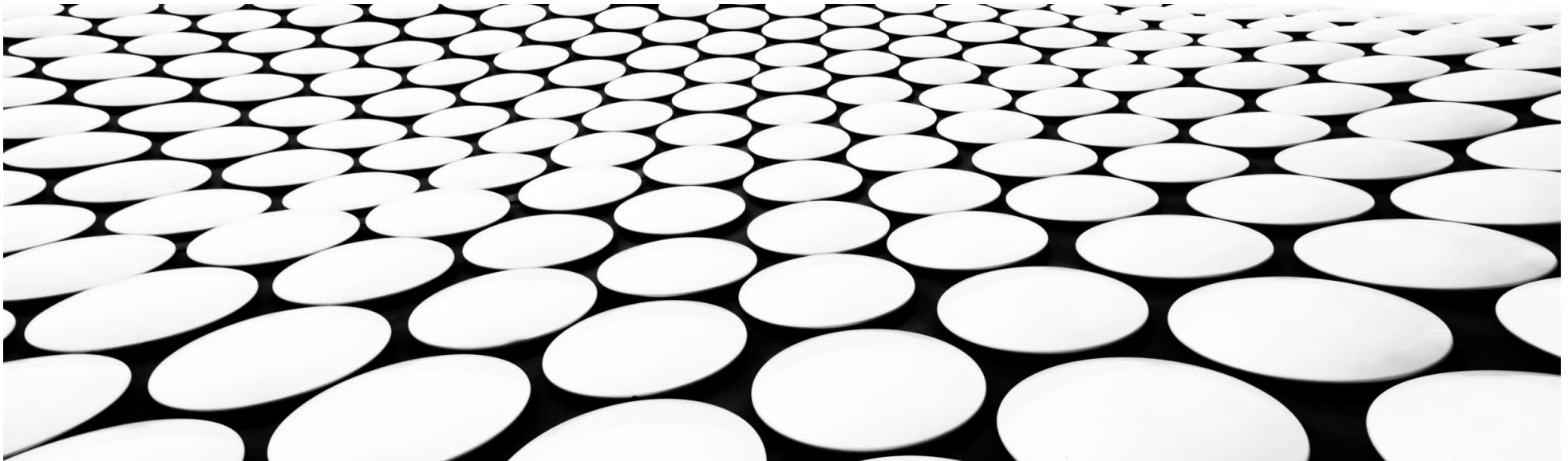


Contents

Week 1: Insights from data	2
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DERIVING INSIGHTS FROM DATA

Input/Output in Data Science





DERIVING INSIGHTS FROM DATA

- Types of insights
- Types of data

Back to Data Science Definition(s)



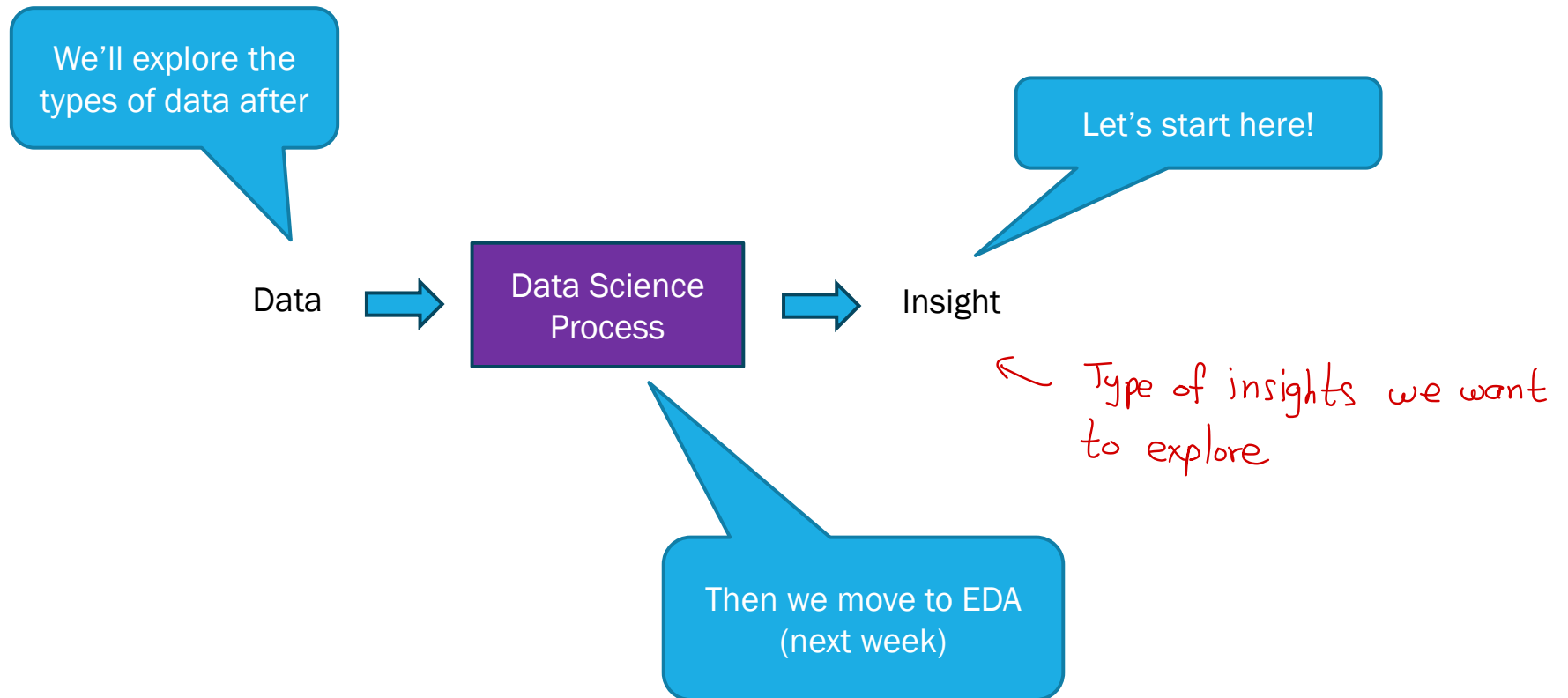
Data science is an interdisciplinary academic field that uses statistics, scientific computing, scientific methods, processing, scientific visualization, algorithms and systems to extract or extrapolate knowledge and **insights** from potentially noisy, structured, or unstructured **data**.

Data science combines math and statistics, specialized programming, advanced analytics, artificial intelligence (AI) and machine learning with specific subject matter expertise to uncover actionable **insights** hidden in an organization's **data**. These insights can be used to guide decision making and strategic planning.



Data science is the study of **data** to extract meaningful **insights** for business. It is a multidisciplinary approach that combines principles and practices from the fields of mathematics, statistics, artificial intelligence, and computer engineering to analyze large amounts of data. This analysis helps data scientists to ask and answer questions like what happened, why it happened, what will happen, and what can be done with the results.

Common: data as input, insights as output



Insights

8 Types of Data Analytics to Improve Decision-Making



Data analytics helps businesses learn from the past, optimize existing resources, and plan for the future. Find 8 ways to leverage data analysis here.

[Contents](#)

Jan 4, 2024 · 8 min read

The Four Main Types of Data Analytics For Decision-Making

Descriptive



What happened? *storytelling*

Diagnostic



Why did something happen?

Predictive



Based on what we know now, what will happen in the future?

Prescriptive



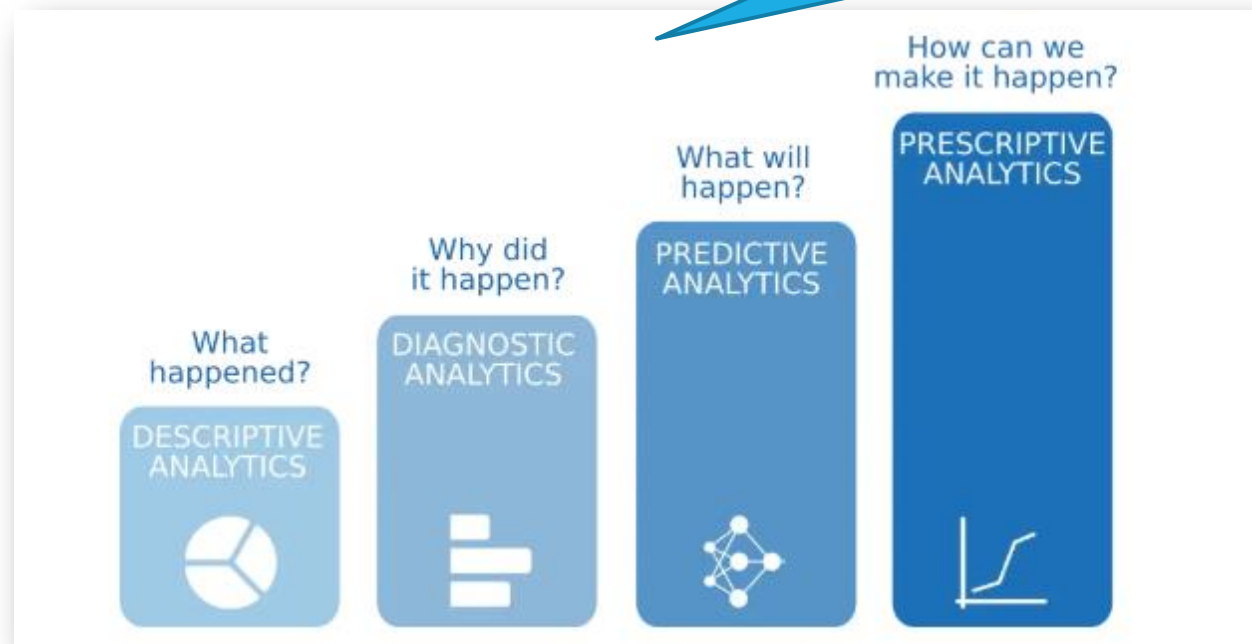
Should we implement some rules or regulation or provide advice based on what we know?
modify future

What is advanced analytics?

Tutorials

@ Pablo Martín August 31, 2023

Many sources (as this one) show these 4 types of analytics



Descriptive

Diagnostic

Predictive

Prescriptive

Descriptive analytics serves as the foundational layer of data analysis. This type of analysis involves examining historical data to gain an understanding of past events. This type of analysis answers the question, “What happened?” in order to plan for the future. Descriptive analytics helps to summarize and visualize data trends, providing the context needed to assess the current state of affairs and identify potential areas of concern or opportunity.

The table below illustrates these parameters for the total amount of money spent by a customer in an online store.

	Minimum	Maximum	Mean	Standard deviation
Total amount (USD)	12	500	51	56

Descriptive
Statistics

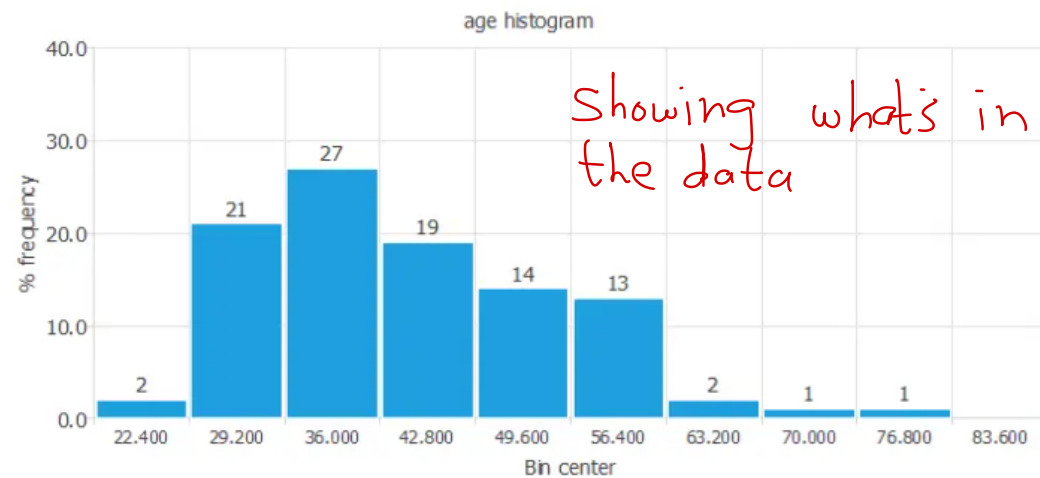
What
happened?

DESCRIPTIVE
ANALYTICS



Example in sales

For example, the following figure depicts a histogram for the age of our customers.



Showing what's in
the data

Histogram
visualization

Descriptive

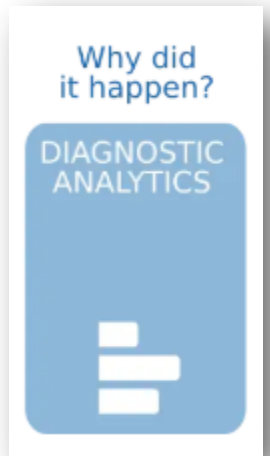
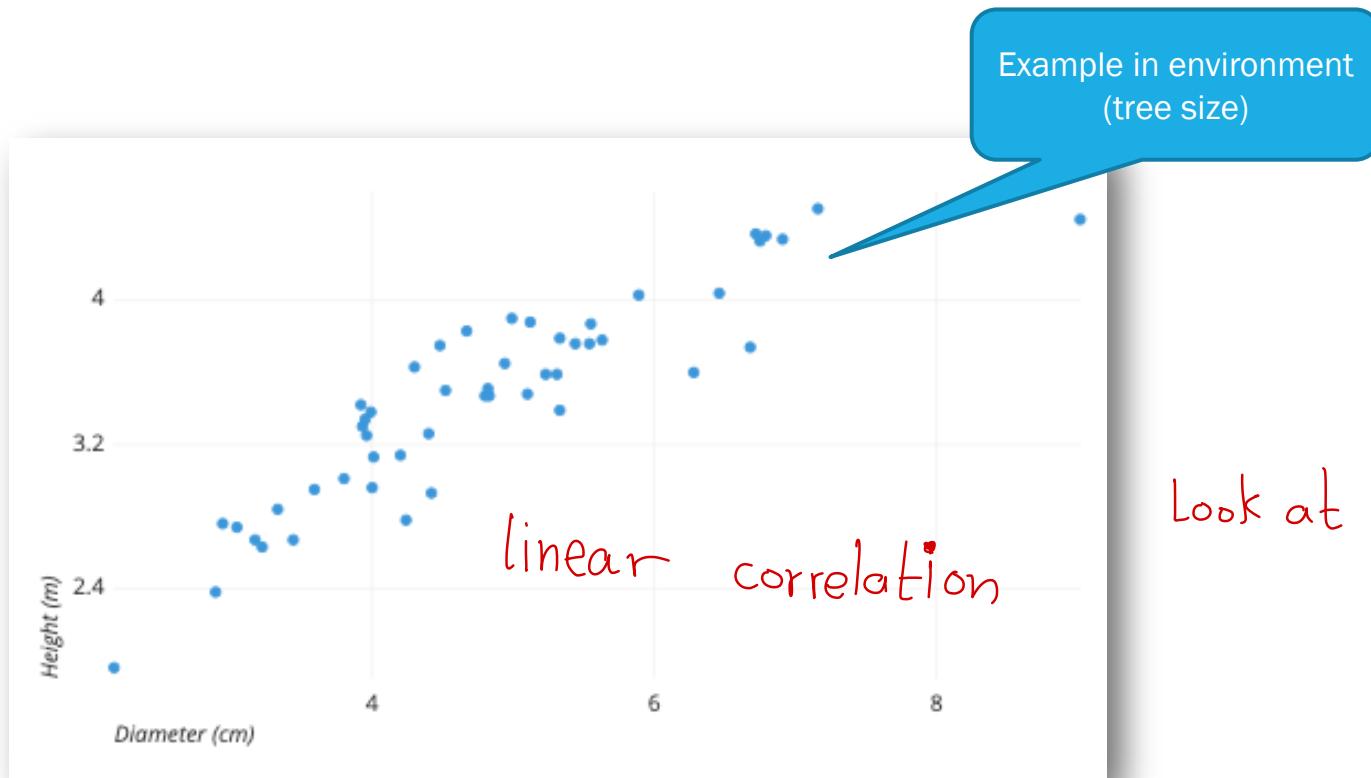
Diagnostic

Predictive

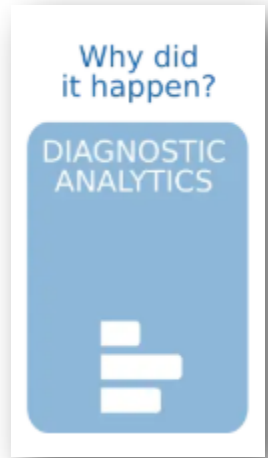
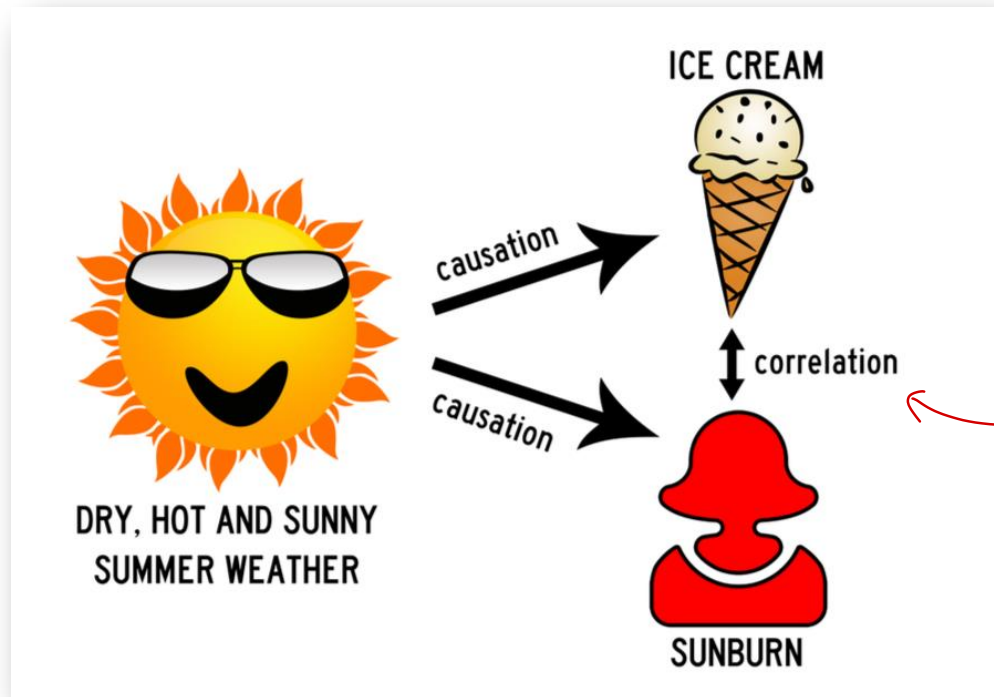
Prescriptive

While descriptive analytics looks at the past, diagnostic analytics digs deeper into why specific events or trends occurred, seeking to uncover the root causes of particular outcomes or issues.

Tricky sometimes



Look at correlation



Don't cause each other

Correlation \neq Causality

Descriptive

Diagnostic

Predictive

Prescriptive

Predictive analytics takes data analysis a step further by forecasting future events or trends, leveraging historical data to build models that can make predictions about what is likely to happen. This type of analysis is an essential tool for proactive decision-making — while no one can see into the future, predictive analytics comes close.

Logistic Regression

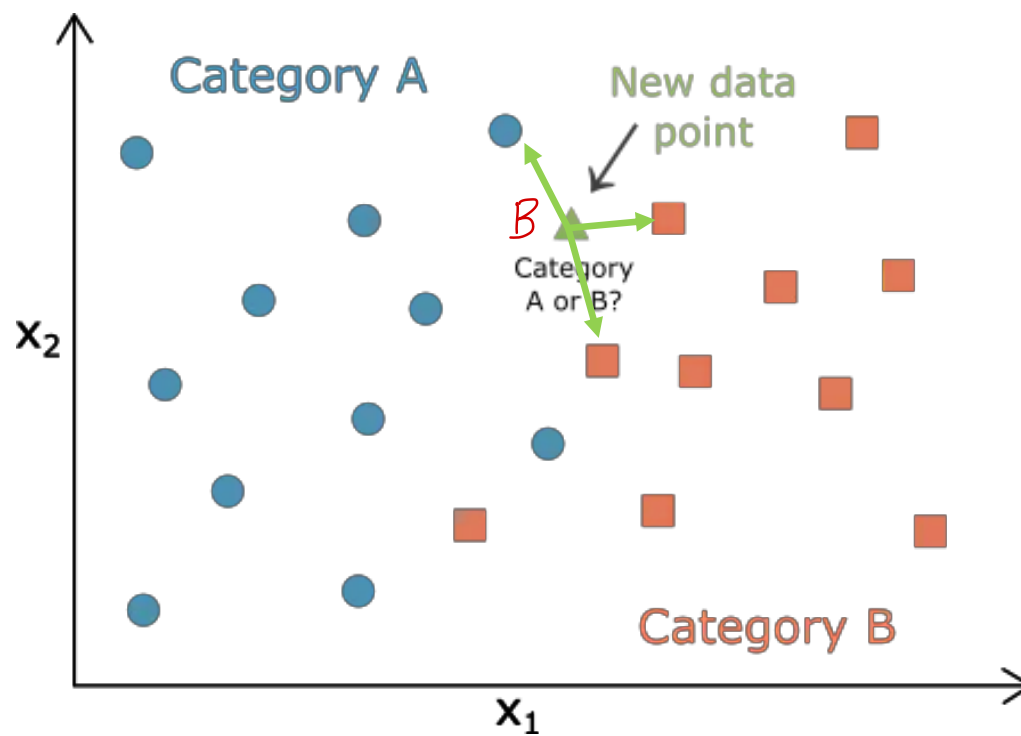


What will happen?

PREDICTIVE ANALYTICS



K – Nearest neighbors



What will happen?

PREDICTIVE ANALYTICS



Descriptive
Diagnostic
Predictive
Prescriptive

Prescriptive analytics goes beyond predicting future events and offers recommendations for actions that will achieve specific outcomes. This type of analytics is highly valuable in improving operational efficiency.



Harvard
Business
School
Online

6 EXAMPLES OF PRESCRIPTIVE ANALYTICS IN ACTION

4. Banking: Fraud Detection

Another algorithmic use of prescriptive analytics is the detection and flagging of bank fraud. With the sheer volume of data stored in a bank's system, it would be nearly impossible for a person to manually detect any suspicious activity in a single account. An algorithm—trained using customers' historical transaction data—analyzes and scans new transactional data for anomalies. For instance, perhaps you typically spend \$3,000 per month, but this month, there's a \$30,000 charge on your credit card.

The algorithm analyzes patterns in your transactional data, alerts the bank, and provides a recommended course of action. In this example, the course of action may be to cancel the credit card, as it could have been stolen.

How can we
make it happen?

PRESCRIPTIVE
ANALYTICS



[Source](#)



To help you learn... ask for examples.



ChatGPT



To help you learn the terms... explicitly type the different insights to remember them.

Knowing that data science insights are either descriptive,
diagnostic, predictive or prescriptive, please provide
some examples of those types of insights.



It's not an oracle.. It can
make mistakes.

1. Descriptive Insights

Definition: These insights summarize past data to understand what happened.

- **Example (Environmental):** "The average air quality index (AQI) in the city has improved by 15% over the last decade due to increased green spaces."
- **Example (Medical):** "The hospital's patient admission rate increased by 20% during flu season compared to the annual average."
- **Example (Business):** "Sales increased by 10% during the holiday season compared to the previous quarter."

2. Diagnostic Insights

Definition: These insights analyze historical data to determine why something happened.

- **Example (Environmental):** "The spike in carbon dioxide levels last quarter was due to a 25% increase in industrial activity."
- **Example (Medical):** "The high readmission rate for patients was linked to incomplete post-discharge instructions provided by nursing staff."
- **Example (Business):** "Customer churn increased because of a delay in shipping during the promotional period."

3. Predictive Insights

Definition: These insights use historical data and machine learning models to predict what might happen in the future.

- **Example (Environmental):** "The model predicts a 30% probability of severe drought next summer based on current rainfall patterns."
- **Example (Medical):** "Patients with high cholesterol and low activity levels have a 70% increased risk of heart disease within the next five years."
- **Example (Business):** "Based on sales trends, revenue is expected to increase by 15% in the next quarter."

4. Prescriptive Insights

Definition: These insights recommend actions based on predictive and diagnostic analyses to achieve desired outcomes.

- **Example (Environmental):** "To reduce air pollution by 20%, prioritize policies that limit industrial emissions and increase public transportation usage."
- **Example (Medical):** "Patients with diabetes should have quarterly check-ups and follow a specific diet plan to reduce the likelihood of complications."
- **Example (Business):** "To increase customer retention, offer a loyalty program and improve response times for customer support inquiries."

Beyond our role
as data scientists



Looking at many examples can be overwhelming... let's fix one variable.

Domain

Environment
Medical
Business
... other domains

Type of insight

Descriptive

Diagnostic

Predictive

Prescriptive

Can you give one example each of descriptive, diagnostic, predictive and prescriptive for the health domain.



What happened?

- "Over the past year, 25% of patients visiting the clinic reported symptoms of anxiety or depression, with the highest prevalence among individuals aged 18–35."

Why did it happen?

- "The increase in anxiety and depression cases among young adults correlates with higher screen time and reduced physical activity during the pandemic."

What might happen?

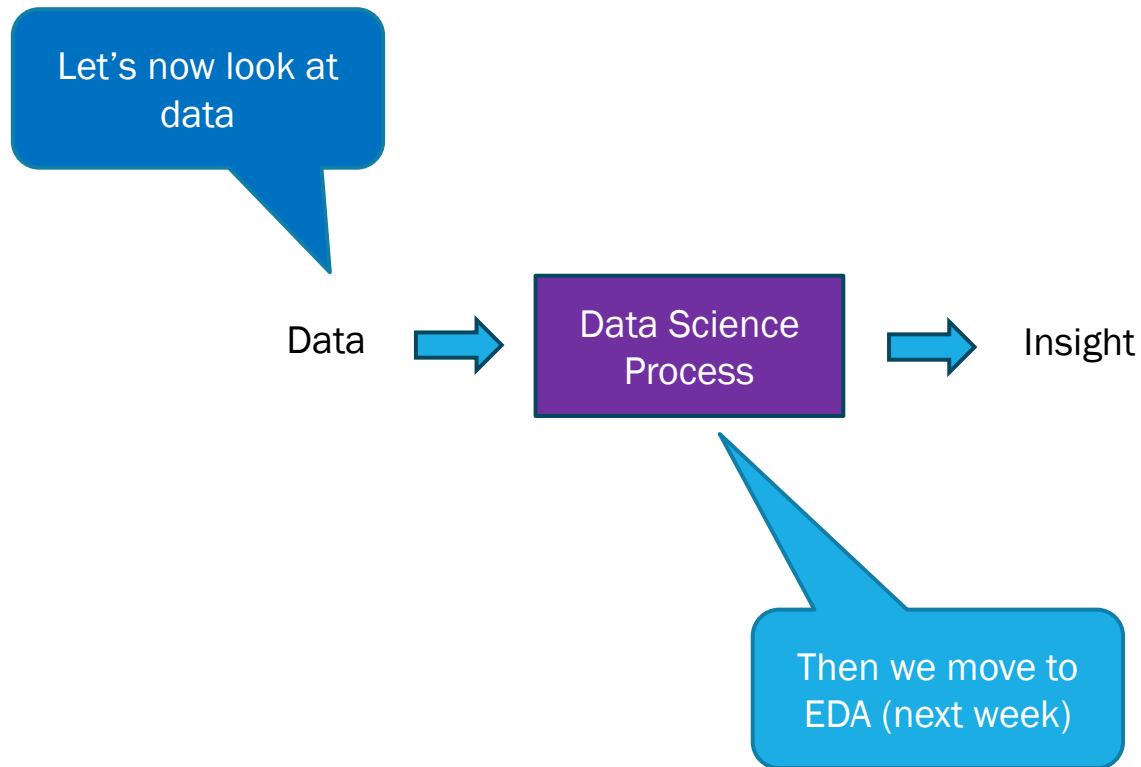
- "Patients with elevated blood pressure and a BMI over 30 have a 40% higher likelihood of developing Type 2 diabetes within the next five years."

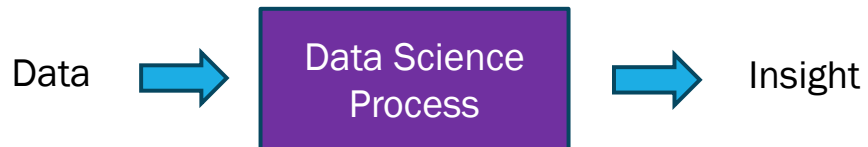
What should be done?

- "To reduce the risk of diabetes in at-risk patients, implement a lifestyle intervention program that includes weekly nutrition counseling and exercise sessions."



Data

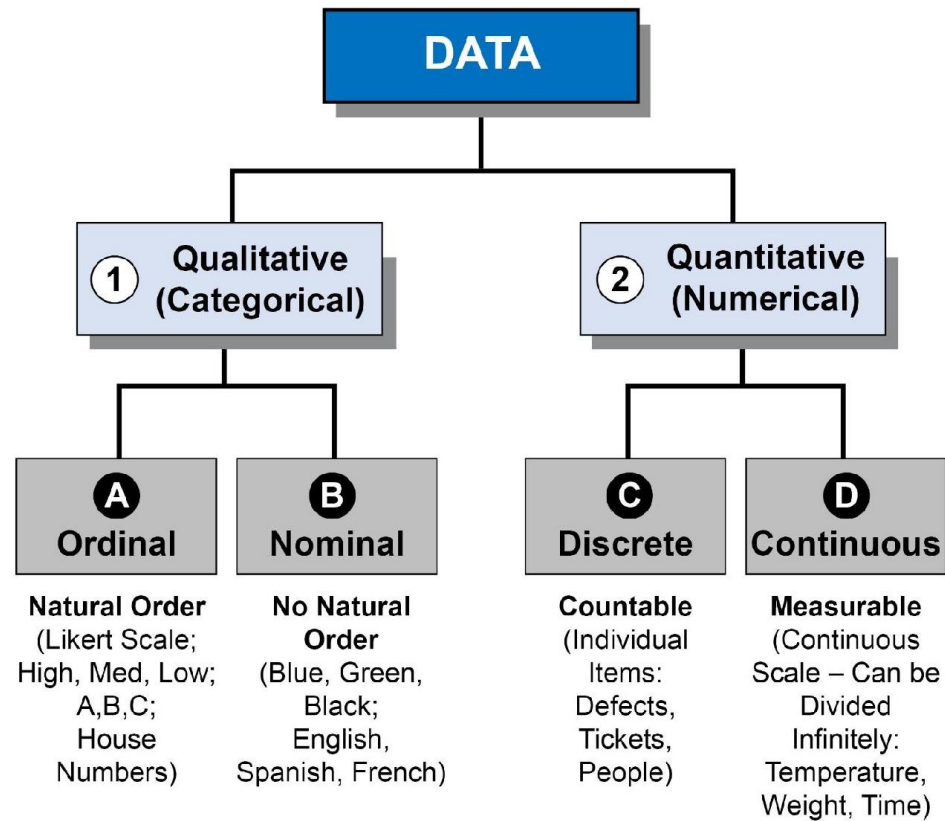


**Dataset
schema**

Column	Unit/Description
Patient ID	Unique identifier (alphanumeric)
Age	Years
Gender	Male/Female
Length of Stay	Days
Number of Diagnoses	Count
Primary Diagnosis	ICD Code
Comorbidities	Count of co-existing conditions
Treatment Type	Categorical (e.g., surgery, medication)
Readmission Within 30d	Yes/No

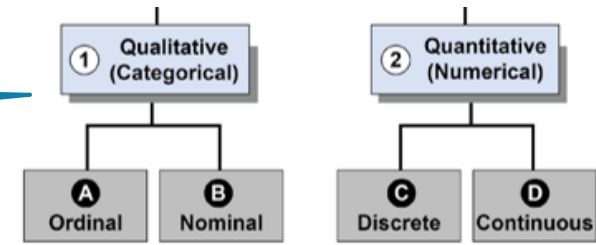
How can we predict the likelihood of hospital readmissions within 30 days based on patient demographics, medical history, and treatment details?

Can we characterize the data? We will not be able to perform the same analysis on the different kinds of data...



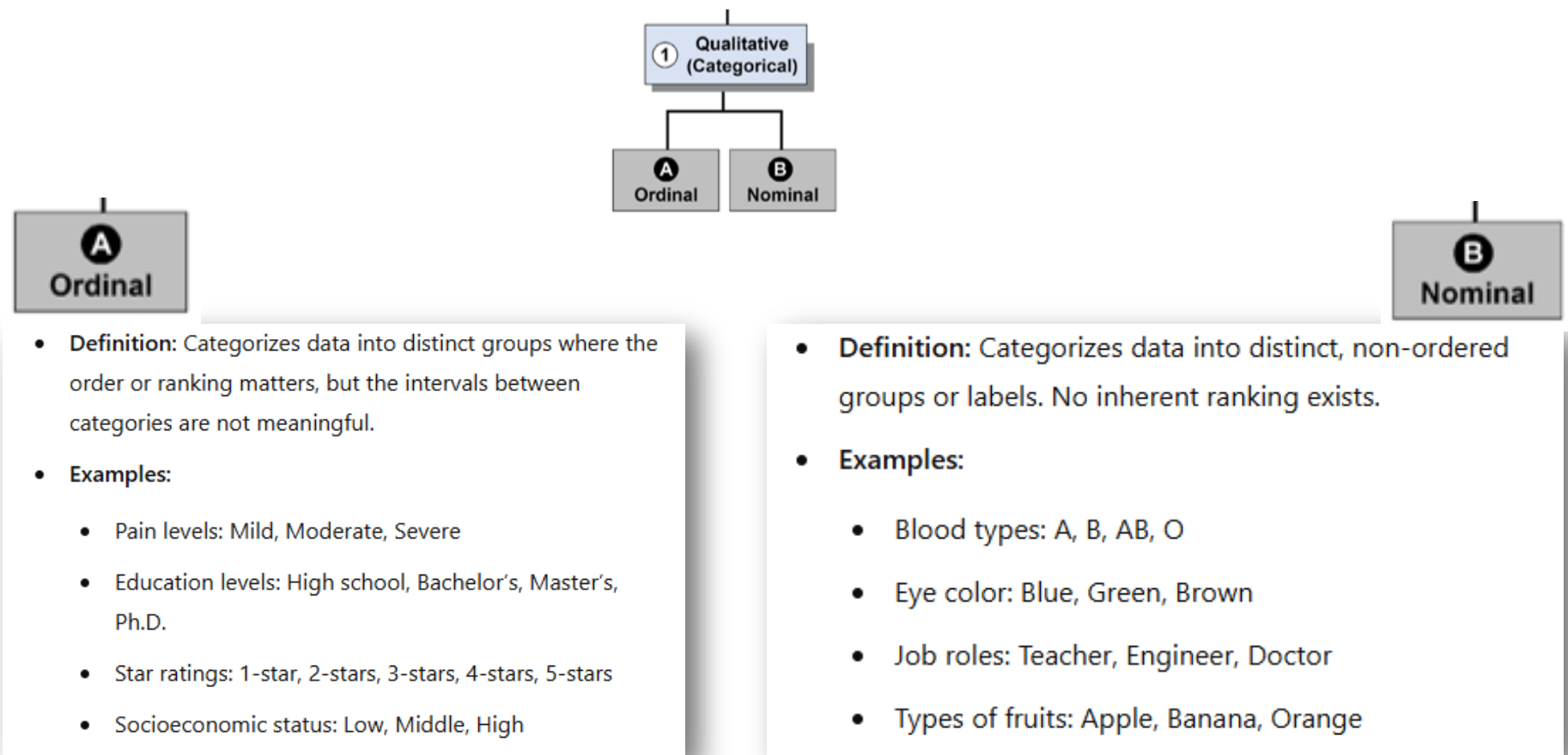
Dataset
schema

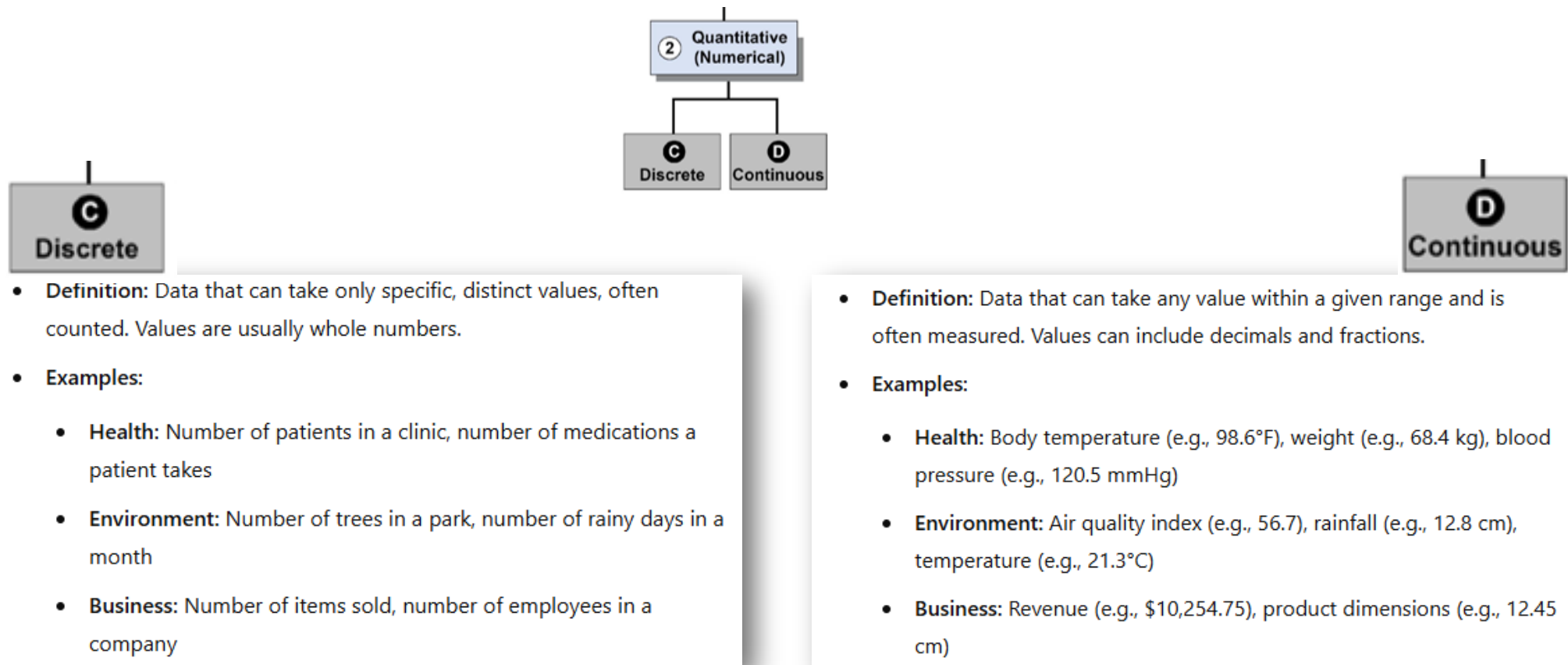
For each row, decide on type:



This is a good place to ask ChatGPT for additional examples!

Column	Unit/Description
Patient ID	Unique identifier (alphanumeric)
Age	Years
Gender	Male/Female
Length of Stay	Days
Number of Diagnoses	Count
Primary Diagnosis	ICD Code
Comorbidities	Count of co-existing conditions
Treatment Type	Categorical (e.g., surgery, medication)
Readmission Within 30d	Yes/No





Different Types of Data



Khushee Kapoor · Follow

5 min read · Aug 28, 2021

There are many other characterizations

Measurement

Quantitative (Numerical)
Qualitative (Categorical)

Format

Structured
Unstructured
Semi-Structured

Volume

Big Data
Small Data

Collection

Primary Data
Secondary Data

Source

Internal Data
External Data

Time

Historical Data
Real-Time Data

Measurement	Format	Volume
Quantitative (Numerical) Qualitative (Categorical)	Structured Unstructured Semi-Structured	Big Data Small Data
Collection	Source	Time
Primary Data Secondary Data	Internal Data External Data	Historical Data Real-Time Data

Data



Data Science
Process



Insight

Insight: Predicting the Impact of Air Quality on Health Outcomes in
Urban Areas

Let's explore these dimensions
further + ask ChatGPT for examples in
support to the provided insight

Predictive analysis

Measurement

Quantitative (Numerical)
Qualitative (Categorical)

Numerical

Data Type	Example
Air Quality	PM2.5 = 45 $\mu\text{g}/\text{m}^3$, NO2 = 25 ppb, O ₃ = 50 $\mu\text{g}/\text{m}^3$
Health Data	Asthma attacks = 15/month, Admissions = 100/week, Mortality rate = 120/1,000,000 people annually
Weather Data	Temperature = 25°C, Wind Speed = 15 km/h, Humidity = 75%

Categorical

Data Type	Example
Pollution Source	Traffic-related: "Highways", "Residential Areas", "Industrial Zones"
Health Conditions	Asthma, Cardiovascular Disease, COPD
Location	Neighborhood: "Downtown", "Suburban", "Industrial Park"

Format

Structured
Unstructured
Semi-Structured

Unstructured Data

Text, Images

The university has 5600 students. Shaun (ID Number: 160801), 18 years old Communication study. Linh with ID number 160802, majoring in Accounting and is 20 years old. Ahmed from Psychology study program, 19 years old, ID number 160803.

Semi-Structured Data

JSON, APIs

```
<University>
  <ID Number="160801">
    <Name="Shaun">
      <Age="18">
        <Program="Communication">
          <ID Number="160802">
            <Name="Linh">
              <Age="20">
                <Program="Accounting">
                  ..... </University>
```

Structured Data

Tabular

ID	Name	Age	Program
160801	Shaun	18	Communication
160802	Linh	20	Accounting
160803	Ahmed	19	Psychology

GLEEMATIC A.I.

GLEEMATIC A.I.

[Source](#)

Format

Structured
Unstructured
Semi-Structured

Structured

Date	PM2.5 ($\mu\text{g}/\text{m}^3$)	NO2 (ppb)	O ₃ ($\mu\text{g}/\text{m}^3$)	Location	Asthma Admissions (per week)	Mortality Rate (per 1,000,000)
2025-01-01	40	30	55	Downtown	100	120
2025-01-02	25	22	40	Suburban	80	110
2025-01-03	50	35	60	Industrial	150	140
2025-01-04	45	30	55	Downtown	130	130

Format

Structured
Unstructured
Semi-Structured

Unstructured

Social Media/News Posts (Text Data):

- "The air quality in Downtown today is terrible! PM2.5 levels above 50 $\mu\text{g}/\text{m}^3$. Breathing difficulties reported."
- "Suburban areas report lower PM2.5 levels today, but still above safe levels."
- "Traffic pollution in industrial zones contributes to worsening respiratory health."
- "More cases of asthma reported in areas with high Ozone levels above 60 $\mu\text{g}/\text{m}^3$."

Medical Notes (Text Data):

- "Patient presents with shortness of breath, worsening asthma symptoms. High PM2.5 levels in the area."
- "COPD patient diagnosed with severe air pollution exposure, advised to stay indoors."
- "Asthma exacerbation due to high NO2 levels and traffic-related pollution exposure."

Format

Structured
Unstructured
Semi-Structured

XML (Weather Data):

```
xml

<weather>
  <entry>
    <timestamp>2025-01-01T12:00:00</timestamp>
    <temperature unit="Celsius">25</temperature>
    <humidity unit="percent">75</humidity>
    <windspeed unit="km/h">15</windspeed>
  </entry>
  <entry>
    <timestamp>2025-01-02T12:00:00</timestamp>
    <temperature unit="Celsius">22</temperature>
    <humidity unit="percent">70</humidity>
    <windspeed unit="km/h">20</windspeed>
  </entry>
</weather>
```

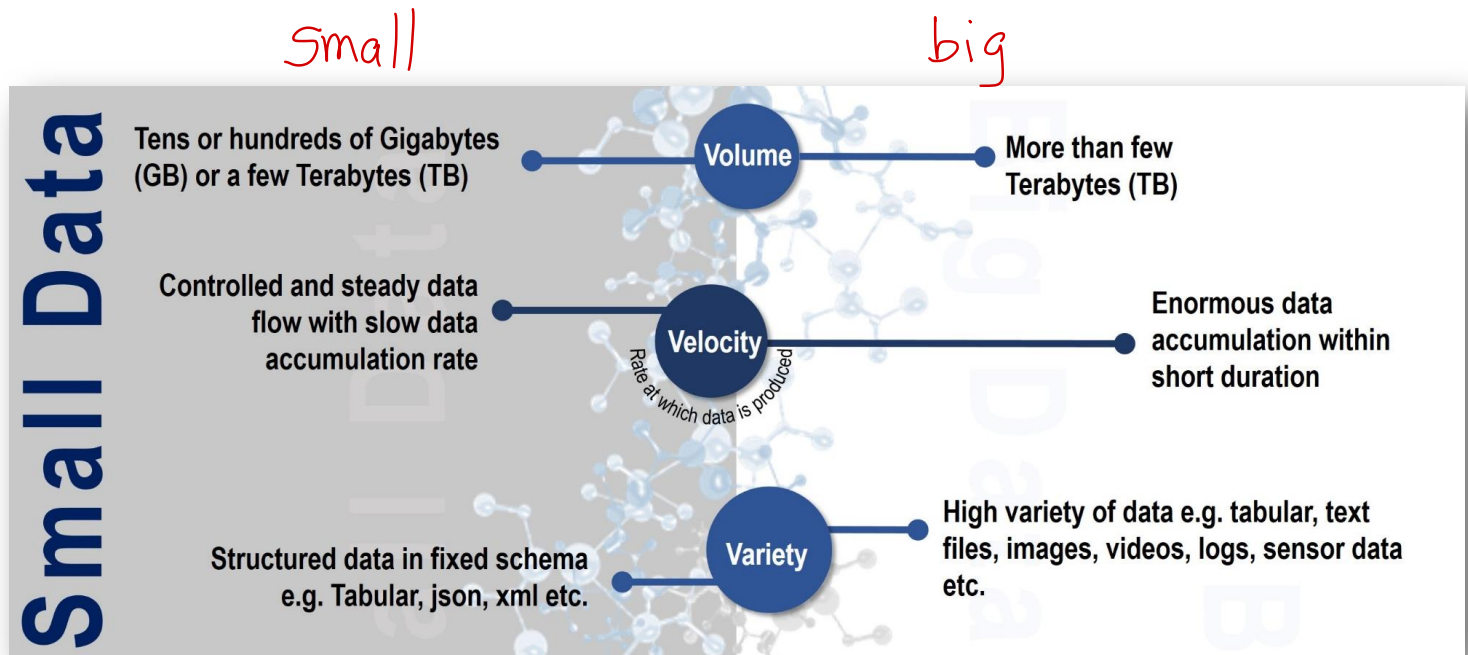
JSON (Air Quality Sensor Data):

Semi-structured

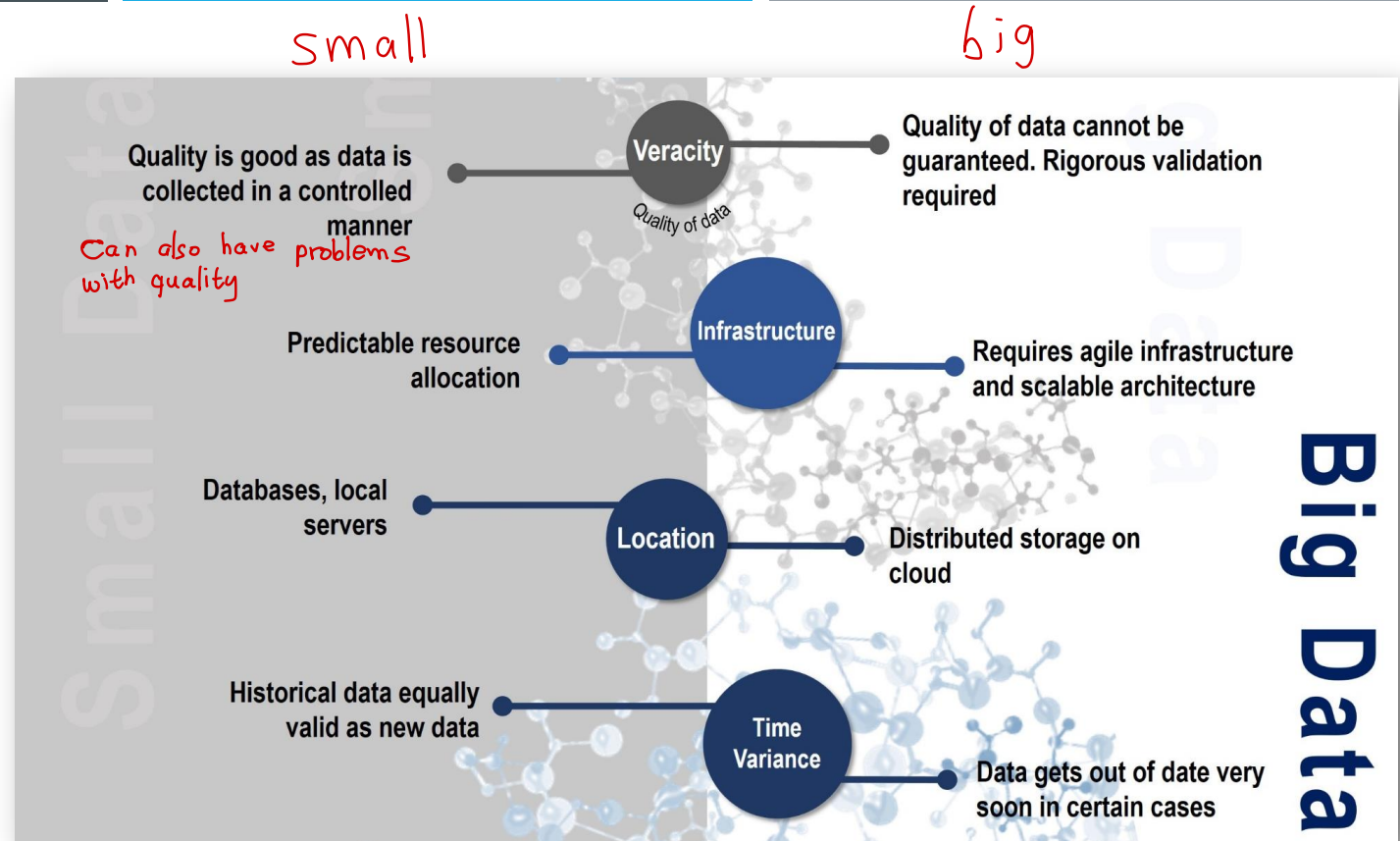
```
json

[
  {
    "timestamp": "2025-01-01T12:00:00",
    "PM2.5": 45,
    "NO2": 30,
    "O3": 55,
    "location": "Downtown"
  },
  {
    "timestamp": "2025-01-02T12:00:00",
    "PM2.5": 40,
    "NO2": 28,
    "O3": 50,
    "location": "Suburban"
  }
]
```


Volume

Big Data
Small Data
[Source](#)

Volume
Big Data Small Data



Volume

Big Data
Small Data

Big data

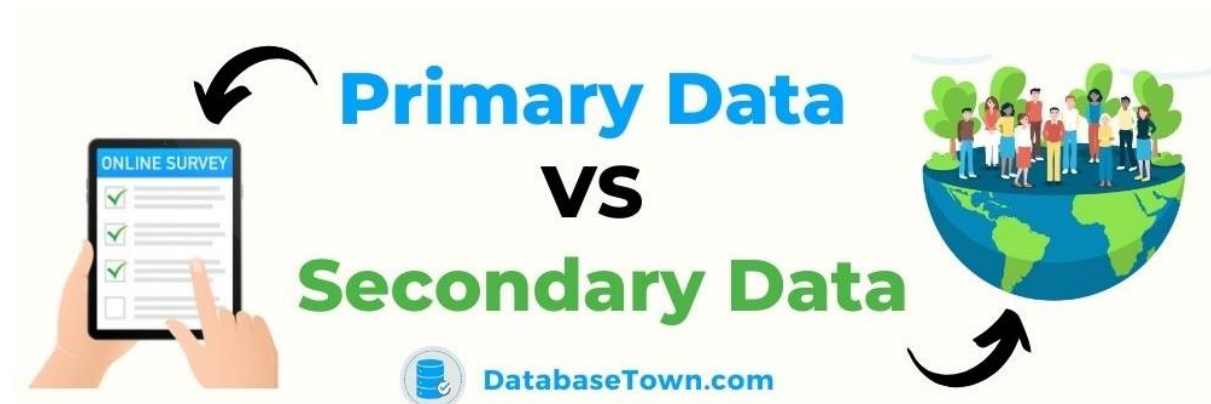
Data Type	Example
Real-time Air Quality	Continuous data streams from 500 sensors across a city, reporting every minute (e.g., 500 sensors \times 1440 minutes per day \times 365 days/year)
Health Data	Health records from 1 million patients with diagnoses, prescriptions, and hospital visits across 10 years

Small data

Data Type	Example
Local Health Study	Data from 200 patients detailing asthma symptoms, medications, and air quality exposure in a specific neighborhood
Pollution Monitoring	Data from a single sensor over the course of 6 months: { Date: 2025-01-01, PM2.5: 40 $\mu\text{g}/\text{m}^3$, NO2: 25 ppb }

Collection

Primary Data
Secondary Data



Primary Data

Secondary Data

Source	Collected firsthand by researcher	Collected by others
Purpose	Specific to current research	May have different original purpose
Time	Takes longer to collect	Quickly available

collected within
company

collected elsewhere

Collection

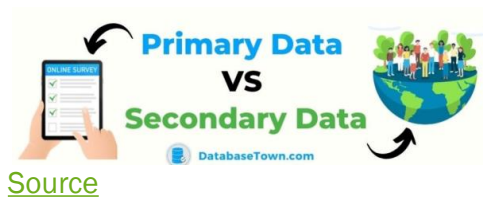
Primary Data
Secondary Data

These are the characteristics of primary data:

- Primary data is collected directly by the researcher,
- It is specific to the research question,
- Up-to-date and current,
- It can be time-consuming and expensive to collect, and
- It gives the researcher full control over the data collection process.

Methods of Collecting Primary Data:

1. Surveys and questionnaires
2. Interviews (face-to-face, phone, or online)
3. Focus groups
4. Observations
5. Experiments
6. Field research



Collection

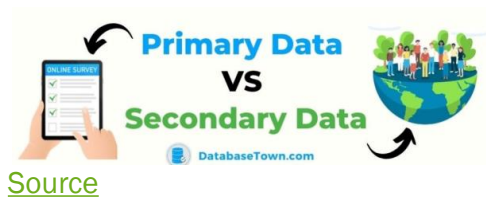
Primary Data
Secondary Data

Key Characteristics of Secondary Data:

- Collected by others for different purposes
- Already existing and readily available
- Often less expensive and faster to obtain
- May not perfectly fit the current research needs
- Researcher has no control over data collection methods

Sources of Secondary Data:

1. Government publications
2. Academic journals and books
3. Census data
4. Company records
5. Industry reports
6. Previous research studies
7. Online databases



Collection

Primary Data
Secondary Data

Primary

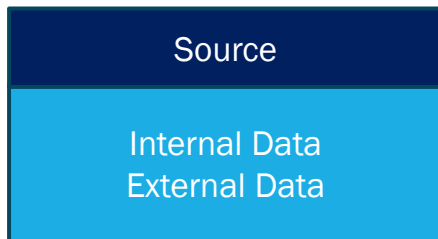
Primary data comes directly from observations or experiments:

Date	PM2.5 ($\mu\text{g}/\text{m}^3$)	NO2 (ppb)	O ₃ ($\mu\text{g}/\text{m}^3$)	Location	Symptoms
2025-01-01	40	30	55	Downtown	Wheezing
2025-01-02	35	25	50	Suburban	Shortness of Breath
2025-01-03	60	40	70	Industrial	Chest Pain

Secondary

Secondary data comes from external sources or previous research:

Study Title	Source	PM2.5 Threshold ($\mu\text{g}/\text{m}^3$)	Health Outcome
"Air Pollution and Respiratory Health"	WHO	35	Increased asthma attacks
"Traffic Pollution and Cardiovascular Disease"	CDC	40	Heart disease correlation



Internal data



User's data

logs, messages, mails



Internal documents

invoices, contracts, notes



IoT Devices

cameras, sensors



Logs

website / platform logs

External data

Web

e-commerce, real estate



Geo

maps, localization, GPS



Files

invoices, documents, sheets



3rd parties

weather, credit card, telco



Internal and External Data: What's the Difference and Why It Matters



Sebastian Berg
CEO, Co-founder

Product March 15, 2023

[Source](#)

Source
Internal Data External Data

The Importance of Internal Data

Internal data is essential because it provides companies with insights into their operations. This data can help companies understand their performance and make informed decisions based on the analysis of their data. It also allows companies to identify areas for improvement and make necessary changes to their operations.

Internal data is also valuable because it is unique to the company. Since internal data is generated within the company, it is specific to the company's operations and can provide a competitive advantage. For example, a company can use its internal sales data to analyze trends and forecast future sales.

Internal and External Data: What's the Difference and Why It Matters



Sebastian Berg
CEO, Co-founder

Product March 15, 2023

[Source](#)

Source
Internal Data External Data

The Value of External Data

External data is important because it provides companies with a broader perspective on the market and industry. It can help companies understand industry trends, benchmark their performance against competitors, and identify new opportunities.

By using external data, companies can gain insights into the behavior and preferences of their target audience. For example, a company can use social media data to analyze how consumers are talking about its brand and products.

External data can also help companies mitigate risks. By analyzing external data such as economic indicators, companies can identify potential risks to their operations, such as changes in the market or regulatory environment.

Internal and External Data: What's the Difference and Why It Matters



Sebastian Berg
CEO, Co-founder

Product March 15, 2023

[Source](#)

Source

Internal Data
External Data

Internal

Internal data refers to data generated within an organization:

Hospital ID	Patient ID	Disease	Admission Type	Air Quality Exposure	Symptoms
HOSP001	123	Asthma	Emergency	High	Wheezing
HOSP002	456	COPD	Scheduled	Low	Shortness of Breath
HOSP003	789	Asthma	Emergency	High	Coughing

External

External data comes from outside sources:

Data Source	PM2.5 ($\mu\text{g}/\text{m}^3$)	NO2 (ppb)	O ₃ ($\mu\text{g}/\text{m}^3$)	Location	Date
EPA	35	30	60	Downtown	2025-01-01
WHO	40	32	58	Suburban	2025-01-01

Time

Historical Data
Real-Time Data

The Essential Fusion: Real-Time and Historical Data

Historical data provides a rich backdrop of information, highlighting long-term trends, patterns and outcomes. Real-time, domain-specific data feeds ensure that ML algorithms are working with the most current information. Integrating real-time data into ML models helps make the predictive insights contextualized and hyper-personalized to the end user in the moment, providing valuable information to **inform strategic decisions**.

AI / DATA

Integrating Real-Time and Historical Data Enhances Decision-Making

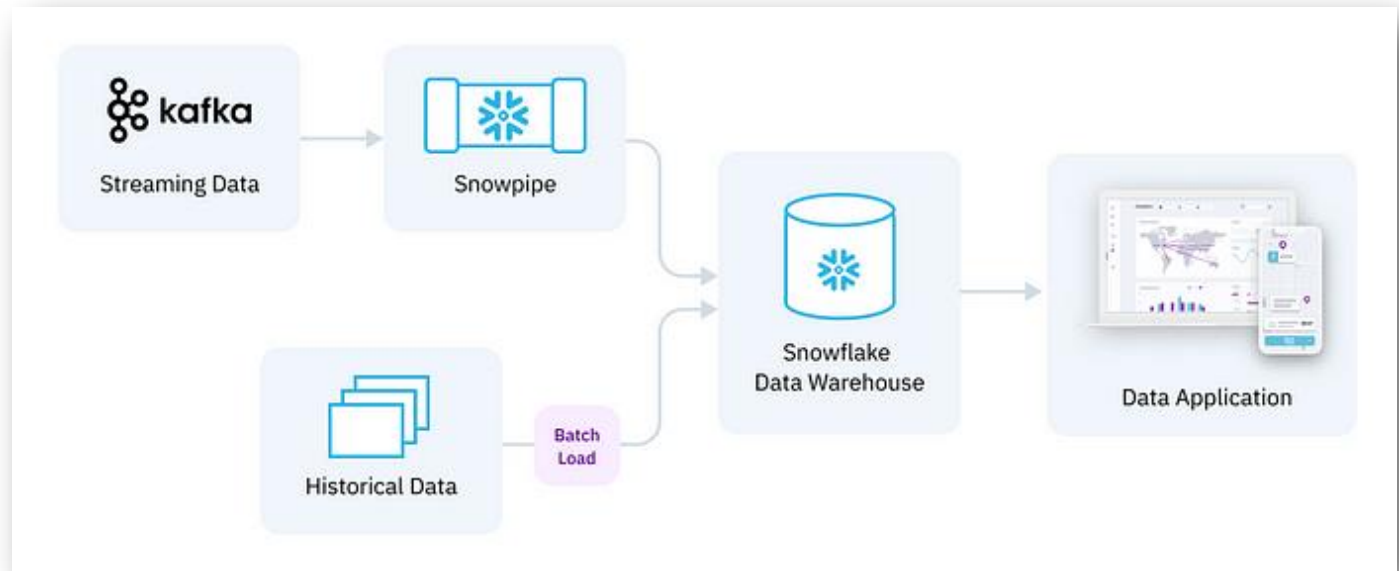
The accuracy and relevance of machine learning-driven predictions depend significantly on the quality and timeliness of the data fed into the models.

Apr 18th, 2024 6:34am by [Rahul Pradhan](#)

[Source](#)

Time

Historical Data
Real-Time Data



Joining Streaming and Historical Data for Real-Time Analytics: Your Options With Snowflake, Snowpipe and Rockset

[Source](#)

Time

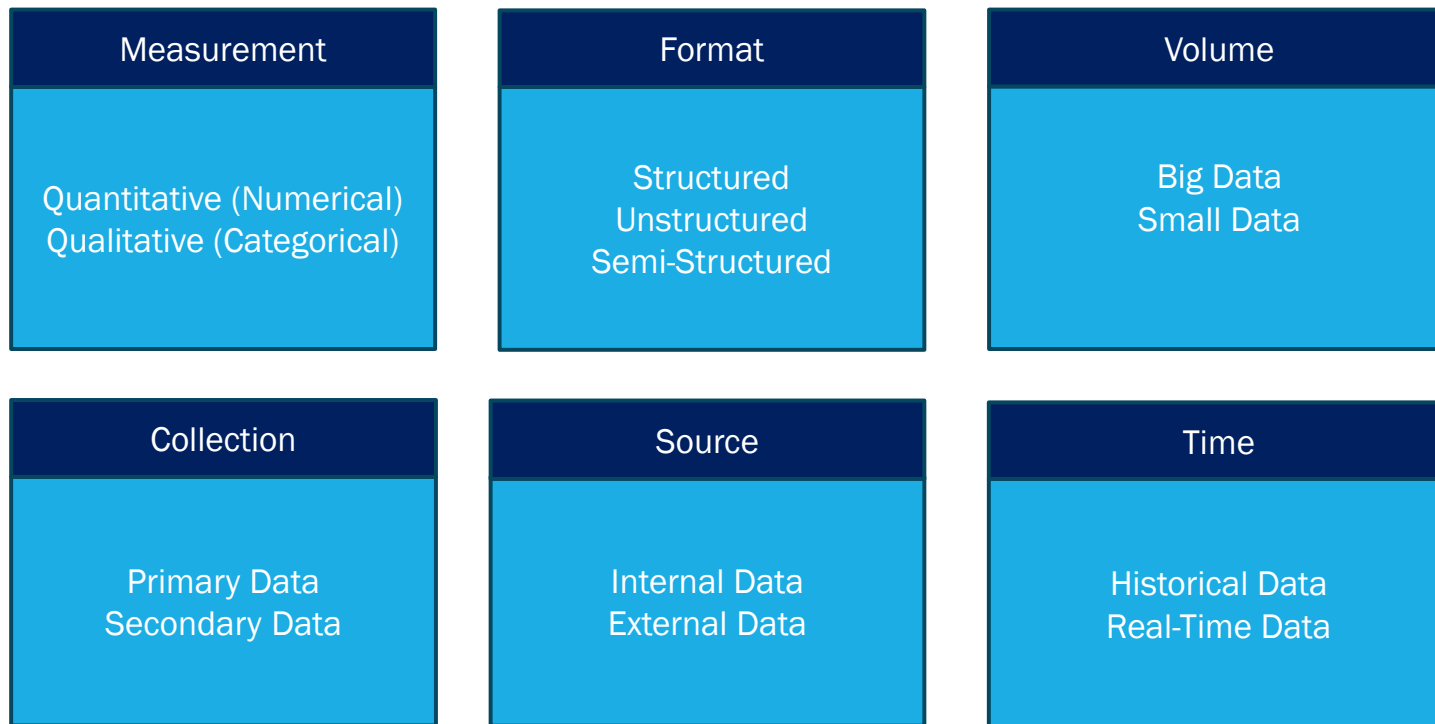
Historical Data
Real-Time Data

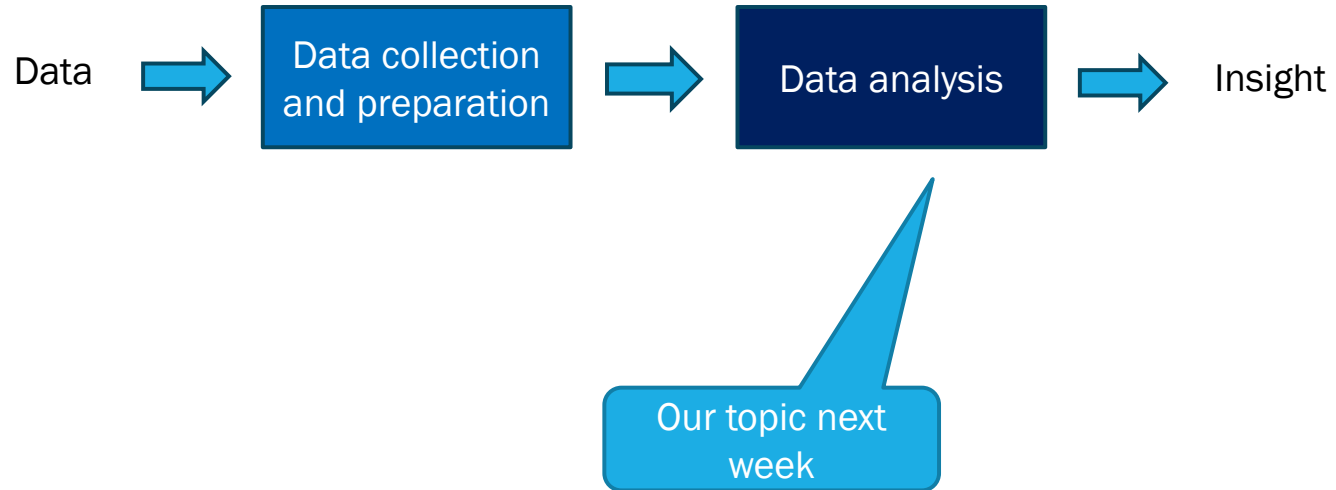
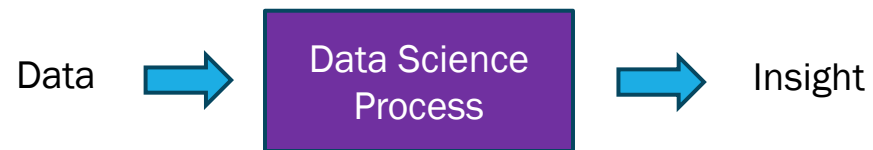
Historical

Data Type	Example
Long-term Air Quality	"PM2.5 levels for the past 10 years in Downtown: 2015 = 40 $\mu\text{g}/\text{m}^3$, 2016 = 45 $\mu\text{g}/\text{m}^3$, ..., 2025 = 30 $\mu\text{g}/\text{m}^3$ "
Health Statistics	"Asthma incidence in the East Coast from 2010-2020: 2010 = 0.05%, 2015 = 0.07%, 2020 = 0.10%"

Real-time

Data Type	Example
Pollution Sensors	Real-time data streamed from multiple sensors across a city: { "timestamp": "2025-01-01T12:00:00", "PM2.5": 42 $\mu\text{g}/\text{m}^3$, "NO2": 30 ppb }
Wearable Health Data	Data from a fitness tracker: "Patient ID: 123, Heart Rate: 75 bpm, Symptoms: Shortness of breath, PM2.5 exposure: High"







DERIVING INSIGHTS FROM DATA

- Types of insights
- Types of data