Data Cleaning Practice

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Data Cleaning Practice Markdown

This is a R markdown of important data cleaning code for future projects. For more information on creating a markdown visit: http://rmarkdown.rstudio.com.

Important packages

```
library("tibble")
library("tidyr")
library("ggplot2")
library("eeptools")
print("Done")
```

```
## [1] "Done"
```

Getting the data

```
library(readr)
my_fake_demographics <- read_csv("my_fake_demographics.csv")
```

```
## Rows: 300 Columns: 5
## ── Column specification
────────────────────────────────────────────────────────
## Delimiter: ","
## chr (4): PAT_DOB, RACE, ETHNICITY, SEX
## dbl (1): PAT_MRN
##
## 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.
```

```
View(my_fake_demographics)
dem.df2 <- my_fake_demographics # Keep the name simple
head(dem.df2)
```

```
## # A tibble: 6 × 5
##   PAT_MRN PAT_DOB    RACE                     ETHNICITY              SEX
##     <dbl> <chr>      <chr>                    <chr>
<chr>
## 1     923 4/5/2007   White                    Not Hispanic or Latino
Female
## 2     942 9/1/2006   <NA>                     <NA>
Female
## 3     356 11/26/2000 White                    Not Hispanic or Latino Male
## 4     844 11/28/2004 Other                    Not Hispanic or Latino
Female
## 5     675 3/3/2013   Black or African-American Not Hispanic or Latino Male
## 6     564 12/13/2013 White                    Not Hispanic or Latino
Female
```

```
summary(dem.df2)
```

```
##     PAT_MRN        PAT_DOB              RACE            ETHNICITY
##  Min.   :100.0   Length:300         Length:300         Length:300
##  1st Qu.:311.5   Class :character   Class :character   Class :character
##  Median :548.0   Mode  :character   Mode  :character   Mode  :character
##  Mean   :548.7
##  3rd Qu.:760.2
##  Max.   :996.0
##      SEX
##  Length:300
##  Class :character
##  Mode  :character
##
##
##
```

```r
str(dem.df2)
```

```
## spc_tbl_ [300 × 5] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
##  $ PAT_MRN  : num [1:300] 923 942 356 844 675 564 758 220 686 728 ...
##  $ PAT_DOB  : chr [1:300] "4/5/2007" "9/1/2006" "11/26/2000" "11/28/2004"
...
##  $ RACE     : chr [1:300] "White" NA "White" "Other" ...
##  $ ETHNICITY: chr [1:300] "Not Hispanic or Latino" NA "Not Hispanic or
Latino" "Not Hispanic or Latino" ...
##  $ SEX      : chr [1:300] "Female" "Female" "Male" "Female" ...
##  - attr(*, "spec")=
##   .. cols(
##   ..   PAT_MRN = col_double(),
##   ..   PAT_DOB = col_character(),
##   ..   RACE = col_character(),
##   ..   ETHNICITY = col_character(),
##   ..   SEX = col_character()
##   .. )
##  - attr(*, "problems")=<externalptr>
```

```r
names(dem.df2)
```

```
## [1] "PAT_MRN"   "PAT_DOB"   "RACE"      "ETHNICITY" "SEX"
```

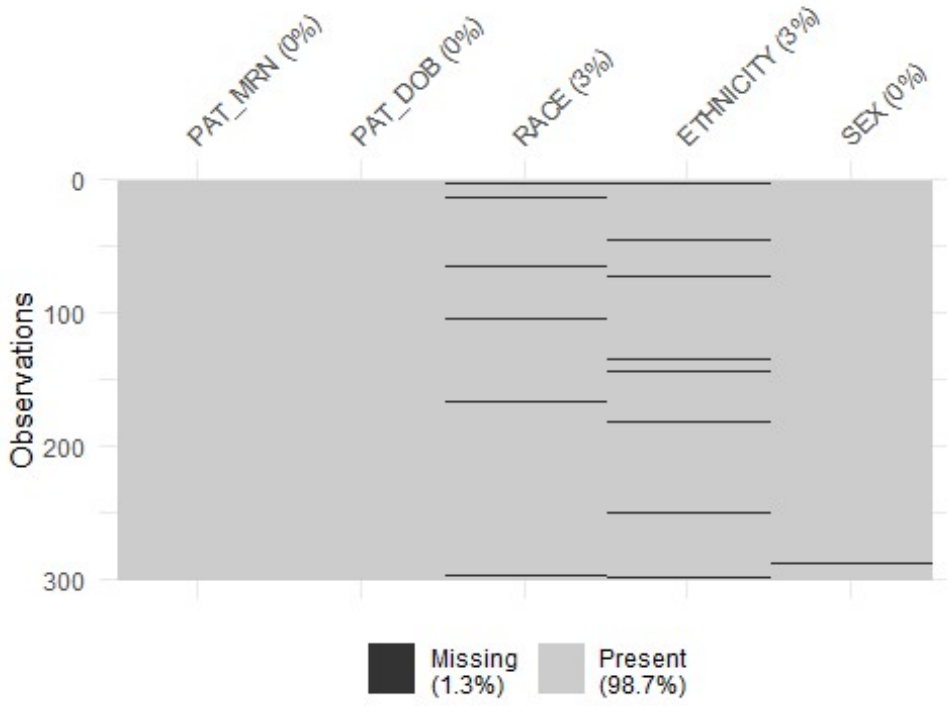
I can see the dimensions, categories, values, and stats of the data

Missing values

```r
sapply(dem.df2, function(x) sum(is.na(x)))
```

```
##   PAT_MRN   PAT_DOB      RACE ETHNICITY       SEX
##         0         0        10         9         1
```

```r
library("visdat")
vis_miss(dem.df2)
```



Imputation

Now lets correct the missing values in “RACE”, “ETHNICITY”, and “SEX”.

```
dem.df2[!complete.cases(dem.df2),] # show rows with missing values
```

```
## # A tibble: 19 × 5
##    PAT_MRN PAT_DOB    RACE                     ETHNICITY              SEX
##      <dbl> <chr>      <chr>                    <chr>
<chr>
##  1     942 9/1/2006   <NA>                     <NA>
Female
##  2     929 6/10/2007  <NA>                     Not Hispanic or Latino
Male
##  3     934 5/10/2005  White                    <NA>
Male
##  4     645 7/21/2005  More Than One Race       <NA>
Male
##  5     574 7/14/2014  <NA>                     Not Hispanic or Latino
Male
##  6     216 10/7/2004  White                    <NA>
Male
##  7     169 6/28/2002  <NA>                     Not Hispanic or Latino
Male
##  8     922 3/1/2006   <NA>                     Not Hispanic or Latino
Male
##  9     524 3/28/2001  <NA>                     Not Hispanic or Latino
```

```
Female
## 10     818 3/24/2001  Other                       <NA>
Female
## 11     543 3/28/2000  <NA>                        Not Hispanic or Latino
Male
## 12     451 4/19/2005  Asian                       <NA>
Male
## 13     231 4/24/2009  <NA>                        Not Hispanic or Latino
Male
## 14     761 5/19/2003  White                       <NA>
Female
## 15     547 2/1/2011   <NA>                        Not Hispanic or Latino
Male
## 16     425 12/14/2004 White                       <NA>
Female
## 17     399 1/10/2014  Black or African-American Not Hispanic or Latino
<NA>
## 18     154 11/26/2006 <NA>                        Not Hispanic or Latino
Female
## 19     988 8/24/2007  Other                       <NA>
Female
```

Ttanic data

These are the packages needed for the next part (imputation)

```
library(ggplot2)
library(dplyr)

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

library(titanic)
library(cowplot)


titanic_train$Age

##   [1] 22.00 38.00 26.00 35.00 35.00    NA 54.00  2.00 27.00 14.00  4.00
58.00
##  [13] 20.00 39.00 14.00 55.00  2.00    NA 31.00    NA 35.00 34.00 15.00
28.00
##  [25]  8.00 38.00    NA 19.00    NA    NA 40.00    NA    NA 66.00 28.00
```

```
42.00
##  [37]    NA 21.00 18.00 14.00 40.00 27.00    NA  3.00 19.00    NA    NA
NA
##  [49]    NA 18.00  7.00 21.00 49.00 29.00 65.00    NA 21.00 28.50  5.00
11.00
##  [61] 22.00 38.00 45.00  4.00    NA    NA 29.00 19.00 17.00 26.00 32.00
16.00
##  [73] 21.00 26.00 32.00 25.00    NA    NA  0.83 30.00 22.00 29.00    NA
28.00
##  [85] 17.00 33.00 16.00    NA 23.00 24.00 29.00 20.00 46.00 26.00 59.00
NA
##  [97] 71.00 23.00 34.00 34.00 28.00    NA 21.00 33.00 37.00 28.00 21.00
NA
## [109] 38.00    NA 47.00 14.50 22.00 20.00 17.00 21.00 70.50 29.00 24.00
2.00
## [121] 21.00    NA 32.50 32.50 54.00 12.00    NA 24.00    NA 45.00 33.00
20.00
## [133] 47.00 29.00 25.00 23.00 19.00 37.00 16.00 24.00    NA 22.00 24.00
19.00
## [145] 18.00 19.00 27.00  9.00 36.50 42.00 51.00 22.00 55.50 40.50    NA
51.00
## [157] 16.00 30.00    NA    NA 44.00 40.00 26.00 17.00  1.00  9.00    NA
45.00
## [169]    NA 28.00 61.00  4.00  1.00 21.00 56.00 18.00    NA 50.00 30.00
36.00
## [181]    NA    NA  9.00  1.00  4.00    NA    NA 45.00 40.00 36.00 32.00
19.00
## [193] 19.00  3.00 44.00 58.00    NA 42.00    NA 24.00 28.00    NA 34.00
45.50
## [205] 18.00  2.00 32.00 26.00 16.00 40.00 24.00 35.00 22.00 30.00    NA
31.00
## [217] 27.00 42.00 32.00 30.00 16.00 27.00 51.00    NA 38.00 22.00 19.00
20.50
## [229] 18.00    NA 35.00 29.00 59.00  5.00 24.00    NA 44.00  8.00 19.00
33.00
## [241]    NA    NA 29.00 22.00 30.00 44.00 25.00 24.00 37.00 54.00    NA
29.00
## [253] 62.00 30.00 41.00 29.00    NA 30.00 35.00 50.00    NA  3.00 52.00
40.00
## [265]    NA 36.00 16.00 25.00 58.00 35.00    NA 25.00 41.00 37.00    NA
63.00
## [277] 45.00    NA  7.00 35.00 65.00 28.00 16.00 19.00    NA 33.00 30.00
22.00
## [289] 42.00 22.00 26.00 19.00 36.00 24.00 24.00    NA 23.50  2.00    NA
50.00
## [301]    NA    NA 19.00    NA    NA  0.92    NA 17.00 30.00 30.00 24.00
18.00
## [313] 26.00 28.00 43.00 26.00 24.00 54.00 31.00 40.00 22.00 27.00 30.00
22.00
## [325]    NA 36.00 61.00 36.00 31.00 16.00    NA 45.50 38.00 16.00    NA
```

```
NA
## [337] 29.00 41.00 45.00 45.00  2.00 24.00 28.00 25.00 36.00 24.00 40.00
NA
## [349]  3.00 42.00 23.00    NA 15.00 25.00    NA 28.00 22.00 38.00    NA
NA
## [361] 40.00 29.00 45.00 35.00    NA 30.00 60.00    NA    NA 24.00 25.00
18.00
## [373] 19.00 22.00  3.00    NA 22.00 27.00 20.00 19.00 42.00  1.00 32.00
35.00
## [385]    NA 18.00  1.00 36.00    NA 17.00 36.00 21.00 28.00 23.00 24.00
22.00
## [397] 31.00 46.00 23.00 28.00 39.00 26.00 21.00 28.00 20.00 34.00 51.00
3.00
## [409] 21.00    NA    NA    NA 33.00    NA 44.00    NA 34.00 18.00 30.00
10.00
## [421]    NA 21.00 29.00 28.00 18.00    NA 28.00 19.00    NA 32.00 28.00
NA
## [433] 42.00 17.00 50.00 14.00 21.00 24.00 64.00 31.00 45.00 20.00 25.00
28.00
## [445]    NA  4.00 13.00 34.00  5.00 52.00 36.00    NA 30.00 49.00    NA
29.00
## [457] 65.00    NA 50.00    NA 48.00 34.00 47.00 48.00    NA 38.00    NA
56.00
## [469]    NA  0.75    NA 38.00 33.00 23.00 22.00    NA 34.00 29.00 22.00
2.00
## [481]  9.00    NA 50.00 63.00 25.00    NA 35.00 58.00 30.00  9.00    NA
21.00
## [493] 55.00 71.00 21.00    NA 54.00    NA 25.00 24.00 17.00 21.00    NA
37.00
## [505] 16.00 18.00 33.00    NA 28.00 26.00 29.00    NA 36.00 54.00 24.00
47.00
## [517] 34.00    NA 36.00 32.00 30.00 22.00    NA 44.00    NA 40.50 50.00
NA
## [529] 39.00 23.00  2.00    NA 17.00    NA 30.00  7.00 45.00 30.00    NA
22.00
## [541] 36.00  9.00 11.00 32.00 50.00 64.00 19.00    NA 33.00  8.00 17.00
27.00
## [553]    NA 22.00 22.00 62.00 48.00    NA 39.00 36.00    NA 40.00 28.00
NA
## [565]    NA 24.00 19.00 29.00    NA 32.00 62.00 53.00 36.00    NA 16.00
19.00
## [577] 34.00 39.00    NA 32.00 25.00 39.00 54.00 36.00    NA 18.00 47.00
60.00
## [589] 22.00    NA 35.00 52.00 47.00    NA 37.00 36.00    NA 49.00    NA
49.00
## [601] 24.00    NA    NA 44.00 35.00 36.00 30.00 27.00 22.00 40.00 39.00
NA
## [613]    NA    NA 35.00 24.00 34.00 26.00  4.00 26.00 27.00 42.00 20.00
21.00
## [625] 21.00 61.00 57.00 21.00 26.00    NA 80.00 51.00 32.00    NA  9.00
```

```
28.00
## [637] 32.00 31.00 41.00    NA 20.00 24.00  2.00    NA  0.75 48.00 19.00
56.00
## [649]    NA 23.00    NA 18.00 21.00    NA 18.00 24.00    NA 32.00 23.00
58.00
## [661] 50.00 40.00 47.00 36.00 20.00 32.00 25.00    NA 43.00    NA 40.00
31.00
## [673] 70.00 31.00    NA 18.00 24.50 18.00 43.00 36.00    NA 27.00 20.00
14.00
## [685] 60.00 25.00 14.00 19.00 18.00 15.00 31.00  4.00    NA 25.00 60.00
52.00
## [697] 44.00    NA 49.00 42.00 18.00 35.00 18.00 25.00 26.00 39.00 45.00
42.00
## [709] 22.00    NA 24.00    NA 48.00 29.00 52.00 19.00 38.00 27.00    NA
33.00
## [721]  6.00 17.00 34.00 50.00 27.00 20.00 30.00    NA 25.00 25.00 29.00
11.00
## [733]    NA 23.00 23.00 28.50 48.00 35.00    NA    NA    NA 36.00 21.00
24.00
## [745] 31.00 70.00 16.00 30.00 19.00 31.00  4.00  6.00 33.00 23.00 48.00
0.67
## [757] 28.00 18.00 34.00 33.00    NA 41.00 20.00 36.00 16.00 51.00    NA
30.50
## [769]    NA 32.00 24.00 48.00 57.00    NA 54.00 18.00    NA  5.00    NA
43.00
## [781] 13.00 17.00 29.00    NA 25.00 25.00 18.00  8.00  1.00 46.00    NA
16.00
## [793]    NA    NA 25.00 39.00 49.00 31.00 30.00 30.00 34.00 31.00 11.00
0.42
## [805] 27.00 31.00 39.00 18.00 39.00 33.00 26.00 39.00 35.00  6.00 30.50
NA
## [817] 23.00 31.00 43.00 10.00 52.00 27.00 38.00 27.00  2.00    NA    NA
1.00
## [829]    NA 62.00 15.00  0.83    NA 23.00 18.00 39.00 21.00    NA 32.00
NA
## [841] 20.00 16.00 30.00 34.50 17.00 42.00    NA 35.00 28.00    NA  4.00
74.00
## [853]  9.00 16.00 44.00 18.00 45.00 51.00 24.00    NA 41.00 21.00 48.00
NA
## [865] 24.00 42.00 27.00 31.00    NA  4.00 26.00 47.00 33.00 47.00 28.00
15.00
## [877] 20.00 19.00    NA 56.00 25.00 33.00 22.00 28.00 25.00 39.00 27.00
19.00
## [889]    NA 26.00 32.00
```

```
sapply(titanic_train, function(x) sum(is.na(x)))
```

```
## PassengerId    Survived      Pclass        Name         Sex         Age
##           0           0           0           0           0         177
```

```
##       SibSp       Parch      Ticket        Fare       Cabin    Embarked
##           0           0           0           0           0           0
```

```
library("visdat")
vis_miss(titanic_train)
```

Simple Imputation

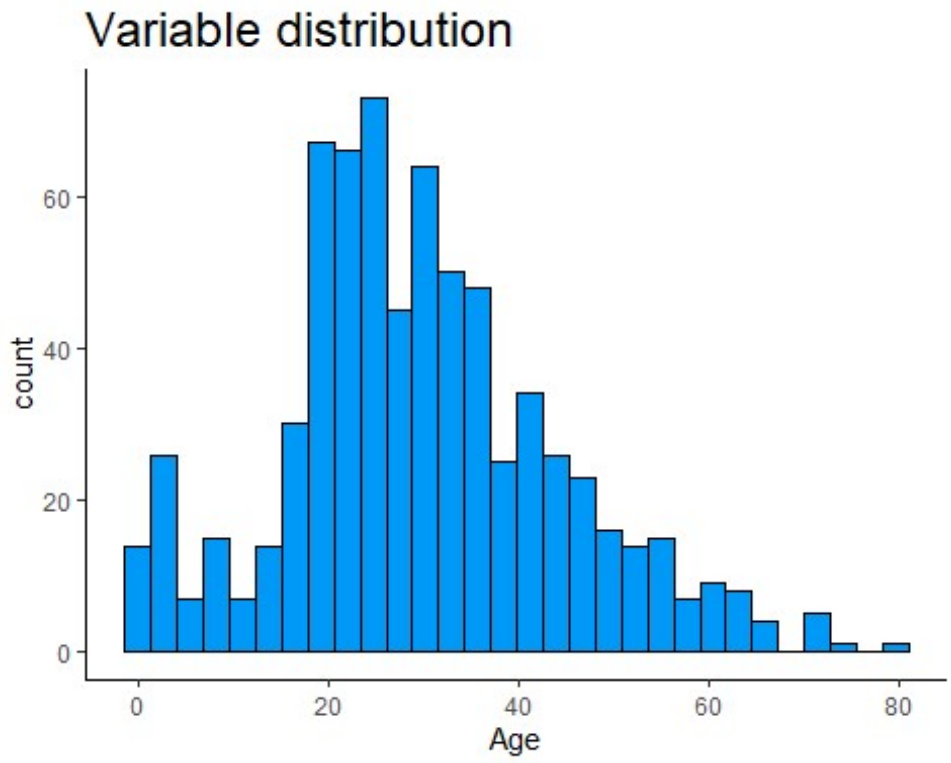
The value_imputed variable will store a data.frame of the imputed ages. The imputation itself boils down to replacing a column subset that has a value of NA with the value of our choice. This will be:

Zero: constant imputation, feel free to change the value. Mean (average): average age after when all NA's are removed. Median: median age after when all NA's are removed. ## Visualize variable distribution This step is important to compare variables before and after imputation.

```
ggplot(titanic_train, aes(Age)) +
  geom_histogram(color = "#000000", fill = "#0099F8") +
  ggtitle("Variable distribution") +
  theme_classic() +
  theme(plot.title = element_text(size = 18))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## Warning: Removed 177 rows containing non-finite values (`stat_bin()`).
```




```
value_imputed <- data.frame(
  original = titanic_train$Age,
  imputed_zero = replace(titanic_train$Age, is.na(titanic_train$Age), 0),
  imputed_mean = replace(titanic_train$Age, is.na(titanic_train$Age),
mean(titanic_train$Age, na.rm = TRUE)),
  imputed_median = replace(titanic_train$Age, is.na(titanic_train$Age),
median(titanic_train$Age, na.rm = TRUE))
)
value_imputed
```

```
##     original imputed_zero imputed_mean imputed_median
## 1      22.00        22.00     22.00000          22.00
## 2      38.00        38.00     38.00000          38.00
## 3      26.00        26.00     26.00000          26.00
## 4      35.00        35.00     35.00000          35.00
## 5      35.00        35.00     35.00000          35.00
## 6         NA         0.00     29.69912          28.00
## 7      54.00        54.00     54.00000          54.00
## 8       2.00         2.00      2.00000           2.00
## 9      27.00        27.00     27.00000          27.00
## 10     14.00        14.00     14.00000          14.00
## 11      4.00         4.00      4.00000           4.00
## 12     58.00        58.00     58.00000          58.00
## 13     20.00        20.00     20.00000          20.00
## 14     39.00        39.00     39.00000          39.00
## 15     14.00        14.00     14.00000          14.00
## 16     55.00        55.00     55.00000          55.00
```

```
## 17      2.00         2.00      2.00000          2.00
## 18        NA         0.00     29.69912         28.00
## 19     31.00        31.00     31.00000         31.00
## 20        NA         0.00     29.69912         28.00
## 21     35.00        35.00     35.00000         35.00
## 22     34.00        34.00     34.00000         34.00
## 23     15.00        15.00     15.00000         15.00
## 24     28.00        28.00     28.00000         28.00
## 25      8.00         8.00      8.00000          8.00
## 26     38.00        38.00     38.00000         38.00
## 27        NA         0.00     29.69912         28.00
## 28     19.00        19.00     19.00000         19.00
## 29        NA         0.00     29.69912         28.00
## 30        NA         0.00     29.69912         28.00
## 31     40.00        40.00     40.00000         40.00
## 32        NA         0.00     29.69912         28.00
## 33        NA         0.00     29.69912         28.00
## 34     66.00        66.00     66.00000         66.00
## 35     28.00        28.00     28.00000         28.00
## 36     42.00        42.00     42.00000         42.00
## 37        NA         0.00     29.69912         28.00
## 38     21.00        21.00     21.00000         21.00
## 39     18.00        18.00     18.00000         18.00
## 40     14.00        14.00     14.00000         14.00
## 41     40.00        40.00     40.00000         40.00
## 42     27.00        27.00     27.00000         27.00
## 43        NA         0.00     29.69912         28.00
## 44      3.00         3.00      3.00000          3.00
## 45     19.00        19.00     19.00000         19.00
## 46        NA         0.00     29.69912         28.00
## 47        NA         0.00     29.69912         28.00
## 48        NA         0.00     29.69912         28.00
## 49        NA         0.00     29.69912         28.00
## 50     18.00        18.00     18.00000         18.00
## 51      7.00         7.00      7.00000          7.00
## 52     21.00        21.00     21.00000         21.00
## 53     49.00        49.00     49.00000         49.00
## 54     29.00        29.00     29.00000         29.00
## 55     65.00        65.00     65.00000         65.00
## 56        NA         0.00     29.69912         28.00
## 57     21.00        21.00     21.00000         21.00
## 58     28.50        28.50     28.50000         28.50
## 59      5.00         5.00      5.00000          5.00
## 60     11.00        11.00     11.00000         11.00
## 61     22.00        22.00     22.00000         22.00
## 62     38.00        38.00     38.00000         38.00
## 63     45.00        45.00     45.00000         45.00
## 64      4.00         4.00      4.00000          4.00
## 65        NA         0.00     29.69912         28.00
## 66        NA         0.00     29.69912         28.00
```

```
## 67     29.00        29.00     29.00000          29.00
## 68     19.00        19.00     19.00000          19.00
## 69     17.00        17.00     17.00000          17.00
## 70     26.00        26.00     26.00000          26.00
## 71     32.00        32.00     32.00000          32.00
## 72     16.00        16.00     16.00000          16.00
## 73     21.00        21.00     21.00000          21.00
## 74     26.00        26.00     26.00000          26.00
## 75     32.00        32.00     32.00000          32.00
## 76     25.00        25.00     25.00000          25.00
## 77        NA         0.00     29.69912          28.00
## 78        NA         0.00     29.69912          28.00
## 79      0.83         0.83      0.83000           0.83
## 80     30.00        30.00     30.00000          30.00
## 81     22.00        22.00     22.00000          22.00
## 82     29.00        29.00     29.00000          29.00
## 83        NA         0.00     29.69912          28.00
## 84     28.00        28.00     28.00000          28.00
## 85     17.00        17.00     17.00000          17.00
## 86     33.00        33.00     33.00000          33.00
## 87     16.00        16.00     16.00000          16.00
## 88        NA         0.00     29.69912          28.00
## 89     23.00        23.00     23.00000          23.00
## 90     24.00        24.00     24.00000          24.00
## 91     29.00        29.00     29.00000          29.00
## 92     20.00        20.00     20.00000          20.00
## 93     46.00        46.00     46.00000          46.00
## 94     26.00        26.00     26.00000          26.00
## 95     59.00        59.00     59.00000          59.00
## 96        NA         0.00     29.69912          28.00
## 97     71.00        71.00     71.00000          71.00
## 98     23.00        23.00     23.00000          23.00
## 99     34.00        34.00     34.00000          34.00
## 100    34.00        34.00     34.00000          34.00
## 101    28.00        28.00     28.00000          28.00
## 102       NA         0.00     29.69912          28.00
## 103    21.00        21.00     21.00000          21.00
## 104    33.00        33.00     33.00000          33.00
## 105    37.00        37.00     37.00000          37.00
## 106    28.00        28.00     28.00000          28.00
## 107    21.00        21.00     21.00000          21.00
## 108       NA         0.00     29.69912          28.00
## 109    38.00        38.00     38.00000          38.00
## 110       NA         0.00     29.69912          28.00
## 111    47.00        47.00     47.00000          47.00
## 112    14.50        14.50     14.50000          14.50
## 113    22.00        22.00     22.00000          22.00
## 114    20.00        20.00     20.00000          20.00
## 115    17.00        17.00     17.00000          17.00
## 116    21.00        21.00     21.00000          21.00
```

```
## 117    70.50        70.50     70.50000          70.50
## 118    29.00        29.00     29.00000          29.00
## 119    24.00        24.00     24.00000          24.00
## 120     2.00         2.00      2.00000           2.00
## 121    21.00        21.00     21.00000          21.00
## 122       NA         0.00     29.69912          28.00
## 123    32.50        32.50     32.50000          32.50
## 124    32.50        32.50     32.50000          32.50
## 125    54.00        54.00     54.00000          54.00
## 126    12.00        12.00     12.00000          12.00
## 127       NA         0.00     29.69912          28.00
## 128    24.00        24.00     24.00000          24.00
## 129       NA         0.00     29.69912          28.00
## 130    45.00        45.00     45.00000          45.00
## 131    33.00        33.00     33.00000          33.00
## 132    20.00        20.00     20.00000          20.00
## 133    47.00        47.00     47.00000          47.00
## 134    29.00        29.00     29.00000          29.00
## 135    25.00        25.00     25.00000          25.00
## 136    23.00        23.00     23.00000          23.00
## 137    19.00        19.00     19.00000          19.00
## 138    37.00        37.00     37.00000          37.00
## 139    16.00        16.00     16.00000          16.00
## 140    24.00        24.00     24.00000          24.00
## 141       NA         0.00     29.69912          28.00
## 142    22.00        22.00     22.00000          22.00
## 143    24.00        24.00     24.00000          24.00
## 144    19.00        19.00     19.00000          19.00
## 145    18.00        18.00     18.00000          18.00
## 146    19.00        19.00     19.00000          19.00
## 147    27.00        27.00     27.00000          27.00
## 148     9.00         9.00      9.00000           9.00
## 149    36.50        36.50     36.50000          36.50
## 150    42.00        42.00     42.00000          42.00
## 151    51.00        51.00     51.00000          51.00
## 152    22.00        22.00     22.00000          22.00
## 153    55.50        55.50     55.50000          55.50
## 154    40.50        40.50     40.50000          40.50
## 155       NA         0.00     29.69912          28.00
## 156    51.00        51.00     51.00000          51.00
## 157    16.00        16.00     16.00000          16.00
## 158    30.00        30.00     30.00000          30.00
## 159       NA         0.00     29.69912          28.00
## 160       NA         0.00     29.69912          28.00
## 161    44.00        44.00     44.00000          44.00
## 162    40.00        40.00     40.00000          40.00
## 163    26.00        26.00     26.00000          26.00
## 164    17.00        17.00     17.00000          17.00
## 165     1.00         1.00      1.00000           1.00
## 166     9.00         9.00      9.00000           9.00
```

```
## 167       NA         0.00     29.69912          28.00
## 168    45.00        45.00     45.00000          45.00
## 169       NA         0.00     29.69912          28.00
## 170    28.00        28.00     28.00000          28.00
## 171    61.00        61.00     61.00000          61.00
## 172     4.00         4.00      4.00000           4.00
## 173     1.00         1.00      1.00000           1.00
## 174    21.00        21.00     21.00000          21.00
## 175    56.00        56.00     56.00000          56.00
## 176    18.00        18.00     18.00000          18.00
## 177       NA         0.00     29.69912          28.00
## 178    50.00        50.00     50.00000          50.00
## 179    30.00        30.00     30.00000          30.00
## 180    36.00        36.00     36.00000          36.00
## 181       NA         0.00     29.69912          28.00
## 182       NA         0.00     29.69912          28.00
## 183     9.00         9.00      9.00000           9.00
## 184     1.00         1.00      1.00000           1.00
## 185     4.00         4.00      4.00000           4.00
## 186       NA         0.00     29.69912          28.00
## 187       NA         0.00     29.69912          28.00
## 188    45.00        45.00     45.00000          45.00
## 189    40.00        40.00     40.00000          40.00
## 190    36.00        36.00     36.00000          36.00
## 191    32.00        32.00     32.00000          32.00
## 192    19.00        19.00     19.00000          19.00
## 193    19.00        19.00     19.00000          19.00
## 194     3.00         3.00      3.00000           3.00
## 195    44.00        44.00     44.00000          44.00
## 196    58.00        58.00     58.00000          58.00
## 197       NA         0.00     29.69912          28.00
## 198    42.00        42.00     42.00000          42.00
## 199       NA         0.00     29.69912          28.00
## 200    24.00        24.00     24.00000          24.00
## 201    28.00        28.00     28.00000          28.00
## 202       NA         0.00     29.69912          28.00
## 203    34.00        34.00     34.00000          34.00
## 204    45.50        45.50     45.50000          45.50
## 205    18.00        18.00     18.00000          18.00
## 206     2.00         2.00      2.00000           2.00
## 207    32.00        32.00     32.00000          32.00
## 208    26.00        26.00     26.00000          26.00
## 209    16.00        16.00     16.00000          16.00
## 210    40.00        40.00     40.00000          40.00
## 211    24.00        24.00     24.00000          24.00
## 212    35.00        35.00     35.00000          35.00
## 213    22.00        22.00     22.00000          22.00
## 214    30.00        30.00     30.00000          30.00
## 215       NA         0.00     29.69912          28.00
## 216    31.00        31.00     31.00000          31.00
```

```
## 217    27.00        27.00     27.00000          27.00
## 218    42.00        42.00     42.00000          42.00
## 219    32.00        32.00     32.00000          32.00
## 220    30.00        30.00     30.00000          30.00
## 221    16.00        16.00     16.00000          16.00
## 222    27.00        27.00     27.00000          27.00
## 223    51.00        51.00     51.00000          51.00
## 224       NA         0.00     29.69912          28.00
## 225    38.00        38.00     38.00000          38.00
## 226    22.00        22.00     22.00000          22.00
## 227    19.00        19.00     19.00000          19.00
## 228    20.50        20.50     20.50000          20.50
## 229    18.00        18.00     18.00000          18.00
## 230       NA         0.00     29.69912          28.00
## 231    35.00        35.00     35.00000          35.00
## 232    29.00        29.00     29.00000          29.00
## 233    59.00        59.00     59.00000          59.00
## 234     5.00         5.00      5.00000           5.00
## 235    24.00        24.00     24.00000          24.00
## 236       NA         0.00     29.69912          28.00
## 237    44.00        44.00     44.00000          44.00
## 238     8.00         8.00      8.00000           8.00
## 239    19.00        19.00     19.00000          19.00
## 240    33.00        33.00     33.00000          33.00
## 241       NA         0.00     29.69912          28.00
## 242       NA         0.00     29.69912          28.00
## 243    29.00        29.00     29.00000          29.00
## 244    22.00        22.00     22.00000          22.00
## 245    30.00        30.00     30.00000          30.00
## 246    44.00        44.00     44.00000          44.00
## 247    25.00        25.00     25.00000          25.00
## 248    24.00        24.00     24.00000          24.00
## 249    37.00        37.00     37.00000          37.00
## 250    54.00        54.00     54.00000          54.00
## 251       NA         0.00     29.69912          28.00
## 252    29.00        29.00     29.00000          29.00
## 253    62.00        62.00     62.00000          62.00
## 254    30.00        30.00     30.00000          30.00
## 255    41.00        41.00     41.00000          41.00
## 256    29.00        29.00     29.00000          29.00
## 257       NA         0.00     29.69912          28.00
## 258    30.00        30.00     30.00000          30.00
## 259    35.00        35.00     35.00000          35.00
## 260    50.00        50.00     50.00000          50.00
## 261       NA         0.00     29.69912          28.00
## 262     3.00         3.00      3.00000           3.00
## 263    52.00        52.00     52.00000          52.00
## 264    40.00        40.00     40.00000          40.00
## 265       NA         0.00     29.69912          28.00
## 266    36.00        36.00     36.00000          36.00
```

```
## 267    16.00        16.00     16.00000          16.00
## 268    25.00        25.00     25.00000          25.00
## 269    58.00        58.00     58.00000          58.00
## 270    35.00        35.00     35.00000          35.00
## 271       NA         0.00     29.69912          28.00
## 272    25.00        25.00     25.00000          25.00
## 273    41.00        41.00     41.00000          41.00
## 274    37.00        37.00     37.00000          37.00
## 275       NA         0.00     29.69912          28.00
## 276    63.00        63.00     63.00000          63.00
## 277    45.00        45.00     45.00000          45.00
## 278       NA         0.00     29.69912          28.00
## 279     7.00         7.00      7.00000           7.00
## 280    35.00        35.00     35.00000          35.00
## 281    65.00        65.00     65.00000          65.00
## 282    28.00        28.00     28.00000          28.00
## 283    16.00        16.00     16.00000          16.00
## 284    19.00        19.00     19.00000          19.00
## 285       NA         0.00     29.69912          28.00
## 286    33.00        33.00     33.00000          33.00
## 287    30.00        30.00     30.00000          30.00
## 288    22.00        22.00     22.00000          22.00
## 289    42.00        42.00     42.00000          42.00
## 290    22.00        22.00     22.00000          22.00
## 291    26.00        26.00     26.00000          26.00
## 292    19.00        19.00     19.00000          19.00
## 293    36.00        36.00     36.00000          36.00
## 294    24.00        24.00     24.00000          24.00
## 295    24.00        24.00     24.00000          24.00
## 296       NA         0.00     29.69912          28.00
## 297    23.50        23.50     23.50000          23.50
## 298     2.00         2.00      2.00000           2.00
## 299       NA         0.00     29.69912          28.00
## 300    50.00        50.00     50.00000          50.00
## 301       NA         0.00     29.69912          28.00
## 302       NA         0.00     29.69912          28.00
## 303    19.00        19.00     19.00000          19.00
## 304       NA         0.00     29.69912          28.00
## 305       NA         0.00     29.69912          28.00
## 306     0.92         0.92      0.92000           0.92
## 307       NA         0.00     29.69912          28.00
## 308    17.00        17.00     17.00000          17.00
## 309    30.00        30.00     30.00000          30.00
## 310    30.00        30.00     30.00000          30.00
## 311    24.00        24.00     24.00000          24.00
## 312    18.00        18.00     18.00000          18.00
## 313    26.00        26.00     26.00000          26.00
## 314    28.00        28.00     28.00000          28.00
## 315    43.00        43.00     43.00000          43.00
## 316    26.00        26.00     26.00000          26.00
```

```
## 317    24.00        24.00     24.00000          24.00
## 318    54.00        54.00     54.00000          54.00
## 319    31.00        31.00     31.00000          31.00
## 320    40.00        40.00     40.00000          40.00
## 321    22.00        22.00     22.00000          22.00
## 322    27.00        27.00     27.00000          27.00
## 323    30.00        30.00     30.00000          30.00
## 324    22.00        22.00     22.00000          22.00
## 325       NA         0.00     29.69912          28.00
## 326    36.00        36.00     36.00000          36.00
## 327    61.00        61.00     61.00000          61.00
## 328    36.00        36.00     36.00000          36.00
## 329    31.00        31.00     31.00000          31.00
## 330    16.00        16.00     16.00000          16.00
## 331       NA         0.00     29.69912          28.00
## 332    45.50        45.50     45.50000          45.50
## 333    38.00        38.00     38.00000          38.00
## 334    16.00        16.00     16.00000          16.00
## 335       NA         0.00     29.69912          28.00
## 336       NA         0.00     29.69912          28.00
## 337    29.00        29.00     29.00000          29.00
## 338    41.00        41.00     41.00000          41.00
## 339    45.00        45.00     45.00000          45.00
## 340    45.00        45.00     45.00000          45.00
## 341     2.00         2.00      2.00000           2.00
## 342    24.00        24.00     24.00000          24.00
## 343    28.00        28.00     28.00000          28.00
## 344    25.00        25.00     25.00000          25.00
## 345    36.00        36.00     36.00000          36.00
## 346    24.00        24.00     24.00000          24.00
## 347    40.00        40.00     40.00000          40.00
## 348       NA         0.00     29.69912          28.00
## 349     3.00         3.00      3.00000           3.00
## 350    42.00        42.00     42.00000          42.00
## 351    23.00        23.00     23.00000          23.00
## 352       NA         0.00     29.69912          28.00
## 353    15.00        15.00     15.00000          15.00
## 354    25.00        25.00     25.00000          25.00
## 355       NA         0.00     29.69912          28.00
## 356    28.00        28.00     28.00000          28.00
## 357    22.00        22.00     22.00000          22.00
## 358    38.00        38.00     38.00000          38.00
## 359       NA         0.00     29.69912          28.00
## 360       NA         0.00     29.69912          28.00
## 361    40.00        40.00     40.00000          40.00
## 362    29.00        29.00     29.00000          29.00
## 363    45.00        45.00     45.00000          45.00
## 364    35.00        35.00     35.00000          35.00
## 365       NA         0.00     29.69912          28.00
## 366    30.00        30.00     30.00000          30.00
```

```
## 367    60.00        60.00     60.00000          60.00
## 368       NA         0.00     29.69912          28.00
## 369       NA         0.00     29.69912          28.00
## 370    24.00        24.00     24.00000          24.00
## 371    25.00        25.00     25.00000          25.00
## 372    18.00        18.00     18.00000          18.00
## 373    19.00        19.00     19.00000          19.00
## 374    22.00        22.00     22.00000          22.00
## 375     3.00         3.00      3.00000           3.00
## 376       NA         0.00     29.69912          28.00
## 377    22.00        22.00     22.00000          22.00
## 378    27.00        27.00     27.00000          27.00
## 379    20.00        20.00     20.00000          20.00
## 380    19.00        19.00     19.00000          19.00
## 381    42.00        42.00     42.00000          42.00
## 382     1.00         1.00      1.00000           1.00
## 383    32.00        32.00     32.00000          32.00
## 384    35.00        35.00     35.00000          35.00
## 385       NA         0.00     29.69912          28.00
## 386    18.00        18.00     18.00000          18.00
## 387     1.00         1.00      1.00000           1.00
## 388    36.00        36.00     36.00000          36.00
## 389       NA         0.00     29.69912          28.00
## 390    17.00        17.00     17.00000          17.00
## 391    36.00        36.00     36.00000          36.00
## 392    21.00        21.00     21.00000          21.00
## 393    28.00        28.00     28.00000          28.00
## 394    23.00        23.00     23.00000          23.00
## 395    24.00        24.00     24.00000          24.00
## 396    22.00        22.00     22.00000          22.00
## 397    31.00        31.00     31.00000          31.00
## 398    46.00        46.00     46.00000          46.00
## 399    23.00        23.00     23.00000          23.00
## 400    28.00        28.00     28.00000          28.00
## 401    39.00        39.00     39.00000          39.00
## 402    26.00        26.00     26.00000          26.00
## 403    21.00        21.00     21.00000          21.00
## 404    28.00        28.00     28.00000          28.00
## 405    20.00        20.00     20.00000          20.00
## 406    34.00        34.00     34.00000          34.00
## 407    51.00        51.00     51.00000          51.00
## 408     3.00         3.00      3.00000           3.00
## 409    21.00        21.00     21.00000          21.00
## 410       NA         0.00     29.69912          28.00
## 411       NA         0.00     29.69912          28.00
## 412       NA         0.00     29.69912          28.00
## 413    33.00        33.00     33.00000          33.00
## 414       NA         0.00     29.69912          28.00
## 415    44.00        44.00     44.00000          44.00
## 416       NA         0.00     29.69912          28.00
```

```
## 417    34.00        34.00     34.00000          34.00
## 418    18.00        18.00     18.00000          18.00
## 419    30.00        30.00     30.00000          30.00
## 420    10.00        10.00     10.00000          10.00
## 421       NA         0.00     29.69912          28.00
## 422    21.00        21.00     21.00000          21.00
## 423    29.00        29.00     29.00000          29.00
## 424    28.00        28.00     28.00000          28.00
## 425    18.00        18.00     18.00000          18.00
## 426       NA         0.00     29.69912          28.00
## 427    28.00        28.00     28.00000          28.00
## 428    19.00        19.00     19.00000          19.00
## 429       NA         0.00     29.69912          28.00
## 430    32.00        32.00     32.00000          32.00
## 431    28.00        28.00     28.00000          28.00
## 432       NA         0.00     29.69912          28.00
## 433    42.00        42.00     42.00000          42.00
## 434    17.00        17.00     17.00000          17.00
## 435    50.00        50.00     50.00000          50.00
## 436    14.00        14.00     14.00000          14.00
## 437    21.00        21.00     21.00000          21.00
## 438    24.00        24.00     24.00000          24.00
## 439    64.00        64.00     64.00000          64.00
## 440    31.00        31.00     31.00000          31.00
## 441    45.00        45.00     45.00000          45.00
## 442    20.00        20.00     20.00000          20.00
## 443    25.00        25.00     25.00000          25.00
## 444    28.00        28.00     28.00000          28.00
## 445       NA         0.00     29.69912          28.00
## 446     4.00         4.00      4.00000           4.00
## 447    13.00        13.00     13.00000          13.00
## 448    34.00        34.00     34.00000          34.00
## 449     5.00         5.00      5.00000           5.00
## 450    52.00        52.00     52.00000          52.00
## 451    36.00        36.00     36.00000          36.00
## 452       NA         0.00     29.69912          28.00
## 453    30.00        30.00     30.00000          30.00
## 454    49.00        49.00     49.00000          49.00
## 455       NA         0.00     29.69912          28.00
## 456    29.00        29.00     29.00000          29.00
## 457    65.00        65.00     65.00000          65.00
## 458       NA         0.00     29.69912          28.00
## 459    50.00        50.00     50.00000          50.00
## 460       NA         0.00     29.69912          28.00
## 461    48.00        48.00     48.00000          48.00
## 462    34.00        34.00     34.00000          34.00
## 463    47.00        47.00     47.00000          47.00
## 464    48.00        48.00     48.00000          48.00
## 465       NA         0.00     29.69912          28.00
## 466    38.00        38.00     38.00000          38.00
```

```
## 467       NA         0.00     29.69912          28.00
## 468    56.00        56.00     56.00000          56.00
## 469       NA         0.00     29.69912          28.00
## 470     0.75         0.75      0.75000           0.75
## 471       NA         0.00     29.69912          28.00
## 472    38.00        38.00     38.00000          38.00
## 473    33.00        33.00     33.00000          33.00
## 474    23.00        23.00     23.00000          23.00
## 475    22.00        22.00     22.00000          22.00
## 476       NA         0.00     29.69912          28.00
## 477    34.00        34.00     34.00000          34.00
## 478    29.00        29.00     29.00000          29.00
## 479    22.00        22.00     22.00000          22.00
## 480     2.00         2.00      2.00000           2.00
## 481     9.00         9.00      9.00000           9.00
## 482       NA         0.00     29.69912          28.00
## 483    50.00        50.00     50.00000          50.00
## 484    63.00        63.00     63.00000          63.00
## 485    25.00        25.00     25.00000          25.00
## 486       NA         0.00     29.69912          28.00
## 487    35.00        35.00     35.00000          35.00
## 488    58.00        58.00     58.00000          58.00
## 489    30.00        30.00     30.00000          30.00
## 490     9.00         9.00      9.00000           9.00
## 491       NA         0.00     29.69912          28.00
## 492    21.00        21.00     21.00000          21.00
## 493    55.00        55.00     55.00000          55.00
## 494    71.00        71.00     71.00000          71.00
## 495    21.00        21.00     21.00000          21.00
## 496       NA         0.00     29.69912          28.00
## 497    54.00        54.00     54.00000          54.00
## 498       NA         0.00     29.69912          28.00
## 499    25.00        25.00     25.00000          25.00
## 500    24.00        24.00     24.00000          24.00
## 501    17.00        17.00     17.00000          17.00
## 502    21.00        21.00     21.00000          21.00
## 503       NA         0.00     29.69912          28.00
## 504    37.00        37.00     37.00000          37.00
## 505    16.00        16.00     16.00000          16.00
## 506    18.00        18.00     18.00000          18.00
## 507    33.00        33.00     33.00000          33.00
## 508       NA         0.00     29.69912          28.00
## 509    28.00        28.00     28.00000          28.00
## 510    26.00        26.00     26.00000          26.00
## 511    29.00        29.00     29.00000          29.00
## 512       NA         0.00     29.69912          28.00
## 513    36.00        36.00     36.00000          36.00
## 514    54.00        54.00     54.00000          54.00
## 515    24.00        24.00     24.00000          24.00
## 516    47.00        47.00     47.00000          47.00
```

```
## 517    34.00        34.00     34.00000          34.00
## 518       NA         0.00     29.69912          28.00
## 519    36.00        36.00     36.00000          36.00
## 520    32.00        32.00     32.00000          32.00
## 521    30.00        30.00     30.00000          30.00
## 522    22.00        22.00     22.00000          22.00
## 523       NA         0.00     29.69912          28.00
## 524    44.00        44.00     44.00000          44.00
## 525       NA         0.00     29.69912          28.00
## 526    40.50        40.50     40.50000          40.50
## 527    50.00        50.00     50.00000          50.00
## 528       NA         0.00     29.69912          28.00
## 529    39.00        39.00     39.00000          39.00
## 530    23.00        23.00     23.00000          23.00
## 531     2.00         2.00      2.00000           2.00
## 532       NA         0.00     29.69912          28.00
## 533    17.00        17.00     17.00000          17.00
## 534       NA         0.00     29.69912          28.00
## 535    30.00        30.00     30.00000          30.00
## 536     7.00         7.00      7.00000           7.00
## 537    45.00        45.00     45.00000          45.00
## 538    30.00        30.00     30.00000          30.00
## 539       NA         0.00     29.69912          28.00
## 540    22.00        22.00     22.00000          22.00
## 541    36.00        36.00     36.00000          36.00
## 542     9.00         9.00      9.00000           9.00
## 543    11.00        11.00     11.00000          11.00
## 544    32.00        32.00     32.00000          32.00
## 545    50.00        50.00     50.00000          50.00
## 546    64.00        64.00     64.00000          64.00
## 547    19.00        19.00     19.00000          19.00
## 548       NA         0.00     29.69912          28.00
## 549    33.00        33.00     33.00000          33.00
## 550     8.00         8.00      8.00000           8.00
## 551    17.00        17.00     17.00000          17.00
## 552    27.00        27.00     27.00000          27.00
## 553       NA         0.00     29.69912          28.00
## 554    22.00        22.00     22.00000          22.00
## 555    22.00        22.00     22.00000          22.00
## 556    62.00        62.00     62.00000          62.00
## 557    48.00        48.00     48.00000          48.00
## 558       NA         0.00     29.69912          28.00
## 559    39.00        39.00     39.00000          39.00
## 560    36.00        36.00     36.00000          36.00
## 561       NA         0.00     29.69912          28.00
## 562    40.00        40.00     40.00000          40.00
## 563    28.00        28.00     28.00000          28.00
## 564       NA         0.00     29.69912          28.00
## 565       NA         0.00     29.69912          28.00
## 566    24.00        24.00     24.00000          24.00
```

```
## 567    19.00        19.00     19.00000          19.00
## 568    29.00        29.00     29.00000          29.00
## 569       NA         0.00     29.69912          28.00
## 570    32.00        32.00     32.00000          32.00
## 571    62.00        62.00     62.00000          62.00
## 572    53.00        53.00     53.00000          53.00
## 573    36.00        36.00     36.00000          36.00
## 574       NA         0.00     29.69912          28.00
## 575    16.00        16.00     16.00000          16.00
## 576    19.00        19.00     19.00000          19.00
## 577    34.00        34.00     34.00000          34.00
## 578    39.00        39.00     39.00000          39.00
## 579       NA         0.00     29.69912          28.00
## 580    32.00        32.00     32.00000          32.00
## 581    25.00        25.00     25.00000          25.00
## 582    39.00        39.00     39.00000          39.00
## 583    54.00        54.00     54.00000          54.00
## 584    36.00        36.00     36.00000          36.00
## 585       NA         0.00     29.69912          28.00
## 586    18.00        18.00     18.00000          18.00
## 587    47.00        47.00     47.00000          47.00
## 588    60.00        60.00     60.00000          60.00
## 589    22.00        22.00     22.00000          22.00
## 590       NA         0.00     29.69912          28.00
## 591    35.00        35.00     35.00000          35.00
## 592    52.00        52.00     52.00000          52.00
## 593    47.00        47.00     47.00000          47.00
## 594       NA         0.00     29.69912          28.00
## 595    37.00        37.00     37.00000          37.00
## 596    36.00        36.00     36.00000          36.00
## 597       NA         0.00     29.69912          28.00
## 598    49.00        49.00     49.00000          49.00
## 599       NA         0.00     29.69912          28.00
## 600    49.00        49.00     49.00000          49.00
## 601    24.00        24.00     24.00000          24.00
## 602       NA         0.00     29.69912          28.00
## 603       NA         0.00     29.69912          28.00
## 604    44.00        44.00     44.00000          44.00
## 605    35.00        35.00     35.00000          35.00
## 606    36.00        36.00     36.00000          36.00
## 607    30.00        30.00     30.00000          30.00
## 608    27.00        27.00     27.00000          27.00
## 609    22.00        22.00     22.00000          22.00
## 610    40.00        40.00     40.00000          40.00
## 611    39.00        39.00     39.00000          39.00
## 612       NA         0.00     29.69912          28.00
## 613       NA         0.00     29.69912          28.00
## 614       NA         0.00     29.69912          28.00
## 615    35.00        35.00     35.00000          35.00
## 616    24.00        24.00     24.00000          24.00
```

```
## 617    34.00        34.00     34.00000          34.00
## 618    26.00        26.00     26.00000          26.00
## 619     4.00         4.00      4.00000           4.00
## 620    26.00        26.00     26.00000          26.00
## 621    27.00        27.00     27.00000          27.00
## 622    42.00        42.00     42.00000          42.00
## 623    20.00        20.00     20.00000          20.00
## 624    21.00        21.00     21.00000          21.00
## 625    21.00        21.00     21.00000          21.00
## 626    61.00        61.00     61.00000          61.00
## 627    57.00        57.00     57.00000          57.00
## 628    21.00        21.00     21.00000          21.00
## 629    26.00        26.00     26.00000          26.00
## 630       NA         0.00     29.69912          28.00
## 631    80.00        80.00     80.00000          80.00
## 632    51.00        51.00     51.00000          51.00
## 633    32.00        32.00     32.00000          32.00
## 634       NA         0.00     29.69912          28.00
## 635     9.00         9.00      9.00000           9.00
## 636    28.00        28.00     28.00000          28.00
## 637    32.00        32.00     32.00000          32.00
## 638    31.00        31.00     31.00000          31.00
## 639    41.00        41.00     41.00000          41.00
## 640       NA         0.00     29.69912          28.00
## 641    20.00        20.00     20.00000          20.00
## 642    24.00        24.00     24.00000          24.00
## 643     2.00         2.00      2.00000           2.00
## 644       NA         0.00     29.69912          28.00
## 645     0.75         0.75      0.75000           0.75
## 646    48.00        48.00     48.00000          48.00
## 647    19.00        19.00     19.00000          19.00
## 648    56.00        56.00     56.00000          56.00
## 649       NA         0.00     29.69912          28.00
## 650    23.00        23.00     23.00000          23.00
## 651       NA         0.00     29.69912          28.00
## 652    18.00        18.00     18.00000          18.00
## 653    21.00        21.00     21.00000          21.00
## 654       NA         0.00     29.69912          28.00
## 655    18.00        18.00     18.00000          18.00
## 656    24.00        24.00     24.00000          24.00
## 657       NA         0.00     29.69912          28.00
## 658    32.00        32.00     32.00000          32.00
## 659    23.00        23.00     23.00000          23.00
## 660    58.00        58.00     58.00000          58.00
## 661    50.00        50.00     50.00000          50.00
## 662    40.00        40.00     40.00000          40.00
## 663    47.00        47.00     47.00000          47.00
## 664    36.00        36.00     36.00000          36.00
## 665    20.00        20.00     20.00000          20.00
## 666    32.00        32.00     32.00000          32.00
```

```
## 667    25.00        25.00     25.00000          25.00
## 668       NA         0.00     29.69912          28.00
## 669    43.00        43.00     43.00000          43.00
## 670       NA         0.00     29.69912          28.00
## 671    40.00        40.00     40.00000          40.00
## 672    31.00        31.00     31.00000          31.00
## 673    70.00        70.00     70.00000          70.00
## 674    31.00        31.00     31.00000          31.00
## 675       NA         0.00     29.69912          28.00
## 676    18.00        18.00     18.00000          18.00
## 677    24.50        24.50     24.50000          24.50
## 678    18.00        18.00     18.00000          18.00
## 679    43.00        43.00     43.00000          43.00
## 680    36.00        36.00     36.00000          36.00
## 681       NA         0.00     29.69912          28.00
## 682    27.00        27.00     27.00000          27.00
## 683    20.00        20.00     20.00000          20.00
## 684    14.00        14.00     14.00000          14.00
## 685    60.00        60.00     60.00000          60.00
## 686    25.00        25.00     25.00000          25.00
## 687    14.00        14.00     14.00000          14.00
## 688    19.00        19.00     19.00000          19.00
## 689    18.00        18.00     18.00000          18.00
## 690    15.00        15.00     15.00000          15.00
## 691    31.00        31.00     31.00000          31.00
## 692     4.00         4.00      4.00000           4.00
## 693       NA         0.00     29.69912          28.00
## 694    25.00        25.00     25.00000          25.00
## 695    60.00        60.00     60.00000          60.00
## 696    52.00        52.00     52.00000          52.00
## 697    44.00        44.00     44.00000          44.00
## 698       NA         0.00     29.69912          28.00
## 699    49.00        49.00     49.00000          49.00
## 700    42.00        42.00     42.00000          42.00
## 701    18.00        18.00     18.00000          18.00
## 702    35.00        35.00     35.00000          35.00
## 703    18.00        18.00     18.00000          18.00
## 704    25.00        25.00     25.00000          25.00
## 705    26.00        26.00     26.00000          26.00
## 706    39.00        39.00     39.00000          39.00
## 707    45.00        45.00     45.00000          45.00
## 708    42.00        42.00     42.00000          42.00
## 709    22.00        22.00     22.00000          22.00
## 710       NA         0.00     29.69912          28.00
## 711    24.00        24.00     24.00000          24.00
## 712       NA         0.00     29.69912          28.00
## 713    48.00        48.00     48.00000          48.00
## 714    29.00        29.00     29.00000          29.00
## 715    52.00        52.00     52.00000          52.00
## 716    19.00        19.00     19.00000          19.00
```

```
## 717    38.00        38.00     38.00000          38.00
## 718    27.00        27.00     27.00000          27.00
## 719       NA         0.00     29.69912          28.00
## 720    33.00        33.00     33.00000          33.00
## 721     6.00         6.00      6.00000           6.00
## 722    17.00        17.00     17.00000          17.00
## 723    34.00        34.00     34.00000          34.00
## 724    50.00        50.00     50.00000          50.00
## 725    27.00        27.00     27.00000          27.00
## 726    20.00        20.00     20.00000          20.00
## 727    30.00        30.00     30.00000          30.00
## 728       NA         0.00     29.69912          28.00
## 729    25.00        25.00     25.00000          25.00
## 730    25.00        25.00     25.00000          25.00
## 731    29.00        29.00     29.00000          29.00
## 732    11.00        11.00     11.00000          11.00
## 733       NA         0.00     29.69912          28.00
## 734    23.00        23.00     23.00000          23.00
## 735    23.00        23.00     23.00000          23.00
## 736    28.50        28.50     28.50000          28.50
## 737    48.00        48.00     48.00000          48.00
## 738    35.00        35.00     35.00000          35.00
## 739       NA         0.00     29.69912          28.00
## 740       NA         0.00     29.69912          28.00
## 741       NA         0.00     29.69912          28.00
## 742    36.00        36.00     36.00000          36.00
## 743    21.00        21.00     21.00000          21.00
## 744    24.00        24.00     24.00000          24.00
## 745    31.00        31.00     31.00000          31.00
## 746    70.00        70.00     70.00000          70.00
## 747    16.00        16.00     16.00000          16.00
## 748    30.00        30.00     30.00000          30.00
## 749    19.00        19.00     19.00000          19.00
## 750    31.00        31.00     31.00000          31.00
## 751     4.00         4.00      4.00000           4.00
## 752     6.00         6.00      6.00000           6.00
## 753    33.00        33.00     33.00000          33.00
## 754    23.00        23.00     23.00000          23.00
## 755    48.00        48.00     48.00000          48.00
## 756     0.67         0.67      0.67000           0.67
## 757    28.00        28.00     28.00000          28.00
## 758    18.00        18.00     18.00000          18.00
## 759    34.00        34.00     34.00000          34.00
## 760    33.00        33.00     33.00000          33.00
## 761       NA         0.00     29.69912          28.00
## 762    41.00        41.00     41.00000          41.00
## 763    20.00        20.00     20.00000          20.00
## 764    36.00        36.00     36.00000          36.00
## 765    16.00        16.00     16.00000          16.00
## 766    51.00        51.00     51.00000          51.00
```

```
## 767       NA         0.00     29.69912          28.00
## 768    30.50        30.50     30.50000          30.50
## 769       NA         0.00     29.69912          28.00
## 770    32.00        32.00     32.00000          32.00
## 771    24.00        24.00     24.00000          24.00
## 772    48.00        48.00     48.00000          48.00
## 773    57.00        57.00     57.00000          57.00
## 774       NA         0.00     29.69912          28.00
## 775    54.00        54.00     54.00000          54.00
## 776    18.00        18.00     18.00000          18.00
## 777       NA         0.00     29.69912          28.00
## 778     5.00         5.00      5.00000           5.00
## 779       NA         0.00     29.69912          28.00
## 780    43.00        43.00     43.00000          43.00
## 781    13.00        13.00     13.00000          13.00
## 782    17.00        17.00     17.00000          17.00
## 783    29.00        29.00     29.00000          29.00
## 784       NA         0.00     29.69912          28.00
## 785    25.00        25.00     25.00000          25.00
## 786    25.00        25.00     25.00000          25.00
## 787    18.00        18.00     18.00000          18.00
## 788     8.00         8.00      8.00000           8.00
## 789     1.00         1.00      1.00000           1.00
## 790    46.00        46.00     46.00000          46.00
## 791       NA         0.00     29.69912          28.00
## 792    16.00        16.00     16.00000          16.00
## 793       NA         0.00     29.69912          28.00
## 794       NA         0.00     29.69912          28.00
## 795    25.00        25.00     25.00000          25.00
## 796    39.00        39.00     39.00000          39.00
## 797    49.00        49.00     49.00000          49.00
## 798    31.00        31.00     31.00000          31.00
## 799    30.00        30.00     30.00000          30.00
## 800    30.00        30.00     30.00000          30.00
## 801    34.00        34.00     34.00000          34.00
## 802    31.00        31.00     31.00000          31.00
## 803    11.00        11.00     11.00000          11.00
## 804     0.42         0.42      0.42000           0.42
## 805    27.00        27.00     27.00000          27.00
## 806    31.00        31.00     31.00000          31.00
## 807    39.00        39.00     39.00000          39.00
## 808    18.00        18.00     18.00000          18.00
## 809    39.00        39.00     39.00000          39.00
## 810    33.00        33.00     33.00000          33.00
## 811    26.00        26.00     26.00000          26.00
## 812    39.00        39.00     39.00000          39.00
## 813    35.00        35.00     35.00000          35.00
## 814     6.00         6.00      6.00000           6.00
## 815    30.50        30.50     30.50000          30.50
## 816       NA         0.00     29.69912          28.00
```

```
## 817    23.00        23.00     23.00000          23.00
## 818    31.00        31.00     31.00000          31.00
## 819    43.00        43.00     43.00000          43.00
## 820    10.00        10.00     10.00000          10.00
## 821    52.00        52.00     52.00000          52.00
## 822    27.00        27.00     27.00000          27.00
## 823    38.00        38.00     38.00000          38.00
## 824    27.00        27.00     27.00000          27.00
## 825     2.00         2.00      2.00000           2.00
## 826       NA         0.00     29.69912          28.00
## 827       NA         0.00     29.69912          28.00
## 828     1.00         1.00      1.00000           1.00
## 829       NA         0.00     29.69912          28.00
## 830    62.00        62.00     62.00000          62.00
## 831    15.00        15.00     15.00000          15.00
## 832     0.83         0.83      0.83000           0.83
## 833       NA         0.00     29.69912          28.00
## 834    23.00        23.00     23.00000          23.00
## 835    18.00        18.00     18.00000          18.00
## 836    39.00        39.00     39.00000          39.00
## 837    21.00        21.00     21.00000          21.00
## 838       NA         0.00     29.69912          28.00
## 839    32.00        32.00     32.00000          32.00
## 840       NA         0.00     29.69912          28.00
## 841    20.00        20.00     20.00000          20.00
## 842    16.00        16.00     16.00000          16.00
## 843    30.00        30.00     30.00000          30.00
## 844    34.50        34.50     34.50000          34.50
## 845    17.00        17.00     17.00000          17.00
## 846    42.00        42.00     42.00000          42.00
## 847       NA         0.00     29.69912          28.00
## 848    35.00        35.00     35.00000          35.00
## 849    28.00        28.00     28.00000          28.00
## 850       NA         0.00     29.69912          28.00
## 851     4.00         4.00      4.00000           4.00
## 852    74.00        74.00     74.00000          74.00
## 853     9.00         9.00      9.00000           9.00
## 854    16.00        16.00     16.00000          16.00
## 855    44.00        44.00     44.00000          44.00
## 856    18.00        18.00     18.00000          18.00
## 857    45.00        45.00     45.00000          45.00
## 858    51.00        51.00     51.00000          51.00
## 859    24.00        24.00     24.00000          24.00
## 860       NA         0.00     29.69912          28.00
## 861    41.00        41.00     41.00000          41.00
## 862    21.00        21.00     21.00000          21.00
## 863    48.00        48.00     48.00000          48.00
## 864       NA         0.00     29.69912          28.00
## 865    24.00        24.00     24.00000          24.00
## 866    42.00        42.00     42.00000          42.00
```

```
## 867    27.00        27.00     27.00000          27.00
## 868    31.00        31.00     31.00000          31.00
## 869       NA         0.00     29.69912          28.00
## 870     4.00         4.00      4.00000           4.00
## 871    26.00        26.00     26.00000          26.00
## 872    47.00        47.00     47.00000          47.00
## 873    33.00        33.00     33.00000          33.00
## 874    47.00        47.00     47.00000          47.00
## 875    28.00        28.00     28.00000          28.00
## 876    15.00        15.00     15.00000          15.00
## 877    20.00        20.00     20.00000          20.00
## 878    19.00        19.00     19.00000          19.00
## 879       NA         0.00     29.69912          28.00
## 880    56.00        56.00     56.00000          56.00
## 881    25.00        25.00     25.00000          25.00
## 882    33.00        33.00     33.00000          33.00
## 883    22.00        22.00     22.00000          22.00
## 884    28.00        28.00     28.00000          28.00
## 885    25.00        25.00     25.00000          25.00
## 886    39.00        39.00     39.00000          39.00
## 887    27.00        27.00     27.00000          27.00
## 888    19.00        19.00     19.00000          19.00
## 889       NA         0.00     29.69912          28.00
## 890    26.00        26.00     26.00000          26.00
## 891    32.00        32.00     32.00000          32.00
```

New variable distribution

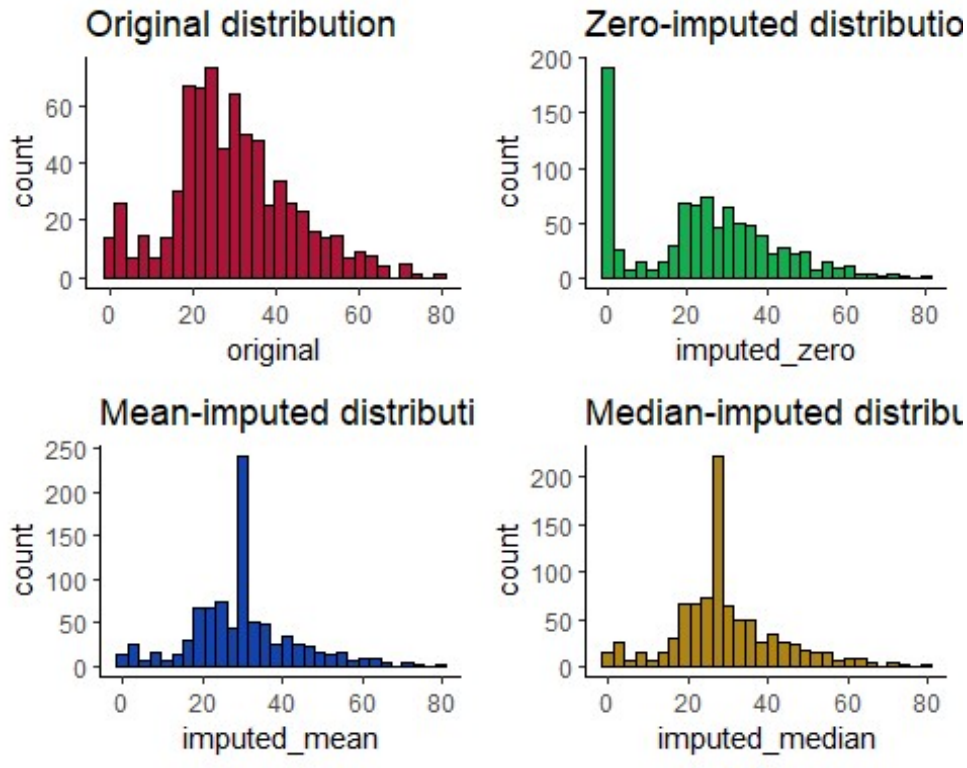
```
h1 <- ggplot(value_imputed, aes(x = original)) +
  geom_histogram(fill = "#ad1538", color = "#000000", position = "identity")
+
  ggtitle("Original distribution") +
  theme_classic()
h2 <- ggplot(value_imputed, aes(x = imputed_zero)) +
  geom_histogram(fill = "#15ad4f", color = "#000000", position = "identity")
+
  ggtitle("Zero-imputed distribution") +
  theme_classic()
h3 <- ggplot(value_imputed, aes(x = imputed_mean)) +
  geom_histogram(fill = "#1543ad", color = "#000000", position = "identity")
+
  ggtitle("Mean-imputed distribution") +
  theme_classic()
h4 <- ggplot(value_imputed, aes(x = imputed_median)) +
  geom_histogram(fill = "#ad8415", color = "#000000", position = "identity")
+
  ggtitle("Median-imputed distribution") +
  theme_classic()

plot_grid(h1, h2, h3, h4, nrow = 2, ncol = 2)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.

## Warning: Removed 177 rows containing non-finite values (`stat_bin()`).

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



MICE

MICE stands for Multivariate Imputation via Chained Equations, and it's one of the most common packages for R users. It assumes the missing values are missing at random (MAR). The basic idea behind the algorithm is to treat each variable that has missing values as a dependent variable in regression and treat the others as independent (predictors). The R mice packages provide many univariate imputation methods.

https://appsilon.com/imputation-in-r/#:~:text=Impute%20Missing%20Values%20in%20R%20with%20MICE&text=It%20assumes%20the%20missing%20values,others%20as%20independent%20(predictors).

We will be using the titanic data to learn about imputation package. ### Examine the data It is important to get a visual representation of missing data and variable distribution when examining new data.

```
library(mice)
```

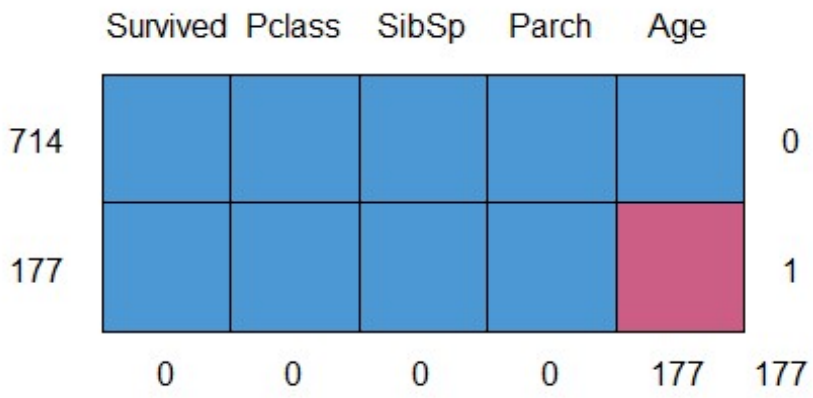
```
##
## Attaching package: 'mice'

## The following object is masked from 'package:stats':
##
##     filter

## The following objects are masked from 'package:base':
##
##     cbind, rbind

titanic_numeric <- titanic_train %>%
  select(Survived, Pclass, SibSp, Parch, Age)

md.pattern(titanic_numeric)
```




```
##     Survived Pclass SibSp Parch Age
## 714        1      1     1     1   1   0
## 177        1      1     1     1   0   1
##            0      0     0     0 177 177
```

I prefer the `sapply` method. I shows the missing values clearly.

```
sapply(titanic_numeric, function(x) sum(is.na(x)))

## Survived   Pclass    SibSp    Parch      Age
##        0        0        0        0      177
```

Onto the imputation now. We'll use the following MICE imputation methods:

- pmm: Predictive mean matching.
- cart: Classification and regression trees.
- laso.norm: Lasso linear regression.

```
mice_imputed <- data.frame(
  original = titanic_train$Age,
  imputed_pmm = complete(mice(titanic_numeric, method = "pmm"))$Age,
  imputed_cart = complete(mice(titanic_numeric, method = "cart"))$Age,
  imputed_lasso = complete(mice(titanic_numeric, method = "lasso.norm"))$Age
)
```

```
##
##  iter imp variable
##   1   1  Age
##   1   2  Age
##   1   3  Age
##   1   4  Age
##   1   5  Age
##   2   1  Age
##   2   2  Age
##   2   3  Age
##   2   4  Age
##   2   5  Age
##   3   1  Age
##   3   2  Age
##   3   3  Age
##   3   4  Age
##   3   5  Age
##   4   1  Age
##   4   2  Age
##   4   3  Age
##   4   4  Age
##   4   5  Age
##   5   1  Age
##   5   2  Age
##   5   3  Age
##   5   4  Age
##   5   5  Age
##
##  iter imp variable
##   1   1  Age
##   1   2  Age
##   1   3  Age
##   1   4  Age
##   1   5  Age
##   2   1  Age
##   2   2  Age
##   2   3  Age
##   2   4  Age
```

```
##   2   5  Age
##   3   1  Age
##   3   2  Age
##   3   3  Age
##   3   4  Age
##   3   5  Age
##   4   1  Age
##   4   2  Age
##   4   3  Age
##   4   4  Age
##   4   5  Age
##   5   1  Age
##   5   2  Age
##   5   3  Age
##   5   4  Age
##   5   5  Age
##
##  iter imp variable
##   1   1  Age
##   1   2  Age
##   1   3  Age
##   1   4  Age
##   1   5  Age
##   2   1  Age
##   2   2  Age
##   2   3  Age
##   2   4  Age
##   2   5  Age
##   3   1  Age
##   3   2  Age
##   3   3  Age
##   3   4  Age
##   3   5  Age
##   4   1  Age
##   4   2  Age
##   4   3  Age
##   4   4  Age
##   4   5  Age
##   5   1  Age
##   5   2  Age
##   5   3  Age
##   5   4  Age
##   5   5  Age
```

```
mice_imputed
```

```
##     original imputed_pmm imputed_cart imputed_lasso
## 1      22.00       22.00        22.00    22.0000000
## 2      38.00       38.00        38.00    38.0000000
## 3      26.00       26.00        26.00    26.0000000
```

```
## 4      35.00       35.00        35.00    35.0000000
## 5      35.00       35.00        35.00    35.0000000
## 6         NA       41.00        29.00    12.4446984
## 7      54.00       54.00        54.00    54.0000000
## 8       2.00        2.00         2.00     2.0000000
## 9      27.00       27.00        27.00    27.0000000
## 10     14.00       14.00        14.00    14.0000000
## 11      4.00        4.00         4.00     4.0000000
## 12     58.00       58.00        58.00    58.0000000
## 13     20.00       20.00        20.00    20.0000000
## 14     39.00       39.00        39.00    39.0000000
## 15     14.00       14.00        14.00    14.0000000
## 16     55.00       55.00        55.00    55.0000000
## 17      2.00        2.00         2.00     2.0000000
## 18        NA       50.00        23.00    36.2084409
## 19     31.00       31.00        31.00    31.0000000
## 20        NA       32.00        27.00    37.1670819
## 21     35.00       35.00        35.00    35.0000000
## 22     34.00       34.00        34.00    34.0000000
## 23     15.00       15.00        15.00    15.0000000
## 24     28.00       28.00        28.00    28.0000000
## 25      8.00        8.00         8.00     8.0000000
## 26     38.00       38.00        38.00    38.0000000
## 27        NA        6.00        22.00    30.2084768
## 28     19.00       19.00        19.00    19.0000000
## 29        NA        5.00        13.00     0.2872436
## 30        NA       50.00        33.00    15.8389904
## 31     40.00       40.00        40.00    40.0000000
## 32        NA       18.00        49.00    38.3412421
## 33        NA       27.00        27.00    50.6203735
## 34     66.00       66.00        66.00    66.0000000
## 35     28.00       28.00        28.00    28.0000000
## 36     42.00       42.00        42.00    42.0000000
## 37        NA       21.00        16.00    19.0567504
## 38     21.00       21.00        21.00    21.0000000
## 39     18.00       18.00        18.00    18.0000000
## 40     14.00       14.00        14.00    14.0000000
## 41     40.00       40.00        40.00    40.0000000
## 42     27.00       27.00        27.00    27.0000000
## 43        NA        6.00        23.00    23.8833545
## 44      3.00        3.00         3.00     3.0000000
## 45     19.00       19.00        19.00    19.0000000
## 46        NA        6.00        23.00    33.9011903
## 47        NA       39.00        21.00    37.7589708
## 48        NA       32.00        32.00     4.1145001
## 49        NA       27.00        17.00    14.0367950
## 50     18.00       18.00        18.00    18.0000000
## 51      7.00        7.00         7.00     7.0000000
## 52     21.00       21.00        21.00    21.0000000
## 53     49.00       49.00        49.00    49.0000000
```

```
## 54     29.00       29.00        29.00    29.0000000
## 55     65.00       65.00        65.00    65.0000000
## 56        NA       40.00        35.00    21.0101239
## 57     21.00       21.00        21.00    21.0000000
## 58     28.50       28.50        28.50    28.5000000
## 59      5.00        5.00         5.00     5.0000000
## 60     11.00       11.00        11.00    11.0000000
## 61     22.00       22.00        22.00    22.0000000
## 62     38.00       38.00        38.00    38.0000000
## 63     45.00       45.00        45.00    45.0000000
## 64      4.00        4.00         4.00     4.0000000
## 65        NA       31.00        47.00    34.9323710
## 66        NA       20.00         4.00    -1.1858972
## 67     29.00       29.00        29.00    29.0000000
## 68     19.00       19.00        19.00    19.0000000
## 69     17.00       17.00        17.00    17.0000000
## 70     26.00       26.00        26.00    26.0000000
## 71     32.00       32.00        32.00    32.0000000
## 72     16.00       16.00        16.00    16.0000000
## 73     21.00       21.00        21.00    21.0000000
## 74     26.00       26.00        26.00    26.0000000
## 75     32.00       32.00        32.00    32.0000000
## 76     25.00       25.00        25.00    25.0000000
## 77        NA       41.00        37.00    13.5209858
## 78        NA       41.00        32.00    44.2016707
## 79      0.83        0.83         0.83     0.8300000
## 80     30.00       30.00        30.00    30.0000000
## 81     22.00       22.00        22.00    22.0000000
## 82     29.00       29.00        29.00    29.0000000
## 83        NA       32.00         5.00    21.6905167
## 84     28.00       28.00        28.00    28.0000000
## 85     17.00       17.00        17.00    17.0000000
## 86     33.00       33.00        33.00    33.0000000
## 87     16.00       16.00        16.00    16.0000000
## 88        NA       50.00        40.50    36.2709520
## 89     23.00       23.00        23.00    23.0000000
## 90     24.00       24.00        24.00    24.0000000
## 91     29.00       29.00        29.00    29.0000000
## 92     20.00       20.00        20.00    20.0000000
## 93     46.00       46.00        46.00    46.0000000
## 94     26.00       26.00        26.00    26.0000000
## 95     59.00       59.00        59.00    59.0000000
## 96        NA       25.00        20.00    11.8518436
## 97     71.00       71.00        71.00    71.0000000
## 98     23.00       23.00        23.00    23.0000000
## 99     34.00       34.00        34.00    34.0000000
## 100    34.00       34.00        34.00    34.0000000
## 101    28.00       28.00        28.00    28.0000000
## 102       NA       41.00        25.00    56.3317260
## 103    21.00       21.00        21.00    21.0000000
```

```
## 104    33.00       33.00        33.00    33.0000000
## 105    37.00       37.00        37.00    37.0000000
## 106    28.00       28.00        28.00    28.0000000
## 107    21.00       21.00        21.00    21.0000000
## 108       NA       21.00        24.00    34.7759708
## 109    38.00       38.00        38.00    38.0000000
## 110       NA       14.00        25.00    25.4333132
## 111    47.00       47.00        47.00    47.0000000
## 112    14.50       14.50        14.50    14.5000000
## 113    22.00       22.00        22.00    22.0000000
## 114    20.00       20.00        20.00    20.0000000
## 115    17.00       17.00        17.00    17.0000000
## 116    21.00       21.00        21.00    21.0000000
## 117    70.50       70.50        70.50    70.5000000
## 118    29.00       29.00        29.00    29.0000000
## 119    24.00       24.00        24.00    24.0000000
## 120     2.00        2.00         2.00     2.0000000
## 121    21.00       21.00        21.00    21.0000000
## 122       NA       34.00        43.00    29.9150940
## 123    32.50       32.50        32.50    32.5000000
## 124    32.50       32.50        32.50    32.5000000
## 125    54.00       54.00        54.00    54.0000000
## 126    12.00       12.00        12.00    12.0000000
## 127       NA       25.00        30.00    38.6124034
## 128    24.00       24.00        24.00    24.0000000
## 129       NA       20.00        18.00    32.8382233
## 130    45.00       45.00        45.00    45.0000000
## 131    33.00       33.00        33.00    33.0000000
## 132    20.00       20.00        20.00    20.0000000
## 133    47.00       47.00        47.00    47.0000000
## 134    29.00       29.00        29.00    29.0000000
## 135    25.00       25.00        25.00    25.0000000
## 136    23.00       23.00        23.00    23.0000000
## 137    19.00       19.00        19.00    19.0000000
## 138    37.00       37.00        37.00    37.0000000
## 139    16.00       16.00        16.00    16.0000000
## 140    24.00       24.00        24.00    24.0000000
## 141       NA       40.50        40.50    28.6947707
## 142    22.00       22.00        22.00    22.0000000
## 143    24.00       24.00        24.00    24.0000000
## 144    19.00       19.00        19.00    19.0000000
## 145    18.00       18.00        18.00    18.0000000
## 146    19.00       19.00        19.00    19.0000000
## 147    27.00       27.00        27.00    27.0000000
## 148     9.00        9.00         9.00     9.0000000
## 149    36.50       36.50        36.50    36.5000000
## 150    42.00       42.00        42.00    42.0000000
## 151    51.00       51.00        51.00    51.0000000
## 152    22.00       22.00        22.00    22.0000000
## 153    55.50       55.50        55.50    55.5000000
```

```
## 154    40.50       40.50        40.50    40.5000000
## 155       NA        6.00        17.00    32.4644025
## 156    51.00       51.00        51.00    51.0000000
## 157    16.00       16.00        16.00    16.0000000
## 158    30.00       30.00        30.00    30.0000000
## 159       NA       50.00        19.00    29.4688992
## 160       NA       17.00        11.00    15.2850495
## 161    44.00       44.00        44.00    44.0000000
## 162    40.00       40.00        40.00    40.0000000
## 163    26.00       26.00        26.00    26.0000000
## 164    17.00       17.00        17.00    17.0000000
## 165     1.00        1.00         1.00     1.0000000
## 166     9.00        9.00         9.00     9.0000000
## 167       NA       16.00        22.00    38.3186692
## 168    45.00       45.00        45.00    45.0000000
## 169       NA       31.00        22.00    50.3224176
## 170    28.00       28.00        28.00    28.0000000
## 171    61.00       61.00        61.00    61.0000000
## 172     4.00        4.00         4.00     4.0000000
## 173     1.00        1.00         1.00     1.0000000
## 174    21.00       21.00        21.00    21.0000000
## 175    56.00       56.00        56.00    56.0000000
## 176    18.00       18.00        18.00    18.0000000
## 177       NA        4.00         3.00    17.2731957
## 178    50.00       50.00        50.00    50.0000000
## 179    30.00       30.00        30.00    30.0000000
## 180    36.00       36.00        36.00    36.0000000
## 181       NA        9.00        16.00    -5.8922827
## 182       NA       22.00        32.00    38.6181756
## 183     9.00        9.00         9.00     9.0000000
## 184     1.00        1.00         1.00     1.0000000
## 185     4.00        4.00         4.00     4.0000000
## 186       NA       46.00        50.00    30.9309157
## 187       NA       12.00        33.00    31.7403979
## 188    45.00       45.00        45.00    45.0000000
## 189    40.00       40.00        40.00    40.0000000
## 190    36.00       36.00        36.00    36.0000000
## 191    32.00       32.00        32.00    32.0000000
## 192    19.00       19.00        19.00    19.0000000
## 193    19.00       19.00        19.00    19.0000000
## 194     3.00        3.00         3.00     3.0000000
## 195    44.00       44.00        44.00    44.0000000
## 196    58.00       58.00        58.00    58.0000000
## 197       NA       25.00        32.00    19.9774278
## 198    42.00       42.00        42.00    42.0000000
## 199       NA        5.00        29.00    22.0728488
## 200    24.00       24.00        24.00    24.0000000
## 201    28.00       28.00        28.00    28.0000000
## 202       NA        9.00        11.00    -5.8387578
## 203    34.00       34.00        34.00    34.0000000
```

```
## 204    45.50       45.50        45.50    45.5000000
## 205    18.00       18.00        18.00    18.0000000
## 206     2.00        2.00         2.00     2.0000000
## 207    32.00       32.00        32.00    32.0000000
## 208    26.00       26.00        26.00    26.0000000
## 209    16.00       16.00        16.00    16.0000000
## 210    40.00       40.00        40.00    40.0000000
## 211    24.00       24.00        24.00    24.0000000
## 212    35.00       35.00        35.00    35.0000000
## 213    22.00       22.00        22.00    22.0000000
## 214    30.00       30.00        30.00    30.0000000
## 215       NA       41.00        24.00    29.3798801
## 216    31.00       31.00        31.00    31.0000000
## 217    27.00       27.00        27.00    27.0000000
## 218    42.00       42.00        42.00    42.0000000
## 219    32.00       32.00        32.00    32.0000000
## 220    30.00       30.00        30.00    30.0000000
## 221    16.00       16.00        16.00    16.0000000
## 222    27.00       27.00        27.00    27.0000000
## 223    51.00       51.00        51.00    51.0000000
## 224       NA       25.00        51.00    17.5732781
## 225    38.00       38.00        38.00    38.0000000
## 226    22.00       22.00        22.00    22.0000000
## 227    19.00       19.00        19.00    19.0000000
## 228    20.50       20.50        20.50    20.5000000
## 229    18.00       18.00        18.00    18.0000000
## 230       NA       38.00         8.00    29.5414528
## 231    35.00       35.00        35.00    35.0000000
## 232    29.00       29.00        29.00    29.0000000
## 233    59.00       59.00        59.00    59.0000000
## 234     5.00        5.00         5.00     5.0000000
## 235    24.00       24.00        24.00    24.0000000
## 236       NA        6.00        31.00    43.0579306
## 237    44.00       44.00        44.00    44.0000000
## 238     8.00        8.00         8.00     8.0000000
## 239    19.00       19.00        19.00    19.0000000
## 240    33.00       33.00        33.00    33.0000000
## 241       NA       39.00        20.00    12.9211804
## 242       NA       25.00        33.00    38.6403310
## 243    29.00       29.00        29.00    29.0000000
## 244    22.00       22.00        22.00    22.0000000
## 245    30.00       30.00        30.00    30.0000000
## 246    44.00       44.00        44.00    44.0000000
## 247    25.00       25.00        25.00    25.0000000
## 248    24.00       24.00        24.00    24.0000000
## 249    37.00       37.00        37.00    37.0000000
## 250    54.00       54.00        54.00    54.0000000
## 251       NA       50.00        24.00    46.4533726
## 252    29.00       29.00        29.00    29.0000000
## 253    62.00       62.00        62.00    62.0000000
```

```
## 254    30.00       30.00        30.00    30.0000000
## 255    41.00       41.00        41.00    41.0000000
## 256    29.00       29.00        29.00    29.0000000
## 257       NA       34.00        33.00    42.3339320
## 258    30.00       30.00        30.00    30.0000000
## 259    35.00       35.00        35.00    35.0000000
## 260    50.00       50.00        50.00    50.0000000
## 261       NA       50.00        18.00    30.6024136
## 262     3.00        3.00         3.00     3.0000000
## 263    52.00       52.00        52.00    52.0000000
## 264    40.00       40.00        40.00    40.0000000
## 265       NA       34.00        33.00    32.3275518
## 266    36.00       36.00        36.00    36.0000000
## 267    16.00       16.00        16.00    16.0000000
## 268    25.00       25.00        25.00    25.0000000
## 269    58.00       58.00        58.00    58.0000000
## 270    35.00       35.00        35.00    35.0000000
## 271       NA       46.00        46.00    56.9063088
## 272    25.00       25.00        25.00    25.0000000
## 273    41.00       41.00        41.00    41.0000000
## 274    37.00       37.00        37.00    37.0000000
## 275       NA       27.00        18.00    38.4803956
## 276    63.00       63.00        63.00    63.0000000
## 277    45.00       45.00        45.00    45.0000000
## 278       NA       64.00        34.00    20.2053476
## 279     7.00        7.00         7.00     7.0000000
## 280    35.00       35.00        35.00    35.0000000
## 281    65.00       65.00        65.00    65.0000000
## 282    28.00       28.00        28.00    28.0000000
## 283    16.00       16.00        16.00    16.0000000
## 284    19.00       19.00        19.00    19.0000000
## 285       NA       62.00        47.00    57.0354644
## 286    33.00       33.00        33.00    33.0000000
## 287    30.00       30.00        30.00    30.0000000
## 288    22.00       22.00        22.00    22.0000000
## 289    42.00       42.00        42.00    42.0000000
## 290    22.00       22.00        22.00    22.0000000
## 291    26.00       26.00        26.00    26.0000000
## 292    19.00       19.00        19.00    19.0000000
## 293    36.00       36.00        36.00    36.0000000
## 294    24.00       24.00        24.00    24.0000000
## 295    24.00       24.00        24.00    24.0000000
## 296       NA       29.00        22.00    52.4009253
## 297    23.50       23.50        23.50    23.5000000
## 298     2.00        2.00         2.00     2.0000000
## 299       NA       40.00        24.00    23.9057226
## 300    50.00       50.00        50.00    50.0000000
## 301       NA        5.00        32.00    41.2246630
## 302       NA       10.00        33.00    16.7424097
## 303    19.00       19.00        19.00    19.0000000
```

```
## 304       NA       34.00        46.00    28.1484100
## 305       NA       41.00        28.50    41.2063632
## 306     0.92        0.92         0.92     0.9200000
## 307       NA       22.00        35.00    18.2292858
## 308    17.00       17.00        17.00    17.0000000
## 309    30.00       30.00        30.00    30.0000000
## 310    30.00       30.00        30.00    30.0000000
## 311    24.00       24.00        24.00    24.0000000
## 312    18.00       18.00        18.00    18.0000000
## 313    26.00       26.00        26.00    26.0000000
## 314    28.00       28.00        28.00    28.0000000
## 315    43.00       43.00        43.00    43.0000000
## 316    26.00       26.00        26.00    26.0000000
## 317    24.00       24.00        24.00    24.0000000
## 318    54.00       54.00        54.00    54.0000000
## 319    31.00       31.00        31.00    31.0000000
## 320    40.00       40.00        40.00    40.0000000
## 321    22.00       22.00        22.00    22.0000000
## 322    27.00       27.00        27.00    27.0000000
## 323    30.00       30.00        30.00    30.0000000
## 324    22.00       22.00        22.00    22.0000000
## 325       NA       17.00        11.00   -11.3372306
## 326    36.00       36.00        36.00    36.0000000
## 327    61.00       61.00        61.00    61.0000000
## 328    36.00       36.00        36.00    36.0000000
## 329    31.00       31.00        31.00    31.0000000
## 330    16.00       16.00        16.00    16.0000000
## 331       NA        0.75        36.00    28.0585742
## 332    45.50       45.50        45.50    45.5000000
## 333    38.00       38.00        38.00    38.0000000
## 334    16.00       16.00        16.00    16.0000000
## 335       NA       48.00        35.00    41.5240108
## 336       NA       34.00        16.00    19.1326503
## 337    29.00       29.00        29.00    29.0000000
## 338    41.00       41.00        41.00    41.0000000
## 339    45.00       45.00        45.00    45.0000000
## 340    45.00       45.00        45.00    45.0000000
## 341     2.00        2.00         2.00     2.0000000
## 342    24.00       24.00        24.00    24.0000000
## 343    28.00       28.00        28.00    28.0000000
## 344    25.00       25.00        25.00    25.0000000
## 345    36.00       36.00        36.00    36.0000000
## 346    24.00       24.00        24.00    24.0000000
## 347    40.00       40.00        40.00    40.0000000
## 348       NA       12.00        36.00    10.5511069
## 349     3.00        3.00         3.00     3.0000000
## 350    42.00       42.00        42.00    42.0000000
## 351    23.00       23.00        23.00    23.0000000
## 352       NA       31.00        47.00    45.6647794
## 353    15.00       15.00        15.00    15.0000000
```

```
## 354    25.00       25.00        25.00    25.0000000
## 355       NA       25.00        32.00    32.4982789
## 356    28.00       28.00        28.00    28.0000000
## 357    22.00       22.00        22.00    22.0000000
## 358    38.00       38.00        38.00    38.0000000
## 359       NA       21.00        16.00    29.2764157
## 360       NA       19.00        22.00    44.4613098
## 361    40.00       40.00        40.00    40.0000000
## 362    29.00       29.00        29.00    29.0000000
## 363    45.00       45.00        45.00    45.0000000
## 364    35.00       35.00        35.00    35.0000000
## 365       NA       28.00        25.00    31.3171093
## 366    30.00       30.00        30.00    30.0000000
## 367    60.00       60.00        60.00    60.0000000
## 368       NA       19.00        26.00    25.0106237
## 369       NA       19.00        24.00     9.0823378
## 370    24.00       24.00        24.00    24.0000000
## 371    25.00       25.00        25.00    25.0000000
## 372    18.00       18.00        18.00    18.0000000
## 373    19.00       19.00        19.00    19.0000000
## 374    22.00       22.00        22.00    22.0000000
## 375     3.00        3.00         3.00     3.0000000
## 376       NA       27.00        31.00    17.7828915
## 377    22.00       22.00        22.00    22.0000000
## 378    27.00       27.00        27.00    27.0000000
## 379    20.00       20.00        20.00    20.0000000
## 380    19.00       19.00        19.00    19.0000000
## 381    42.00       42.00        42.00    42.0000000
## 382     1.00        1.00         1.00     1.0000000
## 383    32.00       32.00        32.00    32.0000000
## 384    35.00       35.00        35.00    35.0000000
## 385       NA       41.00        21.00    16.5628693
## 386    18.00       18.00        18.00    18.0000000
## 387     1.00        1.00         1.00     1.0000000
## 388    36.00       36.00        36.00    36.0000000
## 389       NA       41.00        19.00    30.0683742
## 390    17.00       17.00        17.00    17.0000000
## 391    36.00       36.00        36.00    36.0000000
## 392    21.00       21.00        21.00    21.0000000
## 393    28.00       28.00        28.00    28.0000000
## 394    23.00       23.00        23.00    23.0000000
## 395    24.00       24.00        24.00    24.0000000
## 396    22.00       22.00        22.00    22.0000000
## 397    31.00       31.00        31.00    31.0000000
## 398    46.00       46.00        46.00    46.0000000
## 399    23.00       23.00        23.00    23.0000000
## 400    28.00       28.00        28.00    28.0000000
## 401    39.00       39.00        39.00    39.0000000
## 402    26.00       26.00        26.00    26.0000000
## 403    21.00       21.00        21.00    21.0000000
```

```
## 404    28.00       28.00        28.00    28.0000000
## 405    20.00       20.00        20.00    20.0000000
## 406    34.00       34.00        34.00    34.0000000
## 407    51.00       51.00        51.00    51.0000000
## 408     3.00        3.00         3.00     3.0000000
## 409    21.00       21.00        21.00    21.0000000
## 410       NA       10.00         0.75     1.9790867
## 411       NA       25.00        26.00    32.9313641
## 412       NA       41.00        44.00    16.7992353
## 413    33.00       33.00        33.00    33.0000000
## 414       NA       44.00        36.00    34.0945665
## 415    44.00       44.00        44.00    44.0000000
## 416       NA        6.00        24.00    42.7013823
## 417    34.00       34.00        34.00    34.0000000
## 418    18.00       18.00        18.00    18.0000000
## 419    30.00       30.00        30.00    30.0000000
## 420    10.00       10.00        10.00    10.0000000
## 421       NA       34.00        22.00    20.8062056
## 422    21.00       21.00        21.00    21.0000000
## 423    29.00       29.00        29.00    29.0000000
## 424    28.00       28.00        28.00    28.0000000
## 425    18.00       18.00        18.00    18.0000000
## 426       NA       25.00        37.00    48.1245837
## 427    28.00       28.00        28.00    28.0000000
## 428    19.00       19.00        19.00    19.0000000
## 429       NA       50.00        17.00    32.8454118
## 430    32.00       32.00        32.00    32.0000000
## 431    28.00       28.00        28.00    28.0000000
## 432       NA       19.00        33.00    10.5281385
## 433    42.00       42.00        42.00    42.0000000
## 434    17.00       17.00        17.00    17.0000000
## 435    50.00       50.00        50.00    50.0000000
## 436    14.00       14.00        14.00    14.0000000
## 437    21.00       21.00        21.00    21.0000000
## 438    24.00       24.00        24.00    24.0000000
## 439    64.00       64.00        64.00    64.0000000
## 440    31.00       31.00        31.00    31.0000000
## 441    45.00       45.00        45.00    45.0000000
## 442    20.00       20.00        20.00    20.0000000
## 443    25.00       25.00        25.00    25.0000000
## 444    28.00       28.00        28.00    28.0000000
## 445       NA       27.00        26.00    27.9467838
## 446     4.00        4.00         4.00     4.0000000
## 447    13.00       13.00        13.00    13.0000000
## 448    34.00       34.00        34.00    34.0000000
## 449     5.00        5.00         5.00     5.0000000
## 450    52.00       52.00        52.00    52.0000000
## 451    36.00       36.00        36.00    36.0000000
## 452       NA       39.00        28.00    30.5831443
## 453    30.00       30.00        30.00    30.0000000
```

```
## 454    49.00       49.00        49.00    49.0000000
## 455       NA        6.00        29.00    41.8959786
## 456    29.00       29.00        29.00    29.0000000
## 457    65.00       65.00        65.00    65.0000000
## 458       NA       27.00        35.00    51.9598206
## 459    50.00       50.00        50.00    50.0000000
## 460       NA       34.00        19.00    44.0714523
## 461    48.00       48.00        48.00    48.0000000
## 462    34.00       34.00        34.00    34.0000000
## 463    47.00       47.00        47.00    47.0000000
## 464    48.00       48.00        48.00    48.0000000
## 465       NA       41.00        51.00    34.4484386
## 466    38.00       38.00        38.00    38.0000000
## 467       NA       44.00        23.00    41.3266004
## 468    56.00       56.00        56.00    56.0000000
## 469       NA        6.00        32.00    10.4094900
## 470     0.75        0.75         0.75     0.7500000
## 471       NA       25.00        22.00    38.9236607
## 472    38.00       38.00        38.00    38.0000000
## 473    33.00       33.00        33.00    33.0000000
## 474    23.00       23.00        23.00    23.0000000
## 475    22.00       22.00        22.00    22.0000000
## 476       NA       29.00        30.00    66.3919073
## 477    34.00       34.00        34.00    34.0000000
## 478    29.00       29.00        29.00    29.0000000
## 479    22.00       22.00        22.00    22.0000000
## 480     2.00        2.00         2.00     2.0000000
## 481     9.00        9.00         9.00     9.0000000
## 482       NA       23.00        26.00    35.5131673
## 483    50.00       50.00        50.00    50.0000000
## 484    63.00       63.00        63.00    63.0000000
## 485    25.00       25.00        25.00    25.0000000
## 486       NA       38.00         8.00    28.3871551
## 487    35.00       35.00        35.00    35.0000000
## 488    58.00       58.00        58.00    58.0000000
## 489    30.00       30.00        30.00    30.0000000
## 490     9.00        9.00         9.00     9.0000000
## 491       NA       28.00        36.00    32.9990563
## 492    21.00       21.00        21.00    21.0000000
## 493    55.00       55.00        55.00    55.0000000
## 494    71.00       71.00        71.00    71.0000000
## 495    21.00       21.00        21.00    21.0000000
## 496       NA       41.00        36.00     6.6118077
## 497    54.00       54.00        54.00    54.0000000
## 498       NA       34.00        16.00    30.3342217
## 499    25.00       25.00        25.00    25.0000000
## 500    24.00       24.00        24.00    24.0000000
## 501    17.00       17.00        17.00    17.0000000
## 502    21.00       21.00        21.00    21.0000000
## 503       NA       50.00        35.00    26.7735425
```

```
## 504    37.00       37.00        37.00    37.0000000
## 505    16.00       16.00        16.00    16.0000000
## 506    18.00       18.00        18.00    18.0000000
## 507    33.00       33.00        33.00    33.0000000
## 508       NA       22.00        24.00    18.6041121
## 509    28.00       28.00        28.00    28.0000000
## 510    26.00       26.00        26.00    26.0000000
## 511    29.00       29.00        29.00    29.0000000
## 512       NA        6.00        26.00     6.4356386
## 513    36.00       36.00        36.00    36.0000000
## 514    54.00       54.00        54.00    54.0000000
## 515    24.00       24.00        24.00    24.0000000
## 516    47.00       47.00        47.00    47.0000000
## 517    34.00       34.00        34.00    34.0000000
## 518       NA       41.00        40.00     7.5677979
## 519    36.00       36.00        36.00    36.0000000
## 520    32.00       32.00        32.00    32.0000000
## 521    30.00       30.00        30.00    30.0000000
## 522    22.00       22.00        22.00    22.0000000
## 523       NA       25.00        24.00    45.4831730
## 524    44.00       44.00        44.00    44.0000000
## 525       NA        6.00        25.00    39.5056190
## 526    40.50       40.50        40.50    40.5000000
## 527    50.00       50.00        50.00    50.0000000
## 528       NA       29.00        54.00    34.9468007
## 529    39.00       39.00        39.00    39.0000000
## 530    23.00       23.00        23.00    23.0000000
## 531     2.00        2.00         2.00     2.0000000
## 532       NA       50.00        33.00    35.8412011
## 533    17.00       17.00        17.00    17.0000000
## 534       NA       26.00         1.00    30.5482360
## 535    30.00       30.00        30.00    30.0000000
## 536     7.00        7.00         7.00     7.0000000
## 537    45.00       45.00        45.00    45.0000000
## 538    30.00       30.00        30.00    30.0000000
## 539       NA        6.00        22.00    27.0516516
## 540    22.00       22.00        22.00    22.0000000
## 541    36.00       36.00        36.00    36.0000000
## 542     9.00        9.00         9.00     9.0000000
## 543    11.00       11.00        11.00    11.0000000
## 544    32.00       32.00        32.00    32.0000000
## 545    50.00       50.00        50.00    50.0000000
## 546    64.00       64.00        64.00    64.0000000
## 547    19.00       19.00        19.00    19.0000000
## 548       NA       50.00        35.00    25.4605829
## 549    33.00       33.00        33.00    33.0000000
## 550     8.00        8.00         8.00     8.0000000
## 551    17.00       17.00        17.00    17.0000000
## 552    27.00       27.00        27.00    27.0000000
## 553       NA       50.00        35.00    11.7601167
```

```
## 554    22.00       22.00        22.00    22.0000000
## 555    22.00       22.00        22.00    22.0000000
## 556    62.00       62.00        62.00    62.0000000
## 557    48.00       48.00        48.00    48.0000000
## 558       NA       31.00        61.00    62.7541741
## 559    39.00       39.00        39.00    39.0000000
## 560    36.00       36.00        36.00    36.0000000
## 561       NA       50.00        31.00    38.7353231
## 562    40.00       40.00        40.00    40.0000000
## 563    28.00       28.00        28.00    28.0000000
## 564       NA       50.00        32.00    26.7711125
## 565       NA       34.00        48.00    43.1980901
## 566    24.00       24.00        24.00    24.0000000
## 567    19.00       19.00        19.00    19.0000000
## 568    29.00       29.00        29.00    29.0000000
## 569       NA       41.00        17.00    29.9934980
## 570    32.00       32.00        32.00    32.0000000
## 571    62.00       62.00        62.00    62.0000000
## 572    53.00       53.00        53.00    53.0000000
## 573    36.00       36.00        36.00    36.0000000
## 574       NA       27.00        32.00    19.3306134
## 575    16.00       16.00        16.00    16.0000000
## 576    19.00       19.00        19.00    19.0000000
## 577    34.00       34.00        34.00    34.0000000
## 578    39.00       39.00        39.00    39.0000000
## 579       NA        9.00        29.00    11.4490184
## 580    32.00       32.00        32.00    32.0000000
## 581    25.00       25.00        25.00    25.0000000
## 582    39.00       39.00        39.00    39.0000000
## 583    54.00       54.00        54.00    54.0000000
## 584    36.00       36.00        36.00    36.0000000
## 585       NA       25.00        40.00    27.7623588
## 586    18.00       18.00        18.00    18.0000000
## 587    47.00       47.00        47.00    47.0000000
## 588    60.00       60.00        60.00    60.0000000
## 589    22.00       22.00        22.00    22.0000000
## 590       NA       50.00        26.00    34.1112780
## 591    35.00       35.00        35.00    35.0000000
## 592    52.00       52.00        52.00    52.0000000
## 593    47.00       47.00        47.00    47.0000000
## 594       NA       40.50        44.00    23.5079989
## 595    37.00       37.00        37.00    37.0000000
## 596    36.00       36.00        36.00    36.0000000
## 597       NA       45.00        21.00    35.7331469
## 598    49.00       49.00        49.00    49.0000000
## 599       NA       34.00        30.00    32.2796277
## 600    49.00       49.00        49.00    49.0000000
## 601    24.00       24.00        24.00    24.0000000
## 602       NA       41.00        39.00    26.2774853
## 603       NA       46.00        60.00    46.5150322
```

```
## 604    44.00       44.00        44.00    44.0000000
## 605    35.00       35.00        35.00    35.0000000
## 606    36.00       36.00        36.00    36.0000000
## 607    30.00       30.00        30.00    30.0000000
## 608    27.00       27.00        27.00    27.0000000
## 609    22.00       22.00        22.00    22.0000000
## 610    40.00       40.00        40.00    40.0000000
## 611    39.00       39.00        39.00    39.0000000
## 612       NA        6.00        35.00    12.0984340
## 613       NA       19.00        33.00     5.3199461
## 614       NA       25.00        26.00    41.3969030
## 615    35.00       35.00        35.00    35.0000000
## 616    24.00       24.00        24.00    24.0000000
## 617    34.00       34.00        34.00    34.0000000
## 618    26.00       26.00        26.00    26.0000000
## 619     4.00        4.00         4.00     4.0000000
## 620    26.00       26.00        26.00    26.0000000
## 621    27.00       27.00        27.00    27.0000000
## 622    42.00       42.00        42.00    42.0000000
## 623    20.00       20.00        20.00    20.0000000
## 624    21.00       21.00        21.00    21.0000000
## 625    21.00       21.00        21.00    21.0000000
## 626    61.00       61.00        61.00    61.0000000
## 627    57.00       57.00        57.00    57.0000000
## 628    21.00       21.00        21.00    21.0000000
## 629    26.00       26.00        26.00    26.0000000
## 630       NA       50.00        55.50    47.6588063
## 631    80.00       80.00        80.00    80.0000000
## 632    51.00       51.00        51.00    51.0000000
## 633    32.00       32.00        32.00    32.0000000
## 634       NA       46.00        71.00    52.0534098
## 635     9.00        9.00         9.00     9.0000000
## 636    28.00       28.00        28.00    28.0000000
## 637    32.00       32.00        32.00    32.0000000
## 638    31.00       31.00        31.00    31.0000000
## 639    41.00       41.00        41.00    41.0000000
## 640       NA        9.00        17.00    18.2386256
## 641    20.00       20.00        20.00    20.0000000
## 642    24.00       24.00        24.00    24.0000000
## 643     2.00        2.00         2.00     2.0000000
## 644       NA       19.00        15.00    17.4292275
## 645     0.75        0.75         0.75     0.7500000
## 646    48.00       48.00        48.00    48.0000000
## 647    19.00       19.00        19.00    19.0000000
## 648    56.00       56.00        56.00    56.0000000
## 649       NA       34.00        74.00    40.0913346
## 650    23.00       23.00        23.00    23.0000000
## 651       NA       50.00        42.00    17.9481815
## 652    18.00       18.00        18.00    18.0000000
## 653    21.00       21.00        21.00    21.0000000
```

```
## 654       NA       19.00        15.00    36.9441558
## 655    18.00       18.00        18.00    18.0000000
## 656    24.00       24.00        24.00    24.0000000
## 657       NA       25.00        18.00    23.3587348
## 658    32.00       32.00        32.00    32.0000000
## 659    23.00       23.00        23.00    23.0000000
## 660    58.00       58.00        58.00    58.0000000
## 661    50.00       50.00        50.00    50.0000000
## 662    40.00       40.00        40.00    40.0000000
## 663    47.00       47.00        47.00    47.0000000
## 664    36.00       36.00        36.00    36.0000000
## 665    20.00       20.00        20.00    20.0000000
## 666    32.00       32.00        32.00    32.0000000
## 667    25.00       25.00        25.00    25.0000000
## 668       NA       34.00        30.00    35.2542855
## 669    43.00       43.00        43.00    43.0000000
## 670       NA       27.00        49.00    12.1678125
## 671    40.00       40.00        40.00    40.0000000
## 672    31.00       31.00        31.00    31.0000000
## 673    70.00       70.00        70.00    70.0000000
## 674    31.00       31.00        31.00    31.0000000
## 675       NA       16.00        62.00    39.4938356
## 676    18.00       18.00        18.00    18.0000000
## 677    24.50       24.50        24.50    24.5000000
## 678    18.00       18.00        18.00    18.0000000
## 679    43.00       43.00        43.00    43.0000000
## 680    36.00       36.00        36.00    36.0000000
## 681       NA        6.00        34.00    31.6122966
## 682    27.00       27.00        27.00    27.0000000
## 683    20.00       20.00        20.00    20.0000000
## 684    14.00       14.00        14.00    14.0000000
## 685    60.00       60.00        60.00    60.0000000
## 686    25.00       25.00        25.00    25.0000000
## 687    14.00       14.00        14.00    14.0000000
## 688    19.00       19.00        19.00    19.0000000
## 689    18.00       18.00        18.00    18.0000000
## 690    15.00       15.00        15.00    15.0000000
## 691    31.00       31.00        31.00    31.0000000
## 692     4.00        4.00         4.00     4.0000000
## 693       NA       27.00        29.00    23.0366036
## 694    25.00       25.00        25.00    25.0000000
## 695    60.00       60.00        60.00    60.0000000
## 696    52.00       52.00        52.00    52.0000000
## 697    44.00       44.00        44.00    44.0000000
## 698       NA       27.00        22.00     8.2525614
## 699    49.00       49.00        49.00    49.0000000
## 700    42.00       42.00        42.00    42.0000000
## 701    18.00       18.00        18.00    18.0000000
## 702    35.00       35.00        35.00    35.0000000
## 703    18.00       18.00        18.00    18.0000000
```

```
## 704    25.00       25.00        25.00    25.0000000
## 705    26.00       26.00        26.00    26.0000000
## 706    39.00       39.00        39.00    39.0000000
## 707    45.00       45.00        45.00    45.0000000
## 708    42.00       42.00        42.00    42.0000000
## 709    22.00       22.00        22.00    22.0000000
## 710       NA       20.00         9.00     4.8696650
## 711    24.00       24.00        24.00    24.0000000
## 712       NA       62.00        39.00    29.5797626
## 713    48.00       48.00        48.00    48.0000000
## 714    29.00       29.00        29.00    29.0000000
## 715    52.00       52.00        52.00    52.0000000
## 716    19.00       19.00        19.00    19.0000000
## 717    38.00       38.00        38.00    38.0000000
## 718    27.00       27.00        27.00    27.0000000
## 719       NA       41.00        28.00    13.7627442
## 720    33.00       33.00        33.00    33.0000000
## 721     6.00        6.00         6.00     6.0000000
## 722    17.00       17.00        17.00    17.0000000
## 723    34.00       34.00        34.00    34.0000000
## 724    50.00       50.00        50.00    50.0000000
## 725    27.00       27.00        27.00    27.0000000
## 726    20.00       20.00        20.00    20.0000000
## 727    30.00       30.00        30.00    30.0000000
## 728       NA       27.00        32.00     7.8362031
## 729    25.00       25.00        25.00    25.0000000
## 730    25.00       25.00        25.00    25.0000000
## 731    29.00       29.00        29.00    29.0000000
## 732    11.00       11.00        11.00    11.0000000
## 733       NA       22.00        55.00    30.6825032
## 734    23.00       23.00        23.00    23.0000000
## 735    23.00       23.00        23.00    23.0000000
## 736    28.50       28.50        28.50    28.5000000
## 737    48.00       48.00        48.00    48.0000000
## 738    35.00       35.00        35.00    35.0000000
## 739       NA       34.00        21.00    34.3379903
## 740       NA       34.00        28.00    38.8673336
## 741       NA       48.00        41.00    36.0037279
## 742    36.00       36.00        36.00    36.0000000
## 743    21.00       21.00        21.00    21.0000000
## 744    24.00       24.00        24.00    24.0000000
## 745    31.00       31.00        31.00    31.0000000
## 746    70.00       70.00        70.00    70.0000000
## 747    16.00       16.00        16.00    16.0000000
## 748    30.00       30.00        30.00    30.0000000
## 749    19.00       19.00        19.00    19.0000000
## 750    31.00       31.00        31.00    31.0000000
## 751     4.00        4.00         4.00     4.0000000
## 752     6.00        6.00         6.00     6.0000000
## 753    33.00       33.00        33.00    33.0000000
```

```
## 754    23.00       23.00        23.00    23.0000000
## 755    48.00       48.00        48.00    48.0000000
## 756     0.67        0.67         0.67     0.6700000
## 757    28.00       28.00        28.00    28.0000000
## 758    18.00       18.00        18.00    18.0000000
## 759    34.00       34.00        34.00    34.0000000
## 760    33.00       33.00        33.00    33.0000000
## 761       NA       34.00        28.00    35.7354333
## 762    41.00       41.00        41.00    41.0000000
## 763    20.00       20.00        20.00    20.0000000
## 764    36.00       36.00        36.00    36.0000000
## 765    16.00       16.00        16.00    16.0000000
## 766    51.00       51.00        51.00    51.0000000
## 767       NA       62.00        62.00    23.7825652
## 768    30.50       30.50        30.50    30.5000000
## 769       NA       39.00        32.00    29.0982249
## 770    32.00       32.00        32.00    32.0000000
## 771    24.00       24.00        24.00    24.0000000
## 772    48.00       48.00        48.00    48.0000000
## 773    57.00       57.00        57.00    57.0000000
## 774       NA       50.00        17.00     5.2711940
## 775    54.00       54.00        54.00    54.0000000
## 776    18.00       18.00        18.00    18.0000000
## 777       NA       25.00        22.00    13.4648873
## 778     5.00        5.00         5.00     5.0000000
## 779       NA       50.00        31.00    29.5814071
## 780    43.00       43.00        43.00    43.0000000
## 781    13.00       13.00        13.00    13.0000000
## 782    17.00       17.00        17.00    17.0000000
## 783    29.00       29.00        29.00    29.0000000
## 784       NA       21.00        18.00    36.6376459
## 785    25.00       25.00        25.00    25.0000000
## 786    25.00       25.00        25.00    25.0000000
## 787    18.00       18.00        18.00    18.0000000
## 788     8.00        8.00         8.00     8.0000000
## 789     1.00        1.00         1.00     1.0000000
## 790    46.00       46.00        46.00    46.0000000
## 791       NA       41.00        20.00    51.2489376
## 792    16.00       16.00        16.00    16.0000000
## 793       NA       17.00        14.00   -21.7410350
## 794       NA       29.00        22.00    39.9129990
## 795    25.00       25.00        25.00    25.0000000
## 796    39.00       39.00        39.00    39.0000000
## 797    49.00       49.00        49.00    49.0000000
## 798    31.00       31.00        31.00    31.0000000
## 799    30.00       30.00        30.00    30.0000000
## 800    30.00       30.00        30.00    30.0000000
## 801    34.00       34.00        34.00    34.0000000
## 802    31.00       31.00        31.00    31.0000000
## 803    11.00       11.00        11.00    11.0000000
```

```
## 804     0.42        0.42         0.42     0.4200000
## 805    27.00       27.00        27.00    27.0000000
## 806    31.00       31.00        31.00    31.0000000
## 807    39.00       39.00        39.00    39.0000000
## 808    18.00       18.00        18.00    18.0000000
## 809    39.00       39.00        39.00    39.0000000
## 810    33.00       33.00        33.00    33.0000000
## 811    26.00       26.00        26.00    26.0000000
## 812    39.00       39.00        39.00    39.0000000
## 813    35.00       35.00        35.00    35.0000000
## 814     6.00        6.00         6.00     6.0000000
## 815    30.50       30.50        30.50    30.5000000
## 816       NA       31.00        47.00    51.7061280
## 817    23.00       23.00        23.00    23.0000000
## 818    31.00       31.00        31.00    31.0000000
## 819    43.00       43.00        43.00    43.0000000
## 820    10.00       10.00        10.00    10.0000000
## 821    52.00       52.00        52.00    52.0000000
## 822    27.00       27.00        27.00    27.0000000
## 823    38.00       38.00        38.00    38.0000000
## 824    27.00       27.00        27.00    27.0000000
## 825     2.00        2.00         2.00     2.0000000
## 826       NA        6.00        45.00    24.1428791
## 827       NA       50.00        45.00    32.2013332
## 828     1.00        1.00         1.00     1.0000000
## 829       NA       21.00        15.00    -5.9682287
## 830    62.00       62.00        62.00    62.0000000
## 831    15.00       15.00        15.00    15.0000000
## 832     0.83        0.83         0.83     0.8300000
## 833       NA       34.00        28.00    47.3566332
## 834    23.00       23.00        23.00    23.0000000
## 835    18.00       18.00        18.00    18.0000000
## 836    39.00       39.00        39.00    39.0000000
## 837    21.00       21.00        21.00    21.0000000
## 838       NA        6.00        21.00    40.0650283
## 839    32.00       32.00        32.00    32.0000000
## 840       NA       22.00        41.00    21.8590025
## 841    20.00       20.00        20.00    20.0000000
## 842    16.00       16.00        16.00    16.0000000
## 843    30.00       30.00        30.00    30.0000000
## 844    34.50       34.50        34.50    34.5000000
## 845    17.00       17.00        17.00    17.0000000
## 846    42.00       42.00        42.00    42.0000000
## 847       NA        1.00        11.00     2.4238012
## 848    35.00       35.00        35.00    35.0000000
## 849    28.00       28.00        28.00    28.0000000
## 850       NA       48.00        23.00    20.0624897
## 851     4.00        4.00         4.00     4.0000000
## 852    74.00       74.00        74.00    74.0000000
## 853     9.00        9.00         9.00     9.0000000
```

```
## 854    16.00       16.00        16.00    16.0000000
## 855    44.00       44.00        44.00    44.0000000
## 856    18.00       18.00        18.00    18.0000000
## 857    45.00       45.00        45.00    45.0000000
## 858    51.00       51.00        51.00    51.0000000
## 859    24.00       24.00        24.00    24.0000000
## 860       NA       25.00        25.00    17.9165872
## 861    41.00       41.00        41.00    41.0000000
## 862    21.00       21.00        21.00    21.0000000
## 863    48.00       48.00        48.00    48.0000000
## 864       NA        5.00        11.00   -17.4845546
## 865    24.00       24.00        24.00    24.0000000
## 866    42.00       42.00        42.00    42.0000000
## 867    27.00       27.00        27.00    27.0000000
## 868    31.00       31.00        31.00    31.0000000
## 869       NA       34.00        32.00    25.2731270
## 870     4.00        4.00         4.00     4.0000000
## 871    26.00       26.00        26.00    26.0000000
## 872    47.00       47.00        47.00    47.0000000
## 873    33.00       33.00        33.00    33.0000000
## 874    47.00       47.00        47.00    47.0000000
## 875    28.00       28.00        28.00    28.0000000
## 876    15.00       15.00        15.00    15.0000000
## 877    20.00       20.00        20.00    20.0000000
## 878    19.00       19.00        19.00    19.0000000
## 879       NA       41.00        25.00    48.8259457
## 880    56.00       56.00        56.00    56.0000000
## 881    25.00       25.00        25.00    25.0000000
## 882    33.00       33.00        33.00    33.0000000
## 883    22.00       22.00        22.00    22.0000000
## 884    28.00       28.00        28.00    28.0000000
## 885    25.00       25.00        25.00    25.0000000
## 886    39.00       39.00        39.00    39.0000000
## 887    27.00       27.00        27.00    27.0000000
## 888    19.00       19.00        19.00    19.0000000
## 889       NA       54.00        40.00    30.9115653
## 890    26.00       26.00        26.00    26.0000000
## 891    32.00       32.00        32.00    32.0000000
```

Examine the new data

```
h1 <- ggplot(mice_imputed, aes(x = original)) +
  geom_histogram(fill = "#ad1538", color = "#000000", position = "identity")
+
  ggtitle("Original distribution") +
  theme_classic()
h2 <- ggplot(mice_imputed, aes(x = imputed_pmm)) +
  geom_histogram(fill = "#15ad4f", color = "#000000", position = "identity")
+
  ggtitle("PMM-imputed distribution") +
  theme_classic()
```

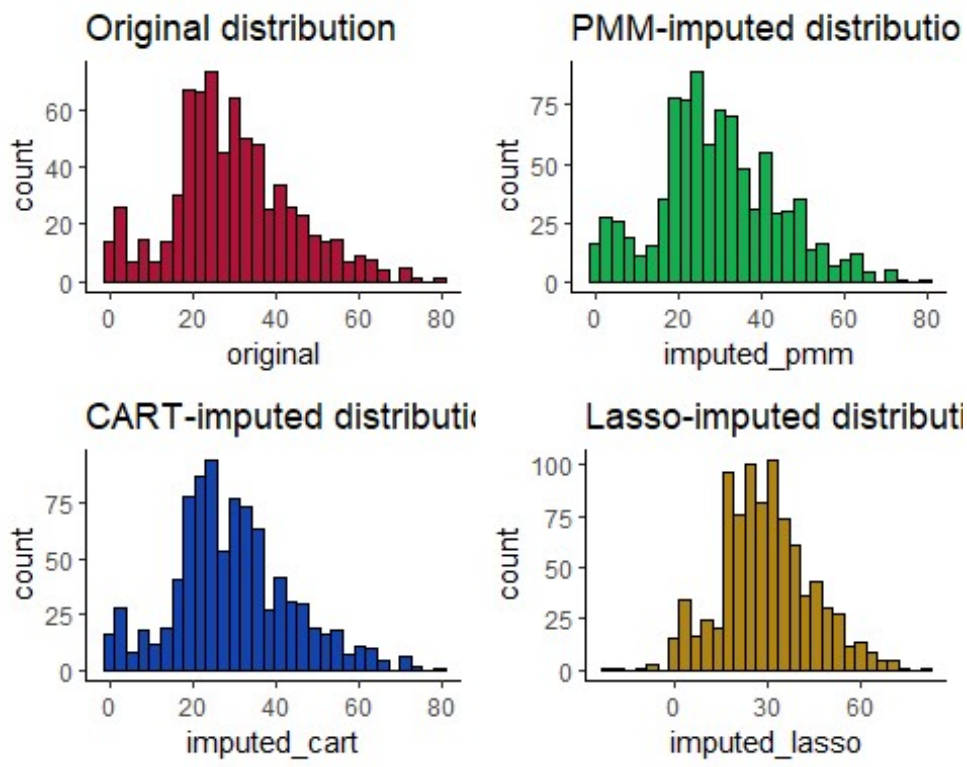
```
h3 <- ggplot(mice_imputed, aes(x =  imputed_cart)) +
  geom_histogram(fill = "#1543ad", color = "#000000", position = "identity")
+
  ggtitle("CART-imputed distribution") +
  theme_classic()
h4 <- ggplot(mice_imputed, aes(x = imputed_lasso)) +
  geom_histogram(fill = "#ad8415", color = "#000000", position = "identity")
+
  ggtitle("Lasso-imputed distribution") +
  theme_classic()

plot_grid(h1, h2, h3, h4, nrow = 2, ncol = 2)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.

## Warning: Removed 177 rows containing non-finite values (`stat_bin()`).

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



Note that there are negative ages that show in the lasso results. negative values will need to be corrected manually.

There are many ways to impute in R. Check out [https://appsilon.com/imputation-in-r/#:\\](https://appsilon.com/imputation-in-r/#:\~:text=Impute%20Missing%20Values%20in%20R%20with%20MICE&text=It%20as

sumes%20the%20missing%20values,others%20as%20independent%20(predictors) for more information.

Patient demographics

Now back to working with our patient demographic data `dem.df2` (these are fake demographics).

```
head(dem.df2)
```

```
## # A tibble: 6 × 5
##   PAT_MRN PAT_DOB    RACE                      ETHNICITY              SEX
##     <dbl> <chr>      <chr>                     <chr>
<chr>
## 1     923 4/5/2007   White                     Not Hispanic or Latino
Female
## 2     942 9/1/2006   <NA>                      <NA>
Female
## 3     356 11/26/2000 White                     Not Hispanic or Latino Male
## 4     844 11/28/2004 Other                     Not Hispanic or Latino
Female
## 5     675 3/3/2013   Black or African-American Not Hispanic or Latino Male
## 6     564 12/13/2013 White                     Not Hispanic or Latino
Female
```

Add CURRENT_AGE column

The objective of this task is to learn how to copy, add, and calculate a new data to a df.

```
dem.df2$CURRENT_AGE <- 0 # add the CURRENT_AGE column with 0 as a place
holder value
head(dem.df2)
```

```
## # A tibble: 6 × 6
##   PAT_MRN PAT_DOB    RACE                      ETHNICITY       SEX
CURRENT_AGE
##     <dbl> <chr>      <chr>                     <chr>           <chr>
<dbl>
## 1     923 4/5/2007   White                     Not Hispanic o… Fema…
0
## 2     942 9/1/2006   <NA>                      <NA>            Fema…
0
## 3     356 11/26/2000 White                     Not Hispanic o… Male
0
## 4     844 11/28/2004 Other                     Not Hispanic o… Fema…
0
## 5     675 3/3/2013   Black or African-American Not Hispanic o… Male
0
```

```
## 6     564 12/13/2013 White                       Not Hispanic o… Fema…
0

# create the date variable
as.Date

## function (x, ...)
## UseMethod("as.Date")
## <bytecode: 0x00000238c98cbde0>
## <environment: namespace:base>

install.packages("tidyr")

## Warning: package 'tidyr' is in use and will not be installed

library("tidyr")
dem.df2 %>% drop_na()

## # A tibble: 281 × 6
##    PAT_MRN PAT_DOB    RACE                       ETHNICITY      SEX
CURRENT_AGE
##      <dbl> <chr>      <chr>                      <chr>          <chr>
<dbl>
##  1     923 4/5/2007   White                      Not Hispanic … Fema…
0
##  2     356 11/26/2000 White                      Not Hispanic … Male
0
##  3     844 11/28/2004 Other                      Not Hispanic … Fema…
0
##  4     675 3/3/2013   Black or African-American Not Hispanic … Male
0
##  5     564 12/13/2013 White                      Not Hispanic … Fema…
0
##  6     758 11/16/2005 White                      Not Hispanic … Fema…
0
##  7     220 5/19/2002  White                      Not Hispanic … Male
0
##  8     686 10/16/2004 Black or African-American Not Hispanic … Fema…
0
##  9     728 8/6/2004   White                      Not Hispanic … Male
0
## 10     507 8/12/2001  White                      Not Hispanic … Fema…
0
## # ℹ 271 more rows

# solution: Missing value where true/false needed
library("eeptools")
dem.df2$CURRENT_AGE <- dem.df2$PAT_DOB # copy a column
library(lubridate)

##
## Attaching package: 'lubridate'
```

```
## The following object is masked from 'package:cowplot':
##
##     stamp

## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union

# make sure that the dates are in the same format
dem.df2$CURRENT_AGE <- as.Date(dem.df2$PAT_DOB, format = "%m/%d/%Y")
dem.df2$PAT_DOB <- as.Date(dem.df2$PAT_DOB, format = "%m/%d/%Y")
# convert to age in years
dem.df2$CURRENT_AGE <- age_calc(dem.df2$CURRENT_AGE, units = "years")
head(dem.df2)

## # A tibble: 6 × 6
##   PAT_MRN PAT_DOB    RACE                       ETHNICITY       SEX
CURRENT_AGE
##     <dbl> <date>     <chr>                      <chr>           <chr>
<dbl>
## 1     923 2007-04-05 White                      Not Hispanic o… Fema…
16.4
## 2     942 2006-09-01 <NA>                       <NA>            Fema…
16.9
## 3     356 2000-11-26 White                      Not Hispanic o… Male
22.7
## 4     844 2004-11-28 Other                      Not Hispanic o… Fema…
18.7
## 5     675 2013-03-03 Black or African-American Not Hispanic o… Male
10.4
## 6     564 2013-12-13 White                      Not Hispanic o… Fema…
9.66
```

Pulling specific data from a df

Extract all female patients ages greater than or equal to 10.

```
subset(dem.df2, SEX == 'Female' & CURRENT_AGE >= 10)

## # A tibble: 135 × 6
##    PAT_MRN PAT_DOB    RACE                       ETHNICITY      SEX
CURRENT_AGE
##      <dbl> <date>     <chr>                      <chr>          <chr>
<dbl>
##  1     923 2007-04-05 White                      Not Hispanic … Fema…
16.4
##  2     942 2006-09-01 <NA>                       <NA>           Fema…
16.9
##  3     844 2004-11-28 Other                      Not Hispanic … Fema…
18.7
```

```
##  4     758 2005-11-16 White                    Not Hispanic … Fema…
17.7
##  5     686 2004-10-16 Black or African-American Not Hispanic … Fema…
18.8
##  6     507 2001-08-12 White                    Not Hispanic … Fema…
22.0
##  7     964 2004-06-09 Other                    Not Hispanic … Fema…
19.2
##  8     203 2009-10-08 White                    Not Hispanic … Fema…
13.8
##  9     518 2013-06-22 White                    Not Hispanic … Fema…
10.1
## 10     895 2006-06-07 White                    Not Hispanic … Fema…
17.2
## # ℹ 125 more rows
```

Plots

Now we will work on creating plots. Plot patient "SEX".Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot. There are more complicated plot in the 'Simple Imputation' section.

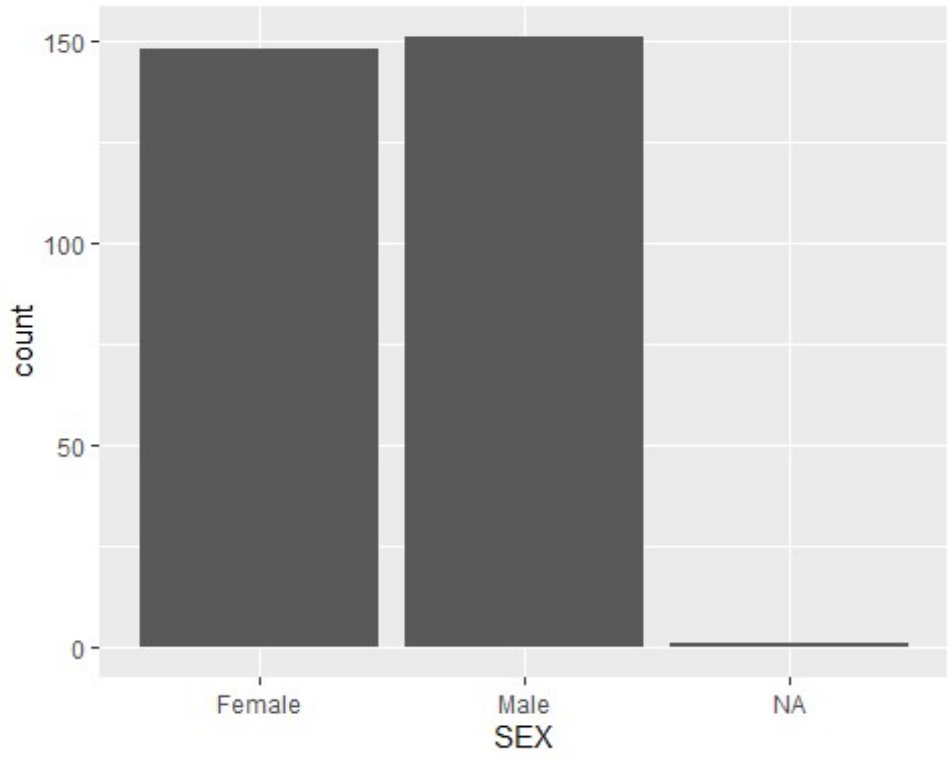
```
library("tidyverse")
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse
2.0.0 ──
## ✓ forcats 1.0.0     ✓ stringr 1.5.0
## ✓ purrr   1.0.1
## ── Conflicts ────────────────────────────────────────
tidyverse_conflicts() ──
## ✖ mice::filter()     masks dplyr::filter(), stats::filter()
## ✖ dplyr::lag()       masks stats::lag()
## ✖ lubridate::stamp() masks cowplot::stamp()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all
conflicts to become errors
```

```
dem.df2 %>% count(SEX)
```

```
## # A tibble: 3 × 2
##   SEX        n
##   <chr>  <int>
## 1 Female   148
## 2 Male     151
## 3 <NA>       1
```

```
ggplot(data = dem.df2) +
  geom_bar(mapping = aes(x = SEX)) # simple bar graph
```



Exporting data

This is the template to export data. `write.csv(DataFrame Name, "Path to export the DataFrame\\File Name.csv", row.names=FALSE)`

```
# Load readr package
library("readr")

write_csv(dem.df2, "new_patientdem.csv")
```

Resources

https://www.r-bloggers.com/2021/04/handling-missing-values-in-r/
https://stackoverflow.com/questions/27096485/change-a-column-from-birth-date-to-age-in-r <[https://sparkbyexamples.com/r-programming/r-subset-data-frame-with-examples/#:\~:text=If%20you%20wanted%20to%20get,variables)%20from%20the%20data%20frame.]>

<(https://sparkbyexamples.com/r-programming/r-subset-data-frame-with-examples/#:~:text=If%20you%20wanted%20to%20get,variables)%20from%20the%20data%20frame.){.uri}>

https://michaelgastner.com/R_for_QR/extracting-values-from-data-frames.html
https://community.rstudio.com/t/dplyr-way-s-and-base-r-way-s-of-creating-age-group-

from-age/89226/3 https://www.datanovia.com/en/lessons/subset-data-frame-rows-in-r/ https://r4ds.had.co.nz/data-visualisation.html
https://www.infoworld.com/article/3573577/how-to-count-by-groups-in-r.html
https://dplyr.tidyverse.org/reference/mutate.html

https://sparkbyexamples.com/r-programming/r-export-csv-using-write-csv/