Case Study: Healthcare Patient Analytics & Prediction

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1. Background

MediCare Hospital, a multi-specialty healthcare provider, struggled with **high patient readmission rates** and **inefficient risk assessment** for critically ill patients. The major challenges included:

- **Delayed identification of high-risk patients**, leading to complications.
- **Lack of real-time analytics**, making it difficult for doctors to take preventive measures.
- **Manual data tracking**, slowing down decision-making and increasing hospital costs.

To address these challenges, **MediCare Hospital** decided to integrate its **Electronic Health Record (EHR) system** with a **cloud-based data warehouse (Google BigQuery)** and use **Power BI for predictive analytics**. The goal was to optimize:

1. **Patient admission & discharge processes**
2. **Early prediction of high-risk cases**
3. **Post-discharge monitoring & follow-up care**
4. **Overall hospital efficiency & patient satisfaction**

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2. Case Study Scope

The project focused on developing a scalable analytics solution by integrating patient admissions, vitals, and treatment data from the **EHR system into Google BigQuery**, with key reporting features in **Power BI**.

Key Components:

- **Patient Admission & Discharge System** – Tracks hospital stays and discharge patterns.
- **Predictive Risk Analysis** – Identifies high-risk patients using AI-based models.
- **Post-Discharge Monitoring** – Automates follow-up scheduling and patient tracking.

The primary objective was to improve **patient care and hospital efficiency** through **data-driven insights**.

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3. Key Activities

1. Data Integration & ETL Process

✓ **Extract** patient admissions, vitals, and lab results from **EHR systems (Epic, Cerner, Meditech)** via **FHIR APIs or HL7**.
✓ **Transform & clean** data using **Python (Pandas, NumPy) and SQL scripts**.
✓ **Store structured data** in **Google BigQuery** for fast querying and reporting.

2. Data Model Design

The solution included key tables for structured analytics:

Table Name	Description
Patients	Stores patient demographics & medical history.
Admissions	Tracks hospital admissions & discharges.
Vitals	Stores real-time vitals (heart rate, BP, oxygen levels, etc.).
Treatments	Information on prescribed drugs & procedures.
Readmission_Risk	Predictive model output for high-risk cases.

3. Predictive Analysis Using Python (Pandas & AI Models)

- Load data into **Pandas** for preprocessing and exploratory analysis.
- Apply **Machine Learning (Logistic Regression, Random Forest, XGBoost)** to **predict readmission risk**.
- Identify key **risk factors** such as **age, chronic conditions, past hospital visits, and abnormal vitals**.

4. Analytics & Reporting (Power BI Dashboards)

- **Hospital Admission Trends** – Tracks daily admissions & discharges.
- **High-Risk Patient Prediction** – Identifies critical cases requiring extra care.
- **Vitals Monitoring Dashboard** – Displays abnormal trends in patient vitals.
- **Readmission Rate Analysis** – Evaluates effectiveness of treatments & follow-ups.
- **Post-Discharge Follow-Up Tracker** – Automates appointment scheduling & patient monitoring.

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4. Results & Business Impact

✅ **30% reduction** in hospital readmission rates.
✅ **Early identification of high-risk patients**, improving survival rates.
✅ **Automated risk scoring**, reducing manual workload by **50%**.
✅ **Improved patient satisfaction** with better post-discharge follow-ups.

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5. Conclusion

By integrating **EHR with cloud-based analytics**, **MediCare Hospital** improved **patient monitoring, risk prediction, and healthcare decision-making**. AI-driven **predictive models** enabled **better resource management** and **preventive patient care**, leading to overall hospital efficiency and higher patient satisfaction.

1. Table: Patients

Stores basic patient demographic and medical history details.

Column Name	Data Type	Description	Constraints
patient_id	INT	Unique identifier for the patient	**PK**
first_name	VARCHAR(50)	Patient's first name	NOT NULL
last_name	VARCHAR(50)	Patient's last name	NOT NULL
dob	DATE	Date of birth	NOT NULL
gender	VARCHAR(10)	Gender (Male/Female/Other)	NOT NULL
contact_no	VARCHAR(15)	Phone number	NOT NULL
address	VARCHAR(255)	Home address	NULLABLE
chronic_conditions	VARCHAR(255)	List of chronic diseases	NULLABLE

Sample Data:

patient_id	first_name	last_name	dob	gender	contact_no	address	chronic_conditions
101	John	Doe	1985-06-12	Male	9876543210	123 Main St	Diabetes, Hypertension
102	Emily	Smith	1992-08-25	Female	8765432109	456 Elm St	Asthma

patient_id	first_name	last_name	dob	gender	contact_no	address	chronic_conditions
103	Robert	Johnson	1975-03-30	Male	7654321098	789 Oak St	None

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2. Table: Admissions

Tracks hospital admissions, discharges, and treatment details.

Column Name	Data Type	Description	Constraints
admission_id	INT	Unique identifier for each admission	**PK**
patient_id	INT	Patient who was admitted	**FK → Patients(patient_id)**
admission_date	DATE	Date of hospital admission	NOT NULL
discharge_date	DATE	Date of discharge	NULLABLE
diagnosis	VARCHAR(255)	Initial diagnosis	NOT NULL
doctor_id	INT	Attending doctor	**FK → Doctors(doctor_id)**
room_no	VARCHAR(10)	Assigned hospital room	NULLABLE

Sample Data:

admission_id	patient_id	admission_date	discharge_date	diagnosis	doctor_id	room_no
2001	101	2025-02-10	2025-02-15	Pneumonia	301	A102
2002	102	2025-02-18	NULL	Severe Asthma Attack	302	B210
2003	103	2025-01-20	2025-01-25	Hypertension	303	C305

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3. Table: Vitals

Stores real-time vitals recorded during a hospital stay.

Column Name	Data Type	Description	Constraints
vital_id	INT	Unique identifier for each record	**PK**
admission_id	INT	Link to admission	**FK → Admissions(admission_id)**
recorded_time	TIMESTAMP	Time of vital recording	NOT NULL
heart_rate	INT	Heart rate (bpm)	NOT NULL
blood_pressure	VARCHAR(10)	Blood pressure (systolic/diastolic)	NOT NULL
oxygen_level	INT	Oxygen saturation (%)	NOT NULL
temperature	DECIMAL(5,2)	Body temperature (°F)	NOT NULL

Sample Data:

vital_id	admission_id	recorded_time	heart_rate	blood_pressure	oxygen_level	temperature
5001	2001	2025-02-10 08:30	80	120/80	98	98.6
5002	2001	2025-02-11 10:15	85	130/85	96	99.2
5003	2002	2025-02-18 09:00	95	140/90	92	100.1

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4. Table: Treatments

Stores medical treatments, medications, and procedures during hospitalization.

Column Name	Data Type	Description	Constraints
treatment_id	INT	Unique identifier for treatment	**PK**
admission_id	INT	Related admission record	**FK → Admissions(admission_id)**

Column Name	Data Type	Description	Constraints
treatment_date	DATE	Date of treatment	NOT NULL
procedure	VARCHAR(255)	Procedure name	NULLABLE
medication	VARCHAR(255)	Prescribed medication	NOT NULL
dosage	VARCHAR(50)	Dosage instructions	NULLABLE

Sample Data:

treatment_id	admission_id	treatment_date	procedure	medication	dosage
7001	2001	2025-02-11	Oxygen Therapy	Amoxicillin	500mg 2x daily
7002	2002	2025-02-19	Nebulization	Prednisone	10mg 1x daily
7003	2003	2025-01-22	Blood Pressure Monitoring	Metoprolol	50mg 1x daily

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5. Table: Readmission_Risk (Predictive Model Output)

Stores AI-predicted risk scores for readmission.

Column Name	Data Type	Description	Constraints
risk_id	INT	Unique identifier for prediction	**PK**
admission_id	INT	Related admission	**FK → Admissions(admission_id)**
prediction_date	DATE	Date of risk assessment	NOT NULL
risk_score	DECIMAL(5,2)	Probability of readmission (0-1)	NOT NULL
risk_level	VARCHAR(10)	Low, Medium, High	NOT NULL

Sample Data:

risk_id	admission_id	prediction_date	risk_score	risk_level
9001	2001	2025-02-14	0.75	High
9002	2002	2025-02-19	0.85	High
9003	2003	2025-01-24	0.40	Medium

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6. Table: Doctors

Stores doctor information.

Column Name	Data Type	Description	Constraints
doctor_id	INT	Unique identifier for doctor	**PK**
first_name	VARCHAR(50)	First name	NOT NULL
last_name	VARCHAR(50)	Last name	NOT NULL
specialization	VARCHAR(255)	Medical specialty	NOT NULL
contact_no	VARCHAR(15)	Phone number	NOT NULL

Sample Data:

doctor_id	first_name	last_name	specialization	contact_no
301	Alice	Carter	Pulmonologist	555-1234
302	Mark	Wilson	Cardiologist	555-5678
303	Emma	Davis	General Physician	555-9012

Key Constraints Summary

- **Primary Keys (PK):**
  - patient_id, admission_id, vital_id, treatment_id, risk_id, doctor_id
- **Foreign Keys (FK):**
  - admissions.patient_id → patients.patient_id
  - admissions.doctor_id → doctors.doctor_id
  - vitals.admission_id → admissions.admission_id

- treatments.admission_id → admissions.admission_id
- readmission_risk.admission_id → admissions.admission_id