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## ❖ Use Case Proposal: Optimizing Emergency Department (ED) Throughput & Patient Flow

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### 1. Business Understanding & Context

#### 1.1 Industry and Organization Description

- **Industry:** Healthcare Provider (Acute Care Operations). The industry's focus is on improving patient experience, improving population health, and reducing cost.
- **Organization:** Hôpital Charles Nicolle. A public healthcare establishment managing approximately 180,000 Emergency Department (ED) visits annually in the past 4 years. The establishment started using an Electronic Health Record (EHR) system in the recent years but lacks operational insights into patient flow bottlenecks.

#### 1.2 The Business Problem

The Emergency Department is experiencing severe overcrowding and inefficiencies in patient flow, directly threatening patient safety and the hospital's financial stability.

- **The Problem:** Average patient waiting time exceed industry benchmarks and critical resources (beds, staff) are frequently exhausted.
- **Consequences:**
  1. **Patient Safety Risk:** Prolonged wait times correlate with adverse patient outcomes.
  2. **Revenue Leakage:** A high rate of patients "Left Without Being Seen" (LWBS), resulting in significant lost revenue and increased liability.
  3. **Staff Burnout:** Static staffing schedules do not match unpredictable patient arrival surges, leading to overworked staff and high turnover.

Project Goal:

To design and deploy a Business Intelligence solution that visualizes the end-to-end patient journey, enabling administrators to identify and relieve throughput bottlenecks, thereby aiming to reduce the LWBS rate by 40% (e.g., from 5% to 3%) within the first year.

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### 2. Analytical Objectives

This project is built around answering the following analytical questions to diagnose the root causes of ED overcrowding.

#### Operational Efficiency:

1. **Bottleneck Detection:** What is the average duration of each stage in the patient journey (Registration, triage, treatment, discharge)? Where is the longest delay occurring?
2. **Peak Demand Analysis:** Which specific days of the week and hours of the day see the highest volume of patient arrivals requiring immediate attention?
3. **Staffing Alignment:** During peak arrival times, how does the actual active Nurse-to-Patient ratio compare against the recommended clinical standard?

#### Clinical Quality & Risk:

4. **LWBS Risk Profiling:** What is the demographic and presenting symptom profile of patients most likely to "Left Without Being Seen" (LWBS)?
5. **Triage Effectiveness:** What percentage of patients initially classified as "Low Acuity" (ESI Level 4-5) end up being admitted to the hospital, indicating potential triage errors?

6. **Re-admission Risk:** What percentage of patients discharged from the ED return within 72 hours, and for what primary diagnosis?

**Resource Utilization & Throughput:**

7. **Boarding Time:** What is the time patients spend waiting in the ED after a decision has been made to admit them to a main hospital ward?
8. **Diagnostic Delays:** What is the average delay time for patients waiting for an ordered diagnostic test (e.g., CT scan or MRI)?
9. **Doctor Throughput:** What is the variance in "Average Treatment Time" per doctor for similar low-acuity diagnosis codes?
10. **Resource Saturation:** How does the current ED Bed Occupancy Rate trend throughout the day, and at what occupancy percentage do wait times surge most significantly?

### 3. Key Performance Indicators (KPIs)

The following 8 KPIs will be implemented to measure the daily operational health and the success of the BI project.

KPI Name	Formula	Business Relevance
1. Door-to-Doc Time	Time of medical assessment - Time of arrival	The most critical metric for patient satisfaction and safety.
2.LWBS rate (Left Without Being Seen)	$\frac{\text{Patients left without treatment}}{\text{Total ED arrivals}} \times 100$	Measures lost revenue, liability risk, and patient dissatisfaction.
3.Average length of stay (LOS)	Time of discharge - Time of Arrival	Measures total system efficiency; high LOS causes overcrowding.
4.Boarding/waiting time	Time admitted to ward -Decision to admit	The delay in moving patients out of the ER.
5.Bed occupancy rate	$\frac{\text{Occupied beds}}{\text{Total available beds}} \times 100$	Capacity metric: helps predict when the department is nearing saturation.
6. 72-Hour return rate	$\frac{\text{Returns} < 72h}{\text{Total discharges}} \times 100$	Quality of care metric: indicates if patients were discharged prematurely.
7. Patients per staff hour	$\frac{\text{Total patient volume}}{\text{Total nursing hours scheduled}} \times 100$	Efficiency metric used for optimizing staffing and shift planning.
8. Average triage time	Time of triage start -Time of arrival	Measures the speed of initial assessment and risk stratification.

#### 4. Technical scope and data modeling

To successfully answer the analytical questions and track the defined KPIs, the BI solution requires a robust data model based on a star schema design. This design will consolidate data from the hospital's various systems (EHR, Staffing, Administration) into measurable facts linked to descriptive dimensions.

The model will utilize data spanning 4 years of ED activity. With an average of 180,000 annual visits, the dataset will encompass approximately 120,000 rows of patient visit data.

- **Fact Table:**

Table name	Fact_ED_Visit_Metrics
Description	Contains the core measurable metrics (time durations and outcomes) for every single patient visit to the ED.
Grain	One row per unique patient visit (Encounter ID)
Measures	Door_to_Doc_Time (minutes), Total_LOS (minutes), Boarding_Time (minutes), LWBS_Flag (0/1), Returned_72h_Flag (0/1), Total_Staff_Time (minutes), Revenue_Generated (TND)
Foreign keys	FK_Date, FK_Time, FK_Patient, FK_Staff, FK_Diagnosis

- **Dimension tables:**

Table name	Dim_patient	Dim_staff	Dim_date
Attributes	Patient_ID (PK), Acuity_Level (ESI Score 1-5), Admission_Status (Admitted/Discharged/Transferred), Patient_Zip_Code, Patient_Age_Group, Reason_for_Visit	Staff_ID (PK), Staff_Role (MD, RN, Tech), Contract_Type (Full-time/Part-time), Shift_Scheduled, Average_Performance_Score	Date_Key (PK), Full_Date, Day_of_Week, Month_Name, Is_Holiday_Flag, Fiscal_Quarter
Description	Contextual data about the patient.	Contextual data about the healthcare staff (Nurse, Doctor).	Standard time hierarchy.
Uses in Analysis	Segmenting KPIs by patient severity (Acuity) and tracking readmission risk.	Analyzing how staffing mix (Role, Shift) affects KPIs like Door-to-Doc Time.	Analyzing peak demand patterns (Day/Time) and tracking performance.

#### 4. Proposed BI Solution

The solution will be a centralized BI dashboard leveraging time-stamped data from the hospital's Electronic Health Record (EHR) system. The core visualization will be a Patient Flow Sankey Diagram showing patient loss (LWBS) and bottlenecks at each stage.