SDS192 Lab 6

Solutions

Introduction

In this lab, we will study the financial relationships between medical drug and device companies and certain healthcare providers in MA using the Center for Medicare and Medicaid Service's Open Payments Dataset. Specifically, we will determine which ten Massachusetts-based doctors received the most money from medical drug or device manufacturers in 2021. Then we will leverage our custom functions to produce a number of tables and plots documenting information about the payments made to each of these doctors. In doing so, we will update a similar analysis produced by ProPublica in 2018 called Dollars for Docs.

Setting Up Your Environment

1. Run the code below to load today's data frame into your environment.

```
library(tidyverse)
library(lubridate)
library(RColorBrewer)
open_payments_original <- read_csv("https://raw.githubusercontent.com/sds-192-intro-fall22
  select(covered_recipient_npi,
         covered_recipient_first_name:covered_recipient_last_name,
         applicable_manufacturer_or_applicable_gpo_making_payment_id,
         applicable_manufacturer_or_applicable_gpo_making_payment_name,
         recipient_city,
         recipient_state,
         covered_recipient_specialty_1,
         total_amount_of_payment_usdollars,
         indicate_drug_or_biological_or_device_or_medical_supply_1,
         product_category_or_therapeutic_area_1,
         name_of_drug_or_biological_or_device_or_medical_supply_1,
```

```
        date_of_payment,
        nature_of_payment_or_transfer_of_value,
        number_of_payments_included_in_total_amount,
        form_of_payment_or_transfer_of_value,
        dispute_status_for_publication,
        payment_publication_date) |>
  filter(!is.na(covered_recipient_npi))
```

2. Run the code below to clean up this data frame

```
open_payments_cleaned <- open_payments_original |>
  # convert to date-time format
  mutate(across(c(date_of_payment, payment_publication_date), mdy)) |>
  # standardize the formatting of doctors' names
  mutate(covered_recipient_full_name = paste(covered_recipient_first_name, covered_recipie
  mutate(covered_recipient_full_name = toupper(covered_recipient_full_name))
```

It's important to note that the unit of observation in this dataset is a transaction (not a medical practitioner or manufacturer!). That means that a medical practitioner can appear multiple times in the dataset if they've received multiple payments, and a medical drug or device manufacturer can appear multiple times in the dataset if they've disbursed multiple payments. We can identify medical practitioners with the `covered_recipient_npi` column and manufacturers with the `applicable_manufacturer_or_applicable_gpo_making_payment_id` column.

Now that we've standardized the formatting of these names, there ideally should be one full name associated with every `covered_recipient_npi`. Let's compare the length of unique `covered_recipient_npi` values to the length of unique `covered_recipient_full_name` values to check whether this is the case.

Ex 1: Unique Values

I've written a function below called `num_unique`. The function calculates the length of unique values in the vector passed to the argument `x`.

Below, I've selected the two columns in `open_payments_cleaned` that we want to iterate this function over. Determine which `map()` function to use in order to return a numeric vector that indicates the length of unique values in each of these columns. If you've done everything correctly, you should get the output below.

```
num_unique <- function(x) {
 length(unique(x))
}

open_payments_cleaned |>
  select(covered_recipient_npi, covered_recipient_full_name) |>
  map_int(num_unique) # Determine which map function to call here
```

```
      covered_recipient_npi covered_recipient_full_name
                      11837                       11858
```

covered_recipient_npi covered_recipient_full_name

11837 11858

Notice that there are still more full names than `covered_recipient_npi`s, which means that certain doctors have multiple names in this dataset. Below I've written some code to calculate the number unique full names listed for each `covered_recipient_npi` and filter to the rows with more than one name. Can you identify some reasons why we might have multiple names listed for this same medical practitioner in this data frame?

```
open_payments_cleaned |>
  group_by(covered_recipient_npi) |>
  mutate(num_names = length(unique(covered_recipient_full_name))) |>
  ungroup() |>
  filter(num_names > 1) |>
  select(covered_recipient_npi, covered_recipient_full_name) |>
  distinct() |>
  arrange(desc(covered_recipient_npi))
```

```
# A tibble: 292 x 2
   covered_recipient_npi covered_recipient_full_name
                   <dbl> <chr>
 1            1992991657 LANA SCHUMACHER
 2            1992991657 LANA BEAL
 3            1992932453 JESSICA ALLEGRETTI
 4            1992932453 JESSICA RAVIKOFF
 5            1992712178 PASI ANTERO JANNE
 6            1992712178 PASI JANNE
 7            1992187132 FAIZ BAYO-AWOYEMI
 8            1992187132 FAIZ BAYO AWOYEMI
```

```
 9            1982680740 DONALD MARKS
10            1982680740 DON MARKS
# i 282 more rows
```

It could be a doctor's maiden name that they have since changed. It could also be a misspelling or hypocorism. Because of these issues, it is important that we use the `covered_recipient_npi` to identify doctors vs. the full name.

Data Analysis

Our aim is to produce a number of tables and plots for each of the ten MA-based doctors that received the most money from medical drug and device manufacturers in 2021. This means that one of our first analysis steps is to identify those 10 medical practitioners.

Ex 2: Top 10 Doctors

Write code to determine the 10 medical practitioners that received the most money from drug and device manufacturers in 2021, and store your results in `top_10_doctors`. Your final data frame should have 10 rows and columns for `covered_recipient_npi` and `sum_total_payments`.

```
# Uncomment below and write data wrangling code

top_10_doctors <- open_payments_cleaned |>
  group_by(covered_recipient_npi) |>
  summarise(sum_total_payments = sum(total_amount_of_payment_usdollars)) |>
  arrange(desc(sum_total_payments))|>
  slice_max(order_by = sum_total_payments, n = 10)

top_10_doctors
```

```
# A tibble: 10 x 2
   covered_recipient_npi sum_total_payments
                   <dbl>              <dbl>
 1            1194763482          18755428.
 2            1720096738          18751435
 3            1073561973           2112833.
 4            1699732065           1869851.
 5            1952351488            971882.
 6            1194860205            971291.
```

```
 7            1225124787            954938.
 8            1164598801            820476.
 9            1144267899            803031.
10            1568424042            771362.
```

Right now the values that we will eventually want to iterate over in our analysis are stored as columns in a data frame. …but the family of `purrr` functions allows us to apply a function to each element of a vector or list. We want to create a series of vectors from these columns that we can iterate over. We will use the `pull()` function to do this.

Ex 3: Top 10 Doctors IDs

Create a vector of `top_10_doctors_ids` from `top_10_doctors`, using the `pull()` function.

```
# Uncomment and write code below to pull the top 10 doctor IDs into a vector

top_10_doctors_ids <- top_10_doctors |>
  pull(covered_recipient_npi)
```

We also want a vector of doctor names associated with each of these IDs, but remember that there can be multiple names for a single doctor in this dataset. With this in mind, we are going to create a vector of the **first listed name** for a given `covered_recipient_npi` in the dataset. Taking the first listed name as the doctor's name is an imperfect solution. The first listed name could be a misspelling. It could be a doctor's maiden name that they have since changed. This is a temporary solution, and we would want to confirm that we have the correct name for each doctor before publishing any of these findings.

Ex 4: Top 10 Doctors Names

Create a vector containing the names of the doctors associated with the IDs in `top_10_doctors_ids`. First, define the function `get_doctor_name`. This function will:

1. Take a `doctor_id` as an argument
2. Filter `open_payments_cleaned` to that ID
3. Summarize the `first() covered_recipient_full_name` listed for that ID
4. `pull()` the name value

Once this function has been defined, select the appropriate `map()` function to iterate `top_10_doctors_ids` through `get_doctor_name` and store the resulting character vector in `top_10_doctors_names`.

```
get_doctor_name <- function(doctor_id) {
  open_payments_cleaned |>
    filter(covered_recipient_npi == {{doctor_id}})|>
    first()|>
    pull(covered_recipient_full_name)

}

# Iterate the top_10_doctors_ids vector through get_doctor_name and store the results in a
top_10_doctors_names <-
  map_chr(
    .x = top_10_doctors_ids,
    .f = get_doctor_name
  )
```

Now that we have the vectors we want to iterate over, we are ready to start defining our functions.

Ex 5: What Kind of Payments did MA-based Doctors Receive in 2021?

To get started, let's define a function that filters open_payments_cleaned to a given doctor ID, and then calculates how much of each kind of payment has been paid to that doctor. Here is an example of what that data wrangling code would look like for a specific `covered_recipient_npi`:

```
open_payments_cleaned |>
  filter(covered_recipient_npi == 1194763482) |>
  group_by(nature_of_payment_or_transfer_of_value) |>
  summarize(num_payments =
              sum(number_of_payments_included_in_total_amount),
            total_payments = sum(total_amount_of_payment_usdollars))
```

```
# A tibble: 2 x 3
  nature_of_payment_or_transfer_of_value num_payments total_payments
  <chr>                                         <dbl>          <dbl>
1 Consulting Fee                                    4          5428.
2 Royalty or License                                2      18750000
```

1. Wrap the above code in a function named `calculate_payment_type_amts`. Rather than filtering to 1194763482, filter based on the value passed to an argument named `doctor_id`

2. Then, use the `map()` function to apply `calculate_payment_type_amts` to each element in the `top_10_doctors_ids` vector. Running this code should return a list of 10 data frames
3. Finally, pipe in `set_names(top_10_doctors_names)` to set the names for each data frame in the list to the doctor's name

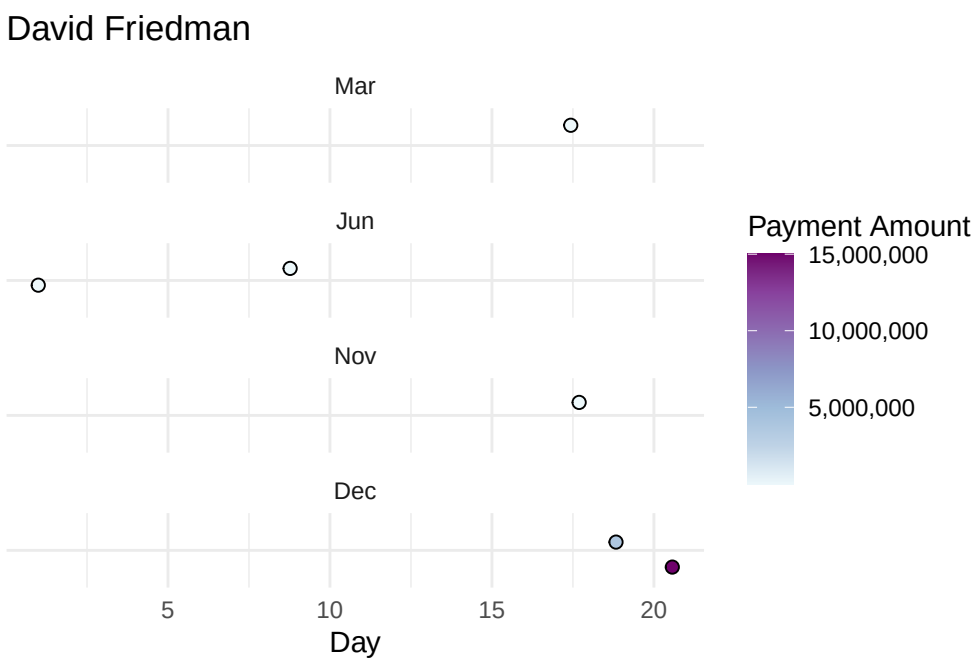
```
# Write calculate_payment_type_amts function here
calculate_payment_type_amts <- function(doctor_id){

open_payments_cleaned |>
  filter(covered_recipient_npi == {{doctor_id}}) |>
  group_by(nature_of_payment_or_transfer_of_value) |>
  summarize(num_payments =
              sum(number_of_payments_included_in_total_amount),
            total_payments = sum(total_amount_of_payment_usdollars))
}

# Iterate calculate_payment_type_amts over top_10_doctors_ids and set names to top_10_doct
doctor_list <- map(
  .x = top_10_doctors_ids,
  .f = calculate_payment_type_amts
)
doctor_list<- doctor_list |> set_names(top_10_doctors_names)
```

Ex 6: When were Payments Made to Each of These Doctors in 2021?

Here's an example of a plot we could create to answer this question for one doctor.

```
open_payments_cleaned |>
    filter(covered_recipient_npi == 1194763482) |>
    ggplot(aes(x = day(date_of_payment),
               y = "",
               fill = total_amount_of_payment_usdollars)) +
    geom_jitter(pch = 21, size = 2, color = "black") +
    theme_minimal() +
    labs(title = "David Friedman",
         y = "",
         x = "Day",
         fill = "Payment Amount") +
    scale_y_discrete(limits = rev) +
    scale_fill_distiller(palette = "BuPu", direction = 1, labels = scales::comma) +
```

```
  facet_wrap(~month(date_of_payment, label = TRUE), nrow = 4)
```



Write a function named `payments_calendar`. The function should:

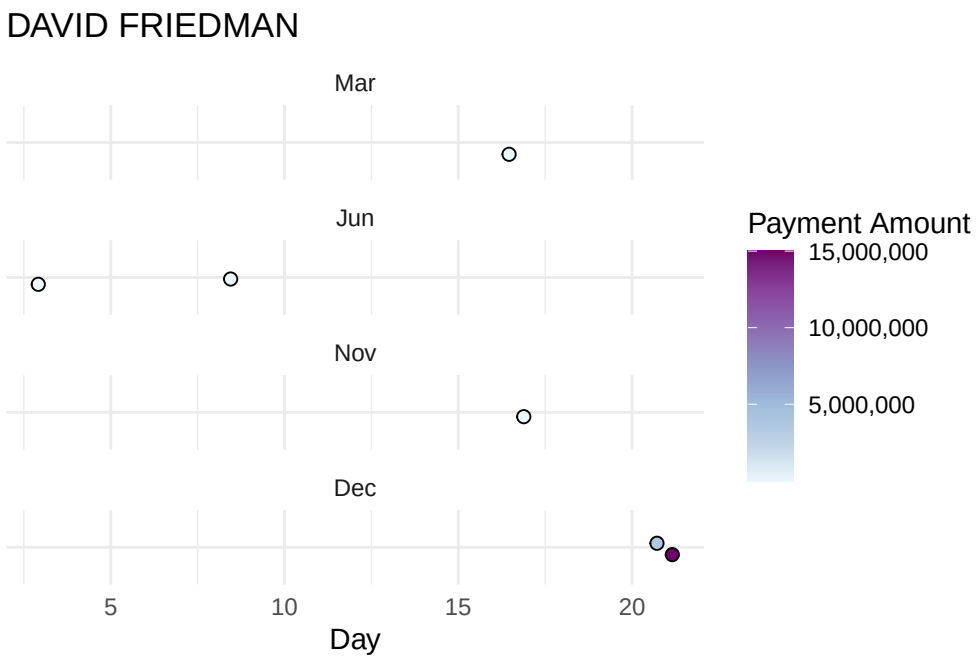
1. Take a `doctor_id` and `doctor_name` as arguments
2. Filter `open_payments_cleaned` to the doctor's ID
3. Create payment calendar plot modeled after the one above
4. Set the title of the plot to the doctor's name

After you've written this function, use the `map2()` function to apply `payments_calendar` to each element in the `top_10_doctors_ids` vector and `top_10_doctors_names` vector.

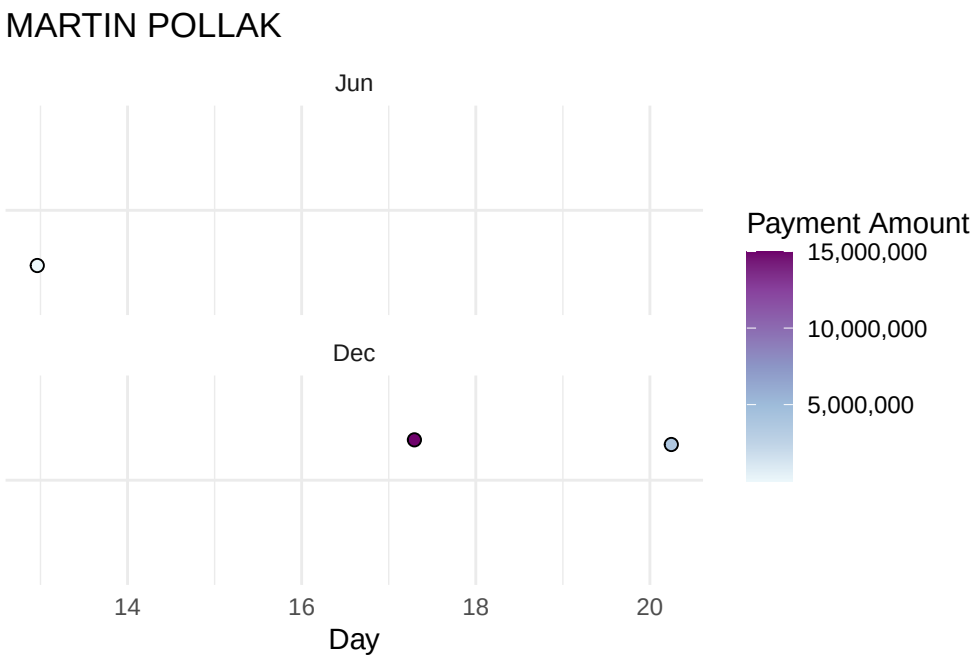
```
# Write payments_calendar function here
payments_calendar <- function(doctor_id , doctor_name){
  open_payments_cleaned |>
    filter(covered_recipient_npi == {{doctor_id}}) |>
    ggplot(aes(x = day(date_of_payment),
               y = "",
               fill = total_amount_of_payment_usdollars)) +
    geom_jitter(pch = 21, size = 2, color = "black") +
    theme_minimal() +
    labs(title = doctor_name,
```

```
          y = "",
          x = "Day",
          fill = "Payment Amount") +
     scale_y_discrete(limits = rev) +
     scale_fill_distiller(palette = "BuPu", direction = 1, labels = scales::comma) +
     facet_wrap(~month(date_of_payment, label = TRUE), nrow = 4)
}
# Iterate payments_calendar over top_10_doctors_ids and top_10_doctors_ids to create 10 pl

map2(
  .x = top_10_doctors_ids,
  .y = top_10_doctors_names,
  .f = payments_calendar
)
```

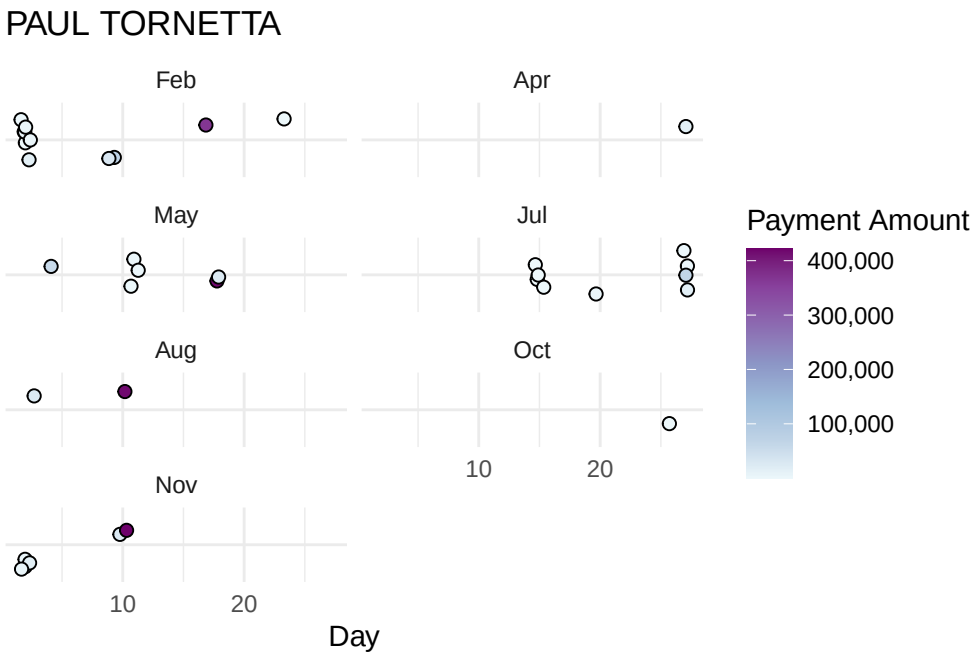
```
[[1]]
```



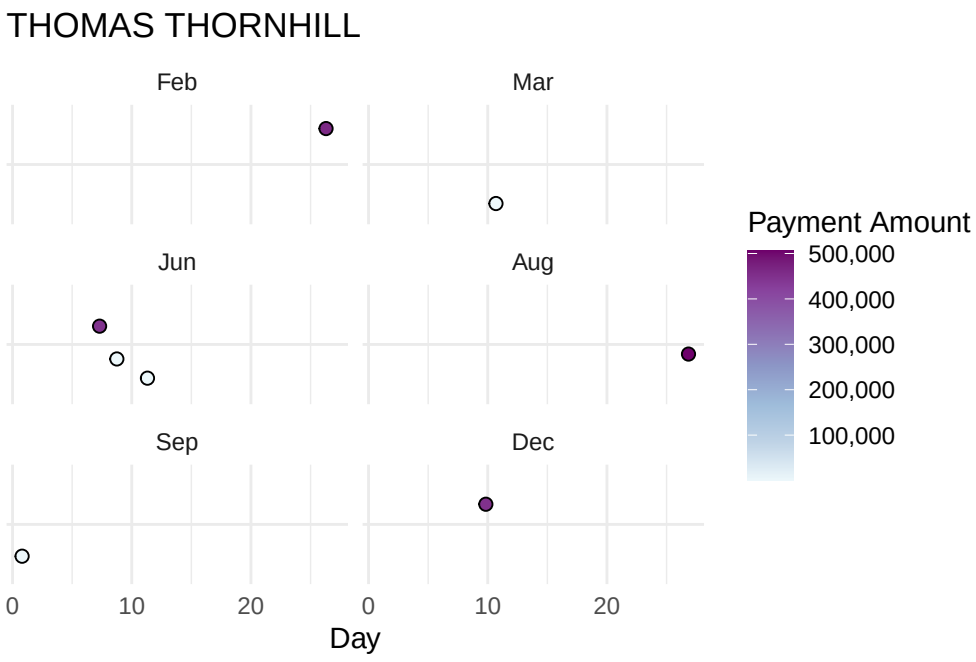

```
[[2]]
```


MARTIN POLLAK
Jun
Dec
14
16
18
20
Day
Payment Amount
15,000,000
10,000,000
5,000,000

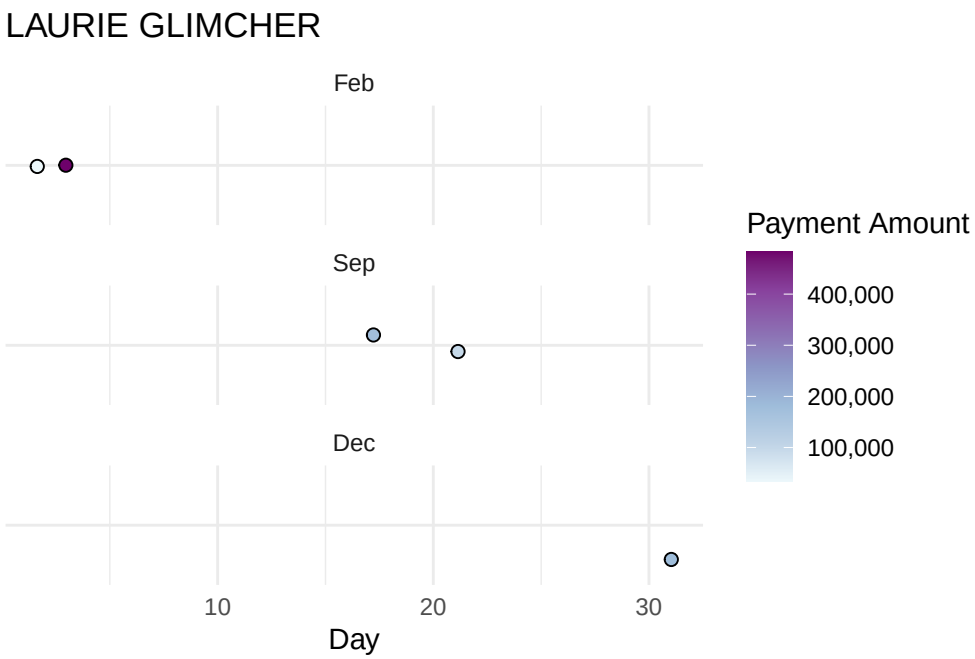
[[3]]


PAUL TORNETTA
Feb
Apr
May
Jul
Aug
Oct
Nov
10
20
Day
Payment Amount
400,000
300,000
200,000
100,000

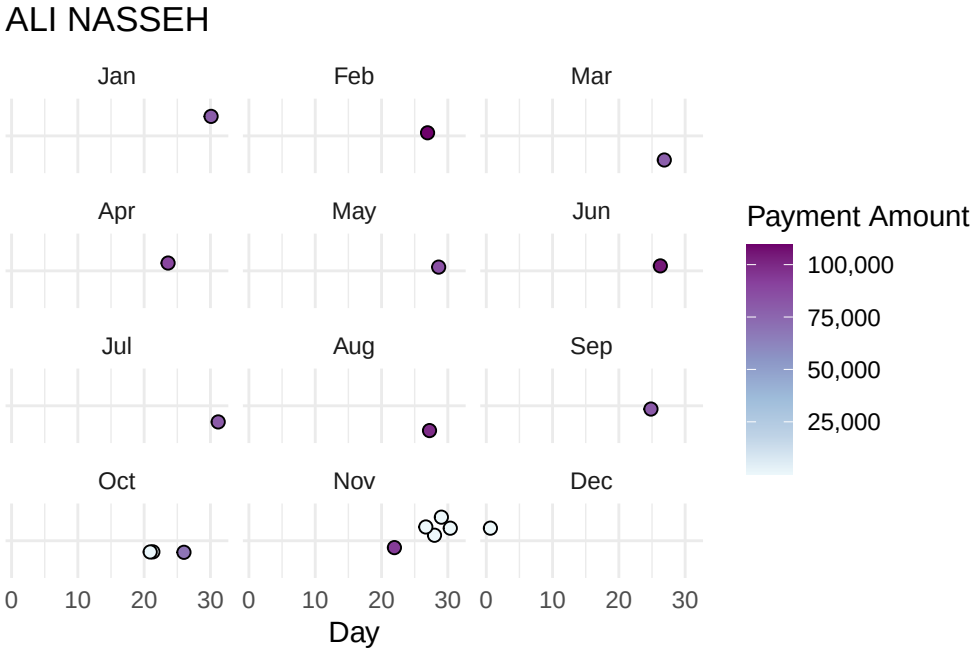
[[4]]


THOMAS THORNHILL
Feb
Mar
Jun
Aug
Sep
Dec
0
10
20
Day
Payment Amount
500,000
400,000
300,000
200,000
100,000

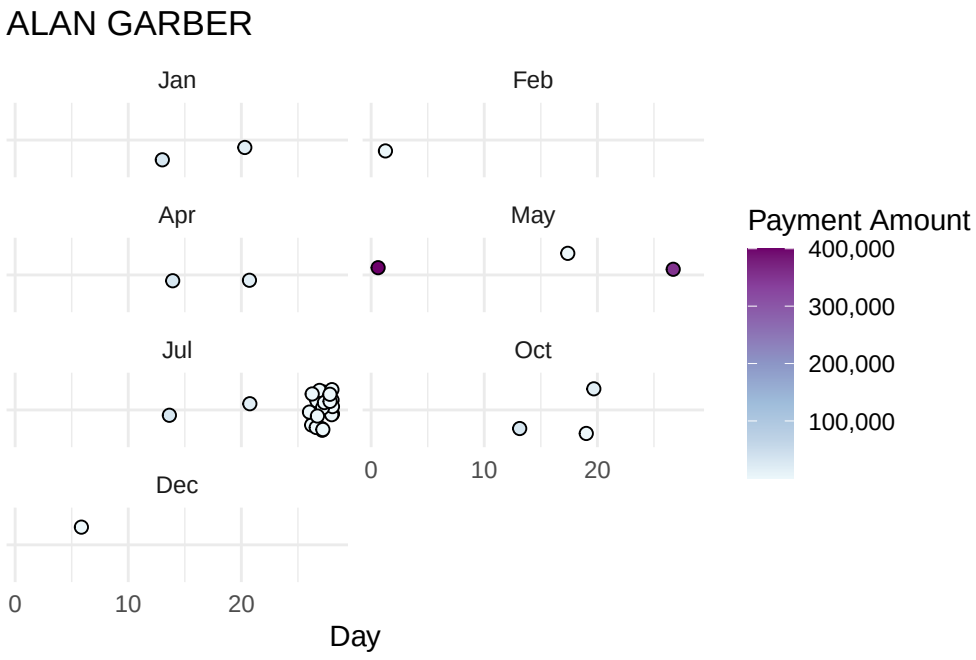
[[5]]


LAURIE GLIMCHER
Feb
Sep
Dec
10
20
30
Day
Payment Amount
400,000
300,000
200,000
100,000

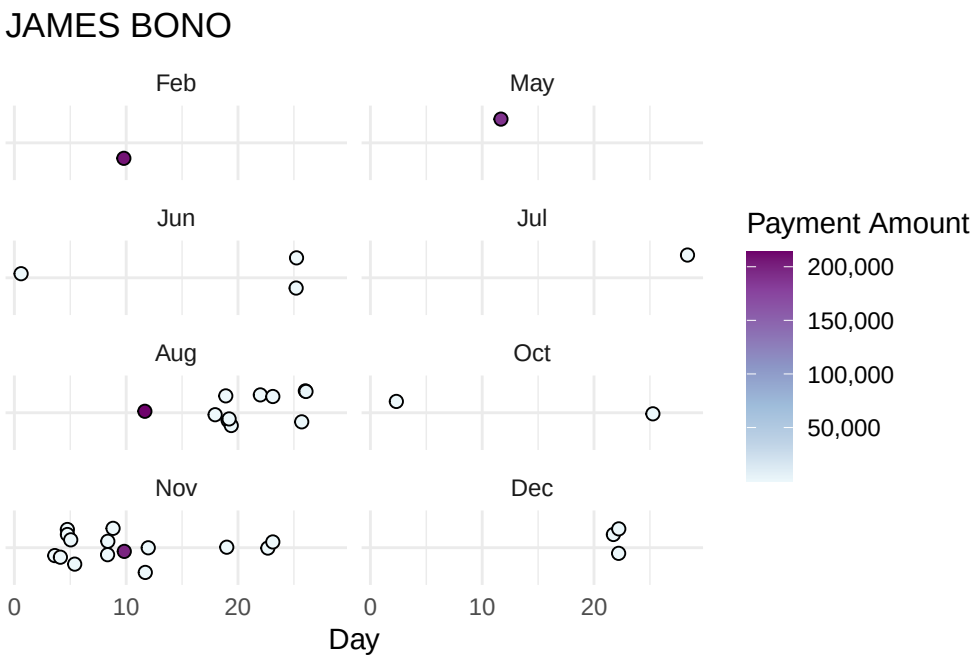
[[6]]


ALI NASSEH
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0
10
20
30
Day
Payment Amount
100,000
75,000
50,000
25,000

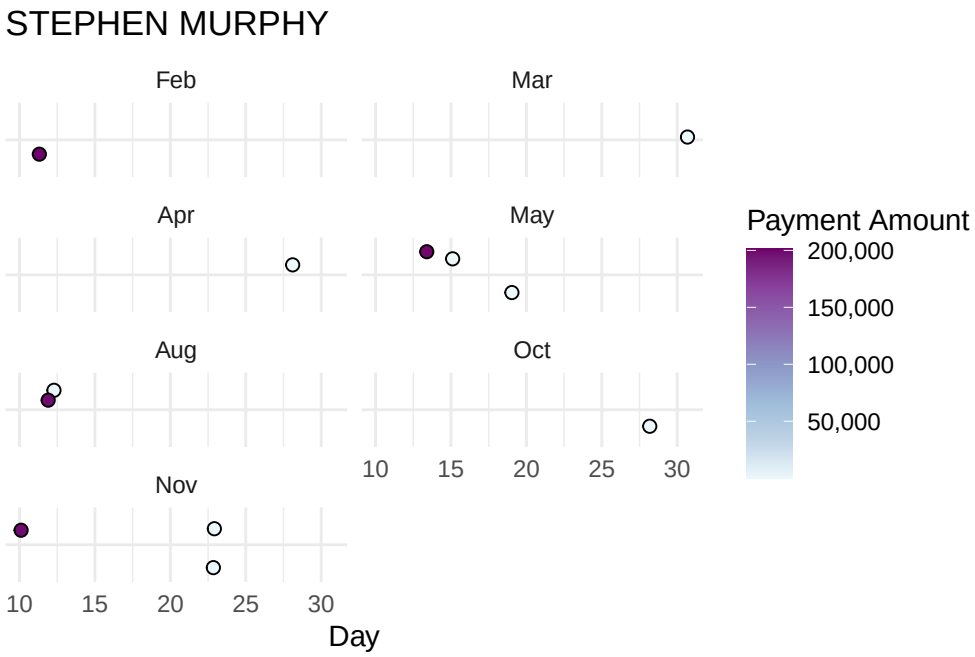
[[7]]


ALAN GARBER
Jan
Feb
Apr
May
Jul
Oct
Dec
0
10
20
Day
Payment Amount
400,000
300,000
200,000
100,000

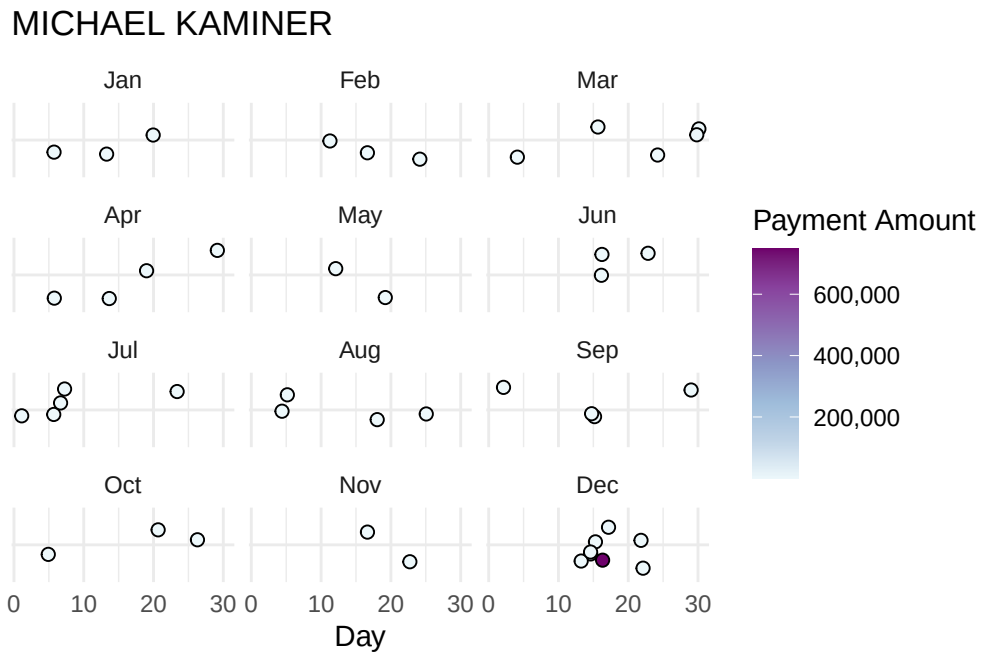
[[8]]


JAMES BONO
Feb
May
Jun
Jul
Aug
Oct
Nov
Dec
0
10
20
Day
Payment Amount
200,000
150,000
100,000
50,000

[[9]]


STEPHEN MURPHY
Feb
Mar
Apr
May
Aug
Oct
Nov
10
15
20
25
30
Day
Payment Amount
200,000
150,000
100,000
50,000

```
[[10]]
```



Ex 7: Which Manufacturers Paid MA-based Doctors in 2021, and through What Forms of Payment?

Finally, let's define a function that filters `open_payments_cleaned` to a given doctor ID and determines how much the doctor received in compensation from different manufacturers, along with the forms of payment from each manufacturer. To do so, we will need to aggregate the data by `covered_recipient_npi`, `applicable_manufacturer_or_applicable_gpo_making_payment_name`, and `form_of_payment_or_transfer_of_value` and calculate the total payments associated with each grouping.

Write a function named `calculate_manufacturer_payments`. The function should:

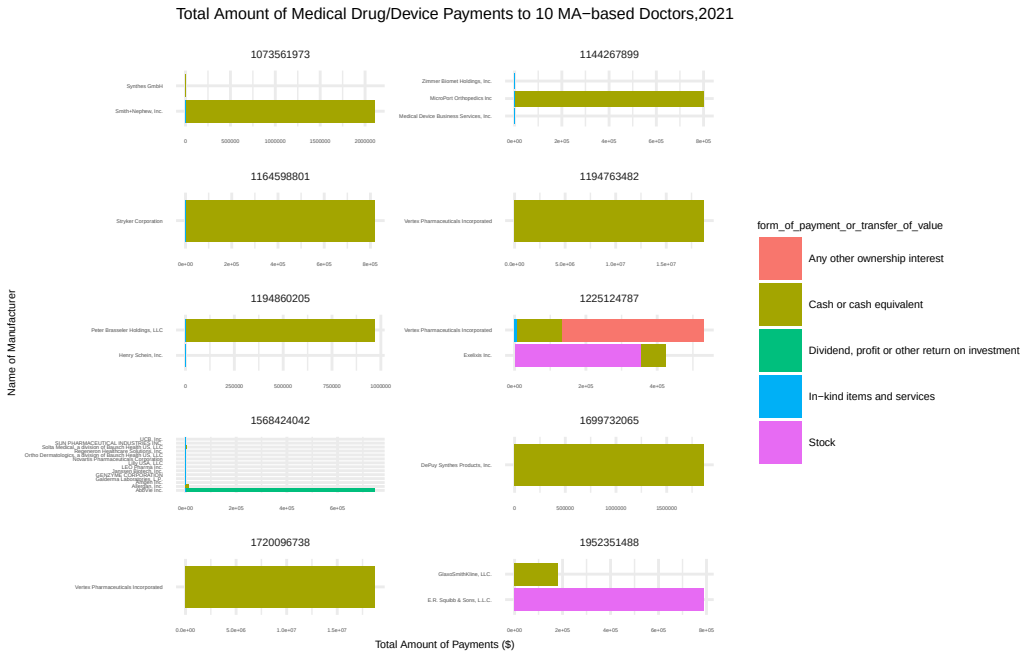
1. Take a `doctor_id` as an argument
2. Filter `open_payments_cleaned` to that ID
3. Aggregate the filtered data by `covered_recipient_npi`, `applicable_manufacturer_or_applicable_gpo` and `form_of_payment_or_transfer_of_value`
4. Calculate the total amount of payments for each grouping
5. Sort the resulting data frame in descending order by the total amount of payments

After you've written this function, use the `map_df()` function to apply `calculate_manufacturer_payments` to each element in the `top_10_doctors_ids` vector. Note how this returns one data frame rather than a list of 10 data frames.

Plot your resulting data frame as a column plot, attempting (to the best of your ability) to match the formatting of the plot below.

```
# Write calculate_manufacturer_payments function here

calculate_manufacturer_payments <- function(doctor_id){
  open_payments_cleaned |>
  filter(covered_recipient_npi == {{doctor_id}})|>
  group_by(
    covered_recipient_npi,
    applicable_manufacturer_or_applicable_gpo_making_payment_name,
    form_of_payment_or_transfer_of_value)|>
  reframe(total = sum(total_amount_of_payment_usdollars))
}


# Iterate calculate_manufacturer_payments over top_10_doctors_ids here

df<- map_df(
  .x = top_10_doctors_ids,
  .f = calculate_manufacturer_payments
)

# Plot resulting data frame here
df |>
  ggplot(aes(
    x = applicable_manufacturer_or_applicable_gpo_making_payment_name,
    y = total,
    fill = form_of_payment_or_transfer_of_value)
    ) +
  geom_col()+
  facet_wrap(facets = ~covered_recipient_npi ,ncol = 2, scales = "free")+
  coord_flip()+
  theme_minimal()+
  theme(title = element_text(size = 5),
        axis.title = element_text(size = 4),
        axis.text = element_text(size = 2),
        strip.text = element_text(size = 4),
```

```
        legend.title = element_text(size = 4),
        legend.text = element_text(size = 4)
        ) +
  labs(title="Total Amount of Medical Drug/Device Payments to 10 MA-based Doctors,2021",
       x="Name of Manufacturer",
       y="Total Amount of Payments ($)")
```




```
  scale_y_continuous(labels = scales::comma)
```

```
<ScaleContinuousPosition>
 Range:
 Limits:    0 --    1
```

```
  df
```

```
# A tibble: 39 x 4
   covered_recipient_npi applicable_manufacturer~1 form_of_payment_or_t~2  total
                   <dbl> <chr>                     <chr>                   <dbl>
 1            1194763482 Vertex Pharmaceuticals I~ Cash or cash equivale~ 1.88e7
 2            1720096738 Vertex Pharmaceuticals I~ Cash or cash equivale~ 1.88e7
```

```
 3           1073561973 Smith+Nephew, Inc.        Cash or cash equivale~ 2.11e6
 4           1073561973 Smith+Nephew, Inc.        In-kind items and ser~ 1.07e2
 5           1073561973 Synthes GmbH              Cash or cash equivale~ 2.5 e2
 6           1699732065 DePuy Synthes Products, ~ Cash or cash equivale~ 1.87e6
 7           1952351488 E.R. Squibb & Sons, L.L.~ Stock                  7.91e5
 8           1952351488 GlaxoSmithKline, LLC.     Cash or cash equivale~ 1.81e5
 9           1194860205 Henry Schein, Inc.        In-kind items and ser~ 2.88e2
10           1194860205 Peter Brasseler Holdings~ Cash or cash equivale~ 9.71e5
# i 29 more rows
# i abbreviated names:
#   1: applicable_manufacturer_or_applicable_gpo_making_payment_name,
#   2: form_of_payment_or_transfer_of_value
```