

# Activity #14 My First QMD File

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2025-11-17

## data wrangling code for armed forces data

```
library(tidyverse) library(rvest) library(googlesheets4)
```

## scrape the ranked data

```
webRanks <- read_html("https://neilhatfield.github.io/Stat184_PayGradeRanks.html")
%>% html_elements(css = "table") %>% html_table()

rawRanks <- webRanks[[1]] # Extract the data frame of ranks
```

## wrangle ranked data

### clean data

```
rawRanks[1, 1] <- "Type" rankHeaders <- rawRanks[1, ] names(rawRanks) <- rankHeaders[1, ]
rawRanks <- rawRanks[-c(1, 26), ]
```

```
cleanRanks <- rawRanks %>% dplyr::select(!Type) %>% # Remove extra column
pivot_longer( cols = !Pay Grade, # The improper name requires backticks names_to =
"Branch", values_to = "Rank" ) %>% mutate( Rank = na_if(x = Rank, y = "-") )
```

```
#load the armed forces data gs4_deauth() forcesHeaders <- read_sheet( ss = "https://docs.google.com/spreadsheets/d/1cn4i0-ymB1ZytWXCwsJiq6fZ9PhGLUvbMBHlzqG4bwo/edit?usp=sharing", col_names = FALSE,
# Turn off Column Names n_max = 3 # read only the first three rows )
```

```
rawForces <- read_sheet( ss = "https://docs.google.com/spreadsheets/d/1cn4i0-ymB1ZytWXCwsJiq6fZ9PhGLUvbMBHlzqG4bwo/edit?usp=sharing", col_names = FALSE, # Turn off Column Names skip = 3, # Skip the first three rows
n_max = 28, # Read only the next 28 rows; drops footer col_types = "c" # Tells R to read
everything as character data )
```

## wrangle armed forces data

```
branchNames <- rep( # Create three copies of each branch x = c("Army", "Navy", "Marine  
Corps", "Air Force", "Space Force", "Total"), each = 3 ) tempHeaders <- paste( # Combine  
branch with other headers c(" ", branchNames), forcesHeaders[3,], sep = "." )
```

```
names(rawForces) <- tempHeaders
```

```
cleanForces <- rawForces %>% rename(Pay.Grade = .Pay Grade) %>% dplyr::select(!contains("Total"))  
%>% # Remove total columns filter(Pay.Grade != "Total Enlisted" & Pay.Grade != "Total  
Warrant Officers" & Pay.Grade != "Total Officers" & Pay.Grade != "Total") %>% # Remove  
total rows; see note below pivot_longer( # Reshape data cols = !Pay.Grade, names_to  
= "Branch.Sex", values_to = "Frequency" ) %>% separate_wider_delim( # Separate  
branches and sex cols = Branch.Sex, delim = ".", names = c("Branch", "Sex") ) %>%  
mutate( Frequency = na_if(Frequency, y = "N/A"), # Convert N/A to missing Frequency  
= parse_number(Frequency) # Parse values as numbers )
```

## merge the data frames

```
key_forcesRanks <- left_join( x = cleanForces, y = cleanRanks, by = join_by(Pay.Grade ==  
Pay Grade, Branch == Branch) )
```

## transform group to individual

```
key_individualRanks <- key_forcesRanks %>% filter(!is.na(Frequency)) %>% # Remove all  
cases with missing counts uncount( weights = Frequency )
```

```
altExample <- rawForces %>% rename(Pay.Grade = .Pay Grade) %>% filter(!grepl(pattern  
= "Total", x = Pay.Grade))
```

```
rawForces <- read_sheet( ss = "https://docs.google.com/spreadsheets/d/1cn4i0-ymB1ZytWXCwsJiq6fZ9PhGL  
col_names = FALSE, skip = 3, n_max = 28, na = c("N/A") # Tells R to treat the N/A as  
missing values
```

## visualization for armed forces

```
echo=FALSE  
library(tidyverse)
```

```
-- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
v dplyr      1.1.4      v readr      2.1.5
v forcats    1.0.1      v stringr    1.5.2
v ggplot2    4.0.0      v tibble     3.3.0
v lubridate  1.9.4      v tidyr      1.3.1
v purrr      1.1.0
-- Conflicts ----- tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()     masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become
```

```
library(rvest)
```

Attaching package: 'rvest'

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

```
guess_encoding
```

```
library(googlesheets4)
library(kableExtra)
```

Attaching package: 'kableExtra'

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

```
group_rows
```

```
# Scrape Rank Data
webRanks <- read_html("https://neilhatfield.github.io/Stat184_PayGradeRanks.html") %>%
  html_elements(css = "table") %>%
  html_table()

rawRanks <- webRanks[[1]] # Extract the data frame of ranks

# Wrangle Rank Data
## Enter a value in the first cell (1, 1)
rawRanks[1, 1] <- "Type"
## Extract actual column headers
```

```
rankHeaders <- rawRanks[1, ]
## Apply headers as column names
names(rawRanks) <- rankHeaders[1,]
```

Warning: The `value` argument of `names<-()` must be a character vector as of tibble 3.0.0.

```
## Remove redundant first row and last row
rawRanks <- rawRanks[-c(1, 26), ]

cleanRanks <- rawRanks %>%
  dplyr::select(!Type) %>% # Remove extra column
  pivot_longer(
    cols = !`Pay Grade`, # The improper name requires backticks
    names_to = "Branch",
    values_to = "Rank"
  ) %>%
  mutate(
    Rank = na_if(x = Rank, y = "--")
  )

# Load Armed Forces Data
gs4_deauth()
forcesHeaders <- read_sheet(
  ss = "https://docs.google.com/spreadsheets/d/1cn4i0-ymB1ZytWXCwsJiq6fZ9PhGLUvbMBH1zqG4bwo/c",
  col_names = FALSE, # Turn off Column Names
  n_max = 3 # read only the first three rows
)
```

v Reading from "US Armed Forces (6/2024)".  
v Range 'Sheet1'.  
New names:

```
rawForces <- read_sheet(
  ss = "https://docs.google.com/spreadsheets/d/1cn4i0-ymB1ZytWXCwsJiq6fZ9PhGLUvbMBH1zqG4bwo/c",
  col_names = FALSE,
  skip = 3,
  n_max = 28,
  col_types = "c"
)
```

```
v Reading from "US Armed Forces (6/2024)".
v Range '4:10000000'.
New names:
```

```
# wrangled armed forces data

branchNames <- rep(
  x = c("Army", "Navy", "Marine Corps", "Air Force", "Space Force", "Total"),
  each = 3
)
tempHeaders <- paste(
  c("", branchNames),
  forcesHeaders[3,],
  sep = "."
)

names(rawForces) <- tempHeaders

cleanForces <- rawForces %>%
  rename(Pay.Grade = `.Pay Grade`) %>%
  dplyr::select(!contains("Total")) %>% # Remove total columns
  filter(Pay.Grade != "Total Enlisted" &
    Pay.Grade != "Total Warrant Officers" &
    Pay.Grade != "Total Officers" &
    Pay.Grade != "Total") %>%

  pivot_longer(
    cols = !Pay.Grade,
    names_to = "Branch.Sex",
    values_to = "Frequency"
  ) %>%
  separate_wider_delim(
    cols = Branch.Sex,
    delim = ".",
    names = c("Branch", "Sex")
  ) %>%
  mutate(
    Frequency = na_if(Frequency, y = "N/A*"), # Convert N/A* to missing
    Frequency = parse_number(Frequency) # Parse values as numbers
  )

# merge dfs ----
```

```

key_forcesRanks <- left_join(
  x = cleanForces,
  y = cleanRanks,
  by = join_by(Pay.Grade == `Pay Grade`, Branch == Branch)
)

# transform group to individual ----
key_individualRanks <- key_forcesRanks %>%
  filter(!is.na(Frequency)) %>% # remove all cases with missing counts
  uncount(
    weights = Frequency
  )

altExample <- rawForces %>%
  rename(Pay.Grade = `.Pay Grade`) %>%
  filter(!grepl(pattern = "Total", x = Pay.Grade))

rawForces <- read_sheet(
  ss = "https://docs.google.com/spreadsheets/d/1cn4i0-ymB1ZytWXCwsJiq6fZ9PhGLUvbMBH1zqG4bwo/c",
  col_names = FALSE,
  skip = 3,
  n_max = 28,
  na = c("N/A*") # Tells R to treat the N/A* as missing values
)

```

v Reading from "US Armed Forces (6/2024)".  
v Range '4:10000000'.  
New names:

```
kable(key_forcesRanks, caption = "Armed Forces Visualization")
```

Table 1: Armed Forces Visualization

Pay.Grade	Branch	Sex	Frequency	Rank
E1	Army	Male	7909	Private
E1	Army	Female	1322	Private
E1	Navy	Male	9051	Seaman Recruit
E1	Navy	Female	2681	Seaman Recruit

Pay.	Grade	Branch	Sex	Frequency	Rank
E1		Marine Corps	Male	7233	Private
E1		Marine Corps	Female	659	Private
E1		Air Force	Male	6564	Airman Basic
E1		Air Force	Female	1607	Airman Basic
E1		Space Force	Male	177	Specialist 1
E1		Space Force	Female	30	Specialist 1
E2		Army	Male	18763	Private
E2		Army	Female	3383	Private
E2		Navy	Male	10969	Seaman Apprentice
E2		Navy	Female	3603	Seaman Apprentice
E2		Marine Corps	Male	14688	Private First Class
E2		Marine Corps	Female	1604	Private First Class
E2		Air Force	Male	6562	Airman
E2		Air Force	Female	1698	Airman
E2		Space Force	Male	159	Specalist 2
E2		Space Force	Female	33	Specalist 2
E3		Army	Male	38802	Private First Class
E3		Army	Female	8169	Private First Class
E3		Navy	Male	23430	Seaman
E3		Navy	Female	7493	Seaman
E3		Marine Corps	Male	35047	Lance Corporal
E3		Marine Corps	Female	3787	Lance Corporal
E3		Air Force	Male	34981	Airman First Class
E3		Air Force	Female	9891	Airman First Class
E3		Space Force	Male	797	Specialist 3
E3		Space Force	Female	210	Specialist 3
E4		Army	Male	81278	Corporal OR Specialist
E4		Army	Female	14619	Corporal OR Specialist
E4		Navy	Male	39241	Petty Officer Third Class

Pay.	Grade	Branch	Sex	Frequency	Rank
E4		Navy	Female	11855	Petty Officer Third Class
E4		Marine Corps	Male	28946	Corporal
E4		Marine Corps	Female	2942	Corporal
E4		Air Force	Male	52399	Senior Airman
E4		Air Force	Female	15324	Senior Airman
E4		Space Force	Male	598	Specialist 4
E4		Space Force	Female	134	Specialist 4
E5		Army	Male	55671	Sergeant
E5		Army	Female	11111	Sergeant
E5		Navy	Male	57238	Petty Officer Second Class
E5		Navy	Female	16254	Petty Officer Second Class
E5		Marine Corps	Male	21481	Sergeant
E5		Marine Corps	Female	2723	Sergeant
E5		Air Force	Male	42576	Staff Sergeant
E5		Air Force	Female	11038	Staff Sergeant
E5		Space Force	Male	901	Sergeant
E5		Space Force	Female	165	Sergeant
E6		Army	Male	50030	Staff Sergeant
E6		Army	Female	7432	Staff Sergeant
E6		Navy	Male	45749	Petty Officer First Class
E6		Navy	Female	9580	Petty Officer First Class
E6		Marine Corps	Male	11667	Staff Sergeant
E6		Marine Corps	Female	1370	Staff Sergeant
E6		Air Force	Male	32242	Technical Sergeant
E6		Air Force	Female	6746	Technical Sergeant
E6		Space Force	Male	696	Technical Sergeant
E6		Space Force	Female	130	Technical Sergeant
E7		Army	Male	30367	Sergeant First Class
E7		Army	Female	4322	Sergeant First Class



Pay.	Grade	Branch	Sex	Frequency	Rank
E7		Navy	Male	18026	Chief Petty Officer
E7		Navy	Female	3098	Chief Petty Officer
E7		Marine Corps	Male	8191	Gunnery Sergeant
E7		Marine Corps	Female	760	Gunnery Sergeant
E7		Air Force	Male	18367	Master Sergeant OR First Sergeant
E7		Air Force	Female	4717	Master Sergeant OR First Sergeant
E7		Space Force	Male	517	Master Sergeant
E7		Space Force	Female	110	Master Sergeant
E8		Army	Male	9287	First Sergeant OR Master Sergeant
E8		Army	Female	1426	First Sergeant OR Master Sergeant
E8		Navy	Male	6500	Senior Chief Petty Officer
E8		Navy	Female	912	Senior Chief Petty Officer
E8		Marine Corps	Male	3559	First Sergeant OR Master Sergeant
E8		Marine Corps	Female	275	First Sergeant OR Master Sergeant
E8		Air Force	Male	3632	Senior Master Sergeant OR First Sergeant
E8		Air Force	Female	1133	Senior Master Sergeant OR First Sergeant
E8		Space Force	Male	100	Senior Master Sergeant
E8		Space Force	Female	38	Senior Master Sergeant
E9		Army	Male	2908	Sergeant Major OR Command Sergeant Major
E9		Army	Female	413	Sergeant Major OR Command Sergeant Major
E9		Navy	Male	2518	Master Chief Petty Officer OR Fleet/Command Master Chief Petty Officer
E9		Navy	Female	323	Master Chief Petty Officer OR Fleet/Command Master Chief Petty Officer
E9		Marine Corps	Male	1518	Sergeant Major OR Master Gunnery Sergeant
E9		Marine Corps	Female	83	Sergeant Major OR Master Gunnery Sergeant
E9		Air Force	Male	1956	Chief Master Sergeant OR First Sergeant
E9		Air Force	Female	506	Chief Master Sergeant OR First Sergeant
E9		Space Force	Male	37	Chief Master Sergeant

Pay.	Grade	Branch	Sex	Frequency	Rank
E9		Space Force	Female	12	Chief Master Sergeant
W1		Army	Male	3817	Warrant Officer
W1		Army	Female	399	Warrant Officer
W1		Navy	Male	30	Warrant Officer
W1		Navy	Female	3	Warrant Officer
W1		Marine Corps	Male	483	Warrant Officer
W1		Marine Corps	Female	48	Warrant Officer
W1		Air Force	Male	NA	Warrent Officer
W1		Air Force	Female	NA	Warrent Officer
W1		Space Force	Male	NA	NA
W1		Space Force	Female	NA	NA
W2		Army	Male	5398	Chief Warrant Officer
W2		Army	Female	653	Chief Warrant Officer
W2		Navy	Male	615	Chief Warrant Officer
W2		Navy	Female	96	Chief Warrant Officer
W2		Marine Corps	Male	738	Chief Warrant Officer
W2		Marine Corps	Female	47	Chief Warrant Officer
W2		Air Force	Male	NA	Chief Warrent Officer
W2		Air Force	Female	NA	Chief Warrent Officer
W2		Space Force	Male	NA	NA
W2		Space Force	Female	NA	NA
W3		Army	Male	2826	Chief Warrant Officer
W3		Army	Female	316	Chief Warrant Officer
W3		Navy	Male	734	Chief Warrant Officer
W3		Navy	Female	102	Chief Warrant Officer
W3		Marine Corps	Male	538	Chief Warrant Officer
W3		Marine Corps	Female	32	Chief Warrant Officer
W3		Air Force	Male	NA	Chief Warrent Officer
W3		Air Force	Female	NA	Chief Warrent Officer

Pay.	Grade	Branch	Sex	Frequency	Rank
W3		Space Force	Male	NA	NA
W3		Space Force	Female	NA	NA
W4		Army	Male	1532	Chief Warrant Officer
W4		Army	Female	149	Chief Warrant Officer
W4		Navy	Male	416	Chief Warrant Officer
W4		Navy	Female	42	Chief Warrant Officer
W4		Marine Corps	Male	265	Chief Warrant Officer
W4		Marine Corps	Female	11	Chief Warrant Officer
W4		Air Force	Male	NA	Chief Warrent Officer
W4		Air Force	Female	NA	Chief Warrent Officer
W4		Space Force	Male	NA	NA
W4		Space Force	Female	NA	NA
W5		Army	Male	514	Chief Warrant Officer
W5		Army	Female	47	Chief Warrant Officer
W5		Navy	Male	69	Chief Warrant Officer
W5		Navy	Female	5	Chief Warrant Officer
W5		Marine Corps	Male	103	Chief Warrant Officer
W5		Marine Corps	Female	8	Chief Warrant Officer
W5		Air Force	Male	NA	Chief Warrent Officer
W5		Air Force	Female	NA	Chief Warrent Officer
W5		Space Force	Male	NA	NA
W5		Space Force	Female	NA	NA
O1		Army	Male	7153	Second Lieutenant
O1		Army	Female	2358	Second Lieutenant
O1		Navy	Male	5012	Ensign
O1		Navy	Female	1545	Ensign
O1		Marine Corps	Male	2292	Second Lieutenant
O1		Marine Corps	Female	370	Second Lieutenant
O1		Air Force	Male	4867	Second Lieutenant

Pay.	Grade	Branch	Sex	Frequency	Rank
O1		Air Force	Female	1897	Second Lieutenant
O1		Space Force	Male	387	Second Lieutenant
O1		Space Force	Female	137	Second Lieutenant
O2		Army	Male	10013	First Lieutenant
O2		Army	Female	3093	First Lieutenant
O2		Navy	Male	5640	Lieutenant Junior Grade
O2		Navy	Female	1769	Lieutenant Junior Grade
O2		Marine Corps	Male	3377	First Lieutenant
O2		Marine Corps	Female	574	First Lieutenant
O2		Air Force	Male	4993	First Lieutenant
O2		Air Force	Female	1889	First Lieutenant
O2		Space Force	Male	409	First Lieutenant
O2		Space Force	Female	160	First Lieutenant
O3		Army	Male	20694	Captain
O3		Army	Female	5739	Captain
O3		Navy	Male	14825	Lieutenant
O3		Navy	Female	4825	Lieutenant
O3		Marine Corps	Male	5298	Captain
O3		Marine Corps	Female	624	Captain
O3		Air Force	Male	15532	Captain
O3		Air Force	Female	5362	Captain
O3		Space Force	Male	1032	Captain
O3		Space Force	Female	246	Captain
O4		Army	Male	12758	Major
O4		Army	Female	3002	Major
O4		Navy	Male	8085	Lieutenant Commander
O4		Navy	Female	2217	Lieutenant Commander
O4		Marine Corps	Male	3610	Major
O4		Marine Corps	Female	333	Major

Pay.	Grade	Branch	Sex	Frequency	Rank
O4		Air Force	Male	10045	Major
O4		Air Force	Female	3395	Major
O4		Space Force	Male	951	Major
O4		Space Force	Female	196	Major
O5		Army	Male	6969	Lieutenant Colonel
O5		Army	Female	1539	Lieutenant Colonel
O5		Navy	Male	5478	Commandar
O5		Navy	Female	1040	Commandar
O5		Marine Corps	Male	1809	Lieutenant Colonel
O5		Marine Corps	Female	138	Lieutenant Colonel
O5		Air Force	Male	7459	Lieutenant Colonel
O5		Air Force	Female	1804	Lieutenant Colonel
O5		Space Force	Male	620	Lieutenant Colonel
O5		Space Force	Female	124	Lieutenant Colonel
O6		Army	Male	3084	Colonel
O6		Army	Female	588	Colonel
O6		Navy	Male	2613	Captain
O6		Navy	Female	421	Captain
O6		Marine Corps	Male	660	Colonel
O6		Marine Corps	Female	49	Colonel
O6		Air Force	Male	2658	Colonel
O6		Air Force	Female	544	Colonel
O6		Space Force	Male	203	Colonel
O6		Space Force	Female	33	Colonel
O7		Army	Male	87	Brigadier General
O7		Army	Female	18	Brigadier General
O7		Navy	Male	90	Rear Admiral (Lower)
O7		Navy	Female	7	Rear Admiral (Lower)
O7		Marine Corps	Male	37	Brigadier General

Pay.	Grade	Branch	Sex	Frequency	Rank
O7		Marine Corps	Female	2	Brigadier General
O7		Air Force	Male	91	Brigadier General
O7		Air Force	Female	14	Brigadier General
O7		Space Force	Male	11	Brigadier General
O7		Space Force	Female	1	Brigadier General
O8		Army	Male	100	Major General
O8		Army	Female	7	Major General
O8		Navy	Male	67	Rear Admiral (Upper)
O8		Navy	Female	3	Rear Admiral (Upper)
O8		Marine Corps	Male	30	Major General
O8		Marine Corps	Female	2	Major General
O8		Air Force	Male	68	Major General
O8		Air Force	Female	8	Major General
O8		Space Force	Male	9	Major General
O8		Space Force	Female	0	Major General
O9		Army	Male	41	Lieutenant General
O9		Army	Female	8	Lieutenant General
O9		Navy	Male	32	Vice Admiral
O9		Navy	Female	4	Vice Admiral
O9		Marine Corps	Male	18	Lieutenant General
O9		Marine Corps	Female	0	Lieutenant General
O9		Air Force	Male	33	Lieutenant General
O9		Air Force	Female	6	Lieutenant General
O9		Space Force	Male	4	Lieutenant General
O9		Space Force	Female	1	Lieutenant General
O10		Army	Male	12	General
O10		Army	Female	1	General
O10		Navy	Male	7	Admiral
O10		Navy	Female	1	Admiral

PayGrade	Branch	Sex	Frequency	Rank
O10	Marine Corps	Male	3	General
O10	Marine Corps	Female	0	General
O10	Air Force	Male	12	General
O10	Air Force	Female	1	General
O10	Space Force	Male	3	General
O10	Space Force	Female	0	General

## narrative text for armed forces

The visualization presents a table showing military branch, personnel sex, pay grade, and frequency counts. While it includes ratios between men and women, sex and rank are independent variables, so differences between them do not imply causation. Even so, the table highlights several key insights. For example, the Army consistently has the largest number of personnel, while the Air Force and Space Force have the smallest. By illustrating these differences across service branches, the data offers useful context for understanding shifts in overall military composition.

## popularity of the baby names

### code for pop baby names

```
library(ggplot2) library(dplyr) library(tidyverse)

instructors <- c("Mabel", "Bessie", "Catherine", "Elizabeth")

subsetNames <- BabyNames %>% filter(name %in% instructors) %>% group_by(name, year)
%>% summarize( total = sum(count), .groups = "drop")
```

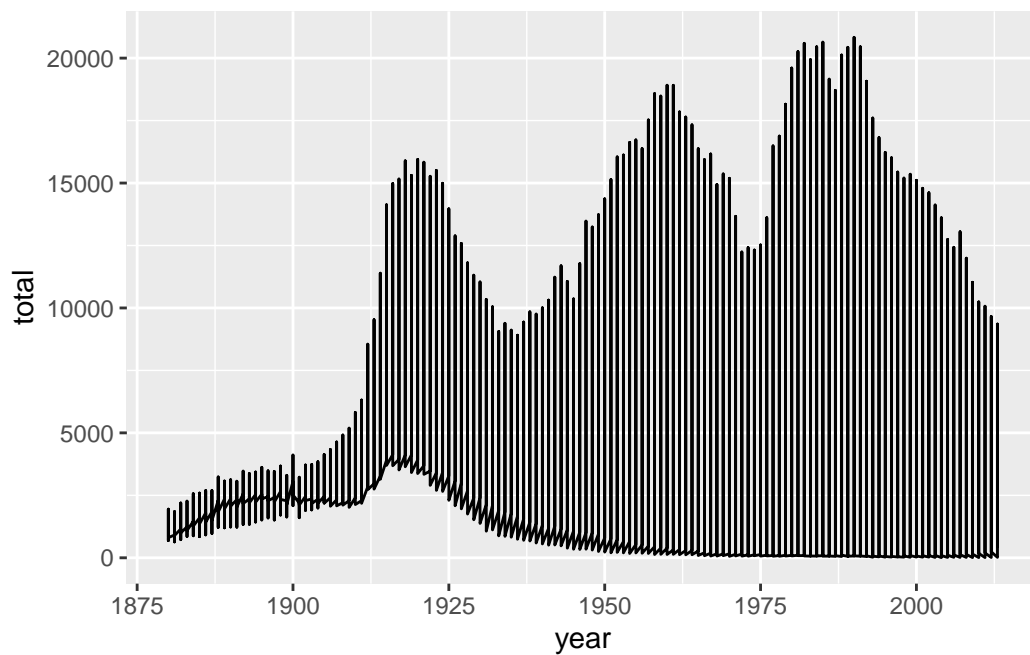
## visualization for popular baby names

```
echo=FALSE

library(ggplot2)
library(dplyr)
library(tidyverse)
library(dcData)
data("BabyNames")

instructors <- c("Mabel", "Bessie", "Catherine", "Elizabeth")

subsetNames <- BabyNames %>%
  filter(name %in% instructors) %>%
  group_by(name, year) %>%
  summarize(
    total = sum(count),
    .groups = "drop"
  )
ggplot(subsetNames, mapping = aes(x = year, y = total))
  + geom_line()
```





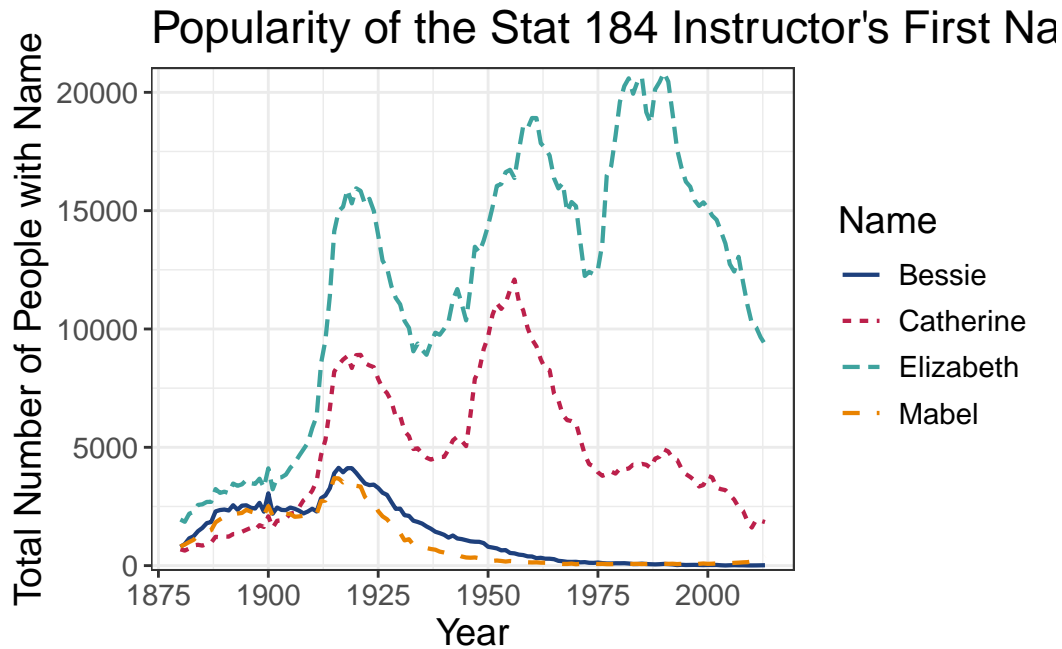
```

psuPalette <- c("#1E407C", "#BC204B", "#3EA39E", "#E98300",
               "#999999", "#AC8DCE", "#F2665E", "#99CC00")

ggplot(subsetName, mapping = aes(
  x = year,
  y = total,
  color = name,
  linetype = name
)) + geom_line(linewidth = 0.75) +
labs(
  title = "Popularity of the Stat 184 Instructor's First Names Over Time",
  x = "Year",
  y = "Total Number of People with Name",
  color = "Name",
  linetype = "Name"
) + scale_y_continuous(
  expand = expansion(mult = 0.01)
) + scale_color_manual(
  values = psuPalette
) +
theme_bw() +
theme(
  text = element_text(size = 14),
  legend.kermy.size = unit(1, "cm")
)

```

Warning in plot\_theme(plot): The `legend.kermy.size` theme element is not defined in the element hierarchy.



## narrative text for popular baby names

alt text: Displaying multiple line graphs on a single plot to show the total number of people with each name across different years.

long description: This visualization presents data for various given names over time. It includes four names and the specific years in which each was recorded. The line graph illustrates how often each name was used in those years. Each line corresponds to a different name, as shown in the legend. The lines reflect different patterns of change—some names rise again in popularity, others show steady declines, and some display fluctuating trends throughout the timeline.

brief paragraph: This data visualization shows how many individuals were given a particular name in each year. It plots a separate line for every name, allowing viewers to see how the popularity of each name changes and grows over time.

## plotting the mathematical function

## code for the box problem

---

```
volume_box <- function(x){ vol <- (48-2x)(32-2x)(x) return(vol) }
```

---

## visualization for box problem

```
library(ggplot2)

volume_box <- function(x){
  vol <- (48-2*x)*(32-2*x)*(x)
  return(vol)
}

#if we want to see max volume at what x
x_vals <- seq(0, 18, 0.01)
volumes <- volume_box(x_vals)
max_volume <- max(volumes)
best_x <- x_vals[which.max(volumes)]

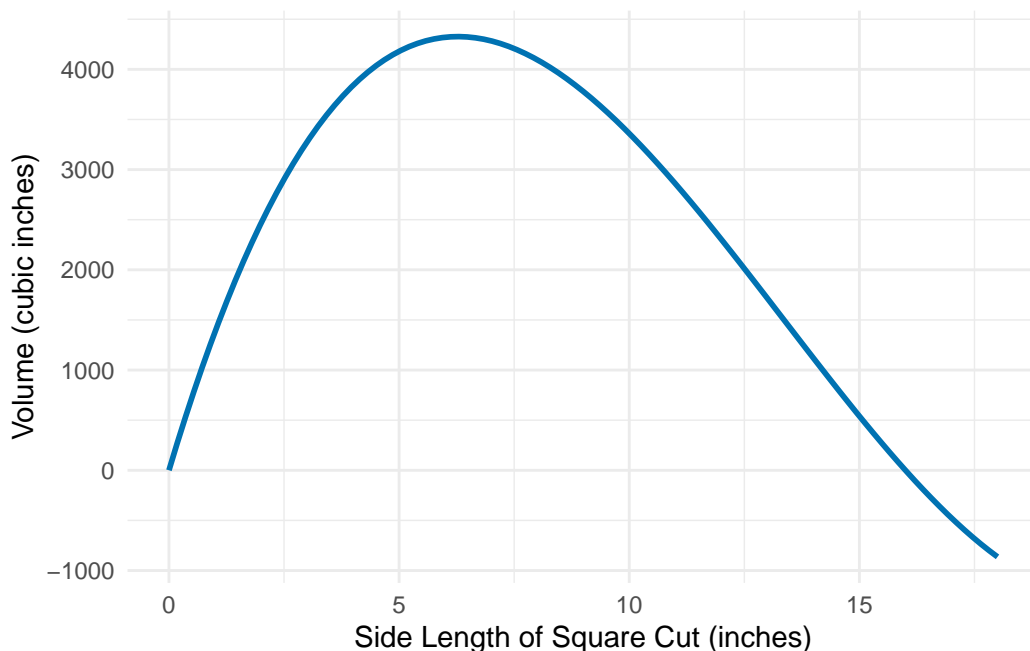
max_volume
```

```
[1] 4326.629
```

```
best_x
```

```
[1] 6.28
```

```
# create the plot
ggplot(data = data.frame(x = c(0, 18)), aes(x = x)) + # x ranges from 0 to half the smallest
  stat_function(fun = volume_box, color = "#0072B2", linewidth = 1) +
  labs(
    x = "Side Length of Square Cut (inches)",
    y = "Volume (cubic inches)"
  ) +
  theme_minimal()
```



## narrative text for box problem

The plot shows how the volume of a box with an open top changes as the side length  $x$  of the square cut from each corner increases. At first, as  $x$  increases from 0, the volume increases because the box gets taller, but beyond a certain point, the volume decreases because the base becomes too small.

For a  $36 \times 48$  inch piece of paper, the maximum volume occurs when  $x = 6.28$  inches, which gives a maximum volume of 4326.629 cubic inches. This visualization helps us see that the optimal side length balances the height of the box with the area of the base to maximize volume.

## What You've Learned So Far

So far in this activity, I've learned how to use R more, especially when it comes to working with real datasets. I got practice pulling data from the web, cleaning it up, and reshaping it into something usable. I also learned how to make clearer visualizations with ggplot2 and how to explain them using alt text and short descriptions. On top of that, writing a custom function for the box problem helped me see how R can be used to explore a mathematical idea and graph it. Overall, I've definitely gotten more comfortable using R to wrangle data, make plots, and communicate what the visuals show.