Slide1 : plot1

This line graph shows the **weekly trend** in COVID-19 deaths in the U.S. over the period from 2020 to 2025.

**Initial Spike in 2020:**

* A large wave of deaths began in early 2020,
* Rolling average highlights a sharp increase and peak, showing the early impact.

**Subsequent Waves (2021–2022):**

* Several significant peaks follow, likely aligning with the **Delta** and **Omicron** variants.
* Each wave shows a **steep rise** and gradual decline in deaths.

1. **Trend Decline Over Time:**
   * Starting around 2022, there is a **notable decrease** in both daily deaths and their average.
   * Suggests improved control: due to **vaccinations**, **treatment improvements**, and **public health measures**.
2. **Recent Stability (2023–2024):**
   * The death counts become relatively low and stable toward the end of the timeline.

Very small fluctuations indicate **low transmission and fatality levels**.

1. **Initial Spike in 2020:**
   * A large wave of deaths began in early 2020, marking the first major outbreak.
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2. **Subsequent Waves (2021–2022):**
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   * Starting around 2022, there is a **notable decrease** in both daily deaths and their average.
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4. **Recent Stability (2023–2024):**
   * The death counts become relatively low and stable toward the end of the timeline.
   * Very small fluctuations indicate **low transmission and fatality levels**.

**Key Findings:**

1. **Initial Surges (2020–2021)**:
   * There are **sharp spikes in deaths** during certain periods—these likely correspond to known waves like:
     + The first major wave (Spring 2020),
     + The winter surge (late 2020 into early 2021),
     + The Delta variant wave (mid to late 2021).
2. **Peaks Follow Variant Waves**:
   * The **tallest peaks** typically reflect periods of high case counts, overwhelmed hospitals, and the emergence of new variants (Delta, Omicron).
3. **Declining Trend (2022–2025)**:
   * From mid-2022 onward, there is a **gradual decrease in death counts**, reflecting:
     + Increased vaccine coverage,
     + Improved treatments,
     + Possibly less severe variants.
4. **Seasonal Patterns**:
   * There may be smaller **recurring upticks in winter months**, suggesting a **seasonal influence** like with flu.
5. **Flattening in Recent Years**:
   * In 2024 and 2025, the trend appears much **flatter**, with fewer and smaller peaks — likely due to high immunity levels and effective public health interventions

Slide3 : plot3

Compare COVID-19 death trends by state over time using small multiples (facets).

Different Peak Timings Across States:

Some states (e.g., New York, California, Florida) had early and pronounced peaks, especially in 2020.Others showed later or multiple waves, reflecting geographic variation in transmission, policy responses, and public behavior.

Magnitude Varies Widely:States with larger populations (e.g., Texas, California) have higher peak counts, while smaller states show lower totals—hence the use of scales = "free\_y".

Multiple Waves:Most states experienced 2–4 visible waves over time, likely aligned with national variant waves (e.g., Alpha, Delta, Omicron).

Diminishing Peaks Over Time:For many states, later peaks are smaller, suggesting improvements in immunity (vaccination/natural infection), medical care, or public health measures.

Local Outbreaks and Responses:

Some states have spikes outside of national trends, possibly due to localized outbreaks, delayed mitigation, or limited healthcare access.

**Plot 4: Heatmap of COVID-19 Deaths by State (Quarterly)**

This heatmap visualizes the **intensity of COVID-19 deaths** across U.S. states **over time**, summarized **quarterly** from 2020 to 2025.

**Key Findings:**

1. **High-Intensity Periods**:
   * Darker shades indicate **higher death counts**. Many states show **dark bands in early 2020 and late 2021**, aligning with major COVID surges (e.g., **original outbreak, Delta, and Omicron waves**).
2. **Temporal Trends**:
   * Most states experienced **highest death tolls during certain quarters**, often corresponding to **winter surges** (e.g., Q4 2020, Q1 2021).
   * The heatmap reveals how **intensity waxed and waned**, with some **intermittent relief** between waves.
3. **Geographic Variation**:
   * States like **Texas, Florida, California, and Pennsylvania** consistently show **brighter tiles**, signaling **larger absolute death counts**, possibly due to population size and state-specific outbreaks.
   * Other states like **Vermont, Hawaii, and Alaska** remain **lighter**, indicating **fewer deaths overall**.
4. **Later Decline in Mortality**:
   * By **2023 and beyond**, many states show **lighter colors**, suggesting a **reduction in COVID-19 deaths**, potentially due to **widespread vaccination**, **prior immunity**, and **improved treatment**.

**Summary of Findings from Plot 5: "Top 5 States by COVID-19 Death Rate for Each Variant Wave"**

This plot gives a **clear snapshot of the top 5 hardest-hit states** (by **death rate per 100,000 people**) during **each major COVID-19 variant wave** from 2020 to 2024.

**Key Observations by Wave:**

**1st Wave: Original (Mar 2020 – Feb 2021)**

* **New York and New Jersey** were among the hardest hit, likely due to early outbreak clusters and overwhelmed healthcare systems.
* States with large metro populations or delayed lockdowns experienced higher per capita deaths.

**2nd Wave: Alpha (Jan – Jun 2021)**

* **Southern states** like **Alabama and Mississippi** appear at the top, reflecting **vaccine hesitancy** and lower initial vaccine rollout in those areas.
* High rates may also reflect under-resourced healthcare systems.

**3rd Wave: Delta (Jul – Nov 2021)**

* A **dramatic shift** is visible: **southern and midwestern states** like **West Virginia, Arkansas, and Missouri** dominate the list.
* Delta was highly transmissible, and the **low vaccination coverage** during this period played a major role.

**4th Wave: Omicron BA.1 (Dec 2021 – Mar 2022)**

* Although Omicron was generally milder, states like **West Virginia and Tennessee** still reported high death rates—again suggesting disparities in healthcare access and comorbidities.

**5th Wave: Omicron BA.2–BA.5–XBB (Apr 2022 – Jun 2023)**

* Death rates decreased overall, but **smaller states** with older populations (e.g., **West Virginia, Kentucky**) continued to have higher per capita rates.

**6th Wave: XBB (Jun 2023 – Mar 2024)**

* Deaths continued declining, but a few states (e.g., **Alaska or Mississippi**) still experienced comparatively higher burden—possibly due to **regional spikes**, lower booster uptake, or healthcare access issues.

**Findings from Plot 7: “COVID-19 Deaths Over Time – Top 10 States”**

This time series plot shows how COVID-19 deaths evolved **month-by-month from March 2020 to December 2021** for the **10 states with the highest total deaths** during that period.

**Key Observations:**

**🔹 Early Surges:**

* **New York** shows a **steep spike in early 2020** (March–May), reflecting the devastating first wave and overwhelmed hospitals.
* This early peak is **unique to New York**, as most other states had smaller or delayed first-wave death curves.

**🔹 Waves Become National:**

* Starting **late 2020 into early 2021**, **all top 10 states** show **synchronized increases** in deaths, especially around:
  + **Winter 2020 (Alpha wave)**
  + **Summer 2021 (Delta wave)**
* This reflects more **widespread national transmission** and variant-driven spikes.

**🔹 High-Burden States:**

* **California, Texas, Florida**, and **New Jersey** show sustained high numbers over time, with **multiple peaks**.
* These states likely appear at the top due to **population size**, but also policy differences, variant waves, and vaccination dynamics.

**🔹 Consistency in Ranking:**

* Despite regional differences in timing, these top 10 states all faced **repeated waves of high mortality**, contributing to their cumulative totals.

**Overall Insight:**

* The plot illustrates how the **pandemic’s impact evolved across states**, with **early regional crises** turning into **nationwide surges**.
* States with **large populations** and/or **early outbreaks** like New York, California, and Texas consistently show **elevated death counts over time**.
* This plot emphasizes the **chronic burden** some states endured across multiple waves—highlighting the need for resilient healthcare infrastructure and timely public health interventions.