Air Quality and Climate Dynamics in California: Critical Facts for Insurance Focus Areas

Mission:

Examine the Dynamic Relationship Between Air Quality and Climate Patterns.
Propose Insurance Solutions for California.

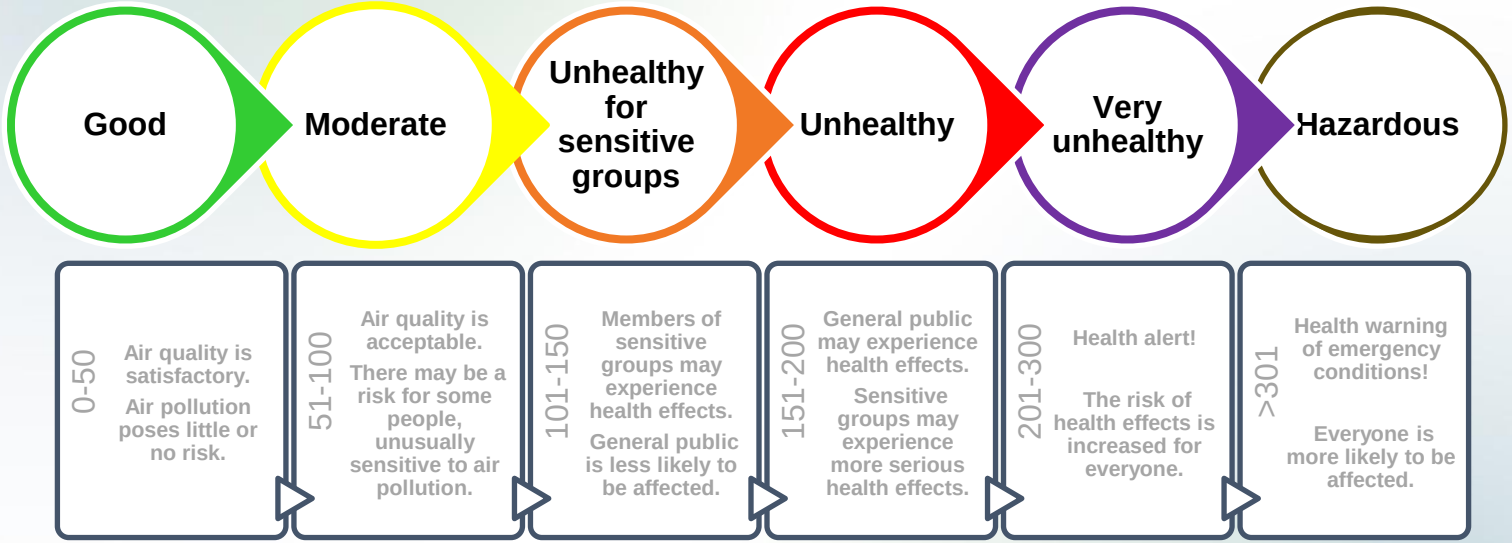
Importance:

By identifying critical factual insights and focus areas in California we can enhance insurance risk assessment, pricing strategies, and policy management.

Why California is an ideal case study for assessing air pollution risks?

- High levels of pollution
- Extensive network of monitoring stations
- Diverse geographic regions
- Strict environmental regulations

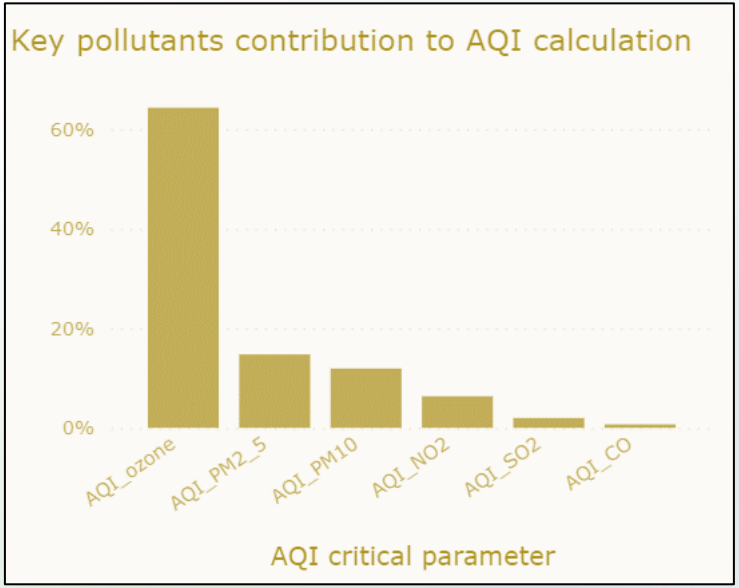
Air Quality Index (AQI)



GOAL: Safeguard public health

Air Quality Index (AQI)

A standardized measure to **assess air quality** based on concentrations of major air pollutants.

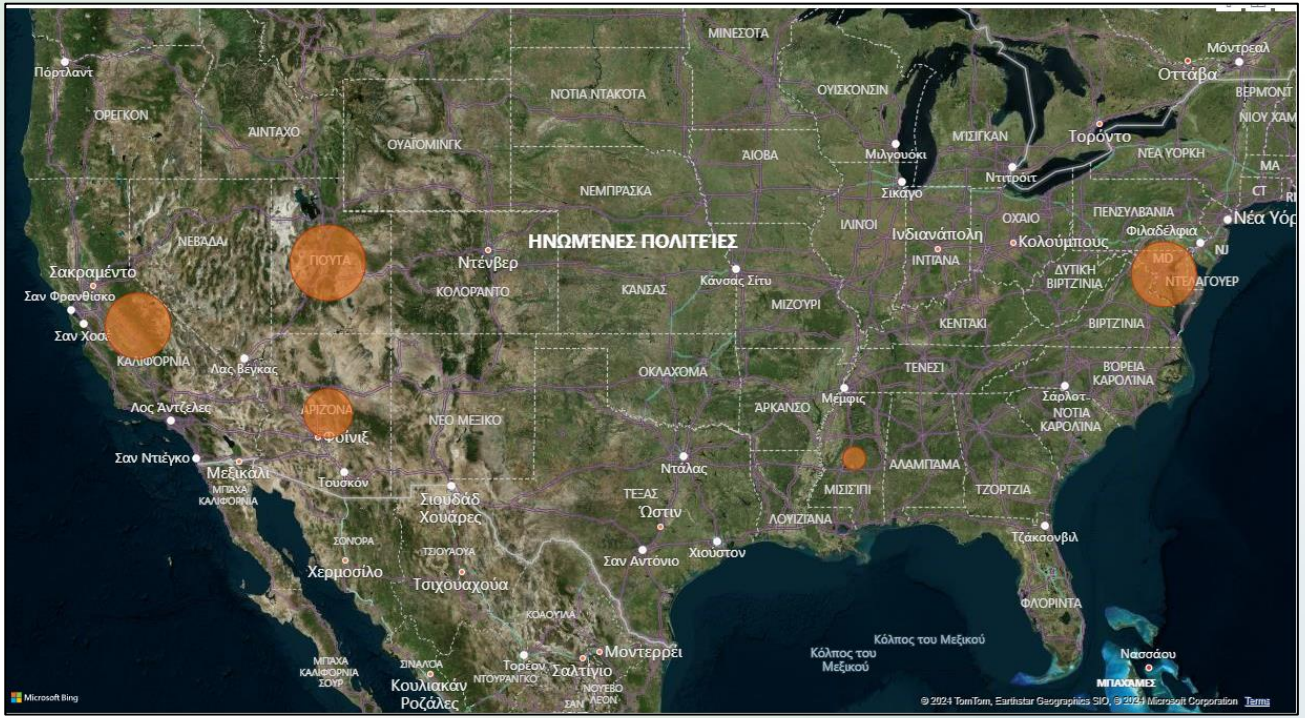


Project Roadmap

Data Collection	Collect Historical Data - Data Source: EPA 20 years of weather, AQI and its key pollutants components daily data for all US states.
Preliminary Analysis	Data Cleaning, Processing and EDA with Python (pandas, numpy) to identify States with the Highest Pollution Levels.
Identify State of interest	Extensive monitoring, high pollution levels, geographic and climatic diversity, and regulatory environment.
Searching for AQI correlations	Analyze the potential relationship between AQI and its key pollutants levels with weather data.
Identify AQI and Heatwaves interplay	- Choose a county known for frequent heatwaves. - Analyze the correlation between heatwaves, temperature spikes, and AQI.
Monthly and Seasonal AQI Trends	Discuss patterns and trends observed in the data.
Compare Urban and Rural AQI and its key pollutants	Analyze AQI data for urban and rural counties.
Synthesize Findings	- Summarize key insights from the analysis. - Highlight the most critical data points and correlations.
Implications for Insurance	How to improve risk assessment, adjust policy pricing, anticipate claims, and develop new products.

States with the worst air quality

20 years AQI average



AQI data: 12M records, 40 variables

Weather data: 6M records, 26 variables

90%

of Californians breathe unhealthful air during some part of the year.

PM2.5 pollution causes over 9K deaths in California annually, with a statistical range from 7K to 11K deaths.

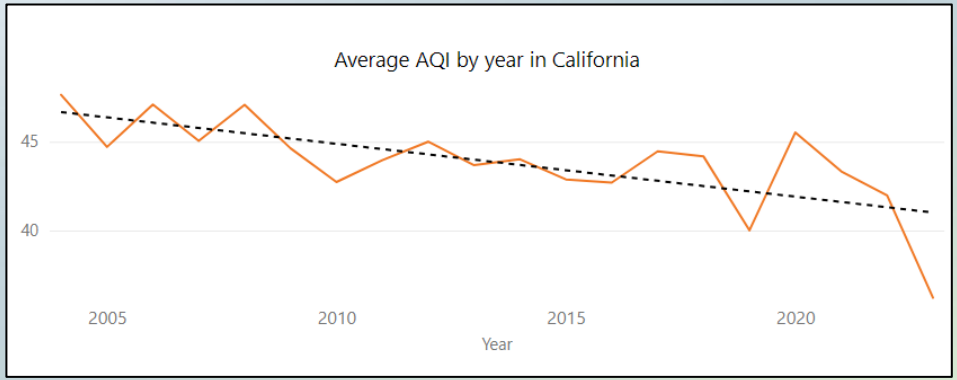
California Air Resources Board,2010

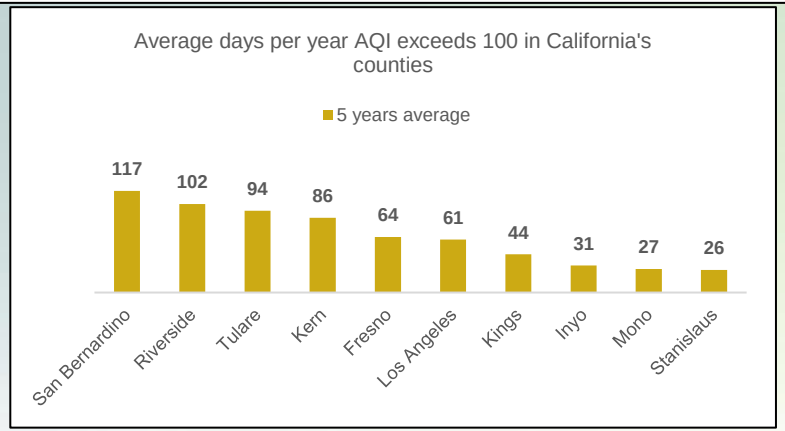
California

3rd largest state by area

- **156K sq mi** land area
- **8K sq mi** water area
- **39M** population
- **40** counties

source://data.census.gov/



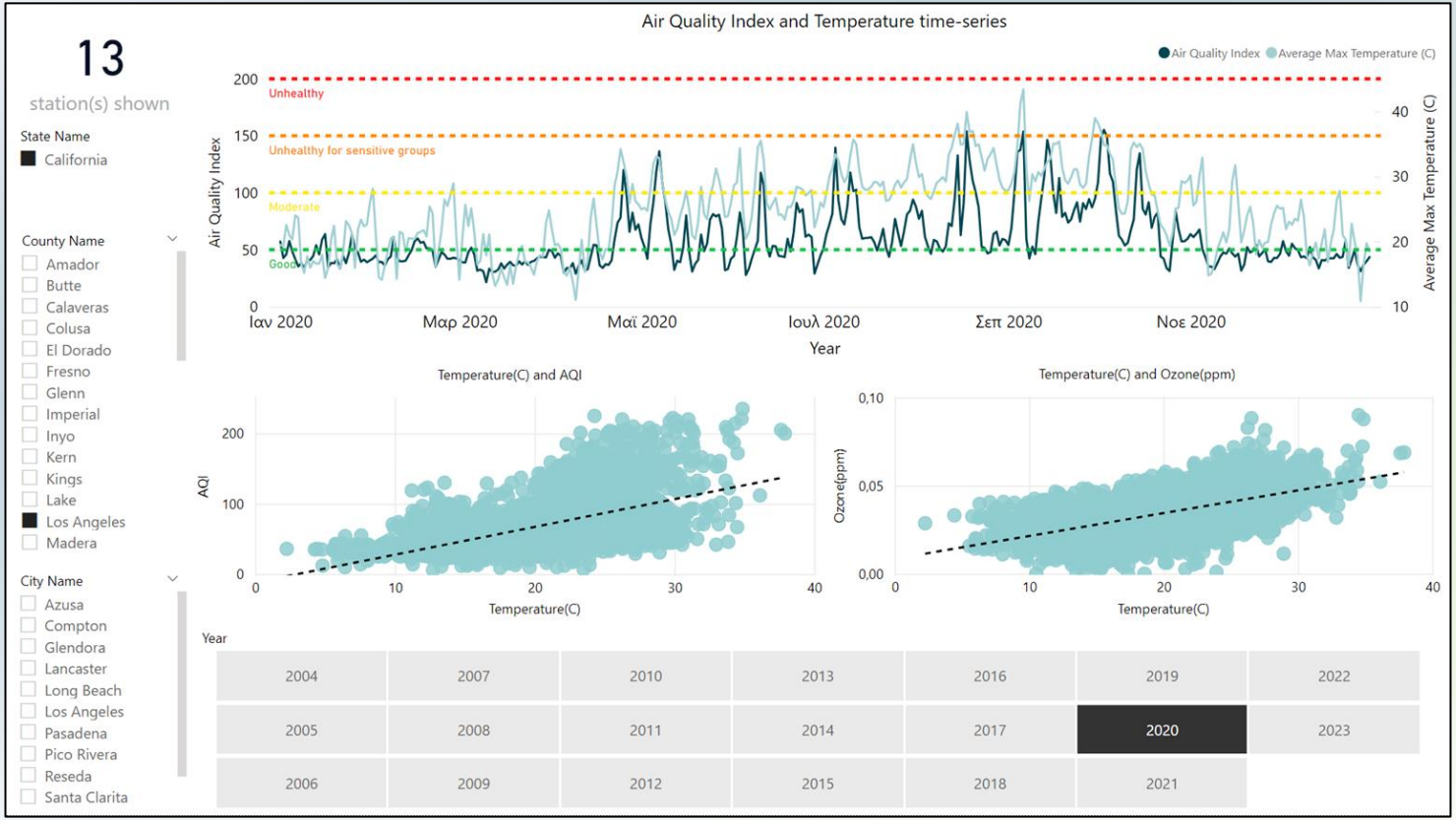


- Wildfires
- Vehicle Emissions
- Warm Climate and Ozone Formation
- Industrial Activities
- Geographical Factors

2004
69 monitoring stations

2022
84 monitoring stations

AQI correlations-Temperature



AQI and Heatwaves interplay in Los Angeles

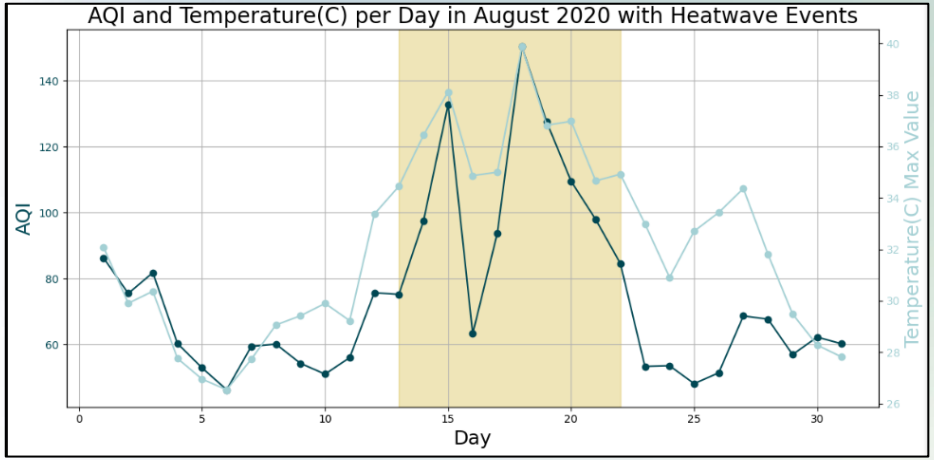
Stagnant Air Conditions

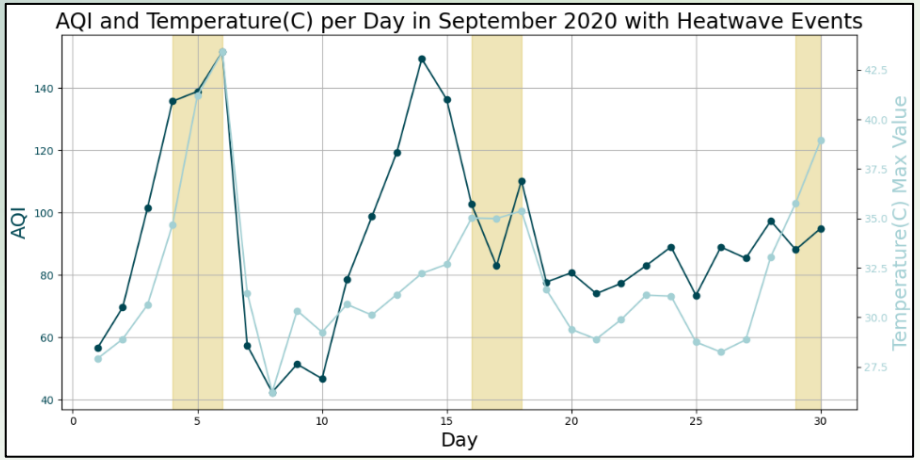
Inversions

Heat Waves

Wildfires

Formation of Ground-Level O3 - Photochemical Reactions

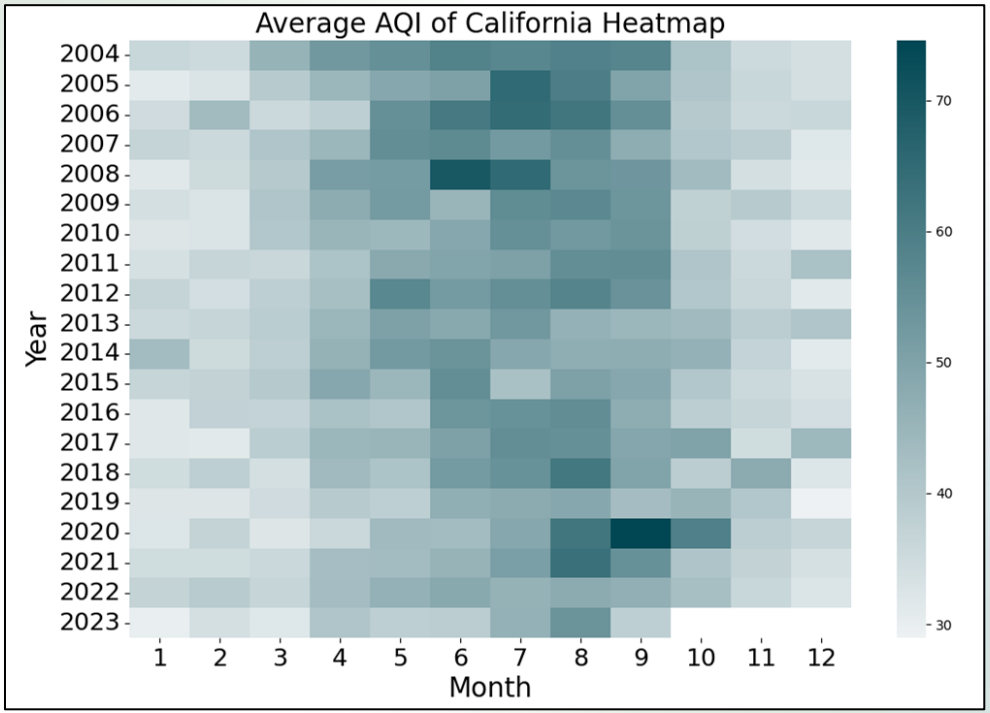




Monthly and seasonal AQI trends in California

SUMMER

Consistent patterns highlighted in air quality across seasons.

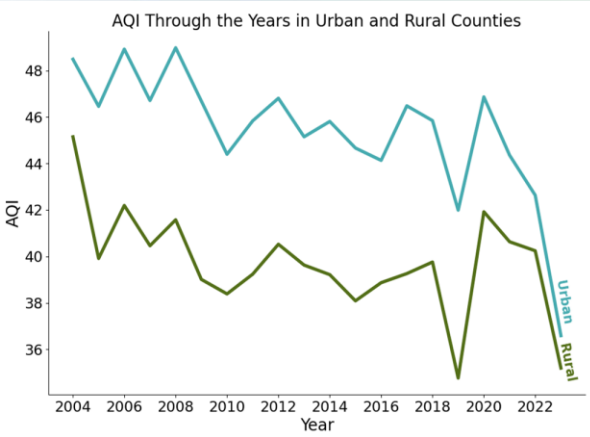


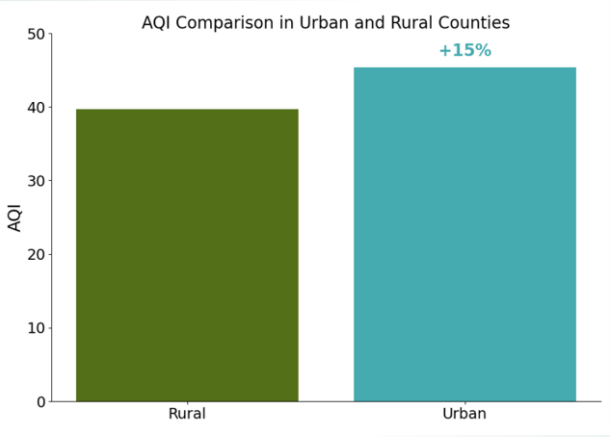
Outbreak of wildfires caused by a series of lightning strikes

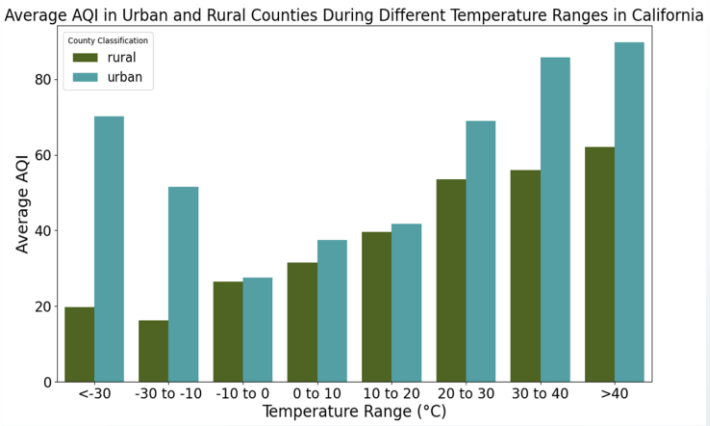
August Complex California's largest recorded wildfire **gigafire**

The median AQI is higher, indicating generally poorer air quality. The spread of AQI values is also larger, suggesting more variability in AQI and some extreme high values.

Urban and Rural AQI in California







Worse air quality in urban areas

Constant pattern throughout the years

Across all temperature ranges

Especially at very low and very high temperatures

Urban and Rural key pollutants in California

Urban

Rural

Concentration of PM10 and PM2.5 is stable over time.

Ozone is on the rise – rural areas seem more affected – COVID19 lockdowns had a positive effect.

The rest of pollutants had in general higher concentration in urban counties.

Key Insights

States to focus	California's hotspots to focus	Temperature Effect	Key Pollutants	Seasonal Variations	Urban vs. Rural
1. Utah 2. California 3. Maryland 4. Arizona 5. Mississippi	1. San Bernardino 2. Riverside 3. Tulare 4. Kern 5. Fresno 6. Los Angeles	High Temperatures Heatwaves Wildfires	O3 PM2.5 PM10	Summer months Winter months - urban	Urban Rural-ozone

Insurance Strategies for Air Quality Risks

Adjust Premiums Based on Localized Air Quality Data

- **Action:** Focus on areas with historically poor air quality. Implement higher premiums in regions experiencing frequent heatwaves and elevated ozone levels due to increased health risks and potential claims.

Develop Specialized Health Coverage

- **Action:** Health insurance products that cover respiratory and cardiovascular conditions exacerbated by air pollution. There is a growing demand for specialized health coverage in affected areas.

Predictive Analytics to Anticipate Claims

- **Action:** Predictive analytics to forecast and prepare for spikes in claims during high risk periods. Use historical data from California's most affected regions. Acting proactively can mitigate financial impact and improve customer service during high-risk periods.

Further Research

- Data Integration
- Spatial Analysis
- Product Development
- Technology Investment

References:

- U.S. Environmental Protection Agency. (2024). Air quality data. Retrieved from https://www.epa.gov/outdoor-air-quality-data
- California Air Resources Board. (2024). Health and air pollution. Retrieved from https://ww2.arb.ca.gov/resources/health-air-pollution
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When did you become an expert
in air pollution and meteorology?
Last night

Appendix

Key Pollutants health effects

Pollutant	Effects on Health and the Environment
Ozone (O_3)	• Respiratory symptoms • Worsening of lung disease leading to premature death • Damage to lung tissue • Crop, forest and ecosystem damage • Damage to a variety of materials, including rubber, plastics, fabrics, paint and metals
PM2.5 (particulate matter less than 2.5 microns in aerodynamic diameter)	• Premature death • Hospitalization for worsening of cardiovascular disease • Hospitalization for respiratory disease • Asthma-related emergency room visits • Increased symptoms, increased inhaler usage
PM10 (particulate matter less than 10 microns in aerodynamic diameter)	• Premature death & hospitalization, primarily for worsening of respiratory disease • Reduced visibility and material soiling
Nitrogen Oxides (NO_X)	• Lung irritation • Enhanced allergic responses
Carbon Monoxide (CO)	• Chest pain in patients with heart disease • Headache • Light-headedness • Reduced mental alertness
Sulfur Oxides (SO_X)	• Worsening of asthma: increased symptoms, increased medication usage, and emergency room visits
Lead	• Impaired mental functioning in children • Learning disabilities in children • Brain and kidney damage
Hydrogen Sulfide (H_2S)	• Nuisance odor (rotten egg smell) • At high concentrations: headache & breathing difficulties
Sulfate	• Same as PM2.5, particularly worsening of asthma and other lung diseases • Reduces visibility
Vinyl Chloride	• Central nervous system effects, such as dizziness, drowsiness & headaches • Long-term exposure: liver damage & liver cancer
Visibility Reducing Particles	• Reduced airport safety, scenic enjoyment, road safety, and discourages tourism
Toxic Air Contaminants About 200 chemicals have been listed as toxic air contaminants	• Cancer • Reproductive and developmental effects • Neurological effects

https://ww2.arb.ca.gov/resources/common-air-pollutants

Calculating AQI Example

1.Monitoring Pollutant Concentrations:

- **Ozone (O_3)**: Measured concentration is 70 parts per billion (ppb).
- **Particulate Matter PM2.5**: Measured concentration is 25 micrograms per cubic meter (µg/m³).

2.Calculating AQI Sub-Indices:

For Ozone (O_3):

- Ozone concentration: 70 ppb.
- AQI breakpoints for ozone (using the EPA standards):
  - 0-54 ppb: Good (AQI 0-50)
  - 55-70 ppb: Moderate (AQI 51-100)

Since 70 ppb falls into the Moderate category:

$AQIO_3=100$

For Particulate Matter PM2.5:

- PM2.5 concentration: 25 µg/m³.
- AQI breakpoints for PM2.5 (using the EPA standards):
  - 0-12.0 µg/m³: Good (AQI 0-50)
  - 12.1-35.4 µg/m³: Moderate (AQI 51-100)

Since 25 µg/m³ falls into the Moderate category:

$AQIPM2.5=66$

3.Determining the Overall AQI:

- Compare the AQI values calculated for ozone and PM2.5.
- In this example:
  - $AQIO_3=100$
  - $AQIPM2.5=66$

  The overall AQI is determined by the highest sub-index value among all pollutants:

Overall $AQI=\max(AQIO_3,AQIPM2.5)=\max(100,66)=100$

4.Interpreting the AQI:

- An overall AQI of 100 indicates Moderate air quality.
- Health advisories might recommend that sensitive individuals limit prolonged outdoor exertion, particularly during periods of high ozone and particulate matter concentrations..

Air Quality Index