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Zekelman School of Business & Information Technology
Data Analytics for Business

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Project Final Report

Enhancing Emergency Room Efficiency

Group 10

EDUARDO CHAVEZ BARRIENTOS – 0828349
NOUSHIN ASADSAMANI – 0829532
JERUSHA SHEBA MABEN – 0825449
MANUSHREE VENKATESH – 0822892
PEARLIN RONALD PEREIRA – 0815060

Guided By,
Prof. Hanan Swidan

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Abstract

The objective of this project was to develop an effective management system for the Emergency Department (ED) using data from the MIMIC-IV database. The system was designed to address critical issues in the ED such as patient care delays, prolonged waiting times, and overcrowding. The project plan included the development of six key components: real-time patient tracking, optimized medicine reconciliation, improved diagnoses management, simplified Pyxis system integration, an acuity-based triage system, and routine vital signs monitoring.

The real-time patient tracking system was designed to manage patient flow from the point of entry to exit in the ED. The optimized medicine reconciliation process ensured accurate and updated information about patients' current medications. Improved diagnoses management involved post-discharge analysis of billed diagnoses data to gain a deeper understanding of patients' conditions and inform future treatment planning. The simplified Pyxis system integration aimed to improve medication management in the ED. The acuity-based triage system prioritized patient treatment using triage data such as vital signs and acuity levels. Lastly, the routine vital signs monitoring system automated the collection and evaluation of routine vital signs for admitted patients.

Acknowledgments

We would like to express our profound gratitude to Professors Hannan Swidan and Jhon Ulakovich for their invaluable assistance in this project. Their expertise and guidance have been instrumental in helping us navigate the complexities of healthcare systems and reach out to relevant institutions. We appreciate their unwavering support and collaboration throughout this project.

Despite the challenging situation we faced through the data gathering, it highlighted the resilience and adaptability of our team. We were able to swiftly respond, adapt, and continue our work, turning a potential setback into an opportunity for learning and growth, thanks to the guidance and support from Professors Jhon and Hannan.

Once again, we extend our heartfelt thanks to Professors Jhon and Hannan for their contributions. Their insights and expertise have greatly enriched this project, and we look forward to future collaborations.

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Introduction

The Emergency Department (ED) is a critical component of healthcare, serving as the first point of contact for a diverse cohort of patients with varying degrees of medical severity. The ED operates under resource constraints, with human attention being the most valuable resource that needs to be effectively allocated to maximize positive patient outcomes. Recent advances in algorithmic approaches have opened up exciting opportunities for enhancing the quality of care delivered in the ED.

The ED faces significant challenges such as patient care delays, prolonged waiting times, and overcrowding. These challenges are exacerbated by limited resources, including medical personnel and equipment. Striking the right balance between addressing urgent cases and providing timely care for less severe conditions is a constant struggle. Effective solutions necessitate careful coordination and resource optimization to efficiently navigate the complexities of emergency care. This project aims to improve the operations of the ED by leveraging the wealth of data provided by the MIMIC-IV from a Boston-area tertiary academic medical center.

The MIMIC-IV database provides a wealth of detailed, real-world healthcare data that can be leveraged to address the challenges faced by the ED. By analyzing and applying this data, we can develop effective solutions that enhance patient care, improve resource management, and create a more efficient and responsive emergency care environment.

Dataset Description

MIMIC-IV is a relational database containing real hospital stays for patients admitted to a tertiary academic medical center in Boston, MA, USA. MIMIC-IV contains comprehensive information for each patient while they were in the hospital: laboratory measurements, medications administered, vital signs documented, and so on. MIMIC-IV is separated into “modules” to reflect the provenance of the data. There are currently five modules: “hosp” - hospital level data for patients: labs, micro, and electronic medication administration; “icu” - ICU level data. These are the event tables, and are identical in structure to MIMIC-III (chartevents, etc); “ed” - data from the emergency department; “cxr” - lookup tables and meta-data from MIMIC-CXR, allowing linking to MIMIC-IV; “note” - deidentified free-text clinical notes. For this Project we stick into the “ed” module that contains data for emergency department patients collected while they are in the ED. Information includes reason for admission, triage assessment, vital signs, and medicine reconciliation.

Data Pre-Processing

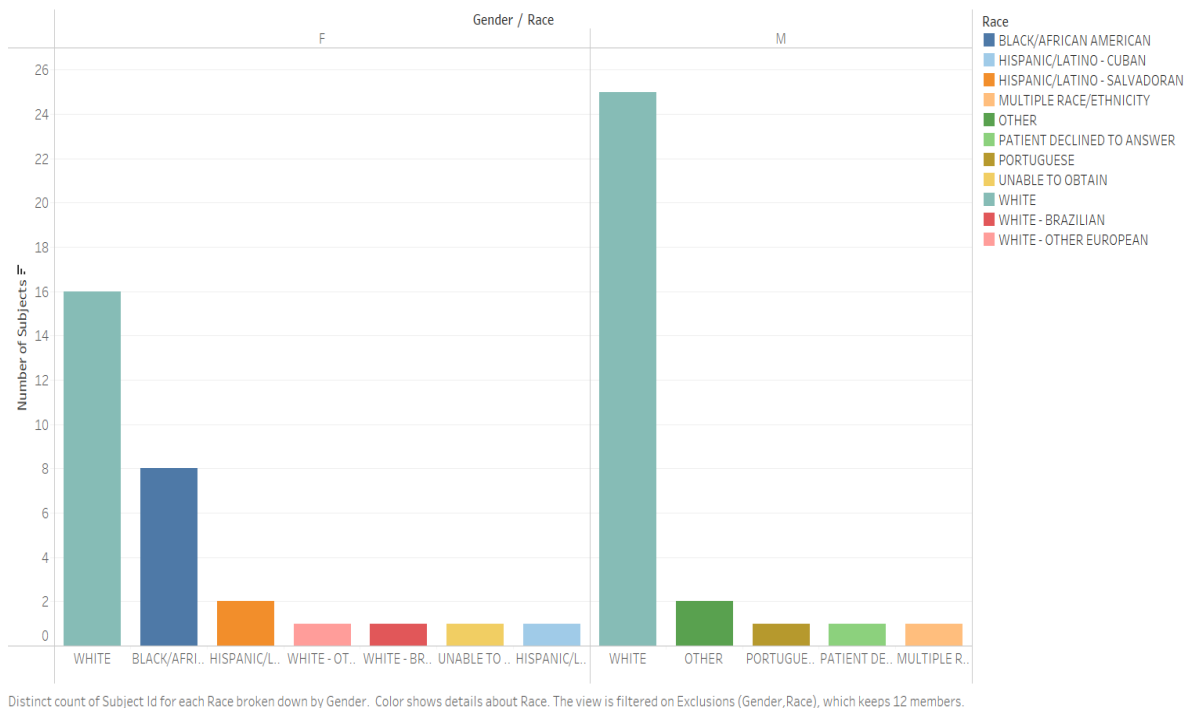
The dataset in question is composed of six interrelated tables. These tables are interconnected, meaning that they share common identifiers that allow them to be linked together. In this case, the common identifier is 'subject_id', which serves as the primary key.

The first step in our data preprocessing was to merge these six tables into one comprehensive dataset. This was done using the 'subject_id' as the primary key. By merging the tables in this way, we were able to create a unified view of the data, making it easier to analyze and draw insights from. Next, we conducted a thorough search for duplicate entries and null values within the dataset. Duplicate entries can skew the results of our analysis, while null values can cause errors in our predictive models. Therefore, it was crucial to identify and address these issues early on. We used various data cleaning techniques to handle duplicates and null values. For instance, duplicate entries were removed to ensure that each record in our dataset was unique. Null values, on the other hand, were handled based on their nature and impact on the overall dataset.

After completing the data cleaning process, we were left with a clean, structured dataset. This dataset consisted of 284,823 samples, with each sample having 43 features.

Visualization

Number of Subjects by Race and Sex

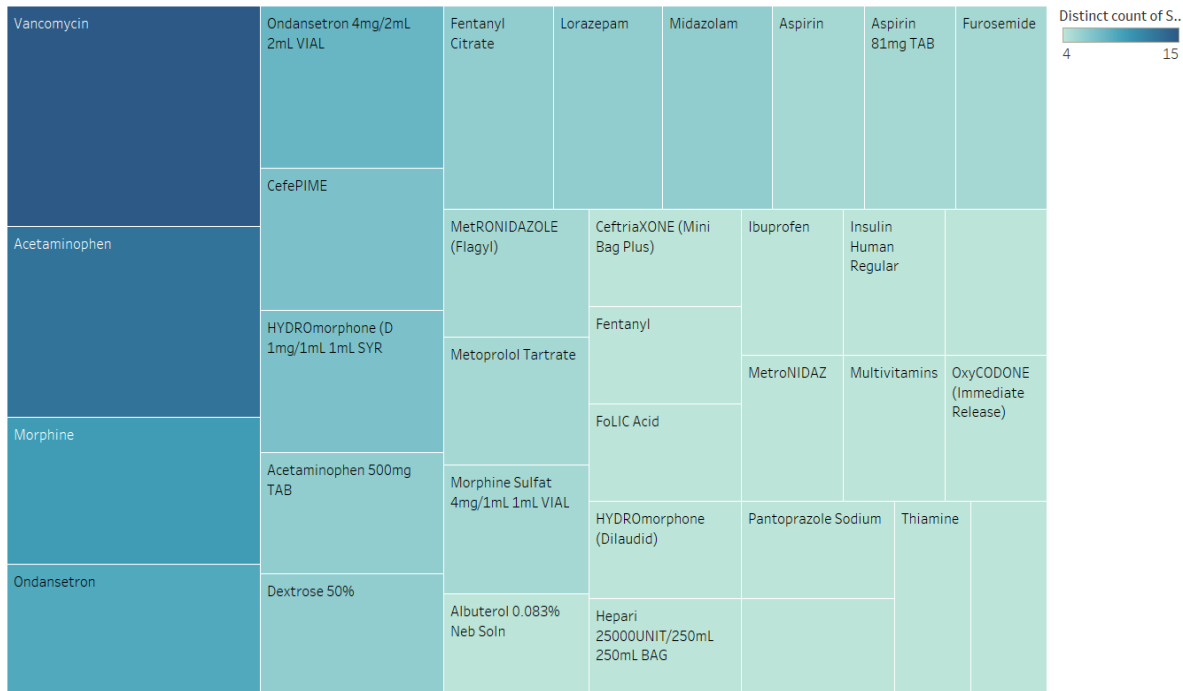


The depicted data reveals a notable gender discrepancy in emergency room (ER) casualties, indicating a higher incidence among men.

Delving into male admissions, a predominant representation is observed among white individuals, with other races/ethnicities following in frequency. In the realm of female ER visits, white women emerge as the most frequently admitted subgroup, trailed by Black/African and Hispanic/Latino - Salvadorian women. Interestingly, Hispanic/Latino - Cuban women exhibited the lowest frequency of ER visits.

These findings not only underscore the gender-specific patterns in emergency healthcare utilization but also emphasize racial variations within these gender-based trends. The data prompts further exploration into the factors contributing to these disparities, potentially informing targeted healthcare interventions and resource allocation to address the specific needs of diverse demographic groups in emergency medical settings.

Commonly Used Drugs



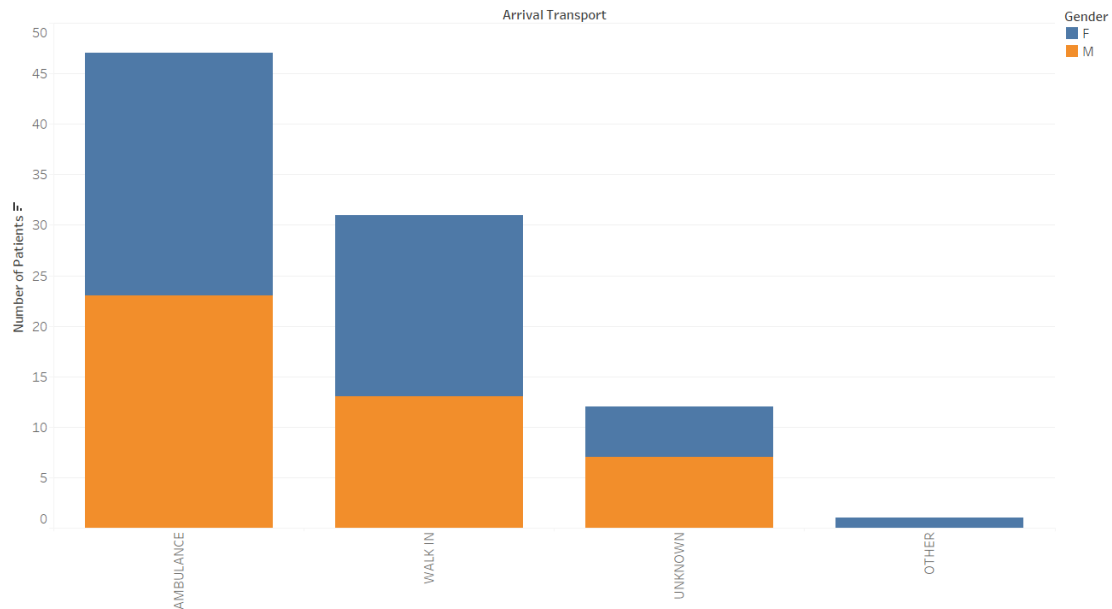
Name Y. Color shows distinct count of Subject Id. Size shows distinct count of Subject Id. The marks are labeled by Name Y. The view is filtered on Name Y and distinct count of Subject Id. The Name Y filter excludes Null. The distinct count of Subject Id filter includes values greater than or equal to 4.

Vancomycin emerged as the predominant pharmaceutical intervention in the emergency room (ER), commonly employed to address a spectrum of bacterial infections. Notably, its therapeutic efficacy extends to severe skin and soft tissue infections, bacterial pneumonia, bone and joint infections, and bloodstream infections.

Following closely in utilization were paracetamol and morphine, serving as staples for managing fever and pain, respectively. Morphine, with its broader applications, is administered for trauma, post-surgical pain, chest pain, and respiratory distress, with due consideration given to potential opioid-related risks.

Conversely, Fentanyl, Folic Acid, Hydromorphone, and several others ranked among the least frequently administered drugs in the ER. The nuanced pattern of drug usage underscores the diverse medical conditions encountered in emergency healthcare settings. Understanding the prevalence of specific medications not only aids in optimizing treatment protocols but also prompts a deeper exploration into the rationale behind differential drug selection. This insight may prove instrumental in refining emergency medical practices and tailoring pharmaceutical interventions to the unique demands presented by a range of clinical scenarios in the ER.

Mode of Arrival



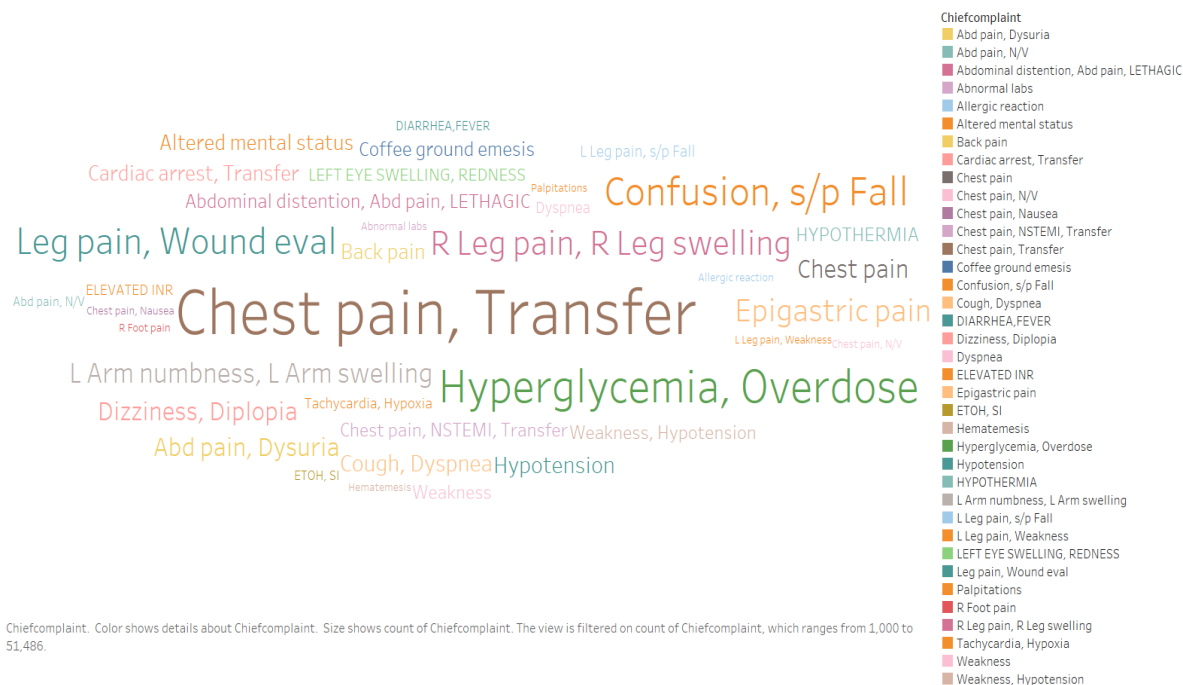
Number of Patients for each Arrival Transport. Color shows details about Gender.

Examining the modes of arrival in the emergency room, a predominant influx was observed through ambulances, constituting the majority of patient arrivals, followed by walk-ins and other unspecified modes.

Intriguingly, a nuanced gender-based trend emerged, revealing that women were slightly more inclined than men to arrive via ambulance. Furthermore, women constituted a larger proportion of walk-ins compared to their male counterparts. The varied modes of arrival underscore the diverse pathways through which individuals access emergency healthcare.

The prevalence of ambulance arrivals suggests the urgency and critical nature of cases, while the higher proportion of women among walk-ins prompts further exploration into the factors influencing their healthcare-seeking behavior. These gender-specific patterns in arrival modes shed light on the complex interplay of medical, logistical, and sociocultural factors that contribute to the dynamics of emergency medical care utilization. Understanding these trends facilitates targeted interventions, ensuring responsive and effective emergency healthcare delivery tailored to the diverse needs and preferences of patients.

Complaints and Symptoms



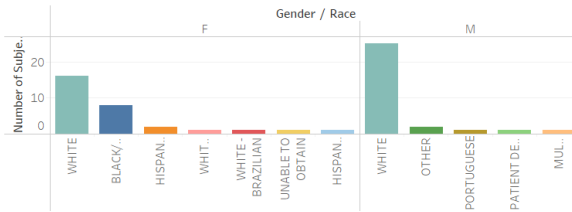
The depicted word cloud analysis illuminates prevalent reasons for emergency room (ER) admissions. Notably, a substantial number of patients were either transferred from another medical facility or admitted with complaints of chest pain, marking these as the most prominent factors driving ER visits.

Following closely in frequency were admissions attributed to hyperglycemia and overdose, highlighting the significant role of metabolic and pharmaceutical factors in emergency healthcare. In contrast, abnormal test results and hematemesis emerged as the least common reasons for ER admissions, underscoring the relatively infrequent occurrences of these medical conditions.

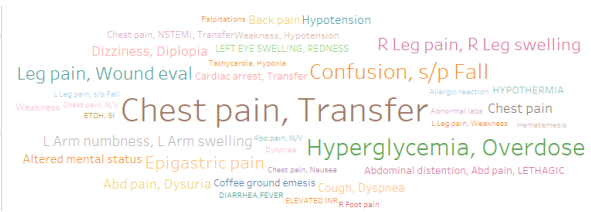
This nuanced insight into the primary drivers of ER admissions provides a comprehensive overview of the diverse clinical scenarios encountered. Recognizing the predominant reasons for seeking emergency medical care informs healthcare professionals, aiding in timely and targeted interventions. Moreover, understanding the less frequent causes allows for a holistic approach to emergency healthcare, ensuring preparedness for a spectrum of medical presentations and facilitating efficient resource allocation in emergency settings.

IntelliCare ER: Enhancing Emergency Room Operations with MIMIC-IV Dataset

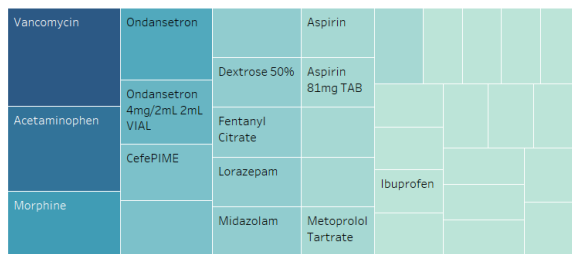
Number of Subjects by Race and Sex



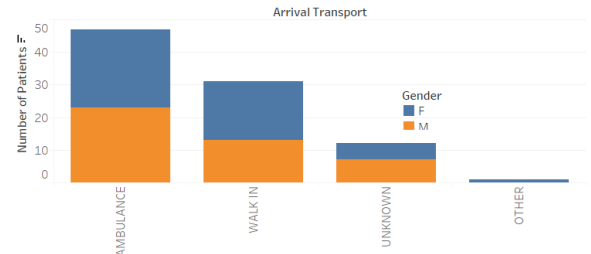
Complaints and Symptoms



Commonly Used Drugs



Mode of Arrival



The dashboard provides a comprehensive visual overview of diverse aspects within the emergency healthcare domain. Through insightful visualizations, it elucidates gender-based disparities in casualty rates, highlighting a higher incidence among men. Racial variations are evident, with white individuals predominantly represented among male admissions, and a similar trend observed among white women in the female cohort.

Pharmaceutical patterns in the emergency room are detailed, emphasizing Vancomycin's prevalence in treating various bacterial infections, followed by paracetamol and morphine for fever and pain management. Additionally, the dashboard delves into the modes of patient arrival, revealing a majority arriving by ambulance. It uncovers gender-specific tendencies, where women exhibit a higher likelihood of ambulance arrivals and constitute a larger proportion of walk-ins.

The word cloud analysis encapsulates prevalent reasons for ER admissions, underscoring chest pain and transfers from other hospitals as primary drivers. Hyperglycemia and overdosage rank as notable causes, while abnormal test results and hematemesis emerge as less common triggers. This dashboard serves as a valuable tool for healthcare professionals, offering nuanced insights to inform targeted interventions and enhance emergency medical practices.

Conclusion

In the initial stages of Exploratory Data Analysis (EDA) with our dataset, standard procedures such as `df.head()`, `df.tail()`, `df.sample(10)`, `df.describe()`, `df.isnull().sum()` etc. were employed to gain a preliminary understanding of the data's structure. However, a crucial observation was the presence of numerous null values, posing a challenge for data preprocessing.

Given the substantial data loss that would result from outright removal of null entries, an alternative strategy was pursued. The decision was made to impute missing values by replacing them with the mean of each respective column, ensuring the retention of a significant portion of the dataset while addressing the gaps. This method of handling missing data allows for a more comprehensive analysis, leveraging the available information.

In the broader context of EDA in Python, the process typically involves summarizing data statistics, identifying and handling missing values, exploring relationships between variables, and visualizing distributions. The strategic approach to null value imputation aligns with the goal of preserving data integrity while enabling a more thorough examination of patterns and trends within the dataset.

The preliminary analysis of the MIMIC-IV dataset has provided valuable insights into the operations of the Emergency Department (ED).

While the project is currently on hold due to the semester holidays, the initial findings have laid a solid foundation for future work. The next steps will involve a more in-depth analysis of the data, the development of predictive models, and the implementation of strategies to improve patient care and resource management in the ED.

Despite the project being in its early stages, the potential for impactful insights and improvements in ED operations is evident. The continuation of this project in the coming months promises to yield strategies that could significantly enhance the quality of care in the ED and contribute to a more efficient and effective healthcare system.