AUGSBURG UNIVERSITY TEACHING CASE

DATA ANALYTICS FOR EMERGENCY PREPAREDNESS AND RESPONSE DURING THE COVID-19 PANDEMIC IN MINNESOTA

Jeffrey Clement wrote this case solely to provide material for class discussion. The author does not intend to illustrate either effective or ineffective handling of a public health situation. The "problems" with the data set were deliberately introduced for the purpose of identifying and fixing them. Development of this case was supported by an Emergency Preparedness and Response Curriculum Development Project Grant from the Minnesota Private College Fund in partnership with the Minnesota Department of Health.

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Covid-19 is a respiratory infection that can cause a range of symptoms and can be deadly. In late 2019 and into 2020, it was particularly dangerous from a public health perspective because humans had not been exposed to the virus previously, so individuals' immune systems had a hard time fighting the virus, and there was no herd immunity, so the virus could spread rapidly.

Once the danger was identified, public health agencies around the world began to track the spread of the virus to allocate limited resources and inform the response, like implementing lockdowns. Data analytics were central to this process.

In this case, you will act as a public health analyst at the Minnesota Department of Health, reviewing the spread of Covid-19 to inform planning for future pandemics. Allocating limited resources, including clinicians like doctors and nurses, and equipment like ventilators, relies on this kind of planning.

The question you must answer is this:

Did Covid-19 spread differently in rural counties than in urban counties?

ANALYTICS FOR PUBLIC HEALTH AND EMERGENCY PREPAREDNESS AND RESPONSE

The Role of Data Analytics to Support Public Health and EPR Functions

The US Centers for Disease Control has developed and published what they term *Public Health Emergency Preparedness and Response Capabilities*. These capabilities are functions or skills "designed to advance the emergency preparedness and response capacity of state and local public health systems." The capabilities are designed to support "everyday use" wherever possible because it can be difficult to justify investing resources in projects that might only be used in an emergency. Instead, the CDC suggests that public health organizations should be ready for everyday needs but also be prepared to handle emergencies like natural disasters or pandemics.

Data analytics are core to several of the EPR capabilities. For example, the *public health surveillance* function is to "conduct or support ongoing systematic collection, analysis, interpretation, and management of public health-related data to effectively detect, verify, characterize, and manage a threat, hazard, risk, or incident of public health concern throughout and following an incident."[1] However, analytics are crucial across the spectrum of EPR. Managing the medical surge response, for example, is based on defining "incident needs and available health care personnel and resources through the collection and analysis of data, including resource tracking."[2]

Analytics is about using data to find answers to questions. Instead of guessing, analysts use data and past trends to provide answers. But there are some important points to remember. First, you need to ask the right questions. Second, if the data isn't good, the analysis will be wrong—bad data means bad results. Third, every analysis has limits—it might only work in certain situations or for certain groups of people. Finally, just having the analysis isn't enough; you need the right decisions and resources to make it useful. Data analytics, even advanced ones like AI, are not magic. It *supports* other functions and can make them more effective—it does not replace them.

Data Analytics Jobs in Public Health and EPR

Like most fields, there are data analytics roles in public health and EPR. These jobs might have titles like public health data analyst, research data coordinator, clinical data analyst, statistician (or biostatistician), and so on. People interested in these roles should consider a degree in statistics, data science, or a Masters in Public Health with a data concentration.

Most people who collect, analyze, interpret, and ultimately make decisions based on data are *not* data analysts and do not have a specific degree focused on data analytics, though. As we mentioned, analytics can help inform every EPR function, so knowing how to conduct and interpret data analyses is important across the spectrum of EPR roles.

Discussion Question 1

Can AI tools like ChatGPT or Google Gemini replace public health professionals? Can they augment or assist with EPR tasks?

ANALYTICS TOOLS AND INFRASTRUCTURE

Analytics Software – Many Options to Choose From

Spreadsheet programs like Microsoft Excel and Google Sheets are popular tools for data analysis. Many people use them because they are easy to get and work with. Spreadsheets can do a lot and are good for small tasks. But they have downsides too. They can't handle very large datasets, and it's hard to see all the formulas, making it tough to check the work. When spreadsheets aren't enough, analysts use special software that requires writing code. Some examples are R, SAS, STATA, SPSS, and Python. Analysts might also use a coding language called SQL to get data from databases. For making data visualizations, many organizations use software like Microsoft PowerBI and Tableau.

The software you pick depends on the task, your training, and what software other people in your organization are using. Cost can be a factor too; notably, open-source options like R and Python are free.

Data Analysis Cycle

As you plan your analysis, it can be useful to think of it as a process that is broken down into steps. The Data Analysis Cycle presented in is an iterative process, and you may go forwards and backwards as you identify issues.[3] It has four main steps, with step three being broken into three sub-steps.

Step 1: Import

In Step 1, you import your data into the software you are using for analysis. This may include manually entering data, scanning forms, downloading it from a server, or accessing a database using SQL. At this step, you want to ensure your data is being accurately imported.

Step 2: Tidy

Tidy data means that the data is stored in logical way.[*] Do the variable names all make sense? Is the data stored in a form that will work for your analysis?

Step 3: Understand

In this step, which is divided into three sub-steps, we will iteratively seek to understand our data and answer the questions we have.

> *3a: Transform*
>
> We often need to change the data in some way. For example, we might filter it to only include certain observations (just people over the age of 18, or only people who live in a certain county). Or we might need to calculate age from people's date of birth. Or calculate the rate of diseases per 10,000 people who live in a county.
>
> *3b: Visualize*
>
> Next, we examine the data by graphing it, looking at the distribution, outliers, and so on.
>
> *3c: Model*
>
> After visualizing the data, we may formally model it using regression or machine learning (for example). As we do this, we may need to further transform it and visualize it.

Step 4: Communicate

After we have come to understand the data and found an answer to our question, we can communicate the answer to our coworkers or the public. This often means putting together graphs and tables.

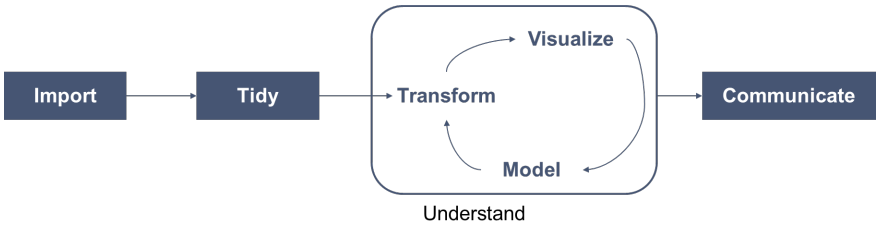


Figure 1: The Data Analysis Cycle

[*] There is also a technical term "tidy data," which means that each row is an observation and each column is a variable. This is a bit beyond the scope of the case, so the data we use in this case is already "tidied," but you will often come across data that is not "tidy" in this way.

Data Infrastructure, Cybersecurity and Backups

Data infrastructure needs vary by organization, but it is best to work with your IT team to make sure the service meets your needs and follows the organization's rules. It is very common nowadays to use a cloud database for large data, where the data is stored on an internet-connected server that is accessible remotely. Most people would consider the organization's data infrastructure and cybersecurity something that the falls under the IT department, but teams will often end up developing their own workflows or purchase devices that IT does not track. For example, a team might buy an iPad for data collection and save the data to a cloud service like Dropbox—but that might not properly secure the data.

Cybersecurity, which just means maintaining the security of digital information and systems, is especially important in healthcare. In the United States, many types of health care data are covered by the Health Information Portability and Accessibility Act (HIPAA) which lays out specific storage and access restrictions.[4] Two particular threats are data theft and ransomware attacks. Data theft occurs when an unauthorized user accesses organizational data; they may be stealing it to sell or to commit identity theft.[5] In a ransomware attack, a bad actor deploys encryption software that prevents an organization from being to access their own data until a ransom is paid.[6]

Another consideration is backups. A common guideline is the 3-2-1-1 rule of backups: An organization should have at least 3 copies of important data, stored on 2 types of media (e.g., hard drive and magnetic tape), 1 of which is offsite (at a different facility), and 1 of which is "air gapped" or not connected to the internet.[7] Having an air-gapped backup is useful because it is accessible even if the organization's main systems get "hacked." Usually, an organization's IT staff will take care of this, but sometimes teams will start collecting or saving data that IT does not know about or using a system that is not covered by IT's backups. This can also arise if data is saved locally on a particular device's hard drive (such as on one user's laptop).

The best practice is to consult with your organization's IT team to ensure that the software and systems you are using are right for the type of data you are collecting and analyzing.

Discussion Question 2

What could happen if a public health organization suffered a ransomware attack and was unable to access any of their data? How could they mitigate this risk?

MONITORING COVID-19 CASE COUNTS IN MINNESOTA

Now that we have talked a little about data analytics in general, let's analyze some data and try to determine if the rate of Covid-19 cases was much different in rural and urban counties in Minnesota.

Data Source

The Minnesota Department of Health monitored Covid-19 case counts and hospitalizations to inform the public health response and allocate resources. This data was published on their website as the Covid-19 Surveillence Data - Case Rate by County of Residence.[8] The data on whether counties are urban or rural comes from the Minnesota State Demographic Center.[9]

An excerpt is provided as an Excel file called "MN DHS County Case Data - Student Version.xlsx" which includes some problems/errors introduced for instructional purposes. A data dictionary is included as Exhibit 1.

LOAD DATA AND LOOK FOR MISSING DATA

Loading Data in Tableau

When you open Tableau, it should show the data connection screen. The dataset provided for this assignment is an Excel file, so click on "Microsoft Excel" on the left menu (Connect → To a File → Microsoft Excel). See Figure 2.

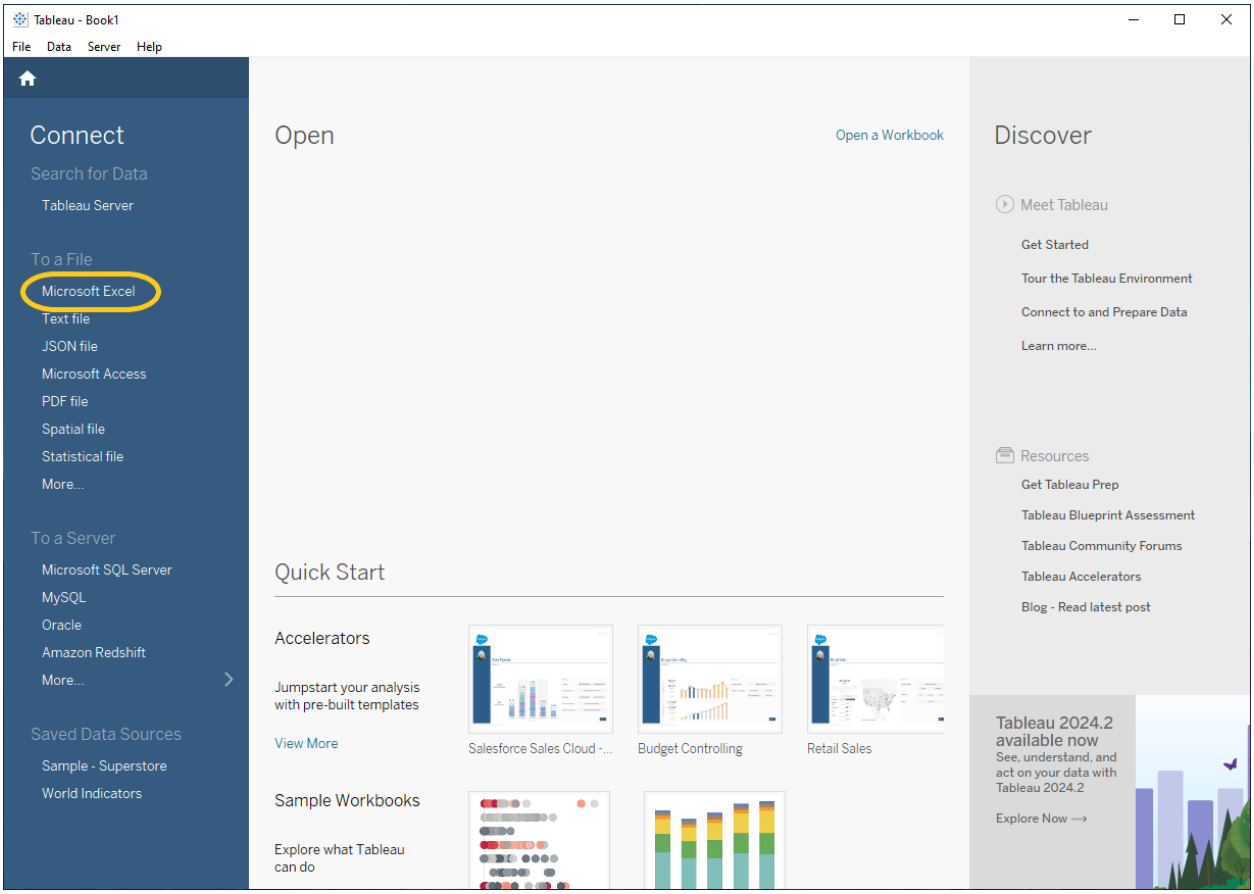


Figure 2

Navigate to where the file "MN DHS County Case Data – Student Version.xlsx" is saved on your computer, select it, and click Open, as shown in Figure 3.

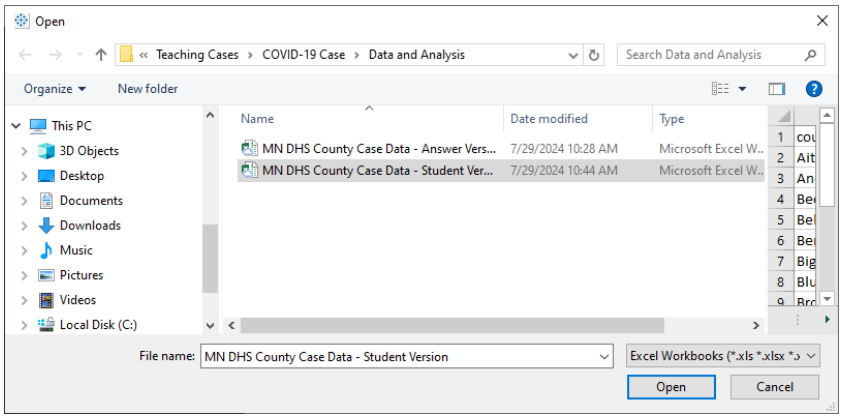


Figure 3

Tableau will show that there are two Sheets in the file. Double click on the "Case Count Data" sheet (or click and drag it from the left into the large white space on the right). Look at the "Table Details" preview on the bottom of the screen. We have the Covid-19 Case Count, by County, for given time periods (Figure 4).

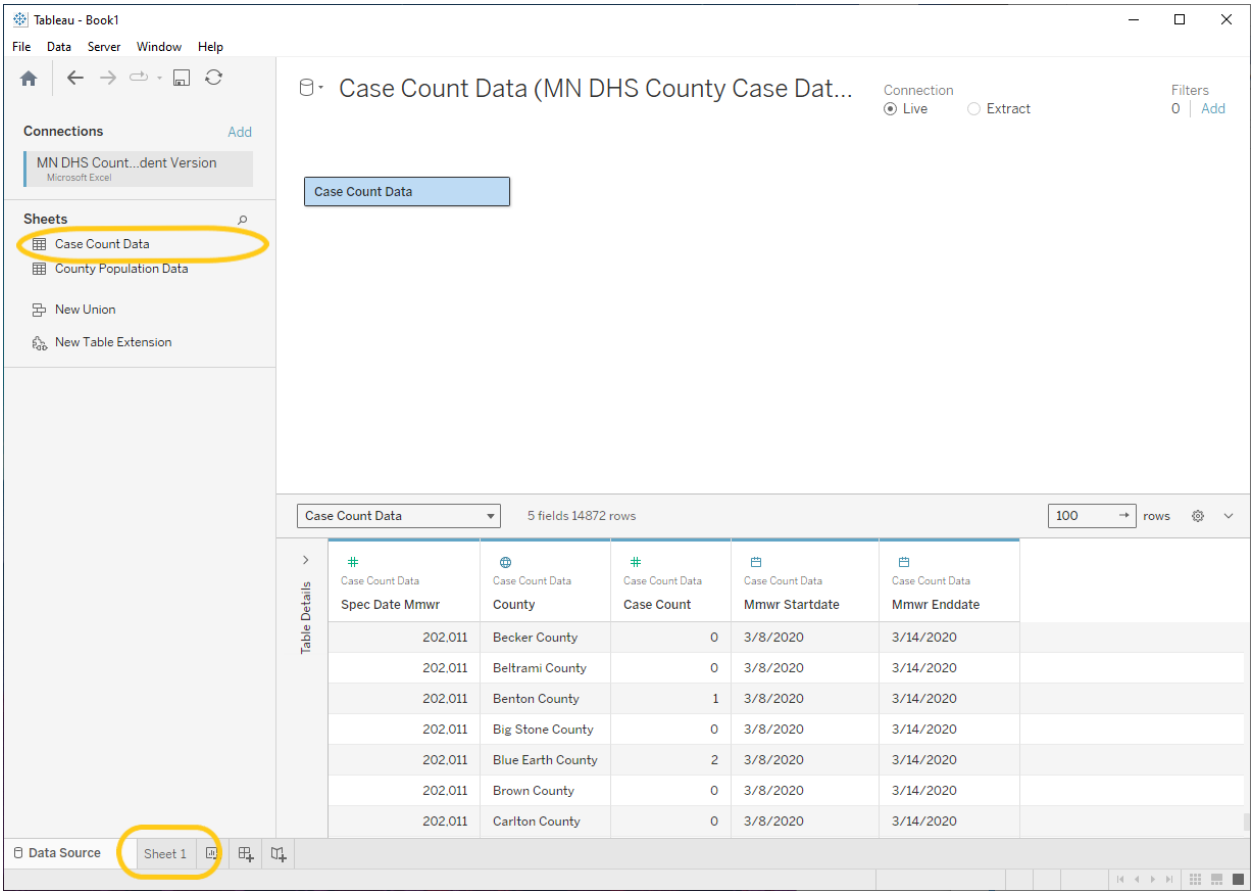


Figure 4

Inspecting the Row Count

We should have one report for each county for each time period, so let's check that that is true. Click the "Sheet 1" tab on the bottom of the screen to go to your first Worksheet. Double click on the "Sheet 1" tab so that you can edit the name and give the Worksheet a title. Call the worksheet "Row Count Analysis."

Data fields are added to Tableau by clicking on them on the left menu and dragging them to where you want them. Click the County field and drag it over to the Rows field near the top.

Next, drag the Case Count Data (Count) measure to the Text box under Marks (just to the Right of the data fields) near the middle of the screen. See Figure 5.

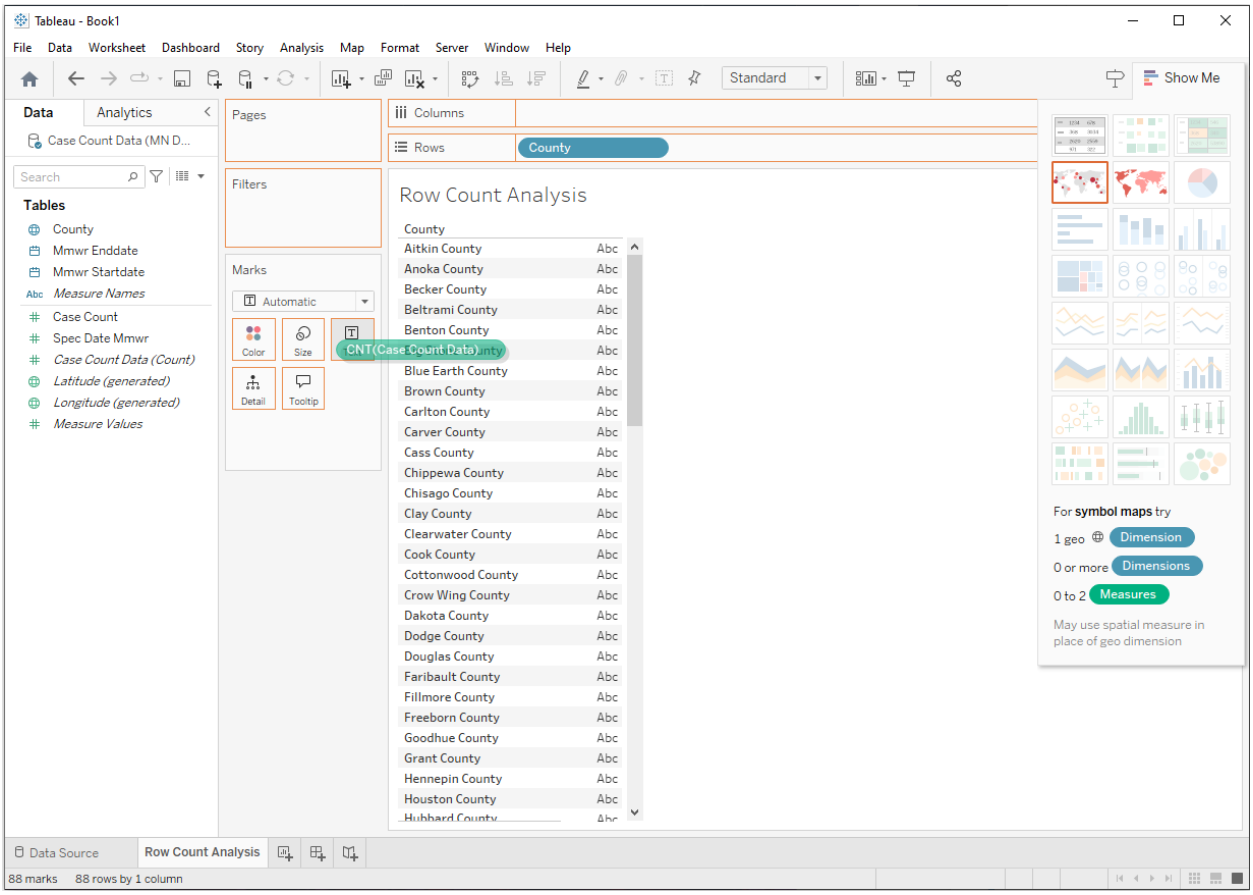


Figure 5

We should have 169 observations for each county. Scroll through the data and see if that is the case. *(Hint: There are two counties with the wrong number of observations.)* It looks we are missing data for Washington County and have too many entries for Anoka County.[†]

[†] These errors were introduced into the data for this case and are not present in the real Minnesota Department of Health dataset.

Types of Missing Data

Collecting high quality data is one of the major challenges that all analysts face, especially in situations related to public health. For example, many people who got Covid-19 and knew they probably had it (i.e., were symptomatic) just stayed home and never got tested, so the number of cases reported was lower than the true number. This type of data missingness is very difficult to address and is probably not something you can address at the analysis stage, but it may be something you can at least *diagnose*. Other times, you can identify problems that can be fixed.

There are three types of missing data:

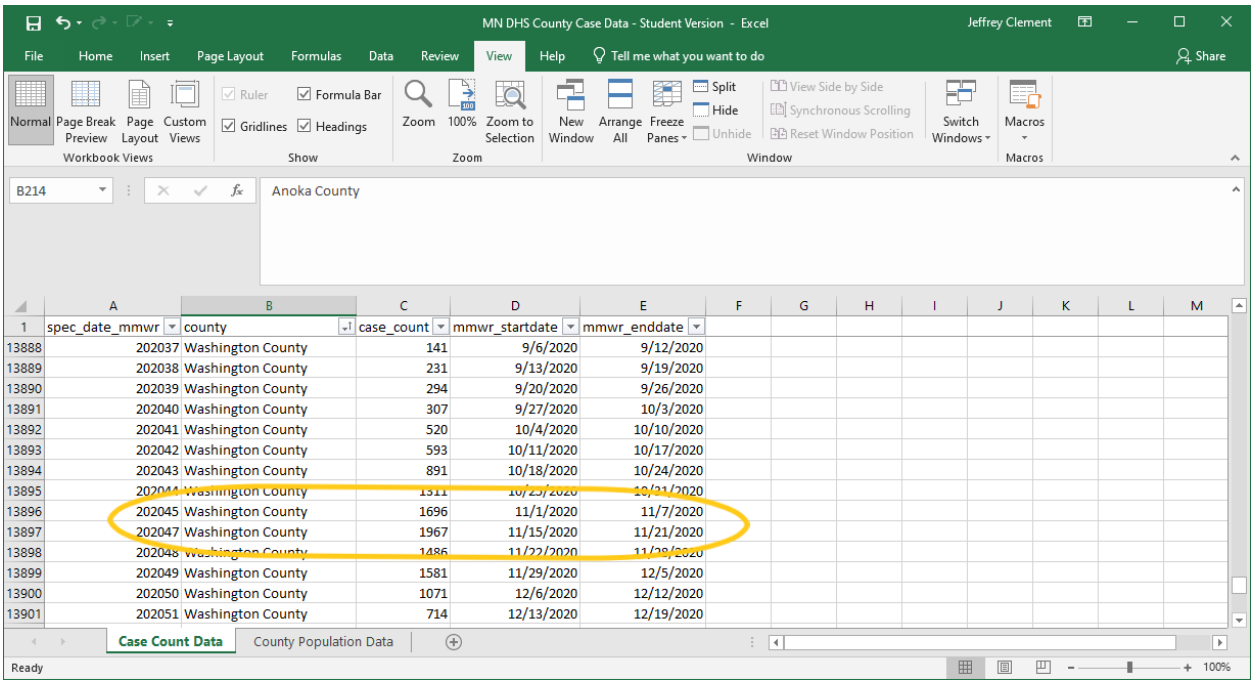
- Missing Not at Random (MNAR): Data that is MNAR means that data is missing in a systematic way correlated with a variable that we cannot observe. MNAR data will give you the wrong results. For example, let's say we are adding Covid-19 test results with a phone survey about symptoms people might have. If sick people are less likely to answer the phone than healthy people, most of our answers will be from healthy people. This will make us think that fewer people have symptoms in the community than actually do.
- Missing At Random (MAR): Data that is MAR means it is missing in a way that follows a pattern we can see. For example, if we're doing a phone survey about Covid-19 symptoms and people over 60 are more likely to answer than people under 60, and we know their ages, we can adjust for age in our analysis. Analyses with MAR data might or might not give biased results—it depends.
- Missing Completely at Random (MCAR): Data that is MCAR means that there is no systematic pattern to the missing data. Data that is MCAR will not give biased results (although if you have a lot of missing data you will have a smaller sample size).

Fix the Missing Washington County Data and the Delete the Extra Anoka County Data

Tableau is not the best tool for working with the raw data. We will look at it in Excel (since we will also be able to make changes to the data that way). Always be very careful making changes to the data!

Open the file in Excel (or Google Sheets or Apple Numbers) by navigating to the file in your file system (like Windows File Explorer or Apple Finder) and inspect the data. Investigate why Washington County seems to be short one row.

The entry for spec_date_mmwr 202046 (11/8/2020) is missing (See Figure 6).



	A	B	C	D	E
1	spec_date_mmwr	county	case_count	mmwr_startdate	mmwr_enddate
13888	202037	Washington County	141	9/6/2020	9/12/2020
13889	202038	Washington County	231	9/13/2020	9/19/2020
13890	202039	Washington County	294	9/20/2020	9/26/2020
13891	202040	Washington County	307	9/27/2020	10/3/2020
13892	202041	Washington County	520	10/4/2020	10/10/2020
13893	202042	Washington County	593	10/11/2020	10/17/2020
13894	202043	Washington County	891	10/18/2020	10/24/2020
13895	202044	Washington County	1311	10/25/2020	10/31/2020
13896	202045	Washington County	1696	11/1/2020	11/7/2020
13897	202047	Washington County	1967	11/15/2020	11/21/2020
13898	202048	Washington County	1486	11/22/2020	11/28/2020
13899	202049	Washington County	1581	11/29/2020	12/5/2020
13900	202050	Washington County	1071	12/6/2020	12/12/2020
13901	202051	Washington County	714	12/13/2020	12/19/2020

Figure 6

Insert a row (or add it to the end of the spreadsheet) and insert the data shown in Table 1.

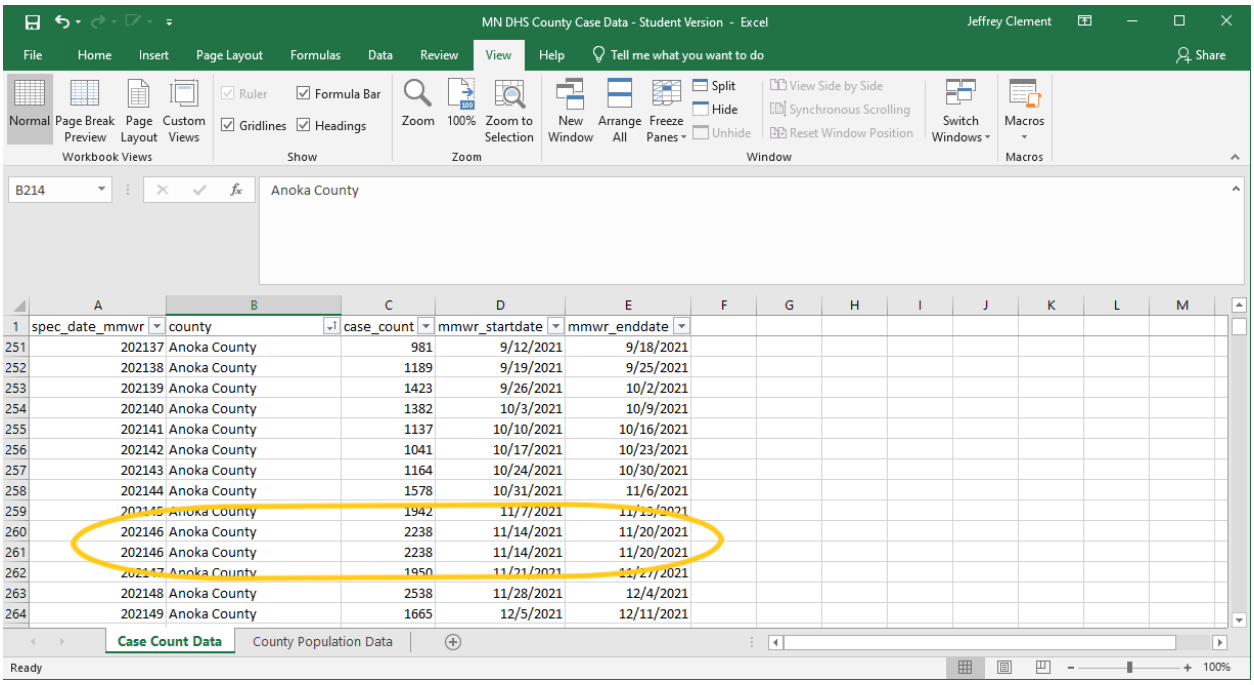
Table 1: Missing Washington County Data

spec_date_mmwr	county	case_count	mmwr_startdate	mmwr_enddate
202046	Washington County	2123	11/8/2020	11/14/2020

Discussion Question 3

What are some things that could cause some data points to be completely missing (like this county that missed one of the weekly case counts)? As far as you can tell, is this data point more likely to be Missing Completely at Random (MCAR) or Missing Not at Random (MNAR)?

Next, investigate why Anoka County seems to have an extra row, with the entry for spec_date_mmwr 202146 duplicated (See Figure 7).



	A	B	C	D	E
1	spec_date_mmwr	county	case_count	mmwr_startdate	mmwr_enddate
251	202137	Anoka County	981	9/12/2021	9/18/2021
252	202138	Anoka County	1189	9/19/2021	9/25/2021
253	202139	Anoka County	1423	9/26/2021	10/2/2021
254	202140	Anoka County	1382	10/3/2021	10/9/2021
255	202141	Anoka County	1137	10/10/2021	10/16/2021
256	202142	Anoka County	1041	10/17/2021	10/23/2021
257	202143	Anoka County	1164	10/24/2021	10/30/2021
258	202144	Anoka County	1578	10/31/2021	11/6/2021
259	202145	Anoka County	1942	11/7/2021	11/13/2021
260	202146	Anoka County	2238	11/14/2021	11/20/2021
261	202146	Anoka County	2238	11/14/2021	11/20/2021
262	202147	Anoka County	1950	11/21/2021	11/27/2021
263	202148	Anoka County	2538	11/28/2021	12/4/2021
264	202149	Anoka County	1665	12/5/2021	12/11/2021

Figure 7

This row (shown in Table 2) is duplicated. Select one of the duplicated entries and delete that row.

Table 2: Duplicated Anoka County Data

spec_date_mmwr	county	case_count	mmwr_startdate	mmwr_enddate
202146	Anoka County	2238	11/14/2021	11/20/2021

After you make the changes to the data, save the Excel file, and go back to Tableau. Right click on the Case Count Data up at the top left, and select "Refresh." Washington County and Anoka County should each have 169 rows now.

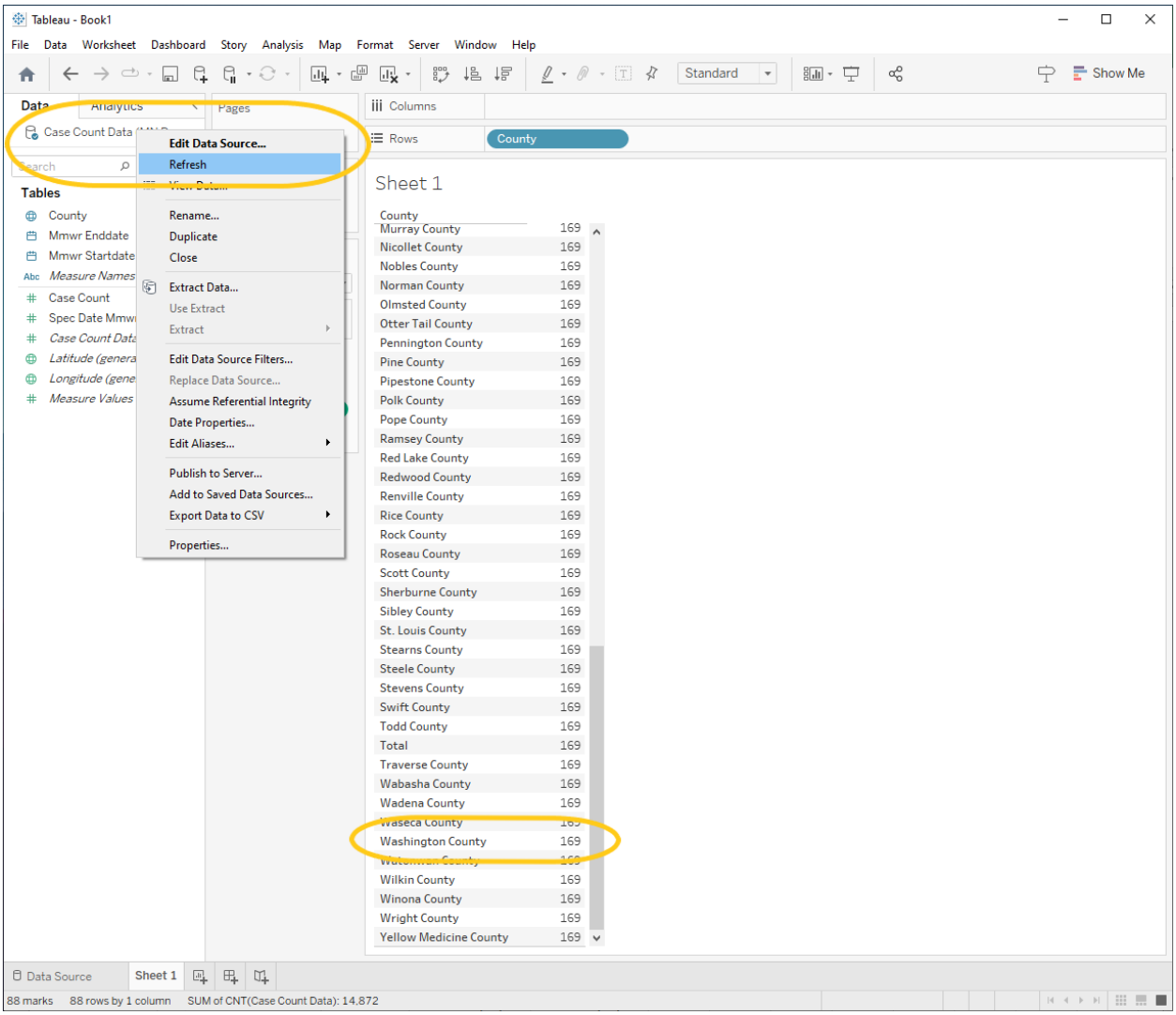


Figure 8

Discussion Question 4

Even though we have the same number of data points for each county (weekly reports) this dataset almost certainly is missing data because the case counts are too low. Why are the case counts probably too low? Is that data more likely to MCAR or MNAR?

Case Count by County

The next step is to look at the case count by county. Add a worksheet by clicking on the "New Sheet" icon near the bottom of the screen. It will create a new sheet called "Sheet 2." Double click on the sheet name to rename it "Cases Over Time." Drag "Mmwr Enddate" to the Columns field and Case Count to the Rows as shown in Figure 9.

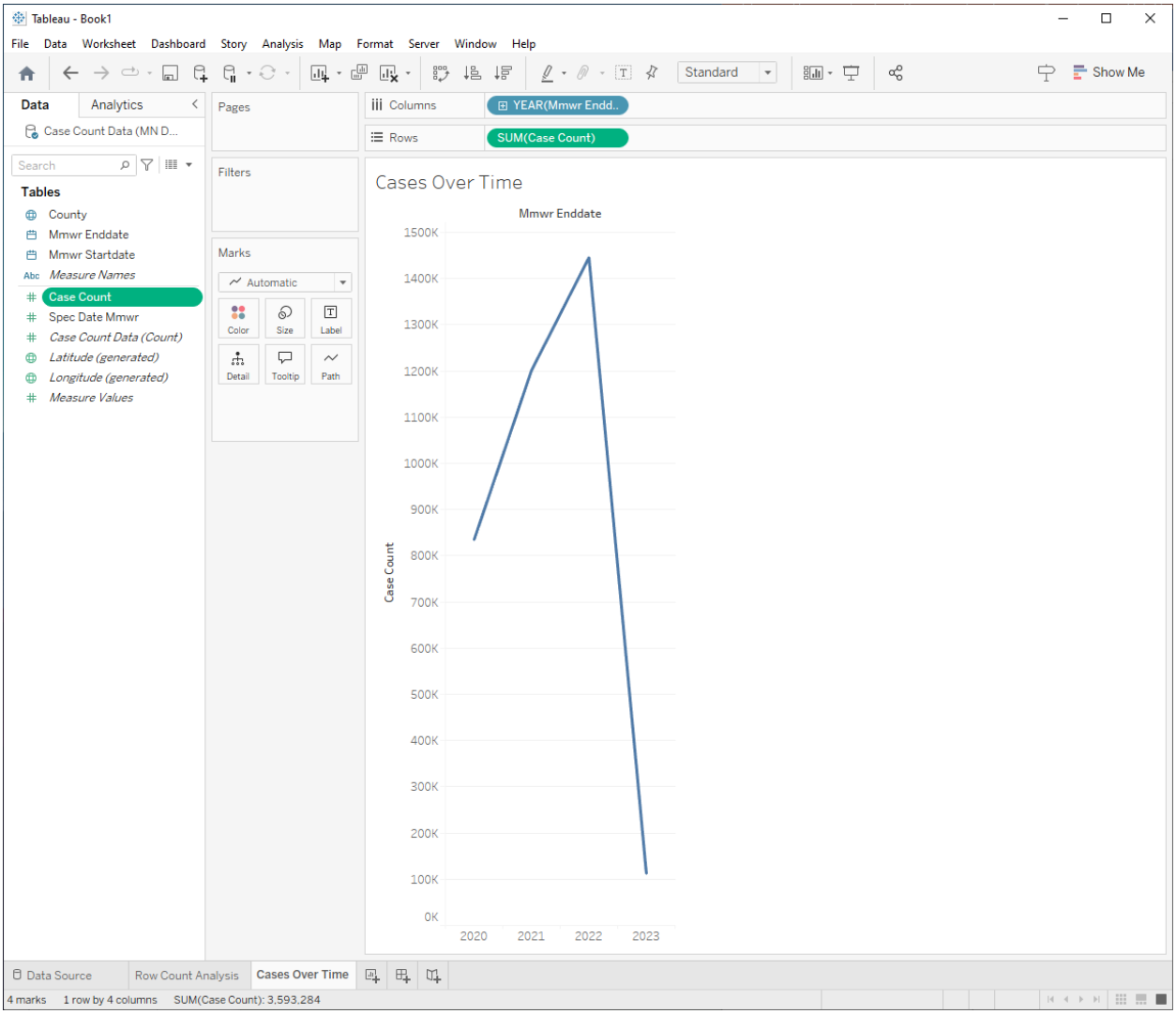


Figure 9

Notice that Tableau aggregated dates at the Year level, and aggregated Case Counts with the SUM function. Let's make the analysis a little more granular by looking at monthly data.

Click on the blue pill in the Columns field that says YEAR(Mmwr Enddate), and select the Month *May 2015* option in the dropdown. If you select the first Month dropdown, it will aggregate all the data across years (adding up January 2021, January 2022, January 2023). See Figure 10.

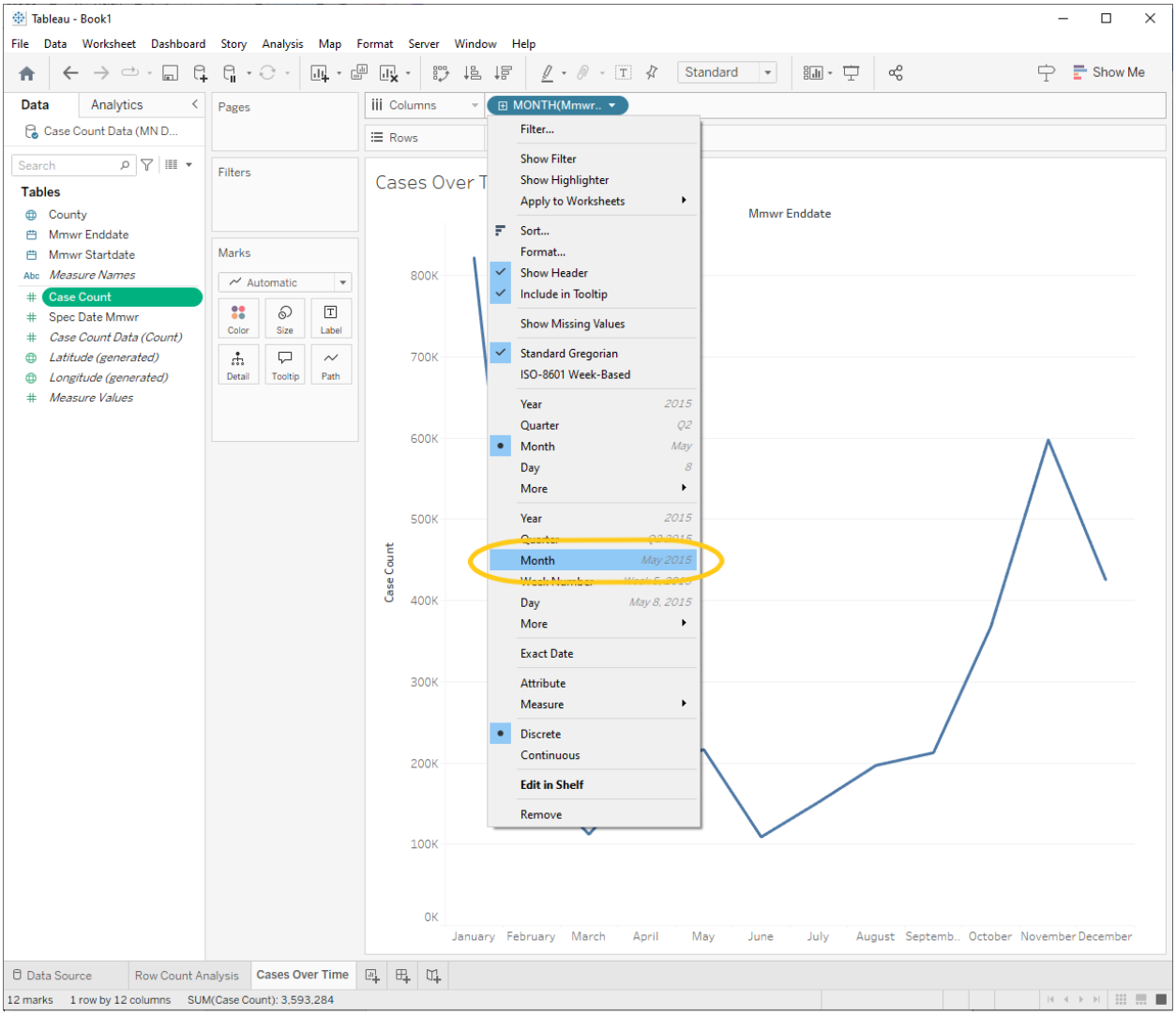


Figure 10

Are these numbers accurate? Look through the list of county names in the Row Count Analysis sheet…look at the Ts. The original dataset included rows with the county name “Total” and the case count totaling up all of the cases.

Discussion Question 5

The original dataset includes each county as well as a row labeled "Total" that is the sum of each individual county's cases. What is the effect of this row on our analysis up to this point?

In other words, when this row is included, there are approximately 700k cases in Jan 2022, but what should the right number be?

To fix this, drag the County into the Filter field. A dialogue box will appear. First, select "All" to include all counties, and then un-click "Total". The Selection in the Summary at the bottom of the dialogue box should say "Selected 87 of 88 values," as shown in Figure 11.

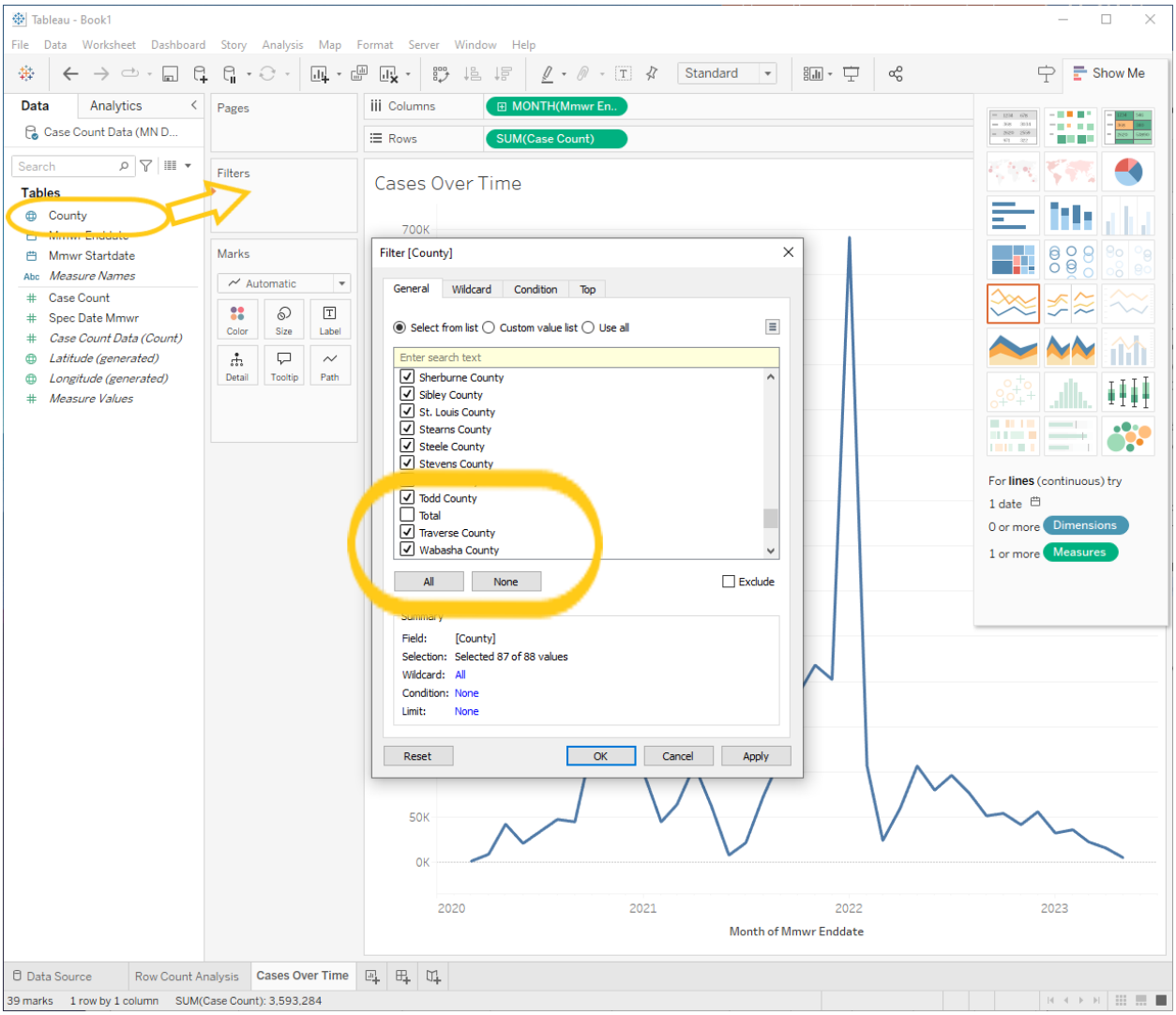


Figure 11

Notice the shape of the graph is the same, but the number of cases has dropped by half.

Next, let's look at the trends by county. Drag "County" from the data pane on the left into the Rows field; put it to the *left* of SUM(Case Count). We should have a series of line graphs showing the number of cases over time.

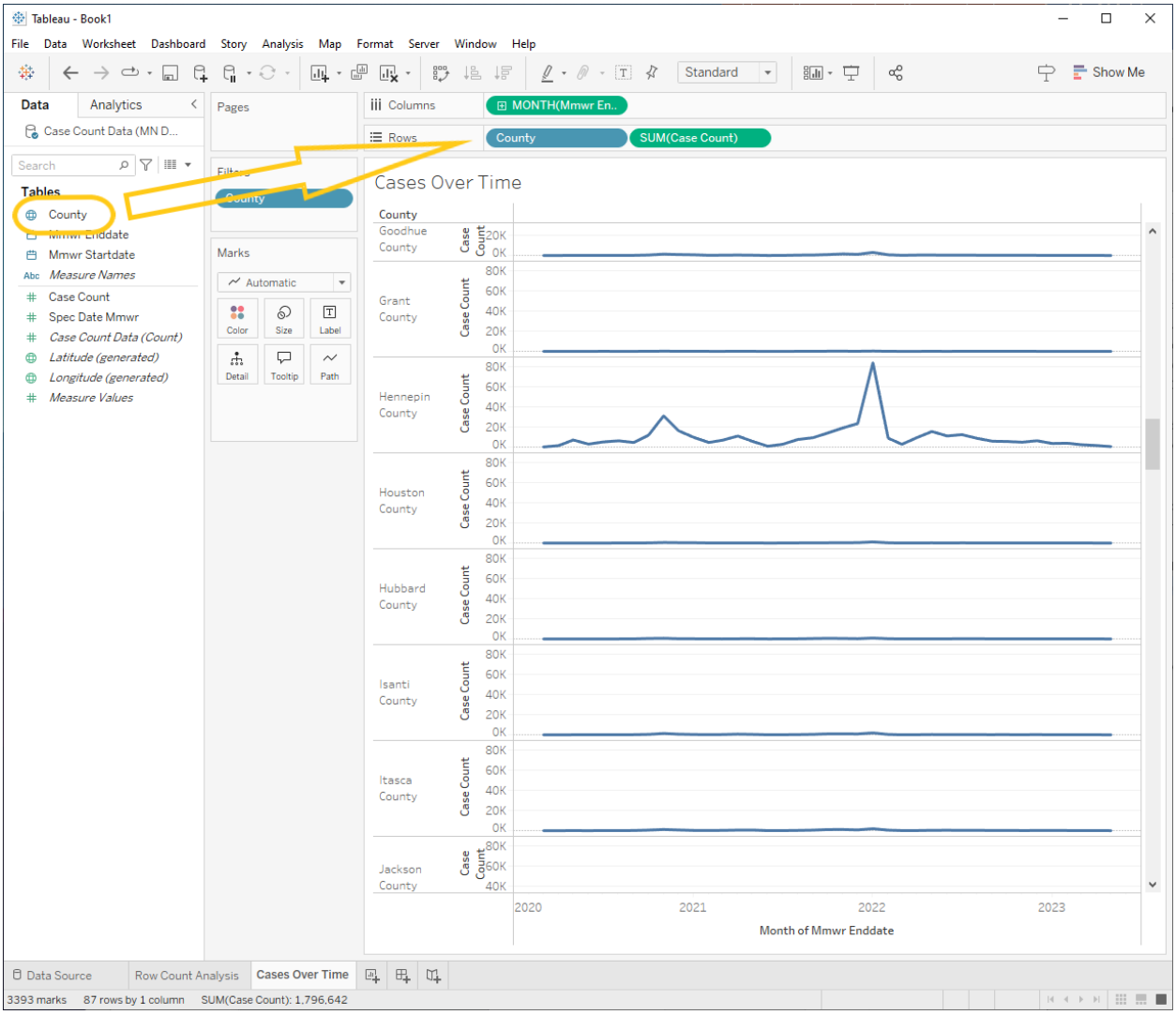


Figure 12

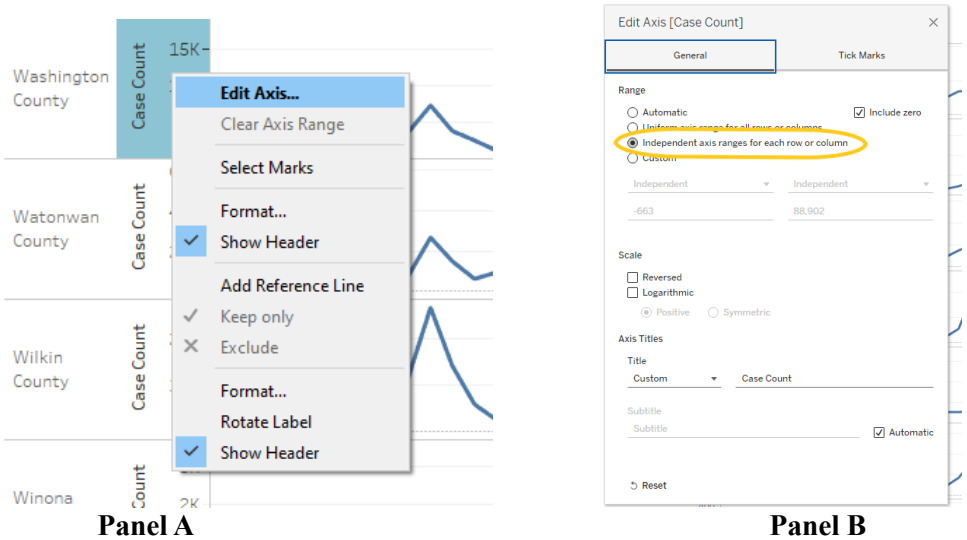
Hennepin County is visible, but the rest of them are not. All of the graphs have the same Y-axis, and it looks like Hennepin county has a lot of cases but the rest of the counties are much lower. They just look like flat lines.

Discussion Question 6

Why does Hennepin County probably have so many more cases than the rest of the state?[‡]

To fix this issue and let each county have its own independent Y-axis range, *right* click on any of the county Y-axes, and then click Edit Axis. (See Figure 13, Panel A).

On the dialogue box that pops up, under the Range setting on the General Pane, select Independent axis ranges for each row or column. (See Figure 13, Panel B).



Panel A **Panel B**

Figure 13

[‡] Hint: If you are not familiar with Minnesota, look at the County Population sheet in the data file.

After changing to the Independent axis setting, you should see a graph that looks like Figure 14.

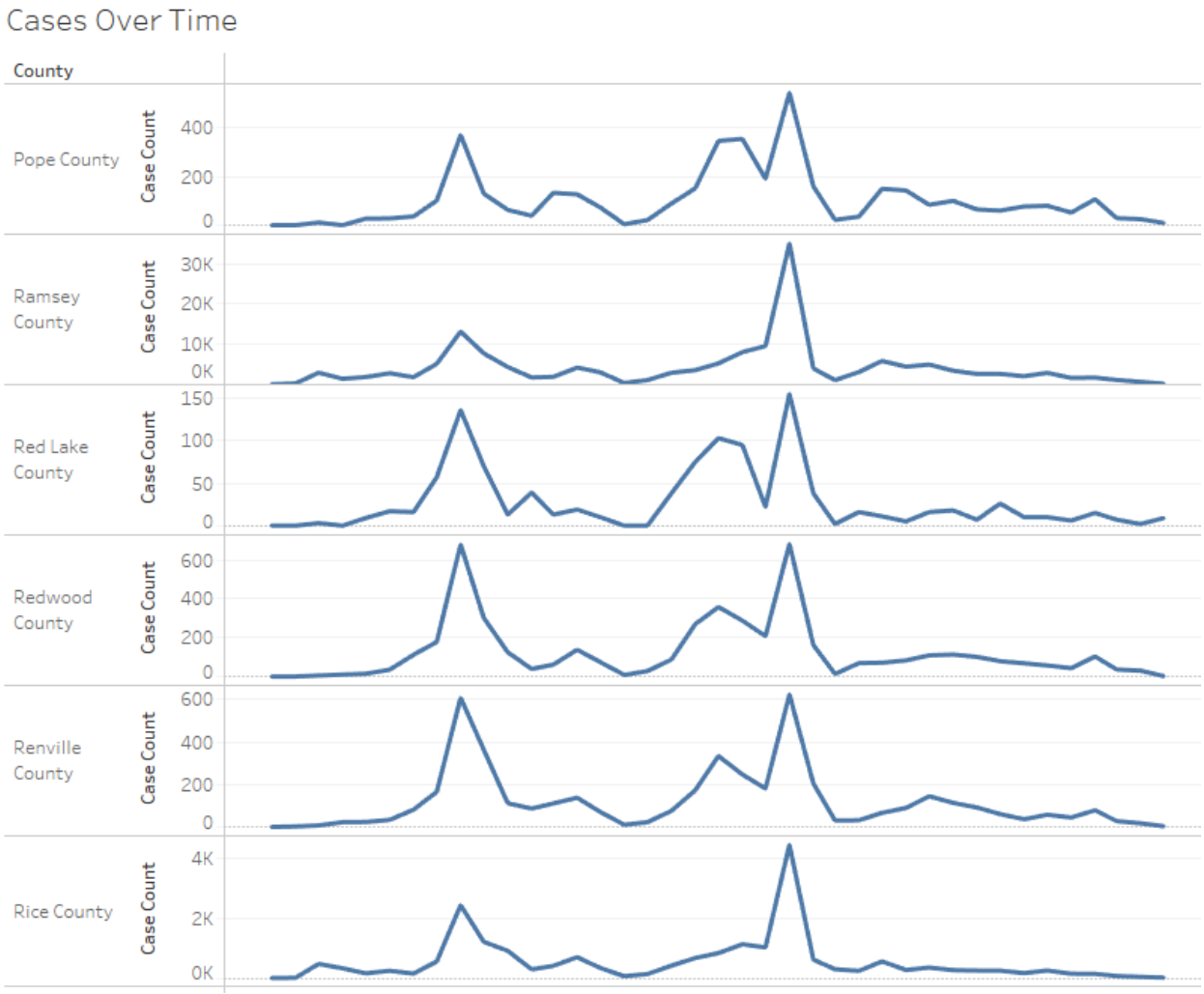


Figure 14

Are the trends between counties similar?

Examine Case Prevalence (Rate)

Does it make sense to compare two counties if they have different populations? A county that has more people is also more likely to have more people get sick. To do that, we need to compare the number of cases to the population.

So we need the population data, and need to connect our Covid-19 Case Count Data with the County Population Data.

Click on the Data Source tab on the bottom left of the screen. Drag the County Population Data sheet from the left pane (under Sheets) into the middle of the screen (to the right of the Case Count Data) box (See Figure 15). This is called *joining* the two data tables.

The most important part of these "table relationships" is how the two tables relate to one another. In this case, the county name is the "key variable."

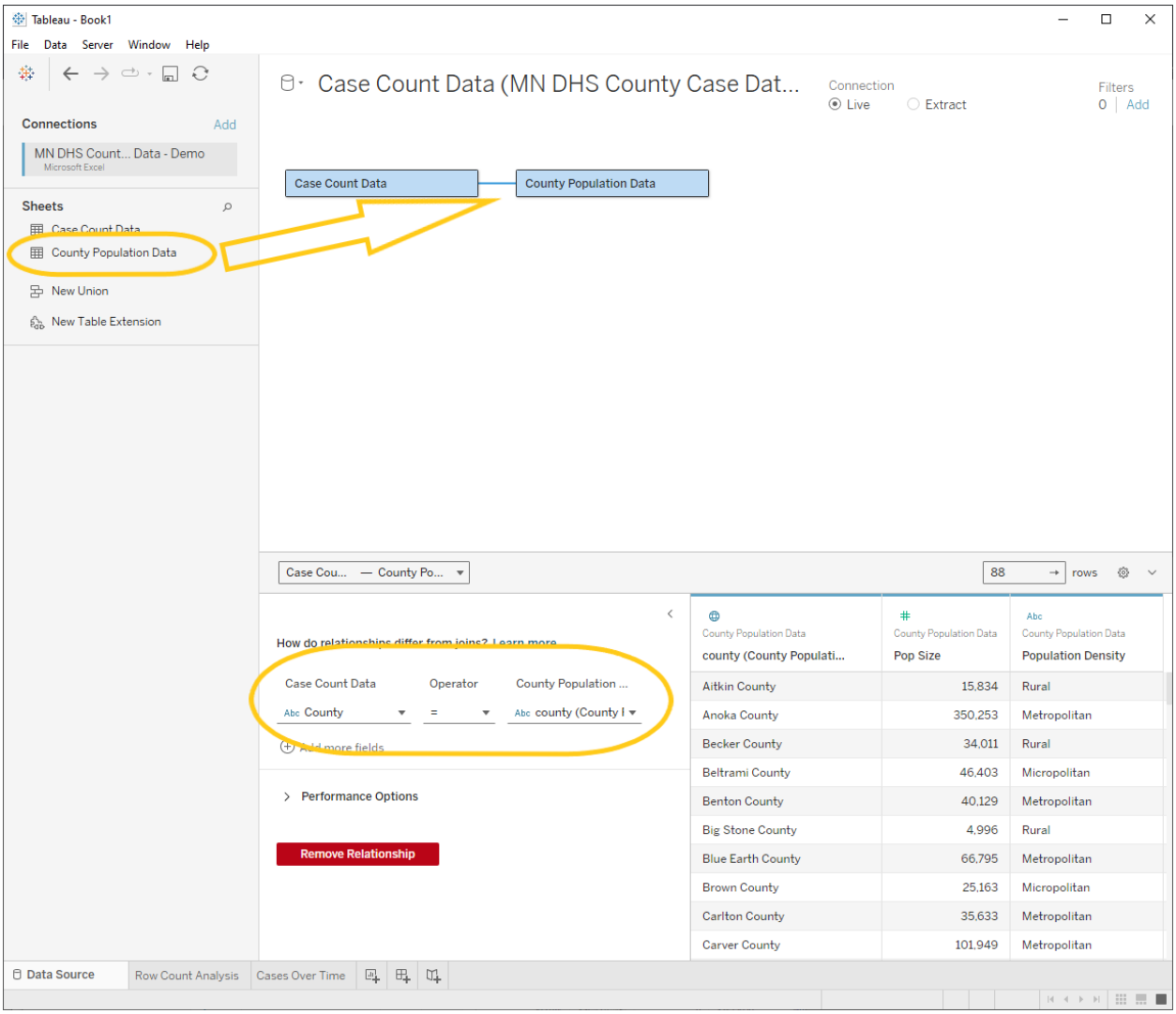


Figure 15

You should now have two Tables on the left and can access the demographic data to calculate the prevalence.

Right click in the white space under the tables on the left and select the option “Create Calculated Field” option in the dialogue box that appears (Figure 16).

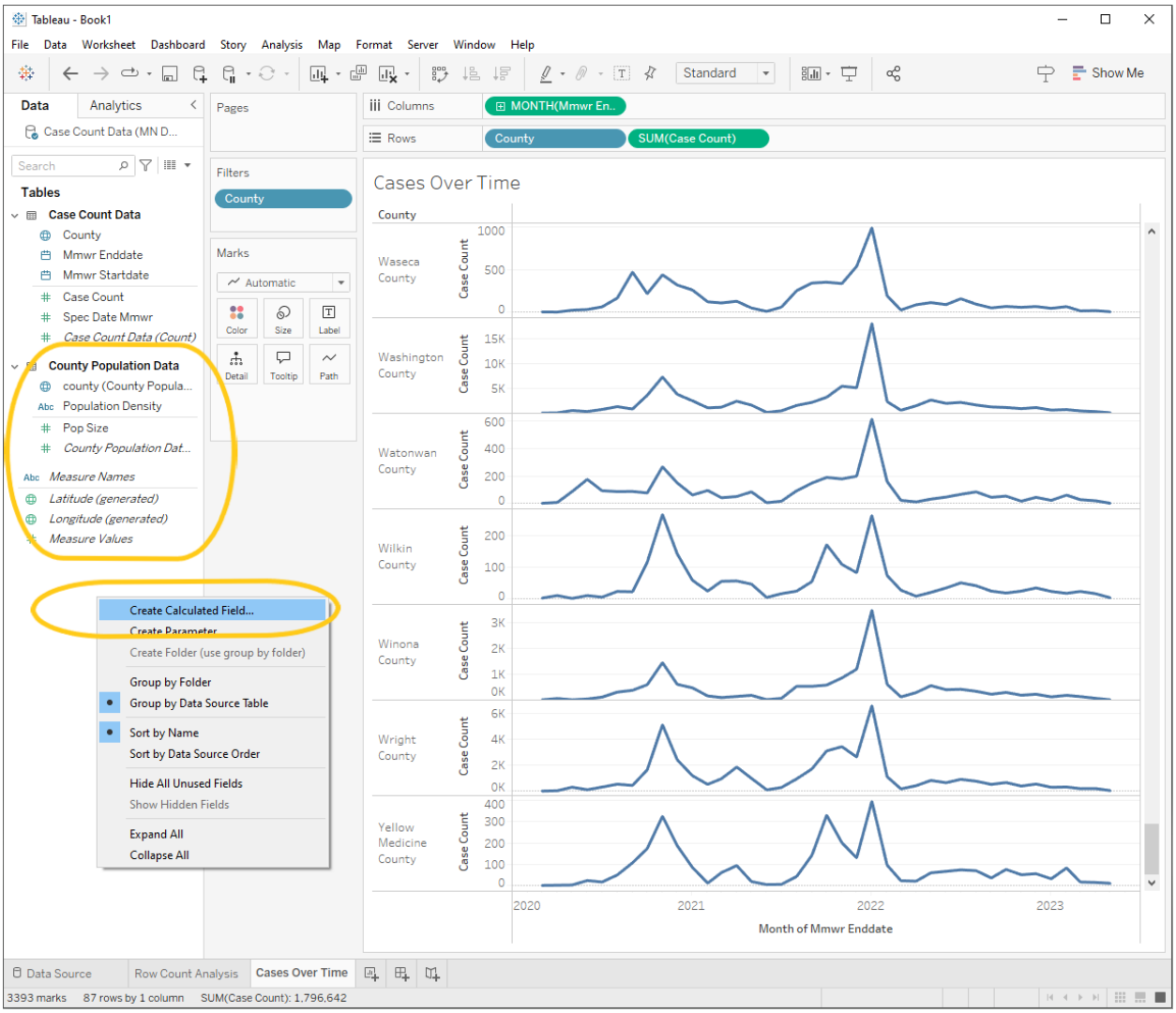


Figure 16

We will calculate the prevalence as the Case Rate per 10,000 people. In the dialogue box that pops up, name the variable “Case Rate Per 10k” instead of CalculatedField. The formula should be typed as:

```
[Case Count]/[Pop Size]*10000
```

The variable names (Case Count and Pop Size) should turn orange as you complete the name and Tableau should tell you “The calculation is valid” in the bottom left (Figure 17).

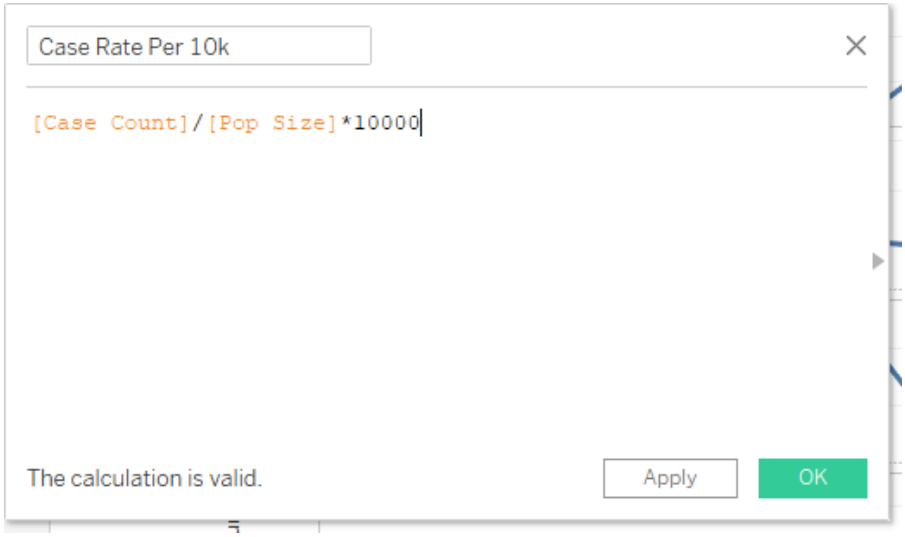


Figure 17

Now that we have created a variable for Case Rate Per 10k, we need to put that on the graph. Right click on the SUM(Case Count) pill in the Rows field, and select the “Remove” option at the bottom of the dialogue box that appears.

Now, drag the new Case Rate per 10k field to the Rows field (Figure 18). Notice that even though Tableau would vary the Y axes, it doesn't need to anymore…we are now comparing apples to apples.

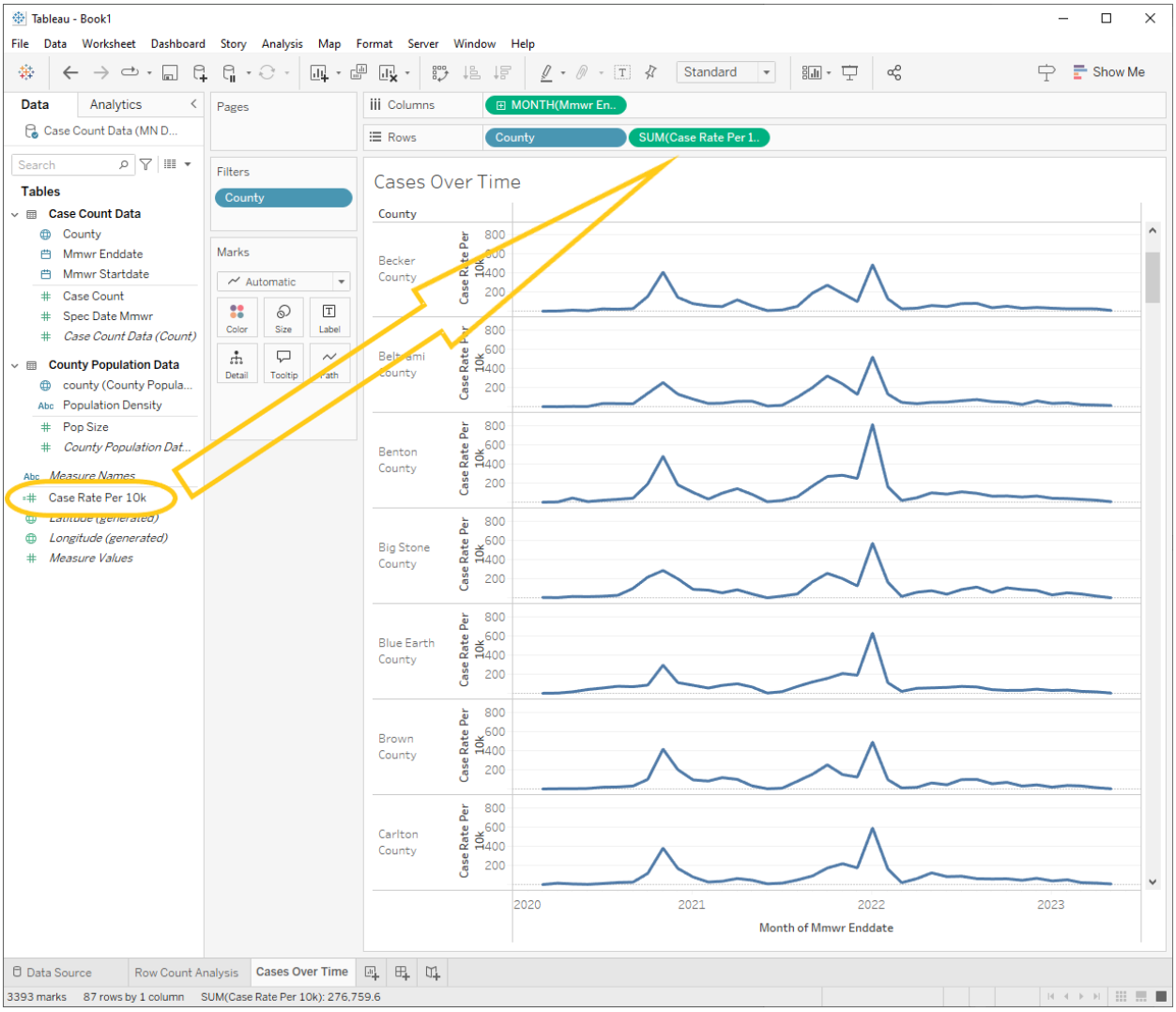


Figure 18

Compare Rural and Urban Areas

The next step is to look at compare the prevalence between urban and rural areas. Add a worksheet by clicking on the "New Sheet" icon near the bottom of the screen. It will create a new sheet called "Sheet 3." Double click on the sheet name to rename it "Case Rate by Demographics."

Drag Mmwr_end_date to the columns field, and update it to aggregate at the monthly level (look back at Figure 10 if you need a reminder).

Drag the new Case Rate Per 10k to the Rows field.

Then, drag the Population Density field from the data pane on the left onto the "Color" box in the Marks field (near the center of the screen; it has four colored dots arranged in a square).

We now see the graph in Figure 19.

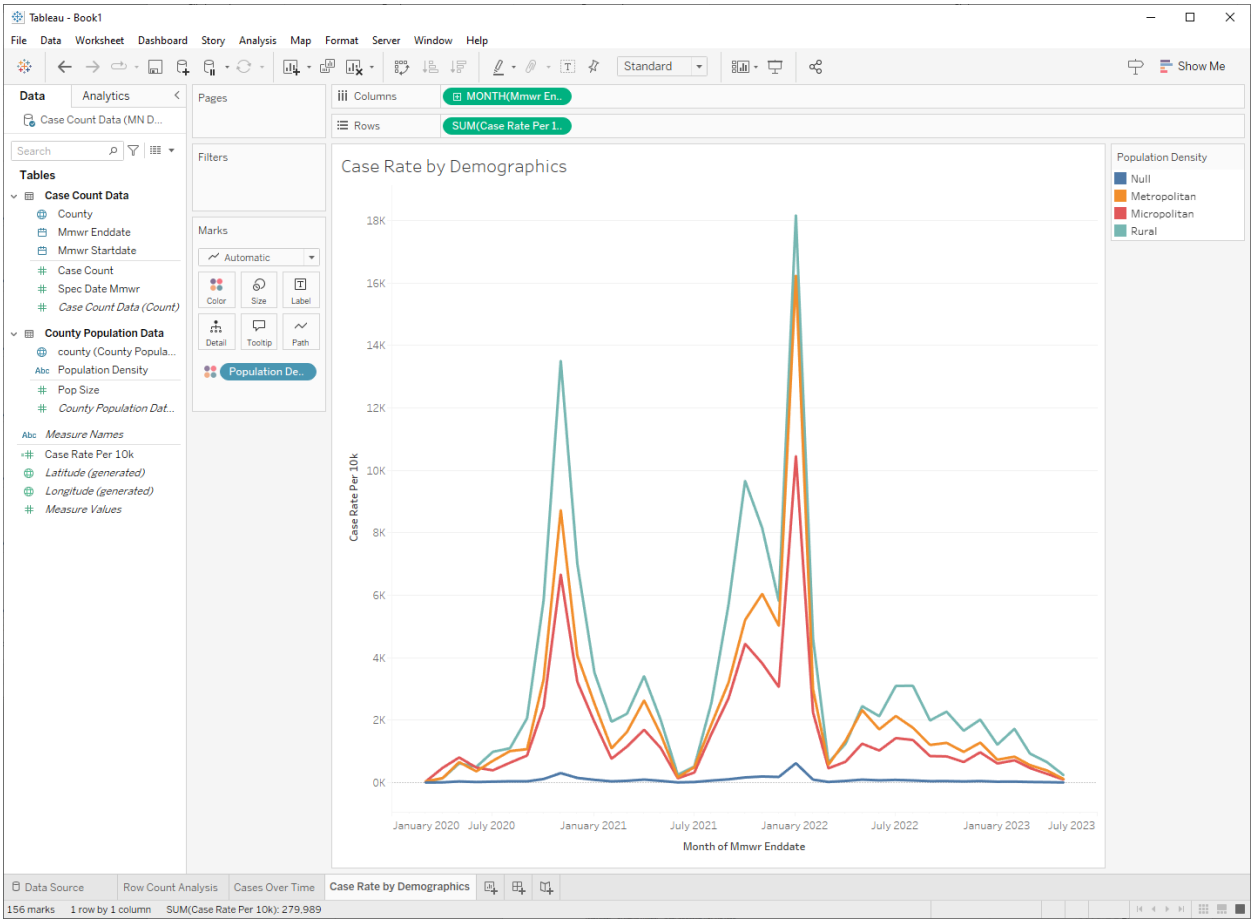


Figure 19

There are a few problems with this that we will address. First, we see categories for Metropolitan, Micropolitan, and Rural areas, as we would expect, but we also have a group called "Null." Second, the aggregation for Case Rate Per 10k is "SUM."

Which value ("county") has no density classification? It's the Total value that is lurking in the dataset. We filtered it out for the Cases Over Time sheet back in Figure 11, but the Filter is not applied to the Case Rate by Demographics sheet.

To apply the filter to the Case Rate by Demographics Sheet, click on the tab for the Cases Over Time sheet, *right* click on the blue County pill on the Filters field near the upper middle of the screen). On the dialogue box that pops up, select "Apply to Worksheets → All Using This Data Source" as shown in Figure 20.

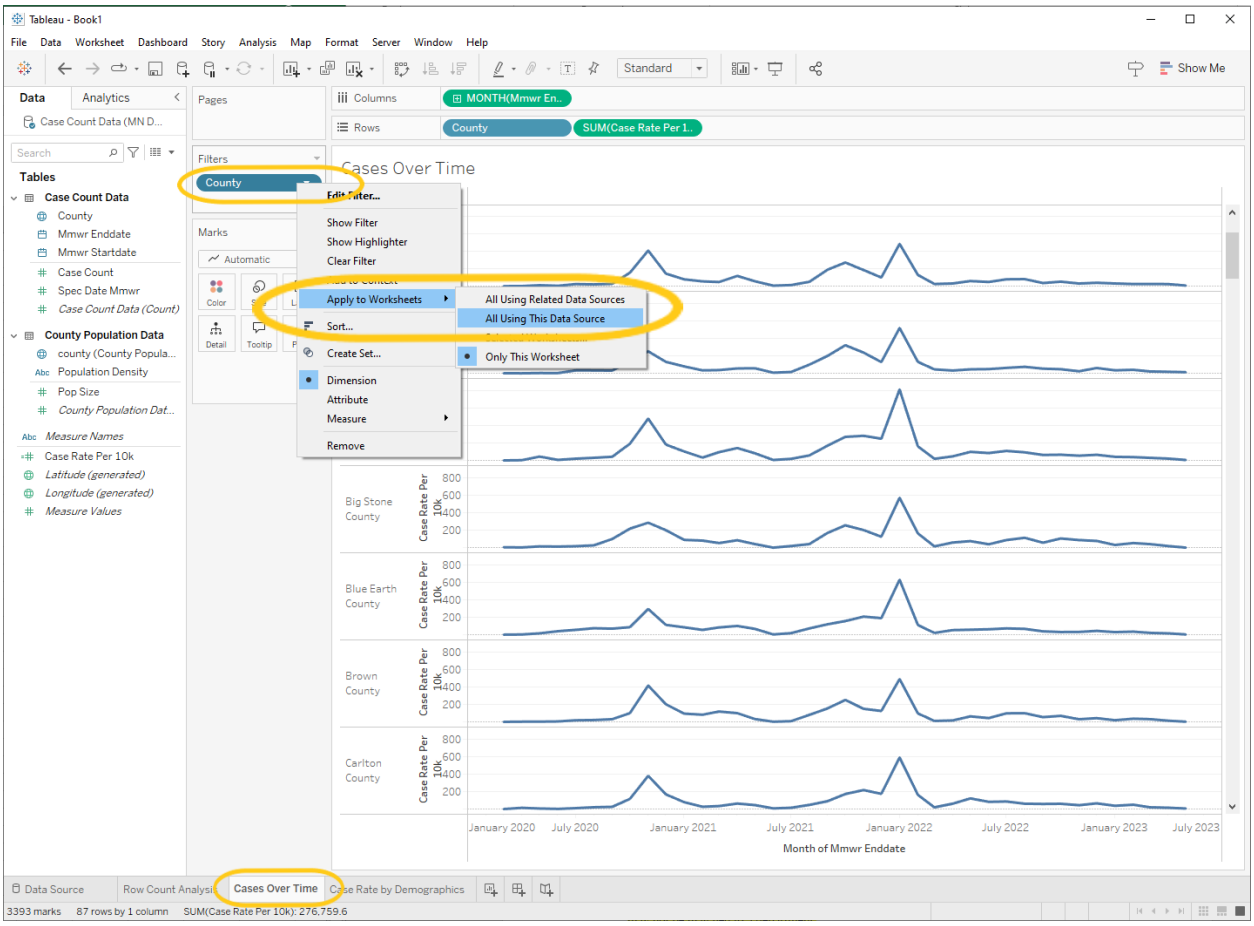


Figure 20

Now, click the tab at the bottom to go back to the Case Rate by Demographics sheet.

It looks like Rural and Metropolitan counties have much higher case rates.

However, if you look at the Rows field, we see that Case Rate Per 10k is being *added* up for all of the counties in each category by the SUM function. If one county has a case rate of 100 cases per 10k, and

another county has a case rate of 200 cases per 10k, their average is 150 cases per 10k…but if they are summed up our final number is 250 which is not right!

To fix this, click on the green SUM(Case Rate Per 10k) pill in the Rows field, and on the dialogue box that pops up click the one that says Measure (Sum) and change it to "Average" as shown in Figure 21.

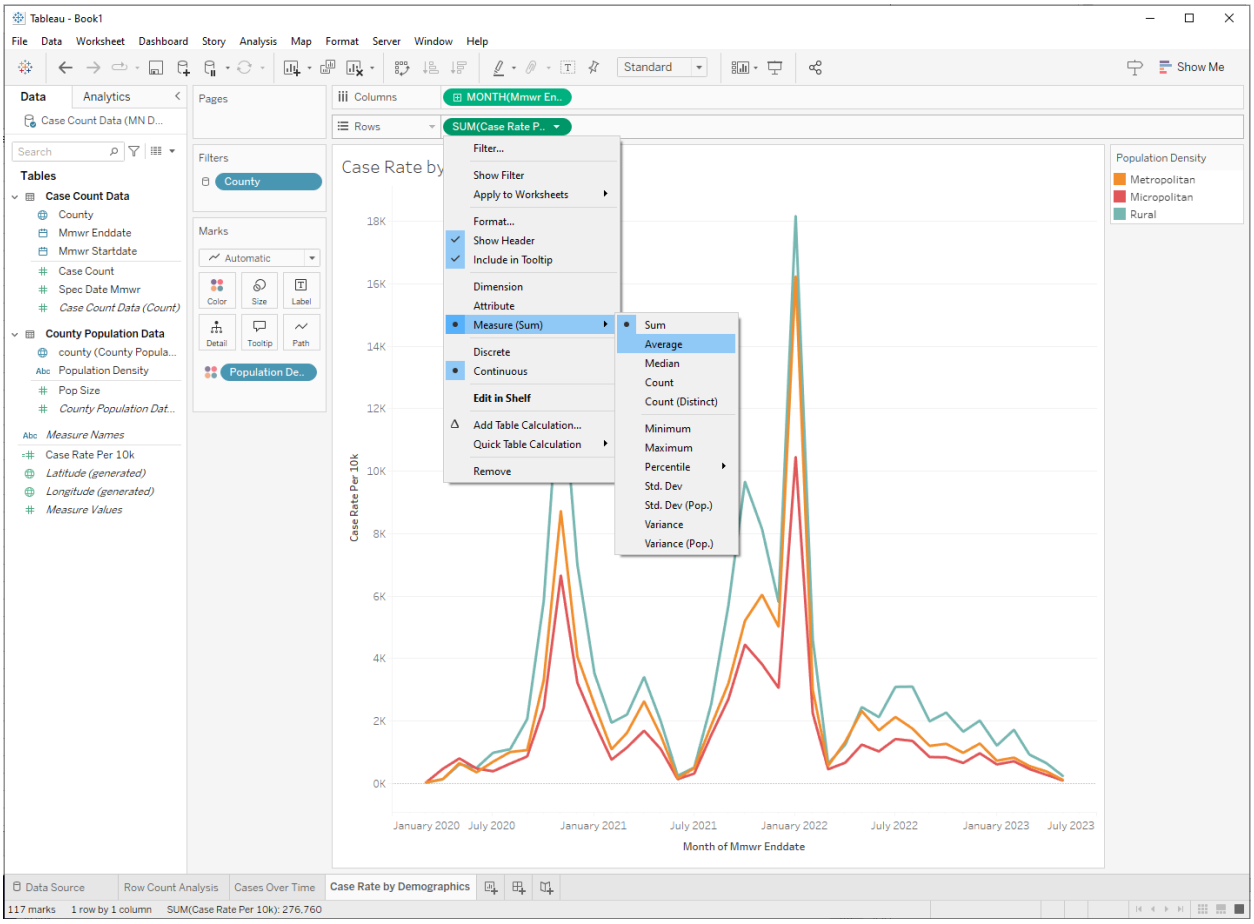


Figure 21

Now, instead of adding up the cases, they are being properly averaged (Figure 22).

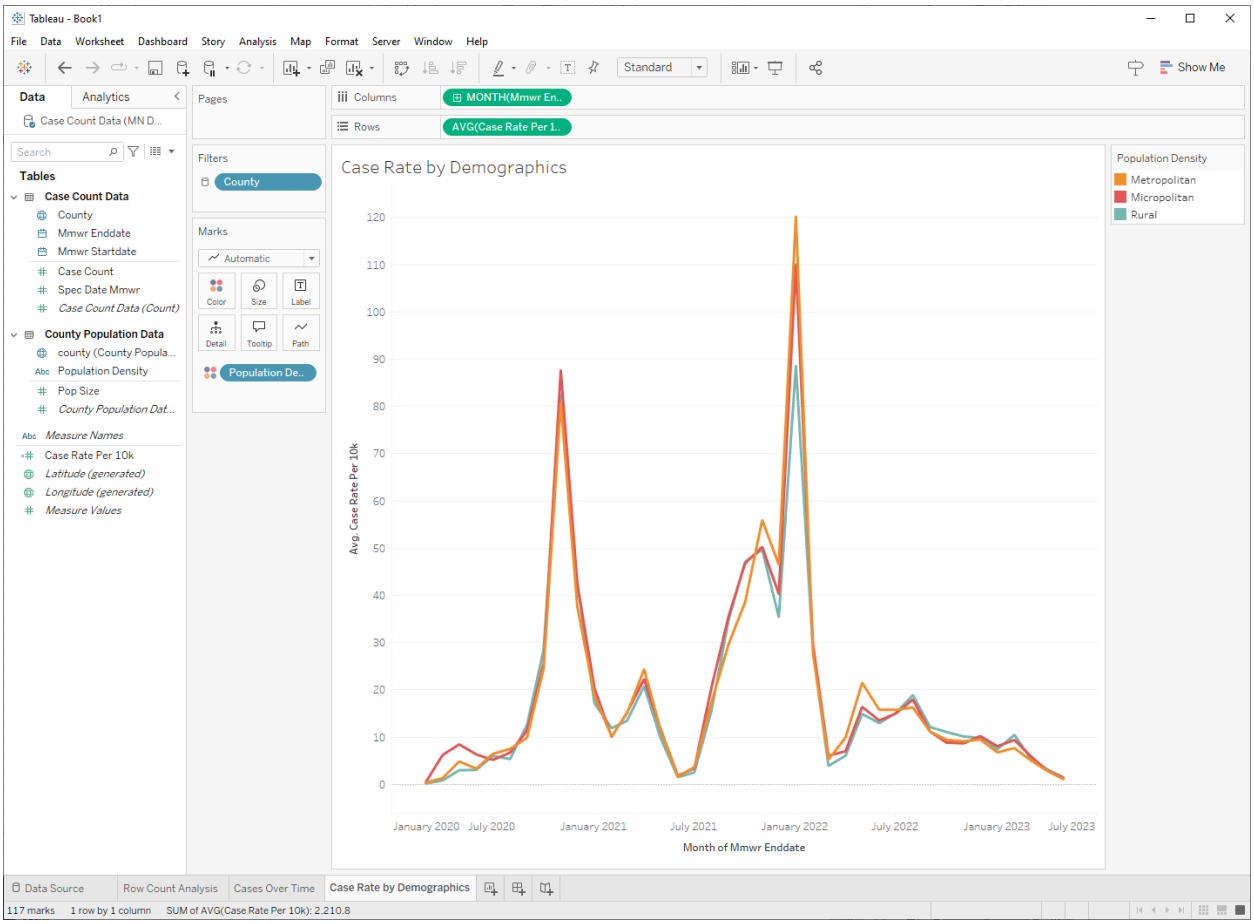


Figure 22

NEXT STEPS

With the final figure (Figure 22), we can now evaluate whether the case counts of Covid-19 were different in rural and urban areas.

Discussion Question 7

Are trends in Covid-19 cases different between rural and urban areas? Does it make more sense to talk about case count or prevalence (count per 10k people) or are both important?

EXHIBIT 1: COVID-19 DATA EXTRACT

Data Extract

The data extract contains more than 14,000 weekly counts of Covid-19 cases by county in Minnesota from March 2020 to May 2023.

The data was released by the Minnesota Department of Health. There are two tables (sheets) in the workbook; one has Covid-19 case count data and the other has county demographic data.

Data Dictionary – Case Count Data

Variable	Description
spec_date_mmwr	Numeric string indicating the MMWR week; MMWR weeks follow a specific convention set out by the US DHHS. MMWR weeks range from 1 to 53; the first week of the year with at least four days will be Week 1 and could potentially include Dec 29-31 of the previous year. MMWR weeks always begin on Sunday and end on Saturday.
county	Text string with the county name
case_count	Numeric count of the number of suspected or confirmed Covid-19 cases
mmwr_startdate	Date of the start (first day) of the reporting period (MMWR week)
mmwr_enddate	Date of the end (last day) of the reporting period (MMWR week)

Data Dictionary – County Population Data

Variable	Description
county	Text string with the county name
pop_size	Numeric count of the county population
population_density	Text string with the classification of the county as Rural, Metropolitan, or Micropolitan as defined by the US Office of Management and Budget. Metropolitan areas have an urban core ("downtown") with 50,000 or more residents; Micropolitan areas have an urban core with 10,000-49,999 residents.

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