2022-23 Scenario

Cause of Death & Intervention Programs

Student Workbook

A program of The Actuarial Foundation

Modeling The Future Challenge

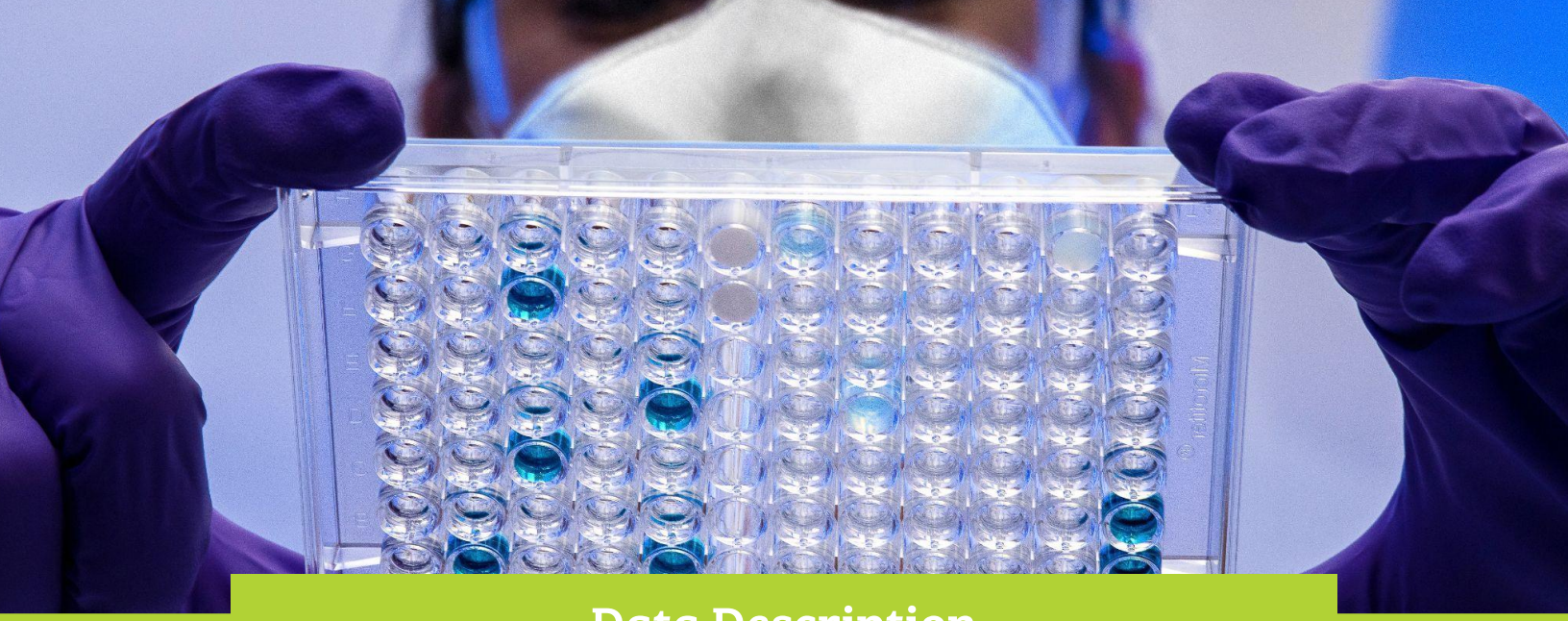
Scenario Introduction

According to the National Center for Health Statistics, life expectancy at birth in the United States has declined in recent years despite worldwide life expectancy increasing. The impact of the COVID-19 pandemic on US life expectancy has been an additional blow and ongoing public health crisis. However, the trend of decreasing US life expectancy has sociological researchers at a health and wellness think tank in Washington DC alarmed by the recent US trend. According to the 2018 article in smithsonian.com "On average, life expectancy across the globe is steadily ticking upward—but the same can't be said for the United States. Three reports newly published by the Centers for Disease Control and Prevention highlight a worrying downward trend in Americans' average life expectancy, with the country's ongoing drug crisis and climbing suicide rates contributing to a third straight year of decline." The world continues to grapple with questions regarding COVID-19; has it come and gone? Will the trends continue? What is the long-term impact on life expectancy?

You have been hired as an actuarial consultant for the think tank to help them understand trends in American life expectancy, and to help identify areas where targeted intervention is most likely to have significant results. You locate the CDC WONDER database that lists the causes of death by state and by year in the US.

After researching trends and interventions from other countries, the researchers identified three potential interventions for the US: suicide prevention education program, an opiod rehabilitation program, and a social outreach program from individuals considered at risk of developing heart disease.. The programs in these other countries noted the following costs and reductions in mortality and are projected to have similar costs and outcomes in the pilot in the US. The annual costs and expected benefits of each are summarized in the table below. Researchers believe that the % reduction in mortality will be an annual decrease for each year that the program is implemented.

Program	Annual Expected Cost	% annual reduction in mortality expected
Suicide	$4,000,000	8%
Opioid	$40,000,000	6%
Heart Disease	$58,000,000	5%



Data Description

The dataset was compiled from the Center for Disease Control's WONDER database, retrieved August 2022. WONDER (Wide-ranging ONline Data for Epidemiologic Research) is an easy-to-use internet system that makes the information resources of the Centers for Disease Control and Prevention (CDC) available to public health professionals and the public at large.

With over 100,000 lines of data in the raw data pulled from WONDER, the researcher found it necessary to combine the specific International Classification of Diseases 10th Revision (ICD-10) codes for causes of death under a more general cause of death listing for meaningful and accessible analysis to be conducted.

Unless otherwise noted in a question, teams should use the 1999-2020_Data_Final tab in the spreadsheet. In this tab, there are 31,109 lines of data retrieved and cleaned from the Center for Disease Control's WONDER database.

The columns for this dataset include:

- Year
- Cause of Death
- State
- Number of Deaths

Some questions require written answers, some mathematical calculations, and some require both. The questions follow the five steps of the Actuarial Process and additional perspective can be found by referencing each section of the Actuarial Process Guide. Examine the data spreadsheet attached to this scenario to answer the questions on the following pages.

Part 1:
Problem Definition

Questions from this part of the scenario build upon Part 1 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

1. **Describe in a few sentences two different groups, industries, sectors, or other areas of society that would experience a loss due to an increase in mortality rates in the United States.**

2. **Describe in no more than a few sentences an example of how insurance may be used to help mitigate or manage the losses you noted in question 1. (hint: reference the Actuarial Process Guide section 1.3)**

3. **Describe in no more than a few sentences an example of how implementing new policies, procedures, or systems to help change behaviors of those involved may be used to help mitigate or manage the losses you noted in this scenario.**

4. **Describe in no more than a few sentences an example of how those involved in the scenario may be able to help modify the possible outcomes to help mitigate or manage the losses you noted.**

Part 2:
Data Identification & Analysis

Questions from this part of the scenario build upon Part 2 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

5. **Based on the five categories outlined in the Actuarial Process Guide (Section 2.1), what category (or categories) do you classify the attached dataset into? Provide a rationale for your reasoning.**

6. **Based on your answer to the previous question, identify one limitation there is on the types of questions or analysis that you can perform on the data?**

7. **Beyond the data provided in the attached spreadsheet, identify one other type of data or piece of information that could be valuable in analyzing the risks associated with evaluating cause of death and evaluation of impact of policy programs? (hint: reference Actuarial Process Guide section 2.1)**

8. **The researcher compiling this dataset compared select causes of death after pulling the raw data to the numbers from the last dataset published from the CDC for 1999-2017. The researcher compared the raw data to the last published dataset to check and see if any cleaning was needed. Use the table below to answer the following questions.**

Selected Causes of Death	1999-2017 (Last Published)	1999-2020 (Raw Data)
Accidents (unintentional injuries)	4,695,640	2,460,168
All Causes	95,457,138	117,336,580
Alzheimer's disease	2,989,632	1,710,456
Cerebrovascular diseases	5,453,046	2,681,047
Chronic lower respiratory diseases	5,189,854	2,811,355
Diabetes mellitus	2,799,886	1,312,394
Diseases of heart	24,445,280	12,230,857
Influenza and pneumonia	2,189,282	1,089,286
Intentional self-harm (suicide)	1,394,032	753,901
Malignant neoplasms	21,687,288	10,817,779
Nephritis, nephrotic syndrome and nephrosis	1,717,226	797,232

Based on this information, what might have indicated to the researcher in this comparison of the 1999-2017 Last Published dataset and the 1999-2020 Raw Dataset that cleaning of the data was needed?

Part 3:
Mathematical Modeling

Questions from this part of the scenario build upon Part 3 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

Providing justification and numbers used in determining your answers will increase the likelihood of credit awarded for correct process even if slight errors are made in calculations.

9. **The information in the Scenario Introduction describes the % annual reduction in mortality expected for each of the programs listed - this is an assumption made to simplify the modeling process. How and why might this assumption limit the realism of modeling and forecasting future impact of the programs? Describe one way in which easing or revisiting this assumption could lead to an interesting and useful analysis in future years.**

10. **What are the ten leading causes of death in the US identified in the data from 1999 to 2020 based on average number of deaths per year? Rank the causes in your response and include the totals.**

11. **Do any of the top ten leading causes of death change when considering total deaths from 1999 to 2020 instead of average number of deaths? Explain and justify your answer.**

Part 3, continued

12. **If you choose a person at random from among those who died in 2015, what is the probability he/she has "Influenza and Pneumonia" indicated as the cause of death?**

13. **If you randomly select a person from New York who died of chronic lower respiratory diseases , in which year was it most likely that he/she died? What is the probability the person died in that year? Explain.**

14. **What is the chance that the cause of death was cancer (ie, malignant neoplasm) for a randomly selected individual in the U.S. from 1999-2020?**

15. **The average cost for end-of-life medical care for a cancer patient in the U.S. is $105,500. What is the expected value of loss in medical costs for an individual who dies of cancer?**

Part 3, continued

16. **Create a graphical display that best demonstrates the distribution of the six most common causes of death in 2016.**

17. **Create a scatter plot or line graph that charts each of the top 10 causes of death over the 1999-2020 time period (total sum of deaths, not average deaths). Offer two observations from the chart about the trends in causes of death.**

18. **Create a model that uses time to predict the number of deaths from all causes (consider 1999 as t=0). Give the equation of your model and justify how you chose your model. What might be some limitations or cautions of using this model to predict future death totals considering the sudden increase in deaths due to the onset of the COVID-19 pandemic?**

19. **Since Heart Disease continues to be a leading cause of death in the US, researchers want to predict the number of deaths from it in the future. Use the data to create a model that uses time to predict the number of Heart Disease deaths (consider 1999 as t=0). Give the equation of your model and justify how you chose your model.**

20. **Using this model, predict the number of deaths from heart disease in 2025.**

Part 4:
Critical Thinking & Risk Analysis

Questions from this part of the scenario build upon Part 4 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

Providing justification and numbers used in determining your answers will increase the likelihood of credit awarded for correct process even if slight errors are made in calculations.

21. Using your model created in Question #18, if none of the proposed programs (suicide prevention, opiod, heart disease) are implemented, what is the predicted number of US deaths in 2025?

22. If the suicide prevention program is implemented effectively ONLY (ie, the opioid intervention and heart disease prevention programs are NOT implemented), what is the predicted number of US suicides in 2025?

23. The Smithsonian quote in the Introduction to this scenario suggests that the rises in suicide and drug overdose are some of the leading causes of the decrease in American life expectancy. Does the data support this contention? Consider the information contained in the table below retrieved from the CDC's WISQARS Leading Causes of Death Visualization tool along with the data analysis you have already conducted with the 1999-2020 Cause of Death Dataset in explaining and justifying your answer.

10 Leading Causes of Death, United States
2020, Both Sexes, All Ages, All Races

	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	All Ages
1	Congenital Anomalies 4,043	Unintentional Injury 1,153	Unintentional Injury 685	Unintentional Injury 881	Unintentional Injury 15,117	Unintentional Injury 31,315	Unintentional Injury 31,057	Malignant Neoplasms 34,589	Malignant Neoplasms 110,243	Heart Disease 556,665	Heart Disease 696,962
2	Short Gestation 3,141	Congenital Anomalies 382	Malignant Neoplasms 382	Suicide 581	Homicide 6,466	Suicide 8,454	Heart Disease 12,177	Heart Disease 34,169	Heart Disease 88,551	Malignant Neoplasms 440,753	Malignant Neoplasms 602,350
3	Sids 1,389	Homicide 311	Congenital Anomalies 171	Malignant Neoplasms 410	Suicide 6,062	Homicide 7,125	Malignant Neoplasms 10,730	Unintentional Injury 27,819	Covid-19 42,090	Covid-19 282,836	Covid-19 350,831
4	Unintentional Injury 1,194	Malignant Neoplasms 307	Homicide 169	Homicide 285	Malignant Neoplasms 1,306	Heart Disease 3,984	Suicide 7,314	Covid-19 16,964	Unintentional Injury 28,915	Cerebrovascular 137,392	Unintentional Injury 200,955
5	Maternal Pregnancy Comp. 1,116	Heart Disease 112	Heart Disease 56	Congenital Anomalies 150	Heart Disease 870	Malignant Neoplasms 3,573	Covid-19 6,079	Liver Disease 9,503	Chronic Low. Respiratory Disease 18,816	Alzheimer's Disease 132,741	Cerebrovascular 160,264
6	Placenta Cord Membranes 700	Influenza & Pneumonia 84	Influenza & Pneumonia 55	Heart Disease 111	Covid-19 501	Covid-19 2,254	Liver Disease 4,938	Diabetes Mellitus 7,546	Diabetes Mellitus 18,002	Chronic Low. Respiratory Disease 128,712	Chronic Low. Respiratory Disease 152,657
7	Bacterial Sepsis 542	Cerebrovascular 55	Chronic Low. Respiratory Disease 54	Chronic Low. Respiratory Disease 93	Congenital Anomalies 384	Liver Disease 1,631	Homicide 4,482	Suicide 7,249	Liver Disease 16,151	Diabetes Mellitus 72,194	Alzheimer's Disease 134,242
8	Respiratory Distress 388	Perinatal Period 54	Cerebrovascular 32	Diabetes Mellitus	Diabetes Mellitus 312	Diabetes Mellitus 1,168	Diabetes Mellitus 2,904	Cerebrovascular 5,686	Cerebrovascular 14,153	Unintentional Injury 62,796	Diabetes Mellitus 102,188
9	Circulatory System Disease 386	Septicemia 43	Benign Neoplasms 28	Influenza & Pneumonia 50	Chronic Low. Respiratory Disease 220	Cerebrovascular 600	Cerebrovascular 2,008	Chronic Low. Respiratory Disease 3,538	Suicide 7,160	Nephritis 42,675	Influenza & Pneumonia 53,544
10	Neonatal Hemorrhage 317	Benign Neoplasms 35	Suicide 20**	Cerebrovascular 44	Complicated Pregnancy 191	Complicated Pregnancy 594	Influenza & Pneumonia 1,148	Homicide 2,542	Influenza & Pneumonia 6,295	Influenza & Pneumonia 42,511	Nephritis 52,547

Part 5: Recommendations

Questions from this part of the scenario build upon Part 5 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

Providing justification, explanation, numbers or equations used in justifying your answers will increase the likelihood of credit awarded for correct process and reasoning, even if slight errors are made in computations.

24. The head of the think tank is able to fundraise up to $100,000,000 for program implementations and wishes to use that money to fund two of the programs. If all monies must be spent in one year, which two programs would you recommend she choose? Why?

25. From 1999 to 2009 heart disease was trending downward fairly steadily. The researchers want to see what would happen if we could get heart disease trending down again at the same rate as it was during these years. Project heart disease rates up to 2030 if they were to start trending downward at the 1999-2009 rate.

26. **The think tank wants to recommend piloting the suicide prevention program intervention in <u>one state</u>, which state would each have the most impact and why? Does your recommendation target sheer numbers of lives saved or the trend of the state? Why? Explain your rationale and method.**