Optimizing Logistics of Patient Transportation Process

Final Capstone Report - Fall 2018

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1. Executive Summary

As part of a capstone project, our team reviewed the process for an individual to be discharged from one of four specialty hospitals within the University of Pittsburgh Medical Center (UPMC) System. UPMC operates a hub and spoke system where patients that require acute medical care are sent to the systems specialty hospitals in Pittsburgh. Given this system, the Specialty hospitals operate continuously at near capacity. Due to this operational structure, patients that are ready to be discharged from the hospital, but are still occupying their beds, cause a backup in hospital operations. This backup occurs daily as doctors make their rounds and discharge patients, but the patients do not leave their beds until hours later when proper arrangements can be made. The Heinz College Capstone

Team mapped the process and systems that underpin an individual’s hospital stay, analyzed patient stay data, and sought out process improvements to decrease the time it takes and individual to leave the hospital once they have been discharged.

2. Introduction

2.1. Background

A resounding problem across the health industry and emergency services is that emergency departments are increasingly overfilled and, in turn, are thus slow to get patients moved to the floors. This is augmented by failures in discharge transportation that lead to proximal backups in the entire health system as beds may remain occupied from hours to days by patients without a ride.

2.2. Problem Statement

UPMC is facing the following issues:

- Space limitations because the ICU or floor beds are not available
- Patients waiting in the waiting room or in an emergency room for a bed
- Patients unable to get transferred from community hospitals to the main academic center
- Loss to the hospital in terms of revenue

In addition, the operation process for scheduling the ambulances is not efficient as it involves manual intervention. Multiple calls to the ambulance companies are made for the ride requestc causing the beds to remain occupied for a longer time.

Our work on this project aims to analyze reasons and the processes that are causing discharge delays and provide recommendations for improvement.

2.3. Stakeholders UPMC

Name Organization Contact Detail Role on the

Project

Lenny Weiss UPMC - Department of

Emergency Medicine weissls2@upmc.edu

Project Sponsor, Primary point of contact

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Trish George

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Provider Avinash Vemulapalli UPMC – PARC vemulapallia@upmc.edu Software Engineer

Miles Darby UPMC - PARC darbymo@upmc.edu EMS Specialist

2.4. Stakeholders - CMU

Name Organization Contact Detail Role on the

Project Chris Kowalsky CMU - Faculty chris.kowalsky@gmail.com Faculty Advisor

Anubha Varshney CMU – Grad Student avarshn1@andrew.cmu.edu

Quality Assurance Manager, Data Analyst Dheeraj Jaiman CMU – Grad Student

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Process Manager, Risk Manager, Data Analyst Erica Collins CMU – Grad Student

ericacol@andrew.cmu.edu Project Manager

Xinlu Yao CMU – Grad Student xinluy@andrew.cmu.edu

Financial Manager, Documentation Manager, Data Analyst

3. Project Specifications

3.1. Scope Statement

Project Title: University of Pittsburgh - School of Medicine **Date:** Sept 30, 2018
Prepared by: Erica Collins, Dheeraj Jaiman, Eric Shapiro, Anubha Varshney, Xinlu Yao

Project Justification: The University of Pittsburgh - School of Medicine has identified multiple bottleneck issues relating to hospital capacity. They have identified the time it takes for an individual to leave a hospital once they have been cleared to do so as a major issue within the system and the one to be addressed first. They believe that greater information regarding the number of discharges will help other actors outside the hospital to better serve those discharges and in turn lower the time between a patient being discharge and a patient leaving the hospital.

Product Characteristics and Requirements:

- Analysis of delays throughout the patients' stay in the hospital
- Text analysis of the reason for delay field that the health unit coordinator fills out
  - Classification of reasons for delay
  - Recommendations for ending delays that lead up to the discharge process
- Design and Prototype for PARC data input
  - At a minimum, providing PARC with a user interface so that they no longer manually enter random data but choose form fields
- Recommendations for systems that will lead to a smoother running PARC
- Concepts for a GPS based alert system to dispatch ambulances

Note: From the original project description, we are going to exclude the sector of 911 medical transports

Summary of Project Deliverables

- A graphic or visualization that shows delay reasons and where they occur, summary of issues, recommendations for fixes
- A prototype with improved UI for PARC system
- A document on recommendations for PARC
- A document discussing concepts for a GPS based alert system

Project Success Criteria:

- Client is able to successfully understand how delays are affecting the functioning of hospital system - stakeholder feedback
- Client is able to improve the efficiency of system at PARC - stakeholder feedback

3.2. Project Timeline

Topic Deliverable Notes Learning Objective

Session 1 – (Sept08-Sept14)

Project Organization, roles and responsibilities, client kickoff meeting agenda, project description review with research assignments

Create: Roles and Met responsibilities, client agenda, high level project plan, Bio's, and Skills Inventory

with Stakeholders and went over initial problem set. Toured Facilites and started documentations and stakeholder mapping

Project team organization and formal client communication.

Session 2 – (Sept15-Sept22)

Project Report-out. Review: Roles and responsibilities, client Project Organization, roles and agenda, high level responsibilities, client kickoff

project plan and results, meeting agenda, project description

if appropriate, from the review with research assignments

initial client sessions. Perform Stakeholder Mapping, and Project Risk Assessment.

Worked on documenting terms and findings and Stakeholder Mapping

Project team organization and formal client communication.

Session 3 – (Sept23-Sept30)

Project Report-out. Signed off scope, Final Scope, project plan, and detailed project plans, project assignments

draft of Quality Plan to Creation of the Quality Assurance

be reviewed by Team Plan

and advisor. Project Overview Document review.

Received late data. Signed Off Scope

Problem assessment with Scope development

Session 4 – (Oct1-Oct7)

Client executive summary review; Project Client meeting notes, project plan activities, issue and risk log reviews

Report-out. Final Quality Plan for project development and completion use

Best practice project management methods using (PMI and AGILE principles).

Session 5 – (Oct8-Oct14)

Received Data & Started EDA

Project Report-out. Review of project plan outcomes and next weeks plans

Best practice project management methods using (PMI and AGILE principles).

Session 6 – (Oct15-Oct21)

Client meeting notes, project plan activities, issue and risk log reviews

Completed EDA and Prepared for Midterm

Client meeting notes, project plan activities, issue, risk log reviews, draft of midterm presentation review for client point of contact assessment.

Project Report-out. Draft Mid Term PowerPoint, Issue and Risk Log with mitigation proposals

Midterm Presentation Completed

Problem assessment with Scope development

Session 7 – (Oct22-Oct28) Midterm Presentation; Peer Review

Client approval to proceed with final 7 weeks recommendations. Confidential peer reviews due to advisor

Review of Midterm Presentation during Team Meeting. Peer Review completed.

Problem assessment with Scope development
Session 8 – (Oct29-Nov4)
Project Plan for the remaining 7 weeks, Peer reviews discussed to insure improvements areas are addressed
Project Report-out. Project activities results team review. Completion of Peer Review.
Created project plan. Still need to discuss peer review
Use of project planning technology and project documentation repository.

Project Development Use cases and test scenarios developed with client for user **Session 9 –**
acceptance testing Developing **(Nov5-Nov11)**
Project Risk and Quality Assurance reviews Poster Development Framework
Project Report-out.
Poster Use Quality Assurance: Peer
Framework. Need to process or code reviews
finilize findings
of project planning technology and project documentation repository.

Session 10 – (Nov12-Nov18) Unit Testing

Project Report-out. Project activities results team review. Poster board draft
Developing Poster Framework. Need to finilize findings
Development and formal testing processes
Session 11 – (Nov19-Nov25)
Project Communication of Report-outs, Executive summaries, Proposals, and final project deliverables and knowledge and technology transfer at project closure.
Session 12 – (Nov26-Dec2)
Material to be discussed Final Review of Poster Board Client Executive Summary review Final Paper and Presentation Checklist Template
Project Report-out. Project activities results team review. Poster Board final draft for Poster Creation
Reviewed Material for Final Poster and started drafting finla presentation.
Project Report-out.
User Acceptance testing Quality and Risk log with mitigation
Project team Quality out, proposals. mitigation
review. activities Assurance Review Issues results Final report log,
Final with Final New Stakeholder Meeting David, Lenny, Jessica. GPS, Findings Draft, Data Completed.
Presentation Checklist.
Development and formal testing processes
Session 13 – (Dec3-Dec9)
Project Communication of Report-outs, Executive summaries, Proposals, and final project deliverables and knowledge and technology transfer at project closure.
Session 14 – (Dec10-Dec25)
Project Report-out. Draft Review of final project solution,
PowerPoint and report, User acceptance signoff,
project test results, client Review of final presentation draft
user acceptance testing signoff. Team to discuss lessons learned.
Final Presentation Preperation and Slides
Final Project Presentation in Hamburg Hall and at the client offices (unless client chooses to attend the session at the Heinz College). Technology (or Process) turnover to client Project Closure
Final presentation, paper, and project documentation. Completion of Peer Review.
Report Finalization & Presentation. Project closure

4. Research Interviews

5. Patient Flow Process

Patients arrive at the emergency department through multiple channels, including walk-in (or drive-in) and ambulance. Depending on the nature of the emergency, the patient may be served through an ambulatory or a non-ambulatory section of the emergency department. The patient (or a friend) meets with a receptionist to collect background and information, and a nurse to triage (prioritize and stabilize) the patient. Patients are served by physicians and nurses in treatment rooms, which may be specialized to particular injuries (e.g., orthopedics) or specialized by level of urgency. Before treating the patient, tests (X-ray, CT Scan, MRI, etc.) may be needed through a radiology department. In some cases patients must be moved to an operating room for surgery. Once emergency treatment is completed, it may be necessary to admit the patient to the hospital, in which case the patient is exposed to additional processes and delays. Eventually, the patient undergoes a discharge process, and his or her bed must be prepared for the next patient.

The diagrams below show the patient flow process in UPMC hospitals.

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6. Datasets

6.1. De-identification

6.2. System Architecture

The below diagram provides the high-level overview of our data processing steps categorized as follows:

1
1

1. Pre-process: - we received the following excel files from UPMC. In the pre-processing steps, we removed the records, which does not contain the information, from the datasets, manipulated data fields, and created the unique identifier.

Dataset Name Unique Identifier Pre-processing steps

Milestones VisitNumber_Code,

Hospital_Code, Unit_Code

• Replaced the hospital code 5 with 4

• Dropped the VisitCode field as it is not used in the processing

• Filtered dataset with VisitNumber_Code, Hospital_Code, and Unit_Code non-null

• Calculated the time difference Discharged and Confirmed Discharged and converted it into minutes and hours

• Generated the delay flag

Request to assign

• Replaced the hospital code 5 with 4 VisitNumber_Code,

• Filtered dataset with Hospital_Code,

VisitNumber_Code, AssignedUnit_Code

Hospital_Code, and AssignedUnit_Code non- null

PARC Hospital_Code, Unit_Code,

Room_Code, Bed_Code

• Replaced the hospital code 5 with 4

• Filtered dataset with Hospital_Code, Unit_Code, Room_Code and Bed_Code non-null
2. Transformation: - we merged (inner-join) the milestone and the request to assign datasets based on the above-mentioned unique identifiers
3. Data Analysis and results: - after pre-processing and transforming the datasets we performed the data analytics and share our results.

Issues: 1. Manual creation of the delay flag as it was not populated correctly in the dataset – the delay details field was blank for most of the records 2. PARC dataset does not contain the Visit Number code hence we were unable to
match it with milestones 3. The Room codes are not correctly populated in the datasets
12
Limitation:
1. Analysis is performed at Hospital and Unit code level only. The granularity of analysis (i.e. to include Room_Code and Bed_Code) can be increased once the room code issue is fixed 2. Analysis of merged PARC and Milestone dataset is not performed as we could not
link the PARC dataset with milestones

6.3. Data Specifications

6.3.1. Milestones:

This dataset is from the Teletracking system. It provides information on the discharge details of the patients such as the discharge times, delays and reasons for those delays if any. It also has the location of the patients in the hospitals. Each row denotes a visit made by a patient to the hospital.

Attribute **Attribute**

Type **Description Sample Data**

PendD Datetime
Time that floor "thinks" patient will be soon ready for discharge and they mark them as "pending"
4/30/18 16:39
ConfD Datetime
Time the doctor puts order in system saying patient is good to go and is actually discharged
5/2/18 14:11
Discharged Datetime Time room the patient actually leaves the
5/2/18 21:40

ConfDtoDisch Text Difference ConfD between Discharged and
26975 seconds

Delays Number Number of delays that occur for each patient 1

DelayDetail Text Reason for delay

Transportation-Ambulance- transportation has not arrived

Hospital_Code Number Hospital Identifier 2

VisitNumber_Code Number Unique patient ID/account number 3003

Room_Code Number Room within hospital 196

13

Bed_Code Number Bed within room 16

Unit_Code Number Unit within hospital 3

Created Variables:

Attribute Attribute

Type Description Sample Data

Hosp&Unit object Concatenation of hospital code and unit code 2_17

Delay(hour) float Difference hours between discharged and confD times in

2.366667

delay_flag float Flag based on Delay(hour). If Delay(hour) > 1.9,

then 1.0 else 0.0 1.0

DelayFirstCat object First category from delay detail column Transportation

6.3.2. Request to Assign

This dataset is from the Teletracking system. It provides information on how long it took an individual to get assigned a bed in the hospital. It has timestamps for the time a bed was request and a timestamp for when a bed was assigned as well as other information about where that bed was located in the hospital. It also contains a visit identification number to link between datasets.

Attribute Attribute

Type Description Sample

Data

RequestDateTime Datetime The time the origin unit requested the bed 1/22/18 12:19

AssignedDateTime Datetime The time bed was actually assigned 1/23/2018

12:15

RequesttoAssign Text

Difference between AssignedDateTime and Request DateTime. Please note that it is in seconds and hours:minutes:seconds format

86190 seconds and 3:30:20

VisitNumber_Code Number Unique patient identifier/ account number 20156

Room_Code Number Room Identifier within hospital 426
Bed_Code Number Bed Identifier within hospital 5
OriginUnit_Code Number Unit from which patient arrived 127
AssignedUnit_Code Number Unit to which patient was assigned 17
Hospital_Code Number Hospital Identifier 2

Created Variables:

Attribute Attribute

Type Description Sample

Data

RtA_sconds Float Difference between AssignedDateTime and Request

DateTime.in seconds 83948

Requesthour: Integrer The hour pulled from the RequestDateTime field, in 24

hour time. 3

Use in Project: The data was used to group by Requesthour, Requesthour and Hospital_Code to get the average RtA_sconds for each hour of the day.

6.3.3. PARC

This dataset has information about ambulance scheduling.

Attribute Attribute

Type Description Sample Data

TripDate Datetime Date of trip 7/5/18 12:00

TripPriority Text How quickly trip needs to happen:

when able or asap Routine

TripStatus Text Status of trip Complete

PickupZipcode Number Zip code of the address of place to

pick up patient 15219

OtherDrop Text Drop off location Carleton Senior Care and

Rehabilitation Center

DropoffZipCode Number Drop off Zipcode 15217

Accepted Text

CareLevel Text What level of care is needed BLS, ALS, Wheelchair

Van, etc
ReceivedDateTime Datetime Time call received for request 7/4/18 8:46
RequestedDateTime Datetime What time they want the pickup 7/5/18 12:00
ScheduledDateTime Datetime What time pickup was "scheduled" 7/5/18 10:30
Unit_Code Number Unit Identifier within hospital 78
TripID_Code Number Unique trip ID for PARC only 16210
Agency_Code Number
Unique code for Ambulance/transport company doing the job
7
Room_Code Number Room Identifier within hospital 52
Bed_Code Number Bed Identifier within hospital 5
Hospital_Code Number Hospital Identifier 1 or 2 or 3 or 4

Created Variables

Attribute Attribute

Type Description Sample

Data

Hosp&Unit object Concatenation of hospital code and unit code 2_17
Hosp&Agency object Concatenation of hospital code and agency code 2_15
16
Hosp&Unit&Agency object Concatenation of hospital code, unit code and
agency code 2_17_15
diffSchReq(hours) float Difference between scheduled times and requested
times in hours 2.3

7. EDA

7.1. Milestones

The dataset is from 8 August 2017 to 15 August 2018. Patients' locations have next to 0 null values, but there are a lot of null values in delay details. This is because not all the hospitals are compliant in filling out the delay details. The dataset has 4 hospitals, 2 of which we combined, since one was a wing of the other. So the three hospitals that we analyzed are – Mercy, Presbyterian and Shadyside.

Following graph shows the hourly trend of confirmed discharges and actual discharges throughout the year. **From this we can conclude that:**

- The times when a patient is confirmed to be discharged and when they are actually discharged follow the same trend throughout the year
- Peak times for confirmed discharge are around 10am - 3pm, and peak times for actual discharge are around 2pm - 4pm

For analysis of distribution of patients, we removed duplicate records per VisitNumber_code to get the distribution at visit level. The duplicity was only when there were multiple reasons for delays.

If we look at the distribution of patients per hospital, we see that **Hospital 2 (Mercy) has the most number of visits and Hospital 4 (Presbyterian) the least.**

Since all hospitals do not fill out delay details, and since the "Delay" column has value 1 only if delay details are filled, we had to generate a delay flag based on the difference between Discharged and Confirmed Discharged columns. The rule which is followed in hospitals and which we used to calculate delay flag is that if the difference is greater than 1.9 hours, then it is classified as a 1 and 0 otherwise. It was found that:

Overall, 56% records where delay details were not added, were actually delays. Breaking down per hospital it comes to - Hospital 2 - 65%; Hospital 4 - 49% ; Hospital 6 - 40%.

These numbers give an approximate measure of how much, which hospital is compliant in filling out the details. In addition to above, 12% had delay details entered even though the gap was not more than 2 hours. This shows that there is a need of standardizing the process of entering data.

Using this delay flag, we calculated average delay hours on various parameters.

Hospital 2 has the most number of visits so it faces maximum average delay sounds right. However, even though hospital 6 gets the next most number of visits, but hospital 5 shows a higher average delay time (comparable to hospital 2).

Then we check out the distribution of patients for units within hospitals.

Hospital 2-unit 98 has only 2 rooms and does not get many visitors. Still a lot of delay, because of very large difference in some fields. Hospital 2-Unit 131 seems to be another area with bottlenecks.

7.2. Request To Assign

Hospital 5 (Presbyterian) shows very less average delay while Mercy and Shadyside shows comparatively big delays (in seconds).

7.3. PARC

The PARC dataset is at the trip level. The graph below shows that Hospital 4 (Presbyterian) scheduled the most number of trips, while Hospital 6 (Shadyside) scheduled the least number of trips. But the maximum average delay is shown by Hospital 2 (Mercy).

If we look at agencies, most number of trips were scheduled for agency 31 and 7. While agency 31 had some average delay in scheduling, agency 7 showed less amount of delay as compared to others.

2
1

8. Text Analysis

We did text analytics on the delay_detail column in milestone dataset. By extracting the main categories from the column and counting the number of each categories, we can tell that 13881 delay records are related to transportation, 2597 delay records are related to nursing related problems. The graph confirmed the assumption that transportation is a crucial factor that causes delay in patients discharge.

Then we extracted the subcategories from the transportation category, the plot shows that in the transportation category, private vehicles, ambulance and family pickup are

top three reasons that cause transportation delays. Since private vehicle and family pickup have an overlapping issue, we want to recategorize private vehicle category.

Before processing this step, we have to do some data cleaning first. We use bags of words method. All the verbs, punctuations, numbers are removed. We manually create a family pickup category include all the words related to family members. The plot tells us that most detailed explanation of the private vehicle category mentions family number. Thus, private vehicle, besides related to bus and taxi, has a big overlapping part with family pickup category. Family pickup is the critical problem resulted in delay in discharge.

9. Time Series Analysis:

9.1. Milestones Delays Time Series Analysis-

2
3

From the plot, we can tell that the peak delay hour is around 10 to 12.

The plots above tell us each hospital delay counts in transportation category in last year. However, there is limitation when we do delay counts in transportation category. Since, a lot of delays do not have detail delay description entered in the dataset and each hospital has different compliance level in recording details, the delay counts we have cannot represent delay situation of the real situation of the hospital as there will be reporting bias. For example, from the plot we can tell there is an increasing trend of delay in hospital 2, but since Hospital2 (Mercy) has a bigger compliance problem than other hospitals, we cannot tell from the increasing trend whether it resulted from increasing transportation delays or from the improved compliance in hospital 2 during latter part of the year.

9.2. Request to Assign Time Series Analysis

The time it takes to have a bed assigned after it is requested is a key indicator of how full the hospital is at any one time. Every patient, no matter how they enter the hospital has to request and be assigned a bed if they are admitted. When it takes longer to get a patient to a bed, it means that they are waiting in another part of the hospital, taking up space and causing delays. When a patient is unable to leave the surgery recovery unit (PACU) because they are unable to get a bed assignment, this causes a substantial added cost to the hospital due to staffing requirements of the PACU. This is just one example of added cost burden due to long assignment wait times. Beyond cost and capacity reasons, if a patient is unable to be assigned a bed, they are not able to receive the lifesaving treatment they require, and this can put their life in jeopardy.

To look at how bed assignment is affected by patients not leaving the hospital after they have been medically cleared to do so, we graphed the time it takes to get a bed in the hospital in seconds by the hour of the day (blue line). We then subtracted the mean for the day at each hour increment so that the graph shows when the Hospital is above or below the mean for bed assignment wait times. After a bed becomes available, it has to be cleaned, we have also graphed the average time it takes to clean a room on the graph so that we can see if that effects wait times (orange line). Finally, we have graphed counts of patients who have been confirmed that they are medically ready to leave the hospital (green line) as well as counts of when those patients actually leave the hospital (red line).

2
5

From these graphs we see the issues play out in different forms of severity between the hospitals. It should be noted that hospital operations follow a normal work day schedule. As doctors begin their rounds, patients begin to be discharged in the early morning hours, starting around 4 AM. As the day progresses, the time it takes to get a bed assignment begins to creep up until

mid-morning, approximately 9:30 AM, as those patients who were deemed medically ready to leave the hospital begin to leave. The time to get a bed continues to fall for the rest of the day. The time it takes to get a bed assigned goes back below its daily average between one and three PM depending on the hospital.

9.3. PARC Time Series Analysis

August has less data available, hence there is a dip, but September is an anomaly here. Other than that all the three times follow a similar trend throughout the year.

2
7

Most of the requests are received between 10am and 1pm. Requested and Scheduled hours follow each other closely except during 6pm to 8 pm.

• 44% of ambulance trips are scheduled at least 1 hour after the requested time
• 37% are scheduled when they are requested or early

Most of the trips made by ambulances are in Pennsylvania, but around 21% go out of state as well.

The above graph shows that ambulances with drop off zip codes that are at a significant distance outside of Pittsburgh, take the longest to book.

10. GPS Design

10.1. Problem Statement

The existing process for scheduling ambulance rides is not optimal. PARC receives the request for a new ride via ECIN system. Then they make the phone calls (iterative) to an ambulance driver to check whether they can accept the ride or not? Once, the ride is confirmed they inform the case manager/social worker via text page. This leads to a delay in the discharge of a patient.

10.2. Proposed Solution

To improve the efficiency of the process, we proposed an automated solution to:

- Place a request for a new ride by the case manager/social worker
- Automatically match with the ambulance
- Send confirmation back to the hospital

The above mentioned three aims can be achieved by a GPS based mobile application.

10.3. Working concepts of GPS based Application

GPS is a space-based satellite navigation-based system. It provides the exact position of an object on or near the earth surface in all-weather condition. It provides information about location, navigation, and time. Mainly, it answers the following five questions: Where am I? Where am I going? Where are you? What’s the best way to go there? When will I get there?

The GPS consists of the following three

components:

- The Space Segment: - Satellites and transmitted signals
- The Control Segment: - ground stations to ensure the satellites are working properly
- The User Segment: - receivers, which can be hold in the hand or mount in the car. The receivers convert the radio signal send by the satellites into four dimensions of X, Y, Z (position), and Time. The following diagram explains the flow of information.

In the context of non-emergency medical transportation, the GPS based application can offer the following solutions:

- Plan more effective routes: - The GPS based application can help in maximizing the efficiency of the routes. If some roads are busy, It can also re- route the paths in real time so that the patients are not late for their drop or appointments. It also helps in finding the shortest path between two locations.

- Avoid Route Redundancies: - The GPS based application can help in avoiding the double coverage i.e. two drivers picking up and dropping off patients in similar areas at similar times. The GPS based application helps in planning the routes better and avoid redundancies.

- Fast Emergency Location When Needed: - The GPS based application provides real-time information about the location. So, the application can be used to know where the emergencies services are provided or receive the directions to help patients get the nearest emergency facility.

- Fleet Tracking: - The GPS based application can be used to identify, locate and maintain contact reports with one or more fleet vehicles in real time.

In summary, the GPS based application is an effective tool for efficient route planning, managing the drivers, and getting patients to their appointment on time.

10.4. Application Proposed Functionality

The mobile application will mainly have the following functionalities:

1. Users -

The mobile application will have the following three types of users:

• Admin: - The admin user will be the someone higher authority at the UPMC. Their access to the application will be very less restricted. This means that they will be able to see all the activities happening in the ecosystem. In addition, they will also have access to reporting capabilities.

• Hospital Staff: - The access of hospital staff (PARC, HUC, and nursing staff) will be limited to the scheduling a ride and canceling the confirmed ride from the ambulance driver. They will be able to track the ambulance location via a map. They will also be able to see their history.

• Ambulance Driver: - The access of ambulance driver will be limited to see all the request coming from the hospital for the ride, accepting a ride, and canceling a ride. They will also have access to their history. Once the ride is accepted, they won't be able to accept another ride unless they cancel the previous one. Once the patient is on-board, they won't be able to cancel the ride.

2. UI Views –

The mobile application will have the following views/screens.

• Login/Sign-up: - This will be the landing page of the application. This will allow the users to sign-up or login.

• Map View: - This view will show a google map to both the hospital staff and the ambulance drivers.

○ The hospital staff will be able to view all the ambulances along with the one that has accepted their request on a map. This will help them in tracking and knowing how much time the ambulance will take to reach the hospital. ○ The ambulance drivers will be able to see the hospital from which the request is coming. This will help them in knowing the location from where the request is coming and then decide whether to accept it or not? This will also help in navigation and routing during the travel.

• Place a Ride request: - The hospital staff will have access to this view. They will be able to enter the following details and place a request for a new ride. ○ Patient Information ○ Pickup Information ○ Patient Drop Address ○ Type of care needed

Once, the ride is confirmed by the driver, they will get the notification.

• Accept the Ride: - This ambulance driver will have access to this view. They will see the requests for a patient drop coming from the hospital and then accept a ride.

• Reporting: - Only, the admin users will have access to this view. They will be able to see the following summaries: ○ Number of the requested ride in a day ○ Number of the completed ride in a day ○ Number of the canceled ride in a day ○ Number of the delayed ride in a day

3. Data –

The application will store the following information:

• Visit Number Code (FIN number of a patient)

• Trip ID

• Trip Date

• Trip Priority

• Trip Status

• Pickup Location (Address)

• Pickup Other

• PickUp Zipcode

• Other Drop

• Dropoff Location (address)

• Dropoff Zipcode

• Agency

• Accepted

• Care Level

• Hospital Code

• Unit Code

• Room Code

• Bed Code

• Received Request Place Date Time

• Requested Date Time

• Schedule Date Time

• Ambulance Arrival Time at Hospital

• Ambulance Leave Time from Hospital

• Patients feedback

4. Matching of Rides with Ambulance –

The ride request with the ambulance drivers will be matched based on the following criteria's:

• Facilities needed and available in ambulance e.g. care level (BLS, ALS, Wheelchair Van) – this will be the primary criteria

• Pickup address – the ambulance which is nearest to the pickup location will be matched first and so on

• Drop off zip code – the ambulance which is not willing to take a drop in a location will not be matched

10.5. Potential issues and recommendations for resolution

We can categorize the potential issues and the recommendations in the following three categories:

Category Potential Issues Recommendations

companies 2.
Tentative demand
the ambulance
companies 2.
Tentative demand

Peopl
e

1. The unwillingness of

ambulance
companies to sign-up
for the new program

the ambulance

1. An Incentive program
can be developed for

3
3

Process 1. Change in operation

process for ride scheduling
1. Training manual and
program for PARC personnel
Technology
1. Separate team (or the UPMC's IT team) can maintain the operation of new application 2.
Data linkage layer can 1. New technology
be created between the (application) need to be

GPS based application maintained by the
and other systems of UPMC
UPMC for the data load 2. Sync of data with other
3. ETL process can be systems of UPMC
created to load a. Data Formats
(incremental and full b. Data Load
load) the data into the strategy
GPS application and extract out the data from the application – these processes can format the data in the desired format

10.6. Future work

In terms of future work, we recommend the following two options:

1. Outside Vendor: - We found that there are existing vendors that provide the medical transportation solution. We recommend that the UPMC team analyzes the capabilities and pricing of these solutions. Based on the analysis results, UPMC can outsource the ride scheduling to the vendor, which meets the requirements and cost- effective. The table below summarizes the capabilities of three different vendors.

Vendor
Name **Capabilities Website Link** Roundtrip 1. Online booking and
monitoring of rides 2. Integrated with Epic, Cerner,
and Allscripts system 3. 99% on-time arrival rate
https://www.rideroundtrip.com/
Acuity- Link
1. Real-time GPS tracking and
ETAs 2. Automatic selection of closet
vehicle based on the required level of care (ALS, BLS, Wheelchair, etc.) 3. Mobile application (iOS and
Android) available
https://www.acuity-link.net/
34
4. Data capture, reporting, and
analysis 5. SaaS-based service model 6. 3-way chat feature allowing
to share medical information in real-time Veyo 1. GPS tracking to know the vehicle location and routes that they have taken 2. A flexible fleet model allowing capacity to scale up and down as needed 3. Mobile application (iOS and
Android) available
https://veyo.com/

2. In-house application: - The second option is to develop the application and deployed it in-house. The application to be maintained by the UPMC team. The pros and cons of this option are as follows:

Pros Cons 1. Flexibility to customize the
application based on the requirements 2. The Application can be easily

linked to other UPMC systems such as PARC, ECIN, Teletracking, etc. 3. Control of data lies with the
UPMC
1. Overhead of development and maintenance of the application
35

11. Recommendations

Based on our analysis, we came up with some recommendations which can help UPitt and UPMC optimize their workflow regarding the discharge process of patients. We have 3 primary recommendation focuses. They include: Data Entry, New Technology, and Operation & Analytics –

11.1. Data Entry

We advise that UPMC improve their data entry process by requiring uniform entry by staff for delay details. We advise to require compliance and implement more automation and drop-down menus. We also advise UPMC to maintain unique identifiers that are consistent through all applications and patient flow processes. Finally, we advise more uniform location detail entry for the patients in the system.

11.2. New Technology

Our primary recommendation for new technology is to create a GPS based application that handles ride scheduling for patients.

11.3. Operations & Analytics

Our recommendation for improvements in operational performance include better links of PARC with Teletracking in order to track the patient journey by providing ambulance scheduled times to Teletracking. Analytics can span multiple pieces of our recommendation, but specific suggestions include using visualization tools to model patient flow patterns & peak times and using tools to better track consumer and patient processes and feedback.

12. Best Practices

Through researching other hospitals we found that many are using analytics and lean practices to improve the problems detailed in our scope. Two notable examples include lean practices that have been implemented at Health First, and prediction algorithms developed by the University of Maryland. At health first they established the Central Patient Logistics Center, a bed management center headed by non-clinical staff with a "bird's eye view". The hospital also implemented centralized registration, centralized utilization review, transfer access nurses and an electronic intensive care unit.

Additionally, researchers at University of Maryland College Park used Tree-based supervised machine learning algorithms to predict if patients are expected to leave by 2pm or Midnight. In their results they observe that observation status is the most critical predictor relative to predicting the outcome. Patients who are not on observation status (i.e., an intermittent care status to evaluate whether they need to be admitted) tend to stay, regardless of any of their other conditions. Patients who are on observation status are more likely to be discharged only when their elapsed LOS exceeds approximately 12 h or if they reported chest pain as their chief complaint.

This proves that issues such as bed wait times and discharge delays are very common in hospital challenges and that analytics has been proven to improve these challenges. We believe UPMC is in a strong place to implement some of these practices in order to create a best hospital operational model possible and reduce delays and wait times significantly.

Citations: J Am Med Inform Assoc. 2016 Apr
https://www.healthcareitnews.com/news/case-study-health-system-slashes-hospital-bed-wait-times-tapping-lean-it

13. Lessons Learned

• Need to follow the compliances to get the patient specific data containing personal information

• Healthcare data is messy and non-structured, preprocessing is required to use it for analytics purpose

• For the data de-identification, the CMU team should work closely with the UPMS and get involved at the initial stage of project itself

• Support of project sponsor is critical in the success of project - try to engage them as much as possible

14. Next Steps

After completing the current capstone project, we noted many avenues for further investigation and development that future capstone projects could explore. Below are three possible projects that would be substantial undertakings.

▪ **Review of Costs Incurred by Patients who stay beyond their initial Discharge Time:** The outcome of this project could be a model to decide if and how much of an incentive could be offered to an ambulance company or another relevant party that is keeping the patient from leaving the hospital. The hope is that the incentive would reduce the time the patient is in the hospital after they are able to be discharged. The data required for this task would be further data from teletracking, insurance information, and other relevant cost data from the hospital.

▪ **Predictive model to help facility PARC operations:** Currently PARC is calling Ambulance carries to identify who can provide transportation for the patient in the hospital. This model would order the companies in likelihood of their probability to take the patient at the requested time. It could also take some of the burden off the PARC employees by ensuring the transportation provider accepts the insurance of the patient. The data required for this project would be as much historical PARC ride request data as possible. Insurance information, as well as what transportation companies take which insurance.

▪ **Predictive models to know how many patients will get discharged at different points of time:** This project would seek to accurately predict when a patient would be discharged from the hospital and how many would require specific types of transportation methods. This would allow the hospital to anticipate capacity needs for discharging patients. The only data available to the capstone team was metadata on the patient's location within the hospital and when they left the hospital. No health data was made available. As it is understood by the capstone team, patient health information is stored as unstructured text in the patients record. The team could take two avenues, look for other health diagnostic data collected on all patients or parse the unstructured data. Either would be a substantial task.

▪ **Adopt GPS-based application for ride scheduling:** This project would focus on implementing either all or some portion of the GPS system outlined in this report. Any roll out of such a system will required a large amount of preparation and negotiation to make sure that all stakeholders are on board with the new system and participate accordingly.

The data requirements for this project would be minimal but the stakeholder logistics would be immense. Creating a GPS-based application to help automate the PARC process would be a natural progression from the base this capstone project has provided.

15. Glossary

Administrator on Duty (AOD): At least 2 individuals with a minimum of a nursing degree act at the AOD 24/7 in a UPMC hospital assigning beds.

Admissions Discharges and Transfers (ADT): This acronym is used to describe systems that track the Admissions, Discharges and Transfers from the hospital.

Electronic Health Record (EHR): A digital version of an individual's health record. This file contains all vitals data and other treatment information of the patient.

Emergency Department (ED): The department of the hospital that all patients who show up at the hospital with an injury/medical condition will be sent for initial screening and treatment.

Health Unit Coordinator (HUC): The individual in each unit who manages phone, Teletracking, and patient movement.

MedCall: A group of people that use Central Logic .They take in information for Central Logic. Then beds booking can be done in MediPAC and update in Teletracking.

Operating Room (OR): The place where surgeries take place.

Post Anesthesia Care Unit (PACU): Unit in the hospital where surgical patients recover from anesthesia after having surgery. Patients are only in the unit for a short amount of time (hours).

PARC: The business unit at UPMC that handles all ride requests from UPMC facilities (hospitals, nursing home, etc.).

Surgical Scheduler: Similar to a HUC but instead of for hospital unit, works with surgery patients and the schedule for the operating room.

System
s

Canopy: System used by a HUC to discharge a patient. Used for ride scheduling and denoting delay reasons.

Central Logic: System used to take in pre-admission information by MedCall group.

Cerner: System used for electronic health record.

ECIN: System that is used for transportation referrals by PARC. It ties into Canopy.

Epic: System used to create reservations for admission to the hospital.

MediPAC: System for ADT requests.

PARC System: Information system used to complete PARC's mission. Contains patient information related to ride requests (rides include ambulances and wheelchair vans).

Surginet: A product made by Cerner. The system is used to schedule patients for the Operating Room.

Teletracking: System used to track a patient's journey throughout the hospital.

Methods to Leave the Hospital

Ambulance: A specialized vehicle to transport individuals. When discharging patients, it is used for patients who cannot walk or would have trouble leaving under their own volition.

Family Pickup: A personal vehicle of the patient's family is used to take the patient home.

Private Vehicle: A personal vehicle of the patient, family, or friends is used to take the patient home. It can also be a taxi, bus etc.

Taxi: A car for hire that will pickup and drop an individual off at a location for a fee. Used for patients who do not have a ride and can move under their own volition. Patients also have to be able to afford the cost of the ride.

Wheelchair Van: A specialized vehicle for transporting individuals who are in wheelchairs.

16. Risks Log