

Problem set 3

2025-02-02

Max points: 12.

In the next problem set, we plan to explore the relationship between COVID-19 death rates and vaccination rates across US states by visually examining their correlation. This analysis will involve gathering COVID-19 related data from the CDC's API and then extensively processing it to merge the various datasets. Since the population sizes of states vary significantly, we will focus on comparing rates rather than absolute numbers. To facilitate this, we will also source population data from the US Census to accurately calculate these rates.

In this problem set we will learn how to extract and wrangle data from the data US Census and CDC APIs.

All answers should be submitted in `pset-03-wrangling.qmd`. Be sure to include a rendered version of your file and a raw code file that successfully would render on a new computer.

1. (1 point) Get an API key from the US Census at https://api.census.gov/data/key_signup.html. You can't share this public key. But your code has to run on a TFs computer. Assume the TF will have a file in their working directory (i.e. in the `BIOSTAT620_pset_sol/p3/` directory, assuming that you place `pset-03-wrangling.qmd` in the `BIOSTAT620_pset_sol/p3/` folder) named `census-key.R` with the following one line of code:

```
census_key <- "A_CENSUS_KEY_THAT_WORKS"
```

Write a first line of code for your problem set that defines `census_key` by running the code in the file `census-key.R`.

```
# Load the file where the API Key is stored  
source("census-key.R")
```

2. (1 point) The [US Census API User Guide](#) provides details on how to leverage this valuable resource. We are interested in vintage population estimates for years 2021 and 2022. From the documentation we find that the *endpoint* is:

```
# 2. Construct GET request using httr2

url <- "https://api.census.gov/data/2021/pep/population"
```

Use the **httr2** package to construct the following GET request.

`https://api.census.gov/data/2021/pep/population?get=POP_2020,POP_2021,NAME&for=state:*&key=Y`

Create an object called `request` of class `httr2_request` with this URL as an endpoint. Print out `request` to check that the URL matches what we want.

```
# 2. Construct GET request using httr2
# Define the API URL
url <- "https://api.census.gov/data/2021/pep/population"

library(httr2)

# Make the API request
request <- request(url) %>%
  req_url_query(get = "POP_2020,POP_2021,NAME", `for` = "state:", key = census_key)

# Perform the request and check the response
response <- request %>% req_perform()

# Check the status code
status_code <- resp_status(response)
print(paste("Status Code:", status_code))
```

```
[1] "Status Code: 200"
```

```
# Print the response content
content <- response %>% resp_body_string()
print(content)
```

```
[1] "[[\"POP_2020\\\", \"POP_2021\\\", \"NAME\\\", \"state\\\"],\n[\"3962031\\\", \"3986639\\\", \"Oklahoma\\\""
```

3. (1 point) Make a request to the US Census API using the `request` object. Save the response to an object named `response`, and print it out here. Check the response status of your request and make sure it was successful. You can learn about *status codes* [here](#).

```
response <- request %>% req_perform()

status_code <- resp_status(response)
print(paste("Status Code:", status_code))
```

```
[1] "Status Code: 200"
```

4. (1 point) Use a function from the **httr2** package to determine the content type of your response (print it out).

```
content_type <- resp_content_type(response)
print(paste("Content Type:", content_type))
```

```
[1] "Content Type: application/json"
```

5. (1 point) Use just one line of code and one function to extract the data into a matrix. Print out the first few rows of the matrix (title: `population`). Hints: 1) Use the `resp_body_json` function. 2) The first row of the matrix will be the variable names and this OK as we will fix in the next exercise.

```
population_list <- response %>%
  resp_body_json()

population_df <- as.data.frame(do.call(rbind, population_list))
head(population_df)
```

	V1	V2	V3	V4
1	POP_2020	POP_2021	NAME	state
2	3962031	3986639	Oklahoma	40
3	1961455	1963692	Nebraska	31
4	1451911	1441553	Hawaii	15
5	887099	895376	South Dakota	46
6	6920119	6975218	Tennessee	47

6. (1 point) Examine the `population` matrix you just created. Notice that 1) it is not tidy, 2) the column types are not what we want, and 3) the first row is a header. Convert `population` to a tidy dataset. Remove the state ID column and change the name of the column with state names to `state_name`. Add a column with state abbreviations called `state`. Make sure you assign the abbreviations for DC and PR correctly. Hint: Use the `janitor` package to make the first row the header. Print out the first few rows of your cleaned dataset.

```
library(tidyverse)
```

```
-- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
v dplyr      1.1.4      v readr      2.1.5
v forcats    1.0.0      v stringr    1.5.1
v ggplot2    3.5.1      v tibble     3.2.1
v lubridate  1.9.3      v tidyr      1.3.1
v purrr      1.0.2
-- 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(janitor)
```

Attaching package: 'janitor'

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

`chisq.test`, `fisher.test`

```
population_clean <- population_df %>%
  as_tibble() %>%
  row_to_names(row_number = 1)

# remove state column
population_clean <- population_clean %>%
  select(-state)

# rename NAME column to state_name
population_clean <- population_clean %>%
  rename(state_name = NAME)
```

```

# parse all relevant columns to numeric
population_clean <- population_clean %>%
  mutate(
    POP_2020 = as.numeric(POP_2020),
    POP_2021 = as.numeric(POP_2021)
  )

# add state abbreviations using state.abb variable mapped from the state.name variable
population_clean <- population_clean %>%
  mutate(
    state_abb = state.abb[match(state_name, state.name)],
    state_abb = case_when(
      state_name == "District of Columbia" ~ "DC",
      state_name == "Puerto Rico" ~ "PR",
      TRUE ~ state_abb
    )
  )

population_clean <- population_clean %>%
  mutate(state_name = sapply(state_name, as.character))

head(population_clean)

```

```

# A tibble: 6 x 4
  POP_2020 POP_2021 state_name state_abb
    <dbl>    <dbl> <chr>      <chr>
1  3962031  3986639 Oklahoma    OK
2  1961455  1963692 Nebraska    NE
3  1451911  1441553 Hawaii      HI
4   887099   895376 South Dakota SD
5  6920119  6975218 Tennessee  TN
6  3114071  3143991 Nevada      NV

```

7. (1 point) As a check, make a barplot of states' 2021 and 2022 populations. Show the state names in the y-axis ordered by descending population size. Hint: You will need to use `facet_wrap`.

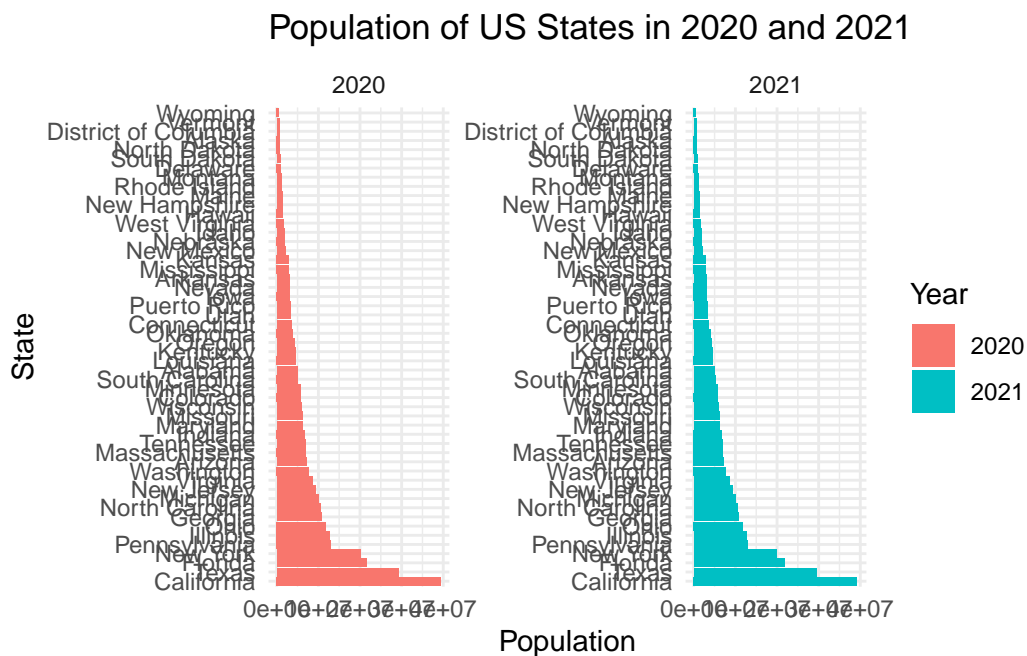
```

population_long <- population_clean %>%
  pivot_longer(cols = c(POP_2020, POP_2021),
    names_to = "Year",
    values_to = "Population") %>%

```

```
mutate(Year = gsub("POP_", "", Year)) %>%
  arrange(desc(Population))
```

```
ggplot(population_long, aes(x = reorder(state_name, -Population), y = Population, fill = Year)) +
  geom_col(position = "dodge") +
  coord_flip() +
  facet_wrap(~Year, scales = "free_y") +
  labs(title = "Population of US States in 2020 and 2021",
       x = "State",
       y = "Population") +
  theme_minimal()
```



```
head(population_long, 10)
```

```
# A tibble: 10 x 4
  state_name state_abbr Year Population
  <chr>      <chr>   <chr>    <dbl>
1 California CA      2020    39499738
2 California CA      2021    39237836
3 Texas     TX      2021    29527941
4 Texas     TX      2020    29217653
```

5	Florida	FL	2021	21781128
6	Florida	FL	2020	21569932
7	New York	NY	2020	20154933
8	New York	NY	2021	19835913
9	Pennsylvania	PA	2020	12989625
10	Pennsylvania	PA	2021	12964056

8. (1 point) The following URL:

```
url <- "https://github.com/datasciencelabs/2024/raw/refs/heads/main/data/regions.json"
```

points to a JSON file that lists the states in the 10 Public Health Service (PHS) defined by CDC. We want to add these regions to the `population` dataset. To facilitate this create a data frame called `regions` that has two columns `state_name`, `region`, `region_name`. One of the regions has a long name. Change it to something shorter. Print the first few rows of regions. Make sure that the region is a factor.

```
library(jsonlite)
```

Attaching package: 'jsonlite'

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

```
flatten
```

```
library(purrr)
```

```
library(tidyverse)
```

```
url_regions <- "https://github.com/datasciencelabs/2024/raw/refs/heads/main/data/regions.json"
```

```
regions_data <- fromJSON(url_regions)
```

```
head(regions_data)
```

	region	region_name
1	1	New England
2	2	New York and New Jersey, Puerto Rico, Virgin Islands
3	3	Mid-Atlantic
4	4	Southeast

5	5	Midwest
6	6	South Central

states

1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
2	New Jersey, New York, Puerto Rico, Virgin Islands
3	Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia
4	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee
5	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin
6	Arkansas, Louisiana, New Mexico, Oklahoma, Texas

```
regions_clean <- regions_data %>%
  unnest(cols = c(states)) %>%
  rename(state_name = states)

head(regions_clean)
```

```
# A tibble: 6 x 3
  region region_name state_name
<list>   <chr>      <chr>
1 <int [1]> New England Connecticut
2 <int [1]> New England Maine
3 <int [1]> New England Massachusetts
4 <int [1]> New England New Hampshire
5 <int [1]> New England Rhode Island
6 <int [1]> New England Vermont
```

```
regions_clean <- regions_clean %>%
  mutate(region_name = case_when(
    region_name == "East South Central" ~ "ESC",
    TRUE ~ region_name
  ))

regions_clean <- regions_clean %>%
  mutate(region_name = as.factor(region_name))

head(regions_clean)
```

```
# A tibble: 6 x 3
  region region_name state_name
<list>   <fct>      <chr>
1 <int [1]> New England Connecticut
```



```

2 <int [1]> New England Maine
3 <int [1]> New England Massachusetts
4 <int [1]> New England New Hampshire
5 <int [1]> New England Rhode Island
6 <int [1]> New England Vermont

```

9. (1 point) Add a region and region name columns to the `population` data frame using the joining methods we have learned. Print out the first few rows.

```

population_with_region <- population_clean %>%
  left_join(regions_clean, by = "state_name")

# Convert region columns to integer types
population_with_region <- population_with_region %>%
  mutate(region = as.integer(unlist(region)))

head(population_with_region)

```

```

# A tibble: 6 x 6
  POP_2020 POP_2021 state_name  state_abbr region region_name
    <dbl>    <dbl> <chr>      <chr>      <int> <fct>
1  3962031  3986639 Oklahoma    OK          6 South Central
2  1961455  1963692 Nebraska    NE          7 Central Plains
3  1451911  1441553 Hawaii      HI          9 Pacific
4   887099   895376 South Dakota SD          8 Mountain States
5  6920119  6975218 Tennessee  TN          4 Southeast
6  3114071  3143991 Nevada      NV          9 Pacific

```

10. (1 point) From reading <https://data.cdc.gov/> we learn the endpoint <https://data.cdc.gov/resource/pwn4-m3yp.json> provides state level data from SARS-COV2 cases. Use the **httr2** tools you have learned to download this into a data frame. Is all the data there? If not, comment on why.

```

# Load required library
library(httr2)
library(jsonlite)
library(dplyr)

# Define API endpoint
api <- "https://data.cdc.gov/resource/pwn4-m3yp.json"

# Send GET request and retrieve response
cases_raw <- request(api) |>

```

```
req_perform() |>
  resp_body_json(simplifyVector = TRUE) |>
  as_tibble()
```

```
# Print first few rows to check data
```

```
head(cases_raw)
```

```
# A tibble: 6 x 10
```

	date_updated <chr>	state <chr>	start_date <chr>	end_date <chr>	tot_cases <chr>	new_cases <chr>	tot_deaths <chr>
1	2023-02-23T00:00:00.~	AZ	2023-02-1~	2023-02~	2434631.0	3716.0	33042.0
2	2022-12-22T00:00:00.~	LA	2022-12-1~	2022-12~	1507707.0	4041.0	18345.0
3	2023-02-23T00:00:00.~	GA	2023-02-1~	2023-02~	3061141.0	5298.0	42324.0
4	2023-03-30T00:00:00.~	LA	2023-03-2~	2023-03~	1588259.0	2203.0	18858.0
5	2023-02-02T00:00:00.~	LA	2023-01-2~	2023-02~	1548508.0	5725.0	18572.0
6	2023-03-23T00:00:00.~	LA	2023-03-1~	2023-03~	1580709.0	1961.0	18835.0

```
# i 3 more variables: new_deaths <chr>, new_historic_cases <chr>,
```

```
# new_historic_deaths <chr>
```

11. (1 point) The reason you see exactly 1,000 rows is because CDC has a default limit. You can change this limit by adding `$limit=10000000000` to the request. Rewrite the previous request to ensure that you receive all the data. Then wrangle the resulting data frame to produce a data frame with columns `state`, `date` (should be the end date) and `cases`. Make sure the cases are numeric and the dates are in `Date` ISO-8601 format. Print out the first several rows.

```
# Load required libraries
```

```
library(httr2)
```

```
library(jsonlite)
```

```
library(dplyr)
```

```
library(lubridate)
```

```
# Define API endpoint with an increased limit
```

```
api <- "https://data.cdc.gov/resource/pwn4-m3yp.json?$limit=10000000000"
```

```
# Send GET request and retrieve response
```

```
cases_raw <- request(api) |>
```

```
  req_perform() |>
```

```
  resp_body_json(simplifyVector = TRUE) |>
```

```
  as_tibble()
```

```
# Print column names to confirm available data
print(colnames(cases_raw))
```

```
[1] "date_updated"      "state"              "start_date"
[4] "end_date"          "tot_cases"          "new_cases"
[7] "tot_deaths"        "new_deaths"         "new_historic_cases"
[10] "new_historic_deaths"
```

```
# Ensure correct column names
cases_cleaned <- cases_raw |>
  select(state, end_date, new_cases) |> # Use `new_cases` instead of `new_case`
  rename(date = end_date, cases = new_cases) |>
  mutate(
    cases = as.numeric(cases), # Convert cases to numeric
    date = as.Date(date)       # Convert date to Date format (ISO-8601)
  )

# Print first few rows to verify
head(cases_cleaned)
```

```
# A tibble: 6 x 3
  state date      cases
  <chr> <date>    <dbl>
1 AZ    2023-02-22  3716
2 LA    2022-12-21  4041
3 GA    2023-02-22  5298
4 LA    2023-03-29  2203
5 LA    2023-02-01  5725
6 LA    2023-03-22  1961
```

12. (1 point) For 2020 and 2021, make a time series plot of cases per 100,000 versus time for each state. Stratify the plot by region name and make a separate line plot for each state. Don't use colors for this plot, but set `alpha = 0.2` to make the plots more easily visible. Make sure to label your graph appropriately.

```
library(ggplot2)
library(dplyr)

cases_normalized <- cases_cleaned %>%
  left_join(population_with_region, by = c("state" = "state_abbr")) %>%
```

```

mutate(
  cases_per_100k = (cases / POP_2021) * 100000
)

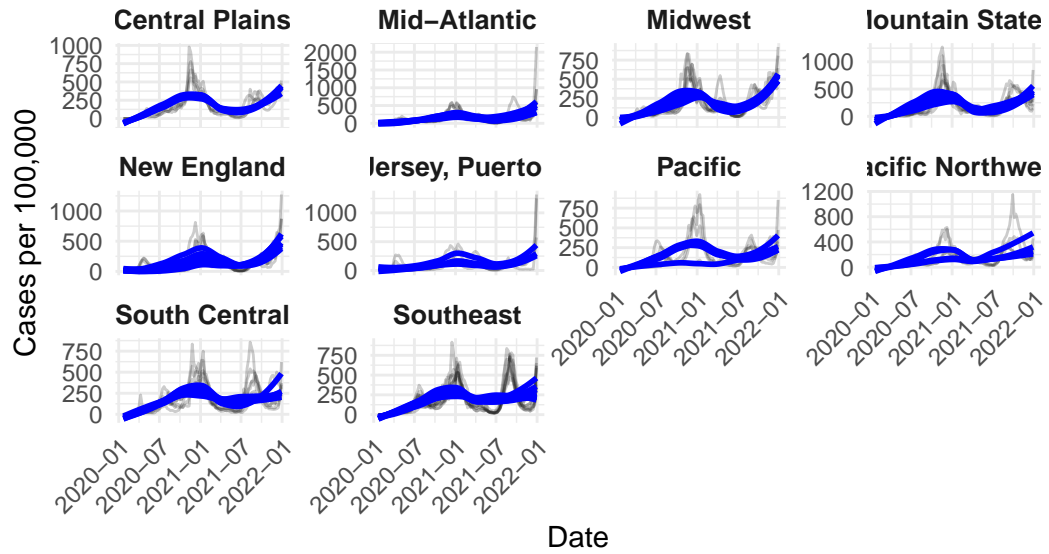
cases_filtered <- cases_normalized %>%
  filter(!is.na(cases_per_100k)) %>%
  filter(format(date, "%Y") %in% c("2020", "2021"))

ggplot(cases_filtered, aes(x = date, y = cases_per_100k, group = state)) +
  geom_line(alpha = 0.2) +
  facet_wrap(~ region_name, scales = "free_y") +
  labs(
    title = "COVID-19 Cases per 100,000 Population (2020-2021)",
    x = "Date",
    y = "Cases per 100,000",
    caption = "Data Source: CDC"
  ) +
  theme_minimal() +
  theme(
    strip.text = element_text(size = 10, face = "bold"),
    axis.text.x = element_text(angle = 45, hjust = 1)
  ) +
  geom_smooth(se = FALSE, color = "blue", alpha = 0.3)

```

`geom_smooth()` using method = 'loess' and formula = 'y ~ x'

COVID-19 Cases per 100,000 Population (2020–2021)



Data Source: CDC