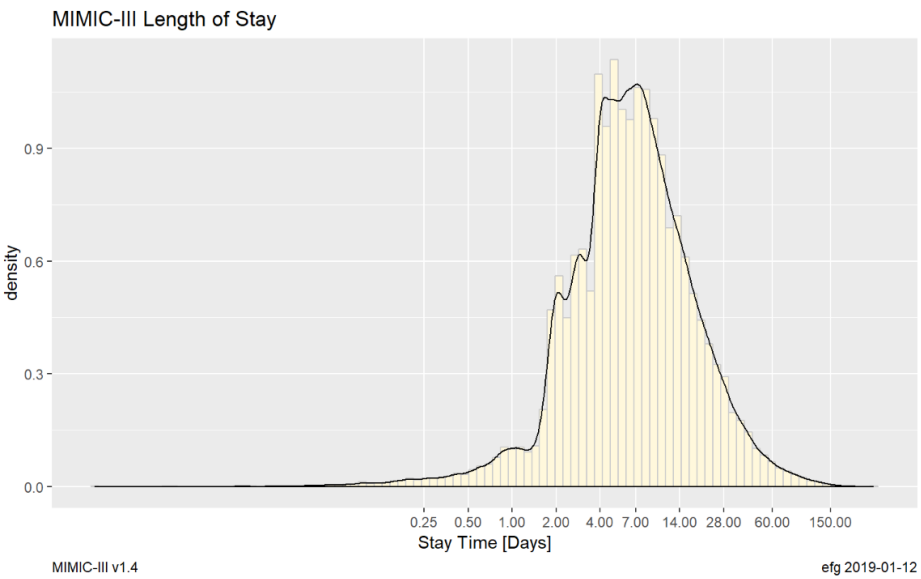
admissions/Admissions.html

MIMIC-III Exploration
Admissions Table

How does visit time vary?

Length of Stay = Discharge Time - Admit Time

```
admissions %>%
  select(admittime, dischtime, deathtime)                    %>%
  collect()                                                  %>%
  mutate(StayDays = as.double(dischtime - admittime) / 1440)  %>%
  filter(StayDays > 0)                                       %>%

  ggplot(aes(x = StayDays, y = ..density..))                      +
    geom_histogram(fill="cornsilk", color="grey80", bins = 100)    +
    geom_density()                                                 +
    scale_x_log10(breaks = c(0.25, 0.50, 1, 2, 4, 7, 14, 28, 60, 150),
                  minor_breaks = NULL)                             +
    labs(title="MIMIC-III Length of Stay",
         x = "Stay Time [Days]",
         caption=c(plotCaptionLeft, plotCaptionRight))             +
    theme(plot.caption = element_text(hjust=c(0.0,1.0)))
```



Note log scale
Length-of-Stays often used in predictive modeling

admissions/Admissions.html

MIMIC-III Exploration Admissions Table

6.7 discharge_location

```
admissions                          %>%
  group_by(discharge_location)      %>%
  summarize(n = n())                %>%
  Show()
```

discharge_location	n
ICF	47
HOSPICE-MEDICAL FACILITY	153
DISC-TRAN CANCER/CHLDRN H	669
DEAD/EXPIRED	5854
HOME	18962
LEFT AGAINST MEDICAL ADVI	365
SNF-MEDICAID ONLY CERTIF	1
REHAB/DISTINCT PART HOSP	6429
HOME WITH HOME IV PROVIDR	67
DISC-TRAN TO FEDERAL HC	11
LONG TERM CARE HOSPITAL	2305
SNF	7705
SHORT TERM HOSPITAL	1534
OTHER FACILITY	63
HOSPICE-HOME	402
HOME HEALTH CARE	13963
DISCH-TRAN TO PSYCH HOSP	446

6.8 insurance

```
admissions                          %>%
  group_by(insurance)               %>%
  summarize(n = n())                %>%
  Show()
```

insurance	n
Government	1783
Self Pay	611
Medicare	28215
Private	22582
Medicaid	5785

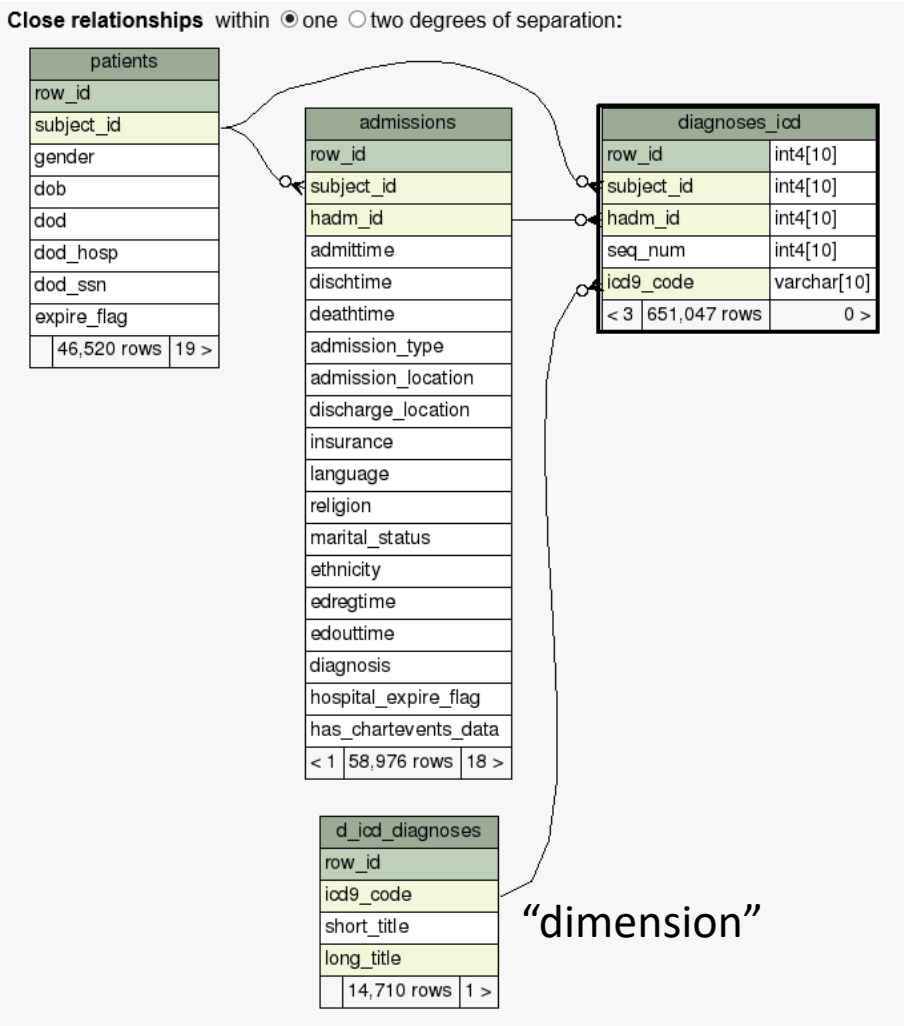
admissions/Admissions.html

MIMIC-III Exploration Diagnoses Tables

MIMIC-III Diagnoses Tables

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration Diagnoses Tables



https://mit-lcp.github.io/mimic-schema-spy/tables/diagnoses_icd.html

MIMIC-III Exploration
Diagnoses Tables

Fact Table

3.2.3 Sample records

```
factDiagnoses  %>%
  arrange(subject_id, row_id)  %>%  # control order
  head(5)                      %>%
  Show(caption = "Sample Records from Diagnoses Fact Table,
diagnoses_icd")
```

Sample Records from Diagnoses Fact Table, diagnoses_icd

row_id	subject_id	hadm_id	seq_num	icd9_code
1	2	163353	1	V3001
2	2	163353	2	V053
3	2	163353	3	V290
4	3	145834	1	0389
5	3	145834	2	78559

3.2.2 Record count

n	diagnosesCodes
651047	6984

diagnoses_icd/Diagnoses.html

Dimension Table

3.1.3 Sample records

```
dimDiagnoses          %>%
  arrange(icd9_code)  %>%
  head(10)            %>%
  Show(caption = "Sample Records from Diagnoses Dimension Table, d_icd_diagnoses")
```

Sample Records from Diagnoses Dimension Table, d_icd_diagnoses

row_id	icd9_code	short_title	long_title
233	0010	Cholera d/t vib cholerae	Cholera due to vibrio cholerae
234	0011	Cholera d/t vib el tor	Cholera due to vibrio cholerae el tor
235	0019	Cholera NOS	Cholera, unspecified
236	0020	Typhoid fever	Typhoid fever
237	0021	Paratyphoid fever a	Paratyphoid fever A
238	0022	Paratyphoid fever b	Paratyphoid fever B
239	0023	Paratyphoid fever c	Paratyphoid fever C
240	0029	Paratyphoid fever NOS	Paratyphoid fever, unspecified
241	0030	Salmonella enteritis	Salmonella gastroenteritis
242	0031	Salmonella septicemia	Salmonella septicemia

3.1.2 Record count

n
14567

MIMIC-III Exploration Diagnoses Tables

Inner Join

Join dimension table to fact table

3.3.1 inner_join

```
factDiagnoses                                    %>%
  inner_join(dimDiagnoses, by = "icd9_code")     %>%
  head()                                         %>%
  collect()                                      %>%
  str()
```

```
Classes 'tbl_df', 'tbl' and 'data.frame':   6 obs. of  8 variables:
 $ row_id.x  : int  307770 497329 513229 398507 579783 408925
 $ subject_id : int  27367 65733 69141 44437 83908 46693
 $ hadm_id    : int  136441 168926 136542 181557 180356 183574
 $ seq_num    : int  7 9 1 10 3 4
 $ icd9_code  : chr  "0030" "0030" "0031" "0038" ...
 $ row_id.y  : int  241 241 242 249 249 250
 $ short_title: chr  "Salmonella enteritis" "Salmonella enteritis" "Sa
pticemia" "Salmonella infection NEC" ...
 $ long_title : chr  "Salmonella gastroenteritis" "Salmonella gastroen
almonella septicemia" "Other specified salmonella infections" ...
```

diagnoses_icd/Diagnoses.html

Remove with: `select(-starts_with("row_id"))`

MIMIC-III Exploration
Diagnoses Tables

Inner Join

```
factDiagnoses                                  %>%
  inner_join(dimDiagnoses, by = "icd9_code")   %>%
  arrange(subject_id, row_id.x)                %>%  # control order
  head(5)                                      %>%
  collect()                                    %>%
  Show(caption = "Sample Diagnoses Records (Fact + Dimension)")
```

Sample Diagnoses Records (Fact + Dimension)

row_id.x	subject_id	hadm_id	seq_num	icd9_code	row_id.y	short_title	long_title
1	2	163353	1	V3001	13695	Single lb in-hosp w cs	Single liveborn, born in hospital, delivered by cesarean section
2	2	163353	2	V053	12202	Need prphyl vc vrl hepat	Need for prophylactic vaccination and inoculation against viral hepatitis
3	2	163353	3	V290	13688	NB obsrv suspct infect	Observation for suspected infectious condition
4	3	145834	1	0389	660	Septicemia NOS	Unspecified septicemia
5	3	145834	2	78559	12992	Shock w/o trauma NEC	Other shock without mention of trauma

Fact

Dimension

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Diagnoses Tables

Inner Join: Missing Records?

3.2.2 Record count

```
factDiagnoses %>%
  summarize(n = n(),
            diagnosesCodes = n_distinct(icd9_code)) %>%
  Show()
```

n	diagnosesCodes
651047	6984

Why were so many fact records lost in join?

```
factDiagnoses                                  %>%
  inner_join(dimDiagnoses, by = "icd9_code")   %>%
  count()                                      %>%
  Show()
```

n
634709

651,047 – 634,709 = 16,338 missing records
Dimension table does not have entries for ~144 icd9_codes in fact table.
One way to fix: update the dimension table to have all possible codes.

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration Diagnoses Tables

Left Join fills in NULL values

3.2.2 Record count

```
factDiagnoses %>%
  summarize(n = n(),
            diagnosesCodes = n_distinct(icd9_code)) %>%
  Show()
```

n	diagnosesCodes
651047	6984

3.3.2 left_join

Keep all diagnosis codes even if not in dimension table using a `left_join`. This will create NULLs for diagnosis descriptions.

```
factDiagnoses                                  %>%
  left_join(dimDiagnoses, by = "icd9_code")    %>%
  count()                                      %>%
  Show()
```

n
651047

Examples with missing short_titles

Database NULLs become NAs

```
factDiagnoses                                  %>%
  left_join(dimDiagnoses, by = "icd9_code")    %>%
  filter(is.na(short_title))                   %>%
  head(2)                                      %>%
  Show()
```

row_id.x	subject_id	hadm_id	seq_num	icd9_code	row_id.y	short_title	long_title
1524	117	140784	2	7895	NA	NA	NA
1529	117	140784	7	2765	NA	NA	NA

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses Counts

4.1 Summarize Diagnoses Counts

```
diagnosesCounts <-
  factDiagnoses                        %>%
  filter(!is.na(icd9_code))            %>%
  group_by(icd9_code)                  %>%
  count()                              %>%
  ungroup()                            %>%
  left_join(dimDiagnoses,
            by = "icd9_code")          %>%
  select(n, everything(), -row_id)     %>%
  arrange(desc(n))                     %>%
  collect()

nrow(diagnosesCounts)
```

```
[1] 6984
```

Many of the ICD 9 diagnoses codes in the dimension table are never referenced.

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses Counts: Top 10

4.1.1 Top 10

```
diagnosesCounts %>% head(10) %>% Show()
```

n	icd9_code	short_title	long_title
20703	4019	Hypertension NOS	Unspecified essential hypertension
13111	4280	CHF NOS	Congestive heart failure, unspecified
12891	42731	Atrial fibrillation	Atrial fibrillation
12429	41401	Crnry athrscl natve vssl	Coronary atherosclerosis of native coronary artery
9119	5849	Acute kidney failure NOS	Acute kidney failure, unspecified
9058	25000	DMII wo cmp nt st uncntr	Diabetes mellitus without mention of complication, type II or unspecified type, not stated as uncontrolled
8690	2724	Hyperlipidemia NEC/NOS	Other and unspecified hyperlipidemia
7497	51881	Acute respiratry failure	Acute respiratory failure
6555	5990	Urin tract infection NOS	Urinary tract infection, site not specified
6326	53081	Esophageal reflux	Esophageal reflux

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses by Age Intervals

4.3 Summarize Diagnoses by Age Intervals

```
admitAges <-
  factDiagnoses                                %>%
  inner_join(factPatients,
             by = "subject_id")                %>%
  inner_join(factAdmissions,
             by = c("subject_id",
                    "hadm_id"))                            %>%
  select(subject_id, hadm_id, icd9_code, dob, admittime)   %>%
  collect()                                                %>%
  mutate(    # collect from database and use R for mutate
          delta         = admittime - dob,
          admitAgeYears = as.numeric((admittime - dob)) / ( 365.25 * 86400),  # seconds
          ageInterval   = pmin(90, 10 * admitAgeYears %/% 10)    # age decades; 90 is 90+
          )

nrow(admitAges)
```

pmin = parallel min

```
[1] 651047
```

Sample records

```
admitAges %>%
  head(2) %>%
  Show()
```

subject_id	hadm_id	icd9_code	dob	admittime	delta	admitAgeYears	ageInterval
109	172335	40301	2117-08-07	2141-09-18 10:32:00	761049120 secs	24.11619	20
109	172335	486	2117-08-07	2141-09-18 10:32:00	761049120 secs	24.11619	20

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses by Age Intervals

Counts by age intervals

```
table(admitAges$ageInterval)
```

```
     0     10     20     30     40     50     60     70     80     90
 46791   2821  17857  25990  56645 101425 131705 131789 101652  34372
```

Interval percentages

```
round(100 * table(admitAges$ageInterval) / nrow(admitAges), 2)
```

```
    0    10    20    30    40    50    60    70    80    90
 7.19  0.43  2.74  3.99  8.70 15.58 20.23 20.24 15.61  5.28
```

Here “0” means 0-9, “10” means 10-19, …, “80”" means 80-89, “90”" means 90+

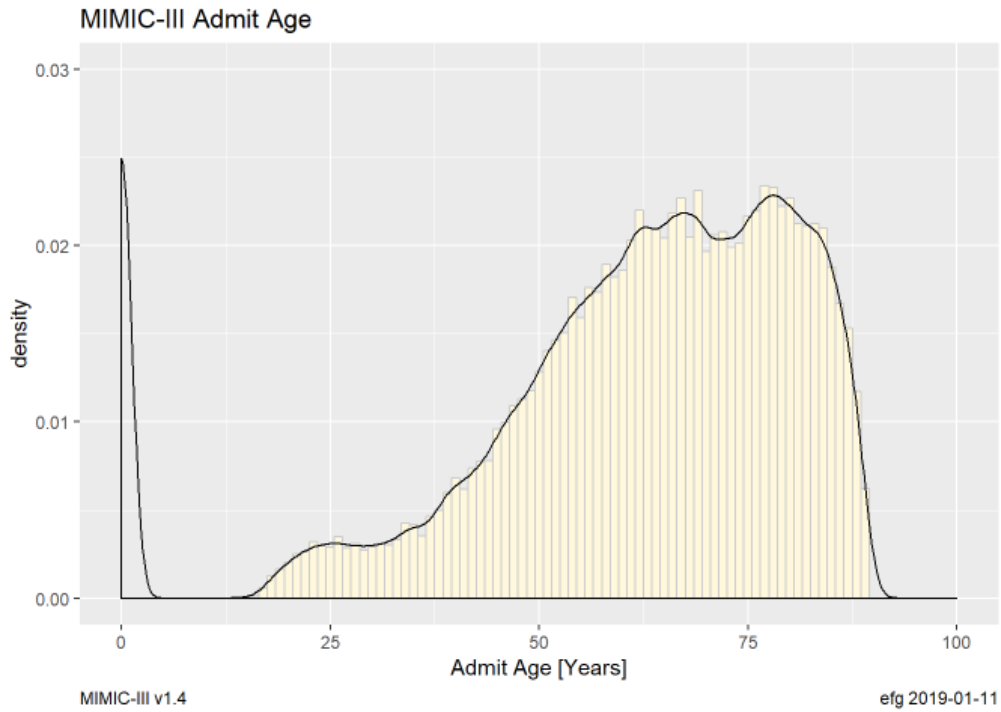
MIMIC-III has fairly old patients and very few teenagers

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses by Age Intervals

4.3.1 Admit Age Density

```
ggplot(admitAges, aes(x = admitAgeYears, y = ..density..))      +
    geom_histogram(fill="cornsilk", color="grey80", binwidth=1) +
    geom_density()                                              +
    xlim(0, 100)                                                +
    ylim(0.00, 0.03)                                            +
    labs(title="MIMIC-III Admit Age",
         x = "Admit Age [Years]",
         caption=c(plotCaptionLeft, plotCaptionRight))          +
    theme(plot.caption = element_text(hjust=c(0.0,1.0)))
```



diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses by Age Intervals

4.3.2 Counts by diagnosis and age interval

```
admitAgesCounts <-
  factDiagnoses                                  %>%
  inner_join(factPatients,
             by = "subject_id")                  %>%
  inner_join(factAdmissions,
             by = c("subject_id",
                    "hadm_id"))                  %>%
  select(subject_id, hadm_id, icd9_code, dob, admittime)  %>%
  collect()                                                %>%   # extract data from DB
  mutate(                                                        # normal R processing
          delta         = admittime - dob,
          admitAgeYears = as.numeric((admittime - dob)) / ( 365.25 * 86400),  # seconds
          ageInterval   = pmin(90, 10 * admitAgeYears %/% 10)    # age decades; 90 is 90+
        )                                        %>%
  group_by(icd9_code, ageInterval)               %>%
  count()                                        %>%  # counts in long format
  ungroup()                                      %>%
  arrange(icd9_code, ageInterval)                %>%
  spread(ageInterval, n, fill=0)                 %>%  # long to wide format
  mutate(RowTotal = rowSums(.[-1], na.rm=TRUE)) %>%
  select(icd9_code, RowTotal, everything())      %>%  # reorder variables
  arrange(desc(RowTotal))                        %>%  # descending order
  left_join(dimDiagnoses, by = "icd9_code",           # add code labels
            copy = TRUE)                         %>%  # table to tibble
  select(-row_id)                                %>%  # remove a variable
  rename( "0s"= "0", "10s"="10", "20s"="20", "30s"="30",
         "40s"="40", "50s"="50", "60s"="60", "70s"="70",
         "80s"="80", "90+"="90")                       # slightly better names

nrow(admitAgesCounts)
```

```
[1] 6985
```

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses by Age Intervals

```
admitAgesCounts  %>%
  head(5)        %>%
  Show()
```

icd9_code	RowTotal	0s	10s	20s	30s	40s	50s	60s	70s	80s	90+	short_title	long_title
4019	20703	13	6	109	433	1489	3479	5035	5184	3744	1211	Hypertension NOS	Unspecified essential hypertension
4280	13111	13	7	67	208	644	1500	2722	3527	3161	1262	CHF NOS	Congestive heart failure, unspecified
42731	12891	0	2	19	71	316	1138	2652	3961	3496	1236	Atrial fibrillation	Atrial fibrillation
41401	12429	0	0	6	135	614	1815	3241	3488	2431	699	Crnry athrscl natve vssl	Coronary atherosclerosis of native coronary artery
5849	9119	4	7	169	307	707	1424	1777	2088	1837	799	Acute kidney failure NOS	Acute kidney failure, unspecified

Can be a “shopping” list to identify research cohorts.

diagnoses_icd/Diagnoses.html

MIMIC-III Exploration
Summarize Diagnoses by Age Intervals

Add total row at bottom

```
admitAgesCounts <-
  bind_rows(admitAgesCounts,
            bind_cols(icd9_code = "ColumnTotal",
                      admitAgesCounts %>%
                        summarize_if(is.numeric, sum, na.rm=TRUE)))
```

```
admitAgesCounts  %>%
  tail(3)        %>%
  Show()
```

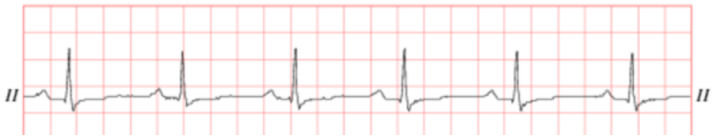
icd9_code	RowTotal	0s	10s	20s	30s	40s	50s	60s	70s	80s	90+	short_title	long_title
V9089	1	0	0	0	1	0	0	0	0	0	0	Retain FB NEC	Other specified retained foreign body
V9103	1	0	0	0	1	0	0	0	0	0	0	Twin gest-dich/diamniotc	Twin gestation, dichorionic/diamniotic (two placentae, two amniotic sacs)
ColumnTotal	651047	46791	2821	17857	25990	56645	101425	131705	131789	101652	34372	NA	NA

diagnoses_icd/Diagnoses.html

Take Home

- MIMIC-III is a great data source for data science experiments and predictive analytics projects involving electronic health records.
- MIMIC-IV to appear in 2019?
- Waveform and chest x-ray data are available to explore via separate downloads.

THE MIMIC-III WAVEFORM DATABASE



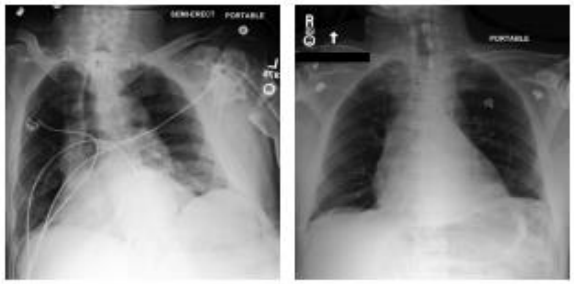


Figure 1: Images which exhibit variation in MIMIC-CXR. F