

# MTFC Scenario Quest 2023-24

Team Name	The Data Divas
Team ID #	16411
Proposal Topic Title	<i>Quantifying the Risks of Medical Misdiagnosis Among Patients of Color</i>

# Mission 1 Ski Resort Prompts

---

- 1.1 - *Who is at risk?*

In 3-5 sentences, describe what other groups (in addition to the ski resorts themselves) might be at risk in this scenario? In other words, what other groups have the potential for loss due to the climate change noted in the scenario description? Identify at least two other groups who may have a loss related to lower expected ski resort profits due to climate change?

Climate change is a catalyst for detrimental economic concerns for local and national businesses engaged in ski-related commerce. Due to elevated levels of climate concern, local businesses supporting the ski resort guests, such as hospitality and dining, suffer as a result of a decrease in customers. Climate change-related disengagement also pertains to ski resort suppliers, who see a decrease in profit when demand levels for ski resorts plummets. Forced audience disengagement as a result of climate change affects both local and national municipalities through a downfall in demand, carrying negative financial implications.

- 1.2 - *Defining the Risk*

To be able to conduct a valuable research project, we must be able to characterize the risk in quantifiable terms. In other words, we have to get down to the numbers. In 3-5 sentences, consider the risk to the ski resorts themselves - what kind of quantified values can you identify that could be valuable numerical ways of characterizing the risk?

Flooding caused by global heat rise can cause extensive damage to infrastructure, including roads, bridges, buildings, and utilities. This can disrupt transportation networks and damage critical facilities, such as power plants and water treatment facilities. The economic impact can be substantial due to repair costs and lost productivity. In the best-case scenario, flooding is managed effectively, resulting in minimal damage, and the affected areas recover relatively quickly. In a worst-case scenario, the economic impact is severe, with businesses forced to shut down, and communities struggling to rebuild, as well as severe environmental impacts damaging key infrastructure including ski lifts, resort facilities, ground maintenance equipment, and on-site technology. There could also be loss of life if evacuation measures are insufficient or delayed, making this problem high-risk due to the possibility of various dangerous and detrimental events taking place.

- 1.3 - *Understanding Potential Recommendations*

The goal of a Modeling the Future Challenge project is to make recommendations on how to best mitigate or manage the risks your team has identified. In the Actuarial Process Guide, we define three types of risk mitigation strategies: (1) Insurance, (2) Behavior Change, and (3) Modifying Outcomes.

To mitigate the risks of climate-related losses in modern ski resorts, actions through insurance, behavioral changes, and modification of the outcomes of these losses are essential in ensuring that stakeholders, impacted individuals, and fragile natural settings are best supported. Through increased investment in insurance, local

and commercial ski resorts can be protected from the increasing risk of extreme weather and degradation of infrastructure, key components in creating a safe and enjoyable ski experience for visitors and ski enthusiasts. While insurance has the ability to protect the ski resort's physical assets and allows the ski resort to maintain its temporary functions, key changes in human behavior must be made to avoid the continuation of harmful environmental actions. One key change could be the use of alternative, and renewable forms of energy, a component that could directly decrease the impact of emissions on heat-related climate impacts, and could also incentivize energy-users through various private and federal funding programs. In addition, ski resorts and involved stakeholders could modify the outcomes of climate-centric issues by altering ski seasons, modifying the recreational activities taking place on ski mountains, and investing in new restorative infrastructure to preserve the function of the mountain.

---

## Mission 1 - Team Project Proposal Prompt

*Your MTFC team has the freedom to define your own research project where you will identify a project topic, identify risks, find and analyze data, create a mathematical model, conduct a risk analysis, and make recommendations for risk mitigation strategies. Your team should identify a topic that you propose to study, model, and create a report on in Phase 2: Projects. For Phase 1 with this submission, you are proposing what you will study by responding to these prompts - you are not expected to conduct a full analysis, build a mathematical model, or make data-informed recommendations at this stage.*

### **Identify the Topic**

- In 3-5 sentences, summarize what is the topic your team is proposing to investigate and why it is important.
  - Provide a statement on what the topic is and why it is important.
  - Has it seen a sudden or recent change that brings it to the forefront?
  - Who does it affect, where is it prevalent, is it tied to any other areas of impact?

**Our Response:** Racial motivations in the healthcare industry create a disproportionately large risk of misdiagnosis of patients of minority races. Due to explicit risk (prejudice) and implicit risk (automatic grouping in our brains), patients of color are not given diagnoses nor care of equal quality compared to white patients. This problem is deeply rooted in the medical field, as a majority of the research and data used has been collected from patients of European descent. The most commonly misdiagnosed conditions are fatal, including stroke, infections, and cancer. However, this issue can potentially be mitigated by utilizing unbiased AI models with higher quality training.

---

### **Identify Potential Risks**

- In 3-5 sentences, identify and describe 2-3 areas of risk for an individual, society, or organizations/industry/governmental groups related to your topic. Hypothetically, what could be a "best case scenario" outcome for the risks identified? What could be a "worst case scenario" outcome for the risks identified?

**Our Response:** When considering the impacts of medical misdiagnosis on an individual, societal, and organizational/industrial/governmental scale, the best case scenario is that the misdiagnosis that had taken place was misdiagnosed as being more severe/more dangerous than the true diagnosis. However, due to various factors, including bias, location, funding, and situational factors, misdiagnosis can have greater effects to both human health as well as healthcare organizations and medical professionals. Medical misdiagnosis can lead to legal action, injustice, and fatality or risk of long-term medical conditions due to not pursuing treatment sooner. In addition, medical misdiagnosis weakens the sustainability and validity of healthcare and medical programs, as the heightened risks of medical misdiagnosis among people of color produces a system incapable of treating a diverse population. To avoid risks to patients at an individual level, impacts to health organizations, and the greater medical industry, increased risk of misdiagnosis due to a factor such as race, location, and funding should be addressed through greater societal reform, and can be minimized if organizations and governments take action against bias or deep-rooted historical underrepresentation.

---

### ***Identify Risk Mitigation Strategies***

The goal of the MTFC project is to be able to make recommendations to appropriate audiences based on the risk analysis and modeling you have conducted to mitigate the risk of loss. In the Actuarial Process Guide, 3 risk mitigation strategies are described (insurance, behavior change, modifying outcomes).

- In 1-2 sentences per risk mitigation strategy, describe how each of the three risk mitigation strategies could mitigate (lessen the severity of) risks you identified associated with the topic. When thinking about how the risk mitigation strategy, identify who (individual, society, organization/government) would be impacted by its implementation?

### **Our Response:**

#### 1. Insurance

Insurance allows patients with medical misdiagnosis to minimize the high costs associated with modern medical treatment and lessens the severity of unexpected or previously avoidable medical costs. However, initial treatment from proper diagnosis could lessen these costs overall and reduce its financial immensity, yet fails to prevent unforeseen and possibly life-threatening medical events from occurring.

#### 2. Behavior Change

As described in the Actuarial Process Guide, behavioral change can minimize risk or lower severity through incentive to change behaviors. One such application to the issue of medical misdiagnosis in the healthcare industry is the funding of, and therefore incentivization, of programs dedicated to increasing medical diagnostic statistics or medical attention towards people of color who have been historically underrepresented in medical data as well as increased attention to medical diagnostic training programs, especially for conditions that are more common in minority races.

#### 3. Modifying Outcomes

Medical misdiagnosis can lead to amplified medical issues on an individual level as well as the risk to hospitals and health organizations of legal action through the filing of medical malpractice claims. To

mitigate this risk, diagnosis can be reinforced by utilizing unbiased artificial intelligence technologies or increasing the investment or funding of healthcare for misdiagnosed patients, an issue that is prevalent to many regardless of race.

---

## Mission 2 Ski Resort Prompts

These prompts can be found on pages 18-19 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 23-29 of the [Actuarial Process Guide](#).

Our Responses:

### 2.1 - What questions do you need to answer in order to characterize the risks to the ski resort in this scenario?

In order to characterize the risks to the ski resort due to climate change, the following questions should be asked:

1. How does climate change specifically affect the amount of snow per year? Is there a pattern or model that can be developed to observe the decrease in snow fall?
2. Does the time of snowfall change per year? Is snow becoming more common in the beginning of the year, or the end of the year before?
3. How heavy is the snowfall? How many inches are to be expected every time it snows? Is there a way we can model the decrease over the years?
4. What other climate changes come with the decrease in snowfall? Is there an increase in wind and a decrease in temperatures? How will this affect the ski resort and how can we model this?

### 2.2 - What kind of data is valuable?

In the Actuarial Process Guide, five types of data are identified that may be valuable in analyzing risks and making recommendations on mitigation strategies. The five types of data identified in the actuarial process guide are, data that helps define historical trends, data that projects future trends, data that helps separate potential outcomes, data that help with determining the severity of potential losses, and defining the frequency of potential outcomes.

The data provided on the three ski resorts for this scenario includes some valuable information; however, there may be additional data that you would want to improve your analysis. For example, comments and testimonies from people may be helpful in determining how dire the general public feels the situation is and incorporating a qualitative perspective in an analytical analysis as well.

In 2-3 sentences, describe:

1. Which of the five types of data identified in the Actuarial Process Guide are provided in this scenario's dataset and what valuable information is the data able to tell us?
2. What additional data would be valuable in conducting a risk analysis and mitigation project for this scenario?

### Our Response:

1. The data provided on the three ski resorts for this scenario can fall under the following three categories: data that helps define historical trends, data that help with determining the severity of potential losses, and defining the frequency of potential outcomes. The data helps us define historical trends because the data tells us the resort name (one of the three), the level of snowfall, and the profit. This outlines the patterns that occur every year, which gives us definitions of the historical trends. The data also helps us determine the severity of potential losses, as it helps us correlate the various factors that affect the

profit to the potential loss that was experienced. Finally, the data given helps determine the frequency of potential outcomes as it provides us the data to put into our model. It allows us to observe the historical patterns and correlations, and then predict future losses.

2. Additional data to help conduct a risk analysis could take many forms. As explained in the question, comments and testimonies from skiers would be very helpful in order to assess the quality of the ski resort. In order to convert qualitative data into quantitative data, the feedback of the skiers can be assessed in the form of a poll or similar technique. In addition to this, numerical data including the number of visitors and the number of partnerships with other companies would also be helpful information to further understand how global warming affects the ski resorts over the years.

### 2.3 - What kind of analysis can be done with the attached ski resort data?

1. In 2-3 sentences, identify what kind of summary statistics can be conducted by identifying:
  - a. The sample size (usually denoted by  $n$ ) and identification of data types (categorical or numerical).
  - b. The center of the data or values (mean/median/mode value, etc).
  - c. The spread (range, standard deviation, etc).
2. In 2-3 sentences, provide an argument for or against the helpfulness of plotted graphs and charts (histograms, bar charts, box plots, frequency distribution tables, scatter plots, pie charts, etc.) for helping us to understand the distribution of values.
3. In 1-2 sentences, address what is a limitation of this dataset? What information might be missing to fully characterize the risks to the ski resorts?

### Our Response:

1. By identifying the sample size and identifying the data types, we will be able to derive assumptions and check the conditions to make sure the data is valid. If we are unable to confirm all the conditions required, we will have to find alternate ways to validate the data or find entirely new data. By identifying the data type, we will know how to properly check the data and what kind of statistical evaluations we will have to perform. The center of the data and/or the values will give us a general idea of what the data is like. It will be a starting point for our observations, where we can state claims like "The average profit throughout all the years is \_\_\_\_." Then, we can also make more specific claims like "The average profit for a year with \_\_\_\_ snowfall is \_\_\_\_" which will give us a good idea of how to create our model and create our parameters. The spread is just as important if not more important, as it helps us further refine our parameters and have some confidence when we present claims about the data (mean, mode, etc.)
2. Plotted graphs such as histograms, bar charts, and box plots can help us understand the distribution of values because they provide a visual representation of the data. While tables do provide a lot of data, the reader is often left confused and may even be overwhelmed due to the sheer amount of numbers. By utilizing plotted charts and graphs, data is more easily readable, and the general takeaways are easy to see. Overall, graphs help simplify the data and allow for the visual of clear patterns.
3. The data given lacks specificity in the amount of snowfall. The ratings of "light," "typical," and "heavy."

## Mission 2 - Team Project Proposal Prompt

### **Identify Driving Research Questions for Your Topic**

*Driving research questions should be 1-2 sentences each with probing, open-ended, and aligned with the goals of addressing the issue of risk.*

- List 2-3 driving research questions whose answers would be needed in order to mitigate the risk of your project topic.

### **Our Response:**

- 1) The risk of medical misdiagnosis due to race and ethnicity encompasses various factors, including income, language, insurance, and various location-based factors, such as crime rate, air quality, or local medical funding programs. In order to better quantify risk for people of color, these factors must be considered when quantifying contingencies and risks to human wellbeing. To address these factors, what is the weight, or risk of each individual component of risk, and how can they be addressed in a final risk analysis statistic?
- 2) Medical misdiagnosis caused by bias can be caused by implicit, explicit, or historically deep-rooted biases that have left resounding impacts on the modern healthcare industry. To better identify the root of medical misdiagnosis, how can the origin of bias be identified? Is deep-rooted bias quantifiable, or traceable, and how can it be mitigated or prevented?
- 3) Increased healthcare costs from previously preventable health conditions can be a significant result of medical misdiagnosis. What is the financial risk of medical misdiagnosis? How much financial product is spent every year to treat as a result of unforeseen health effects due to misdiagnosis?

---

### **Identify the Type of Data You Hope to Find**

*As you begin to look for data related to your project, some teams experience a dissonance between what data they hope to find and what data is actually available. It can be easy to lose sight of what data would actually enable your team to explore the project, so articulating the data that you hope to find is valuable.*

- Describe in 2-3 sentences what the "perfect" or "ideal" data/datasets) would be that would enable you to answer and explore the questions you posed. Think about what the data would include - frequency? location? dates? Charts?

### **Our Response:**

In the pursuit for effective and applicable data sources relevant to the issue of race-based misdiagnosis, a central focus on socioeconomic and racial statistics as well as recorded misdiagnoses will be essential in identifying the concrete risks of misdiagnosis among people of color. Within the focus of socioeconomic and racial statistics, the desired data sources include misdiagnosed patient information (with an emphasis on race, income, insurance, or social competency), location-based information (ethnic and racial population densities, medical care funding programs, crime rates, air quality) to quantify risk when unrelated to race/ethnicity in addition to its relation. Through the acquisition of this data from hospitals, medical service programs, and localized government organizations, risk can be effectively identified and condensed into a general risk analysis for people based on their current condition.



## Identify Potential Data Sources for Your Topic

Since you won't use most of these for the data analysis until the Project Phase, it's important to create thorough notes for yourself and your mentor on each source to reference later.

- Find 2-3 data sources related to the project topic (include links to the sources). For each data source:
  - Provide a 1-2 sentence description of the credibility and scope of the data sources and identify which one (or more than one) of the five categories of data from the Actuarial Process Guide does the data source fall into.
  - In 1-2 sentences, describe what data summaries or visualizations your team would be able to do with this dataset in Phase 2: Projects. Examples could include charts, tables, or descriptive statistics (mean/standard deviation/frequency/range, etc).
  - In 1-2 sentences, identify if the dataset might need any cleaning to be useful or if there is an obvious limitation to using this dataset.

## Our Response:

- 1) Data Source #1 - [Adverse Action Report \(AAR\) and Medical Malpractice Payment Report \(MMPR\) from the National Practitioner Data Bank](#)
- 2) Data Source #2 - [US Census Bureau Demographic Data](#)

The first data source observes the number of malpractice reports and the corresponding costs over the years in different states in the United States. The second data source contains the percentage of minorities for each state. Both these datasets can be combined to form one large dataset potentially showing a relationship between the percentage of minorities in a state, and the number of malpractice cases. Through the integration of demographic data with malpractice report data, these two credible, US government-based sources can be utilized to quantify the risk of malpractice based on location and ethnic and racial background. By visualizing state-based and national risk based on specific demographics, this data can be visualized and the probability of misdiagnosis based on demographic input variables can be expressed. These datasets, when paired, are incredibly useful in identifying where and by how much racial and ethnic bias impacts medical diagnostic decisions. The limitations to these paired datasets are that cost is used to quantify malpractice, which is an undesirable variable to use in this scenario as different medical treatments are not all priced equally. However, this can effectively evaluate the risk of misdiagnosis/malpractice based on geographic location and demographic variables.

- 3) Data Source #3 - [IBD patient misdiagnosis U.S. 2017 | Statista](#)

This data source displays the percentage of patients with inflammatory bowel disease (IBD) who were initially misdiagnosed, based in the United States in 2017. This source is credible, as it was gathered from 4092 and was collected and expressed in the article, *IBD patients that received a misdiagnosis for their condition in the U.S. as of 2017*, Published by John Elflein in January of 2019. This data source can be used to visualize condition-specific misdiagnosis risk, and can be related with other race-based data to quantify the risk of IBD among minorities or societal groups that are identified as being of higher risk. These proportional values can be compared with other conditions or can be used to generate a

statement or hypothesis through proportional significance tests to better quantify risk. This dataset is useful as it is publicly available, free, and has been referenced in other academic works. However, it lacks a comparison to race or ethnicity and is limited to IBD. Finding generalized information about national medical misdiagnosis rates based on race can allow us to better quantify risk and identify effective risk minimization methods.

In addition, we identified the following data sources as alternative forms of data in the case that the data analyzed fails to lead our project to its desired outcome (quantifying risk and developing risk prevention plans). Since our project topic focuses on patient-based/medical data, finding data was difficult due to privacy concerns. Therefore, most of the case-by-case basis data we found was from other countries, or the US data we found was based on general statistics.

- Asia:
  - [Results of multiple logistic regression analysis of DERC.](#)
  - [List of the distribution of all 182 cases of cancer as well as examples of misdiagnosis and undiagnosed diseases.](#)
- Africa:
  - [Sensitivity and threshold analyses of retesting by low-income countries \(LIC\), lower-middle income countries \(LMIC\), and upper-middle income countries \(UMIC\) in Africa.](#)
  - [Costs under retesting and no retesting scenarios, over ten-year time horizon \(2017 USD\).](#)
  - [Review of false positive misdiagnosis in Africa.](#)
- International:
  - [Proportion \(%\) of missed hypertension cases for each of the 9 simplified approaches by WHO world region.](#)

# Mission 3 Ski Resort Prompts

## Our Responses:

### 3.1 - What kinds of math models exist regarding ski resorts?

Conduct some online searches with the ski resort & climate change topic + "math models" / "math modeling" or "modeling." Identify 2-3 articles/studies related to math modeling and ski resorts. Include links to the papers, articles, or websites you used so you can reference them later.

In 3-5 sentences, summarize your findings by addressing the following:

- What kind of results, published papers, and credible literature does this yield? What are some keywords used in the articles you find? Note: You may find it helpful to redo and refine your search to include some of the model descriptions from your initial search.
- Make a list of the kinds of math concepts (means, regression analysis, confidence intervals, statistical tests, charts or tables, etc.) that were utilized by mathematical models you found.
- Did any of the sources include a flowchart or pseudocode describing the mechanics of the model?
- What is helpful in what you found? What was unfamiliar or beyond the math you are familiar with?

### Our Response:

- [Climate Change and Ski Tourism Sustainability: An Integrated Model of the Adaptive Dynamics between Ski Area Operations and Skier Demand](#)
- [A ski injury risk assessment model for ski resorts](#)

An article published by the Journal of Risk Research introduces a ski injury risk assessment model which allows ski resorts to take targeted and preventive actions towards critical ski regions. Typically, ski resorts mostly measure ski injury risk based on the ratios consisting of the number of injuries and number of skier days. This measure can be improved by using ski lift transportation, a more accurate measure of risk than skier days. As figures, the article displays tables of different ski regions along with the overall risk across years (2006-2010). Analyzing more specific parameters will lead to more accurate results, so it's important that when investigating our model, we use logical and the most relevant data to have a precise risk assessment model.

### 3.2 - Components to a mathematical model

We need to identify if there is a difference in profits between light/typical/heavy years - if there isn't any kind of loss or lower profits between the snowfall types, then the question for the resorts and their insurance companies would be whether there really is any risk to profits with climate change.

The following computations in the following questions are the initial values needed to characterize the risks to the ski resorts.

- Prompt 3.2.1 - Compute the **probabilities** of the 3 different snowfall categories for the three resorts.
- Prompt 3.2.2 - Compute the **mean profits** for each of the three resorts for each of the snowfall categories and overall for each resort. Does light snowfall years lead to a difference in profits? In what way?

- Prompt 3.2.3: Compute the expected **value of PROFITS** for each of the three resorts.

See the Actuarial Process Guide pages 14-15 and Mission 4 Briefing for more information on expected value.

**Our Response:**

**3.2.1**

	Probability - Typical	Probability - Heavy	Probability - Light
Alpine Arenas	0.7	0.1	0.2

	Probability - Typical	Probability - Heavy	Probability - Light
Mountain Meadows	0.7	0.1	0.2

	Probability - Typical	Probability - Heavy	Probability - Light
White haven	0.7	0.1	0.2

**Our Response:**

**3.2.2**

Average Profit (\$thousands)(years) Alpine Arena	Average Profit (\$thousands) (years) Mountain Meadows	Average Profit (\$thousands)(years) White Haven
752	811.15	724.4
Average Profit (\$thousands)(typical) Alpine Arena	Average Profit (\$thousands)(typical) Mountain Meadows	Average Profit (\$thousands) (typical) White Haven
759.6	787.775	798.5
Average Profit (\$thousands) (heavy) Alpine Arena	Average Profit (\$thousands) (heavy) Mountain Meadows	Average Profit (\$thousands) (heavy) White Haven
992	850.75	645
Average Profit (\$thousands) (light) Alpine Arena	Average Profit (\$thousands) (light) Mountain Meadows	Average Profit (\$thousands) (light) White Haven
685.6	686	504.75

Light snowfall years have lower average profit, decreasing overall profit of all three ski resorts. Because light snowfall is associated with reduced revenue due to decreases in customer attendance, average profit in light snowfall years reduces the average profit of all three ski resorts.

## Our Response:

### 3.2.3:

#### Alpine Arena

$$(0.7 * 759.6) + (0.1 * 992) + (0.2 * 685.6) = 768.04 \text{ Profit (\$thousands)}$$

#### Mountain Meadows

$$(0.7 * 787.775) + (0.1 * 850.75) + (0.2 * 686) = 773.72 \text{ Profit (\$thousands)}$$

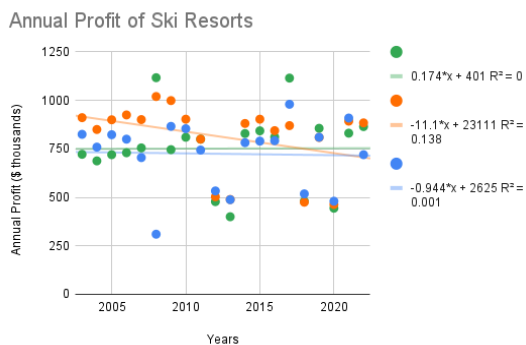
#### White Haven

$$(0.7 * 798.5) + (0.1 * 645) + (0.2 * 504.75) = 724.4 \text{ Profit (\$thousands)}$$

## 3.3 - Linear Regression

- Prompt 3.3.1 - Calculate the least-squares linear regression for each of the resorts.
  - Create a graph with the plots of profits over the 20 years and their corresponding trend lines.
  - Include the trend line equations and correlation coefficients
- Looking at all the years, is one of these resorts in more trouble or have a riskier profit projection than the others? Explain and justify your answers.
- What assumptions are you making about typical vs heavy or light snowfall years and resort profits? Include 2-3 different assumptions.

## Our Response:



- Alpine Arena:  $y = 0.174x + 401$ ,  $R^2 = 0$

Mountain Meadows:  $y = -11.1x + 23111$ ,  $R^2 = 0.138$

White Havens:  $y = -0.944x + 2625$ ,  $R^2 = 0.001$
- One resort is having a riskier time than the other, it is Mountain Meadows. As we can see in the graph, the trend line of Mountain Meadows has a decreasing slope, of -11.1, which is the most steep slope out of the rest of the resorts, which have a close to 1 slope. A slope of -11.1 means that every year, the ski resort makes a profit of around 11,100 less than the previous year.

## Mission 3 - Team Project Proposal Prompt

### **Modeling Research on your Topic**

Conduct some online searches with your topic + "math models", "math modeling" or "modeling".

- In 3-5 sentences, summarize and describe the results of your online searches by answering the following questions:
  - What kind of results, published papers, and credible literature does this yield?
  - What are some key words used in the articles you find? Redo and refine your search to include some of the model descriptions from your initial search.
  - What is helpful in what you found? What was unfamiliar or beyond the math you are familiar with?

### **Our Response:**

- These are the sources we found:
  - [How scientists are subtracting race from medical risk calculators | Science](#)
  - [Race and Genetic Ancestry in Medicine – A Time for Reckoning with Racism](#)
  - [Research: Artificial intelligence can fuel racial bias in health care, but can mitigate it, too](#)
  - [Implicit Racial/Ethnic Bias Among Health Care Professionals and Its Influence on Health Care Outcomes: A Systematic Review](#)
  - [Misdiagnosis: Race-Conscious Approaches to Medical Education](#)
  - [Dissecting racial bias in an algorithm used to manage the health of populations | Science](#)
  - [AI systems can detectDissecting racial bias in an algorithm used to manage the health of populations | Science patient race, creating new opportunities to perpetuate health disparities](#)
- Key words:
  - Race, ethnicity, genetic, clinical, diagnosis, predictors, artificial intelligence, machine learning, bias, medicine, health care.
- Overall, these existing mathematical models and developing artificial intelligence (AI) tools view medical misdiagnosis risk through the lens of bias and injustice towards racial groups in health-related settings. It is helpful that each source addresses race and bias, which are two major components to our proposed project. Results are primarily pieces of academic literature, which aim to evaluate whether bias exists, and to what extent it does. However, the AI models introduce a more solution-based approach and attempt at evaluating the drawbacks and benefits of employing AI to diagnose health conditions and to better understand the biases present in AI models as well as the approach to be taken in minimizing these biases.

---

### **Identify Mathematical Modeling Methods to Consider in the Project Phase**

- In 3-5 sentences, based on your research, provide a consideration for:
  - What kind of mathematical analysis seems to be fruitful to pursue in the Project Phase for your proposed topic?
  - Provide a summary of your findings with links and identify how this informs your next steps in mathematical analysis.

**Our Response:** In the Project Phase, we hope to analyze the relationship between a complex societal issue, which requires the consideration of many variables, which should be weighted to account for their impact on

risk of misdiagnosis among people of color. With the intention of quantifying risk, it is likely that our mathematical analysis will involve analyzing the risk of bias through quantitative analysis tools. One such quantitative analysis tool is the Cochrane 'risk of bias' assessment, which assesses 7 evidence-based domains to review the bias present within an author's judgment in a medical setting. This process involves assessing the source of risk, including incomplete results, selective reporting, and bias in sample selection. This quantitative analysis will allow our group to determine the source of bias in a diverse array of medical research results.

Bias-Assessment Tools/Resources found:

- [Risk of Bias Assessment - Systematic Review and Evidence Synthesis - Research Guides at University of Minnesota Minneapolis](#)
  - [Assessing risk of bias in included studies](#)
- 

### ***Goals of a Mathematical Model in the Project Phase***

- In 2-3 sentences, describe what - ideally - you hope that a mathematical model would be able to do for you? How could it help you identify the frequency & severity of risk and the changes over time or other elements that will help you characterize risk?

A mathematical model could allow our group to assess the role of variables such as race, ethnicity, gender, immigration status, location, air quality, and more, in the assessment of medical conditions. In developing a mathematical model that weighs the role of each factor, specific risk can be quantified and individuals and communities with the highest risk of misdiagnosis can be identified. In identifying this group at risk, funding, investment, or increased focus can be directed towards high-needs communities.

# Mission 4 Ski Resort Prompts

Responses:

## 4.1 - Are there any risky outliers?

Deviations from the typical snowfall can be anticipated as part of the risks of conducting a business that is largely dependent on external factors. Even with that, a significant outlier of note within atypical snowfall years could lead to extreme profit outcomes for Mountain Meadows.

- In 3-5 sentences, address the following and explain your reasoning:
  - Are there any significant outliers in atypical snowfall years?
  - If yes, what could be an explanation for this profit outlier in light of the snowfall? Does this outlier affect all ski resorts equally? Justify your explanation logically and mathematically.
  - If no, explain why not and offer a logical and mathematical case for your reasoning.

**Our Response:**

### 4.1 Response:

In order to determine outliers in atypical snowfall years profits, we analyzed light and heavy snowfall years for Mountain Meadow by graphing the relationship between profit and year. For light snowfall years from 2012 to 2020, the resulting graph shows a declining, negative linear relationship with a R-squared value of 0.94. When applied to heavy snowfall years at Mount Meadow from 2008 to 2017, the graph indicates a negative linear relationship with a slope of -16.7 with a R-squared value of 1. It is difficult to be conclusive about potential outliers from the heavy snowfall data as there are only 2 years on record, but the high R-squared values of both atypical snowfall years show a high level of negative correlation, indicating that there is no profit outlier for the atypical years on record. The negative linear relationship present in both light and heavy snowfall yearly profit decrease can be accounted for by worsening climate rates—too much or too little snow—which are steadily deteriorating ski resort infrastructure through a decrease in customers.

## 4.2 - Risk Analysis

- 4.2.1: Consider the probabilities computed in Prompt 3.2.1 regarding Mountain Meadows.
  - Are the probabilities providing insight into the frequency or the severity of loss? What does this tell you about the distribution of risk? Provide a logical and mathematical explanation in 1-2 sentences.
- 4.2.2: Consider the mean profit at Mountain Meadows computed in Prompt 3.2.3.
  - Since Mountain Meadows did not report negative profits in any given year, what is a measure of “loss”? How can you define loss for a report even when they have positive profits? Explain in 2-3 sentences

### 4.2.1 Response:

The probabilities don't directly convey the severity of loss, but rather each resort's likelihood of experiencing each type of snowfall. This suggests that the distribution of risk is more about the likelihood of encountering various snowfall conditions rather than the severity of potential losses associated with each type.



#### 4.2 .2 Response:

The measure of loss for the ski resorts can be defined as the deviation from the expected or optimal profit margin. Despite the ski resort reporting positive profits, the difference between the actual profit and the projected profit represents a potential loss. The deviation rates for each of the resorts may be higher during light snowfall years, where actual profit was less than expected.

## Mission 4 - Team Project Proposal Prompt

### **Audiences & Mitigation Strategy Viability**

Revisit the audiences and risk mitigation strategies identified in Mission 1.

In 3-5 sentences, compare and contrast the 3 risk mitigation strategies (insurance, behavior change, modifying outcomes), by addressing the following:

- Based on the data, analysis, and potential math modeling, does one of these risk mitigation strategies seem more viable than another? Explain.
- Does this change or adjust your perspective on the audience or approach in any way? Why or why not? Describe and provide a justification for your reasoning.

### **Our Response:**

If we were to implement one of these three risk mitigation strategies, they would take the following forms:

- Insurance - Patients will have the option to be insured against malpractice and misdiagnosis. If misdiagnosed or mistreated, they will be able to get a percentage off of future treatments and medical scans to be compensated for the time lost and other inconveniences due to the malpractice.
- Behavior change - Medical professionals constantly encourage patients to get a second diagnosis from another professional in the field in order to solidify the diagnosis and future course of action.
- Modifying outcomes - Medical professionals a part of malpractice cases in court cases will be punished more harshly, and therefore be cautious to perform a similar mistake in the future.

We believe insurance would be the most viable form to mitigate racial disparities in the healthcare system, and in particular malpractice/misdiagnosis, because it can be a solution that is implemented swiftly and is very concrete. The success of the other solutions require more enforcement and the impact may not be as easily measurable as with insurance.

---

### **Goals for Mitigation Strategy**

In 2-3 sentences, consider potential outcome scenarios for the risk(s) you identified in Mission 1.

- What does the current trajectory and forecast for your topic lead if no interventions are made?
- What would be the goal and hope for the impact that the risk mitigation strategy would have?

### **Our Response:**

If no actions are taken to reduce the risks of misdiagnosis, individual fatality and long-term health

effects as well as legal action and an unstable health industry are possible outcomes. Ignoring the heightened risk of medical misdiagnosis among people of color is a sign that current medical systems are failing to deliver what they promise to communities of higher risk. It is essential that risk be evaluated and addressed for high-needs communities so that the healthcare industry promotes the betterment of a flawed system and the approach of a more equitable future.

---

## Mission 5 Ski Resort Prompts

These prompts can be found on pages 36-38 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 34-35 of the [Actuarial Process Guide](#).

Responses:

### 5.1 - What is the current state and trajectory of Mountain Meadows?

- In 2-3 sentences backed by logical and mathematical justification based on the data, modeling, and analysis, summarize and characterize the projection for the risk of loss and trends for Mountain Meadows based on current status if no interventions or mitigation strategies are implemented.

#### Our response:

If no mitigation strategies are implemented towards Mountain Meadow's loss, the deviation between expected versus actual yearly profits will grow, forcing actual profits to fall behind severely. Currently, the largest profit loss threatening Mount Meadows is average profit during light snowfall years; during these years, the negative deviation between expected and actual profits puts the ski resort at an economically unsustainable position.

### 5.2 - Risk Mitigation Strategies for Mountain Meadows

Considering the current state of the resort and future projections, how can Mountain Meadows consider one or more risk mitigation strategies to improve their situation for the future. The following will explore each of the three risk mitigation strategies as outlined in the Actuarial Process Guide.

- **Risk Mitigation Strategy: Behavior Change**
  - Identify 2-3 behavior changes (eg, a sustainability initiative to combat climate change) that Mountain Meadows could implement to mitigate the risk of loss.
  - From the perspective of the expected value and trends along with the feasibility (timeframe, cost, impact, etc.), what are some potential drawbacks of the resort strategizing behavior changes that would detract from their expected return on investment? Provide 1-2 sentences justifying your answer.
- **Risk Mitigation Strategy: Modifying Outcomes**
  - Identify 2-3 concepts the resort could implement to modify outcomes (eg, building an indoor rec center as a revenue source that operates independent of the snowfall) to mitigate the risk of loss in profits.
- **Risk Mitigation Strategy: Insurance**
  - In 2-3 sentences, describe how an insurance policy could benefit Mountain Meadows. What could insurance do to help reduce or mitigate the risk of financial loss to the resort?

#### Our Response:

##### **Risk Mitigation Strategy: Behavior Change**

To mitigate the losses Mountain Meadows may face due to climate change, they can begin by making behavior changes to the operation of their ski resort, which include various sustainability initiatives, such as a heavy push for whole company recycling, water conservation in facilities, and consistent use of biodegradable products, especially in the food section of the ski resort. While these initiatives will make an impact on the ski resort carbon footprint, one should note that implementing change is not always free of cost. Modifying the entire

ski-resort so that it's more fuel efficient, water conservant, and biodegradable means that there has to be an initial investment. Typically, these investments are more than what operating costs would be without sustainability in mind, which is why many companies are deterred from enacting it. The expected value for the Mountain Meadow's annual profit would drop as the investment into cleaner reusable materials would increase operating costs and cut into revenue.

### Risk Mitigation Strategy: Modifying Outcomes

In order to mitigate climate-led changes in economic profit, ski resorts can diversify their activities that aren't snow-related in the winter to help raise losses. By expanding their services during the winter time, resorts can invest in more attractive lodging and dining options, as well as provide venue space for indoor events. Past winter-related activities, ski resorts can transform their nature-heavy assets and invest in year-round attractions to generate revenue during all 4 seasons for increased profits. Ski resorts can also re-evaluate pricing, incentivizing guests through increased discounts. While this may initially cause ski resorts to lose on profits, implementing discounts will generate increased audience appeal.

### Risk Mitigation Strategy: Insurance

As a result of climate change, the type of snowfall a skiing season will receive, along with other forms of uninviting weather, will impact the amount of people that will go skiing, decreasing revenue for the business. Investing in an insurance plan that will protect and mitigate loss would be useful for a business model that is reliant on the unpredictability of the weather and season. In the case of light snowfall years, this insurance policy will help alleviate potential losses by decreasing the difference between expected and actual profit.

## 5.3 - What impact does this insurance policy have for Mountain Meadows?

Mountain Meadows Resort is concerned about their declining profits. They believe that in large part, the cause of their decline is due to an overall decrease in snowfall in their region. They are considering purchasing an insurance policy that would pay the resort for \$100,000 for "lost revenue" during light snowfall years. The policy costs \$30,000 per year.

- Construct a probability distribution chart for the expected profit using the average profit for the 20 years of historical data if Mountain Meadow buys this insurance policy.

With Insurance	Mean Profit	Probability
Light	686 Profit (\$thousands)	14/20 = 0.7
Typical	787.78 Profit (\$thousands)	4/20 = 0.2
Heavy	850.75 Profit (\$thousands)	2/20 = 0.1

- Calculate the expected value of Mountain Meadow's profit and the standard deviation of the expected profit with this insurance policy.

$$(686 * 0.7) + (787.78 * 0.2) + (850.75 * 0.1) = \mathbf{722.83 \text{ Profit (\$thousands)}}$$

Standard deviation:

$$\sqrt{(686 - 722.83)^2(0.7) + (787.78 - 722.83)^2(0.2) + (850.75 - 722.83)^2(0.1)}$$

= **58.56 Profit (\$thousands)**

- For Mountain Meadow, in 2-3 sentences, compare your answers for their standard deviation and mean profit values with and without this insurance policy. Interpret the values for the different profits in context - what does this mean for them in terms of profit variability?

Mountain Meadow has an average profit value of \$773,720 without their insurance policy. With insurance the average profit goes down slightly to \$722,830. This makes sense because the insurance company has to profit from selling their policy to Mountain Meadow.

- Ultimately, the goal of the risk mitigation strategy recommendation is to improve the situation for Mountain Meadows. How does the risk mitigation strategy address the risks for Mountain Meadows?

This risk mitigation strategy ensures that Mountain Meadow is not hurt by “lost revenue” during light snowfall years. This new insurance policy protects them in case they lose profits during light snowfall years due to decreased customers. While Mountain Meadows has to pay an insurance policy cost of \$30,000, the purchased insurance policy gives them \$100,000 of lost profits.

## Mission 5 - Team Project Proposal Prompt

### *Recommendation Differences Between Mitigation Strategies*

Revisit the risk mitigation strategies identified for your topic in Mission 1.

- Considering the 3 types of risk mitigation strategies and your evaluation on what might be most fruitful, in 2-3 sentences address:
  - What could a potential recommendation be for the risk mitigation strategy your team identified in Mission 4 for your topic?
  - What metrics would you use to prioritize which one risk mitigation strategies could be taken?

### **Our Response:**

With consideration of the Actuarial Process Guide’s highlighted actuary recommendations for applying the stated risk mitigation strategies, we would recommend on a project-level that risk be mitigated by addressing insurance policy and introducing new insurance products and opportunities, such as the reduction of healthcare costs to victims of medical misdiagnosis and malpractice as well as the addressment of protective insurance policies in place for malpracticing health organizations. In addition to direct support for patients who are facing misdiagnosis, we would recommend that government financial investment be promoted to address medical gaps and promote the medical research of conditions that high-risk communities face. Through these project-specific recommendations, the problem stated in Mission 1, which centers around the heightened risk of misdiagnosis for people of color, can be addressed and effective strategies for reducing the risk of medical misdiagnosis can be identified.

---

### **Considering New Problems Introduced by the Risk Mitigation Strategies**

*In 2-3 sentences, offer some ideas on whether there could be any unintended consequences of the recommended risk mitigation strategies? Identify 1-2 potential pitfalls of the recommendations.*

#### **Our Response:**

1. Insurance - Medical malpractice cases are very complex and require long wait times in court. As a result, more time is being wasted simply proving that malpractice occurred, and therefore, this further prevents the patient from obtaining treatment as they need to wait for the case to be completed before receiving insurance pay-out.
2. Behavior change - Companies may be against their medical staff recommending a second consultation with another company as this drives away customers.
3. Modified outcomes - Punishing all malpractice cases is often aligned with a decrease of medical professionals, as people in the healthcare industry generally avoid involvement in legal action.

---

### **Goals for Situation Improvement**

Ultimately, the goal of your MTFC project is to model the future and recommend a strategy to improve the outlook for the future for your project topic. In 3-5 sentences, summarize:

- What improvements would you hope your recommendations would lead to for your project topic (ie, what is your best case scenario outcome)? Explain.

#### **Our Response:**

Our goals for this project are to establish a future in which an equitable health care system allows for the minimization of race, ethnicity, and societal factor-induced medical misdiagnosis. Through the pursuance of actionable recommendations, including implementing concrete insurance policy and encouraging government investment towards health research, we hope to implement a mathematical model to quantify the effects of demographic and location-based factors on individual risk of medical malpractice or misdiagnosis and direct the stated recommendations to communities at the highest risk in the United States. In pursuing the stated recommendations and approaching risk mitigation strategies, we can promote a future of equitable healthcare treatment. In addition to equity, we foresee a future in which advancing technologies, such as artificial intelligence, can be implemented into modern, flawed systems, to approach misdiagnosis on the basis of racial or ethnic disparities. This best-case scenario is possible, through the implementation of an effective risk assessment and addressment model in a complex modern society.