HealthMan

ADDING BUSINESS ACUMEN TO YOUR PROFESSIONAL EXPERTISE

CLARITY

Bringing Clarity to Healthcare

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Content Outline

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What is LOS?

Case Justification

Roydon Au

Key Implications of Inaccurate LOS

1 Clinical

Impaired clinical capabilities
Resources inefficiency

2 Financial

Stagnancy of patient throughput
Slower revenue & wasted opportunities

3 Operational

Inefficient patient intake
Delayed Procedures
Lesser available wards

4 Experiential

Compromise patient experiences
Increase in the risk of infections

5 Health

Insufficient LOS
Unnecessarily long LOS

Case Justification

Roydon Au

1

African Healthcare System

- One of the worst healthcare systems in the world
- Lowest government funding in the world for health
- Far behind in technology

2

Resulted in

- Inadequate Human Resource
- Poor Resource Allocation
- Poor Healthcare Infrastructure

3

Raw Information

- Raw and disorganized Information
- No in-built system to guide doctors

4

Root Cause

- Wide range of data that doctors are unable to process
- Uninformed and Inaccurate Prescription of LOS

Problem Statement

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Root Cause

1 **Wide range of information for doctors to process**

- Doctors neglect the efficient management of hospital resources when assessing a patient's needs

Problem Identification

Inaccurate prescription of patient **Length of Stay (LOS)**

Over prescription

Under prescription

Business Opportunity

Roydon Au

Better Resource Allocation

Reduce wastage of resources

Better manpower allocation

Enhanced Inpatient Experience

Better Quality of Service

Greater Patient Flow & Reduce Waiting Time

Minimised Risk of Spread

Targeted Outcomes

Timothy Chang

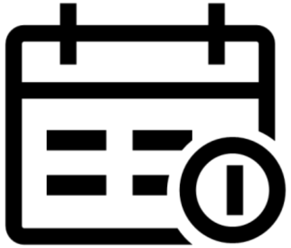
How Might We?

Target 1	Target 2
Develop a system to assist doctors in prescribing LOS consistently & accurately?	**Determine the most significant actionable areas for Hospital Management to directly reduce unnecessary LOS?**

Approach 1: Consistent & Accurate LOS Prediction

Timothy Chang

Prescribe LOS consistently & accurately



Who is the target audience?

Doctors who prescribe inpatient stay to patients

What is the solution ?

1. Accurate Machine Learning-Generated Predictions of LOS to guide doctors' decisions
2. Interactive Hospital Management Dashboard for comprehensive overview of data

What is the impact ?

1. Minimize under / over-prescription of LOS
2. Efficient macro-managing of inpatient stay

Approach 1: Consistent & Accurate LOS Prediction

Predictive Modelling Approach

Data Preparation → **Machine Learning** → **Evaluation**

Hospital Inpatient Data

- **Multi-Adaptive Regression Splines**
- **Classification and Regression Tree (CART)**
- **Random Forest**

Selected Best Model

Approach 1: Consistent & Accurate LOS Prediction

Timothy Chang

Comparison of Predictive Models

Model	Normalised RMSE
MARS Degree 1 (Original Dataset)	7.484%
MARS Degree 2 (Original Dataset)	6.877%
MARS Degree 1 (Log Dataset)	12.918%
MARS Degree 2 (Log Dataset)	11.657%

Model	Normalised RMSE
CART Optimal Max Depth 7 (Original Dataset)	6.776%
CART Optimal Max Depth 9 (Log Dataset)	12.243%

Model	Normalised RMSE
Random Forest Optimized Model (Original Dataset)	6.757%
Random Forest Optimized Model (Log Dataset)	11.377%

Model	Normalised RMSE
MARS, Degree 2 with Original Dataset	6.877%
CART, Max Depth of 7 with Original Dataset	6.776%
Random Forest with Original Dataset	6.757%

Approach 1: Consistent & Accurate LOS Prediction

Evaluation of Model

Prediction Accuracy

1 RMSE

Model	Normalised RMSE
MARS, Degree 2 with Original Dataset	6.877%
CART, Max Depth of 7 with Original Dataset	6.776%
Random Forest with Original Dataset	6.757%

- All models perform better than accuracy benchmark of 9.524%

2 Overprediction / Underprediction

Model	Overprediction (%)	Underprediction %
MARS, Degree 2 with Original Dataset	55.536%	44.464%
CART, Max Depth of 7 with Original Dataset	59.112%	40.887%
Random Forest with Original Dataset	64.375%	35.615%

- Underprediction holds a greater implication than overprediction

Explainability

Cart → MARS → Random Forest

Simple ... Complex

- Ease of understanding of the model

Ease of Implementation

Model	Prediction Time
MARS, Degree 2	0.03992 s
CART, Max Depth of 7	0.04991 s
Random Forest	35.686 s

- Have a minimal impact in a clinical situation

Approach 1: Consistent & Accurate LOS Prediction

Model of Choice

Lower Required Processing Power

Comparable Accuracy with Random Forest

CART

Greater Explaining Power

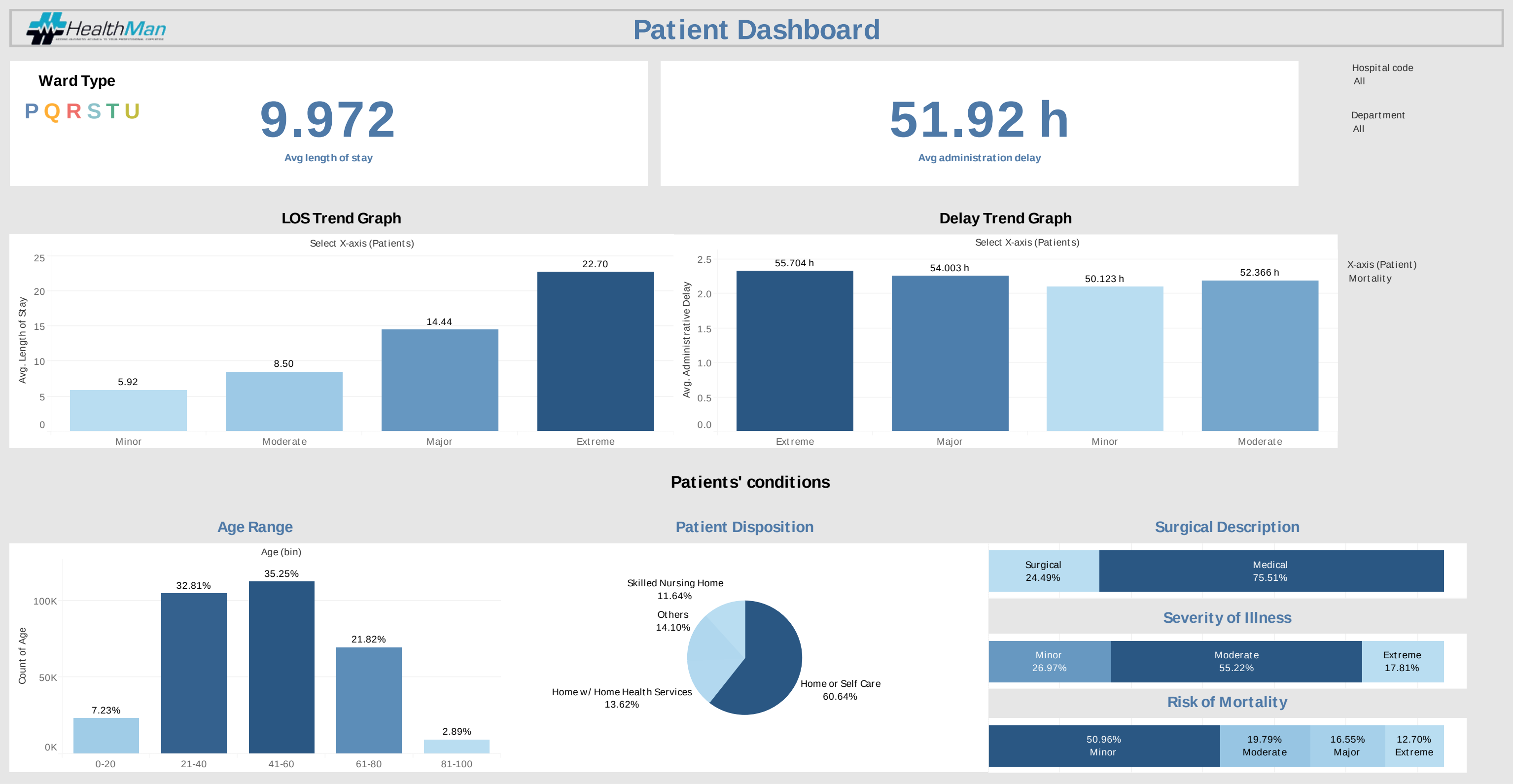
Gentler Learning Curve

Approach 1: Consistent & Accurate LOS Prediction

Timothy Chang

Interactive Dashboards for Doctors

Dashboard



Use Cases

Support doctor's decision making beyond numerical predictions by CART

Non-Technical Overview of Patient Status

- Length of Inpatient Stay
- Surgical Procedures
- Severity of Illness
- Discharge or Transfer Plans

Reference when making Ward Rounds

Approach 2: Targeting unnecessary LOS

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Paul Low

Identify priority areas to reduce unnecessary LOS

Who is the target audience?

Hospital management

What is the solution ?

1. To prepare an accurate CART model with significant actionable variables
2. Use of Dashboard to enhance explainability
   - Identify potential bottle necks

What is the impact ?

1. Helps identify specific target areas to rectify
2. Ensures efficient resource allocation & faster decision making

Identify priority areas to reduce unnecessary LOS

Variable Importance

Directs hospitals to channel resources towards significant actionable areas to reduce unnecessary LOS

Medical + Administrative Variables

	Feature_Importance
Administrative_Delay	0.668621
Severity_of_Illness	0.119980
APR_Medical_Surgical_Description_Surgical	0.104354
APR_Risk_of_Mortality	0.041229
APR_Medical_Surgical_Description_Medical	0.016504
Patient_Disposition_Home or Self Care	0.010561
Patient_Disposition_Skilled Nursing Home	0.008066
Payment_Typology_1_Medicare	0.007202
Patient_Disposition_Home w/ Home Health Services	0.006695
Payment_Typology_1_Medicaid	0.006291

Most significant variable in predicting the LOS

Top 3 problems: Paper-based, Analogue data & Information collection methods

Serve as a pivotal cause of Administrative Delay

Identify priority areas to reduce unnecessary LOS

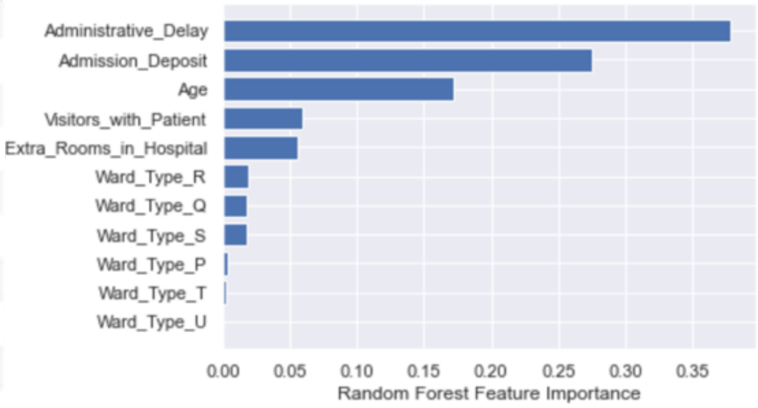
Paul Low

Variable Importance

Actionable Variables

RMSE	
Model with all predictors	6.776%
Model with the subset of predictors	7.408%

	Feature_Importance
Administrative_Delay	0.974970
Admission_Deposit	0.012506
Age	0.007073
Visitors_with_Patient	0.003200
Ward_Type_Q	0.001252
Ward_Type_S	0.000511
Ward_Type_T	0.000282
Ward_Type_R	0.000131
Available_Extra_Rooms_in_Hospital	0.000076
Ward_Type_P	0.000000
Ward_Type_U	0.000000



Feature Importance across CART and Random Forest are consistent

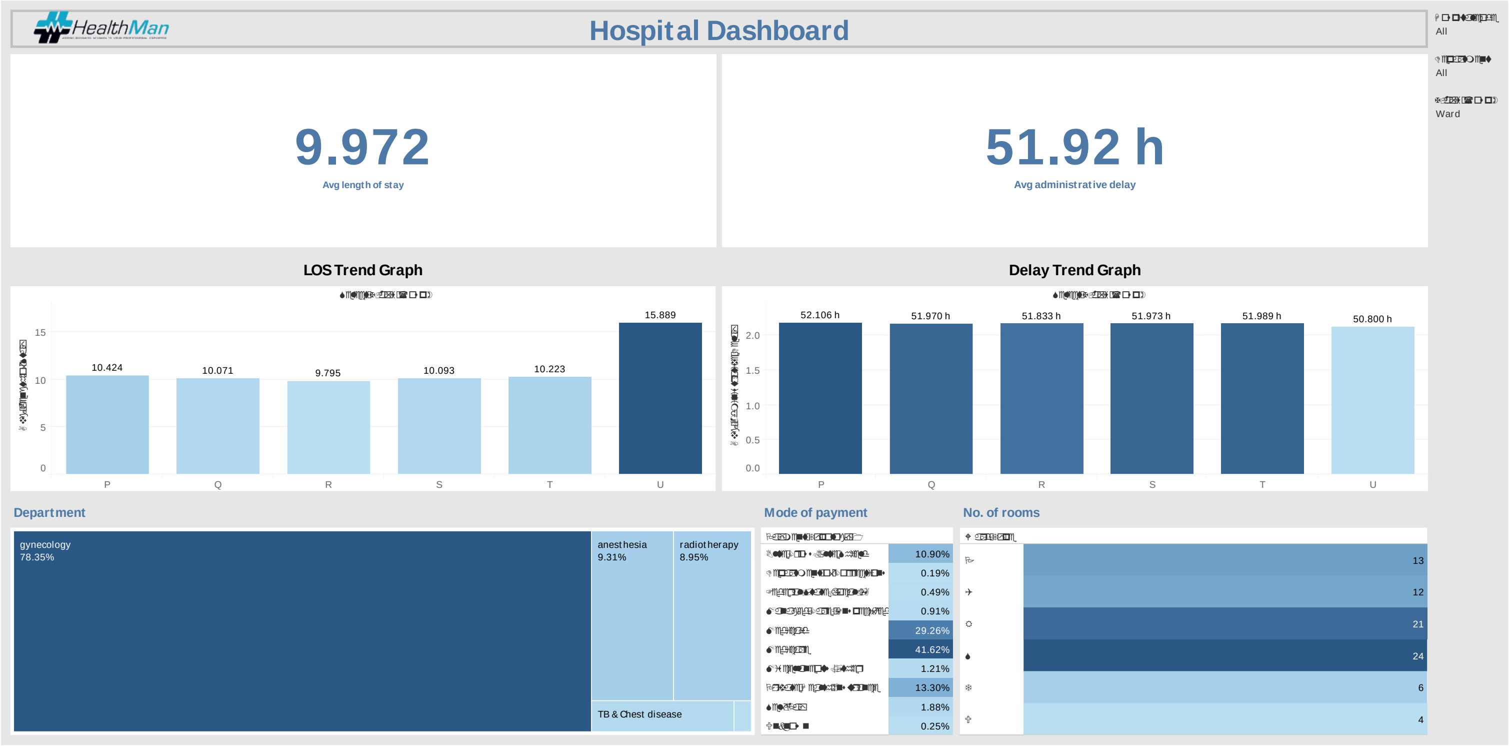
- **Administrative Delay** is still the most significant variable
- Other variables also play a role in influencing LOS

Identify priority areas to reduce unnecessary LOS

Paul Low

Interactive Dashboard for Hospital Management

Dashboard



Use Cases

Non-Technical Overview of Facilities

- Mode of Payment
- Availability of Extra Rooms
- Department

Relevant Information for potential bottlenecks and target areas (Administrative delay)

Objective:

User-Friendly Interface for Consolidated Facilities Information

Michelle Chung

Live Demonstration

Hospital Dashboard

Patient Dashboard

Possible recommendation from Dashboard Findings

Spread of Patients within Wards

Observation

Patients are not split according to the severity

Disorganized management process

Better segmentation of their patients to prevent prolonged length of stay

Inefficiencies in Transfer Processes

Observation

High delays in discharging of patients

Increase unnecessary stay in hospital

Implementation of a shared discharge plan to enhance communication among caregivers

Areas for Improvement

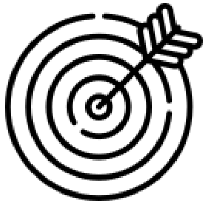
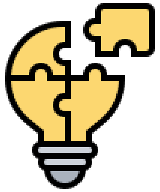
Luo Yiying

Limitations	Elaboration
Limited data on higher LOS	• Data imbalance • Collect more data with patients of higher stay • Creating separate models for different severity types
Limited Qualitative Predictors	• Some predictors were left out in our machine learning approach • A time series forecast for patient inflow would value add to a hospital management's decision making
Limited Information	• Limited information for some factors • Unable to analyze factors in greater detail
Manpower	• Our solution facilitates the planning and allocation of resources by hospital management • Limited by the amount of resources hospitals can work with

Conclusion

Luo Yiying

In all..

Problem Statement	Analytics Solution	Recommendations
		
Inaccurate Prescription of LOS is detrimental to patients and hospitals	1 **ML Model (CART) for consistent and accurate LOS prediction**	1 **Improve segmentation of patients to prevent prolonged length of stay**
	2 **Interactive Dashboard for monitoring of significant actionable areas**	2 **Shared Discharge Plan**

Thank you

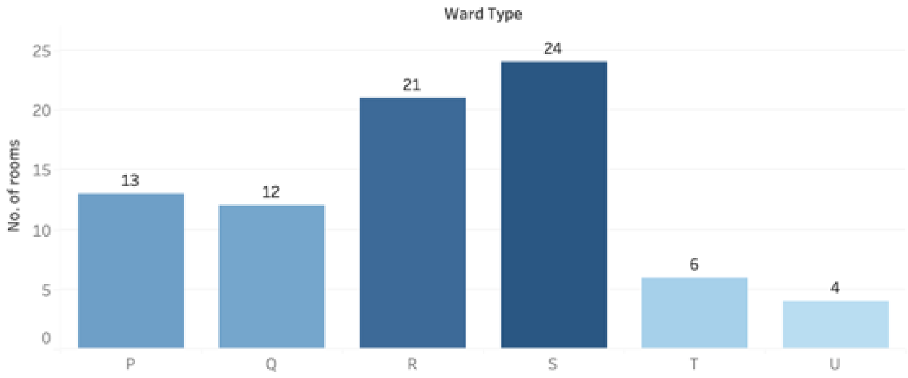
Appendix

Wards

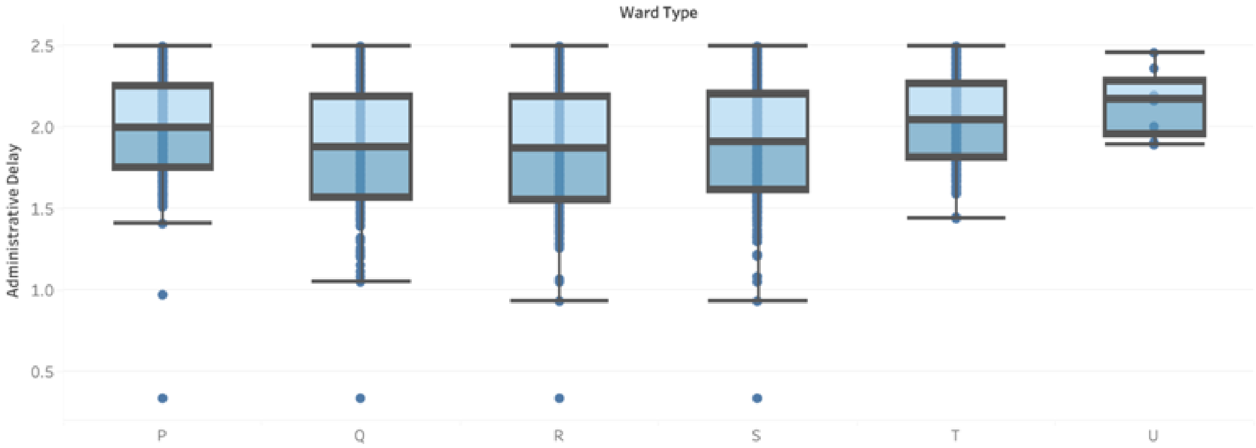
Average LOS

Ward Type	
P	10.42
Q	10.07
R	9.80
S	10.09
T	10.22
U	15.89

No. of rooms

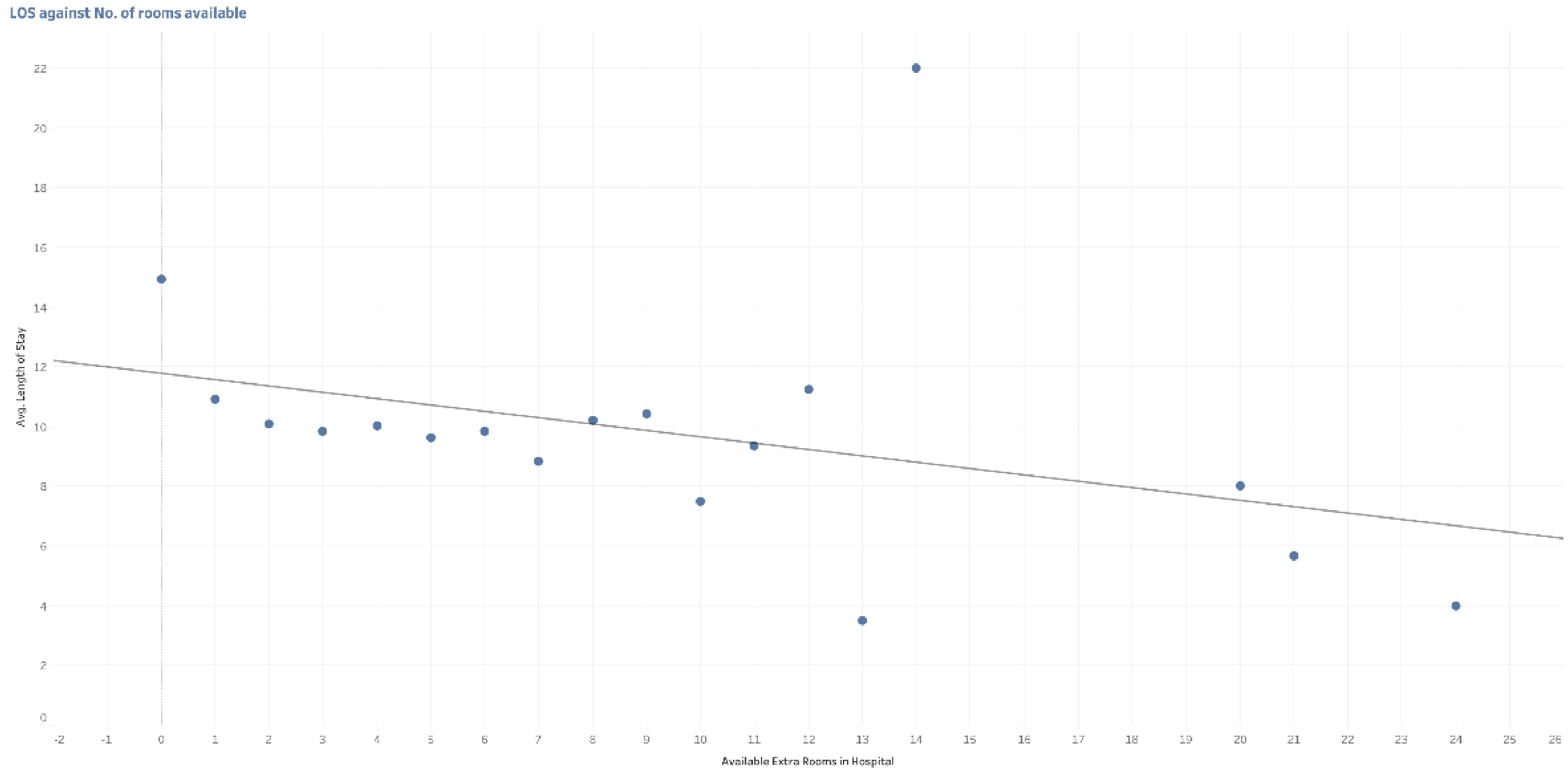


Trend of delay



The lower the number of available rooms per ward, the higher the average administrative delay.

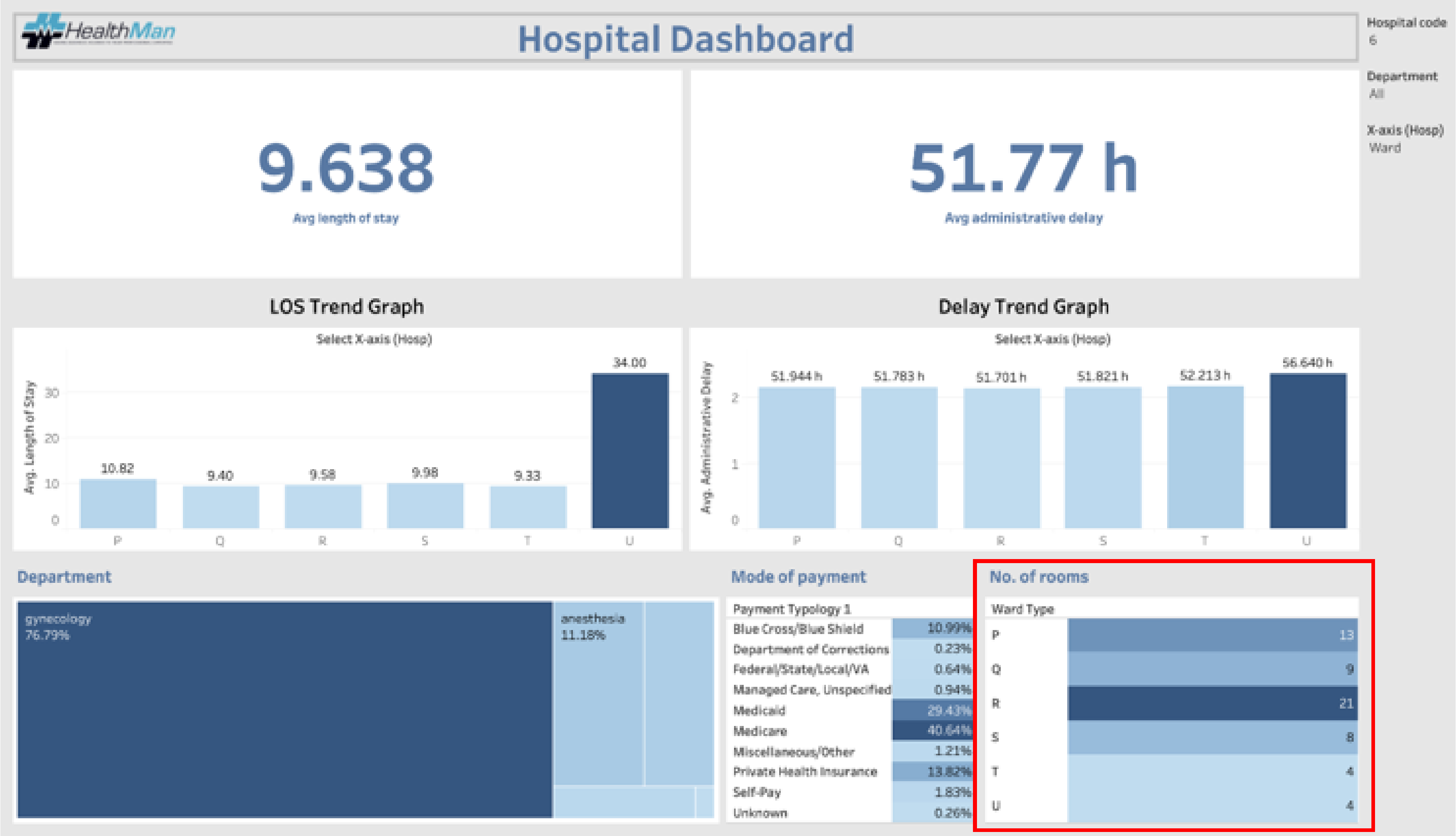
Appendix



The plot of average of Length of Stay for Available Extra Rooms in Hospital.

The greater the number of available rooms per ward, the lower the average length of stay

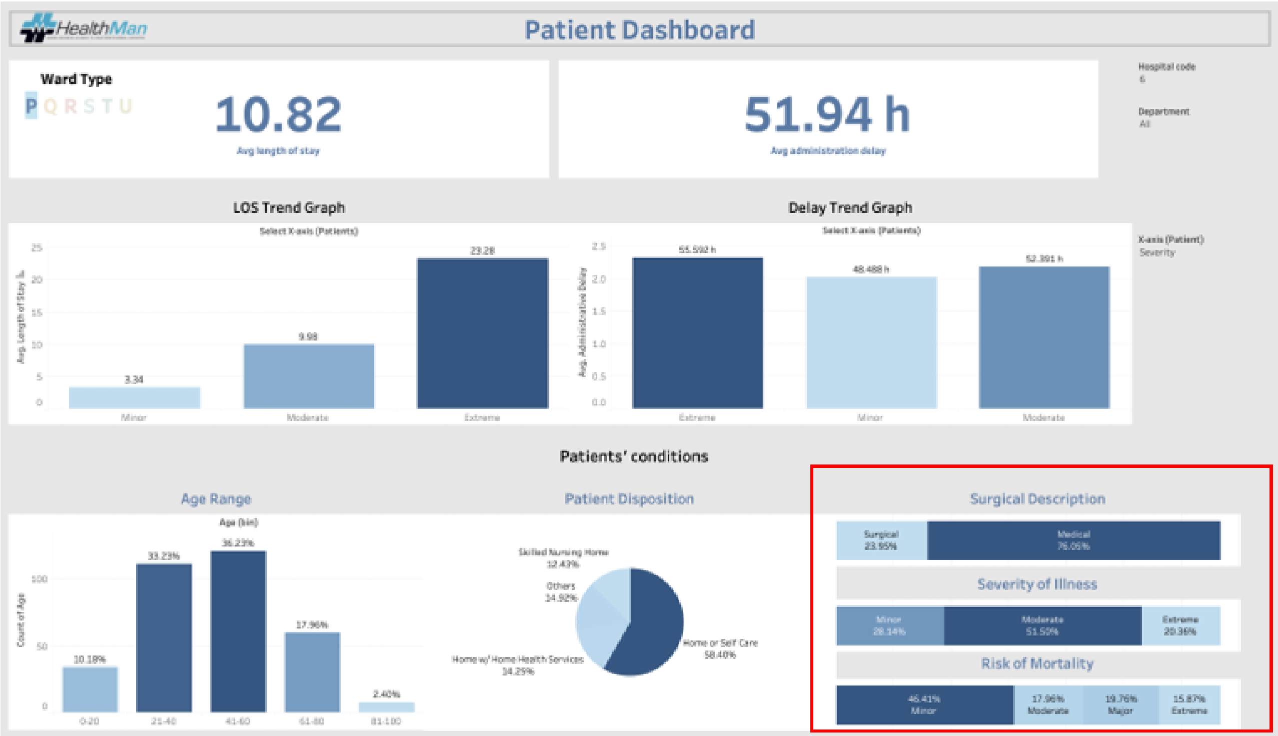
Appendix



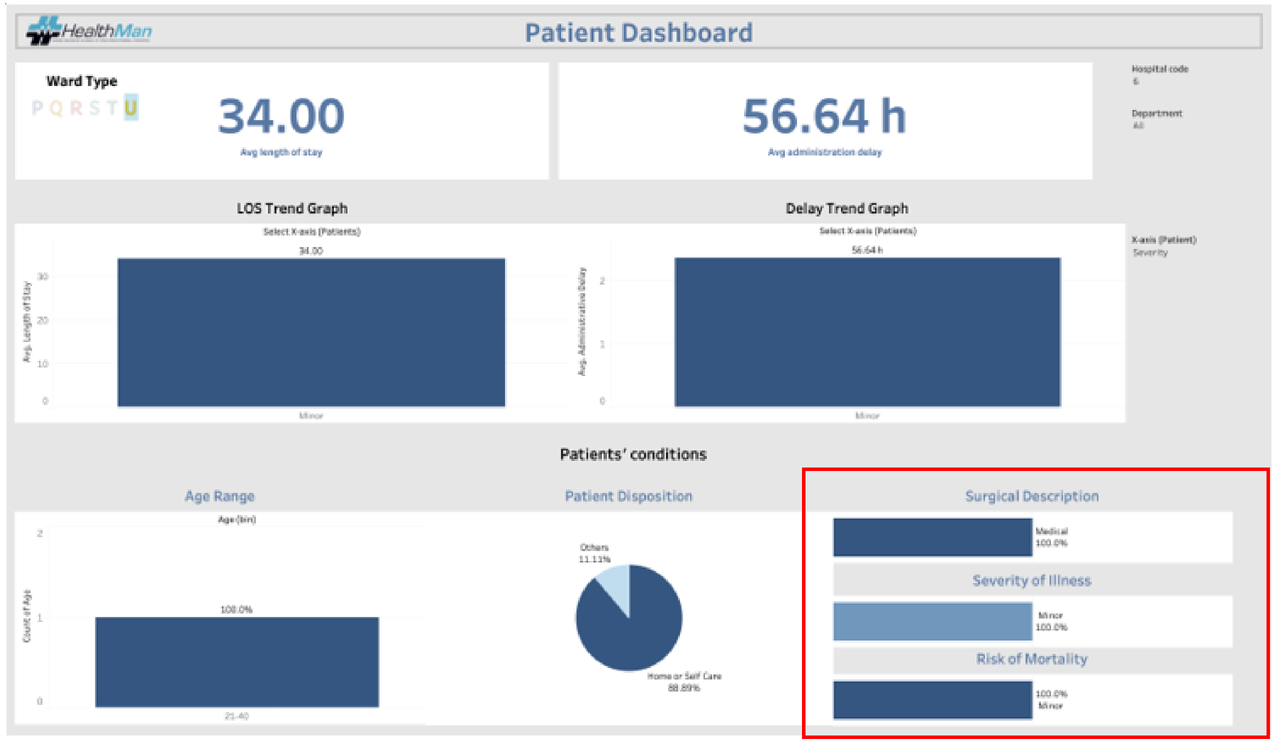
Section 9.2.1 in written report

(Help doctors understand vacancy to prevent overcrowding in wards)

Appendix



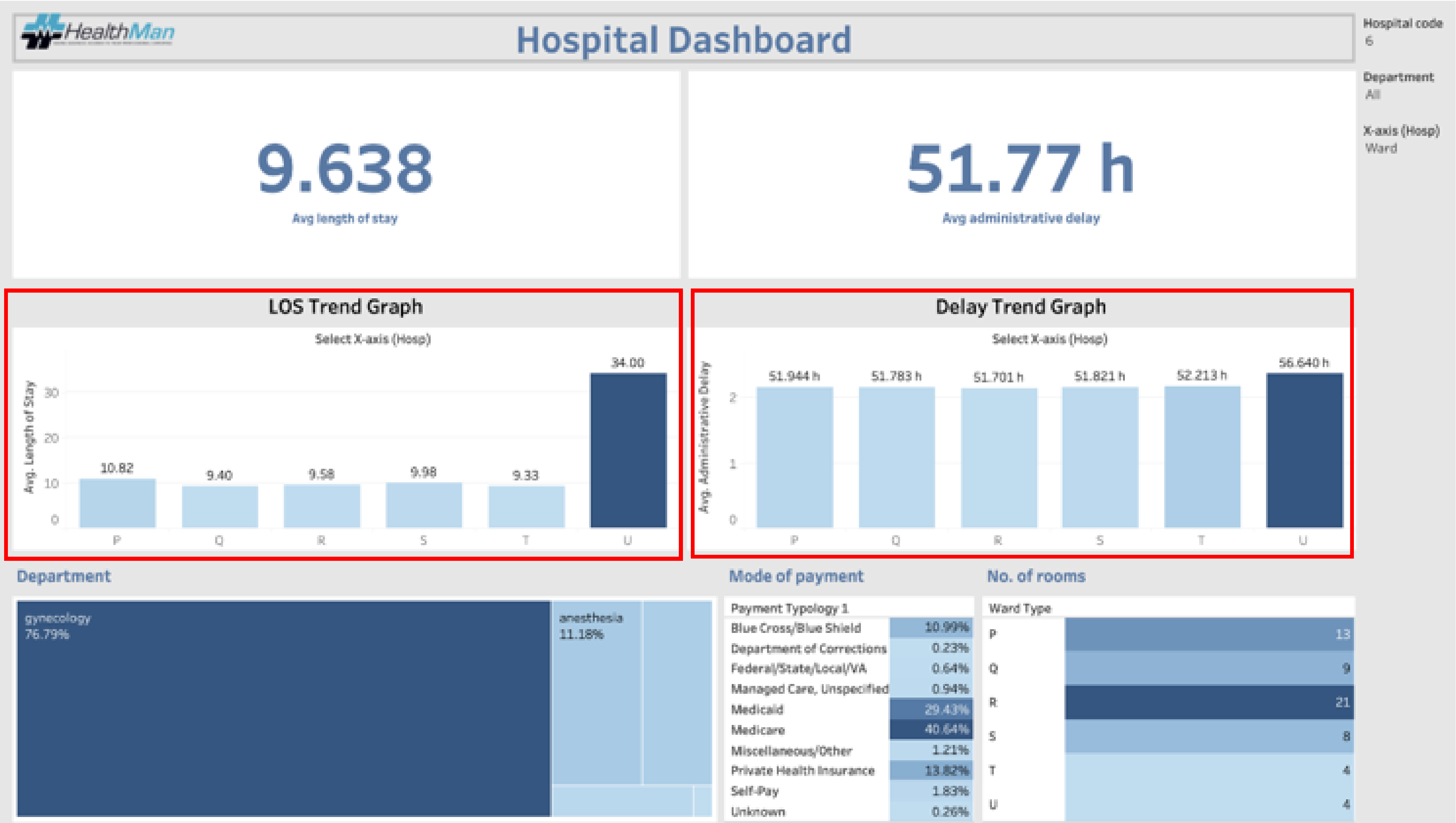
Before



After

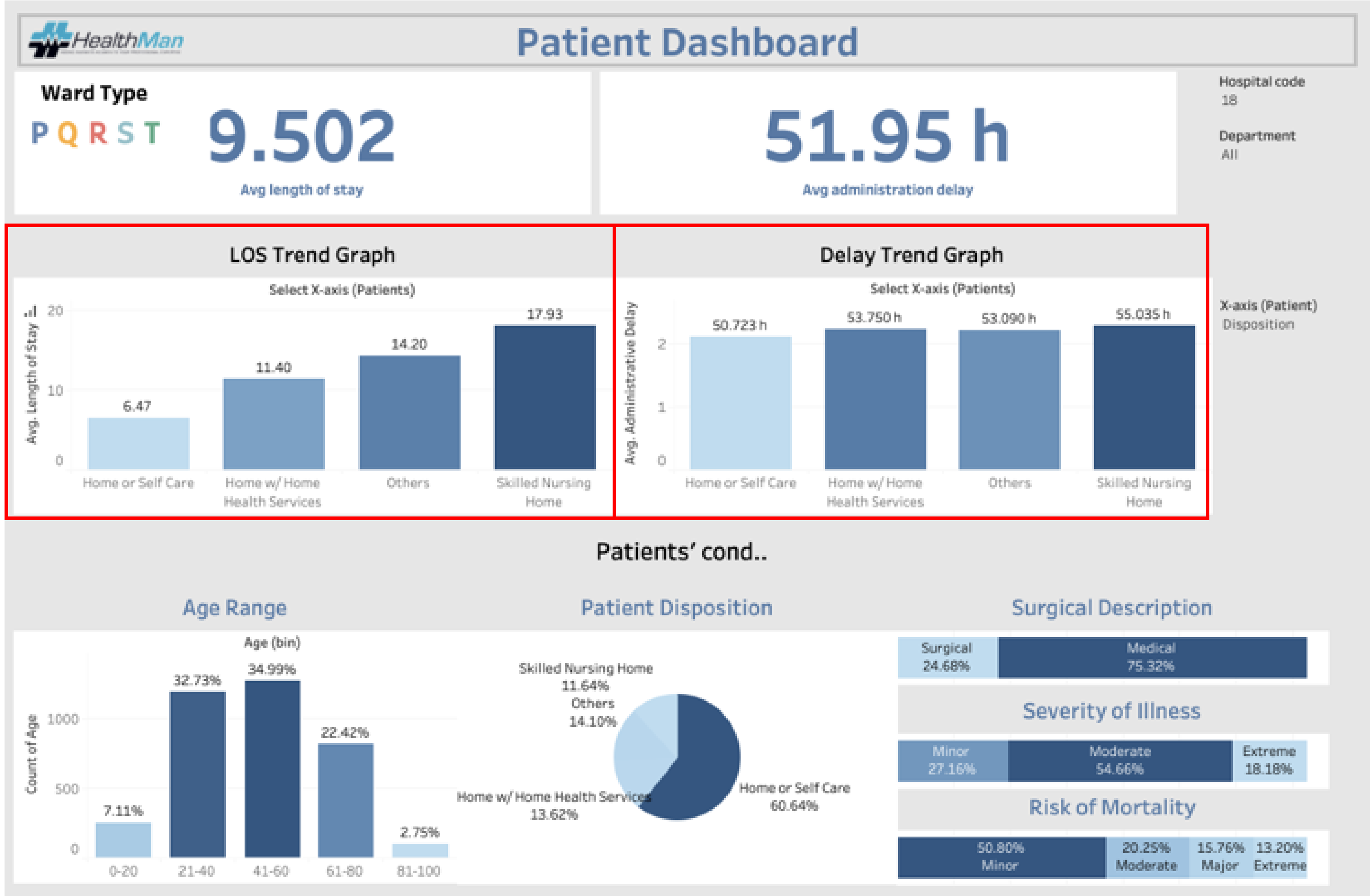
Section 9.2.1 in written report (Help doctors understand severity spread of patients in different wards)

Appendix



Section 9.2.2 and 9.2.3 in written report
(Help hospital management identify high LOS/Delay, eg ward U highest LOS/Delay
Further prevents bottlenecks)

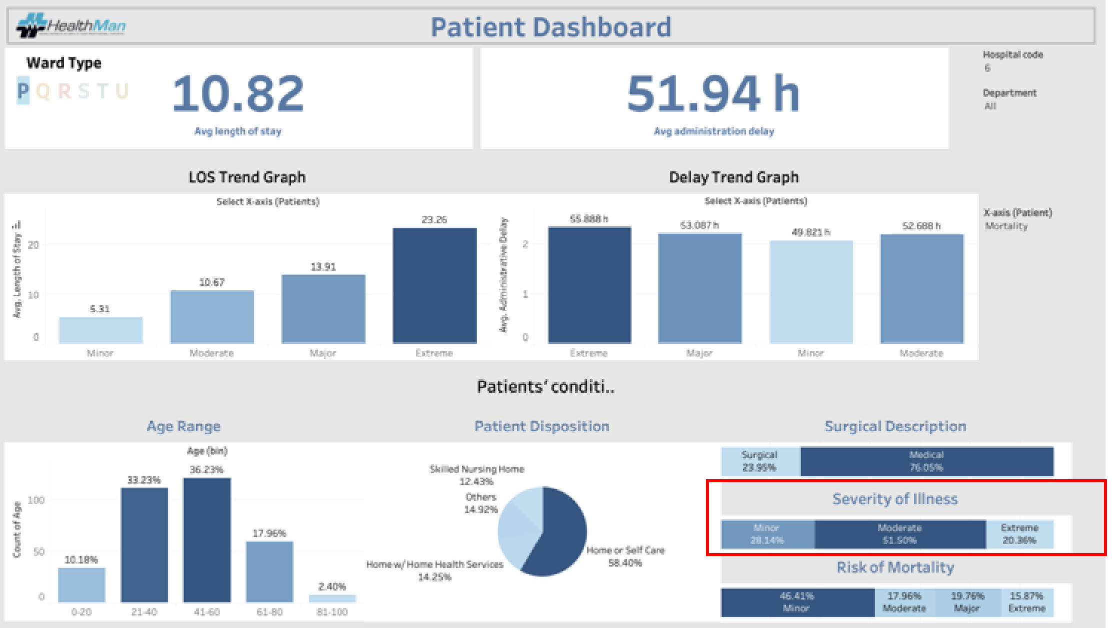
Appendix

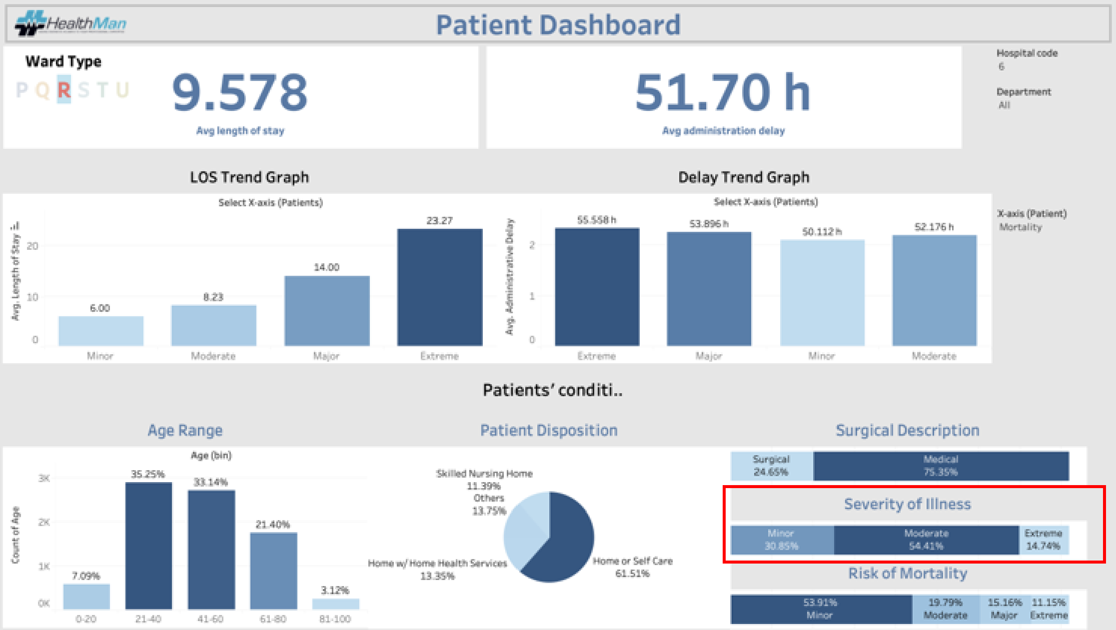


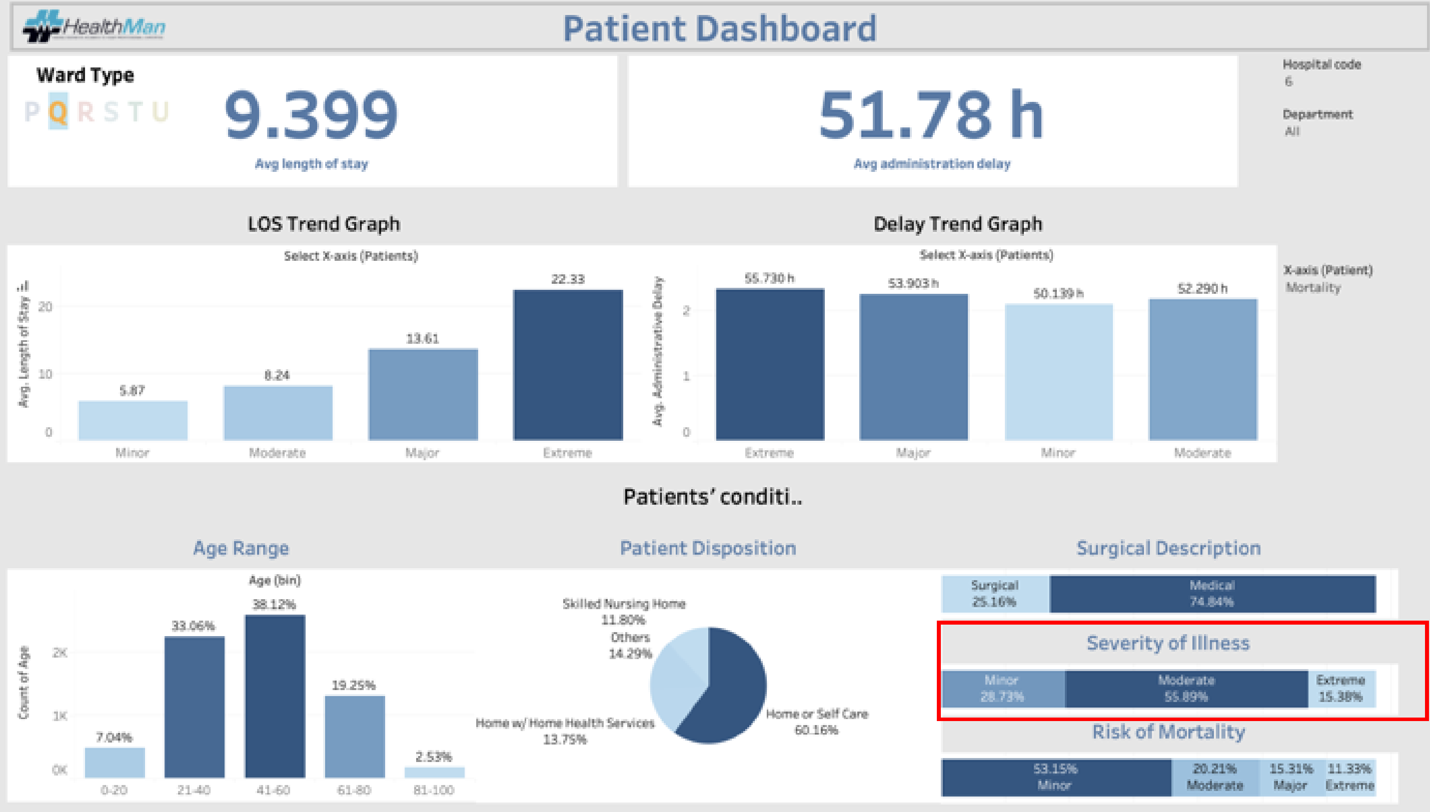
Section 9.2.2 in written report

(Help hospital management target patient related processes with high LOS/Delay, EG: Discharge to skilled nursing home has highest LOS/Admin Delay)

Appendix







Section 10.1 in written report
(Similar severity spread within different ward types which could prolong LOS)