Taking a Closer Look at Using the Emergency Severity Index Tool at Emergency Department Triage for Patients Who Present with Suspected Acute Coronary Syndrome

by

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Background: Emergency department (ED) nurses should rapidly identify potential patients with acute coronary syndrome (ACS) because delays in care could impact patient outcomes.

Purpose: This study aims to describe the various ED resources utilized by patients with suspected ACS and identify general characteristics of this population. Additionally, evaluate associations of utilization patterns and patient characteristics with the assigned level of acuity at initial ED patient-nurse encounter.

Methods: This is a secondary analysis of a retrospective study of ED patients who were suspected of having ACS presenting to one of 17 EDs in a large regional health care system. Descriptive analytics were used to investigate patient demographics, past medical and surgical histories, ED resources, initial presenting vital signs, hospital admissions, and nurse assigned Emergency Severity Index (ESI) levels. Univariate and multivariate linear regression was used to determine associations between patient characteristics and resource utilization. Univariate and multivariate binary logistical regression was used to determine associations of resources with assigned high acuity ESI level and hospital admission.

Results: The sample included 1196 patients (mean [SD] age 65 [14] years, 54% male, 89% white, and 1% Hispanic). Of these, 522 (43%) patients had an in-hospital diagnosis of ACS. Systolic blood pressure was the most commonly documented abnormal vital sign upon ED arrival. Overall hospital admission rate was 72%. Chronic obstructive pulmonary disease showed a statistically significant association with utilization of more ED resources. Patients used an average of 4.5 resources in the ED. Radiologic testing, electrocardiogram done within 10 minutes of arrival, and complex procedures were associated with being assigned high acuity ESI levels. The following ED resources were predictor variables and had an increased likelihood of being admitted to the hospital: electrocardiogram done within 10 minutes, intravenous medication administration, specialty consult, and laboratory testing.

Conclusion: Patients with suspected ACS on average use more resources and have a higher admission rate compared to all ED patients. Nurses should consider patient characteristics, abnormal vital signs, and anticipated resource utilization in this subpopulation when assigning ESI levels. Future work should focus on a larger cohort of patients with suspected ACS.

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1.0 INTRODUCTION

Current reports from the Centers for Disease Control and Prevention (CDC), state there are roughly 130 million Emergency Department (ED) visits in the United States (US) annually (2021). To decide which patients are prioritized, health care personnel categorize patients into different groups based on the severity of illness, which is also known as triage. However, triage is not a modern phenomenon and originated on the French battlefields. During 1797-1801, Napoléon Bonaparte's soldiers conducted military expeditions in Egypt and Syria where they faced a deficit in resources due to a blockade enforced by British soldiers (Nakao et al., 2017). Nearly one-third of the army died in battle or due to illness, forcing military surgeons to prioritize care for the sick and wounded soldiers who could return to the battlefields and fight (Nakao et al., 2017). At the time, French military surgeon Pierre-François Percy was the head general surgeon responsible for the care of the soldiers on the battlefield (Nakao et al., 2017). He also uses the term "trier" in his diary to describe treating wounded soldiers further suggesting Percy was the first to triage individuals needing emergency care (Nakao et al., 2017). From then the idea of triage was passed among nations and historically seen throughout the years in the American Civil War and during the World Wars.

The modern idea of triage was first introduced to American EDs in 1966 when Weinerman et al. published a study investigating the characteristics of ED patients to identify the urgency of their condition and the patterns of medical care provided (1966). Then in the 1980s, the Domestic Preparedness Program of the Department of Defense developed START (Simple Triage and Rapid Transport) making it the first organized civilian triage system (Lee, 2010). Patient criteria for this triage method include the ability to walk, spontaneous breathing, respiratory rate, perfusion determined by radial pulse presence and capillary refill, and mental status (United States Department of Health and Human Resources [HHS], 2021). Based on assessment findings, patients are categorized into four levels of acuity; expectant/black, immediate/red, delayed/yellow, and minor/green (HHS, 2021). However, Kahn et al. found this method of triage has led to over-triaging 54% of individuals (2009). Over-triaging indicates the misidentification of patients who have minor illnesses but appear critically ill at the initial assessment (Gopalan & De Vasconcellos, 2019). Over-triaging individuals can lead to an overuse of resources that could have been directed to others with more serious illnesses (Gopalan & De Vasconcellos, 2019). The researchers hypothesized each triage level would achieve a 90% sensitivity and specificity and ultimately, no triage level met both requirements (Kahn et al., 2009). Additionally, Bhalla et al. found in their analysis that the START triage had an overall sensitivity of 55% and specificity of 85% (2015). These inconsistences prompted the CDC to form an advisory committee and develop the SALT (Sort-Assess-Lifesaving Interventions-Treatment/Transport) triage algorithm. This particular method assesses patient mobility, obvious life threats, breathing/respiratory distress, mental status, circulation, major hemorrhaging, survivability based on current resources, and minor injuries (Lerner et al., 2008). Similar to the START method, SALT categorizes patients into the same four levels of acuity. The overall efficacy of the SALT triage tool has also been questioned, for Bhalla et al. identified a sensitivity of 65% and 88% specificity for the tool (2015).

Despite their popularity in the prehospital setting, the START and SALT triage methods are not the most commonly used triage tool in EDs. According to the American Hospital Association survey, 72% of patients across 3,024 different hospitals were triaged utilizing the Emergency Severity Index (ESI) (McHugh et al., 2012). More specifically, larger hospitals, teaching hospitals, and EDs with more than 100,000 patient visits per year were more likely to report using the ESI tool (McHugh et al., 2012).

2.0 BACKGROUND

The Emergency Severity Index is a four-step triage tool created by Richard Wuerz and David Eitel in 1998 with the intention of standardizing ED triage. The American College of Emergency Physicians (ACEP) and the Emergency Nurses Association (ENA) both endorse the use of a single system across the US, such as the ESI, to optimize the quality of patient care (2017). However, it is critical to evaluate triage systems and their effectiveness as medicine continues to change. ACEP and the ENA support continual research and investigation to further refine patient acuity assignment, especially for high-risk populations such as those with suspected acute coronary syndrome (ACS) (2017). Due to its complex symptomology and time-sensitive treatment outcomes, ACS is one of many high-risk conditions that timely treatment could affect patient outcomes. Approximately every 39 seconds an American has a myocardial infarction (MI) leading to roughly 805,000 new and reoccurring coronary events annually (Virani et al., 2021). Acute coronary syndrome is one of the most time-sensitive conditions that must be rapidly and accurately identified in the triage setting (Virani et al., 2021). However, due to a complex symptom presentation, it can be incredibly difficult for ED nurses to identify. Furthermore, the American College of Cardiology and the American Heart Association recommend that specific goals be met for the patients presenting to the ED with symptoms suggestive of ACS: obtain an electrocardiogram within 10 minutes of arrival; have a patient evaluated by a health care provider within 10 minutes; and initiate thrombolytics within 30 minutes or percutaneous coronary intervention within 90 minutes of arrival (O’Gara et al., 2013). In order to meet these goals, it is suggested that a patient be triaged as ESI levels 1-2 (high acuity) and moved to an area for the initiation of care (Sanders and DeVon, 2016). Prior literature has shown that only 38%-54% of patients with ACS were correctly triaged (Frisch et al., 2020; Sanders and DeVon, 2016). Frisch et al. compared the classification performance of the assigned nurse ESI level to the downstream outcome of ACS in the indexed hospitalization in patients who were highly suspicious of a coronary event (2020). The area under the receiver operating characteristic (ROC) curve for ESI was 0.656 indicating ESI did not perform as well in the prediction of a coronary event (Frisch et al., 2020). Wu et al. found in a group of 564,412 patients with a final diagnosis of a MI that 30% had a different initial diagnosis (2018). The need for an improved triage tool is critical, especially one that correctly identifies high acuity patients, such as those with ACS as this could lead to the reduction of mortality by 10-20% (Virani et al., 2021; Wu et al., 2018).

The ESI triage tool categorizes patients into different levels of acuity based on assessment of the respiratory and cardiovascular systems, mental status, high-risk situations (e.g., condition requiring time-sensitive treatment, patient deterioration, or a patient with a potential threat to life, limb, or organ.), severe pain/distress, vital signs, and anticipated ED resource utilization (Gilboy et al., 2020). Unlike START or SALT, the ESI tool sorts patients into five categories with the highest acuity being assigned to level 1 and lowest acuity to level 5. Figure 1 briefly depicts the ESI process and the four steps needed to triage a patient (Gilboy et al., 2020).

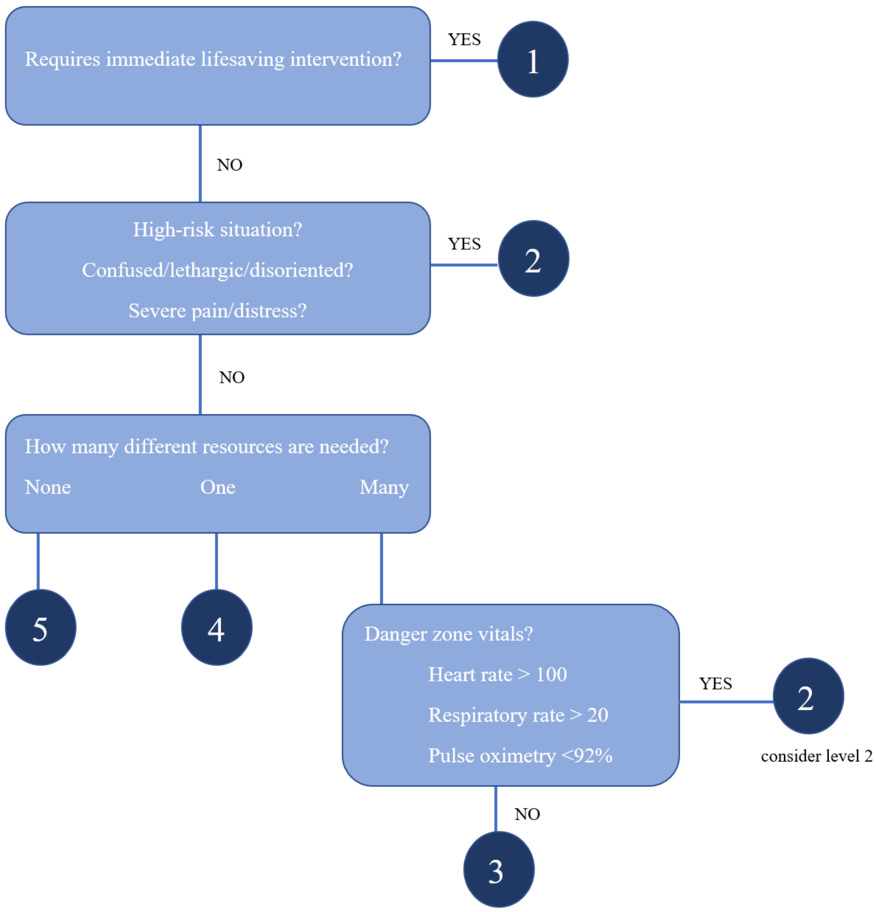

Figure 1: FLOW OF THE EMERGENCY SEVERITY INDEX ALGORITHM

The ESI tool starts with step one also known as "decision-point" A. In this step, the nurse assesses the need for immediate life-saving intervention (Gilboy et al., 2020). The 2020 ESI implementation handbook describes patients requiring immediate life-saving interventions as those who are intubated upon arrival to the ED, apneic, pulseless, severe respiratory distress, pulse oximetry < 90%, acute mental status changes, or unresponsive (Gilboy et al.). If the patient meets any of the above criteria then the triage process ends and the patient is assigned to ESI level 1. If not, then the nurse continues on to decision-point B.

At decision-point B, the nurse determines if the patient is stable to wait for care. The ESI algorithm recommends a patient should not wait if there is a high-risk situation, if the patient is confused/lethargic/disoriented, or if the patient is in severe pain or distress (Gilboy et al., 2020). If a patient presents to the ED with a chief complaint, sign(s) and/or symptom(s), or history suggestive of a problem or condition that is serious and, unless dealt with promptly, can deteriorate rapidly, are considered to be in high-risk situations prompting the assignment of ESI level 2 (Gilboy et at., 2020). Considering evaluation of signs and symptoms is the driving force of triage, it is critical to accurately map out a triage algorithm that guides nurses in determining the best acuity level for the patient Arslanian-Engoren, 2005, 2009; Garbez et al., 2011; Stanfield, 2015). The ESI handbook depicts that patients presenting with active chest pain, signs of a stroke, possible ectopic pregnancy, and suicidal or homicidal patients are in high-risk situations (Gilboy et al., 2020). Assessment of baseline alterations in mental status by checking for confusion, lethargy, or disorientation is used to further decision-making point B. Gilboy et al. depicts several examples of patients meeting these criteria: new onset confusion in an elderly patient, a three-month-old child whose mother reports the child is sleeping all of the time, and an adolescent found confused and disoriented (2020). Lastly, nurses assess for severe pain or distress in decision-point B. Assessing for severe pain or distress is determined by clinical observation and/or patient self-report of pain on a numerical scale from zero to ten with a score of seven or greater depicting severe pain. (Gilboy et al., 2020). The handbook states that if the pain score is 7or greater the patient may be triaged to level 2, but it is not required (Gilboy et al., 2020). The rationale for this is a majority of patients report to the ED for pain, and the needs for a patient with an ankle fracture are different than the needs for a patient with suspected ACS (Gilboy et al., 2020). Ultimately, if a patient meets any of the criteria for decision-point B, then they are assigned ESI level 2 (with nurses' discretion).

Decision-point C anticipates patient resource utilization and can be used to anticipate the disposition of the patient in terms of hospital admission, observation unit admission, hospital transfer, or discharge. Table 1 describes the ESI handbook's depiction of what is and is not considered a resource (Gilboy et al., 2020). ESI level 3 patients are predicted to use two or more resources, ESI level 4 patients use one resource, and ESI level 5 patients require no resources. Nurses are encouraged to use clinical judgment and previous experiences in order to evaluate routine care for a variety of patients with different chief complaint(s) upon arrival to the ED (Gilboy et al., 2020). Therefore, nurses anticipate specific patient resources that may be used during the ED visit and assign an acuity level accordingly.

Table 1: LIST OF EMERGENCY SEVERITY INDEX RESOURCES

Emergency Department Resources	Not Considered Resources
• Laboratory testing • Electrocardiogram/radiographs • Computed tomography, magnetic resonance imaging, ultrasound, angiography • Intravenous fluids • Intravenous, intramuscular, and nebulized medications • Specialty consultation • Simple procedure (laceration repair, urinary catheter) • Complex procedure (intubation, procedural sedation)	• History and physical (including pelvic examination) • Point-of-care testing • Saline or heparin lock • Oral, subcutaneous, topical, and sublingual medications • Tetanus immunization • Phone call to primary care provider • Simple wound care • Crutches, splints, or slings

If the patient is expected to use more than two resources, then the nurse is directed to decision-point D. This final decision-point evaluates patients' initial ED vital signs. More specifically, nurses assess for "danger-zone vital signs" such as increased heart rate (i.e., > 100 beats per minute), increased respiratory rate (i.e., > 20 respirations per minute), or pulse oximetry (i.e.,< 92%) (Gilboy et al., 2020). If patients' vital signs fall within abnormal parameters and are anticipated to use two or more resources, then it is up to the nurse's judgment to consider assigning level 2 instead of level 3. By assigning level 2 over level 3 based on vital signs, it can be concluded that the nurse believes that the severity of illness is greater. Therefore, it is appropriate to assign a higher acuity level as the patient is at high risk for deterioration, has a time-sensitive condition, or potentially serious condition (Gilboy et al., 2020).

3.0 PURPOSE AND SPECIFIC AIMS

The overall purpose of this study is to describe and characterize the various ED resources utilized by patients with suspected ACS and study the associations of such utilization patterns with the assigned level of severity of illness at initial ED patient triage.

Specific Aim 1: Identify the patient demographics and clinical characteristics, and their association with frequency of patient-level resource utilization (e.g., laboratory tests, radiologic tests, intravenous catheter fluids/medications, etc.) among patients with suspected ACS at initial ED nurse encounter.

Aim 1a. Identify the demographics, past medical and surgical history of the sample (e.g., age, sex, race, past medical history of hypertension, past medical history of diabetes mellitus, past medical history of hyperlipidemia, past medical history of smoking, past surgical history of percutaneous coronary intervention or coronary artery by-pass graft, etc.).

Aim 1b. Identify the frequency of specific resources used during the ED visit.

Aim 1c. Assess for associations between the number of resources utilized and patient characteristics, including age, sex, and past medical/surgical history.

Specific Aim 2: Explore the association between assigned ESI level and frequency and type of ED resource utilization as well as admission decisions.

Aim 2a. Identify the accuracy of the assigned ESI levels in relation to the number of resources utilized per patient ED visit.

Aim 2b. Identify if specific resources (e.g., electrocardiogram, laboratory tests, radiologic tests, intravenous catheter fluids/medications, etc.) are associated with ESI high acuity levels (1-2) versus ESI middle/low acuity levels (3-5).

Aim 2c. Identify the distribution of admission to the hospital across all ESI levels.

Aim 2d. Determine if there is an association between specific resources and admission to the hospital.

Specific Aim 3: Explore the frequency of documented abnormal vital signs throughout the entire sample.

4.0 METHODS, DESIGN, AND SETTING

This was a secondary analysis of Improving Emergency Department Nurse Triage via Big Data Analytics study (Frisch, 2020). The Frisch study was a retrospective, correlational, descriptive cohort study of patients who present to the ED with symptomology suggestive of ACS (see Table 2). In 2018, 17 EDs within the UPMC system were evaluated and all patients presenting with ACS symptoms were recruited. From that cohort, 1196 random patients were selected and patient data were extracted from the hospital's electronic medical system known as UPMC-Cerner.

Table 2: POSSIBLE SIGNS AND SYMPTOMS OF ACUTE CORONARY SYNDROME

Frequent Acute Coronary Syndrome Symptoms	Less Frequent Acute Coronary Syndrome Symptoms
• Chest pain • Chest heaviness • Chest discomfort/burning • Chest pressure • Chest tightness • Chest squeezing • Chest pain that radiates to arm • Chest pain that radiates the neck/jaw/back/abdomen • Dyspnea • Shortness of breath • Syncope • Presyncope/near passing out • Palpitations	• Nausea • Vomiting • Indigestion • Abdominal pain • Sternal pain • Jaw/neck pain • Cough • Fever • Epigastric pain • Arm pain/discomfort • Unexplained fatigue • Chest wall tenderness • Ear discomfort • Retrospective pressure/heaviness/burning • Pleuritic pain

Improving Emergency Department Nurse Triage via Big Data Analytics study was approved by the Institutional Review Board of University of Pittsburgh (STUDY18110026). The study poses minimal risk as there was no patient contact and routine care data was extracted from the electronic medical records by reviewers blinded to study outcomes. To protect the confidentiality, all extracted data was de-identified before storage and the linkage list was kept separate from the data. The current secondary analysis was approved by Dr. Salah Al-Zaiti and Dr. Stephanie Frisch.

4.1 STUDY POPULATION AND SIZE

All patients who sought emergency care during 2018 in one of the 17 EDs in a large regional health care system that utilizes Cerner© electronic charting system and the Emergency Severity Index for triage were eligible for the study. The cohort was then randomly reduced to 1196 patients by excluding those less than 20 years of age, interfacility transfers, and patients from specialized hospitals such as UPMC Western Psychiatric Hospital and UPMC's Children's Hospital of Pittsburgh. Those less than 20 were excluded The Office of Health Record Research Request randomized an equal subset of patients that met the following criteria: 1) symptomology at ED presentation suggestive of ACS (see Table 2); 2) had a cardiac troponin (cTn) laboratory value > 0.1; or 3) had the presence of cardiac procedure codes (e.g., coronary angiogram, single-photon emission computerized tomography [SPECT] scan with an exercise stress test, and SPECT scan with drug-induced stress test). Patients who were a trauma alert or stroke alert upon ED arrival were excluded in addition to those who had an ST-segment elevation myocardial infarction (STEMI) on the first 12-lead electrocardiogram (ECG). The American College of Cardiology and the American Heart Association recommend an electrocardiogram be completed within 10 minutes of arrival to the ED for anyone with suspicion of an ACS event (O'Gara et al., 2013). This is typically completed at triage to identify STEMIs. STEMI diagnosis patients were excluded since their ED diagnosis and triage assessment is commonly based on a single diagnostic test (electrocardiogram) rather than a more diverse range of symptomatology seen in unstable angina and non-ST-segment elevation myocardial infarctions (NSTEMI). Figure 2 demonstrates the patient flow diagram for this study.

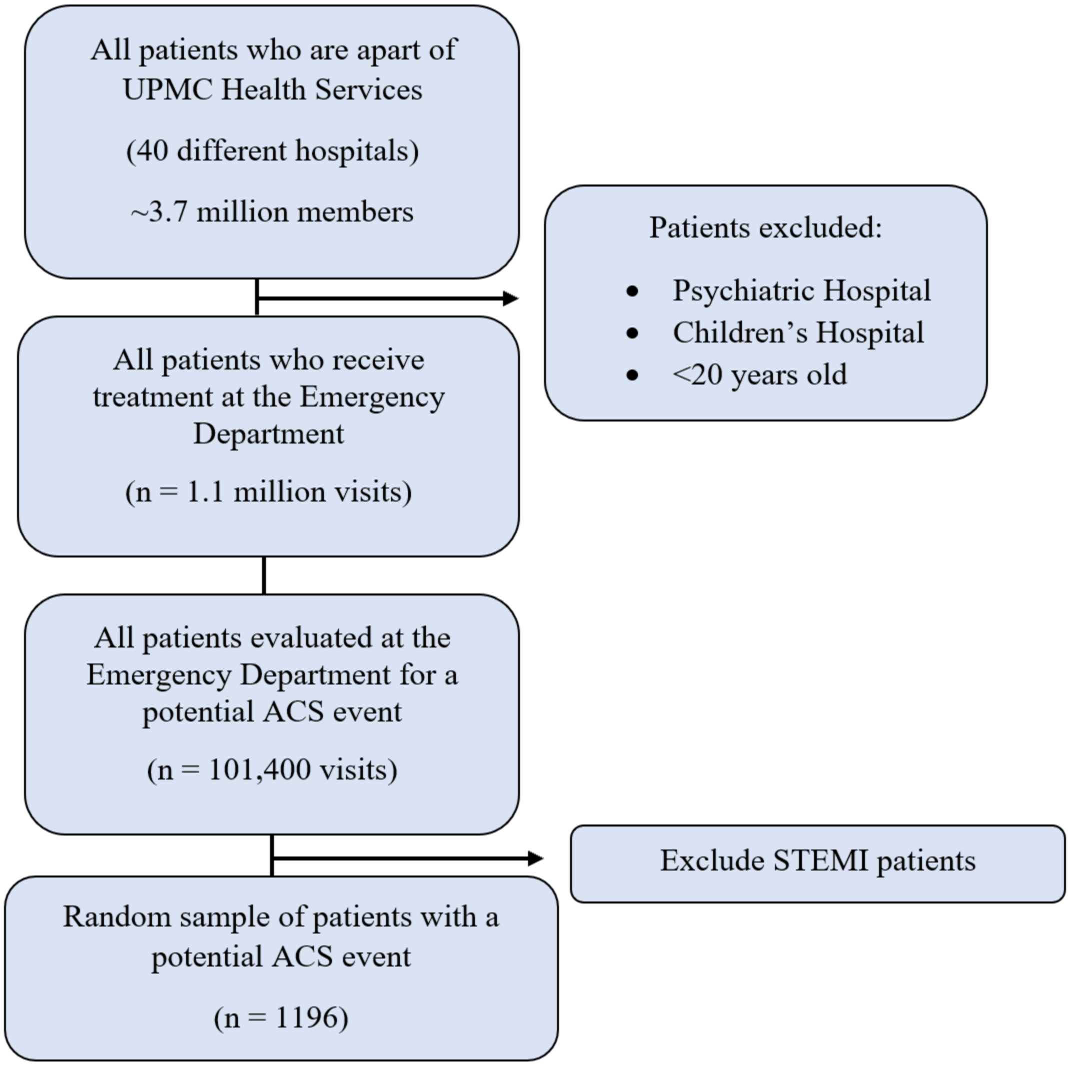

Figure 2: FLOW CHART OF STUDY POPULATION

4.2 VARIABLES AND DATA COLLECTION

4.2.1 SPECIFIC AIM 1 VARIABLES

Upon evaluation of the current literature, a list of patient factors that are commonly assessed at the initial nurse triage and are recommended by the American College of Cardiology was created (Amsterdam et al., 2014). Each patient chart was systematically reviewed by trained individuals who were provided a detailed protocol for data extraction from the electronic health record (EHR), known as UPMC-Cerner. Reviewers attended a two-hour training session by an electronic health record expert. All data were stored in REDCap, which is HIPAA compliant (Harris, Taylor, Thielke, Minor, et al., 2019; Harris, Taylor, Thielke, Payne, et al., 2009). Data were extracted from an apriori patient list of variables from the EHR. The following variables were extracted from the EHR for Specific Aim 1: 1) demographics (e.g., sex, age, race, ethnicity); 2) patient self-report past medical/surgical history and chart reviewed past medical/surgical history (e.g., history of smoking, history of cardiovascular disease, history of previous percutaneous coronary intervention, etc.); and 3) specific resources utilized throughout the ED stay based on the guidelines set forth by the ESI algorithm as detailed in Table 3 (Gilboy et al., 2020).

Table 3: EMERGENCY DEPARTMENT RESOURCES RECOMMENDED BY THE EMERGENCY SEVERITY INDEX TOOL HANDBOOK

Emergency Department Resources
Laboratory testing (blood)

Specialty consultation (Patient is seen by any advance practice provider or physician, i.e., neurology, cardiology, urology, etc. and does not include being seen by an ED provider or a hospitalist.)
Radiologic testing (i.e., ultrasound, x-ray, computed tomography, computed tomography angiography, magnetic resonance imaging, nuclear testing- single-photon emission computed tomography scan, transthoracic echocardiogram, ventilation-perfusion scan)
Intravenous fluids (hydration)
Intravenous, intramuscular, or nebulized medications
Electrocardiogram done within 10 minutes of arrival to the ED
Simple procedure (laceration repair, urinary catheter)
Complex procedure (procedural sedation, intubation, central line placement, arterial line placement, use of emergency department crash cart, use of defibrillator, active titration of intravenous medications)

4.2.2 SPECIFIC AIM 2 VARIABLES

The independent variables for Specific Aim 2 are the patient-level ED resources as listed above in Table 3 of section 4.2.1. Then examined the frequency of resources each patient uses throughout their ED stay as a continuous variable.

The primary outcome for this aim is the ESI level defined by the ESI algorithm. Decision point C in the algorithm categorizes ESI into levels 1-3, 4, and 5 based on the number of resources expected to be used in the ED. ESI levels 1-3 utilize two or more resources, ESI level 4 utilizes one resource, and ESI level 5 utilizes zero resources as detailed in the ESI Implementation

Handbook (Gilboy et al., 2020). Specific Aim 2b divides ESI levels into two groups: high acuity (ESI level 1-2) and middle/low acuity (ESI levels 3-5) based on the recommendations by the ESI Implementation Handbook (Gilboy et al., 2020). ESI levels documented in the EHR were extracted from the initial nurse triage encounter. The secondary outcome as seen in Specific Aim 2c is patient admission to the hospital (yes or no) which was also obtained from the electronic health record.

4.2.3 SPECIFIC AIM 3 VARIABLES

Patients' initial nurse encounter vital signs were extracted from the electronic health record and categorized as follows: 1) heart rate less than 60 beats per minute or greater than 100 beats per minute, 2) systolic blood pressure less than 90 mm Hg or greater than 160 mm Hg, 3) respiratory rate greater than 20 respirations per minute, 4) oxygen saturation less than 92%, and 5) initial pain rating equal to or greater than seven on a verbal numerical rating scale from zero to ten. Then the frequencies of abnormal vital signs for those assigned ESI level 3 were examined.

4.3 STATISTICAL ANALYSIS

All statistics were performed using SPSS® Statistics software version 25 of International Business Machines (IBM) Corporation in Armonk, New York. Before any inferential analysis, detailed descriptive analysis was performed on each variable. Continuous variables were described using mean with standard deviation (SD) or median with interquartile range if not normally distributed. Categorical variables were summarized as frequencies with their associated percentages. Graphical techniques were used to identify outliers.

In Specific Aim 1, a detailed descriptive analysis of patient demographics, patient characteristics (i.e., past medical/surgical history), and ED resources utilized was performed. For aim 1c, a linear regression model was conducted to examine the associations of patient characteristics and the number of resources used during their ED visit. First, univariate analysis was performed and all patient characteristic variables associated with the number of resources p value < 0.1 were included in the multivariate linear regression. Lastly, patient characteristic variables with a p value < 0.05 were reported as statistically significant in the final model. Predictor patient characteristic variables were reported as coefficients and 95 percent confidence intervals.

For Specific Aim 2a, a descriptive analysis of the number of resources used across all ESI levels was performed. Then ESI was categorized into three groups: 1) two or more resources used in the ED visit, 2) one resource used in the ED visit, and 3) no resources used in the ED visit. The distribution was compared to the recommended number of resources used per each ESI level per the guidelines of the ESI handbook as described in section 4.2.2. This determined the accuracy rate of the assigned ESI level. In Specific Aim 2b, a binary logistic regression was conducted with patient resources as predictors associated with ESI levels 1 and 2 (high acuity) versus ESI levels 3-5 (middle/low acuity). Univariate associations $p < 0.1$ were included in a multivariable binary logistic regression model. A backward elimination approach was conducted to remove predictors with $p \geq 0.1$ in multivariable models (Hosmer et al., 2013). For the final identification of predictors, it was determined that predictor variables with ESI levels high in the multivariable binary logistic regression model with a $p < 0.05$. Predictor variables are reported as adjusted odds ratios with 95 percent confidence intervals. In Specific Aim 2c, descriptive analysis was done to identify the frequency of hospital admission across all ESI levels. Lastly, in Specific Aim 2d, another binary logistical regression model was performed for the outcome of admission to the hospital (yes/no). Patient resources were predictor variables in the univariate analysis with a p value < 0.1 were included in the multivariate analysis. Predictor variables with a p value < 0.05 were statistically significant and reported as adjusted odds ratios with 95 percent confidence intervals.

Finally, for specific aim 3, a detailed descriptive analysis was performed to identify the frequency of abnormal vital signs across all ESI levels. The categorical variables (abnormal vital signs) were summarized as frequencies with their associated percentages. Graphical techniques were used to identify outliers.

5.0 RESULTS

5.1 SPECIFIC AIM 1

5.1.1 SPECIFIC AIM 1a RESULTS

Specific Aim 1a identified the demographics and past medical and surgical history of the sample. As seen in Table 4, the sample included 1196 patients with a mean (SD) age of 65 (14) years; 54% were male; 89% white; and 1% Hispanic. Of these, 522 (43%) patients had a final in-hospital diagnosis of ACS. The frequency of specific past medical/surgical history for the sample is also detailed in Table 4. The top five most reported past medical/surgical histories for the sample were hypertension, dyslipidemia, current or prior smoking history, gastroesophageal reflux disease, and coronary artery disease.

Table 4: DISTRIBUTION OF PATIENT CHARACTERISTICS

Patient Characteristics	All Patients (n=1196)
Demographics	
Age (years, mean ± standard deviation)	65 ± 14
Sex (male)	654 (54%)
Body mass index (mean ± standard deviation)	30.89 ± 7.57
Ethnicity [n (%)]	
Hispanic	16 (1%)
Race [n (%)]	
White	1080 (89%)
Black/African American	115 (10%)

Other	17 (1%)
Past Medical/Surgical History [n (%)]	
Hypertension	873 (73%)
Dyslipidemia	644 (54%)
Smoking	
prior or current use	642 (54%)
never smoked	554 (46%)
Gastroesophageal reflux disease	514 (43%)
Coronary artery disease	407 (34%)
Diabetes mellitus	385 (32%)
Previous percutaneous coronary intervention	326 (27%)
Previous myocardial infarction	263 (22%)
Atrial fibrillation	234 (20%)
Chronic obstructive pulmonary disease	224 (19%)
Heart Failure	191 (16%)
Previous percutaneous coronary intervention with stenting	180 (15%)
Cancer	161 (14%)
Peripheral vascular disease	167 (14%)
Previous coronary artery bypass graft	128 (11%)
Angina	109 (10%)
Pacemaker	88 (7%)
Stroke	111 (9%)
Obstructive sleep apnea	92 (8%)
Pulmonary embolism	38 (3%)
Peripheral artery disease	34 (3%)

5.1.2 SPECIFIC AIM 1b RESULTS

Specific Aim 1b identified the frequency of specific resources used during the ED visit. The results of this sub aim are displayed in Table 5. The frequency of resources is defined as the total number of how many patients using a specific resource during their ED stay. Patients averaged using 4.5 (SD ± 1.6) resources during their ED stay. The maximum number of resources used was 11 and the minimum number used was one. The top three most commonly used resources were laboratory testing, radiologic testing, and intravenous medication.

Table 5: FREQUENCY OF EMERGENCY DEPARTMENT RESOURCES

ED Patient Level Resource	[n (%)]
Laboratory testing	1178 (99%)
Radiologic testing	1089 (91%)
Intravenous medication	628 (53%)
Electrocardiogram done within 10 minutes of arrival to emergency department	554 (46%)
Intravenous fluids	311 (26%)
Specialty consult	131 (11%)
Nebulizer medication	128 (11%)
Simple procedure	109 (9%)
Complex procedure	93 (8%)
Intramuscular medication	32 (3%)

5.1.3 SPECIFIC AIM 1c RESULTS

Specific Aim 1c sought to identify if there is an association between the number of resources utilized and patient characteristics, including age, sex, and past medical/surgical history. The following patient factors had a $p < 0.1$ in univariate analysis and were included as candidate predictor variables in multivariate linear regression (see Table 6): 1) age, 2) past medical history of hypertension, 3) past medical history of diabetes mellitus, 4) history of smoking, 5) past medical history of atrial fibrillation, 6) previous percutaneous coronary intervention, 7) previous percutaneous coronary intervention with stenting, 8) past medical history of coronary artery disease, 9) past medical history of peripheral artery disease, and 10) past medical history of chronic obstructive pulmonary disease. All multivariate patient factors had a variance factor less than 0.1 indicating a lack of multicollinearity among the candidate predictors. In the final model chronic obstructive pulmonary disease was the only predictor that remained statistically significant (see Table 6).

Table 6: MULTIVARIATE LINEAR REGRESSION OF PATIENT CHARACTERISTICS AND THEIR ASSOCIATIONS WITH EMERGENCY DEPARTMENT RESOURCE UTILIZATION

Patient Characteristics Variables	**Multivariate Analysis**	
	Coefficients (95% Confidence Interval)	**p-value**
Age	0.001 (-0.001, 0.01)	0.731
Hypertension	0.120 (-0.10, 0.34)	0.291
Diabetes mellitus	0.092 (-0.01, 0.19)	0.080
Smoking	0.098 (-0.02, 0.22)	0.114
Atrial fibrillation	0.186 (-0.06, 0.43)	0.133
Previous percutaneous coronary intervention	0.012 (-0.31, 0.33)	0.942
stenting	0.044 (-0.31, 0.40)	0.805
Coronary artery disease	0.051 (-0.22, 0.32)	0.705
Peripheral artery disease	0.362 (-0.19, 0.92)	0.201
Chronic obstructive pulmonary disease	0.480 (0.24, 0.73)	< **0.001**

5.2 SPECIFIC AIM 2

5.2.1 SPECIFIC AIM 2a RESULTS

Specific Aim 2a identified the accuracy of the assigned ESI levels in relation to the number of resources utilized per patient ED visit. Patients were correctly triaged if the number of resources utilized in the ED correlated to the ESI algorithm. Results in Table 7 show that 98.2% of all ESI levels were correctly assigned based on the prediction of how many resources would be used in the ED. ESI levels 1-3 were correctly triaged 98.7% of the time. ESI level 4 was correctly triaged 20% of the time. Lastly, the one patient assigned ESI level 5 used seven resources, thus ESI level 5 was not correctly triaged based on anticipated resource use.

Table 7: DISTRIBUTION OF PATIENTS USING MANY RESOURCES VERSUS ONE RESOURCE

Emergency Severity Index Level	Use of Many Resources (2 or more)	Use of One Resource
1-3	1068	14
4	4	1
5	1	0

5.2.2 SPECIFIC AIM 2b RESULTS

Specific Aim 2b assessed if specific resources were associated with ESI high acuity levels (1-2) or middle/low acuity levels (3-5). All possible ED resources described in Table 3 of section 4.2.1. were entered into the univariate analysis. The following patient factors had a $p < 0.1$ in univariate analysis and were included as candidate predictor variables in multivariable binary logistical regression (see Table 8): 1) radiologic testing, 2) intravenous medication, 3) electrocardiogram done within 10 minutes of arrival to the ED, and 4) complex procedure. Ultimately, radiologic testing, electrocardiogram done within 10 minutes of ED arrival, and complex procedure were all significant in the final model and had an increased likelihood of being associated with being assigned a high acuity ESI level (ESI levels 1 and 2) (see Table 8).

Table 8: MULTIVARIATE BINARY LOGISTICAL REGRESSION OF EMERGENCY DEPARTMENT RESOURCES USED AND THEIR ASSOCIATION WITH EMERGENCY SEVERITY INDEX HIGH ACUITY (LEVELS 1-2) VERSUS MIDDLE/LOW ACUITY (LEVELS 3-5)

Emergency Department Resource	**Multivariate Analysis**	
	Adjusted Odds Ratios (95% Confidence Interval)	**p-value**
Radiologic testing	2.01 (1.30, 3.10)	< **0.001**
Intravenous medication	1.19 (0.91, 1.55)	0.200
Electrocardiogram done within 10 minutes of arrival to the ED	2.47 (1.88, 3.25)	< **0.001**
Complex procedure	5.66 (1.30, 24.67)	**0.020**

5.2.3 SPECIFIC AIM 2c RESULTS

Specific Aim 2c identified the distribution of admission to the hospital across all ESI levels. Of the patients assigned ESI level 1, 70 (96%) were admitted to the hospital, and 556 (83%) patients in ESI level 2 were admitted. Of the patients assigned ESI level 3, 227 (68%)

were admitted. Whereas 3 (60%) patients assigned ESI level 4 and 1 (100%) patient assigned ESI level 5 were admitted to the hospital.

Table 9: DISTRIBUTION OF HOSPITAL ADMISSIONS ACROSS ALL EMERGENCY SEVERITY INDEX LEVELS

Emergency Severity Index Level	Number of Hospital Admissions [n(%)]
1	70 (96%)
2	556 (83%)
3	227 (68%)
4	3 (60%)
5	1 (100%)

5.2.4 SPECIFIC AIM 2d RESULTS

Lastly, Specific Aim 2d determined if there is an association between specific resources and admission to the hospital (yes/no). All possible ED resources described in Table 3 of section 4.2.1. were entered into the univariate analysis. The following variables were significant in the univariate analysis with a $p < 0.1$ and were included as candidate predictor variables in multivariate binary logistic regression (see Table 10): 1) electrocardiogram done within 10 minutes of arrival to the ED, 2) complex procedure, 3) simple procedure, 4) intravenous medication, 5) radiologic testing, 6) specialty consult, 7) laboratory testing, and 8) no resources utilized. In the final multivariate model, electrocardiogram done within 10 minutes of arrival to the ED, intravenous medication, specialty consult, and laboratory testing remained statistically significant (see Table 10) and have an increased likelihood of being admitted to the hospital.

Table 10: MULTIVARIATE BINARY LOGISTICAL REGRESSION OF EMERGENCY DEPARTMENT RESOURCES AND THEIR ASSOCIATIONS WITH HOSPITAL ADMISSION (YES/NO)

Emergency Department Resource	Multivariate Analysis	
	Adjusted Odds Ratio (95% Confidence Interval)	**p-value**
Electrocardiogram done within 10 minutes of arrival to ED	1.84 (1.35, 2.51)	**< 0.001**
Complex procedure	2.06 (0.62, 6.86)	0.240
Simple procedure	1.95 (1.00, 3.84)	0.060
Intravenous medication	1.74 (1.28, 2.36)	**< 0.001**
Radiologic testing	3.10 (1.0, 2.59)	0.051
Specialty consult	3.10 (1.53, 6.28)	**< 0.001**
Laboratory testing	4.24 (1.51, 11.92)	**0.010**
No resources utilized	0.54 (0.03, 9.81)	0.680

5.2.5 SPECIFIC AIM 3 RESULTS

Lastly, Specific Aim 3 explored the frequency of documented abnormal vital signs throughout the entire sample. For the vital signs specific to the ESI tool's description of "danger zone vital signs" (see section 4.2.3.), 335 (28%) had an abnormal heart rate, 236 (20%) had an increased respiratory rate, and lastly, 81 (7%) had a decreased pulse oximetry (see Figure 3).

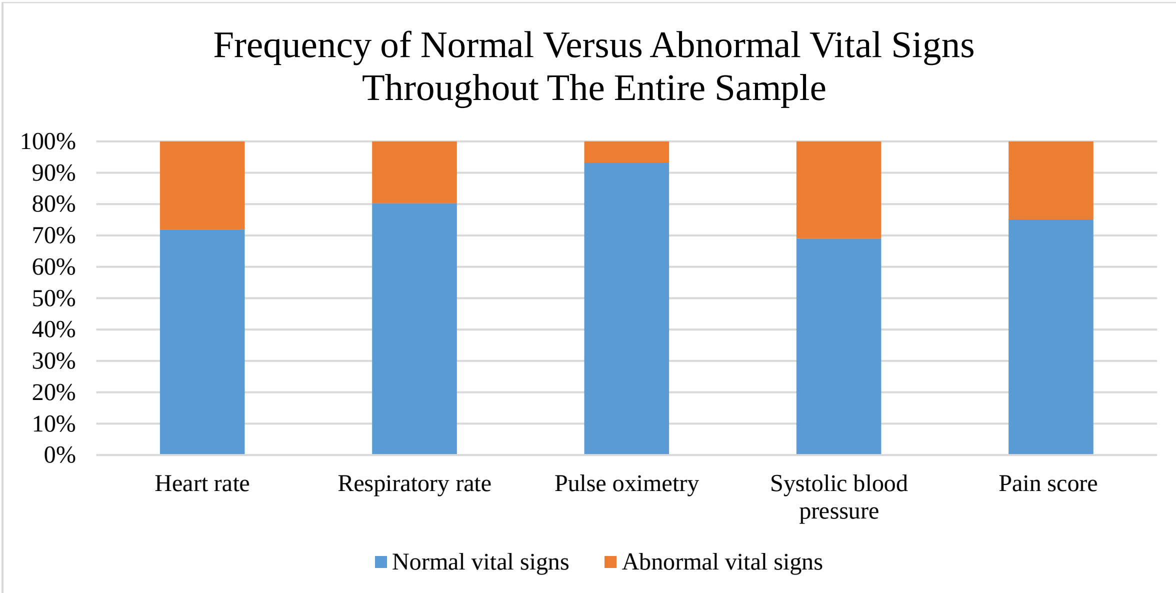

Figure 3: DISTRIBUTION OF ABNORMAL VITAL SIGNS THROUGHOUT THE ENTIRE SAMPLE

Taking into account all vital signs, the most frequently documented abnormal vital sign was systolic blood pressure with 370 (31%) accounts. Additionally, a severe pain score was reported in 298 (25%) patients at the initial nurse encounter (see Figure 3).

Moreover, analysis was performed to determine if patients assigned ESI level 3 had abnormal vital signs indicating they were potentially mis-triaged. In ESI level 3, there were 293 patients presenting to the ED with abnormal vital signs. The distribution of ESI level 3 patients with abnormal vital signs is as follows; 1) 98 (41%) systolic blood pressure, 2) 72 (21%) pain score, 3) 66 (20%) heart rate, 4) 42 (13%) respiratory rate, and 5) 13 (4%) pulse oximetry (see Figure 4).

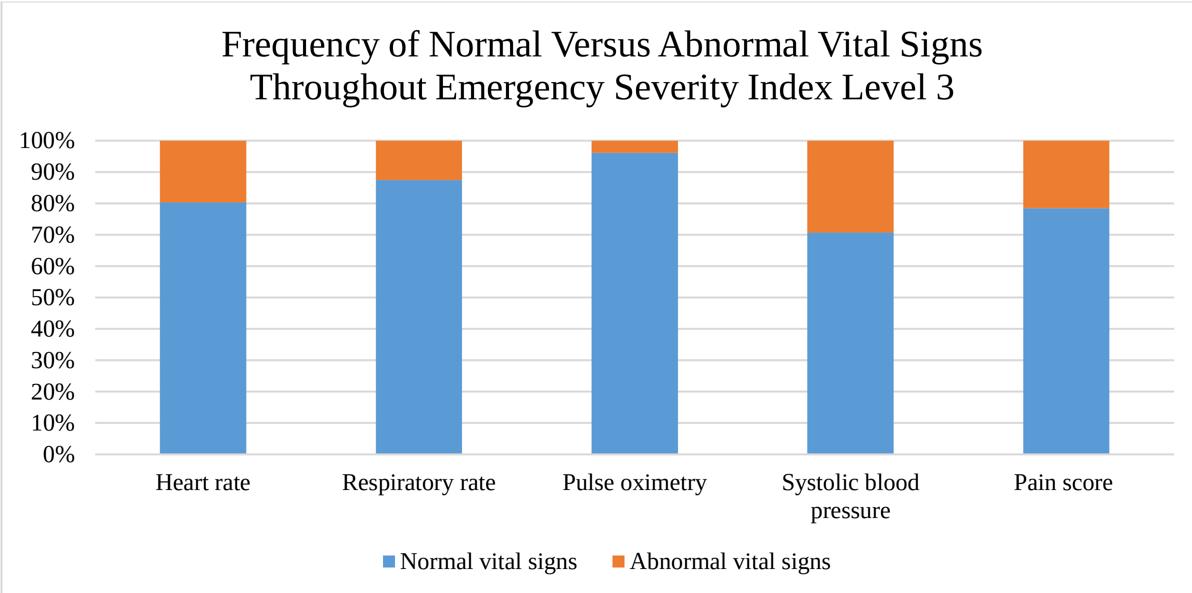

Figure 4: DISTRIBUTION OF ABNORMAL VITAL SIGNS FOR THOSE ASSIGNED EMERGENCY SEVERITY INDEX LEVEL 3

6.0 DISCUSSION

The purpose of this study was to describe and characterize the various ED resources utilized by patients with a suspected ACS event and study the associations of such utilization patterns with assigned illness severity at initial ED patient screening.

Our sample was 1196 patients with a mean age of 65 years, 54% were male, 89% white, and 1% Hispanic. Close to half (43%) of the sample had a final in-hospital diagnosis of ACS. The most frequently reported past medical and surgical histories were: hypertension, dyslipidemia, current or prior smoking history, gastroesophageal reflux disease, and coronary artery disease. Patients in the sample averaged using 4.5 (SD ± 1.6) resources during their ED visit. The maximum number of resources used was 11 and the minimum number used was one. The top three most commonly used resources were laboratory testing, radiologic testing, and administration of intravenous medication. The multivariate linear regression model used to evaluate patient characteristics as predictor variables for the likelihood of using ED resources found that chronic obstructive pulmonary disease was the only statistically significant variable that had an association with an increasing number of ED resources used.

Our results showed that across all ESI levels, 98% of assigned ESI levels were correct based on the prediction of how many resources would be used in the ED; ESI levels 1-3 were predicted to use many resources, ESI level 4 was predicted to use one resource, ESI level 5 was predicted to use no resources. ESI levels 1-3 were assigned correctly 99% of the time based on anticipated resources. ESI level 4 was assigned correctly 20% at the time of ED triage and lastly, the one patient assigned ESI level 5 used seven resources instead of the predicted zero resources, making the assigned ESI level 5 0% correct. A binary logistic regression was conducted to evaluate the associations of specific ED resources to the binary outcome of assigned ESI levels 1-2 (high acuity) or ESI level 3-5 (middle/low acuity). In a binary logistical multivariate analysis, radiologic testing, electrocardiogram done within 10 minutes of ED arrival, and complex procedure were all statistically significant and associated with being assigned an ESI high acuity level (1-2).

Overall, 857 (72%) patients were admitted to the hospital. Each assigned acuity level had different rates of hospitalization, 70 (96%) patients in ESI level 1, 556 (83%) patients in ESI level 2, 227 (68%) patients in ESI level 3, 3 (60%) patients in ESI level 4, and 1 (100%) patient assigned an ESI level 5. In the evaluation of the prediction of hospital admission based on the use of specific resources, the multivariate binary logistical regression determined electrocardiogram done within 10 minutes of arrival to the ED, intravenous medication, specialty consult, and laboratory testing remained statistically significant in the final model. Patients who utilized these specific ED resources during their ED visit were more likely to be admitted to the hospital.

Lastly, the distribution of abnormal vital signs across all assigned ESI levels, specific to each vital sign that is documented in the electronic health record upon arrival to the ED was investigated. Vital signs with the following values were considered abnormal: heart rate (< 60 or > 100 beats per minute), severe pain (≥ 7 on a pain scale ranging from 0-10), respiratory rate (> 20 respirations per minute), pulse oximetry (< 92%), and systolic blood pressure (< 90 or > 160 mm Hg). In total, 335 (28%) people had a documented abnormal heart rate, 298 (25%) people had a documented severe pain score, 236 (20%) people had a documented increased respiratory rate, and lastly, 81 (7%) people had a documented abnormal pulse oximetry reading. Taking into account all possible vital signs, the most frequently documented abnormal vital sign was systolic blood pressure with 370 (31%) accounts.

6.1 IMPORTANCE OF ACURATE TRIAGE FOR THOSE WITH SUSPECTED ACUTE CORONARY SYNDROME

Prompt identification and prioritization of treatment benefit those with suspicion of having ACS. Early identification has the potential to improve mortality rates by 10-20% (Virani et al., 2021; Wu et al., 2018). Lower assignment of ESI levels could delay provider evaluation and treatment times, potentially impacting patient outcomes (Atzema et al., 2009). However, over triage for those without ACS could lead to misuse of resources that could have been potentially allocated to others with more serious conditions. Thus, there is a critical need for an accurate triage tool to optimize ED efficiency while simultaneously aiming to improve patient clinical outcomes.

6.2 PATIENT CHARACTERISTICS OF THOSE WHO HAVE SUSPICION FOR A CORONARY EVENT

The American Heart Association identifies tobacco use, dyslipidemia, hypertension, physical inactivity, obesity, and diabetes as major risk factors for having an ACS event (Virani et al., 2021). Analysis in this study found hypertension, dyslipidemia, and tobacco use were the only modifiable risk factors for ACS in the sample of the top 5 frequently documented past medical and surgical histories. Similarly, in a study identifying the top four conventional risk factors (cigarette smoking, diabetes, hyperlipidemia, and hypertension), at least 1 of the 4 risk factors were present in 85% of women and 81% of men (Khot et al., 2003). However, their population consisted of patients with an established history of coronary heart disease. This study's sample had coronary artery disease at a rate of 34%. Canto et al. also found 86% of their population had at least one of the five coronary heart disease risk factors (2011). Canto et al. determined the frequency of the same four variables in Khot et al.'s study in addition to a family history of coronary artery disease.

Chronic obstructive pulmonary disease was reported 19% of the time in this sample and was a statistically significant predictor variable for the outcome ED resources. Chronic obstructive pulmonary disease and coronary artery disease (a major risk factor for ACS) are not infrequently present in the same patient (Simons, 2019). Patients with chronic obstructive pulmonary disease could potentially have a baseline respiratory status that is already abnormal and may interfere with the prompt identification of ACS. It is reasonable that these patients would use more ED resources to determine if they are indeed experiencing a coronary event. Additionally, short-term mortality rates are higher both during hospitalization and within 30 days of discharge for those who had an acute MI and have a history of chronic obstructive pulmonary disease (Stefan et al., 2012). Special care and consideration should go into the triage process for those presenting with symptoms suggesting of ACS and have a past medical history of chronic obstructive pulmonary disease.

6.3 EVALUATION OF UTILIZATION OF EMERGENCY DEPARTMENT RESOURCES

In the original validation studies completed by Eitel et al., researchers found accuracy rates of assigned ESI levels based on the number of resources as ESI level 3 78%, ESI level 4 59%, ESI level 5 71% across all patients who sought emergency care in the ED. In comparison, this study's sample of those who had suspicion of having a coronary event had lower accuracy rates of assigned ESI levels in the low acuity group (levels 4-5). This indicates these patients are using more resources than what is predicted per the ESI guidelines. Tanabe et al. determined accuracy by identifying the mean resource use per ESI level. ESI level 1 used an average of 5 resources, ESI level 2 used 3.9, ESI level 3 used 3.3, ESI level 4 used 1.2, and ESI level 5 used 0.2 resources (2004). Tanabe et al.'s results remained consistent with the predicted number of resources as defined by the ESI handbook. Determining triage acuity for a patient based on the number of anticipated resource use can be difficult because many different conditions and situations require varying resource use. The contrasting results of ESI accuracy based on predicted resource use may be attributed to differences in the patient population. This study included those with suspected ACS events whereas Eitel et al. included 3,289 different clinical situations assessing any possible condition someone might visit the ED for (2003). Similarly, Tanabe et al. extracted their data from all 403 patients presenting to the ED from May to October of 2001 with any possible condition. This evidence suggests patients with suspected ACS use more resources on average compared to the general ED population, suggesting these patients might be more acutely ill.

6.4 EVALUATION OF HOSPITAL ADMISSION

Overall, 857 (72%) of the sample in this study was admitted to the hospital. In Tanabe et al.'s study, they found a lower overall admission rate of 49% while using ESI version 3 (2004). Even less so, 34% of patients in Eitel et al.'s study were admitted to the hospital and they used ESI version 2 (2003). Wuerz et al. identified an overall hospitalization rate of 28% and was strongly associated with a specific ESI triage level; 92% of patients in level 1 and only 2% in level 5 (2001). Logically those with higher acuity levels are sicker resulting in hospitalization for further evaluation, treatment, and management. These results are comparable to hospitalization rates at each assigned ESI level in this study: 96% (70 patients) in ESI level 1, 83% (556 patients) in ESI level 2, 68% (227 patients) in ESI level 3, 60% (3 patients) in ESI level 4, and 100% (1 patient) in ESI level 5. This study's results showed a similar trend of decreasing hospitalization rates as acuity decreases except for level 5. This discrepancy could also be attributed to the low frequency of patients assigned ESI level 5. Eitel et al. found a similar trend to Wuerz et al.'s study that distribution of hospitalization decreases each level such as 83% in level 1; 67% in level 2; 42% in level 3; 8% in level 4; and 4% in level 5 (2001).

6.5 EVALUATING THE PRESENCE OF ABNORMAL VITAL SIGNS AT EMERGENCY DEPARTMENT TRIAGE

Acute coronary syndrome is a condition that can result in hemodynamic instability causing catastrophic damage to vital organs. There is a well-known association between hypertension and ACS and is additionally supported by being the most frequent past medical history patient characteristic in this sample. High blood pressure causes increased mechanical stress on blood vessels that can contribute to endothelial dysfunction, atherosclerosis progression, and eventually plaque rupture leading to possible coronary artery occlusions (Konstantinou et al., 2019). Not only is hypertension reported 30%-40% among patients with a STEMI, that number climbs to 70% in those experiencing NSTEMIs (Konstantinou et al., 2019). Furthermore, Shah et al. identified out of 100,889 patients diagnosed with acute MI, 68% of patients with an NSTEMI diagnosis had a history of hypertension (2014). Conversely, 62% of patients who experienced a STEMI had hypertension (Shah et al., 2014). In a comparative study done for those experiencing non-ST segment elevation ACS and new-onset hypertension versus prior history of hypertension, those with a prior history were significantly more likely to experience systolic dysfunction, heart failure, and cardiogenic shock (Lee et al., 2013). It is important to note in their study both the prior history of hypertension group and the no prior history of hypertension presented to the ED with an average systolic blood pressure ranging from 140-147 mm Hg (Lee et al., 2013).

It is clearly displayed that prior history of hypertension is a prognostic variable in the diagnosis of ACS. However, there is limited data on the associations between ED presenting blood pressures and patient outcomes. In this study's sample, the number one documented abnormal vital sign in the electronic health record at initial triage was systolic blood pressure. The Acute Coronary Syndrome Israel Survey found those with a presenting low systolic blood pressure (< 110 mm Hg) had a significantly increased hazard ratio for 7-day mortality, 1-year mortality, and major adverse cardiovascular events (MACE) (Shlomai et al., 2015). Lee et al. similarly identified an increased correlation between lower systolic blood pressure (< 100 mm Hg) and in-hospital mortality (2013). The ESI guidelines recommend that the triage nurse should consider the patient's heart rate, respiratory rate, and pulse oximetry at ED triage. While abnormal heart rate was the third-highest reported abnormal vital sign in this study, less than 1/3 of the population were affected. Lee et al. had an average initial triage heart rate of 78 beats per minute in the no prior history of hypertension group and 79 beats per minute in the prior history of hypertension group (2013). The ranges for heart rate were 66-94 beats per minute which did not meet the threshold for this study's constitution of abnormal heart rate (< 60 or > 100 beats per minute) (Lee et al., 2013). There is potential to include the assessment of systolic blood pressure in addition to heart rate, respiratory rate, and pulse oximetry while determining the triage level for patients with suspected ACS.

According to the ESI recommended guidelines, patients with abnormal vital signs should be considered to be assigned a higher acuity triage score, meaning that their ESI level could be assigned an ESI level 2 instead of ESI level 3 (Gilboy et al., 2020). In the study, there were 239 patients that had abnormal vital signs at the initial nurse assessment and had a documented ESI triage level of 3. Patient flow in the ED is complex and assigning patients a high acuity level does not mean that they are immediately taken to a room in the ED for evaluation. Due to ED overcrowding, a situation in which the need for emergency services outweighs available resources in the ED, patients may have extended waiting times (Di Somma et al., 2015; George & Evridiki, 2015; Hong et al., 2013). Overcrowding could potentially delay patient care, leading to worse clinical outcomes. Patients in the waiting room could decompensate, potentially even into a sudden cardiac arrest. This is a serious concern considering coronary artery disease is the leading cause of up to 80% of all cardiac arrests (Yow et al., 2021). By triaging patients with suspicion of ACS and abnormal vital signs to a higher acuity level, there is a high likelihood that those patients will be placed into an ED treatment room and evaluated by an advanced care provider or physician faster than those who were assigned a middle acuity level (i.e., ESI level 3).

6.6 STRENGTHS AND LIMITATIONS

This study has many strengths. Data were collected across 17 EDs as part of a large regional health care system which provided us with a wide variety of patient presentations. Despite the limitations of it being one health care system, the study did include a diverse representation of facilities: academic, level one trauma, community, and rural all using the same EHR charting system.

This study has a few limitations, one of which is data was collected retrospectively from the EHR. Any information not entered into the EHR was not included in the analysis. Additionally, there were multiple data collectors which could have resulted in possible data variability. The same expert users of the EHR trained and evaluated the extraction of data to minimize variability. Data extraction quality checks were completed. Furthermore, this study excluded STEMI patients which removed part of the ACS population from the analyses. The sample lacked racial and ethnic diversity due to the location of the regional health care system located in the mid-Atlantic region. Future research should evaluate the ESI triage tool in different geographical locations, across multiple health care systems, and with the inclusion of STEMI patients to further the understanding of assessing patients with suspicion of ACS at ED triage.

6.7 CLINICAL IMPLICATIONS FOR EMERGENCY DEPARTMENT NURSES

The findings from this study have numerous implications for ED nurses who initially assess, prioritize, and manage patients with potential ACS. First, nurses should be aware that patients who have a past medical history of chronic obstructive pulmonary disease may use more ED resources. This may help with assigning the appropriate ESI triage level upon arrival to the ED. ED nurses could organize care and have better time management, and delegate tasks to others with the anticipation that someone with chronic obstructive pulmonary disease may need more attention.

Secondly, complex procedures, radiologic testing, and having an electrocardiogram done within 10 minutes of arrival were associated with being assigned a documented higher acuity level, therefore nurses could anticipate completing these tasks without having to guess what is needed for these patients. Nurses could prompt the ordering of radiologic testing or anticipate complex procedures, thus leading to efficient patient care. Additionally, nurses should conduct electrocardiograms within 10 minutes of arrival in order to meet the suggested goals of The American College of Cardiology and the American Heart Association (O'Gara, et al., 2013).

Since it was discovered that the completion of electrocardiogram within 10 minutes of arrival, intravenous medication, specialty consultation, and laboratory testing were all significant with the association of hospital admission, the nurse and the ED charge nurse could communicate with the bed management department of the anticipated hospital admission to ensure timely bed assignment. This process has the potential to speed up the hospital admission events, moving patients to their respective admission units, and allowing for more ED bed availability for new patients.

Lastly, it was identified that the average number of resources used was 4.5 across all ESI levels. When considering that six patients were assigned to an ESI level 4 or 5, this is well above the anticipated one to zero resources for each ESI level, respectively. With a majority of patients using more resources than anticipated, there is potential to consider patient vital signs prior to anticipated ED resource utilization in the ESI triage algorithm. Additionally, since abnormal blood pressure was the most commonly documented abnormal vital sign, nurses may want to consider this when assessing the severity of illness and assigning ESI levels. This is especially true because low blood pressure upon ED presentation and history of hypertension were both associated with MACEs in those with ACS (Lee et al., 2013; Shlomai et al., 2015).

7.0 CONCLUSION

ACS is one of many high-risk conditions that present to the ED with complex symptomology and requires time-sensitive treatments for optimal patient outcomes. Mis-triage can cause delays in treatment for patients in need and indirectly affect the care of others in the ED which ultimately, compromises patient outcomes and potentially leads to increased mortality (Ryan et al., 2015; Wolf, 2011). It is invaluable to reevaluate triage systems and their effectiveness as medicine continues to change. ACEP and the ENA also support the continual research and investigation to further refine patient acuity assignment (2017). These results have the implications to affect nurses in EDs everywhere especially considering the majority of EDs across the United States use the ESI algorithm (McHugh et al., 2012). Additionally, with heart disease being the leading cause of death in the United States coupled with someone having a myocardial infarction every 38 seconds, everyone should be aware of the concerns addressed in this study (Virani et al., 2021). Future studies could focus on a larger scale study of the distribution of ED resources, hospital admissions, and patient's initial vital signs to help better understand this subpopulation. Furthermore, nurses should consider patients with a history of chronic obstructive pulmonary disease could use more ED resources, therefore, prompting the assignment of a higher acuity score. Patients with suspected ACS on average use more resources and have a higher admission rate compared to all ED patients. There may be a need to apply different criteria upon initial assessment for this subpopulation to ensure accurate assignment of an ESI level. Ultimately, the continual improvement of ED triage assessment should be focused on patient-centered outcomes and evidence-based practice to provide the highest quality care for the many Americans who may experience a coronary event.

Appendix A DATA DICTONARY FOR THESIS STUDY

VARIABLE	DATA TYPE	DESCRIPTION	OUTCOME
Study ID	Integer	Unique number ID for all enrolled patients	1-1196
Race	Nominal	Race identified as per the patient as listed in the electronic health record	0 = white, 1 = black/African American, 2 = other
Ethnicity	Categorical	Ethnicity identified as per the patient as listed in the electronic health record, Hispanic or Latino	0 = no, 1 = yes
Sex	Nominal	Sex identified as per the patient in the electronic health record	0 = male, 1 = female, 2 = non-binary
Age	Integer	Age in number of years as the patient as listed in the electronic health record	
Body mass index	Integer	Body mass index is a person's weight in kilograms divided by the square of the height in meters as calculated by the height and weight listed in the electronic health record	
Hospital admission	Categorical	Admission to the hospital as listed in the electronic health record	0 = no, 1 = yes
PAST MEDICAL AND SURIGCAL HSITORY			
History of hypertension	Categorical	Known past medical history of hypertension listed in the electronic health record	0 = no, 1 = yes
History of dyslipidemia	Categorical	Known past medical history of dyslipidemia listed in the electronic health record	0 = no, 1 = yes
History of smoking	Nominal	Status of smoking listed in the electronic health record	0 = never, 1 = prior, 2 = current
History of gastroesophageal reflux disease	Categorical	Known past medical history of gastroesophageal reflux disease listed in the electronic health record	0 = no, 1 = yes

History of coronary artery disease	Categorical	Known past medical history of coronary artery disease listed in the electronic health record	0 = no, 1 = yes
History of percutaneous coronary intervention	Categorical	Known past surgical history of percutaneous coronary intervention listed in the electronic health record	0 = no, 1 = yes
History of myocardial infarction	Categorical	Known past medical history of myocardial infarction listed in the electronic health record	0 = no, 1 = yes
History of atrial fibrillation	Categorical	Known past medical history of atrial fibrillation listed in the electronic health record	0 = no, 1 = yes
History of chronic obstructive pulmonary disease	Categorical	Known past medical history of chronic obstructive pulmonary disease listed in the electronic health record	0 = no, 1 = yes
History of heart failure	Categorical	Known past medical history of heart failure listed in the electronic health record	0 = no, 1 = yes
History of percutaneous coronary intervention with stenting	Categorical	Known past surgical history of percutaneous coronary intervention with stenting listed in the electronic health record	0 = no, 1 = yes
History of cancer	Categorical	Known past medical history of cancer listed in the electronic health record	0 = no, 1 = yes
History of peripheral vascular disease	Categorical	Known past medical history of peripheral vascular disease listed in the electronic health record	0 = no, 1 = yes
History of coronary artery bypass graft	Categorical	Known past surgical history of coronary artery bypass graft listed in the electronic health record	0 = no, 1 = yes
History of angina	Categorical	Known past medical history of angina listed in the electronic health record	0 = no, 1 = yes
History of pacemaker	Categorical	Known past surgical history of pacemaker listed in the electronic health record	0 = no, 1 = yes
History of stroke	Categorical	Known past medical history of stroke listed in the electronic health record	0 = no, 1 = yes

History of obstructive sleep apnea	Categorical	Known past medical history of obstructive sleep apnea listed in the electronic health record	0 = no, 1 = yes
History of pulmonary embolism	Categorical	Known past medical history of pulmonary embolism listed in the electronic health record	0 = no, 1 = yes
History of peripheral artery disease	Categorical	Known past medical history of peripheral artery disease listed in the electronic health record	0 = no, 1 = yes
EMERGENCY DEPARTMENT RESOURCES			
Laboratory testing	Categorical	Patient had laboratory testing completed during the emergency department visit	0 = no, 1 = yes
Radiologic testing	Categorical	Patient had radiologic testing (ultrasound, x-ray, computed tomography [CT], CT angiography, magnetic resonance imaging, nuclear testing- SPECT scan, transthoracic echocardiogram, ventilation-perfusion scan) completed during the emergency department visit	0 = no, 1 = yes
Intravenous medication	Categorical	Patient received intravenous medication during the emergency department visit	0 = no, 1 = yes
Intramuscular medication	Categorical	Patient received intramuscular medication during the emergency department visit	0 = no, 1 = yes
Electrocardiogram done within 10 minutes of arrival to emergency department	Categorical	Patient had an electrocardiogram done within 10 minutes of arrival to emergency department during the emergency department visit	0 = no, 1 = yes
Intravenous fluids	Categorical	Patient received intravenous fluids during the emergency department visit	0 = no, 1 = yes
Specialty consult	Categorical	Patient received a specialty consult (Patient is seen by any advance practice provider or physician. i.e., neurology, cardiology, urology etc. and does not include being seen by an emergency department provider or a Hospitalist.)	0 = no, 1 = yes

		during the emergency department visit	
Nebulizer medication	Categorical	Patient received nebulized medication during the emergency department visit	0 = no, 1 = yes
Simple procedure	Categorical	Patient had a simple procedure completed during the emergency department visit	0 = no, 1 = yes
Complex procedure	Categorical	Patient had a complex procedure completed during the emergency department visit	0 = no, 1 = yes
LEVEL OF ASSIGNED ACUITY			
Emergency Severity Index level	Nominal	Emergency Severity Index level identified as per the emergency department nurse as listed in the electronic health record	0 = no assignment, 1 = level 1, 2 = level 2, 3 = level 3, 4 = level 4, 5 = level 5
ABNORMAL EMERGENCY DEPARTMENT VITAL SIGNS			
Abnormal heart rate	Categorical	Emergency department first heart rate value < 60 or > 100 beats per minute listed in the electronic health record	0 = no, 1 = yes
Abnormal respiratory rate	Categorical	Emergency department first respiratory rate value > 24 beats per minute listed in the electronic health record	0 = no, 1 = yes
Abnormal pulse oximetry	Categorical	Emergency department first pulse oximetry value < 92% listed in the electronic health record	0 = no, 1 = yes
Abnormal systolic blood pressure	Categorical	Emergency department first systolic blood pressure value < 90 or > 160 beats per minute listed in the electronic health record	0 = no, 1 = yes
Abnormal pain score	Categorical	Emergency department first pain score value ≥ 7 on a scale ranging from 0-10 listed in the electronic health record	0 = no, 1 = yes

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