Project 8 : SQL + ML Integration

Objective:
Combine **SQL querying power** with **Machine Learning models** to analyze attrition risk.
This project demonstrates how HR teams can query their employee database directly and run pr
on-the-fly, bridging People Analytics with HRIS-like systems.

Why It Matters:

- HR data often lives in databases (HRIS, payroll systems).
- Analysts should be able to run queries and pipe results into ML models.
- This integration makes predictive attrition analytics more practical in enterprise contexts.

✅ SQL + ML Integration

This project demonstrated how SQL queries can be seamlessly combined with Machine Learnin
to run real-time attrition predictions.

Key Takeaways:

- **Database Integration:** HR data stored in SQL (SQLite) was queried directly inside Python.
- **Leakage Prevention:** Attrition labels were properly excluded from inference data.
- **Predictions:** Logistic/XGBoost models predicted attrition risk per employee.
- **Visuals:**
  - Donut Chart → At Risk vs Safe employees.
  - Department-level bar chart → attrition distribution across functions.
  - Probability distribution → highlights prediction spread & threshold sensitivity.
- **Threshold Optimization:** Added adaptive cutoffs to balance risk prediction and reduce fals

Artifacts Produced:

- `hr_dataset.db` → SQLite database with IBM HR data (table = employees).
- SQL utility module → `sql_utils.py` for safe querying & reusable functions.
- Visual charts (saved in `/charts/`):
  - `donut_chart.png`
  - `department_attrition.png`
  - `probability_distribution.png`
- Notebook → with integrated SQL + ML pipeline.

Business Value:

- HR leaders can **query directly** for attrition insights without touching Python code.
- Predictive analytics embedded into HRIS-like SQL workflows.
- Foundation for **real dashboards** (Streamlit / BI tools) where HR managers can pull SQL → predictions → export reports.

```
✅ Created C:\Users\amlanmishra2\data\hr_dataset.db with table 'employees' (1
rows).
```

Setup & DB Creation

```
✅ Created C:\Users\amlanmishra2\data\hr_dataset.db with table 'employees' (1
rows).
```

Quick Database Check

```
📋 Tables: [('employees',)]
```

Helper Function Run Query

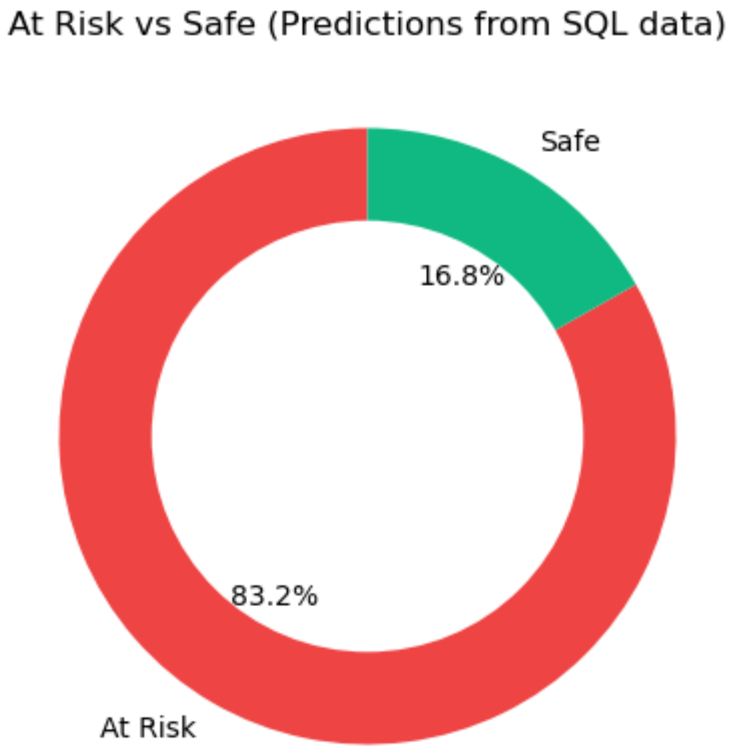
Sample Queries

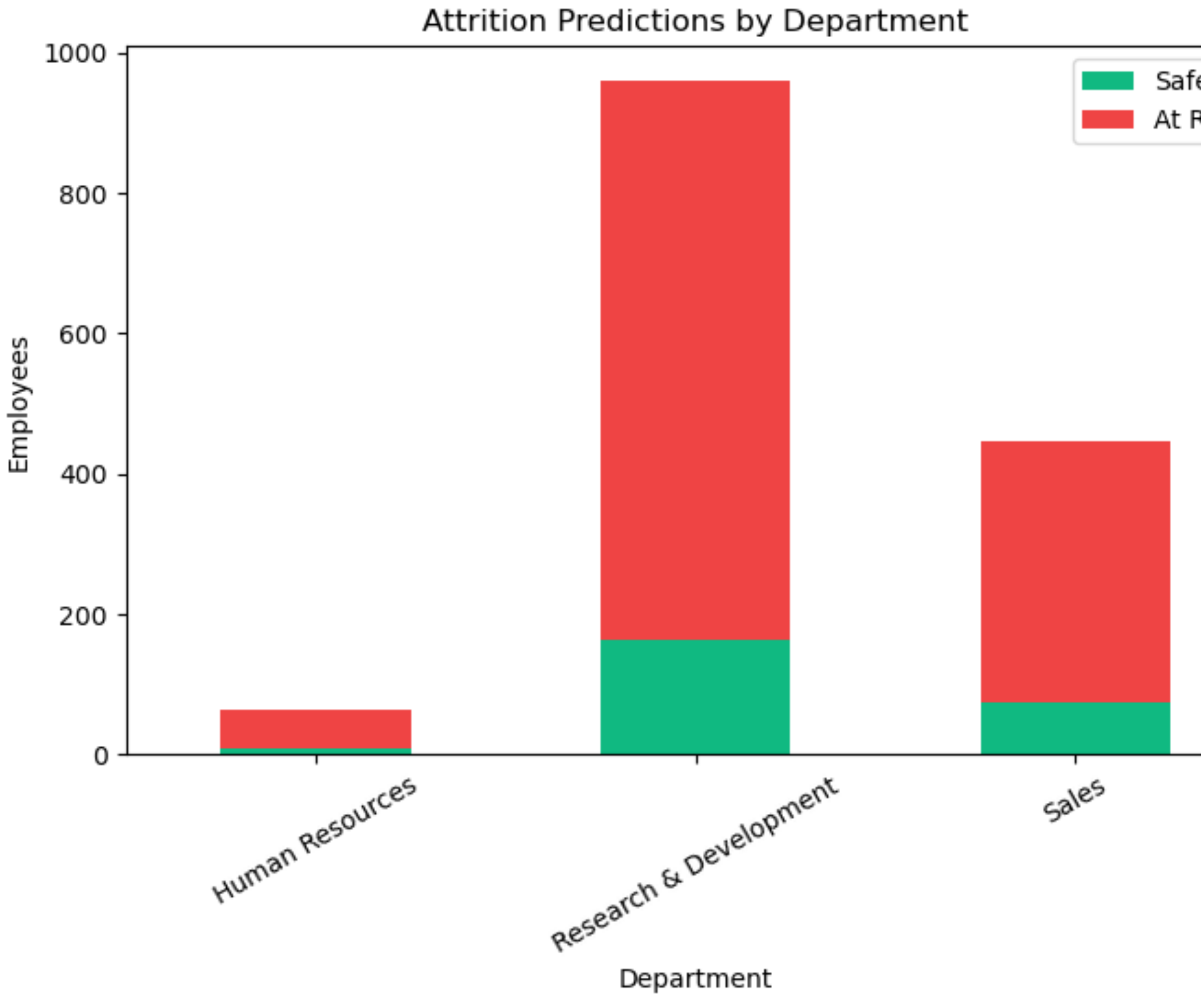
Out[5]:

	Department	total	left_count
0	Research & Development	961	133
1	Sales	446	92
2	Human Resources	63	12

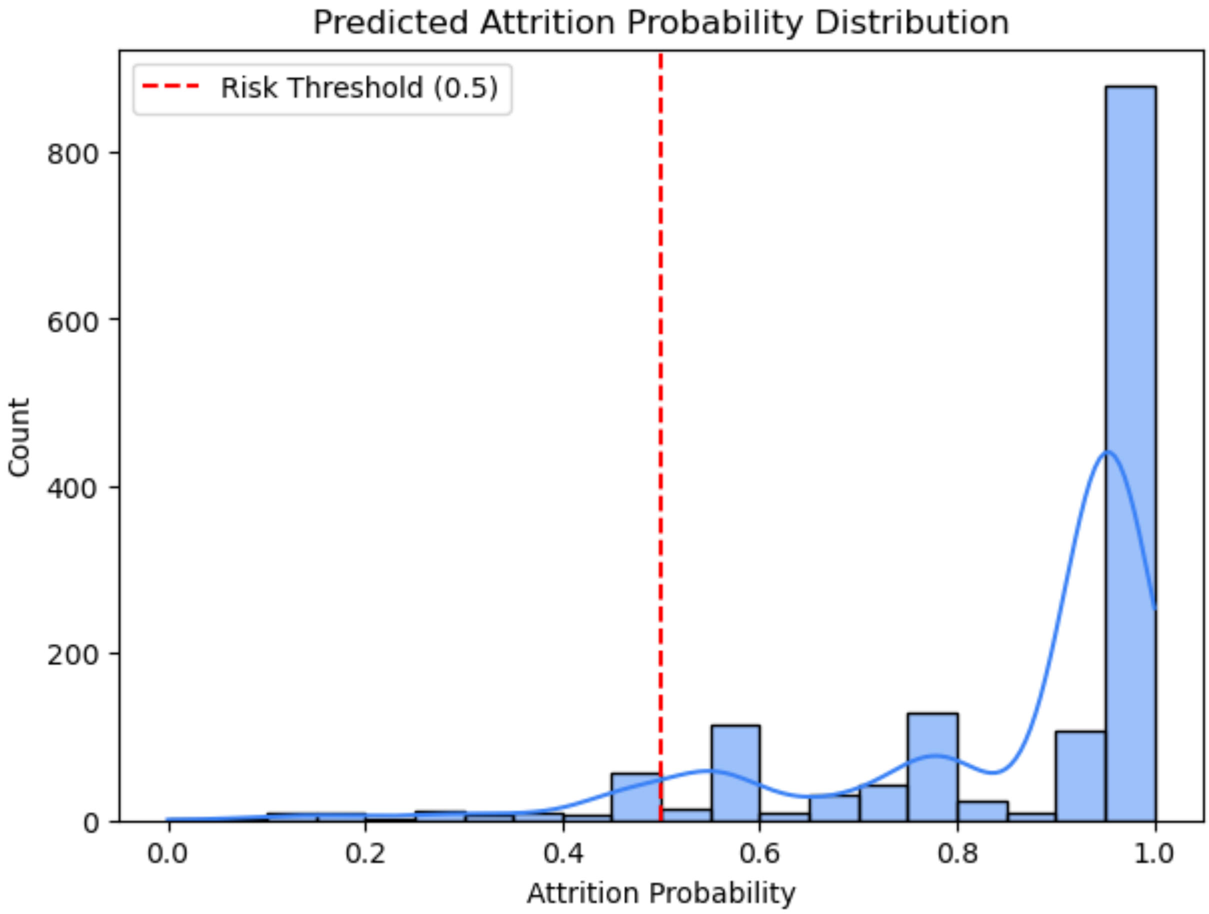
ML Integration & Visualization

```
⚠️ Dropped 'Attrition' column from inference data to avoid leakage.
🔎 Prediction Debug
Probability range: 0.0 to 1.0
Sample stats: [0.46418643 0.7870295  0.95263028 0.95263028 0.96479201]
✅ Using threshold 0.65 → At Risk: 1223, Safe: 247
```




Attrition Predictions by Department
1000
800
600
400
200
0
Employees
Safe
At R
Human Resources
Research & Development
Sales
Department

```
Out[9]:  <function matplotlib.pyplot.show(close=None, block=None)>
```


Predicted Attrition Probability Distribution
Risk Threshold (0.5)
800
600
400
200
0
Count
0.0
0.2
0.4
0.6
0.8
1.0
Attrition Probability

```
📂 Exported artifacts:
- Predictions CSV → data\Attrition_SQL_Predictions.csv
- Charts → images/sql_pred_donut.png, images/sql_pred_dept.png
```