MAISI

CRA Week 6:

Kaplan–Meier Curves and Survival Analysis cont.

Michigan Data Science Team
Fall 2025

Session 6 Agenda

01

Fun Icebreaker!!

Get to know your projectmates!

02

Survival Analysis Recap

Let's go over what we learned last week.

03

Kaplan-Meier Curves

What is this survival model?

04

Interpreting Kaplan-Meier Curves

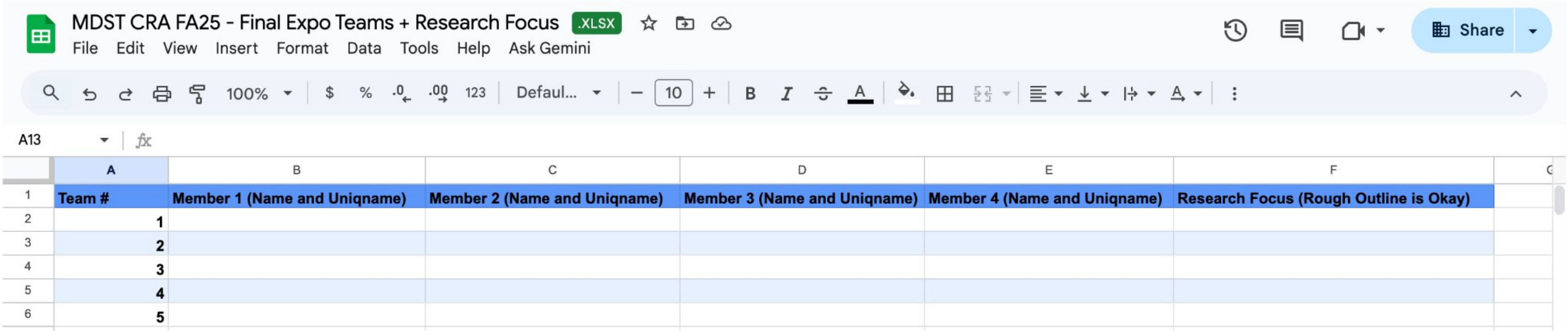
What do our findings tell us about our dataset?

05

Practice Time!

Work on the KM notebook!

But first...



Team #	Member 1 (Name and Uniqname)	Member 2 (Name and Uniqname)	Member 3 (Name and Uniqname)	Member 4 (Name and Uniqname)	Research Focus (Rough Outline is Okay)
1					
2					
3					
4					
5					

Talk to the people around you and start thinking about what you will want to present on at the Final Expo! We will go more in-depth as to what kind of topics you might want to look into, but if you have ideas now, feel free to discuss them and sign up! (you can change your mind later)

Quick Icebreaker!!

Share with the people around you, and **make up your own** if you're feeling creative :)

What are your thoughts on the following food classifications?

- Is a ravioli a dumpling?
- Is a hotdog a sandwich?
- Is an apple a low-entropy salad? (look up 'salad theory')
- Is cereal a soup?

Survival Analysis Review

- Used for analyzing “**time-to-event**” data (in our case, recidivism)
- Traditionally used in healthcare: “What variables affect the risk of a patient in care dying, and how does this look across time?”
- Example in context:
  - Helps us answer questions like: How long does a person go without reoffending after release?
- Identify factors that influence how long individuals remain “event-free” (without reoffending) after release

Facets of Survival Analysis:

- **Survival Function S(t)**: Probability of “surviving” (no event) up to time t
- **Hazard Function h(t)**: Rate of event occurrence at time t

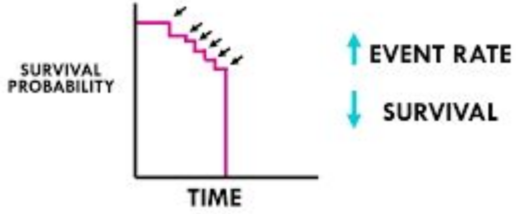
How does this relate to COMPAS?

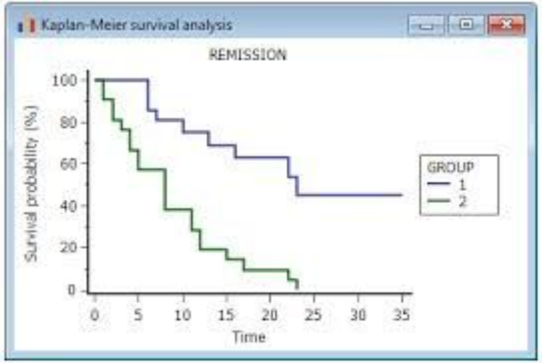
- COMPAS predicts the likelihood of **recidivism**
- Survival analysis can help understand if COMPAS predictions are **biased** or **accurate** over **time**
- **Cox Proportional Hazards Model (Cox PH) (Last Week)**
  - Understand which factors (age, race, prior offenses) increase or decrease recidivism risk, and how that interacts with COMPAS scores
- **Kaplan-Meier Curve (Today!)**
  - Understand descriptive trends by demographics (e.g., age, race)
  - How does recidivism probability change over time for different demographic groups?
  - How does COMPAS assign different “meanings” of scores to different groups?

…

Kaplan-Meier Curves

- **Non-parametric** model used to estimate the **probability** of "**surviving**" (remaining event-free) over time without assuming any specific hazard distribution
- In context, it can help us see how **long** individuals remain **recidivism-free** after release
- Example:
  - Tracking two groups after release—those with prior convictions and those without
  - KM curve shows how many in each group remain event-free (without reoffending) over time
  - Allows us to compare survival between these groups





KM Function

$$S(t) = \prod_{t_i \leq t} \left(1 - \frac{d_i}{n_i}\right)$$

- Big pi: product over all times t_i up to time t
  - t: The time at which we want to know the survival probability (e.g., probability of being event-free at 6 months)
  - t_i : Specific times when events (recidivism) occur within the dataset
- d_i = number of events (e.g., recidivism) occurring at time t_i
- n_i = number of individuals at risk just before t_i
- At each event time t_i the survival probability is **updated** based on the proportion of individuals who remain event-free (KM curve **steps down** with each observed event)
- Suppose we start with 10 people, and 2 reoffend at t = 6 months
  - The survival probability at 6 month$1 - \frac{2}{10} = 0.8$
  - If another event happens at 12 months, with 8 peo$S(12) = 0.8 \times (1 - \frac{1}{8}) \approx 0.7$

Interpreting Kaplan-Meier Curves

- Reading the Curve: Each “**step down**” on the curve represents an **event occurrence** or the probability of **not reoffending** by that **time**
  - Lower curves indicate faster recidivism rates
- Survival Probability at a Given Time: The y-axis value shows the probability of an individual remaining **event-free** up to that point
- Group Comparison: We can plot KM curves for different groups (e.g., individuals with vs. without prior conviction) to visually compare survival rates
- Example:
  - If the curve for those with prior offenses drops more **steeply**, it suggests they are **more likely** to reoffend earlier than those without prior offenses
  - If the survival probability for a group is 0.5 at 1 year, it means that 50% of the group is expected to remain event-free for at least one year

Calculating and Interpreting Median Survival Times

- Overall **median survival** provides a **benchmark** for when 50% of the population reoffends
- Compare survival times for **Low**, **Medium**, and **High** risk to understand how risk scores correlate with recidivism timing

```
# Use subset[‘end’] as the duration data, subset[‘two_year_recid’] as event the indicator
kmf.fit(durations=subset['end'], event_observed=subset['two_year_recid'])
# median_survival_time_ is an attribute of the fitted Kaplan-Meier model
median_survival = kmf.median_survival_time_
print("Median Survival:", median_survival)
```

- If **median_survival_time_** is a number (e.g., 400 days), it means that **half** of the individuals in this group recidivated within 400 days of release.
- If **median_survival_time_** is **inf** (infinity), it means that more than 50% of the group **didn’t** experience recidivism within the observed time frame. In other words, the median survival time **exceeds** the maximum observation period.

Comparing KM using Python

- Analyze survival curves for **Low**, **Medium**, and **High** risk groups to see differences in recidivism
- For example:

```
for risk, color in zip(risk_levels, colors):
  # Isolate data for each specific risk level
  subset = df[ df['score_text'] == risk ]
  # Use subset[‘end’] as the duration data, subset[‘two_year_recid’] as event the indicator
  kmf.fit(durations=subset['end'], event_observed=subset['two_year_recid'])
  kmf.plot(label=f'Risk Level: {risk}') # Plots, sets labels
```

- **zip( )** takes two or more sequences and pairs their elements together into tuples, creating a new sequence of tuples
    - Suppose you have two lists, risk_levels = ['Low', 'Medium', 'High'] and colors = ['blue', 'orange', 'green']
    - When you use zip(risk_levels, colors), it combines these lists into pairs: [('Low', 'blue'), ('Medium', 'orange'), ('High', 'green')]

Cox PH vs. Kaplan-Meier Comparison

Cox PH:

- **Inferential** Analysis: Assesses the effect of **multiple covariates** on the **hazard rate** (risk of event occurring)
- Provides hazard ratios, quantifying how each **factor influences** the risk of reoffending
- Controls for several covariates at once

KM Curves:

- **Descriptive** Analysis: Shows the **probability** of "**surviving**" (remaining event-free) over **time** for groups
- Compare survival probabilities across subgroups **without** considering additional covariates

Cox PH gives **statistical evidence** on covariate effects, KM provides a clear visual summary of **survival trends**

Ex. KM shows if individuals with prior offenses reoffend sooner, while Cox PH confirms and quantifies the effect of prior offense on recidivism risk

Real World Significance

Higher risk levels have **shorter survival** times, indicating **earlier recidivism**

Variances in curves for different genders and races highlight potential systemic **disparities**

Key question: **Even though different groups may have different base risk rates, do COMPAS risk scores have the same significance across groups?**

Median survival times and curves help prioritize **interventions** and indicate areas for potential **model adjustments**

Consider how recidivism data can improve **support services** and ensure **fair**, **data-driven decision-making**

Practice Time!

Let’s check out the survival rates across groups in the context of COMPAS!

Hands-On Data Science!! :O

Next Steps:

1. Find the F25 CRA repo in the MDST GitHub and download all the relevant files in the Week 6 directory (kaplan_meier_blank.ipynb, compas-KM-data.csv)
2. Split into teams of 2-3 (new ones or same as last week)
   a. If you're working with new people, introduce yourselves!!
   b. Start talking about your final presentation topic!!
3. Work on the exercises in the notebooks!
   a. Ask us if you need help!

Pandas Cheat Sheet   Seaborn Cheat Sheet

Reminders

- Don’t share colab notebooks with teammates if you are working at the same time

- Where to put csv and data files
  - Google Drive
    - Need to include:

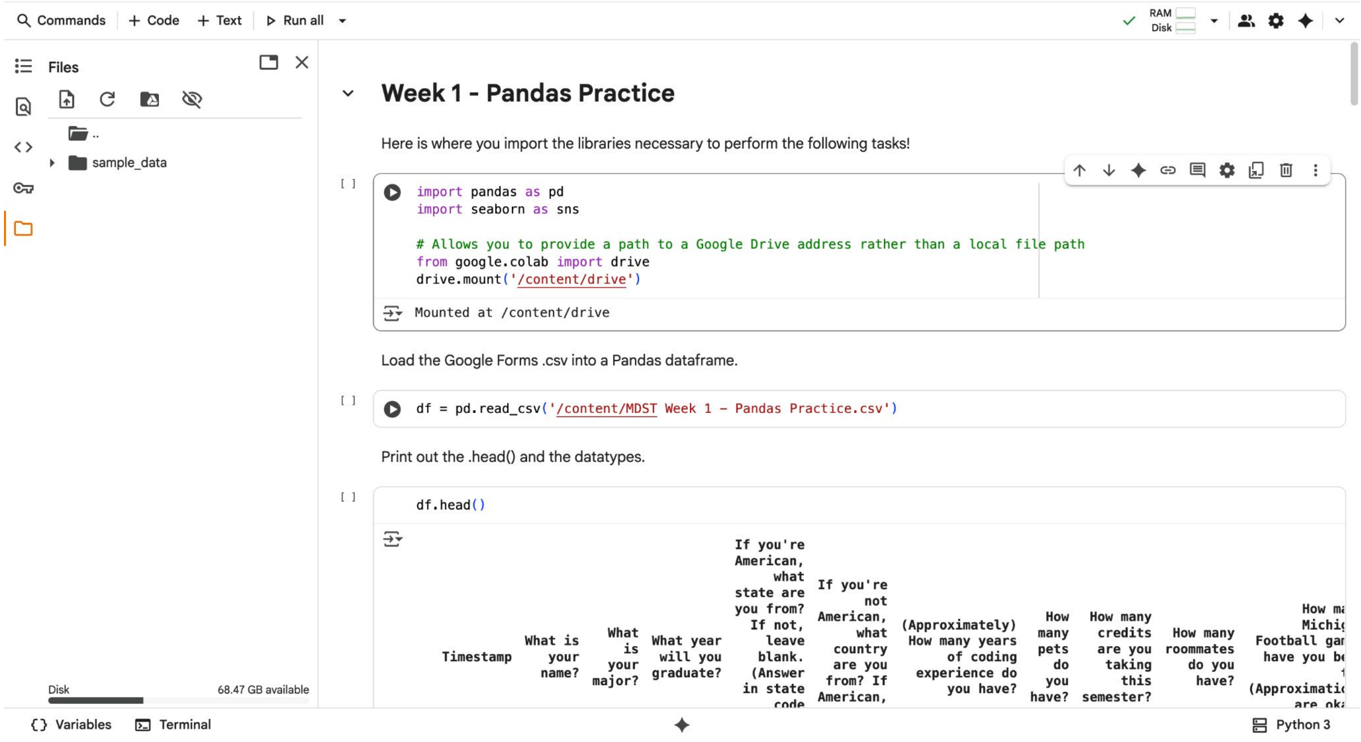
      ```
      from google.colab import drive
      drive.mount('/content/drive')
      ```

      ```
      pd.read_csv(‘/content/drive/MyDrive/[FILE NAME]’)
      ```

  - Colab Files
    - See next slides

Reminders

Click on the folder in the sidebar



Week 1 - Pandas Practice

Here is where you import the libraries necessary to perform the following tasks!

```
import pandas as pd
import seaborn as sns

# Allows you to provide a path to a Google Drive address rather than a local file path
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

Load the Google Forms .csv into a Pandas dataframe.

```
df = pd.read_csv('/content/MDST Week 1 - Pandas Practice.csv')
```

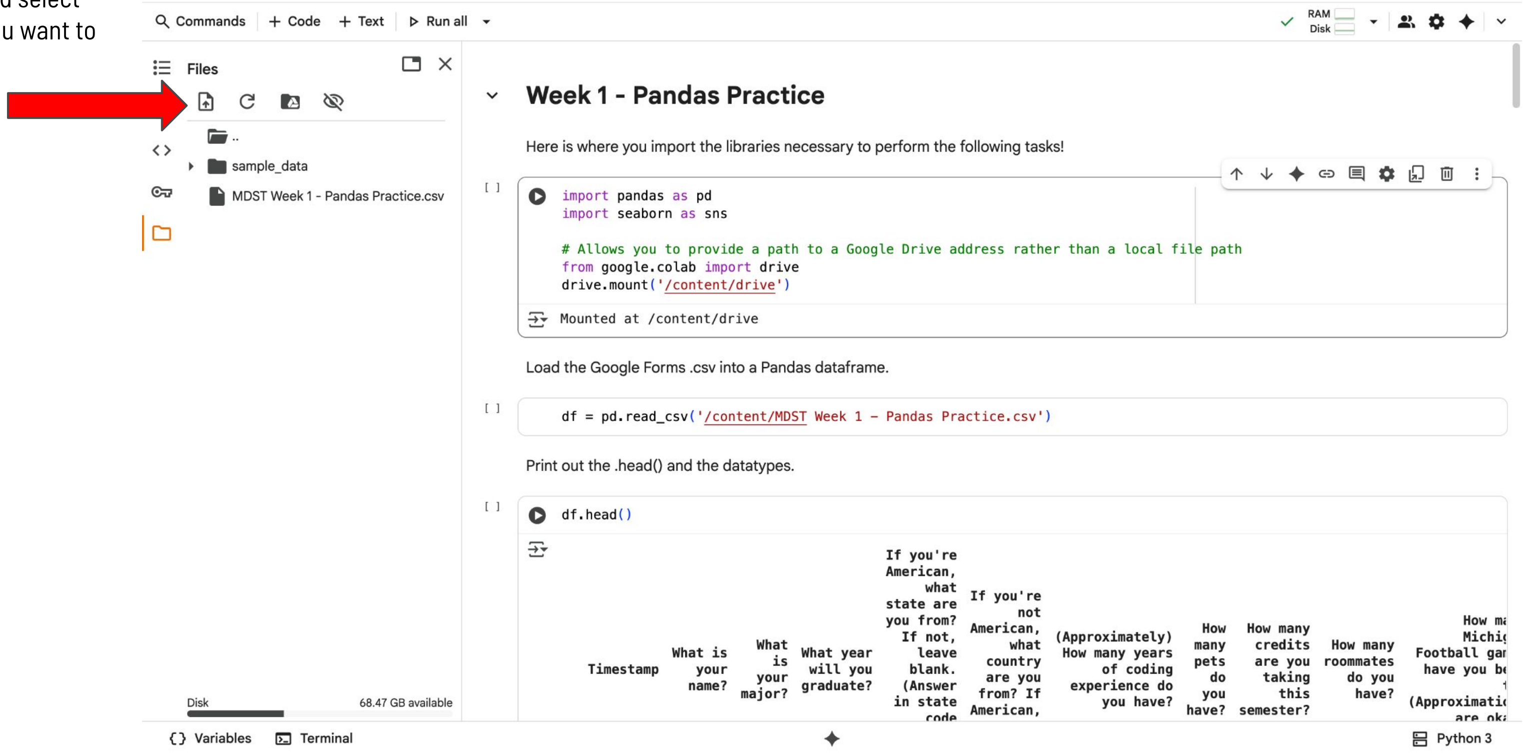
Print out the .head() and the datatypes.

```
df.head()
```

Timestamp	What is your name?	What is your major?	What year will you graduate?	If you're American, what state are you from? If not, leave blank. (Answer in state code	If you're not American, what country are you from? If American,	(Approximately) How many years of coding experience do you have?	How many pets do you have?	How many credits are you taking this semester?	How many roommates do you have?	How ma Michig Football gar have you be (Approximatic are oka

Reminders

Click the upload button and select the file you want to upload



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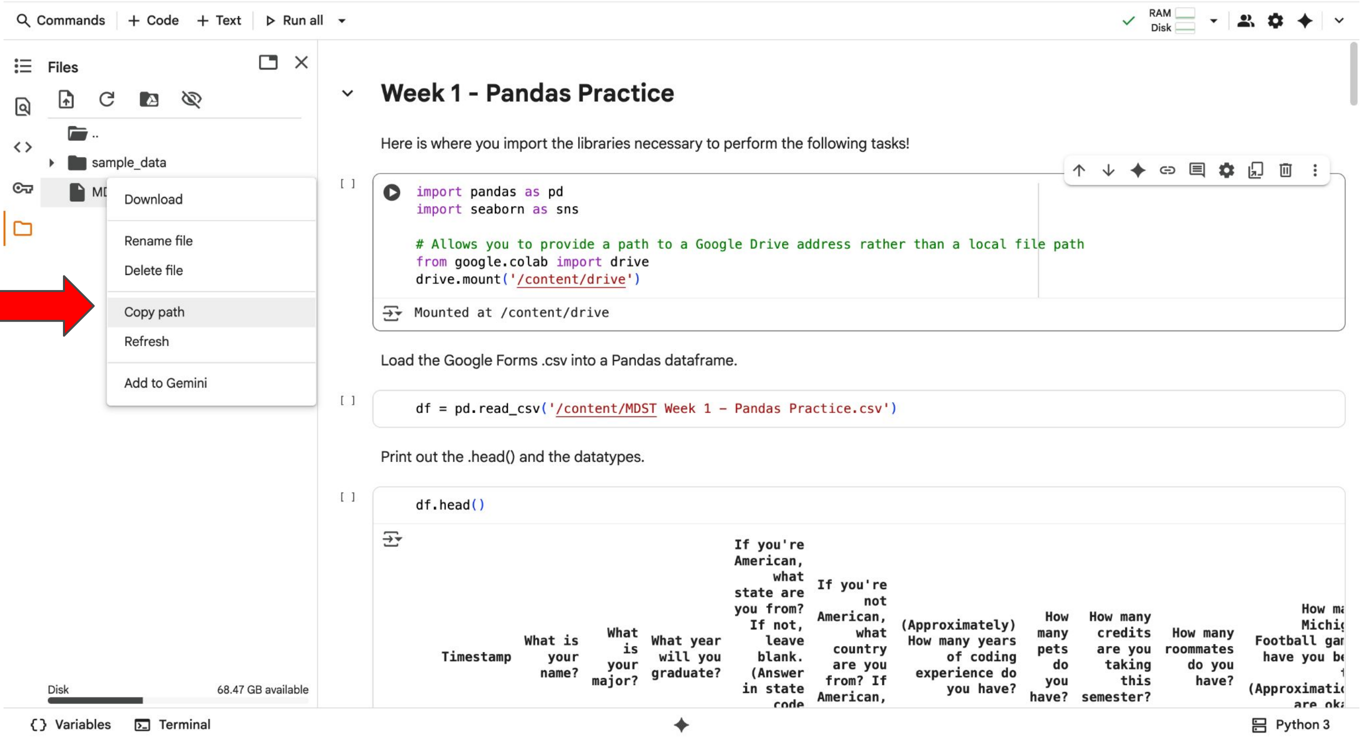
Reminders

Click the three dots and copy the path. Put this in your read function



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