INFOSCI301
Prof. Luyao Zhang
Final Project Report
Qianyue & Zixuan & Yifei

Visualizing Global Suicide Trends: A Data-Driven Exploration of Patterns Across Time, Gender, and Geography

Abstract

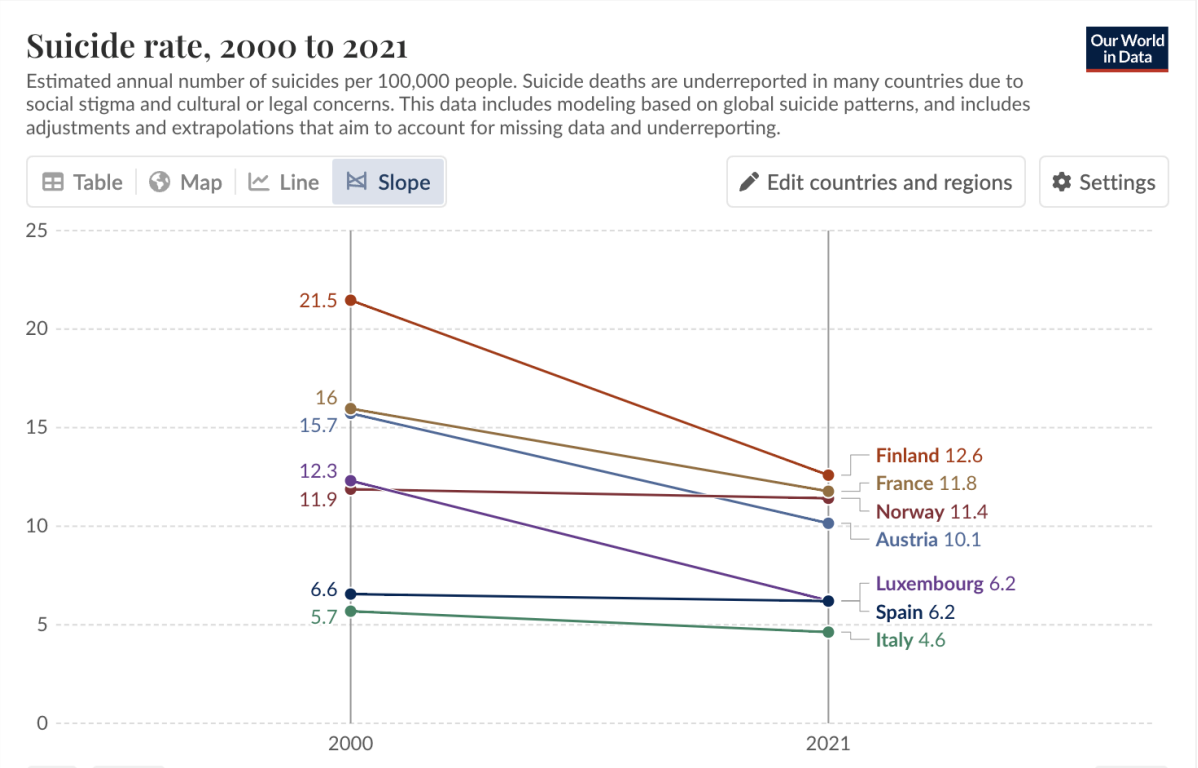
This project investigates global suicide trends using an interactive data visualization approach, combining temporal, demographic, and geographic dimensions to uncover meaningful patterns. Drawing from a comprehensive dataset of suicide statistics disaggregated by country, year, age group, and gender, the analysis reveals both global and localized dynamics in suicide rates. Visualization techniques such as line charts, stacked area plots, and interactive choropleth maps are employed to illustrate shifts over time and regional disparities. The project also lays the foundation for future integration with socio-economic indicators such as GDP, education level, and happiness index. The findings suggest that while the overall number of suicides has declined in recent decades, significant disparities remain, highlighting the need for targeted mental health interventions. This work contributes to data-informed public health strategies and supports the broader discourse on mental well-being at a global scale.

1. Background and Motivation

Suicide is a major global public health issue, claiming over 700,000 lives annually and affecting millions more through emotional, societal, and economic consequences (World Health Organization, 2021). Its complex, multifaceted nature, shaped by cultural stigma, socioeconomic conditions, gender disparities, and limited mental health infrastructure, demands more than just raw statistics. In many societies, suicide is both a deeply stigmatized and underreported phenomenon, complicating the efforts to study and address it effectively. Understanding long-term trends in suicide rates can provide crucial insights for mental health policy and prevention strategies.

A key inspiration for our project came from an online interactive visualization developed by *Our World in Data* (Figure 1), which presented global suicide rates using multiple plots. The clarity of design and interactive features in this visualization allowed users to explore patterns across countries and decades, prompting us to explore similar visual techniques in our work. This example demonstrated how well-structured visuals can uncover hidden patterns in sensitive data and empower audiences to engage critically with complex issues. This visualization aligns closely with our goals: to enhance mental health awareness, support targeted policymaking, and reduce stigma through accessible, evidence-based storytelling. It also informed our design decisions, particularly the integration of interactive elements and the emphasis on demographic segmentation.

Figure 1. Example of a global suicide visualization by Our World in Data



Contribution to SDGs: Good Health and Well-being (Goal 3)
This project aligns with the United Nations Sustainable Development Goal 3: "Ensure healthy lives and promote well-being for all at all ages." By offering clear, accessible visualizations of suicide trends, it enables policymakers, mental health practitioners, and the public to identify at-risk populations and evaluate progress toward suicide prevention. The project emphasizes the importance of mental health data transparency and cross-national comparisons, contributing to early warning systems and more effective policy responses aimed at reducing suicide rates globally.

Team Contribution Statement
This project was a collaborative effort with all team members actively engaged across multiple phases. Data preprocessing and transformation were jointly conducted using Python's Pandas library, with each member responsible for cleaning, reshaping, and verifying data integrity. Visualization tasks were divided among team members: one focused

on temporal trends using Seaborn and Matplotlib, another on age and gender distribution using stacked plots, and a third on designing interactive global maps via Plotly. We held regular meetings to discuss design principles, color encoding, and user experience, informed by key visualization theory chapters. All members contributed to the interpretation of results and the articulation of insights, ensuring a cohesive and well-supported narrative. Final editing and documentation were collaboratively completed.

2. Research Question

This project investigates the temporal trends in suicide occurrences and seeks to identify the underlying patterns and fluctuations over time. The central research question is: How has the total number of suicides evolved over the observed time period, and what factors might explain significant changes in these trends?

3. Application Scenario

Our data visualizations on global suicide trends have potential for real-world applications across public health, policymaking, and media communication. Government agencies and non-profit mental health organizations can use these visualizations to design targeted awareness campaigns. For instance, visual insights into age-specific or gender-based suicide trends can guide interventions toward the most vulnerable groups. Interactive dashboards could be placed on health websites or community centers to promote public understanding and de-stigmatize discussions around suicide. Our visuals can also be used as a reference for policymakers to prioritize mental health funding and services. By identifying regions or demographics with high suicide rates, decision-makers can better allocate limited mental health resources. In addition, news outlets and digital platforms that report on public health issues could incorporate our interactive charts to enrich narratives on mental health. Visualizations can make reports more engaging, helping readers understand patterns that may otherwise be hidden in raw numbers.

4. Methodology

Visualization Techniques

This study employs a visualization-oriented methodology grounded in established principles of information visualization, particularly those outlined by Munzner (2014) and supported by earlier theoretical contributions (Binkley, 1970; Carroll, 2001). The primary dataset comprises global suicide records disaggregated by country, year, gender, and age group, with variables including suicide counts, demographic identifiers, and temporal markers. This structured data schema facilitates robust trend analysis and comparative visualization across spatial and demographic dimensions.

To transform raw data into interpretable insights, a suite of visualization techniques was implemented, aligning with Munzner's (2014) framework of data types, marks and channels, and task abstraction. Key encodings such as lines, bars, and color were selected to represent temporal, categorical, and quantitative variables, respectively. Time-series data were visualized using line graphs, while stacked bar charts captured age- and gender-specific suicide rates, following best practices in time-series and part-to-whole representations. Gender differentiation was achieved through color theory, applying culturally

conventional hues (e.g., blue for males, pink for females) to enhance immediate recognition and interpretability, a method endorsed in visual aesthetics research (Carroll, 2001; Munzner, 2014).

Data abstraction played a crucial role in reshaping the dataset from a wide format into a long format to enable layered demographic comparisons. This restructuring supports stacked visualizations that more clearly illustrate age distributions within gender categories, aligning with Munzner's recommendations for effective encoding of multivariate categorical data. The visual hierarchy and dashboard layout were also designed with user cognition in mind, ensuring logical sequencing and spatial organization that prevent information overload. This design logic reflects Binkley's (1970) and Walton's (1970) insights that user perception is shaped not only by data content but also by its formal structuring.

Spatial visualization was integrated via an interactive choropleth map created with Plotly, enabling dynamic exploration of suicide rates across countries and years. This map follows best practices in spatial encoding by using color gradients to represent ordered quantitative data, specifically for visualizing the suicide rates per 100,000 individuals, thus aligning with Munzner's guidance on encoding ordinal and ratio data. Furthermore, interactive filtering supports task abstraction goals such as discovering anomalies, identifying patterns over time, and making regional comparisons, which could be the objectives central to high-level decision-making in public health (Munzner, 2014).

Overall, the visualization design emphasizes clarity, accessibility, and data integrity through informed encoding choices, spatial logic, and interaction design. The dashboard further adheres to labeling and layout principles, with clearly structured annotations and titles that guide viewer attention and minimize cognitive load. The result is an accessible, theoretically grounded, and empirically rich suite of visualizations capable of supporting both descriptive and comparative insights into global suicide patterns.

Data Sources and Integration

The analysis incorporates suicide datasets obtained primarily from reputable benchmarking sources, specifically, the Global Burden of Disease Study published by the Institute for Health Metrics and Evaluation (IHME) and detailed suicide statistics reported by the World Health Organization (WHO). Integrating these authoritative sources provides a robust foundation for comprehensive analysis, overcoming limitations inherent in relying solely on individual datasets. By merging these datasets, the project achieves enhanced granularity and broader geographical coverage, enabling insights into regional differences and temporal dynamics otherwise unattainable with a single source.

The Centers for Disease Control and Prevention (CDC)'s "Suicide Data and Statistics" dataset, available on the official U.S. Centers for Disease Control and Prevention website (https://www.cdc.gov), provides timely and authoritative data on suicide, one of the leading causes of death in the United States. This dataset breaks down suicide statistics by age, sex, race/ethnicity, and method, offering valuable insights for researchers, policymakers, and public health professionals. Aligned with the FAIR principles, the data is *findable* through a well-maintained government domain, *accessible* to all users without restriction, *interoperable* thanks to standardized formats that allow integration with broader health datasets, and *reusable* due to the CDC's clear documentation and metadata. Furthermore, the dataset

reflects the CARE principles by serving the *collective benefit* of suicide prevention, ensuring *authority to control* through CDC oversight, upholding *responsibility* by sensitively presenting potentially distressing information, and maintaining *ethical* standards in public health reporting. Overall, this resource supports data-driven approaches to mental health, enabling evidence-based action to reduce suicide rates and improve outcomes across different demographic groups.

By integrating the **OECD Causes of Mortality dataset** with the **WHO Suicide Data (1950-2021)**, we can gain a deeper and more comprehensive understanding of the global patterns and trends in mortality, particularly focusing on suicide and its relationship with other causes of death. While the OECD dataset provides detailed information on the leading causes of death across OECD countries, categorized by demographic factors such as age, sex, and health conditions, the WHO dataset offers a long-term, global view of suicide data, spanning over seven decades. Combining these datasets enables us to explore not only the prevalence and demographics of suicide but also how suicide trends correlate with shifts in other causes of death, such as chronic diseases, mental health conditions, and accidents. Additionally, it allows for cross-country comparisons, highlighting how different nations address suicide prevention and related public health issues.

Advanced Tools

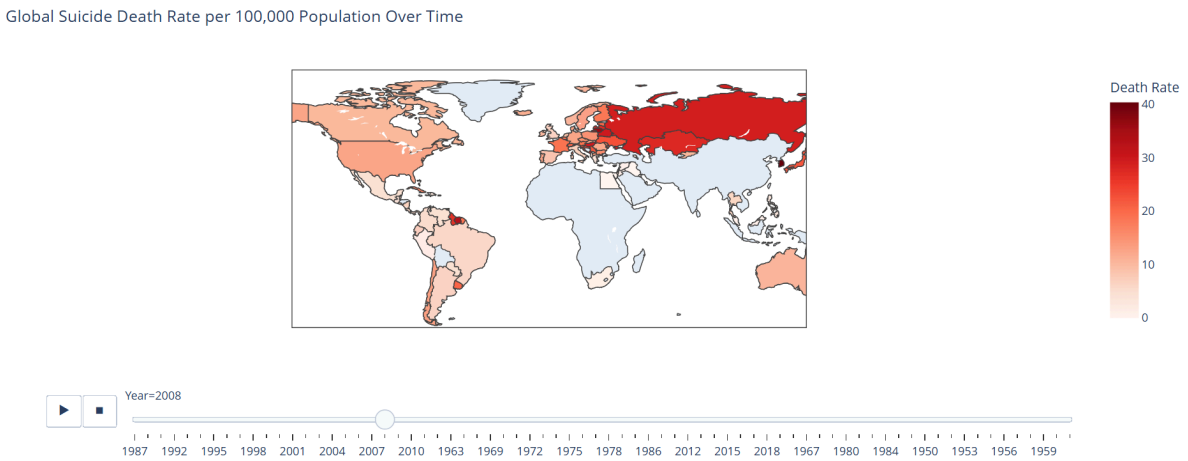
Technically, the project leverages advanced visualization and analytical tools. Plotly facilitates interactive geographic visualizations enhanced with dynamic time sliders, allowing intuitive exploration of longitudinal spatial trends. Additionally, static visualizations, including trend lines and layered plots, were produced using Seaborn and Matplotlib, effectively communicating demographic breakdowns and aggregate temporal changes. Data preprocessing extensively employs the Pandas library, specifically functions such as melt, groupby, sum, and filter, optimizing data structuring for visualization purposes.

Future enhancements will include incorporating Explainable Artificial Intelligence (XAI) frameworks. These advanced analytical tools can systematically identify regions exhibiting significant fluctuations in suicide rates, enabling a deeper exploration of potential underlying causes.

5. Results

The results of the analysis reveal a complex and evolving pattern in global suicide trends over time. As shown in the line chart depicting the total number of suicides across all countries and years, the global suicide rate did not follow a simple linear trajectory. Instead, it exhibits periods of both increase and decline, underscoring the multifaceted and context-specific nature of suicide as a global public health issue.

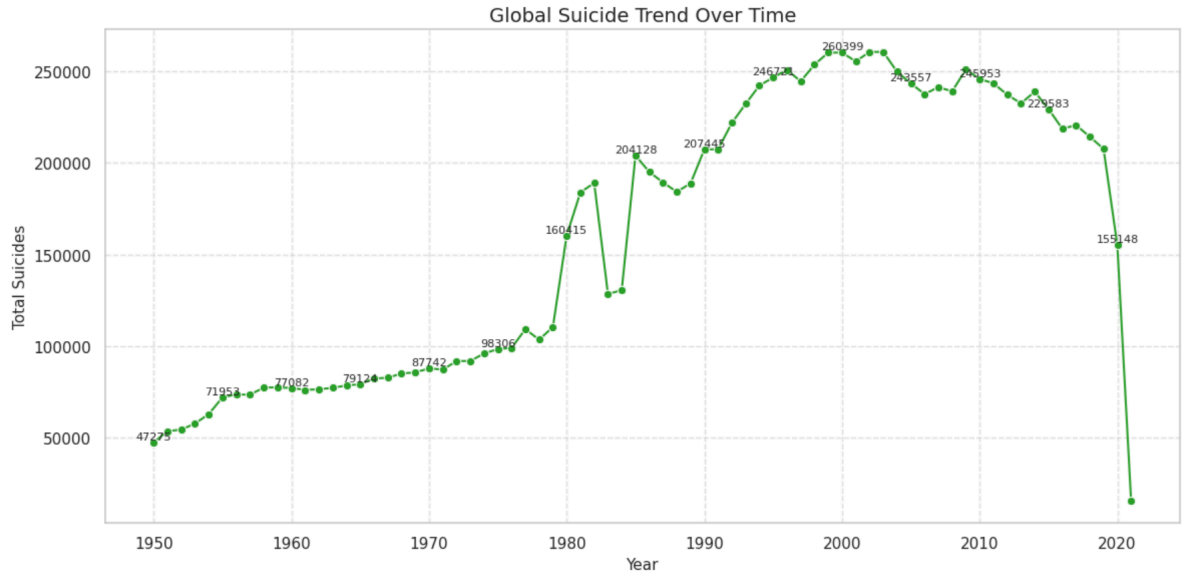
Figure 2. Global Suicide Death Rate per 100,000 Population Over Time



Source: WHO

From the late 1980s to the early 2000s, the total number of suicides experienced a gradual rise. This could be partially attributed to sociopolitical transitions in several regions, including the dissolution of the Soviet Union, the economic crises in East Asia during the 1990s, and rapid urbanization in emerging economies. However, after reaching a peak in the early 2000s, a general downward trend began to emerge, continuing into the 2010s. This decline may be associated with increased awareness of mental health issues, expanded access to psychological support services, and stronger policy interventions in high-risk countries.

Figure 3. Global Suicide Trend Over Time

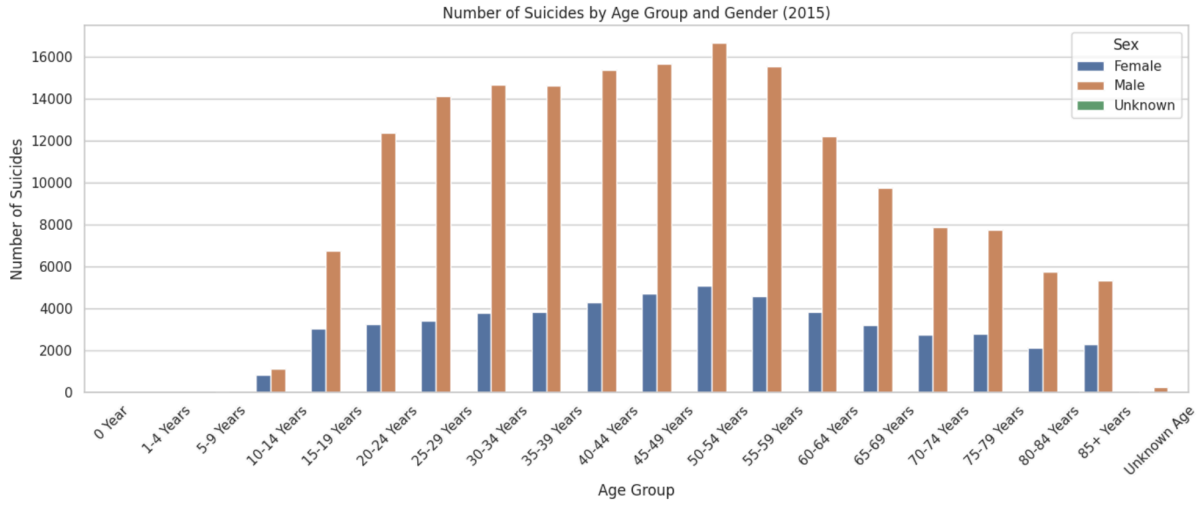


Source: WHO

Despite the overall global trend, this aggregated view masks regional and demographic disparities. For example, suicide rates among middle-aged men in high-income countries remain persistently high, while some low- and middle-income countries show underreported or inconsistent trends due to data collection limitations. Moreover, age and gender segmentation within the data reveals that while suicide rates among the elderly tend to be

higher, the relative increase among young people in certain regions has become more pronounced in recent years.

Figure 4. Number of Suicides by Age Group and Gender (2015)

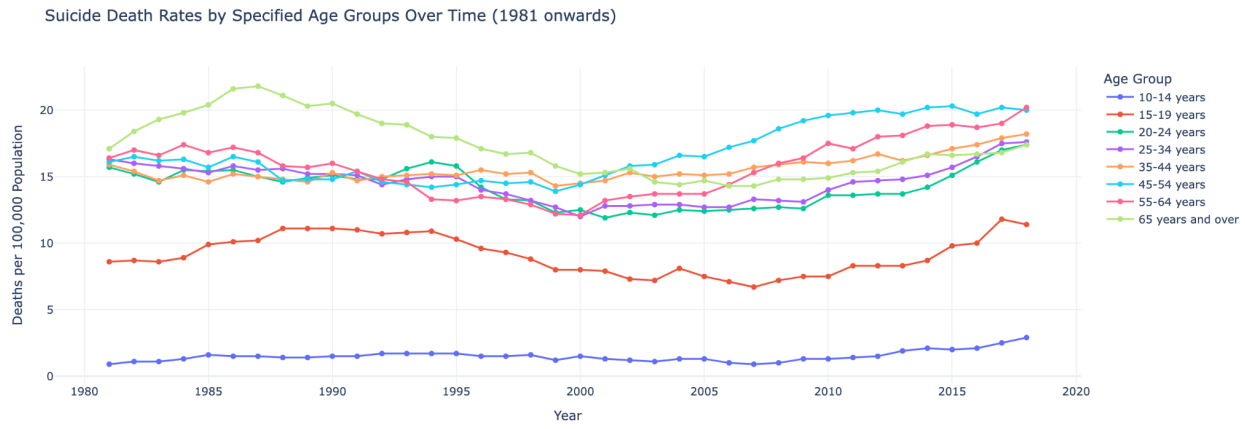


Source: WHO

The visualizations also highlight the effectiveness of interactive tools in uncovering temporal and spatial nuances. The stacked area charts by age group show how the contribution of different age segments to total suicides has shifted over time. Additionally, the Plotly-based interactive world map underscores substantial geographic variability, with suicide hotspots clustering in Eastern Europe and parts of South Asia.

To further contribute to a more comprehensive and data-driven understanding of suicide, this study conducts an in-depth analysis of suicide rate trends within the United States, with the objective of identifying temporal patterns and their potential underlying determinants. The research focuses on demographic dimensions—specifically age, sex, and race/ethnicity—to assess variations in suicide incidence over time. In addition, the study examines the distribution of suicide methods.

Figure 5. Number of Suicides in the U.S. by Age (1981 - 2018)



Source: U.S. Department of Health & Human Services

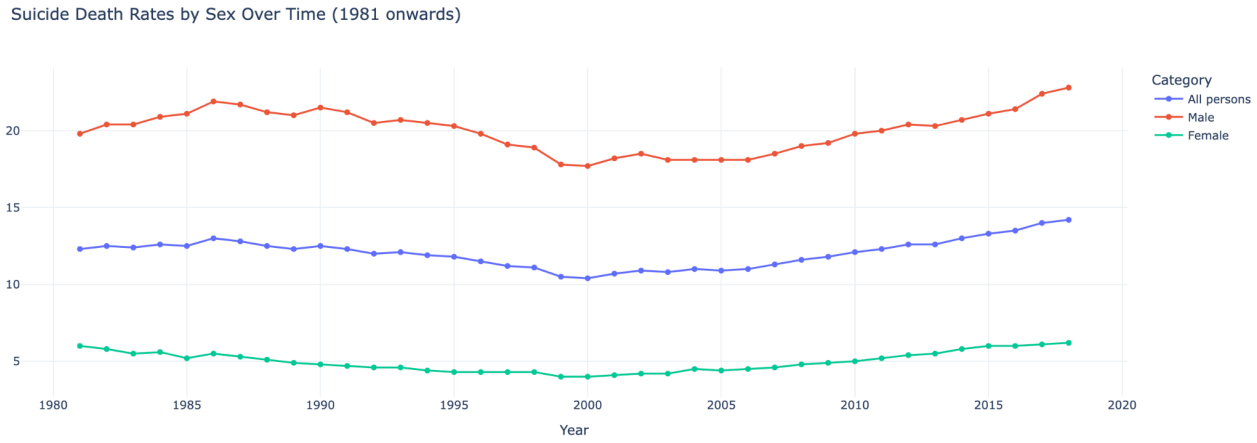
First, among U.S. citizens of different age groups, there are significant disparities in suicide rates. In the earlier decades, older adults—particularly those aged 65 and above—had the highest suicide rates, peaking in the mid-1980s and gradually declining thereafter. This initial trend may have been influenced by limited access to mental health resources, social isolation after retirement, and the stigma surrounding mental illness treatment among older generations (National Council on Aging [NCOA], 2023).

However, a significant shift has occurred in recent decades: adults aged 45–64 and 55–64 have become the groups with the fastest-rising suicide rates, surpassing the elderly. Today's middle-aged population faces mounting economic pressures, including job insecurity, healthcare expenses, and caregiving burdens, all of which may intensify psychological distress.

At the same time, suicide rates among younger populations—especially adolescents aged 10–14 and young adults aged 15–24—have also risen over the past 10 to 15 years. This trend aligns with the rise of social media, cyberbullying, academic stress, and increasing economic instability, all of which may contribute to deteriorating mental health among youth (Martinez-Ales et al., 2020).

https://pmc.ncbi.nlm.nih.gov/articles/PMC8699163/The convergence of these stressors, combined with the underdiagnosis and undertreatment of mental illnesses in both middle-aged and younger populations, has fundamentally reshaped the age distribution of suicide risk in contemporary America.

Figure 6. Number of Suicides in the U.S. by Sex (1981 - 2018)

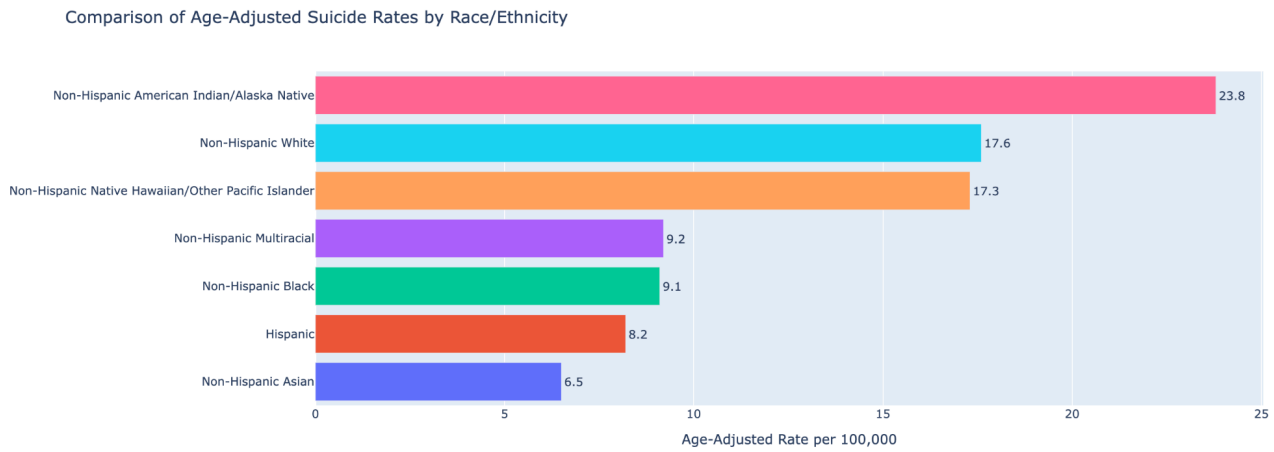


Source: U.S. Department of Health & Human Services

Gender-based trends help us further understand the evolution of suicide trends. Throughout the entire observation period, the suicide rate of men was consistently more than three times that of women. Although the suicide rates of both men and women experienced moderate fluctuations in the 1980s and 1990s, a significant divergence has emerged since the early 21st century: the suicide rate of men has begun to rise sharply, while that of women has increased more slowly.

This difference may be attributed to multiple factors. Men are more likely to attempt highly fatal suicidal acts, especially the use of firearms, and they are also less likely to seek help for mental health. Cultural expectations surrounding masculinity, emotional resilience, and self-reliance may prevent men from receiving treatment or acknowledging their own vulnerability. The economic and social predicaments that many men experience in middle age, such as unemployment, divorce, or social disconnection, can further increase the risk of suicide. Meanwhile, although the suicide rate among women is relatively high, their ways of committing suicide are often less fatal, and they are more likely to seek support through formal or informal networks. Therefore, the gender structure of emotional expression, access to care and method selection plays a key role in shaping these long-term mortality differences.

Figure 7. Number of Suicides in the U.S. by Race (2022)



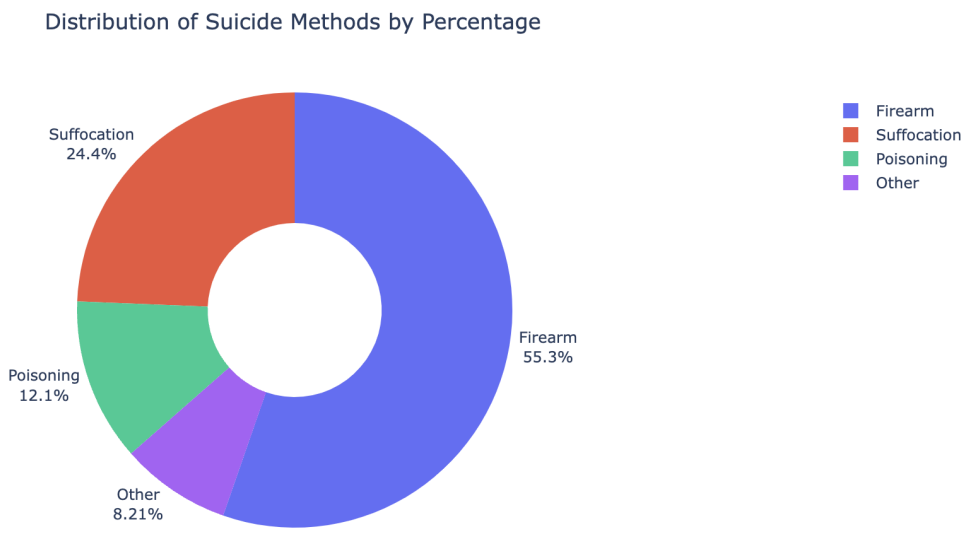
Source: Centers for Disease Control and Prevention

Race and ethnicity add another key dimension to the analysis. According to data from the Centers for Disease Control and Prevention (CDC), non-Hispanic Native Americans and Alaska Natives have the highest suicide rates, far exceeding those of other groups, followed by non-Hispanic whites and Native Hawaiians or other Pacific Islanders.

These persistently high suicide rates are best understood in the context of historical trauma, systemic marginalization, poverty and limited access to culturally appropriate mental health care. Many indigenous groups are particularly confronted with the loss of intergenerational empowerment, land erosion and cultural extinction, all of which have exacerbated the suffering of both collectives and individuals. Although non-Hispanic white Americans have a relatively high average socioeconomic status, the number of so-called "desperate deaths" has increased over the past two decades, especially in rural areas where economic recession and opioid abuse are particularly severe. On the contrary, the suicide rates among non-Hispanic blacks, Hispanics and Asians are significantly lower. Although this may partly reflect underreporting or cultural stigmatization of suicide incidents, strong family ties, religious beliefs or community structures may also provide some protection for these groups. However, these differences should not mask emerging vulnerabilities, especially among

young groups in ethnic minority communities who are increasingly vulnerable to cultural adaptation pressure and discrimination.

Figure 8. Suicide Method



Source: Centers for Disease Control and Prevention

This study further explored the ways of suicide. According to the data statistics of CDC in 2023, firearms are the leading cause of suicide deaths, accounting for more than half of all suicide cases, followed by asphyxia and poisoning. Firearms are particularly evident among victims and the lethality of firearms means that suicide attempts using this method are more likely to cause death than those using other methods (Martinez-Ales et al., 2020).

The wide popularity of firearms in the United States, coupled with the limited enforcement of safe storage laws, has exacerbated this problem. The usage rate of suffocation (including methods such as hanging) has also increased, especially among teenagers and young adults, which may be due to its easy accessibility. Poisoning is usually associated with female suicide attempts, but the mortality rate is relatively low, reflecting the differences in the choice of suicide methods between different genders. The differences in these suicide methods are crucial because they affect not only the outcomes but also the opportunities for intervention; especially, access to firearms remains a modifiable risk factor that can be directly addressed through policy reforms.

Conclusion and Discussion

Our data visualization project reveals disparities in global suicide rates across gender, age groups, and economic contexts. One of the most striking findings is the persistent gender gap: males are consistently more likely to die by suicide than females across nearly all regions and age groups. Additionally, we observed that suicide rates tend to increase with age, particularly among males, with the highest rates often seen in the 75+ age group. This highlights the unique vulnerability of older men, a demographic frequently overlooked in public mental health efforts. Another key insight is the impact of socioeconomic factors.

High-income countries report relatively higher male suicide rates, possibly linked to social isolation, work-related stress, and cultural stigma around seeking help. In contrast, some low- and middle-income countries exhibit rising suicide rates among young females, which may reflect systemic gender inequality, lack of mental health support, or domestic and societal pressures.

These findings underscore the need for culturally sensitive and demographically targeted mental health interventions. Data visualizations proved especially powerful in making these complex patterns visible and accessible to a broad audience—from policymakers to educators to the general public. However, we also acknowledge limitations: the data's reliance on country-level reports may underrepresent suicides in regions with weak reporting infrastructures. Moreover, our visualizations focus primarily on quantitative trends, while qualitative factors such as cultural stigma of mental health policy gaps remain underexplored.

6. Intellectual Merit and Practical Impacts

This project advances the field of data visualization by applying established visual encoding principles to a sensitive and globally significant dataset—suicide statistics. By integrating temporal, geographic, and demographic dimensions into interactive and static visualizations, it demonstrates how multi-dimensional data can be effectively abstracted and communicated. The design choices reflect best practices in visualization theory (Munzner, 2014). Furthermore, the project contributes to the literature by illustrating how storytelling through data can surface patterns that might be obscured in raw statistics, such as gender disparities or region-specific shifts in suicide rates. The methodology also sets a foundation for future research integrating explanatory models like XAI, aligning with emerging trends in interpretable AI-driven data storytelling.

From a societal perspective, this project supports mental health advocacy by making global suicide trends more transparent and understandable for both experts and the general public. Policymakers and public health professionals can use the interactive tool to identify vulnerable demographics, assess the effectiveness of past interventions, and allocate resources more effectively. By aligning with the United Nations Sustainable Development Goal 3 which is Good Health and Well-being, the project emphasizes how data visualization can empower data-driven decision-making in global health. Moreover, by openly presenting the data in an accessible form, the work promotes mental health literacy, encourages public dialogue, and contributes to destigmatizing discussions around suicide.

7. Reflection on Growth and Learning

Transitioning from the individual InfoVis Redesign to our team-based project significantly enhanced our intellectual and professional development. While the redesign project taught us the fundamentals of effective visual encoding and audience awareness, the team project allowed us to build on those skills through collaboration, deeper data exploration, and more ambitious design goals. In-class activities helped sharpen our technical proficiency, while

reinforcing core visualization principles. Attending symposiums broadened my understanding of how data visualization can drive social change, motivating us to choose a socially impactful topic like global suicide trends. The ZhouZhuang Life Mysterious Museum field trip had a particularly strong influence. Its integration of local narratives and immersive visuals showed us the power of storytelling in engaging audiences emotionally. Inspired by that experience, our team prioritized not just clarity in design but also emotional resonance, using color and interactivity to create a more meaningful experience. Overall, this journey taught me that data visualization is not only a technical task but also a human-centered process—one that combines insight, empathy, and design to inform and inspire action.

Acknowledgement

We would like to sincerely thank Professor Luyao Zhang for her invaluable guidance and support throughout this project. We are also deeply grateful to the two guest lecturers, whose insightful talks greatly enriched our perspective. We appreciate our classmates and peers for their collaborative feedback and meaningful discussions during the process. Lastly, we would like to thank everyone else who contributed to this project in various ways.

Data:
CDC dataset:
https://www.cdc.gov/suicide/facts/data.html
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WHO Suicide Data (1950-2021):
https://www.kaggle.com/datasets/kumaranand05/who-suicide-data-1950-2021?select=combined_processed_data.csv

Github Link:

https://github.com/PadparadschaNero/Infosci301-Final/blob/main/README.md#-data-sources

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Appendix_Proposal
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Research Proposal
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1. Data Sources and Integration

The Centers for Disease Control and Prevention (CDC)'s "Suicide Data and Statistics" dataset, available on the official U.S. Centers for Disease Control and Prevention website (https://www.cdc.gov), provides timely and authoritative data on suicide, one of the leading causes of death in the United States. This dataset breaks down suicide statistics by age, sex, race/ethnicity, and method, offering valuable insights for researchers, policymakers, and public health professionals. Aligned with the FAIR principles, the data is *findable* through a well-maintained government domain, *accessible* to all users without restriction, *interoperable* thanks to standardized formats that allow integration with broader health datasets, and *reusable* due to the CDC's clear documentation and metadata. Furthermore, the dataset reflects the CARE principles by serving the *collective benefit* of suicide prevention, ensuring *authority to control* through CDC oversight, upholding *responsibility* by sensitively presenting potentially distressing information, and maintaining *ethical* standards in public health reporting. Overall, this resource supports data-driven approaches to mental health, enabling evidence-based action to reduce suicide rates and improve outcomes across different demographic groups.

By integrating the **OECD Causes of Mortality dataset** with the **WHO Suicide Data (1950-2021)**, we can gain a deeper and more comprehensive understanding of the global patterns and trends in mortality, particularly focusing on suicide and its relationship with other causes of death. While the OECD dataset provides detailed information on the leading causes of death across OECD countries, categorized by demographic factors such as age, sex, and health conditions, the WHO dataset offers a long-term, global view of suicide data, spanning over seven decades. Combining these datasets enables us to explore not only the prevalence and demographics of suicide but also how suicide trends correlate with shifts in other causes of death, such as chronic diseases, mental health conditions, and accidents. Additionally, it allows for cross-country comparisons, highlighting how different nations address suicide prevention and related public health issues.

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https://www.kaggle.com/datasets/kumaranand05/who-suicide-data-1950-2021?select=combined_processed_data.csv

2. Research Question

How can age-specific mortality patterns inform targeted healthcare resource allocation for ageing populations worldwide?

Sub-question:

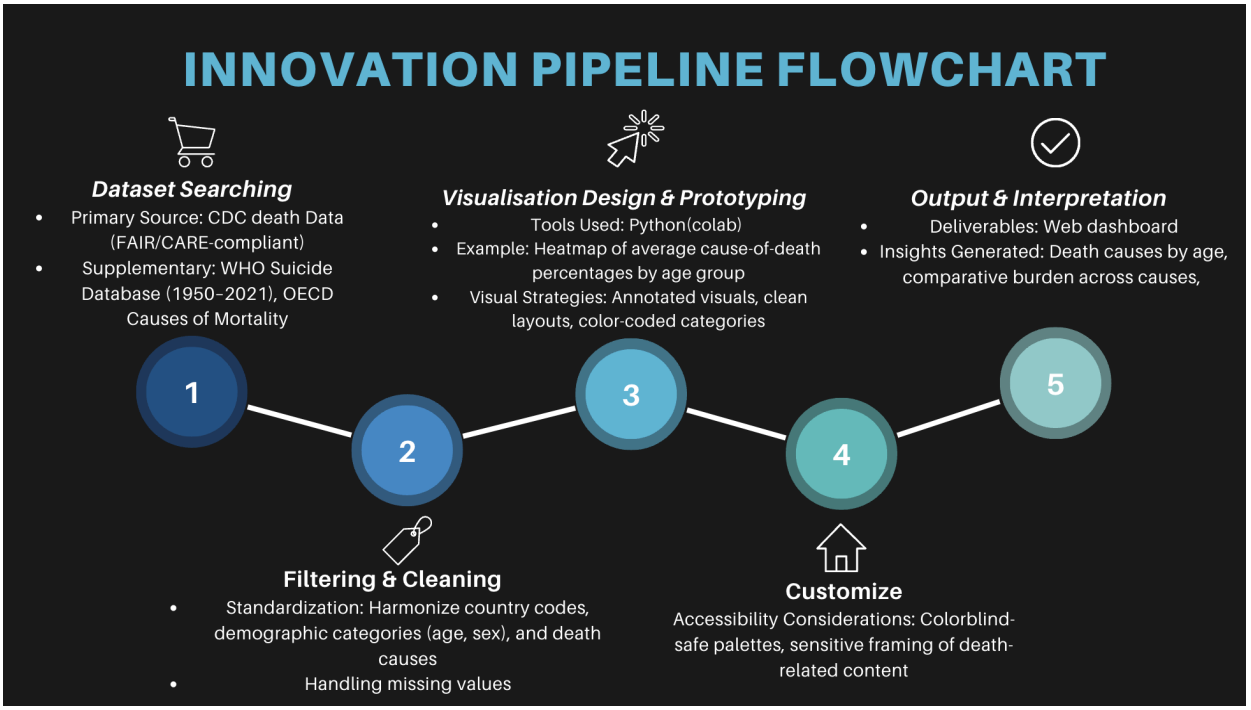
What are the top causes of death for each age group, and how do they shift as people age?

Rationale:

Understanding how leading causes of death vary across age groups is essential for designing age-sensitive healthcare strategies. This sub-question aims to identify which causes of death are more prevalent among younger populations, such as accidents or mental health-related issues, and which dominate among older adults, such as chronic illnesses, falls, or dementia. By mapping these patterns, policymakers can allocate resources more effectively, prioritizing disease prevention and management programs that align with age-specific health burdens. Such insights support data-driven policy to improve health outcomes and reduce avoidable mortality among aging populations.

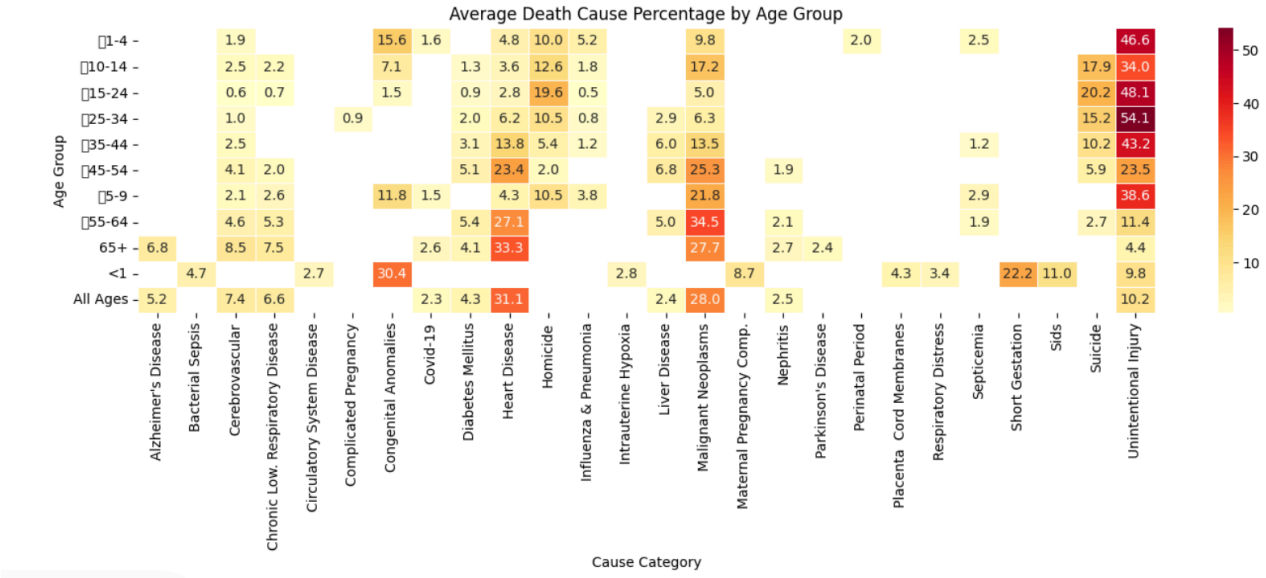
3. Sample Visualizations, Advanced Tools & Innovation Flowchart

Figure 1. Innovation pipeline flowchart



3.1 Prototype Visualisation

Figure 2. Average Death Cause Percentage by Age Group



Source: CDC

3.2 Progress Update: Interactive Visualization Development

Since the initial proposal, we have transitioned from static visualizations to an interactive dashboard using Plotly.

Key improvements include:

Dynamic data exploration: Users can hover over the graphs to see exact mortality percentages by cause and age group.
Enhanced usability: The interactivity allows people to explore hypotheses and trends dynamically rather than relying on static snapshots.
This technological enhancement significantly improves the interpretability and user engagement of the project.

Figure 3. Average Death Cause Percentage by Age Group with interactivity

3.3 Future Improvement

In the future, we plan to develop more intuitive and diverse visualizations to better support data interpretation and storytelling. We will create additional interactive charts and dashboards that allow users to explore age-specific mortality patterns in a more engaging and dynamic way. Visual enhancements, such as optimized color schemes, responsive layouts, and user-friendly interfaces, will also be implemented to improve the overall user experience and accessibility of the visualizations.

3.4 Cite Precedents

Our World in Data. (n.d.). *Self-harm death rates by age*. Retrieved April 20, 2025, from https://ourworldindata.org/grapher/self-harm-death-rates-by-age

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Team Contribution

All team members contributed equally and collaboratively to the successful development of this project. Qianyue Jiao led the data collection and preprocessing phase, ensuring that all datasets adhered to international standards such as FAIR and CARE principles. Yifei Yang focused on exploratory data analysis and the application of potential methods for insight generation, contributing to both the technical depth and interpretability of the project. Zixuan Li was responsible for designing the interactive visualization dashboard and drafting the innovation flowchart, integrating user-centred design principles and technical implementation.