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A Modified EMS System: Transport Ambulance

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Abstract

The cost of ambulance services is very high for patients. A patient who uses an ambulance can expect to pay hundreds of dollars for even the most basic ambulance service. There are many reports of patients receiving basic medical care in an ambulance and being charged extremely high costs as if their injuries were more serious. The problem is that the service levels of EMS systems are not diversified enough to isolate costs. The financial burden of preparing to handle major incidents and managing ambulance vehicles and equipment increases the cost of basic ambulatory services. Since the expensive equipment and vehicles are necessary for high priority emergencies, one of the possible options to reduce costs is to introduce a new type of ambulance within the existing EMS structure, assuming there are enough of these minor incidents that can justify further specialization. This new service will utilize a cheaper vehicle and less expensive equipment to provide affordable care in a sustained way. Ambulance records from the National EMS Information System (NEMSIS) were analyzed to quantify ambulance use within the United States. Using the conclusions drawn from the data, the usage trends and service levels carried out by EMS systems over the course of the year 2014 were found. The data indicates that 18 percent of ambulance deployments involved only minor injuries that could be handled by the new lower tier service level, since they were not life-threatening situations that required expensive equipment, advanced training, or a low response time. This new transport service will utilize a Ram Promaster, and a reduced payload of equipment. If the transport service is deployed, there will be at least a \$50,000 reduction in yearly costs. However, the transport ambulance will only be effective within urban environments. There are also federal and state regulations that will need to be updated should this vehicle go into service, which includes new equipment considerations and safety standards for the new transport ambulance. These will be major barriers to the implementation of this service and may not be worth it for the potential savings to many lawmakers and EMS administrations.

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Chapter 1: EMS Response Services

Emergency Medical Services have been operating in an official capacity within the United States as early as the mid-1800s. In today's modern age, ambulance services have evolved into a critical component in medical emergencies. Instead of simply being transportation to hospitals, patients can receive immediate care that will keep them alive until they can be treated by doctors at a hospital. Unfortunately, the modernization of ambulances is slowly becoming prohibitive in regards to managing costs in a healthcare system. New advances in medical devices are generally enriching the quality of patient care. Devices such as automatic defibrillators and hydraulic cots make saving lives simpler for emergency medical technicians (EMT). Even the vehicles themselves are engineered to withstand heat, cold, vibrations, and crashes that normal vehicles cannot. These ambulances are sturdy, safe, and filled to the brim with life-saving equipment. But, even though the vehicles and equipment are designed to save lives, they are not designed to be cost effective. The total cost for a fully equipped ambulance is over a quarter million dollars, not considering the operating and maintenance costs. For most EMS departments this growing cost is a major concern. The emergency services need modern equipment and services in order to continuously improve the quality of care. A cost cannot be put on human lives so easily, and very few expenses are considered too high in this respect. But what about the cost of a ride to the hospital via an ambulance? Some emergencies simply require some assistance getting to the hospital. There are many news articles and complaints from EMS patients concerning their recent ride on an ambulance: it was extremely expensive. These particular complaints do not come from people who were severely injured or very sick, but from people who accepted a ride to the hospital via an ambulance because of some minor incident. EMS systems and the government are very concerned about ambulances being prepared to handle any emergency that may arise. This is an

understandable course of action. It is more effective to have everything needed than to need something and not have it. But being over-prepared will be cost prohibitive for both the EMS and the patients who use it. The EMS systems have considered this in the past and have bisected their services into two main categories: Basic Life Support and Advanced Life Support. Truthfully, there is a significant difference in price, but the basic life support services are still rather expensive given the nature of their non-emergency incidents.

The goal of this project is to introduce a new level of service that will be reserved only for these minor emergencies. This new service will utilize the conceptual transport ambulance, which will be cheaper to operate and maintain than the normal ambulances. This service will create a low cost emergency service that patients are able to utilize. Instead of being charged for using ambulances equipped to respond to serious emergencies, they will be charged less for using just basic services. In order for this proposed service to be viable, there are few questions that need to be answered. What kind of vehicle will be used for the transport ambulance? What equipment is on board? Who will be operating the ambulance? Finally, how will these ambulances be deployed in an emergency situation? To answer these questions, research on EMS systems, ambulances, EMTs, and emergency medical equipment has been conducted. In order to gauge the viability and usefulness of this modified EMS system, a public dataset from NEMSIS has been analyzed.

An analysis of the history of ambulances, how EMS systems operate, analyzing usage of ambulances from the NEMSIS data, and exploring EMS systems in other countries has been done in Chapter 2. The idea of the transport ambulance came from this background research. Then, the specifics of the transport ambulance have been outlined in Chapter 3. Lastly, the final conclusions of the project and its impact have been recorded in Chapter 4.

Chapter 2: Current Ambulance Strategy

2. Introduction

Ambulances as we know them have been in use in battlefields since the year 1000 A.D. (History of Ambulances, 2010). Ambulances carried medical supplies, but most importantly they provided attention to wounded soldiers. Ambulances didn't become widespread in non-military private use until after the American Civil War. During the 20th century, advancements in medicine brought increasingly well-equipped and complex ambulances. Governments began to support, evaluate and regulate EMS programs to meet stricter standards. These improvements increased the survivability of patients, and ushered in the era of modern ambulances.

There are several steps that need to be completed before care can be given to a patient. Emergency calls are first processed in location based call centers known as PSAPs. The call center gets relevant information and determines which ambulance to send according to a dispatching algorithm (Lim and Braun, 2011). From there, the ambulance must navigate to the scene and find the patient, which is not always simple. The biggest problem facing modern ambulances is inefficiency leading to high costs. First of all, up to 80% of 911 calls are not deemed serious enough to send first responders (Johnson, 2008). Another major problem with 911 calls is location. Presently, a vast majority of emergency calls are from cell phones, which sometimes do not provide an accurate location. The Federal Communications Commission (FCC) is working with cellular companies to rectify this (Kelly & Keefe, 2015). Finally, the largest problem is over preparedness. Modern ambulances are fantastic at being ready for the unexpected, but are not cost effective. It is near impossible for ambulance services to cost less than four figures, even if intensive care is not provided. The ambulance themselves cost upwards of \$300,000 just to purchase, and cost even more in fuel and maintenance (Lindberg, 2011). Ambulances are running

whenever they are not being serviced, in order to maintain the interior temperature. This uses a tremendous amount of fuel. Due to the shared responsibility of payment between users and insurance, reducing costs is complicated. Patient cost cannot be reduced without impacting another part of the emergency care system. However, reducing inefficiencies starts with reducing operating costs of ambulances.

2.1 Ambulance History and General Specifications

While the first military vehicular ambulance dates back to at least the 11th century, it was much later before something resembling ambulances appeared on the civilian front. Medieval medics, trained by Arab and Greek physicians, used carriages and carts to respond to battlefield casualties. Doctors attended to the sick in their own homes. However, it was another 800 years before civilian hospitals, and ambulances became commonplace (History of Ambulances, 2010). Progress in medicine during the American revolutionary war led to the establishment of medical schools for the first time. This was groundbreaking for a time period where a leg fracture could only be treated by amputation. It was not until after the civil war in 1869 that the military ambulance corps branched out to the civilian sector.

2.1.1 The Evolution of Ambulances

Ambulances like the one shown in Figure 1 carried just a driver and one skilled physician, known as an ambulance surgeon, with room for two patients lying down. These surgeons had as little as two years of medical training. For equipment, the ambulance carried "a quart flask of brandy, two tourniquets, a half-dozen bandages, a half-dozen small sponges, some splint material, pieces of old blankets for padding, strips of various lengths with buckles, and a two-ounce vial of persulphate of iron" (Bellevue Hospital - First Municipal, 2009). While Spartan by today's

standards, these basic first aid implements were lifesaving. Even the first ambulances were a significant improvement to civilian medicine and increased patient survivability. Patients no longer needed to wait for a doctor available for a house call, and also had the option to be driven to a nearby hospital.



Figure 1: One of the first early civilian ambulances circa 1969

The first horseless carriages and motorcars introduced in the early 20th century quickly saw use as ambulances. The gasoline engine had been invented, however at the time steam and electric powered cars were more practical than early gas fueled automobiles. The first ambulance was electric, introduced in Chicago in 1899. It had a limited range and an extremely slow top speed (History of Ambulances, 2010). Ironically, it was the electric motor that led to the death of the electric car and over 100 years of gasoline's dominance in automobiles. One of the largest flaws with early gas engines was starting them. The driver needed to crank over the engine by hand with a mechanical crank, much like kick starting a motorcycle. While an average person can pull start a motorcycle engine with ease, larger car engines required great strength. There was also the risk of the engine sharply kicking backwards, taking the hand crank with it and potentially injuring the

person holding the crank. Electric starting systems all but eliminated this risk, and allowed gasoline cars with their larger fuel tanks and ranges to be as reliable to start as a similar electric car.



Figure 2: Tourniquets saved lives at the expense of the injured limb



Figure 3: Early civilian gasoline powered ambulance

As with many things, military ambulance needs and research transitioned into the private sector. WWI ambulances were being equipped with more and more lifesaving devices. Advanced splinting technology allowed limbs to be saved that would have been amputated just a few years ago. Radio technology also allowed field hospitals to communicate with medics. Military use and

mass production reduced the costs of these luxuries to the point where they could be used successfully in civilian ambulances to save lives and limbs. Evidence from WWI shows these advancements had a significant effect on survivability (*History of Emergency Medical*, 1997).



Figure 4: WWI era military ambulance

Radio communications and telephones created organization in the ambulance service. Citizens could call the police in the event of an emergency, but the police could not contact ambulances already on the road, just the hospitals through a clunky switchboard system. Two-way radios allowed police to direct first responders to where they were needed (*History of Ambulances*, 2010). However, ambulances still only provided first-aid and a ride to the hospital. This was a more European approach, compared the large ambulances of today which presently contain up to four medics.

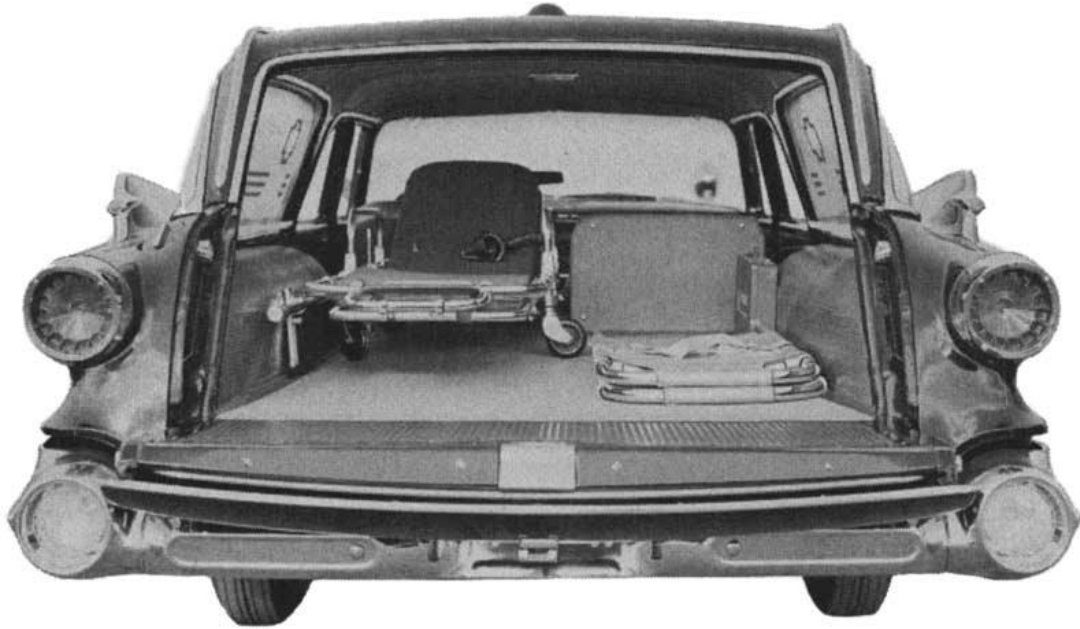


Figure 5: Interior of Dodge car-based ambulance

In an effort to limit preventable death, ambulances became more and more equipped with equipment and instruments to deal with emergencies on site. Defibrillators and CPR equipment became standard issue, however the vehicles chosen had weight limitations. Ambulances at this time were constructed on car or station wagon chassis on which performed poorly with the weight of the added equipment. Purpose built, heavy duty ambulances were required. State and government laws were discussed to regulate ambulances, their crews, and their equipment in an effort to save lives at the scene, before the patient is taken to the hospital.

2.1.2 History of Ambulance Specifications

In 1966, an important paper was published regarding ambulances and patient care. It was titled *Accidental Death and Disability: The Neglected Disease of Modern Society*, written by the Committee on Trauma and Committee on Shock of the National Academy of Sciences— National Research Council. At the time, the greatest cause of death in the United States for people aged between 1 and 37 was personal injury (National Highway Traffic Safety, 1966). Our hospitals had

become proficient at treating fatal diseases, but physical bodily harm was not being adequately addressed. The paper outlined the following improvements:

“Extension of basic and advanced first aid training to greater numbers of the lay public;

Preparation of nationally acceptable texts, training aids, and courses of instruction for rescue squad personnel, policemen, firemen, and ambulance attendants;

Implementation of recent traffic safety legislation to ensure completely adequate standards for ambulance design and construction, for ambulance equipment and supplies, and for the qualifications and supervision of ambulance personnel;

Adoption at the state level of general policies and regulations pertaining to ambulance services;

Adoption at district, county, and municipal levels of ways and means of providing ambulance services applicable to the conditions of the locality, control and surveillance of ambulance services, and coordination of ambulance services with health departments, hospitals, traffic authorities, and communication services;

Pilot programs to determine the efficacy of providing physician-staffed ambulances for care at the site of injury and during transportation;

Initiation of pilot programs to evaluate automotive and helicopter ambulance services in sparsely populated areas and in regions where many communities lack hospital facilities adequate to care for seriously injured persons;

Delineation of radio frequency channels and of equipment suitable to provide voice communication between ambulances, emergency department, and other health-related agencies at the community, regional, and national levels;

Pilot studies across the nation for evaluation of models of radio and telephone installations to ensure effectiveness of communication facilities;

Day to day use of voice communication facilities by the agencies serving emergency medical needs; and

Active exploration of the feasibility of designating a single nationwide telephone number to summon an ambulance.” (National Highway Traffic Safety, 1966)

This calls for significant improvements in vehicular ambulances, as well as the supporting infrastructure. Most importantly, this led to the creation of a single nationwide emergency services hotline: 911. No matter where an accident occurred or where in the country anyone was from, the number to get help would be the same. Centralized dispatching would follow, with organized approaches to specific areas and established communication networks between departments. Also relevant are improvements in first responder training. The Committee on Trauma found ambulance personnel were not adequately educated to save lives. The newly founded Department of Transportation (DOT) outlined regulations and took the lead on better EMT training. Individual states were responsible for creating and funding these programs, with assistance from the government and the DOT itself (National Highway Traffic Safety, 1966). Focus was on heart attacks and cardiac health of patients.

In 1988, EMS programs began to be strictly evaluated by the Federal and State Governments. The programs were judged on the following aspects: Regulation and policy,

resource management, human resources and training, transportation, facilities, communications, public information and education, Medical instruction, trauma systems, and evaluation (*History of Emergency Medical*, 1997).

2.2 An Overview of the EMS Process

The Emergency Medical Service in the United States is integrated with the emergency communications system. A very important and much utilized component of the emergency communications system is the 9-1-1 system. This massive telephone network connects every single person in the country with local emergency services. From the moment someone dials 911, a rapid, yet thorough process is set in motion in order to send aid as quickly as possible to save lives.

2.2.1 The 911 System and PSAP

When a caller dials 911, the call is directed to the local Public Safety Answering Point (PSAP) (Barnes & Rosen, 2014). The operator then asks the caller a series of questions in order to ascertain the nature and severity of the emergency. The operator needs to know which emergency service is needed so they can use their prompt cards to properly dispatch assistance. There are different protocols for the three different emergency divisions: police, fire, and medical. There is a priority for the type of information that the operator needs. First, they need a name and an address. With this information, they will be able to send help if the call is interrupted for some reason. Then, depending on the emergency, the operator will ask more detailed questions to figure out what type of responders are needed on the scene and how quickly they must arrive.

If the caller needs medical assistance, a triage similar to Figure 6 is used. The operator asks where the caller is first, so in case the emergency is severe, help can be dispatched even if the operator is not finished with the inquiry.

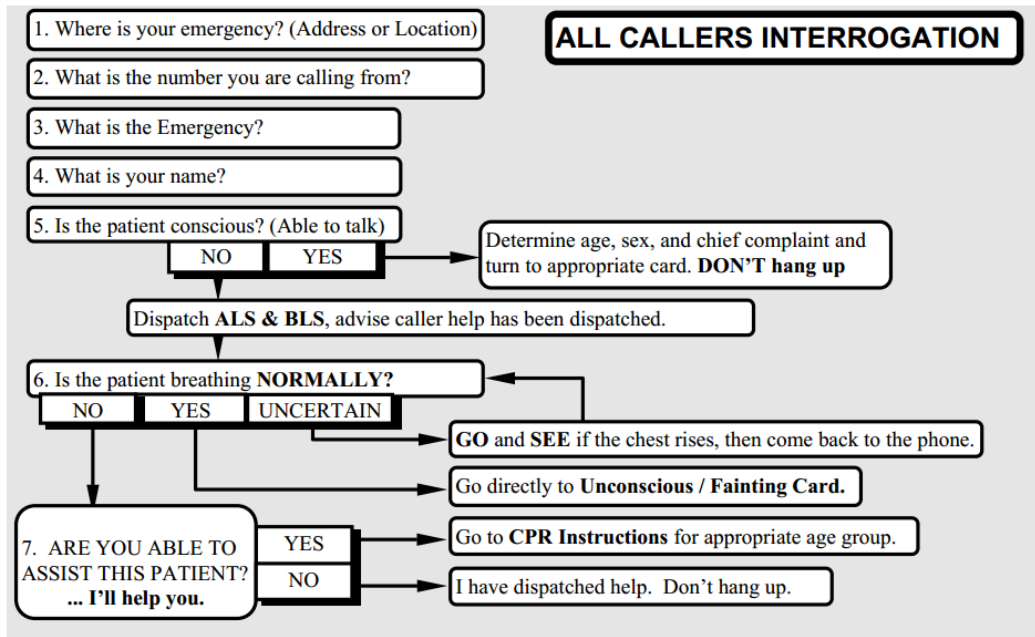


Figure 6: Triage for medical emergencies

The operator also asks about the number the caller is using. Does the number belong to the caller or someone else? Is it a cell phone or land line? These questions are important because the PSAP can easily get a location on their computer to send to the ambulance. Another very important question is whether or not the patient is conscious. If the patient is unconscious, the advanced life support ambulance is sent to the scene immediately because the issue is most likely very serious in this situation. If the patient is conscious and breathing normally, the emergency may not be considered very serious and the operator will inquire further and instruct the caller to care for the patient until help arrives. Many PSAPs categorize calls based on their severity. If a patient needs help immediately, for example if they are unconscious, that incident will be given a high priority. If the patient's issue is not immediately life threatening, the PSAP will give that call a lower

priority. These tiered response systems are only present in large EMS systems with multiple levels of service (St. John, 1983).

Once the operator determines the type of the medical emergency, he or she will use a guide card for the emergency. Figure 7 is the traumatic injury card.

TRAUMATIC INJURY		State of New Jersey EMD Guidecards Version 1/04	
K E Y Q U E S T I O N S	Is patient alert?	Is the patient bleeding?	
	Is patient breathing normally? (Consider breathing card)	IF YES,	From where? How much? How long? Can it be controlled with pressure?
	How was the patient injured?		
	Where is the patient injured?		
	Describe what happened.		
SIMULTANEOUS ALS/BLS		BLS DISPATCH	
D I S P A T C H	Unconscious/not breathing normally. Decreased level of consciousness. Penetrating/crushing injury to head, neck, torso, thigh. Multiple extremity fractures Leg injury above the knee. Uncontrolled bleeding.	Penetrating/crushing injury to hands or feet. Unknown or internal injuries. Minor injuries Concerned caller without apparent injuries to victim. Isolated extremity fracture. Police request stand-by/check for injuries.	

Figure 7: Emergency medical dispatch guide card for traumatic injury

The operator will use the answers to the questions posed to the caller to determine which type of ambulance to send. If the injuries are severe, the advanced life support ambulance is sent, if not, the basic life support ambulance is sent.

2.2.2 Ambulance Dispatch Process

In urban areas such as cities or large suburban towns, dispatching all ambulances from one central location is not efficient. Ambulances on duty are primarily responsible for a certain operating area (Lim & Braunl, 2011). This dynamic dispatch model is widely used in cities all throughout the United States. In a small city, there could be three to four ambulance units standing by in specified locations. This strategy is very useful for minimizing response times. Instead of having the ambulances wait in their garage and travel to each call from the same starting location, they can potentially be closer to their patient and arrive on a scene much faster. This method is similar to having police officers on patrol. There are certain areas of the city where medical calls are more likely to come from depending on the time of the day.

When the dispatcher receives emergency information from the PSAP, the dispatcher assigns the incident to either an ALS or BLS that is closest to the caller. The ambulance accepts the incident and travels to the scene as quickly as possible. The vehicle uses sirens and lights in order to manipulate traffic on the road. Drivers notice the sirens and lights and allow the ambulance to pass. This allows the ambulance to travel very quickly in most cases. However, during high traffic volume, there is often not enough space for drivers to make room for the emergency vehicle, and response time suffers as a result. When the ambulance reaches its destination, EMTs must assess the situation and provide help to the patient. The EMTs locate the patient on the premises first and then evaluate the patient. The crew will have some idea of the nature of the emergency and its severity, so they will bring whatever equipment they need to help the patient. The patient is asked a series of questions, as the paramedics try to figure out exactly what is wrong and document it for further evaluation in the hospital. They can then assist the patient properly. The paramedics can give the patient medicine, or apply treatment like bandages or splints in order to

move the patient. In urban areas, many residences are built up and the patient may have to be carried down multiple flights of stairs. All of these processes and factors mean that the EMTs must spend quite a bit of time on the scene with the patient. In very severe cases, EMTs will not have time for all the documentation and triage, and they must act quickly to get the patient stable enough for transport to the ambulance and then to the hospital (Boone et al, 2014). Figure 8 shows a visual representation of a typical ambulance run.

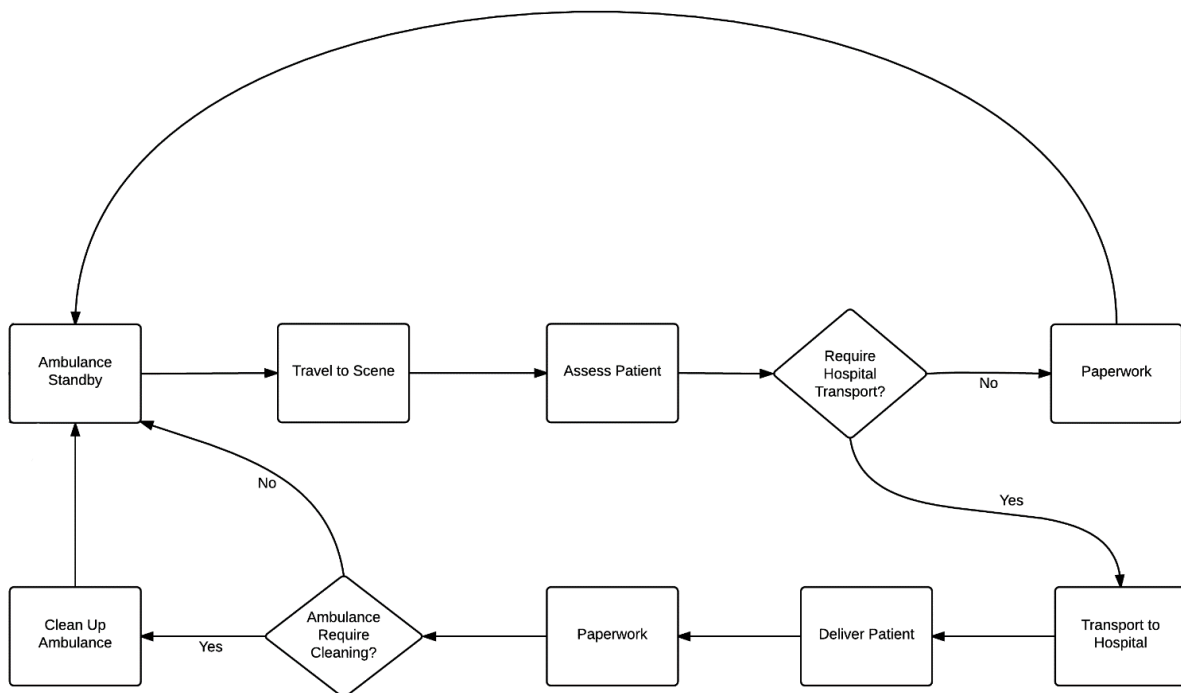


Figure 8: Typical ambulance dispatch process

Most often, the patient needs to be brought to the hospital for further treatment, as their problems may require a doctor’s professional assessment and treatment. EMTs and paramedics will stabilize the patient for transport and transport them to the hospital as quickly as possible. Upon arrival at the emergency room, the ambulance crew will hand off the patient to the doctors. However, the ambulance crew has two tasks at this point. First, the crew is the primary caretaker of the patient until the nurses and doctors are available to see the patient. If the emergency room

is crowded and busy, there may not be nurses or doctors available to take the patient right away. The ambulance crew must remain with the patient and continue to provide care to keep the patient stable until the doctors can take full control (Boone et al, 2014). Secondly, the ambulance crew must inform the doctors about what is wrong with the patient. The crew's description must be as detailed as possible so the doctors can make their own assessment and provide the proper emergency treatment. The doctor will want to know the symptoms, how long the patient has been in a condition, what the ambulance crew provided for the patient, and any complications along the way that the ambulance crew could recall. All this information is important to the doctors and will help the patient survive his or her ordeal. After both these tasks are finished, the ambulance crew is then free to leave. After leaving the patient in the care of the hospital, the ambulance is not yet ready to receive another call. The EMTs must file paperwork for the patient. Additionally, if there is any body fluid such as blood or vomit, or if the patient they transported had a contagious illness, the ambulance must be cleaned and disinfected before it can return to service. After all this is done, the ambulance is ready to make more runs until its shift is over (Boone et al, 2014).

2.2.3 Ambulance Placement and Availability

As mentioned previously, each 911 call is given a priority, and each ambulance stands by in their assigned locations. When a call goes out and an ambulance responds, the area that ambulance is responsible for is left vacant for some time. Ambulances in other areas will then move to cover that area in case another call comes in from there (Lim & Braunl, 2011). On particularly busy nights, the highest priority calls always take precedence over the low priority calls. For example, say an ambulance is assigned a low priority call on a busy night. Nothing detrimental will happen to the patient if the ambulance does not respond immediately. The only ambulance available is dispatched to the scene. However, before the ambulance makes it to the scene, another call comes

in, but this patient needs immediate attention or he will die. Since all the other ambulances are preoccupied, the ambulance responding to the low priority call is the only unit that can help. Therefore, that ambulance is reassigned from its low priority call and must respond to the high priority emergency instead. An ambulance cannot be redirected if the EMTs have a patient in their care, even if the emergency is severe. If all the ambulances are busy and a high priority call comes in, the patient will have to wait until an ambulance from perhaps an adjacent town comes in. In this case, the patient will have to wait significantly longer for an ambulance to arrive.

2.2.4 The Documentation Process

When an ambulance unit responds to a call, they are required to fill out medical documentation about the patient they provided service to. This document is called the patient care form (PCR) (Werfel & Williamson, 2014). The EMT or paramedic will start a PCR for their patient, and that document will be completed by the doctors and clerks at the hospital. Generally, the ambulance crew is responsible for providing the name of the patient, the complaint of the patient, the assessment of the EMT or paramedic, any treatments given to the patient, and how the patient is transported (Werfel & Williamson, 2014). The EMTs are required to be very descriptive in their delineations of the form. If a patient is sick, the description must include what the problem and evaluations are, and how the EMT reach the conclusion for the administered interventions. All assistance given and equipment used must also be clearly documented (Werfel & Williamson, 2014).

2.3 Ambulance Usage Statistics

While ambulance uses are frequently portrayed in dramatic TV shows, movies, and even books, the average American uses ambulances much less frequently. However, certain demographics groups use ambulances disproportionately, often for frivolous reasons. In order to explore this phenomenon more fully, this Section presents a review of the various demographic data available from the patients in the public NEMESIS research data, and compares them with the U.S. Census data of the same time, in order to draw conclusions onto which groups are unduly presenting strain on the system.

2.3.1 Age of Patients

One especially significant factor available in the data set is the age of the patient. No data beyond the 100-year mark are received and thus ages over 100 years are not considered for this report. In the column chart of the data seen in Figure 9, one can observe several sharp increases and trends throughout the ages from 1-100 in Ambulance usage.

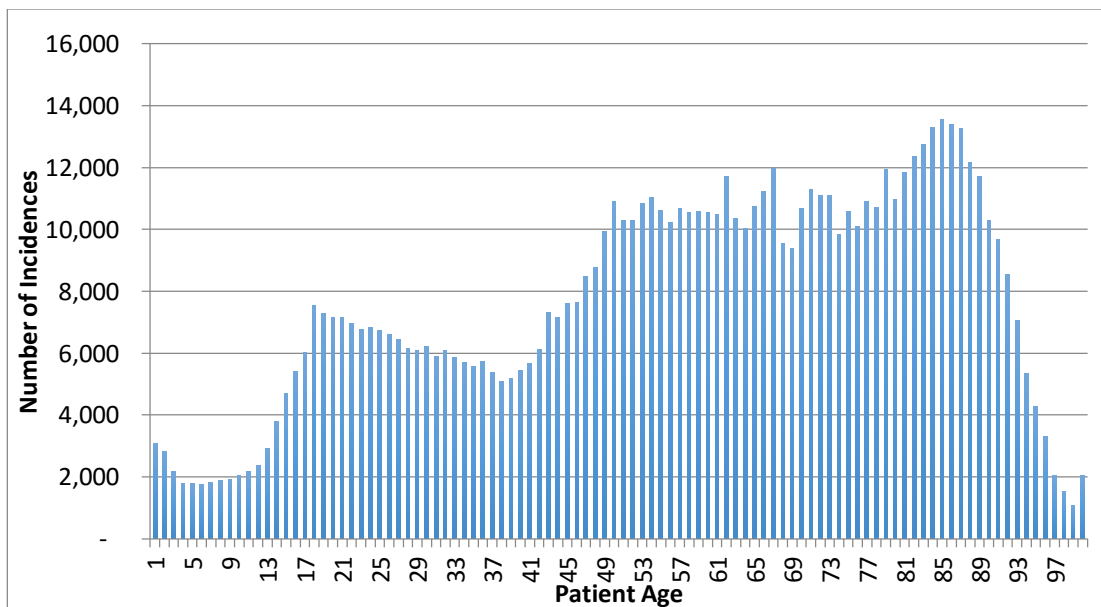


Figure 9: Ambulance use by age

Of particular interest is the sharp increase beginning around age 14, and peaking around age 20. We believe that this signifies the risk taking behavior of many teenagers around that age group. Ambulance use then decreases steadily until around age 40, when it begins to increase again, sharply, until age 55, where it plateaus, more or less, until approximately age 75. It is from that age group from 75-90 that we see the greatest ambulance use of any demographic group. After age 90, the number of ambulance uses by people in that age group decline sharply. Our group believes that this is due to the low proportion of the population in that demographic group. Another way to examine the data depicted in Figure 9, is with a scatterplot and a polynomial model (see Figure 10). Interestingly, a fifth degree polynomial equation fits the age vs. ambulance use chart to an R squared value of .85, indicating a strong connection, specifically, that approximately 85% of the variation in ambulance use could be attributed to age. While the equation cannot capture all the intricacies of the sharp increases and decreases of risk-taking behavior and declining health, the patterns of such are far more visible on the scatterplot, a data visualization device made precisely for such relationship analysis between variables.

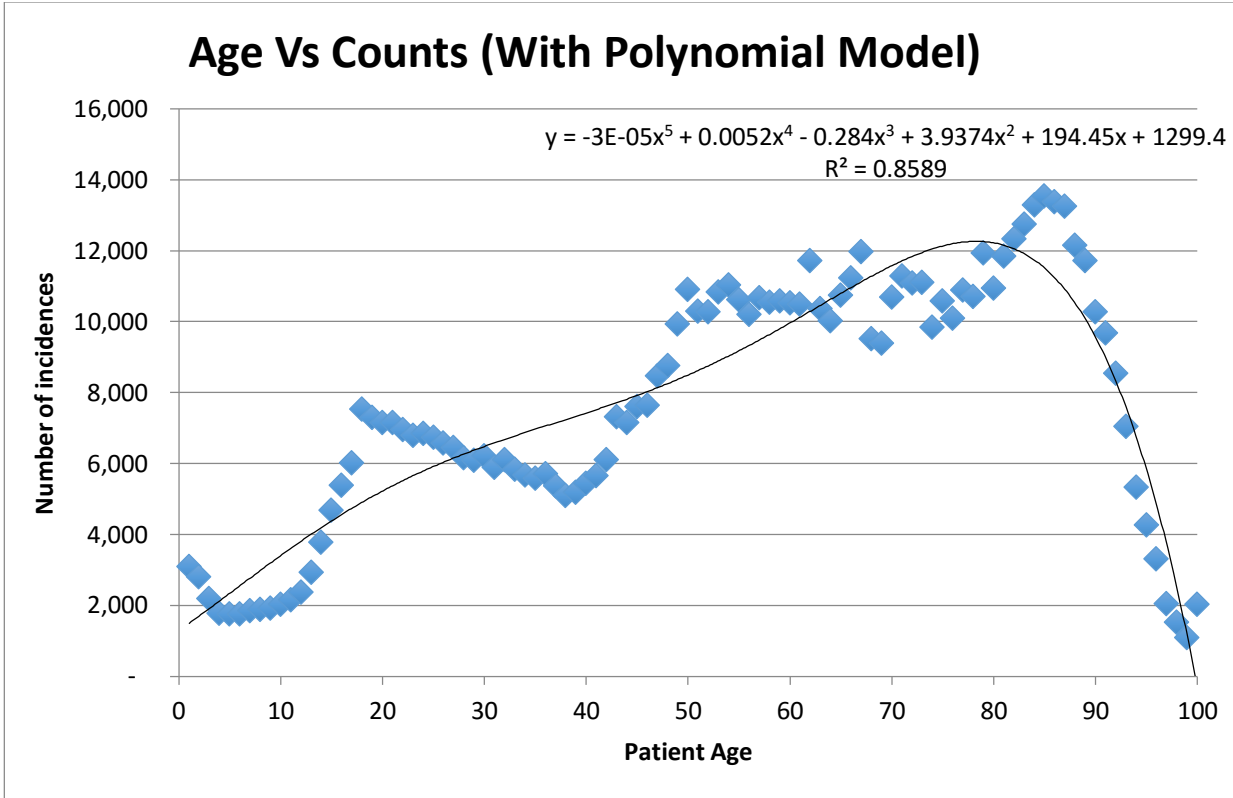


Figure 10: Patients' age vs. incident counts model

These results of ambulance use depicted in Figures 9 and 10 are further compared with the United States Population. By graphing these two disparate variables against each other, a visualization is created of the differences. As can be seen in Figure 11, until the age of 50, most of the population actually underutilizes their share of ambulance calls. There is also clear disproportionate increase of ambulance uses during teenage years and for people in their mid-forties. However, the clearest and most severe disproportionate use in Figure 11 comes from those over the age of 55.

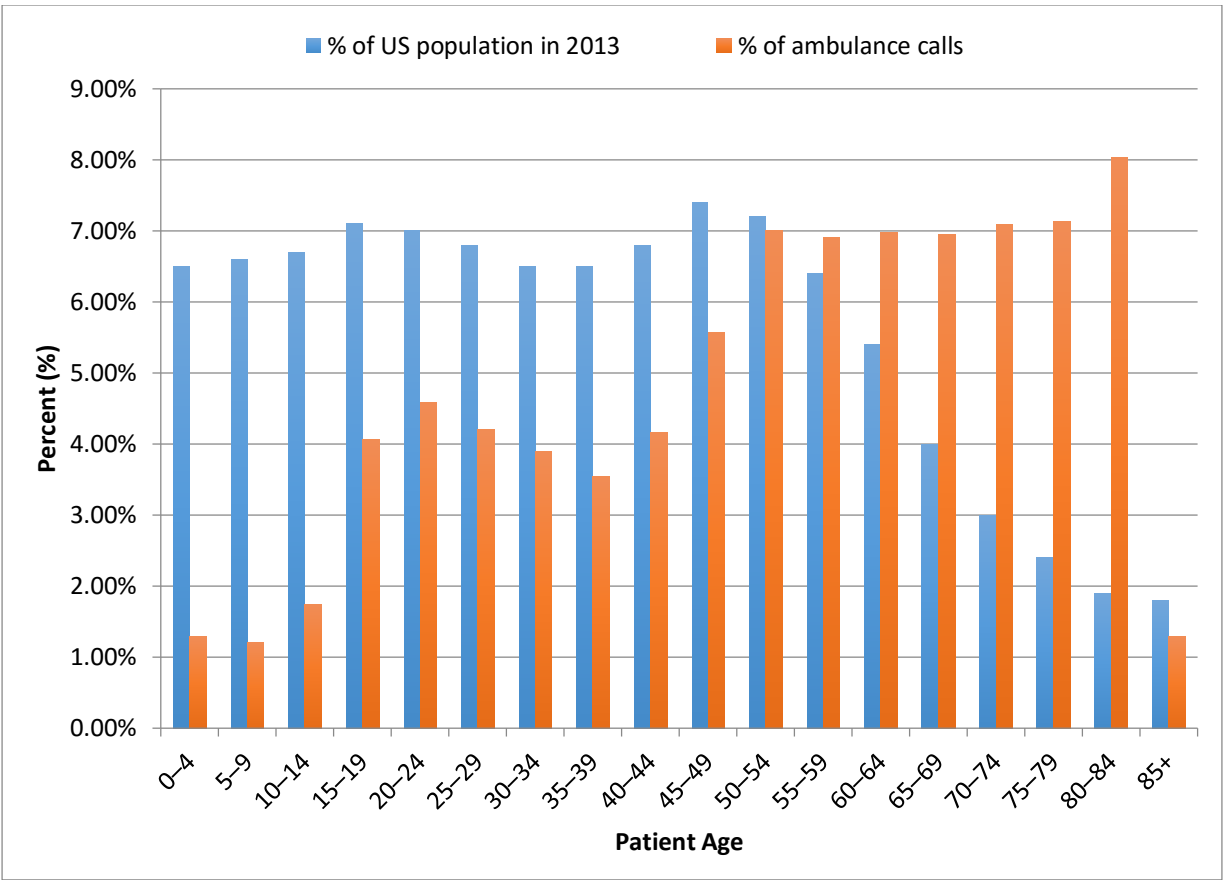


Figure 11: Ambulance usage based on age

In Figure 12, this difference is examined more closely as a discrete variable. Once visualized as a histogram, it is obvious how people under the age of 50 are responsible for disproportionately less ambulance use. It follows, and is also clear from figure 12, that people over 50 are overwhelmingly responsible for disproportionately more.

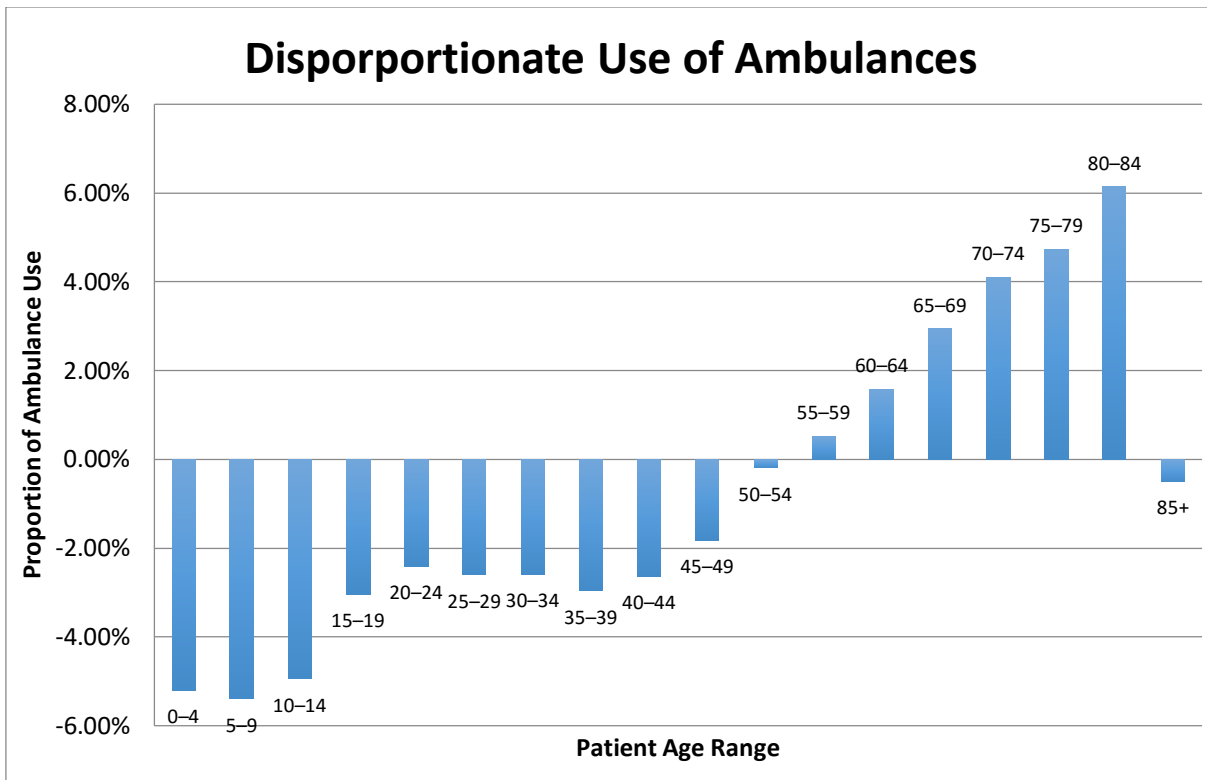


Figure 12: Disporportionate use of ambulances

Again by visualizing the data in a scatterplot as shown in Figure 13, it becomes easy to fit a mathematical model to it and to examine how much of age can be attributed to the differing disproportionate use in different age groups. As can be seen in Figure 13, once the outlier of the 85+ group is eliminated, the data lends itself extremely well to an age explanation—the strength of the model is much greater than just using age to explain ambulance usage. The disproportionate ambulance usage increases neatly along an exponential curve, with an astounding R-squared value of 0.96. This means that 96% of the variation in disproportionate ambulance use among different age groups can be explained by age. This leads our team to conclude that age is definitely a factor in both frequently and disproportionality of ambulance usage.

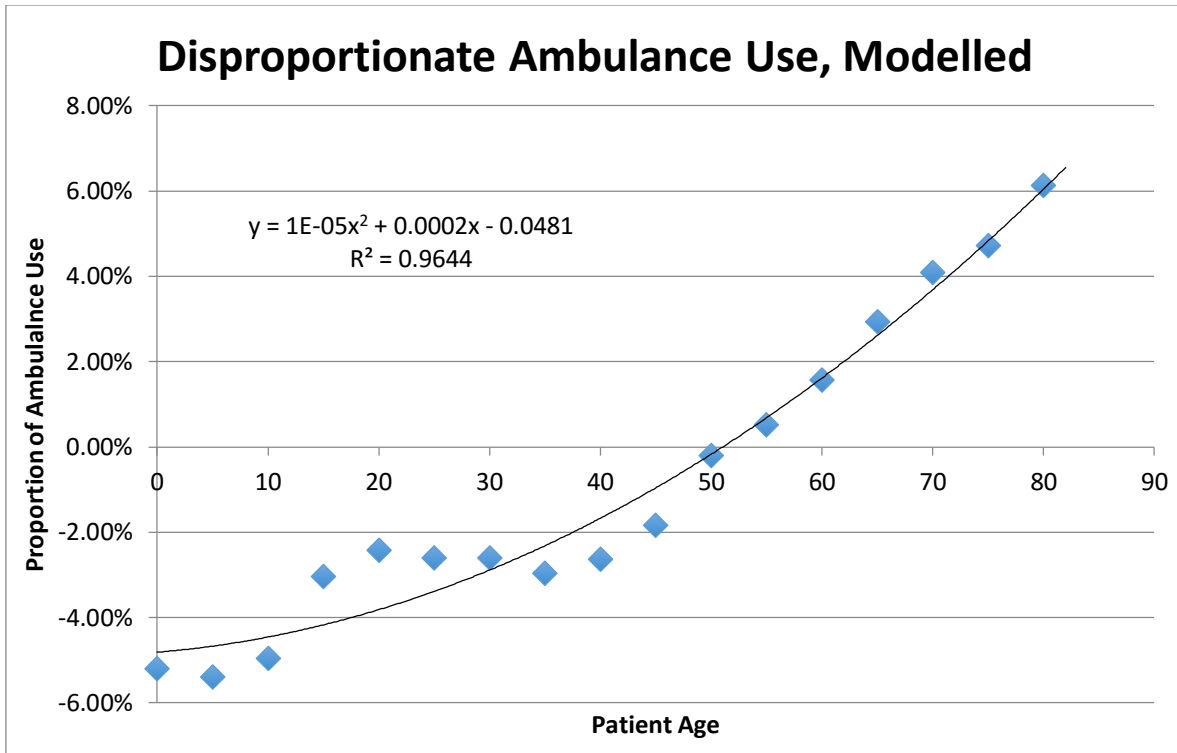


Figure 13: Disproportionate ambulance use model

2.3.2 Gender of Patients

Public NEMSIS research data also includes Gender as a variable, however, not all genders from all patients were recorded in the data set we received. Of an approximate 800,000 records used in this report, only 88% had a known gender, see Figure 14.

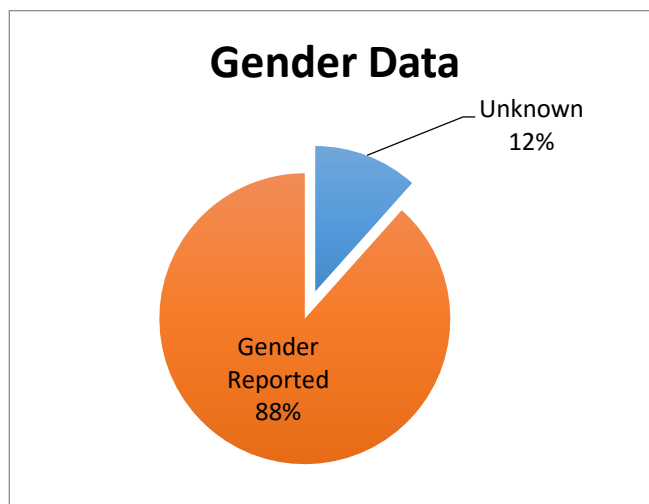


Figure 14: Patient gender data chart

Although a traditional assumption of a 50-50 equality split between the sexes would lead us to conclude that ambulance use would be likewise distributed, there is striking inequality in the data. Of the known data, men make up approximately 47% of ambulance use and women make up 53%. This leads to the question of whether the increased frequency of women's use of ambulance is disproportionate, and perhaps an effect of biological or cultural perceptions of weakness.

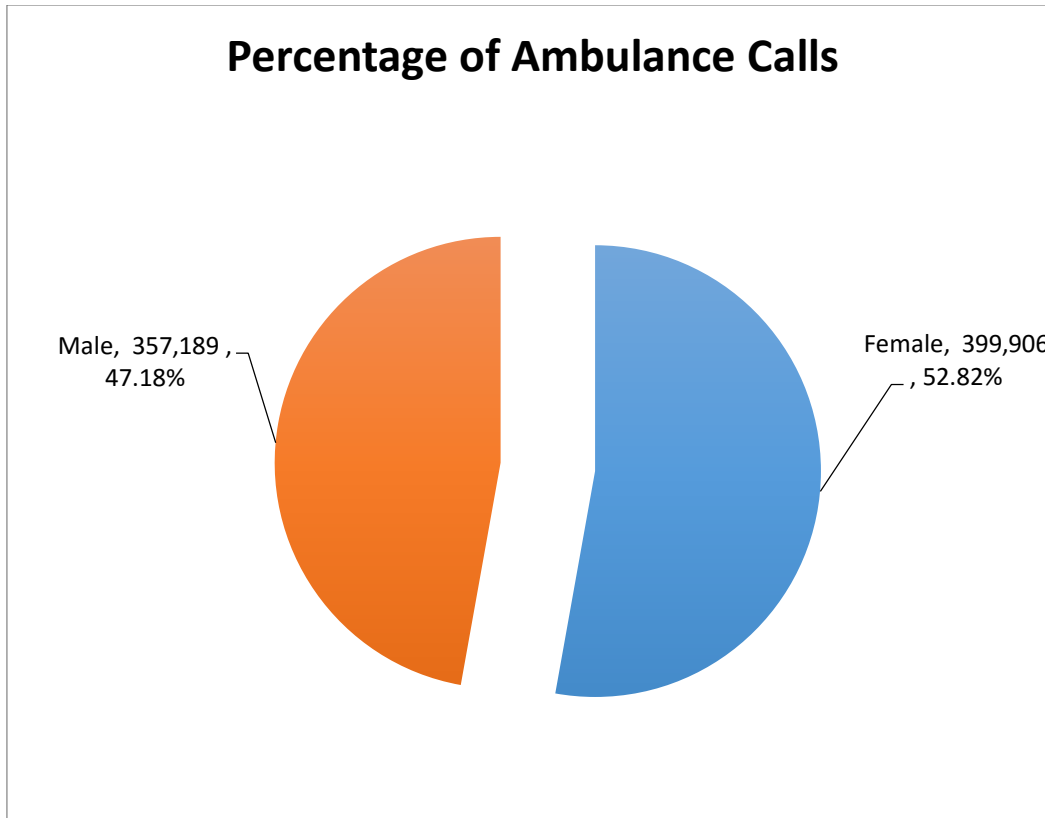


Figure 15: Chart of percentage of ambulance calls

When the demographic gender make-up of the United States population as a whole is considered, one can see that female use does constitute an apparent majority. However, this only explains .76%, leaving over 2% of disproportionate use for which to be accounted.

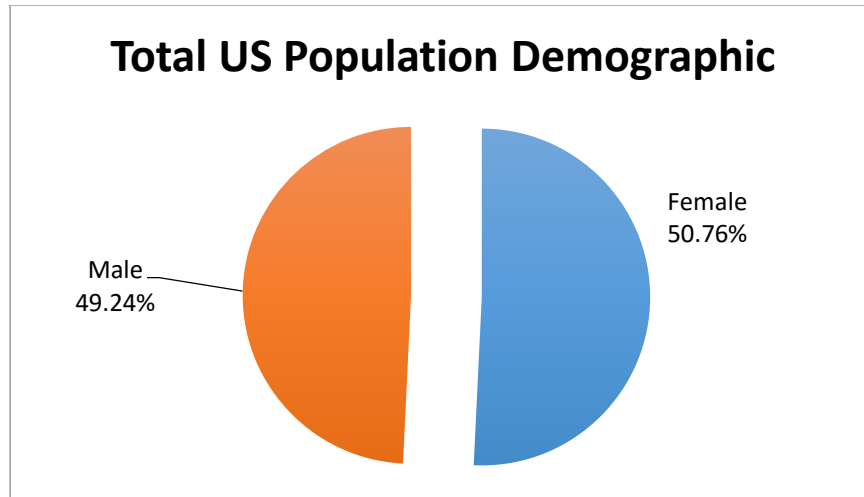


Figure 16: Total US population demographic

Fortunately, there is an easily accessible and proved explanation. While gender ratios tend toward a 50-50 split in the population overall, they do not fit precisely to that even distribution when age is taken into account. At birth, males slightly outnumber females, but as time goes on, women tend to outlive men, leading to a 0.75/1.00 ratio in the 65 and older age group. Since more of the elderly population tends to use ambulances than the rest, this presents itself as a logical hypothesis, and one that is easy to test. Figure 17 shows a summary of the demographic gender/age group from U.S. Census data.

- ❖ at birth: 1.048 male(s)/female
- ❖ under 15 years: 1.04 male(s)/female
- ❖ 15–64 years: 1 male(s)/female
- ❖ 65 years and over: 0.75 male(s)/female
- ❖ total population: 0.97 male(s)/female (2010 est.)

Figure 17: Summary of gender/age from U.S. census data

By combining this information in Figure 17 with the ambulance data, we can create an expected view of how many women and men should be proportionately using ambulances (see Table 1):

Table 1: Percent of ambulance calls based on age range

Age Range	Number of Ambulance Uses	Percentage of Ambulance Uses
0-4	9,880	1.30%
5-9	9,183	1.21%
10-14	13,317	1.75%
15-19	30,939	4.06%
20-24	34,916	4.58%
25-29	32,009	4.20%
30-34	29,733	3.90%
35-39	26,952	3.54%
40-44	31,711	4.16%
45-49	42,417	5.57%
50-54	53,352	7.00%
55-59	52,646	6.91%
60-64	53,137	6.98%
65-69	52,857	6.94%
70-74	54,008	7.09%
75-79	54,229	7.12%
80-84	61,186	8.03%
85+	9,880	1.30%

With a little bit of modeling, it becomes clear that overall, the expected ratios of gender use of ambulance are in proportion when accounting for age. This leads our team to conclude that although women are associated with increased ambulance use, it is not disproportional, and not particularly useful in modeling ambulance operations or client use.

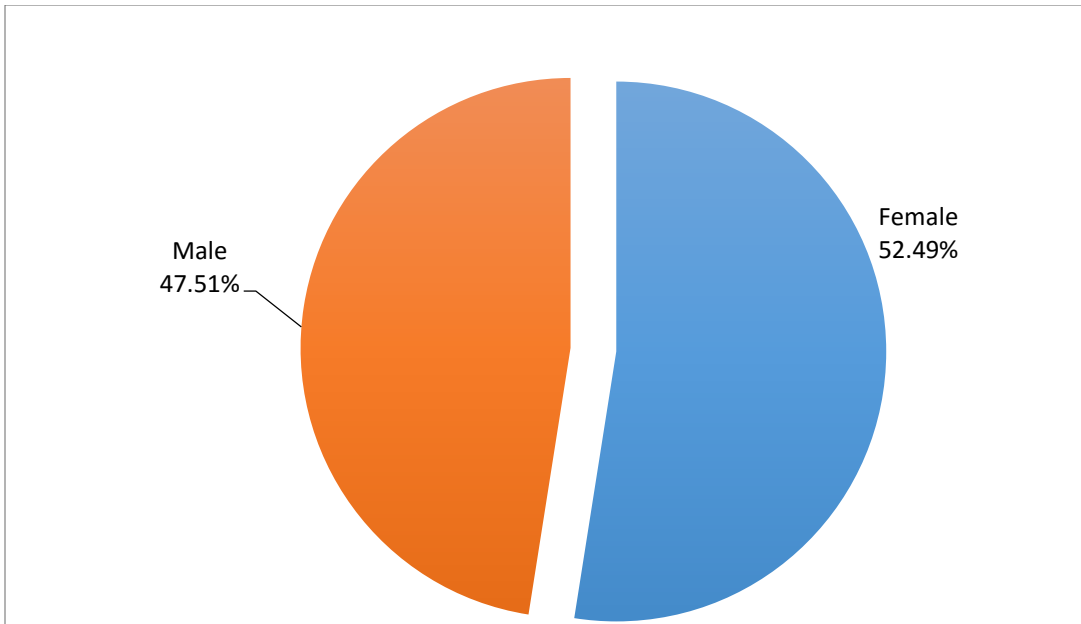


Figure 18: Expected call proportion

2.3.3 Race of Patients

The data from the NEMESIS data set on race is much sparser than either age or gender. 51% of patients in the dataset are not given an identified race (see Figure 19), thereby leaving our team a sample size of only 420,000 patients to look at.

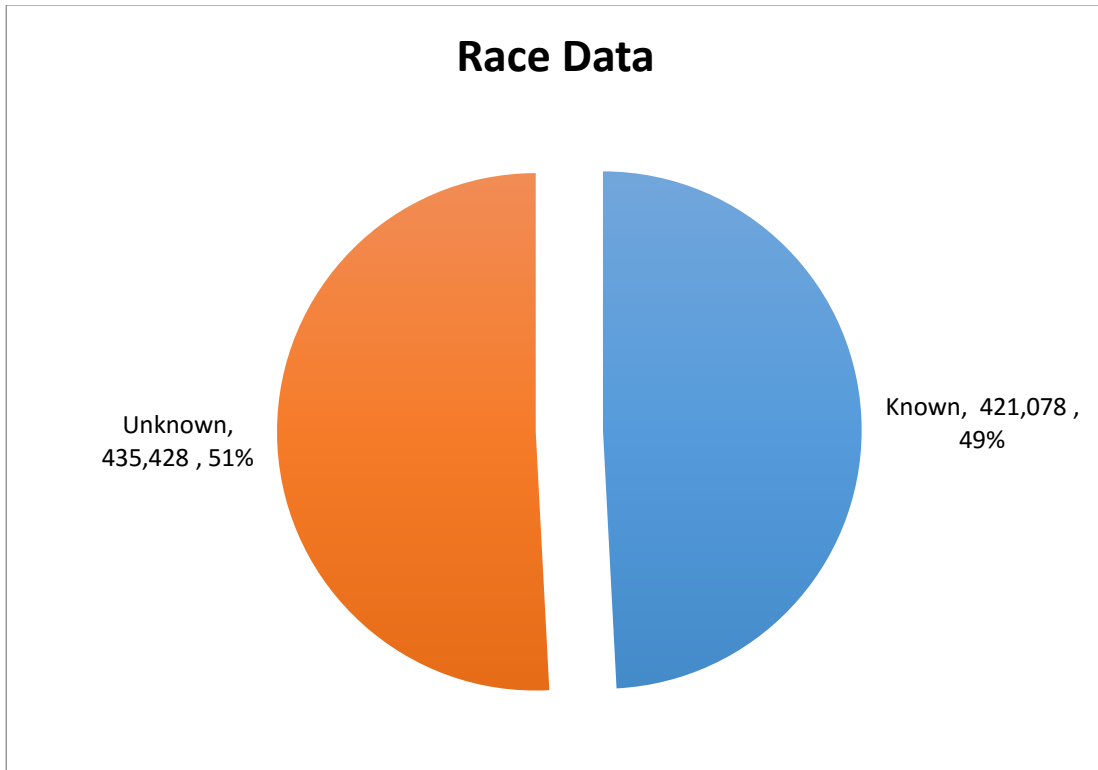


Figure 19: Patient race data

Of the data available, a vast majority is either white or black. A significant portion is also classified under other race which is very unhelpful overall, and does not lend itself to significant analysis. However, it can still be compared with the United States census data, which also has an “other race category. Figure 20 shows counts of race distribution.

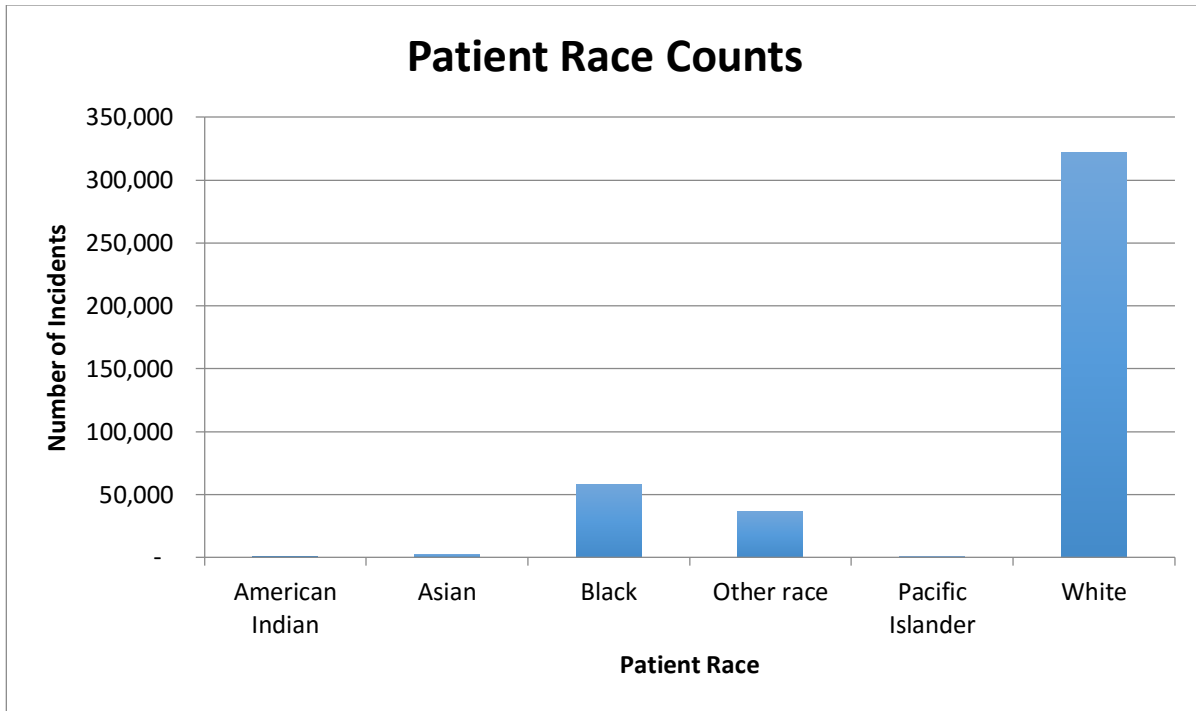


Figure 20: Patient race counts

By comparing the ambulance use percentage data to the U.S. census data, we can see that by race, ambulance use is very proportional to demographic make-up, with a few exceptions. There is an increased in the category of other race in the Ambulance use, and a significant decrease in the Asian category. However, these are largely inconclusive, especially when taking into account the large amount of unknowns potentially skewing the sample size in this section of the data. Therefore, we draw no conclusions about the effects of race in disproportional or change in frequency in ambulance use.

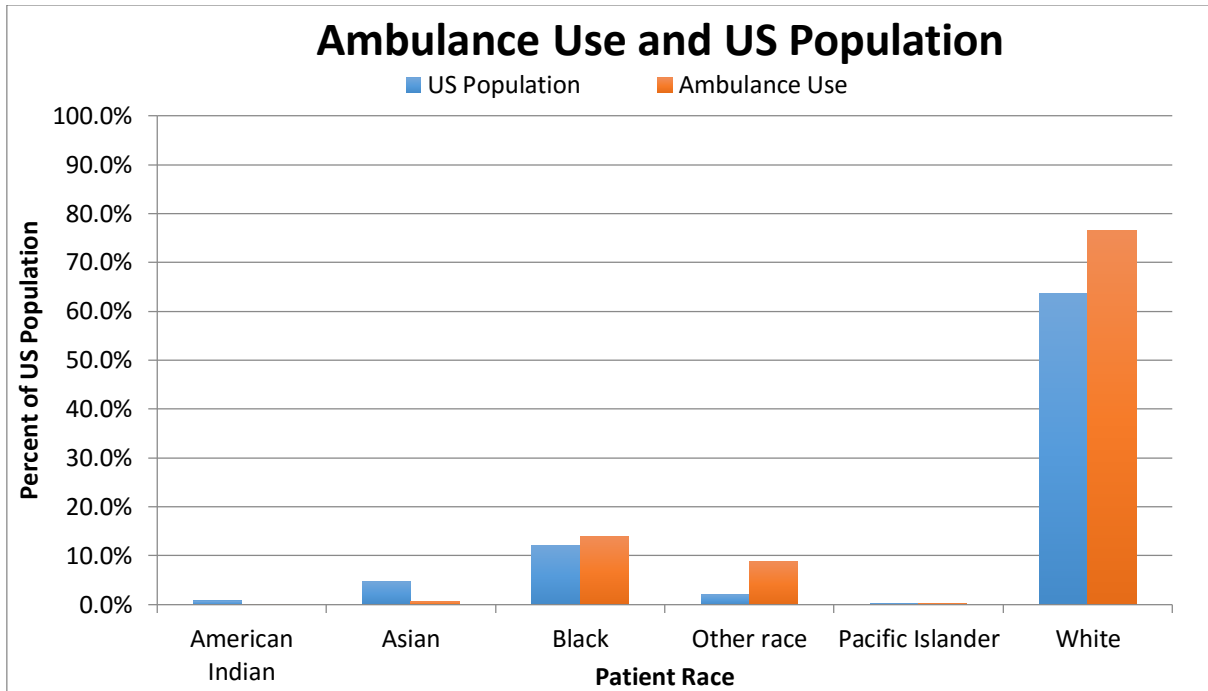


Figure 21: Ambulance use and US population

2.3.4 Seasonality and Time Effects

Using NEMESIS data variable “E05_05”, which carries the “unit en route” data, further analysis was conducted to look for trends and patterns in ambulance use. By month, no apparent seasonality in variation in ambulance use is clearly visible, though there is a small amount of monthly variation. The June and July summer months are particularly low, while October constitutes a slight decrease.

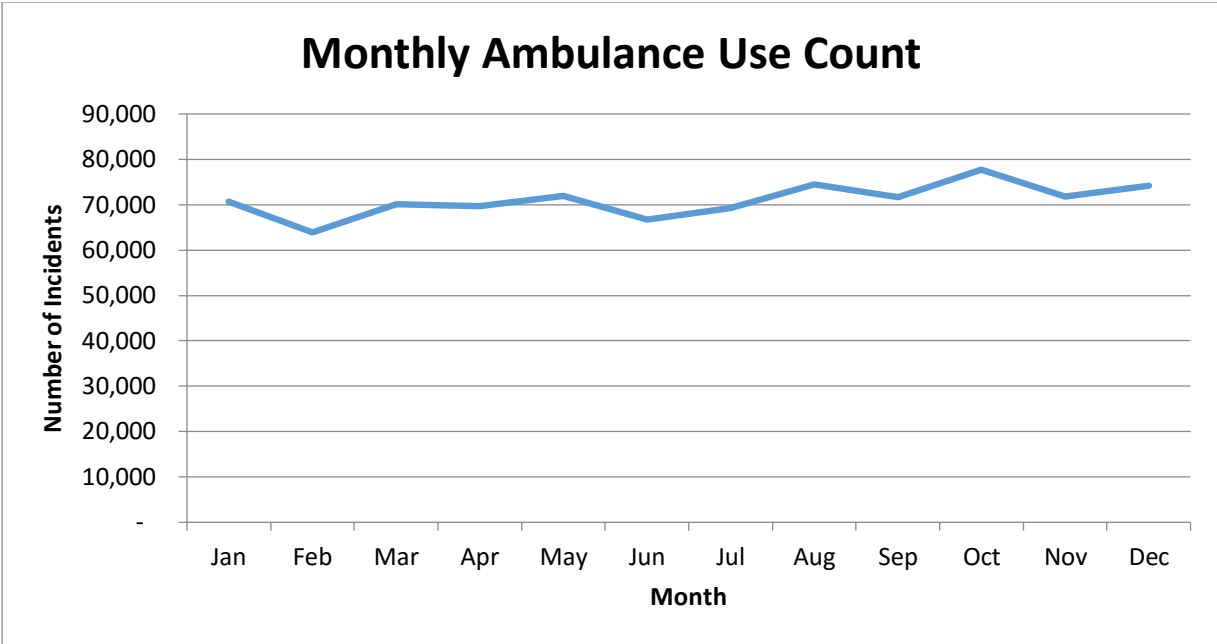


Figure 22: Monthly ambulance use graph

This effect is more clearly visible when the data is combined into quarters. The count of ambulance use increases steadily throughout the year as seen in Figure 23. This is very useful information for operational planning throughout the year. The increase in quarter four represents a 10% increase over ambulance use in quarter one, meaning that more personnel and ambulance vehicles may be needed during those months.

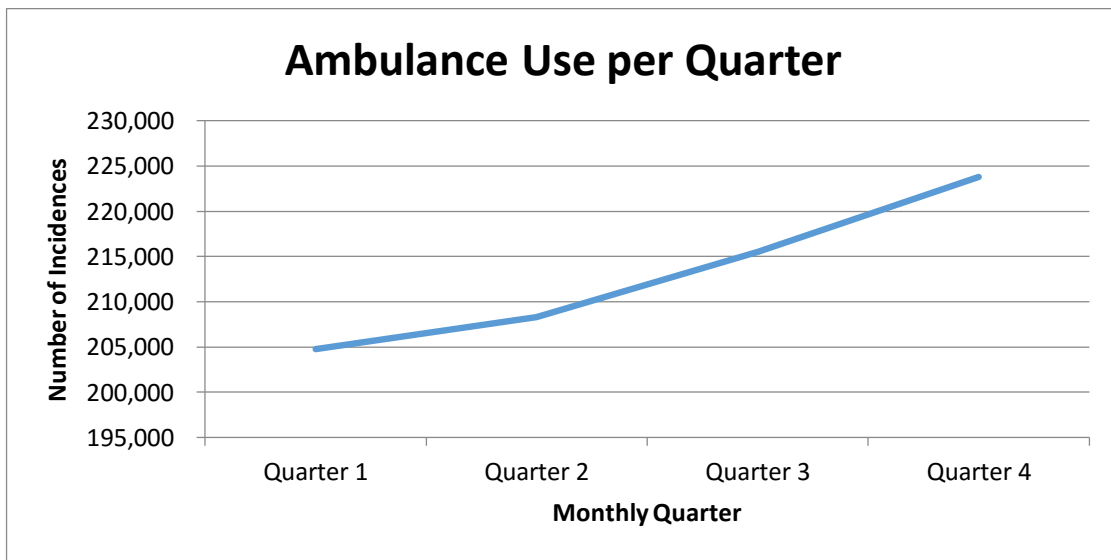


Figure 23: Ambulance count based on quarter

In each month, there is a sharp drop off in the number of calls at the end of the month (see Figure 24). Other than that, the number of calls consistently stays between 2,000 and 2,500 per day within this data set.

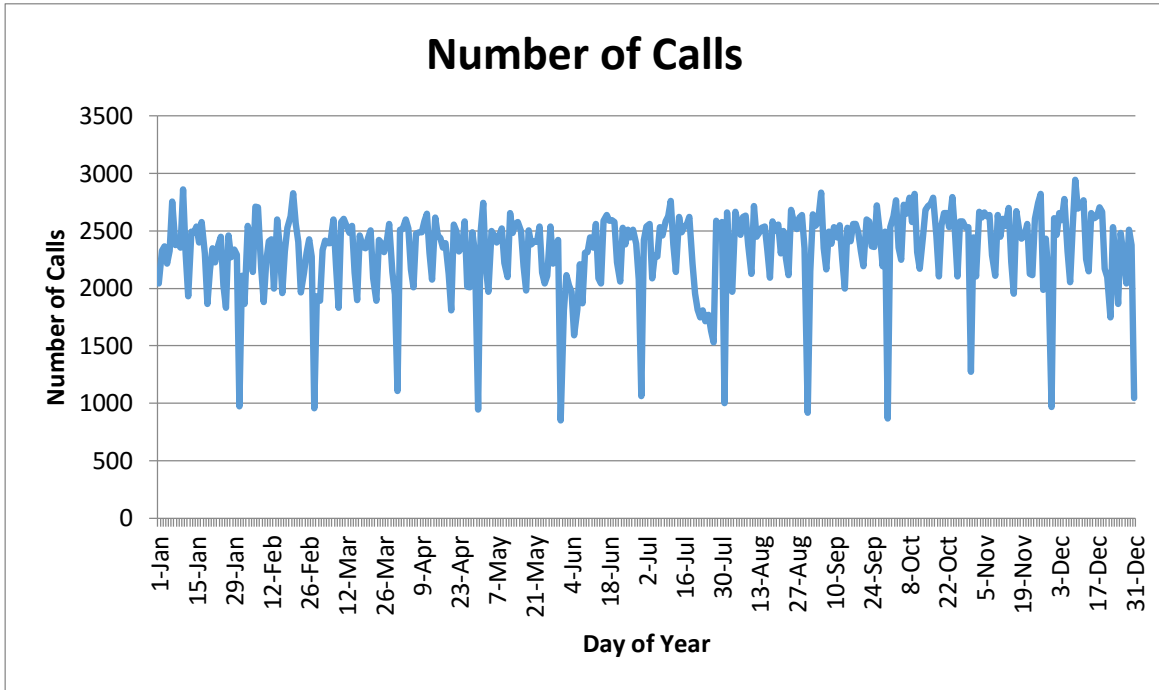


Figure 24: Number of calls by day

From an hourly perspective, the hours around midday, from 11:00 AM-2:00 PM, are associated with the highest frequency of ambulance use. The hours in the middle of the night, from 12:00 AM -5:00 AM, conversely, are the lowest. This is very relevant when planning and considering a more efficient distribution of ambulance resources. For example, personnel shifts should be analyzed and potentially redistributed so that supply better matches demand.

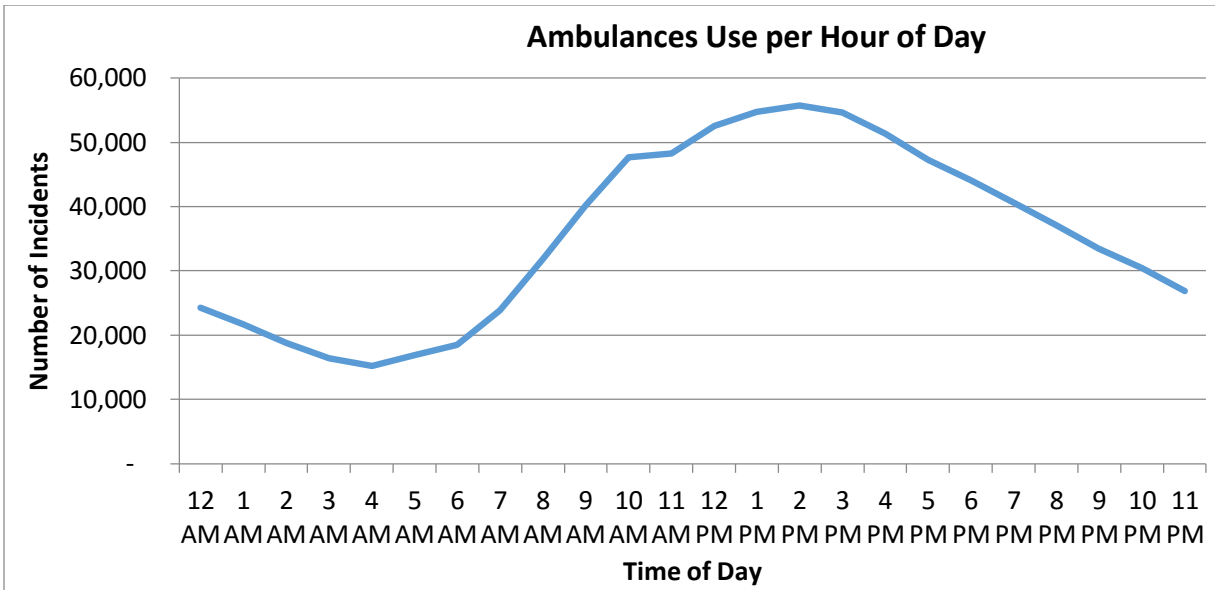


Figure 25: Average hourly ambulance use

2.3.5 Patient Payment Types

Although NEMESIS public data set includes payment type data, this data is even sparser. 84% of patients had no recorded patient classifications. The remaining 16% are the only data available to us that is used for analysis within this Section.

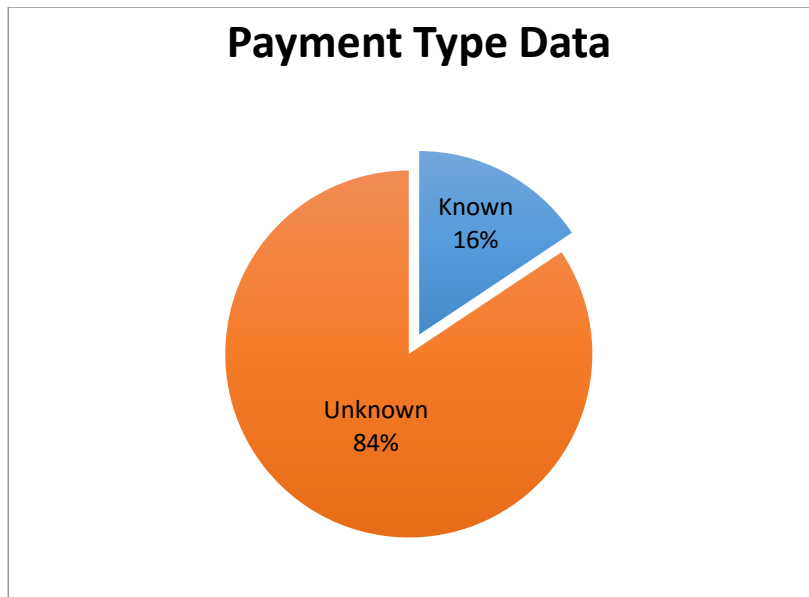


Figure 26: Patient payment type

The data is visualized in a bar chart shown in Figure 27. As can be seen in the figure, Medicare or Medicaid pays for the vast majority of ambulance rides. Insurance also comes in at a count of 40,000 instances, and self-pay represents 5,000. The other three categories, not billed, worker's compensation, and other government, represent an insignificantly small portion of the data, with less than 1,000 counts. That this tell us, is that the government inevitably winds up barring a great portion of the operational costs of the current ambulance systems, although Medicare and Medicaid pass some amount of costs on to the consumers.

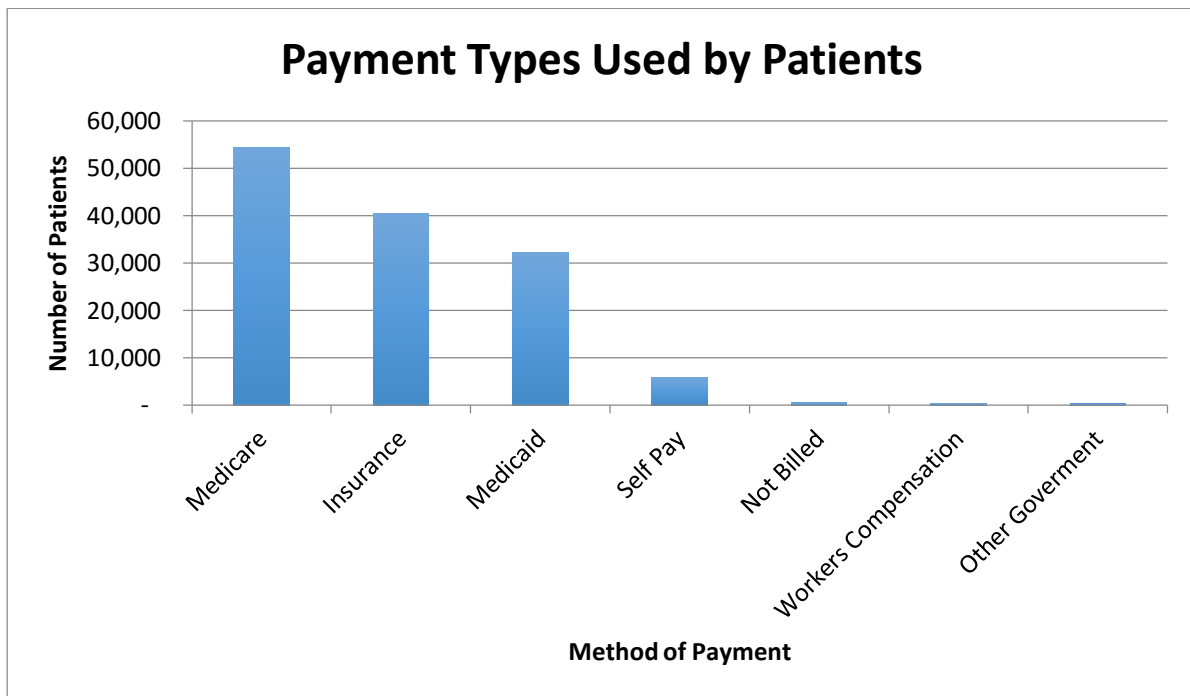


Figure 27: Payment types used by patients

2.3.6 Location of Incident Data

Incident location data is surprisingly abundant in the NEMSIS data set. Only 8% of the data is unknown within the public records, and the remaining 92% is available for analysis.

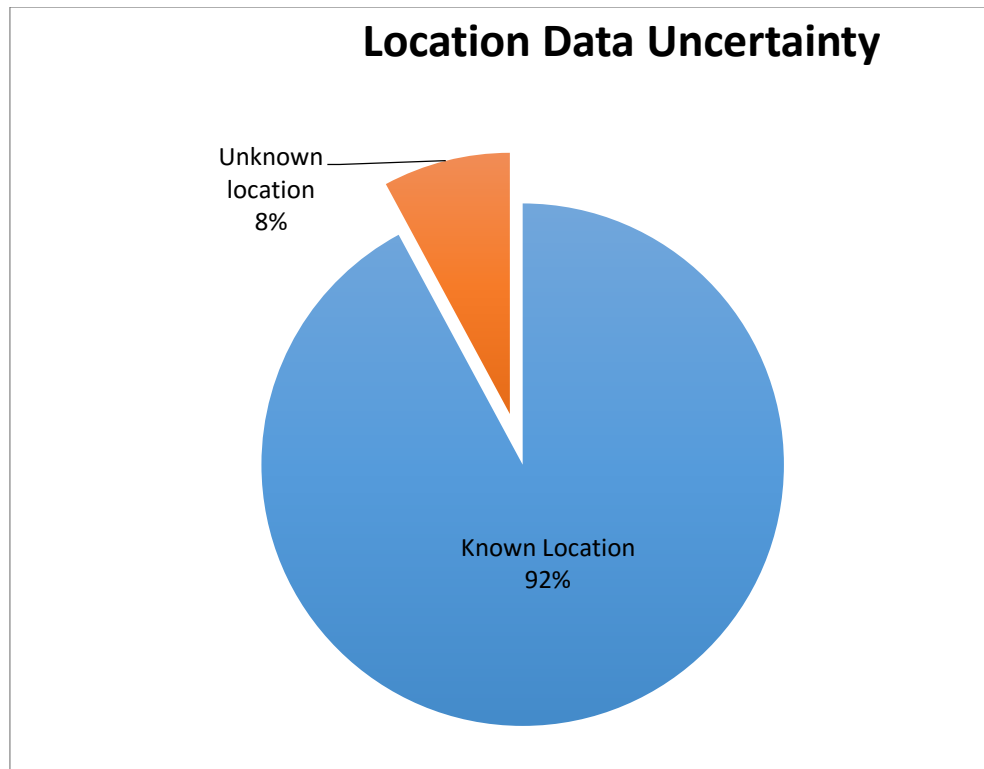


Figure 28: Location data uncertainty

The vast majority of incident locations are of the type home or resident, with health care facility representing another half of that. The next most common incident locations are street or highway, residential institution, public building, or industry or service establishments. While these represent useful information for ambulance process modeling, they are of even more interest for secondary relationship analysis of variables.

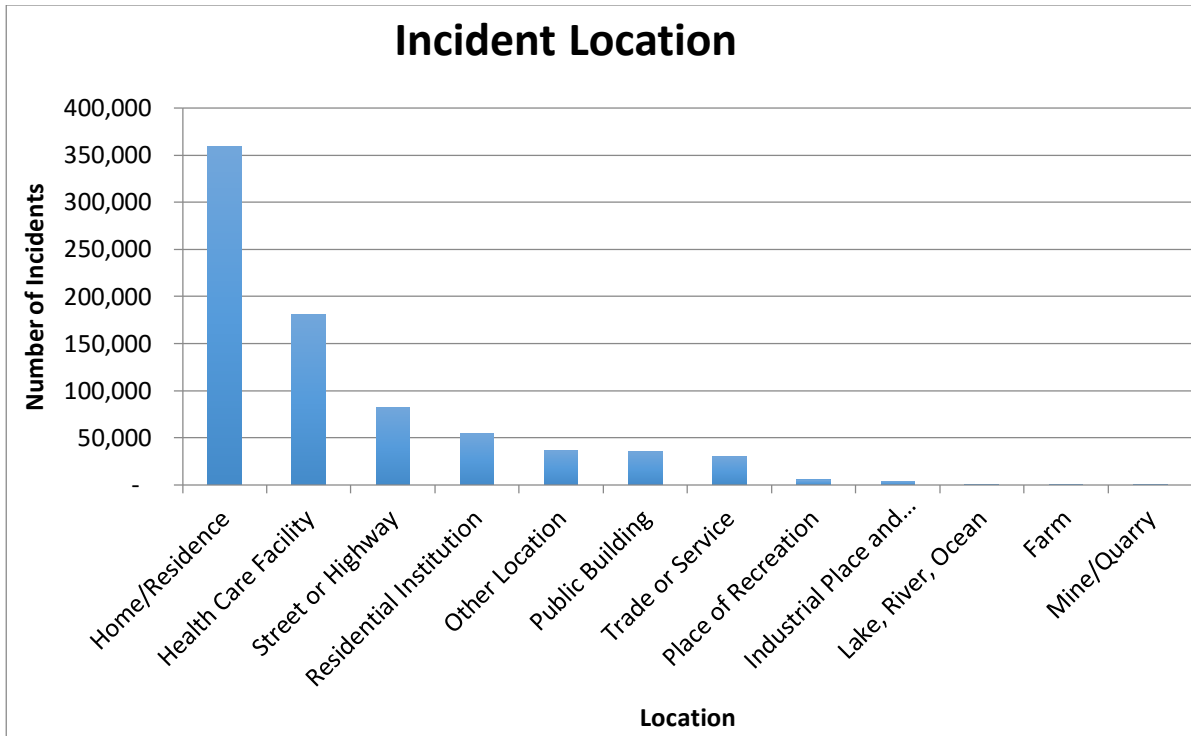


Figure 29: Incident location

2.4 EMS Systems around the World

There are many different kinds of Emergency Medical Services (EMS) around the world and so it makes sense to look at and compare a few of the different systems to see if any of their components could be incorporated into the newly proposed system. It was decided that if certain things were found that worked well from their systems, the most promising aspects from each could be taken and used in the new system. Mainly European countries were focused on because they are other first world countries like the United States of America. It was figured that they would have the most efficient EMS systems among other countries because of their good economic standing. Aside from the United States, European countries such as Germany, France, and the United Kingdom have led the world in Gross Domestic Product for many years.

2.4.1 German-Franco Model vs. Anglo-American Model

The two main EMS models used around the world are the Anglo-American and the German-Franco models. In the Anglo-American system, ambulances are staffed by Emergency Medical Technicians (EMTs) trained in either Advanced Life Support (ALS) or Basic Life Support (BLS). In the German-Franco model, ambulances are staffed by physicians. The Anglo-American model is based on the “scoop and run” philosophy whereas the German-Franco model is based on the “stay and stabilize” philosophy. So in other words, in the Anglo-American model, the patient is brought to the doctor, whereas in the German-Franco model, the doctor is brought to the patient.

The German-Franco model is usually run by physicians which have a broad scope of practice with very advanced technology. It utilizes helicopters and coastal ambulances as well as the regular land ambulances. This model is usually a sub-set of the wider health care system. The philosophy of this model is widely implemented across Europe where emergency medicine is still a relatively young field (Al-Shaqsi et al, 2010). Therefore, their prehospital emergency care is almost always provided by emergency physicians. The on-site emergency doctors have the authority to treat patients in their homes or at the scene based on their clinical judgement. This means that many EMS patients can be treated at the site of the incident instead of being transported to hospitals. Countries such as France, Germany, Greece, Austria, and Malta have well-developed German-Franco EMS systems (Bahman et al, 2007). In this project only the EMS systems in France, Germany, and the United Kingdom are considered. Figure 30 shows the existing and developing prehospital emergency systems around the world (Von Bergh, n.d.).

Existing and Developing Prehospital Emergency Systems Worldwide



Figure 30: Existing and developing prehospital EMS worldwide

The aim of the Anglo-American model is to quickly bring patients to the hospital with less pre-hospital interventions such as on-site treatment. It is usually accompanied with public safety services like the police or fire departments rather than public health services and hospitals (Bahman et al, 2007). The system is run by trained paramedics and EMTs with a clinical oversight. It relies heavily on land ambulance services and less so on aero-medical evacuation or coastal ambulance services. In countries that follow this model, emergency medicine is well-developed and generally recognized as a separate medical specialty. Almost all of the patients in the Anglo-American model are transported to developed Emergency Departments rather than hospital wards by EMS personnel (Al-Shaqsi et al, 2010). Some countries that follow this model of EMS include the United States, Canada, New Zealand, Australia, and Sultanate of Oman.

Table 2: Comparison between Franco-German model and Anglo-American model

Model	Franco-German model	Anglo-American model
No. of patients	*More treated on scene * few transported to hospitals	*Few treated on scene *More transported to hospitals
Provider of care	Medical doctors supported by paramedics	Paramedics with medical oversight
Main motive	Brings the hospital to the patient	Brings the patient to the hospital
Destination for transported patients	Direct transport to hospital wards ie: bypassing EDs	Direct transport to EDs
Overarching organization	EMS is a part of public health organization	EMS is a part of public safety organization

Table 2 shows a comparison between the Franco-German and the Anglo-American models (Al-Shaqsi et al, 2010). While both models have the same primary mission for delivering emergency care for trauma and life threatening illnesses, they differ in delivering non-life threatening care and scheduled transports of stable patients. The conventional European style uses primary care options other than transporting patients to Emergency Departments a lot more than the Anglo-American system (Dick, 2003). If to be transported, patients in Europe are usually escorted directly to a hospital floor where the attending field emergency physician believes the patient's condition will benefit more by direct admission, unlike the American model where all admissions have to go through emergency departments (Bahman et al, 2007).

In terms of outcome or cost effectiveness, many studies have attempted to compare these two models. However, it seems that they are not really comparable because they tend to operate in different contexts with different types of demands to meet. Also, the lack of unified standards between the two models makes comparison an unjustifiable exercise. Therefore, there is currently no evidence that one model is better than the other and studies continue to show conflicting conclusions (Al-Shaqsi et al, 2010). Other than the issue of which model is best, there is the question of which organization in the community should provide EMS. Many have argued for a mixed model between health care organizations and public safety organizations but this approach has the potential for EMS to not be properly funded as it could be considered neither from a public safety system nor from a health care system (Al-Shaqsi et al, 2010). Figure 31 shows the amount of public spending versus the amount of private spending in France, Germany, and the UK. No

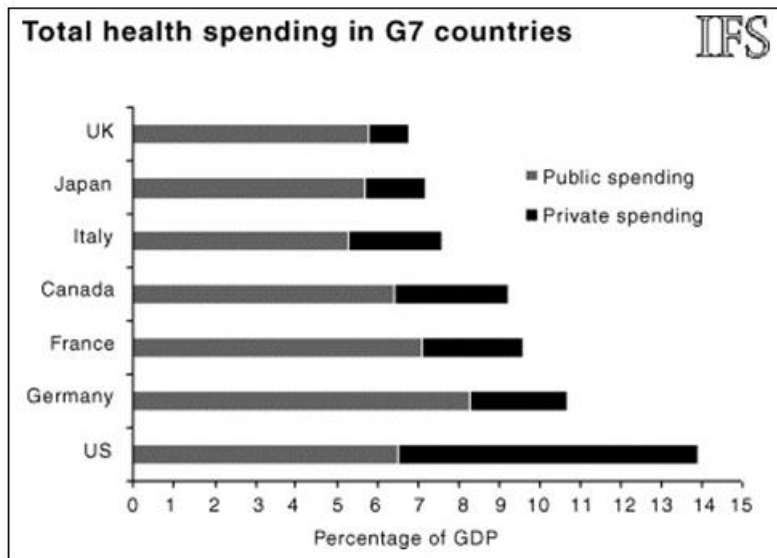


Figure 31: Total health spending for France, Germany, and the UK

model seems to be better than the other and each community should decide on which one suits them better according to their resources, targets, and goals. However, the patient's outcome is what should be the ultimate judging standard on which model is best for a community.

2.4.2 EMS System in France

The emergency medical service system in France is a centrally based, two-tiered, physician-manned system. The first level is composed of basic life support (BLS) of fire department based ambulances. The second level is composed of advanced life support (ALS) of physician staffed-ambulances. France is divided into 105 regional Service d'Aide Médicale d'Urgence (SAMUs) organized as follows: A dispatching center with switchboard operators and dispatching physicians that are situated in a major hospital and cover a given medical region. Switchboard operators receive all medical calls at the dispatching center and forward them to the dispatching physician (Adnet et al, 2004). Figure 32 shows a typical ambulance that is used in France.



Figure 32: Rapid response ambulance, Paris (France)

The dispatching physician then determines the appropriate level of emergency medical response. The dispatching physician has four options based on the severity of the incident and they are: (1)

ambulances staffed by emergency medical technicians, (2) fire-fighters with basic life support skills (including automatic external defibrillators), (3) a general practice physician by private vehicle, and (4) mobile intensive care unit (MICU) or a helicopter if available (Nikkanen et al, 1998). For calls where cardiac arrest or respiratory distress are suspected, the dispatcher can remain on the line and give telephone-assisted instructions on how to administer CPR and the Heimlich maneuver. The time interval between call receipt and arrival at the patient is usually less than fifteen minutes (Adnet et al, 2004).

A key feature of France's EMS system is medical dispatch. This system allows a physician to use his or her medical experience to take a call and determine an appropriate response. The choice of response is wide and this system goes some way to prevent unnecessary use of scarce resources, like the MICUs and helicopters (Nemitz, 1995). The French EMS places great value on the knowledge and skills of physicians and, unlike many EMS systems, makes them the key component of the service. France's system aims to acknowledge that: (1) patients who are most urgently in need of care benefit from the component of the EMS most suited to them, (2) specialized medical teams intervene only in the most serious cases, (3) the most advanced resources, which are inevitably rare and expensive, are used to their best advantage, and (4) the closest hospital is not always the most suitable one. SAMU allows bypass and transport of patients directly to the most appropriate regional treatment center (Adnet et al, 2004).

2.4.3 EMS System in Germany

In Germany, local communities and cities are responsible for the EMS and HEMS (Helicopter Emergency Medical Service) and they are under the responsibility of the States. Non-profit making organizations like the German Red Cross or commercial providers are commissioned to deliver the medical emergency services. Pre-hospital emergency medical care in

Germany is provided by 1800 ambulance stations with 3400 emergency ambulances and 1000 emergency physician staffed vehicles. The HEMS consists of 53 helicopter stations each with a mission range of 50 kilometers. Since the number of calls requiring an emergency physician on the scene is lower than the total number of emergency calls, more ambulances are available than emergency physician staffed vehicles (Roessler et al, 2006).

A fully qualified paramedic who has undergone additional ambulance dispatch training takes emergency calls in the emergency ambulance control center. Their fire brigade and EMS are on the same dispatch system which is separate from their police. Figure 33 shows an example of a German physician response vehicle.



Figure 33: Emergency physician response vehicle, Germany

Depending on the severity of the situation, the dispatcher decides which of Germany's two systems to use to transport the emergency physician to the scene. The first is a stationary system where the physician goes with the ambulance. The second is a rendezvous system where the physician arrives to the scene in a rapid response vehicle, like the one in Figure 33, with all the

necessary equipment but no ability to transport the patient. The stationary system has the advantage that only one vehicle has to be sent but the rendezvous system is more flexible, such that if the patient does not need to be escorted by the physician, the physician is available for the next call much earlier. Their response time for anywhere in Germany is under fifteen minutes (Roessler et al, 2006).

Since Germany's system relies heavily on on-site treatment, the personnel are required to receive extensive training before they can perform on the scene. There are three levels of qualification for the non-physician personnel and they are: Rettungshelfer, Rettungssanitäter, and Rettungsassistent. They require 240 hours, 520 hours, and 2 years (2800 hours) respectively. Most German states require that an emergency ambulance is staffed with at least one experienced Rettungssanitäter (RS, rescue paramedic) and one Rettungsassistent (RA, rescue assistance), preferably two RAs. The German EMS/HEMS is highly efficient and provides sophisticated prehospital treatment for acutely ill patients and trauma victims. However, due to its extensive training program as well as their government's health care cuts, their number of recruits has decreased over the years (Roessler et al, 2006).

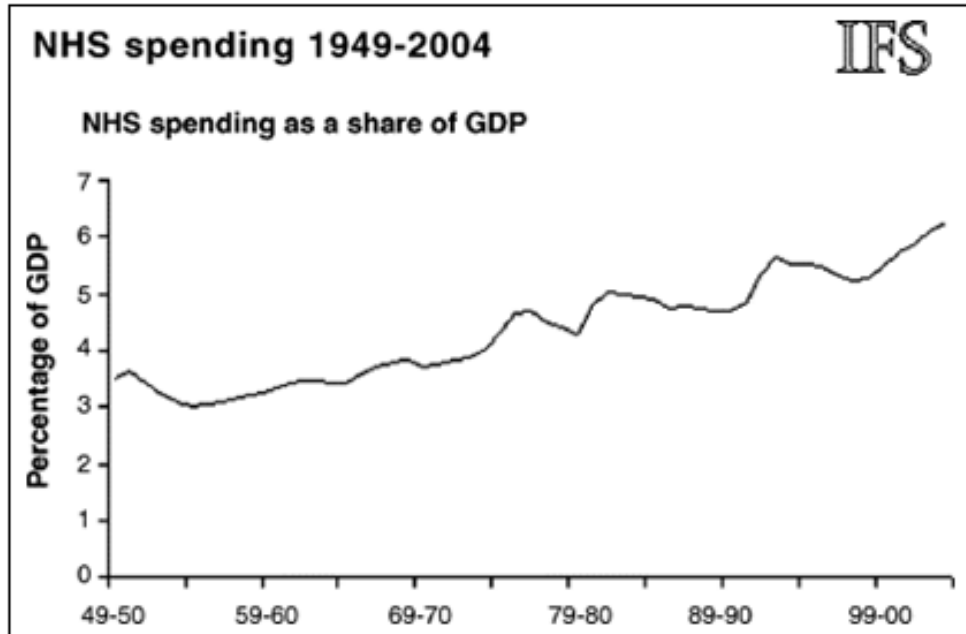


Figure 34: NHS spending from 1949-2004

2.4.4 EMS System in the United Kingdom

The United Kingdom (UK) emergency health care is delivered almost exclusively by the National Health Service (NHS), which is free at the point of delivery for residents and visitors. Funding is derived from general taxation and accounts for a percentage of its gross domestic product (GDP). Figure 34 shows the percent of the UK’s GDP that is spent on its National Health Service (Black et al, 2005). Emergency calls are classified as category A if the presenting condition may be immediately life threatening, category B if the presenting condition is serious but not of life threatening, and category C as a condition which is neither immediately life threatening or serious (Black et al, 2005). This is determined using by Advanced Medical Priority Dispatch System (AMPDS) software used at the time of the emergency call receipt by ambulance control room staff. The UK Government has set standards for Ambulance NHS services that require 75% of category A calls to be responded to within eight minutes of the incident location having been

established, and that 95% of category B and C calls should have a response time of fourteen minutes (urban areas) and nineteen minutes (rural areas) in 95% of calls (Black et al, 2005). Figure 35 shows an example of a UK response vehicle.



Figure 35: Rapid response vehicle, United Kingdom

The UK emergency ambulances are usually staffed by an ambulance paramedic and technician. The decision to mobilize specific resources is made by a senior ambulance control room officer who may or may not have previous experience of delivering prehospital clinical care (Black et al, 2005). For both categories A and B or C calls an emergency response can initially be a rapid response vehicle such as the one shown in Figure 35, or an approved first responder dispatched by and accountable to the ambulance service, rather than an ambulance staffed by a paramedic or EMT equipped to provide treatment at the scene of the incident (Ambulance Services, 2003). The UK ambulance services can also dispatch a regional air ambulance if one is available. In addition, doctors in voluntary immediate care schemes can be mobilized by the control room staff if needed.

In the UK there is some variability in entry requirements for technician/paramedic training between ambulance trusts. Most training is provided by individual ambulance service education

departments and some of the training is hospital-based. For example, the Hertfordshire Ambulance Service has new recruits that undergo a 12-week training program where they learn anatomy and physiology, immediate care, and driving skills. After completing this basic ambulance training and passing a local entry qualification examination, ambulance technicians will spend approximately one year under the direct supervision of a fully trained ambulance technician or paramedic. At the end of the training they are qualified for independent practice but are required to take refresher courses every three years (Black et al, 2005).

After a look was taken at the different types of EMS systems in France, Germany, and the United Kingdom, it was found that the current EMS system in the United States could possibly take into consideration some of their tactics in order to save both the EMS and the patients money. The idea of Germany's emergency physician response vehicle and the UK's rapid response vehicle paved the way for the newly proposed transport ambulance. In the next section the inefficiencies of the current ambulance system in the United States will be examined.

2.5 Inefficiency in Current Ambulance Uses

Wasting ambulance resources begins early in the ambulance process. A large portion of the waste actually begins with problems in the 911-call system. Only about 80% of ambulance service is in 911 responses, however, this still represents the majority of ambulance service work.

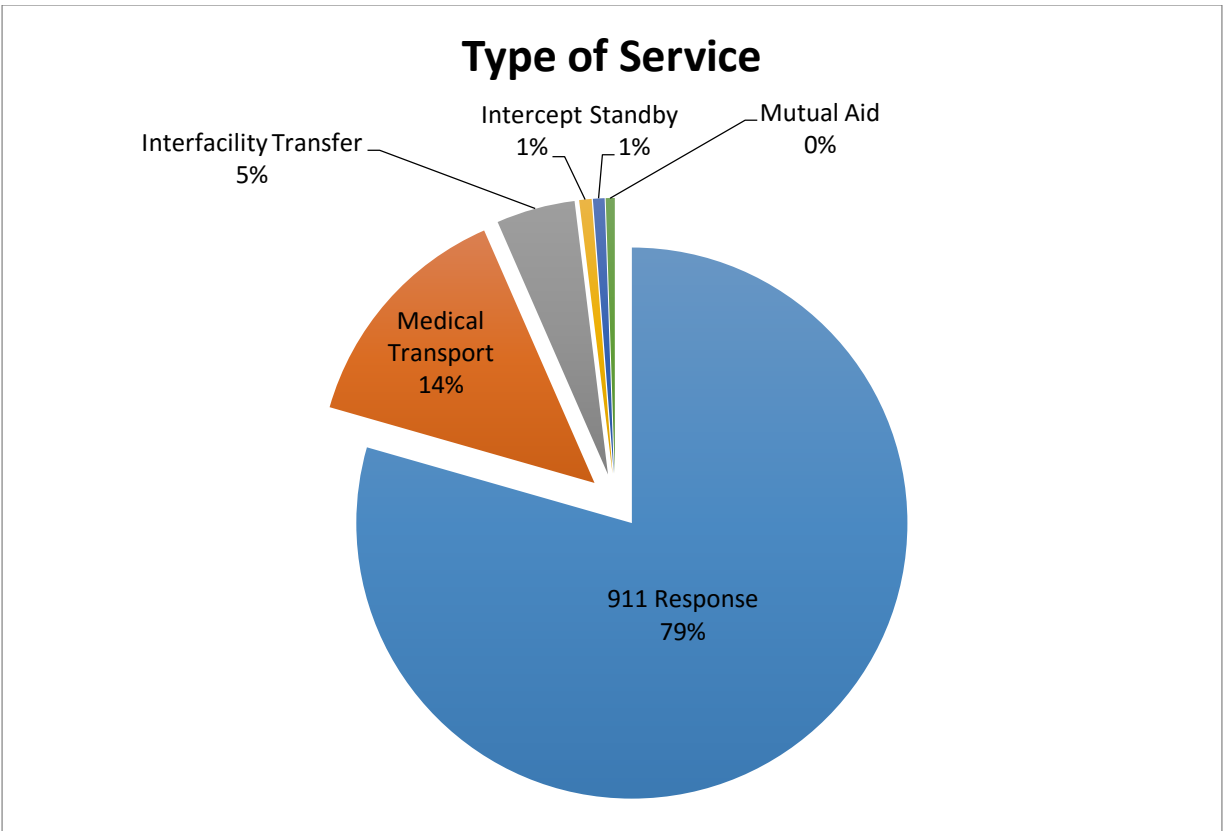


Figure 36: Type of service chart

There are approximately 240 million 911 calls in the United States every year (911 Statistics, 2015). However, by far, most of these calls are not actually related to emergencies and do not necessarily result in an ambulance being dispatched. For example, in some areas like California, non-emergency calls account for up to 80% of all 911 calls (Johnson, 2008). The reasons for these frivolous calls vary and they include: some people genuinely appear to misunderstand the purpose of 911, some are all reporting the same emergency, some people mistakenly believe, for example that, a mild car crash to be an emergency, and some are malicious prank calls. Among the examples of particularly frivolous 911 calls include people calling 911 because their cab didn't show up in a timely manner, because they were unsatisfied with their Subway sandwich, or because their stepfather was bothering them about their chores (Johnson, 2008). In order to attempt to counteract this waste of resources, in 2008, the then Governor of

California, Governor Schwarzenegger passed a law fining people \$50 after their 2nd non-emergency 911 call is made, and has increasing fines for every subsequent offense (Johnson, 2008). However, this remains a significant problem, not the least because it makes it difficult for dispatchers to shift through a large volume of calls to figure out where ambulances must be dispatched.

Another area that adds waste to the 911-calls is difficulty to locate the scene where the caller is. 911 systems often struggle to get precise information about where caller's location is if the caller is on a mobile phone (Kelly & Keefe, 2015). Since approximately a third of 911 calls today are done wirelessly, this represents a growing problem for 911 call centers (911 Statistics, 2015). For example, in Texas, two in three 911 calls don't transmit location to the dispatcher (Kelly and Keefe, 2015). This problem is easily compounded when the call is routed through to a neighboring 911 center, where the operator may not know the area, street names, or locations well enough to clearly understand the caller in a timely manner. This problem is attempting to be addressed by both the FCC and many large cellphone carriers. In 2015, they began working on a legislation that would force carriers to begin increasing the percentage of 911 cellphone calls that transmit location data (Kelly and Keefe, 2015). This legislation would call for 40% of cellphones to be delivering location data by 2017, and to double that number to 80% by 2021 (Kelly and Keefe, 2015). However, it remains to be seen if these requirements will actually be met. A similar deadline was set in the 1990's which called for 66% of cell phone calls to deliver location data during 911 calls by 2002; while the cell phone industry met that requirement in outdoor calls, most calls are now made indoors, where the technology does not work as well. This is because the 911 call center gets their data from the GPS unit through a relay process, but 911 calls frequently end too short or cause errors which give inaccurate results (Kelly & Keefe, 2015).

2.5.1 Ambulance Service Prices

Ambulances are not only expensive to buy, maintain and operate, but expensive for the patients to use. This often comes as an unwelcome surprise to people who do not expect it, and believe that the ambulance is just a medical transport. Nearly a quarter of complaints from dispatch centers are simply for transport or illness, but this does not necessarily reduce the cost incurred, either by the ambulance company or the costs that the patient faces. For example, a two-block ride for one woman, Joanne Freedman, cost \$900—and the only medical service she needed was a ride to the hospital (Rosenthal, 2013).

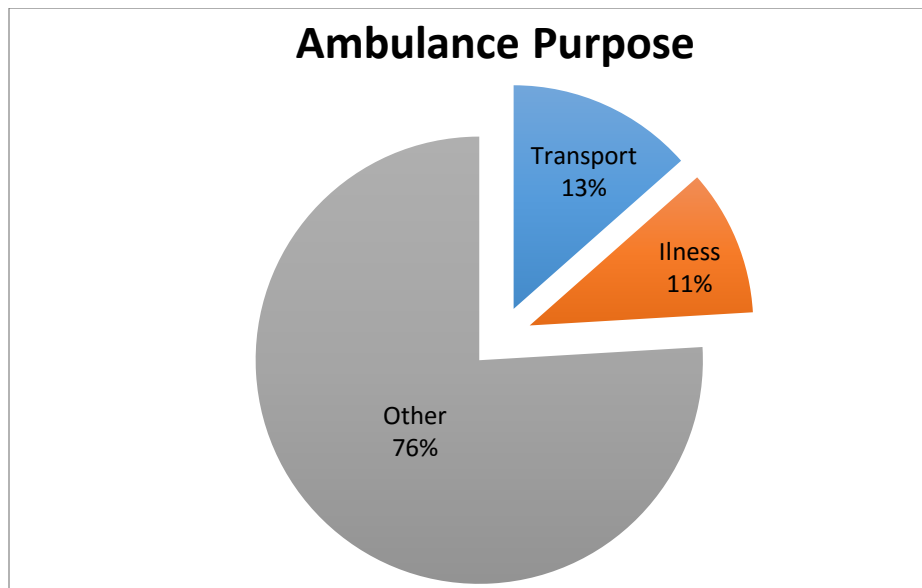


Figure 37: Ambulance purpose chart

Part of this is because ambulances seem to be the most convenient method of transportation when sick or mildly injured. For example, another anecdotal case of this is Kira Milas, who accepted a fifteen minute ambulance ride after swimming into the side of a pool and breaking three teeth (Rosenthal, 2013). Although she did not call the ambulance, it seemed reasonable to her to accept it, so she did---never guessing that she would be billed nearly two thousand dollars for that fifteen-minute service (Rosenthal, 2013). This isn't uncommon, either: although most ambulances

are called by bystanders they are billed to the patient (Rosenthal, 2013). As an additional injury, many health insurances will only cover ambulance fees if there is reason to believe there is serious threat to life or health, which means that people who use ambulances frivolously, even unintentionally, are punished severely (Rosenthal, 2013). The only medical care that Kira Milas accepted from the paramedics was a precautionary neck brace; however, ambulances do not bill based on need or actual use, since those rarely are reflected in their operating costs. This means that a portion of this problem is entirely cultural. Even when there are other working vehicles nearby, people feel inclined to call 911 in an emergency, often unaware of the cost. Only 6% of incidents are in hard to reach areas where people are unlikely to have cars nearby. 23% of incidents are in health care facilities; if one were to be charitable, one could assume that all 23% of those incidents are severe enough that only an ambulance is equipped to handle the emergency. However, 52% of ambulance calls are from a home or residential location. Even assuming that the person in question is incapable of driving, it is difficult to assume that they lack the ability to reach alternative transportation; a taxi can be called as easily as an ambulance. This indicates that this behavior, and those of the 19% in public locations, is only reasonable if their complaints are so severe that they must have life support or other advanced medical interventions immediately.

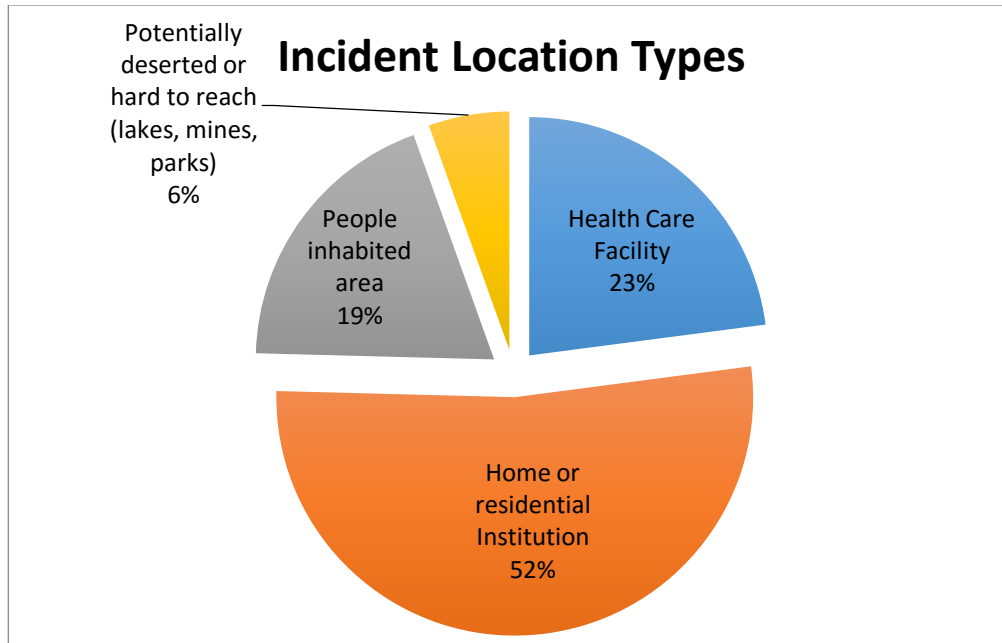


Figure 38: Incident location types chart

Table 3: Incident classification events

Incident Classification	
Home or Residential Institution	
Home/Residence	359,598
Residential Institution	54,517
Health Care Facility	
Health Care Facility	180,938
People inhabited area	
Public Building	35,284
Trade or Service	29,725
Place of Recreation	5,678
Industrial Place and Premises	3,697
Street or Highway	82,023
Potentially Deserted or Hard To Reach	
Lake, River, Ocean	618
Farm	307
Mine/Quarry	119
Other Location	36,565

2.5.2 Effective Ambulance Response to Complaints

Another current challenge with regard to ambulances is their cost-effectiveness. There are a number of areas within the current systems that create waste. For example, of 902 patients who called 911 for non-traumatic abdominal pain and were transported to a hospital for further evaluation, only 7.8% had conditions actually defined as emergencies (Lammers, Roth, and Utecht, 1995). This is a very small fraction, especially considering that the responders the calls have to be qualified to deal with actual emergencies. In addition, while this study had a small sample size, one must remember that abdominal pain is a very common complaint. Although many of the complaints recorded by dispatch (PSAP center) are unknown in the NEMESIS data, (see Figure 39), abdominal pain represents at least 3% of all complaints.

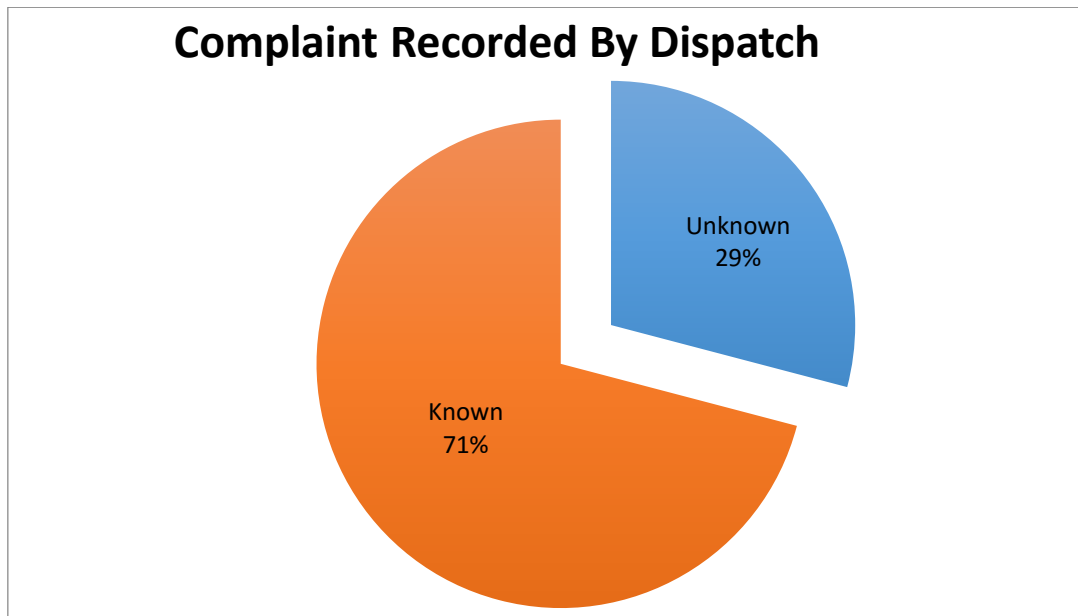


Figure 39: Complaint recorded by dispatch

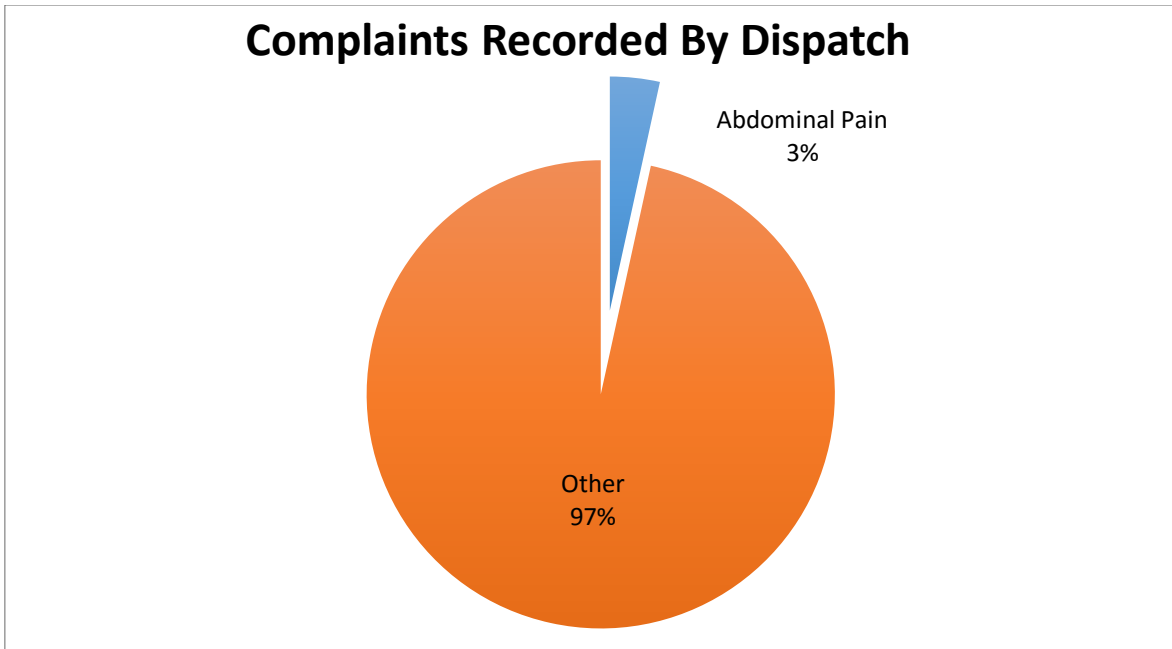


Figure 40: Complaints recorded by dispatch

In figure 40, one can see that abdominal complaints represent a significant portion of complaints reported by dispatch. The marginal cost of dispatching life support ambulances for just abdominal pain complaints was \$3,838 per emergency (Lammers, Roth and Utecht, 1995). When one considers other similar internal complaints that people often mistake as emergencies, such as chest pain, which require even more equipment, it is easy to understand how ambulances are not only extremely expensive for the operating company to run, but for patients to ride in.

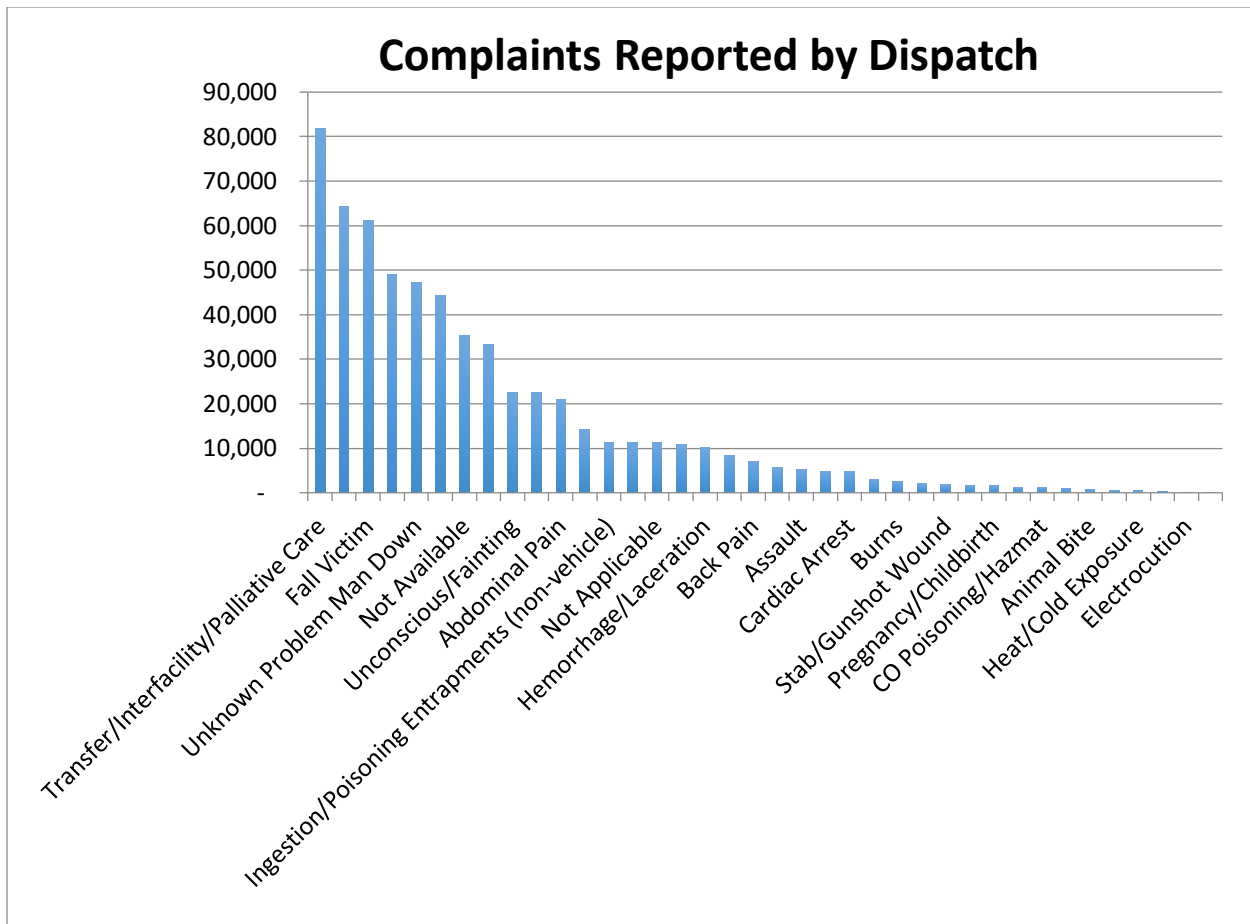


Figure 41: Complaints recorded by dispatch

The approximate distribution of complaints to dispatch can be seen in Figure 41. However, it can be hard to determine from a complaint type the actual seriousness of the incident. Therefore, a useful proxy for the perceived seriousness of the emergency, is the response mode to scene that the ambulance took. That is, whether or not lights and sirens were deemed necessary during the transport. In urgent transports, light and sirens are deemed necessary; however, in non-emergency transports---the ones where normal transportation could have sufficed---lights and sirens are not deemed necessary.

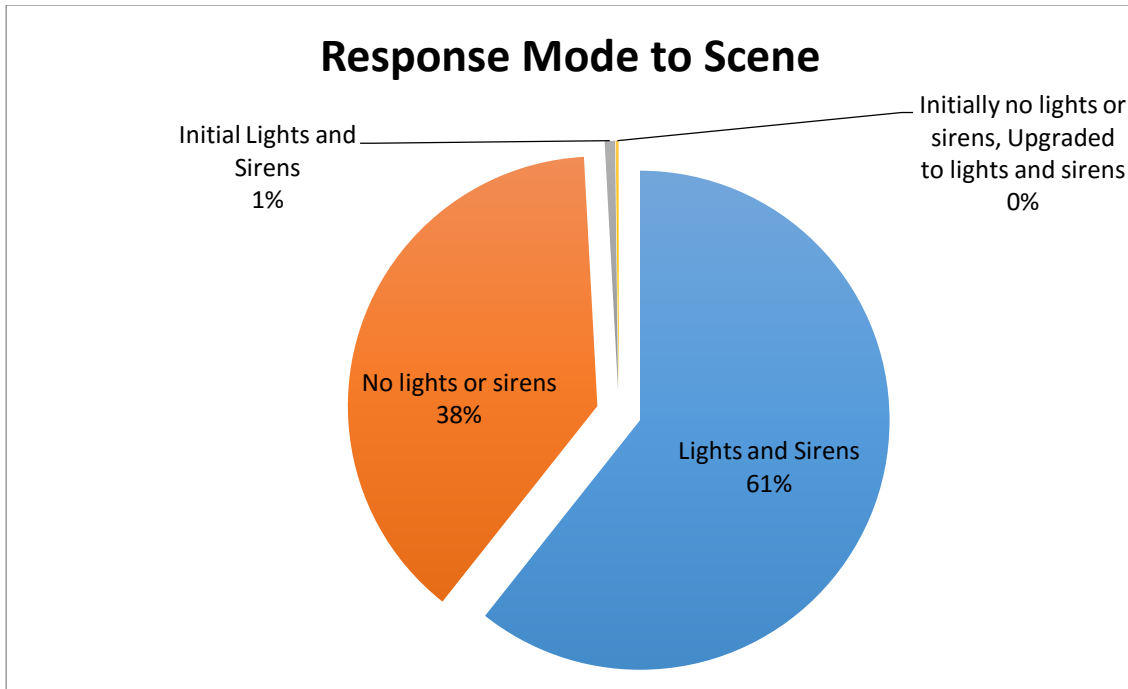


Figure 42: Response mode to scene

When people other than the victim call an ambulance, it can mean, not only that incidents are reported multiple times, clogging up the call centers, but that ambulances are dispatched when there is no willing patient for them to treat. As is seen in Figure 43, Ambulances are often cancelled or arrive only to find a patient receiving treatment, nearly a fifth of the time.

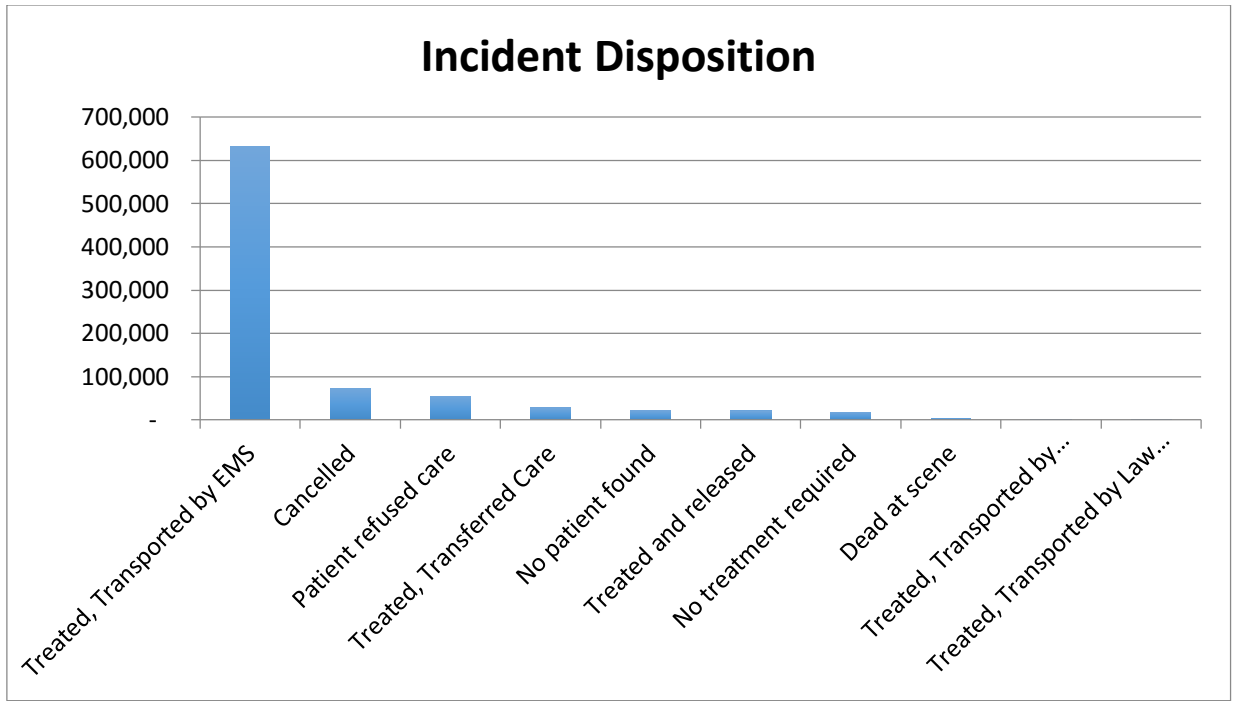


Figure 43: Incident disposition graph

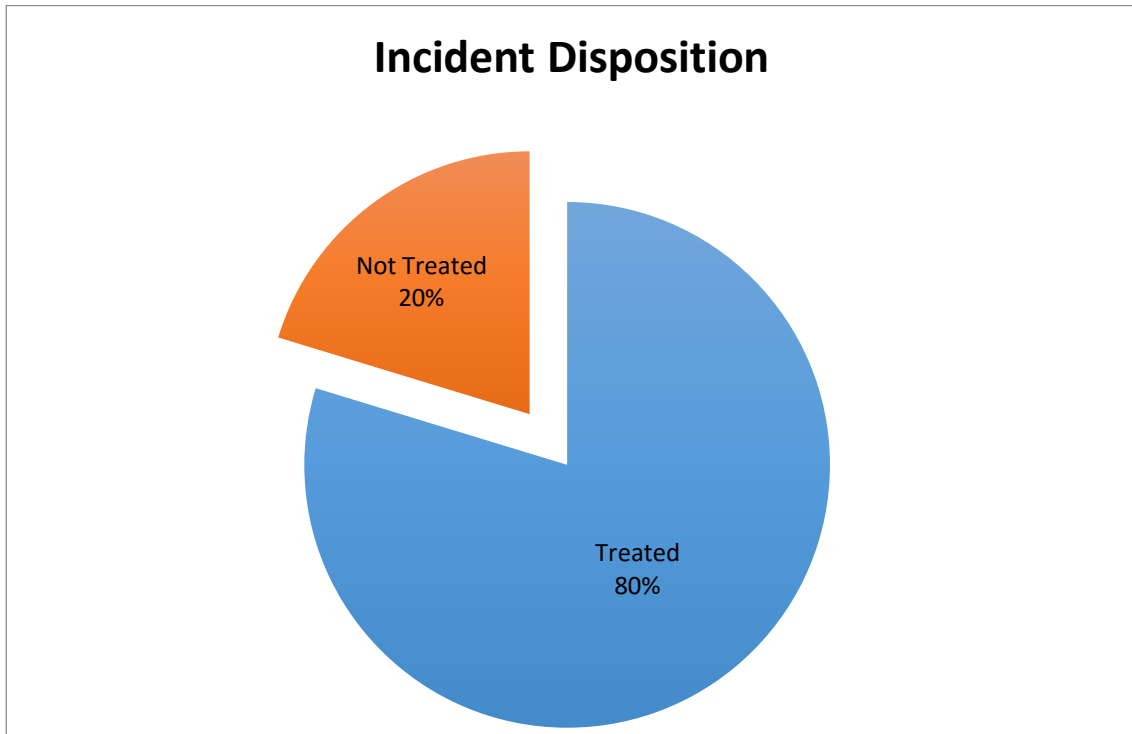


Figure 44: Incident disposition chart

2.5.3 Cost Effectiveness of Ambulances

This naturally leads one to the question: what is cost effectiveness in health care? From a business perspective, the objective is to provide sufficiently satisfactory services enough to collect payment while minimizing costs, in order to maximize profit. However, due to legislation and ethical concerns, the effectiveness of the healthcare must also be taken into consideration. Many consider the effectiveness of healthcare to be the primary objective of the ambulance; yet, this is a questionable objective, since it depends largely upon how much effect the ambulance healthcare actually has, and what aspects of the ambulance equipment and process actually lead to improvement of the patient's health. Although many studies have been done, there remains to be a clear consensus on its impact on patient health.

Ambulatory interventions are important for a timely recovery of patients who are transported by EMTs to the hospital. How such interventions can be measured in terms of healthcare costs. The most universally accepted metric is cost per year of life saved (Muennig, 2008). This means that it is most cost effective approach is to focus efforts on the youngest members of society in need of aid. For example, if an 80-year-old and a 10-year-old are both severely injured, and it will cost \$10,000 to save their lives, the 10-year-old is the more cost effective option. This is because an 80-year-old may only have five years left to live, so it will cost \$2,000 per year of life saved, while the ten-year-old may have another seventy years, which is approximately \$143 per year of life saved.

However, there is another attribute that must be considered along with this metric to accurately value the quality of health and life. If the ten years old in the aforementioned example is already irreparably damaged, then even their seventy years of life may not be desirable as the eighty-year old's five years.

There are different measures that are used to evaluate quality of life, generally focusing on how much the person will be able to do independently, such as tie their own shoes, or communicate with others. “The challenge... is to figure out how best to spend the money we have so that quantity and quality of life can be maximized” (Muennig, 2008). QALY, which stands for quality of life adjusted years, is a way of combining both quality of life and years of life into a single measure. This allows for better evaluation of the various health interventions. The unit of a single QALY is considered to be a year of life lived in perfect health (Muennig, 2008). The previously mentioned health outcomes that change quality of life, such as the abilities to move or work independently, decrease a patient’s QALY score. An additional way to consider this with respect to future uncertainty, since years of life with a condition are often unknown, is with a measure called QALE. QALE stands for quality-adjusted life expectancy, as measured in QALY.

This is used in practice when evaluating incremental cost effectiveness between two different health interventions being considered, with the following equation (Muennig, 2008)

$$\frac{\text{Cost of Intervention A} - \text{Cost of Intervention B}}{\text{QALE A} - \text{QALE B}}, \quad (1)$$

which is the equation that measures the quality of life. Now armed with a matrix to measure cost effectiveness, one can turn to the question of what sort of ambulance related health interventions are cost effective for patients. According to a computer simulation study, for patients experiencing acute myocardial infarction, reducing ambulance response times is cost effective (Cooper et al, 2006), though not all studies have supported their finding. In their simulation, “improving the ambulance response to 75% of calls within 8 minutes resulted in an estimate of 5 deaths prevented, or 57 life years saved per million people per year” (Chase, Roderick, Cooper et al, 2006).

Combined with other treatments, their model predicts 70 years of life saved per million people per year (Chase, Roderick, Cooper et al, 2006).

2.5.4 Difficulties in Improvement

One part of the problem in improving this system is the lack of motivation to change. Oftentimes, high operating costs are not a deterrent because it allows some ambulance companies to simply charge extra for services. This is possible because of Medicare and Medicaid, which subsidize the industry as a common type of payment after ambulance rides are used. While the NEMESIS data does not account for the vast majority of payment types, 14% of the data still includes payment type (see Figure 45).

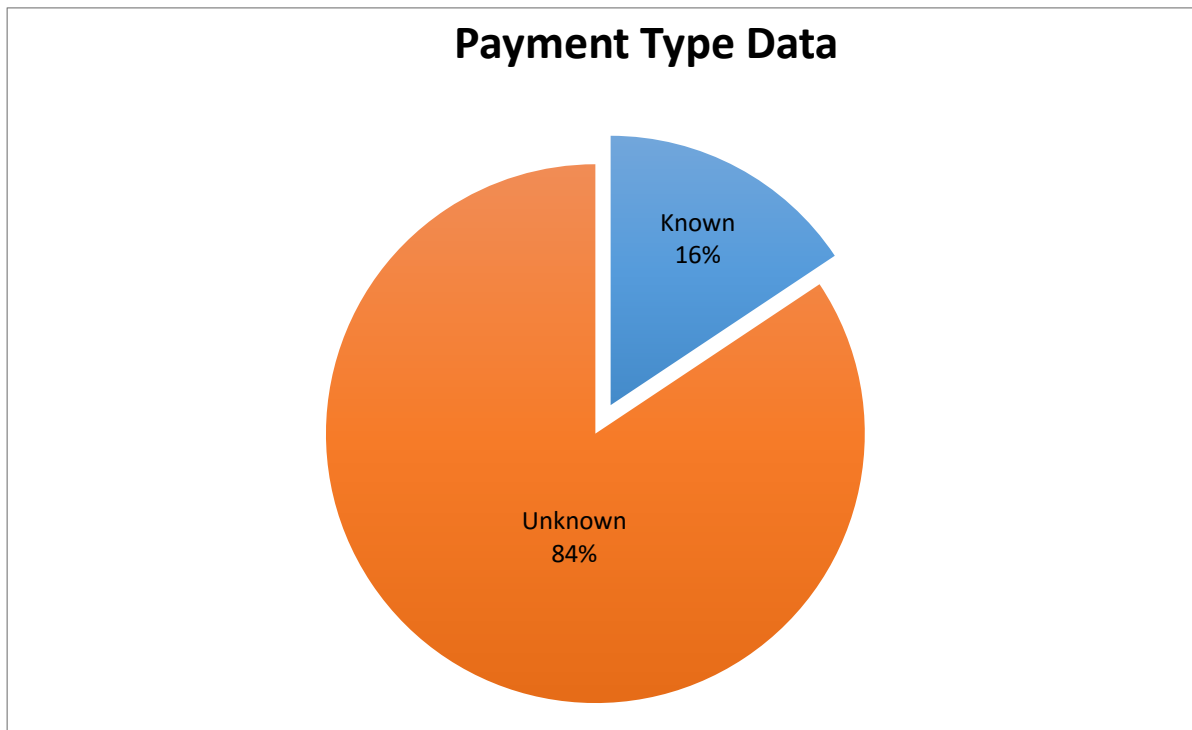


Figure 45: Payment type data chart

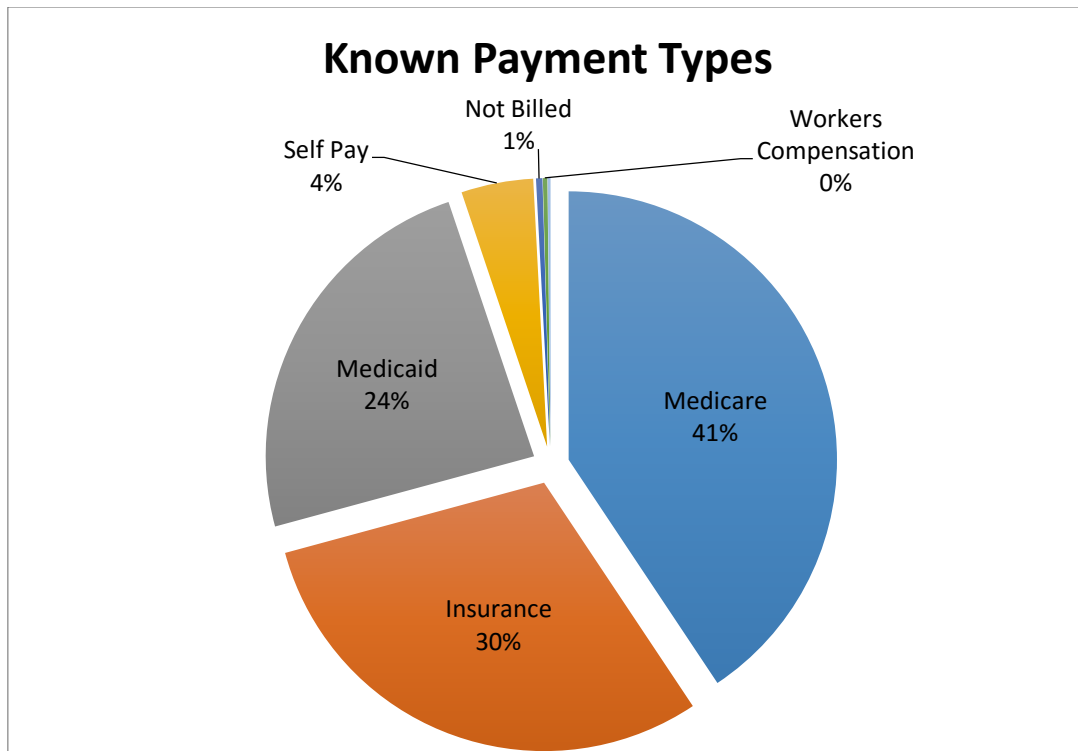


Figure 46: Known payment types breakdown

As seen in Figure 46, Medicare and Medicaid alone account for 65% of payment types in the NEMSIS data. While this sample may be unrepresentative of the entire population, there is no evidence to suggest that. Thus, for the purposes of this analysis, it is assumed to be an unbiased representative sample. This is important because while Medicare receives a discount from ambulance services, its lax considerations have been called “vulnerable to abuse and fraud” in a study by the federal Health and Human Services department (Rosenthal, 2013). This is also evidenced by the rapidly soaring cost of ambulance runs: Medicare ambulance costs are now \$6 billion in 2013—a 300% increase from 2002. (Rosenthal, 2013). With the addition of 30% of payment through insurance, a total of 95% of payment is not paid directly by the consumer, but by a 3rd party.

This does not mean, however, that Medicare allows frivolous or unnecessary ambulance use. Medicare will cover ambulance use only for emergencies where the patient can only be transported safely by ambulance; that is, if the patient's life will not be endangered by any other means of transport besides an ambulance, Medicare will not cover the cost (Medicare Coverage, 2015). Also, Medicare will only cover the cost to the nearest hospital that can provide the care needed for the emergency (Medicare Coverage, 2015). Furthermore, according to a 2015 article on Medicare Coverage, patients can still be held liable, even in genuine emergencies, for a portion of what is called a Medicare approved amount:

“Medicare-approved amount—In Original Medicare, this is the amount a doctor or supplier that accepts assignment can be paid. It may be less than the actual amount a doctor or supplier charges. Medicare pays part of this amount and you're responsible for the difference.”

Ambulance costs have been rising around the world. In some Massachusetts towns, ambulance rates have increased by almost 150% over the past few years (Barnes, 2013). This may be partially attributed to Medicaid and Medicare penetration in communities where Medicare and Medicaid may receive lower rates from ambulance companies. Ambulance companies claim they raise their prices overall to compensate for these lower rates (Barnes, 2013). In addition, companies also cite the increasing complexity of the equipment and care they are expected to provide as a reason for rising prices (Barnes, 2013).

However, the fault of high operating costs is not entirely due to the inadvertent government subsidies of Medicare and Medicaid. In fact, a town with “a high proportion of patients on Medicare limits the ability of a price increase to actually change a department's bottom line (Barnes, 2013). Ambulance Companies claim that the discounted Medicare rates do not cover the

cost of operating ambulances (Rosenthal, 2013) and that may be partially true. Due to the high overhead of keeping ambulances equipped, staffed, and ready to head out on a moment's notice, and the somewhat unpredictable volume of calls—which is how ambulance companies are paid—it can be difficult for ambulance companies to maintain a positive margin. This is especially evident in the divide in costs between rural and urban areas; urban areas cover less land and allow for more patients, lowering operating costs and increasing profits (McArthur, Gregersen and Hagen, 2014). Severe topography can also cause difficulties, and increase expenses, particularly with regard to increased travel time. Why the costs of operating ambulances vary so much across in the United States? There are a variety of reasons. First, ambulance companies as employee of a town charge their customers based on rates determined by that town (Barnes, 2013). Each town naturally has different rates based on the costs of operating in that town, and the average wealth of its citizens. Other emergency departments' policies can also affect pricing (Rosenthal, 2013).

In addition, while Medicare pays the “Medicare-approved amount” (which in most cases is less than what the ambulance charges), ambulance companies will also charge the patients the difference – unless there are specific local laws in place that forbid it (Barnes, 2013).

Chapter 3: Recommendations for a New Transport Ambulance

3. Introduction

Ambulance services are very expensive for tax payers (Barnes, 2013). The best way to decrease costs is to create a new service which is cheaper to operate. A lowered cost of operation should result in a lower cost for using the service. Introducing the concept of the transport ambulance is one solution to decrease costs.

3.1 The Transport Ambulance

The idea of a transport ambulance comes from an analysis of EMS systems around the world. Many developed countries have ambulances similar to the United States, especially in Europe, but they also implement other methods for delivering emergency services. In the United States of America, there are two widely used types of ambulances classified as Advanced Life Support (ALS) and Basic Life Support (BLS) (Definitions., 2006). The ALS ambulances are the largest vehicles and are equipped to respond to wide range of emergencies. BLS ambulances are smaller than ALS vehicles and they are equipped to respond to emergencies that are less serious.

3.1.1 High Cost of Ambulance Services

The US only has these two ambulance types to respond to medical emergencies, while other countries have more variety in their emergency medical service fleet. In London, England, there is a massive volume of traffic during peak hours, and ambulances have a difficult time reaching patients on time. To address this, London EMS implemented motorbikes that paramedics use to circumvent traffic in order to provide some level of care to the patient before the ambulance can make it to the scene (Black & Davies, 2005). London has implemented a unique solution to their traffic issue, and the concept of the transport ambulance is a possible solution to the high

costs of operating ambulances in the US. In many cities and towns across the United States of America, the cost of ambulance services is very high for people who do not pay using insurance. Table 4 shows the costs of ambulance services in certain towns in Massachusetts (Barnes, 2013). There are three baseline charges based on the level of service performed by the EMTs. ALS Level 1 is defined as transportation by ground vehicle and providing either an ALS intervention or an ALS assessment. ALS Level 2 is defined as all of the requirements for Level 1 and in addition to providing certain advanced treatments. A BLS response is defined as ground transport and the use of medical services and equipment that can be administered by an EMT-basic (Definitions., 2006). Table 4 shows how the cost of an ambulance ride is determined. There is an additional cost based on how far the ambulance had to travel to the hospital. Also, some areas choose to add charges based on what equipment was used during the incident. These prices vary widely by location and are determined by a number of factors. The factors for pricing ambulance services include the level of EMTs, the price of the vehicle and equipment, insurance, and fuel costs.

Table 4: Cost of ambulance service in Massachusetts towns (USD)

Town	Base Charge ALS (LVL 1)	Base Charge ALS (LVL 2)	Base Charge BLS	Per Mile	Equipment Charge?
Cohasset	1,376.97	1,992.99	1,159.56	21.09	none
Sharon	1,245.05	1,802.04	1,048.45	36.11	yes
Westwood	625.00	900.00	525.00	15.00	unknown
Foxborough	1,938.12	3,326.48	1,360.94	44.63	None

EMTs have different levels of training depending on their level of certification. An EMT-P (such as paramedic) is the highest certified EMT and also the most expensive. They must undergo more training than basic EMTs. For this reason, they are more specialized and authorized to perform

invasive measures and administered drugs to patients. The prices for ALS services are the highest because ALS ambulances are larger, carry a higher quantity of equipment, and are operated by highly trained paramedics. Basic Life Support ambulances by contrast are smaller, carry less equipment, and are operated by EMT-basics, who require less training and experience than a paramedic. The BLS services are cheaper than ALS services, but they are still relatively expensive. Even the cost of using a BLS ambulance can run up to \$1000 in many places in the United States.

The prices in Table 4 are charges that are experienced by people who do not pay using an insurance plan. Ambulance bills that are paid using either Medicare or private insurance are much lower than the prices listed in Table 4. This is due to contracts between insurance companies and the ambulance services (Medicare Coverage, 2015). However, even people with insurance can be billed full price for an ambulance service if the ambulance that responded is not within the local network. Cities and towns usually have agreements with certain EMS providers, who would then have contracts with a patient's insurance. However, there are private EMS companies that receive calls when the other providers are busy. If one of these companies responds to a patient's call, the patient's insurance may not cover the cost. There have been many cases where patients expected their insurance to cover the cost, only to find out that the EMS provider who responded had no contract with the insurance company (Andrews, 2011).

The prices shown are not just charges for uninsured customers, but they are also a reflection of the cost of doing business for EMS providers. Providers must have enough ambulances and personnel to service their area. But if insurance companies are not paying the providers enough to offset costs, then the remaining costs are then pushed toward people who do not pay insurance (Barnes, 2013). Therefore, by decreasing the cost of doing business for EMS providers, the prices for uninsured customers should also decrease. In an effort to reduce costs for EMS providers and

patients, a modified EMS system proposed in subsequent sections. This modified system is mainly featured as a transport ambulance that is cheaper to purchase, operate, and maintain than a normal BLS ambulance. The modified system will be comprised of ALS, BLS, and transport ambulances.

3.1.2 Current Use of Transport Ambulances

The concept of the transport ambulance is to handle non-emergency medical 911 calls. The patients who require non-emergency services are a significant source of waste in the current EMS system because they do not require advanced medical equipment, or advanced medical procedures. These patients mainly require basic assistance and transportation to the nearest hospital. There is no need for highly equipped ambulances and highly trained professionals to respond to these calls when they could be better utilized in serious emergencies. The proposed transport ambulance must be cheaper to operate than a normal BLS ambulance in order to be a viable solution to cutting costs. To have a cheaper operating cost, the personnel manning the vehicle, the equipment cost, and the cost of the vehicle itself must be lower.

The basic idea of the transport ambulance is no different than the concept of the BLS ambulance. It is a vehicle designed to be smaller than its larger counterpart, the ALS ambulance. The cost of operating the BLS ambulance is also lower than the ALS ambulance. The transport ambulance will continue this trend by being an even more cost effective alternative to the BLS ambulance, without impeding on the roles of either ALS or BLS ambulances.

BLS ambulances are designated for minor emergencies, but the key to their role is that they are also equipped to handle an urgent emergency call if needed. They may not be able to provide the advanced level of care that the ALS ambulance can, but they are still equipped enough to be useful in emergency situations. However, the equipment meant for emergencies are not useful when the

ambulance is dealing with a non-emergency situation, where the patient has no time critical ailments that will require anything more than basic aid and a speedy transport to the hospital.

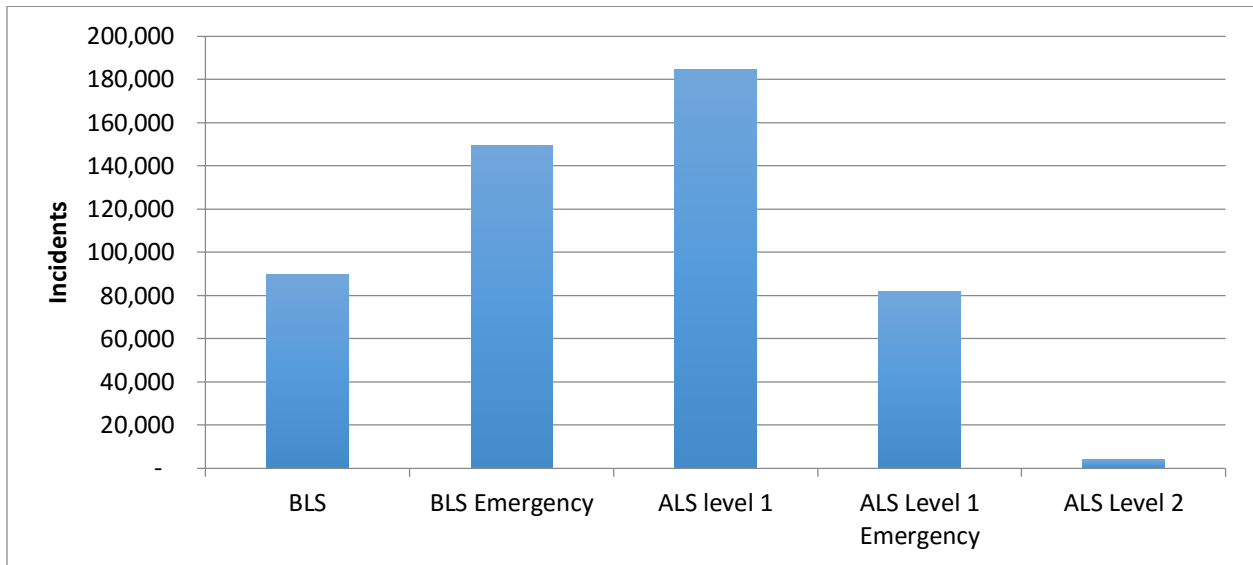


Figure 47: Service level for incidents in New England (2014)

The BLS ambulances are outfitted to handle their most strenuous responsibilities, which are their emergency services (Kass, 2014). When a service is designated as “emergency” that means that the unit responds to the call as quickly as possible, meaning the call is a high priority and the response time must be fast (Definitions., 2006). Figure 47 shows the number of incidents for the main EMS service levels. There is a slight discrepancy in this information that is not apparent and must be noted. The level of service is not necessarily indicative of the type of vehicle that responds to the incident. An ALS ambulance and paramedics can be dispatched to an incident and perform BLS level services, and the report will also state that BLS service was provided. Figure 47 does show, however, that there is a significant amount of non-emergency BLS services that can be handled by a transport ambulance. With the transport ambulance handling the non-emergency BLS calls, more of the BLS ambulances will be available to handle the emergency calls since they will not be as occupied with the minor incidents.

3.1.3 Transport Ambulance Cost Savings

The most significant advantage of the proposed transport ambulance system is the savings in both initial and operating costs. Type I and Type III ambulances are expensive to purchase and operate. The Sunstar ambulance analysis in Florida found that the ambulance vehicle alone (with no medical equipment) costs the county of Pinellas \$122,939 per year. An additional \$182,731 is spent on supplies, equipment, and personnel (Lindberg, 2011). The proposed transport ambulance aims to reduce costs in both areas.

The first and most obvious area of costs savings is in the purchase of the chassis. The smaller Ram ProMaster City costs just \$23,445 MSRP (Ram Trucks, 2015) compared to \$45,040+ for an F450 chassis cab upon which Type III ambulances are built (Ford, 2015).



Figure 48: Ambulance rear compartment under construction

Fleet pricing is available for both vehicles depending on order size. However, this includes only the chassis and powertrain. The ambulance needs to be completed. On a Type III ambulance, a large custom rear compartment is built by a special ambulance outfitter, such as Horton Ambulances, and bolted to the chassis (Figure 48). This is not done by the vehicle manufacturer. No special compartment needs to be welded together for a transport ambulance. A basic model Horton Type III ambulance costs \$133,000 (Ambulance outfitting information, 2016). Including significant dealer markup and labor costs, the bare chassis costs an estimated additional 83,000 to become mechanically complete. This number is derived from the selling price of the ambulance and subtracting the cost of the chassis from the dealer. Figure 49 compares the costs of different ambulance chassis from the vehicle manufacturer.

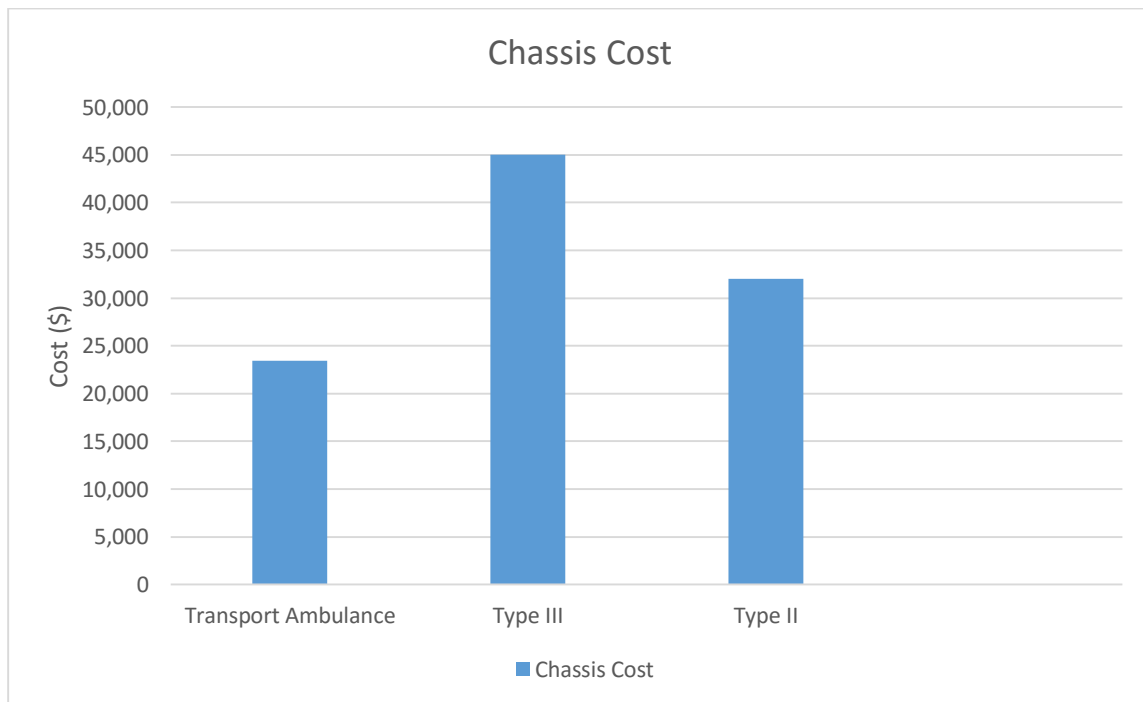


Figure 49: Ambulance platform chassis cost

Medical equipment has not been added in yet, but Horton includes emergency lights, radios, cabinets, climate control, and seats, all of which must be federally compliant. Developing

approved equipment and assembly procedures is where much of the outfitting costs originate. The proposed transport ambulance will be required to meet similar requirements, and thus will incur significant outfitting costs as well. The transport ambulance is more similar in outfitting costs to a medium Type II ambulance than a Type I or Type III because no custom rear compartment is needed. Paint, lettering, tires, and equipment will still need to be added to comply with the certification standards of ambulance vehicles. The transport ambulance is smaller and requires less materials than a Type II to outfit, however the labor costs will be similar. The cost savings in size will be offset by the initial design work needed to outfit a new platform. For the purpose of this analysis, the outfitting cost is assumed to be the same as a Type II. The Holdsworth EMS group found the cost of an average Type II ambulance to be \$85,000, with \$32,000 to purchase the Mercedes Sprinter Chassis. From these two numbers the cost of outfitting is determined to be \$53,000 (see Figure 50), with the lion's share of the spending going to the required high end radio system (Guercia, L, 2013).

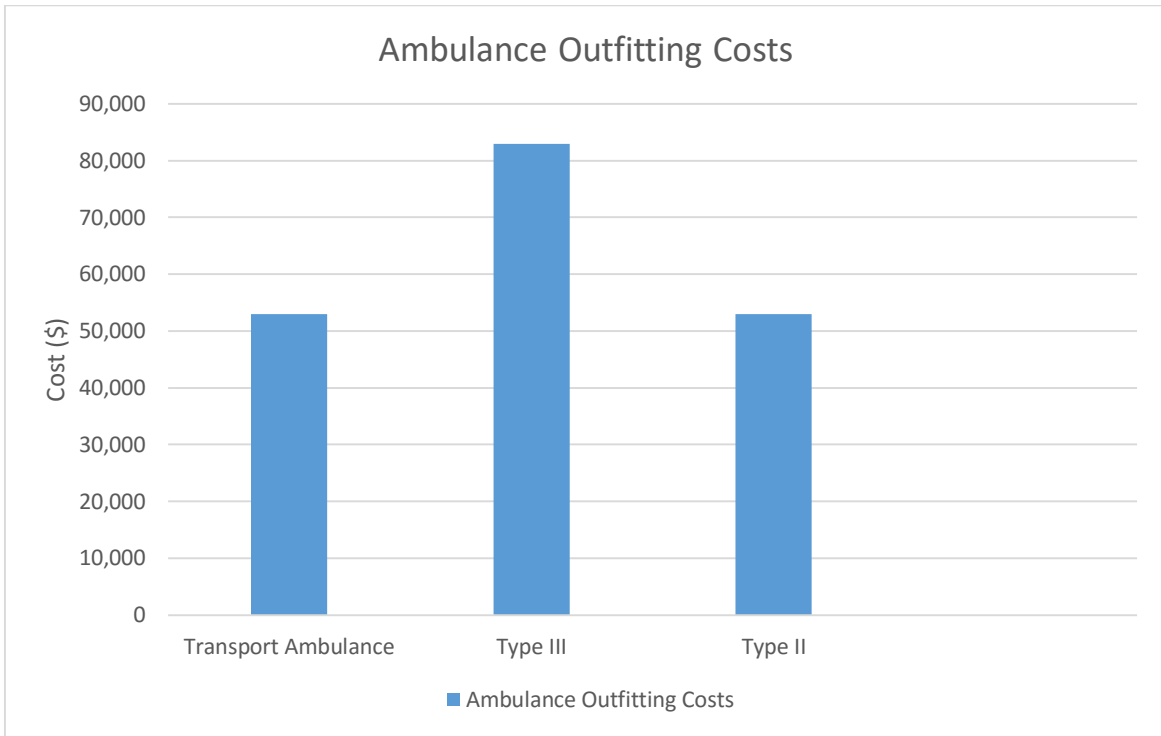


Figure 50: Ambulance outfitting costs

The proposed transport ambulance will also save cost in personnel. The Sunstar ambulance study concluded a typical ambulance is staffed by one paramedic and one EMT, with respective annual salaries averaging \$66,000 and \$42,000 per year respectively (Lindberg, 2011). This equates to a yearly cost of \$108,000 for personnel and leaving around \$75,000 in equipment and supplies costs. Due to its primary function to bring mildly to moderately injured patients to the hospital, the transport ambulance will be staffed with just two EMTs and no paramedics. The seniority and experience of a qualified paramedic will be delivered to patients at the emergency room by doctors. This saves \$24,000 per year in personnel costs.

Equipment costs can also be reduced in a smaller ambulance platform. Transport ambulances aren't required to be "hospitals on wheels" and therefore can eliminate costly items such as \$30,000 heart monitors. The costs for these pieces of equipment is hyper-inflated due to the high demand nature of the health care industry. Limited competition and regulation has allowed

vendors to balloon costs tremendously. Appendix A of this report lists the equipment with which the transport ambulance will be supplied. The estimated total cost for this equipment is \$15,866.48 (Reliable Emergency Vehicles, 2014). This is a huge improvement over the yearly equipment costs of \$75,000 for a full size ambulance, as shown in Figure 51.

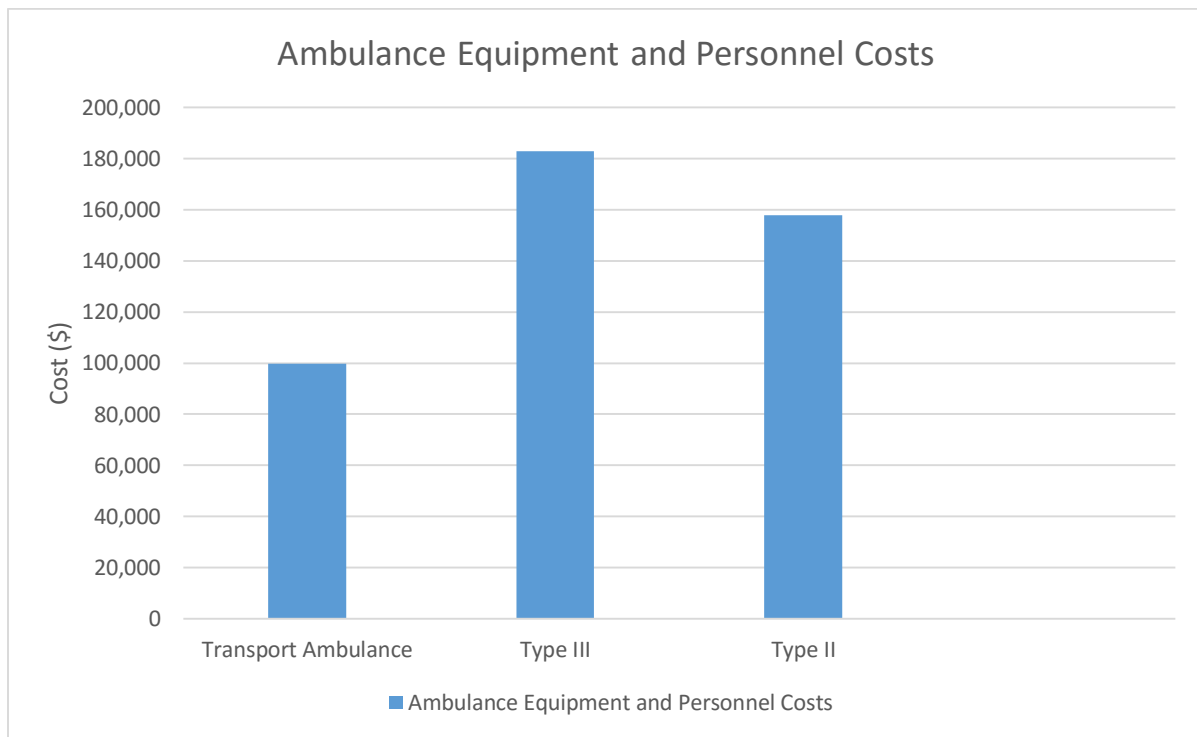


Figure 51: Ambulance equipment costs

Equipment data for Type II ambulances was inconclusive. Some Type II ambulances carry as much equipment as a full size BLS ambulance, where others are just transports. The minimum required equipment is nowhere near as extensive as a full size ambulance. For the purposes of this analysis \$50,000 was chosen for an average equipment cost of a Type II ambulance. In conclusion, the transport ambulance saves money in numerous ways, while still aiming to provide equal service to its larger counterpart. The initial yearly cost to buy and operate a transport ambulance is \$176,311 (see Figure 52). This factors in the startup costs of purchasing the transport ambulances. The annual running costs will be much lower once the ambulances have already been purchased

and equipped. Only supplies and personnel costs will remain, as well as routine maintenance. The savings are passed on to patients.

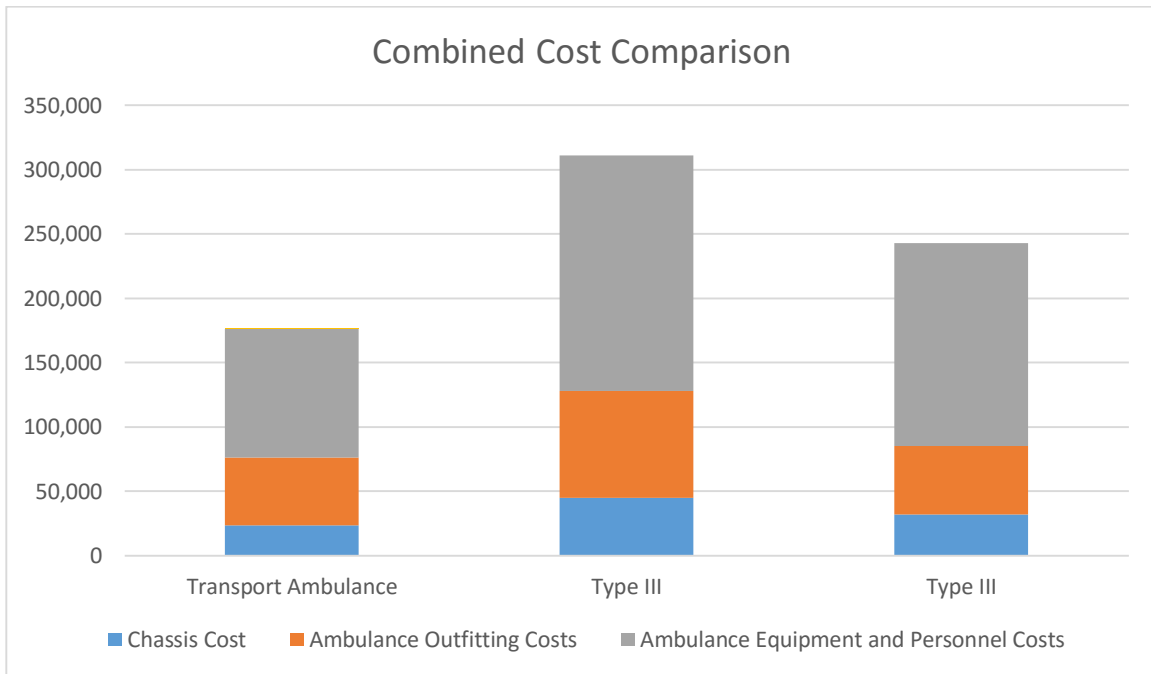


Figure 52: Combined cost analysis

3.2 Transport Ambulance Requirements

For the new proposed system for a smaller transport ambulance, different requirements would be needed other than those of the current ambulances. Since the new transport ambulances would not handle the same types of incidences that the current ambulance does, it would not need the same requirements as the current ambulances. The hope is that the overall cost of the transport ambulances will be much lower than the current ones by changing the requirements. The two main areas of requirements we look to change are the equipment needed on the transport ambulance and the actual vehicle itself.

3.2.1 Proposed Transport Ambulance Equipment

Current ambulances are often referred to as “hospitals on wheels” because they carry just about everything a patient could ever need in the event of an emergency. They carry everything from just a simple Band-Aid to a multi-thousand-dollar defibrillator and even its own oxygen system. They are capable of handling any type of incident from a stubbed toe to a heart attack or stroke. Since the new transport ambulance will not be handling serious emergencies, it would not need all of the equipment that a current ambulance has. Therefore, if that equipment can be limited to just the materials needed for the types of calls that the transport ambulance would respond to (see Table 5), EMS systems could save a lot of money on their equipment costs.

A study was conducted in 2011 in Pinellas County, Florida that investigated what is in a Sunstar ambulance and how much it costs. Pinellas County has seventy four ambulances in their fleet which are owned by Paramedics Plus, but Pinellas has the right to take them should the company default or leave the county. The study found that the Sunstar ambulance system is funded by approximately \$41 million that is collected each year in user fees. The county pays Paramedics Plus about \$21 million a year from those user fees to buy ambulances, fuel and service them, and hire and pay paramedics and EMTs. Pinellas pays another \$2.8 million a year to Paramedics Plus to buy supplies such as bandages and drugs for the ambulances and fire department vehicles that are used for emergency medical services. Most of the \$2.8 million, about \$1.8 million a year, is

used for the Sunstar ambulances (Lindberg, 2011). That is a total annual cost of about \$23 million dollars for just a small county in Florida.

The study also discovered how much it would cost annually to put one of Pinellas' ambulances on the road. Figure 53 shows a breakdown of the cost. It found that about \$182,731 is spent on supplies, equipment, and personnel. Another \$122,939 is spent on the ambulance itself (an AEV Chevrolet/GMC Trauma Hawk Ambulance), the gas to fuel it, and other related costs.

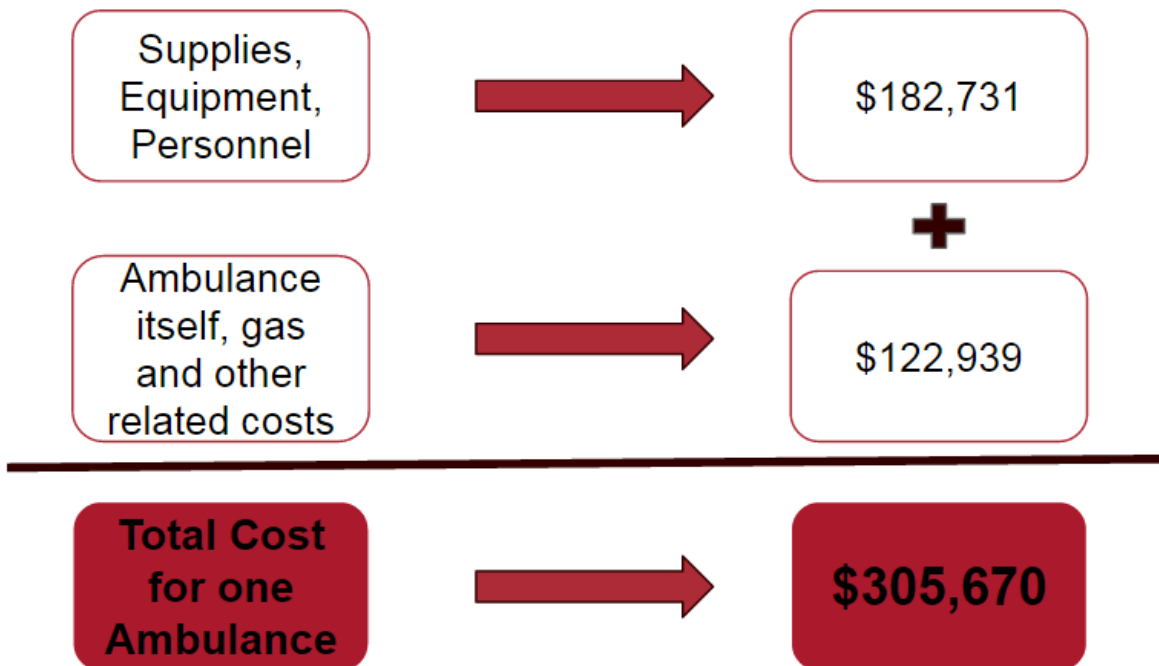


Figure 53: Diagram to show the total annual cost of a Sunstar ambulance

That produces a total cost of \$305,670 for a single ambulance. Pinellas County has up to 64 ambulances on the road at a time (Lindberg, 2011).

So to get just the cost of the equipment alone, the cost of the personnel would be subtracted from the cost of supplies, equipment, and personnel (shown in Figure 53 above). The Sunstar ambulances are usually staffed by one paramedic and one EMT. The average annual salary for a paramedic is \$66,000 and for an EMT it's \$42,000 (Lindberg, 2011). So if those salaries are subtracted from the total annual cost for supplies, equipment, and personnel, the cost for just the

supplies and equipment alone becomes just about \$75,000. That is an awful lot of money to be spent on just supplies and equipment.

Table 5: Proposed medical emergency sorting

Transport Ambulance	ALS or BLS Ambulance	
Abdominal Pain *Animal Bite Back Pain *Burns Diabetic Problem Eye Problem Headache Heat/Cold Exposure Ingestion/Poisoning *Sick Person *Traumatic Injury	Allergies Assault Breathing Problem CO Poisoning/Hazmat Cardiac Arrest Choking Convulsions/Seizure Drowning Electrocutation Fall Victim Heart Problems	Hemorrhage/Laceration Industrial Accident Pregnancy/Childbirth Psychiatric Problem Stab/Gunshot Wound Stroke/CVA Traffic Accident Unconscious/Fainting Unknown Problem Man Down Mass Casualty Incident

One of the main objectives for this project is to limit the amount of monetary waste in the EMS system. By limiting the amount of equipment in the new transport ambulance we are hoping to cut EMS systems' spending costs significantly. We are aware that everything on a current ambulance is regulated by Federal and State laws, but our new transport ambulance will only handle non-life-threatening calls and so, theoretically, will not need all of the current equipment.

A basic life support equipment list is acquired from the Massachusetts Office of Emergency Medical Services (Kass, 2014) that describes every piece of equipment regulated by the state to be on a BLS ambulance. That list is then cross-referenced with the list of incidences that the new transport ambulance would handle (see Table 5) and analyzed to remove anything that seem unnecessary for that incident. Anything that involved the automatic external defibrillator, the installed oxygen system, and the installed suction system are removed from the list as they are found to be expensive and not often needed for non-emergencies. The concluded list of what

equipment is deemed necessary for the types of calls that will be handled can be found in Appendix A.

With the fact that the vehicle of the transport ambulance would be much smaller, the problem of available space for the equipment arose. We would have to make sure that all of the equipment that we decided to keep would be able to fit inside the smaller vehicle. This aspect is outside the scope of this project and therefore not considered in the proper depth that would be needed if the idea of this project is to be implemented. This project just focuses on the analysis of the data and application of the derived results from the data.

3.2.2 Vehicle Candidate Analysis

The success of a transport ambulance relies heavily on appropriate vehicle choice. A modified consumer vehicle will be used that is already compliant with safety and emissions regulations. The ideal vehicle would strike a balance between initial purchase cost, and operating costs (including fuel mileage), while providing adequate space. The transport ambulance is designed to be low cost and agile to bring the patient to a hospital as quickly as possible. Onboard care will be limited.

Ford Transit Connect

<p>\$24,825 Starting MSRP¹</p> <p>\$228 / Mo Lease ⁱ</p> <p>Prices For Feb 29, 2016 And ZIP 01540</p>	<p>View All Offers</p> <p>Search Dealer Inventory</p>	<p>Standard 19/27²</p> <p>EPA-Est. MPG City/Hwy</p>	<p>Seating for 7</p>
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Transit Connect Wagon

Transit Connect Wagon offers class-exclusive* available seven-passenger seating, impressive maneuverability, and ample storage, payload** and towing capacities.

- Long-wheelbase wagon - seating for up to seven with 104.2 cu. ft. of storage capacity available behind the front seats†
- Short-wheelbase wagon - seating for up to five, easy maneuvering and parking on tight city streets with 77.1 cu. ft. of storage capacity available behind the front seats†
- Maximum payload of 1,270 lbs.†† with unsurpassed towing capacity of 2,000 lbs.††

*Class is Small Vans based on Ford Segmentation.
 **Capacity limited by maximum payload restrictions. See dealers for details.
 †With the rear seat backs folded.
 ††When properly equipped.



Figure 54: Ford Transit Connect details from Ford's website



Figure 55: Long wheelbase (LWB) Transit Connect van

The Ford Transit Connect is a light duty minivan available from Ford with fleet pricing. When organizations purchase vehicles in bulk for commercial use, they receive a discount off the sticker price the average consumer pays. This rate varies from dealer to dealer and depends heavily on the type of financing and quantity ordered. A ballpark estimate for the discount for one dozen transport ambulances would be 15-20%, or around \$21,000 for the base Transit van. With the rear seats removed from the extended wheelbase model (see Figure 55), this minivan would make a

fantastic transport ambulance (Ford, 2015). There is adequate room for a stretcher, two medical personnel, and first aid/CPR equipment. Two EMTs can ride comfortably in the vehicle, one will be driving and one will be in the back with the patient. The front passenger seat allows family or other passengers to ride with the patient. It will be easier to load a stretcher into this van rather than a conventional ambulance due to its low ride height.

Chevrolet Colorado



Figure 56: Chevrolet Colorado, photo provided from Car.com

While a minivan-based transport ambulance can provide the necessary rear enclosed space direct from the manufacturer, a modified pickup truck such as the Chevrolet Colorado (see Figure 56) can provide more flexibility. The transport ambulance can be built off a cab and chassis of a small pickup, much like the conventional type I ambulances that are built on a full size pickup truck frame. The bed is removed and a custom built patient care compartment is built on the back. One major advantage of using a custom back approach is space. The rear compartments of vans have a fixed width, which is flush with the driver cab. However, if a custom compartment is built on the back, that compartment can be made wider to accommodate more equipment and supplies.

Figure 57 shows what a type I ambulance might look like when it leaves the manufacturer, before the medical compartment is built on the back. It is possible to downsize this idea into an effective transport ambulance. A custom built box can provide the most versatile transport ambulance with the most space and headroom, however the weight is limited by the chassis of the truck. The 2016 Colorado has a gross weight rating of 5900 pounds, meaning the weight of the truck, personnel, patient, and rear compartment must not exceed 5900 pounds.



Figure 57: Example full size cab and chassis truck

The axles' brakes and suspension can be upgraded to carry more weight, however these upgrades must be tested by the State independently for liability purposes. Due to the cost of this additional step, the truck will only be considered in its stock unmodified form as it leaves the manufacturer. The curb weight of the vehicle is listed as 3930 pounds, leaving almost 2000 pounds. of room to use (Chevrolet, 2015). However, considering the weight of two EMTs and the patient must be included, a target number for the rear compartment would be 1000 pounds, equipment included. This can be done with careful design. Containers, cabinets, seats, and stretchers can be built in for ease of access. This design will give the best performance since it will be designed from the ground up for transport ambulances.

Ram Promaster City



TRADESMAN[®]
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A DELIVERY VEHICLE OR MOBILE WORKSHOP

\$329⁺ ESTIMATED MONTHLY PAYMENT | \$23,445 STARTING MSRP[†]

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CLASS-EXCLUSIVE
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TRANSMISSION[†]

MAX TOWING **2,000** LBS[†]

UP TO
10,000-MILE OIL
CHANGE INTERVAL

BEST-IN-CLASS
178 HP[†] AND 174 LB-FT
OF TORQUE[†] WITH
STANDARD ENGINE
CONFIGURATION

BEST-IN-CLASS
MAX PAYLOAD 1,883 LBS[†]

AVAILABLE
UCONNECT[®] 5.0 WITH
5-INCH TOUCHSCREEN

BEST-IN-CLASS
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CU FT OF
CARGO CAPACITY[†]

CONVENIENT
60/40 SPLIT
REAR DOORS

Figure 58: Ram Promaster specifications from manufacturer's website

The Ram Promaster City is a small van similar to the Ford Transit Connect. The two are direct competitors. The Promaster is rated with a higher weight capacity and has better fuel economy (see Figures 61 and 62), but is a less reliable platform (Ram Trucks, 2015). The Chrysler nine speed automatic transmissions are plagued with problems occurring at very low mileage.



Figure 59: The rear seats can be removed for additional rear space

Comparison

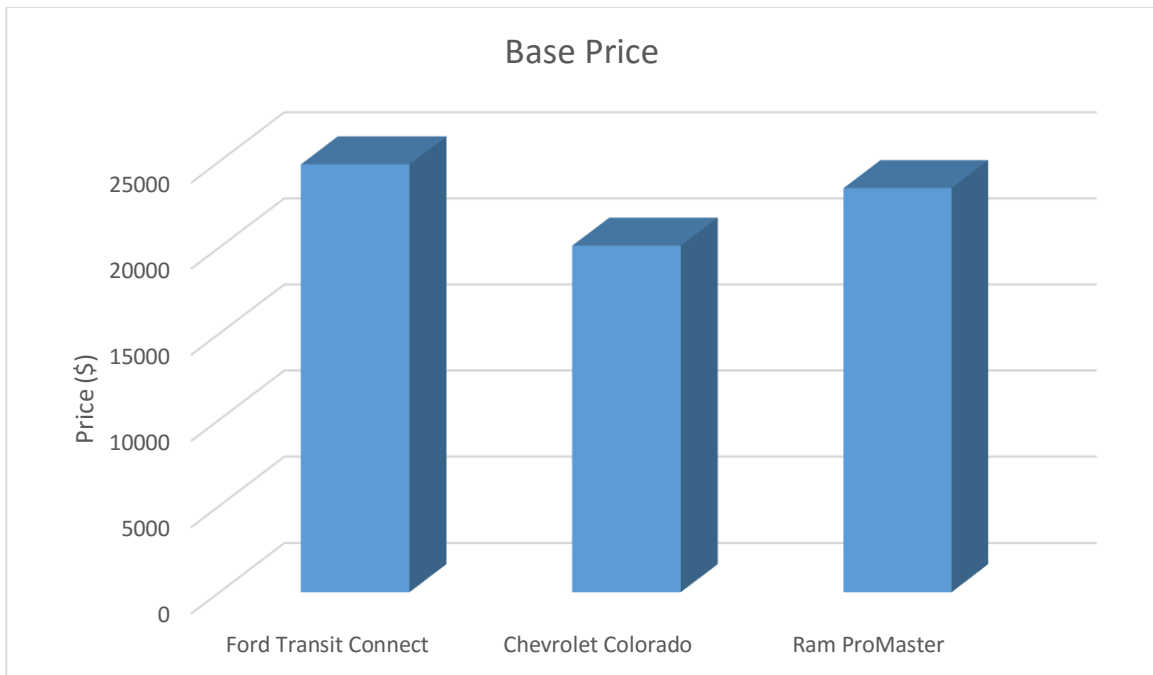


Figure 60: Base price of vehicles before modifications

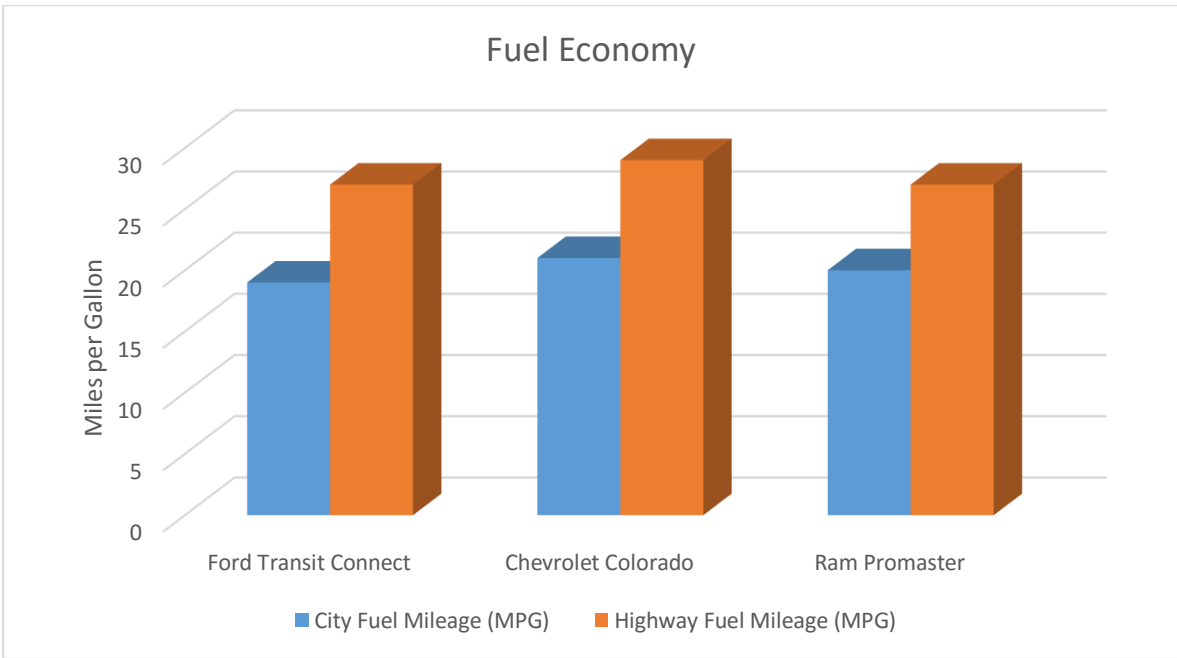


Figure 61: Comparison of fuel economy before modifications

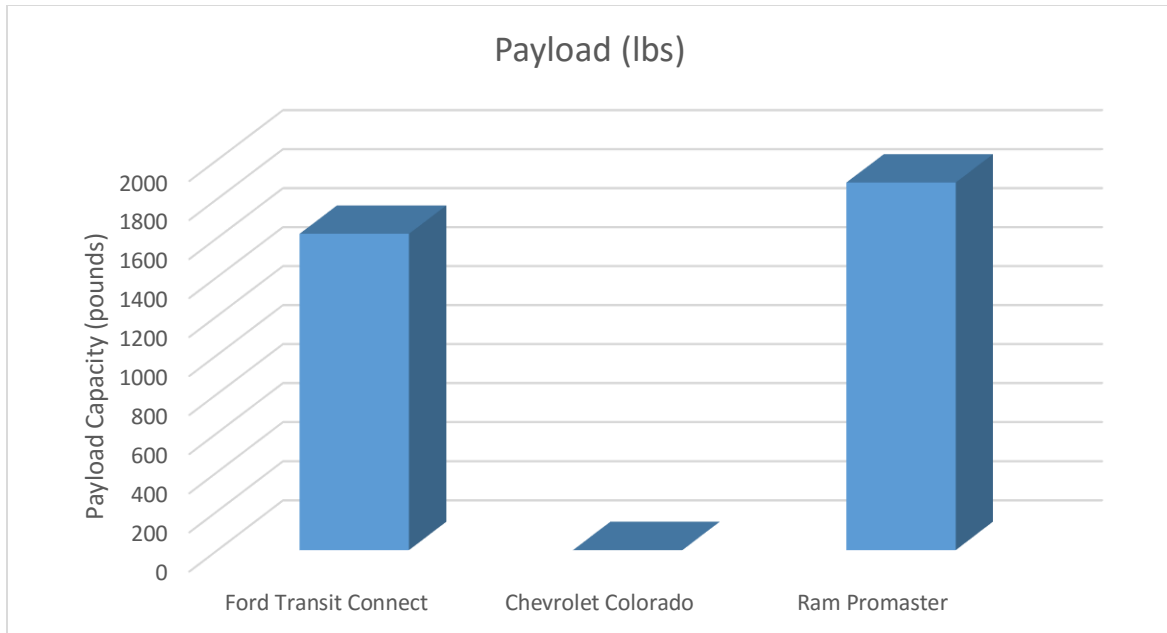


Figure 62: Comparison of weight capacity

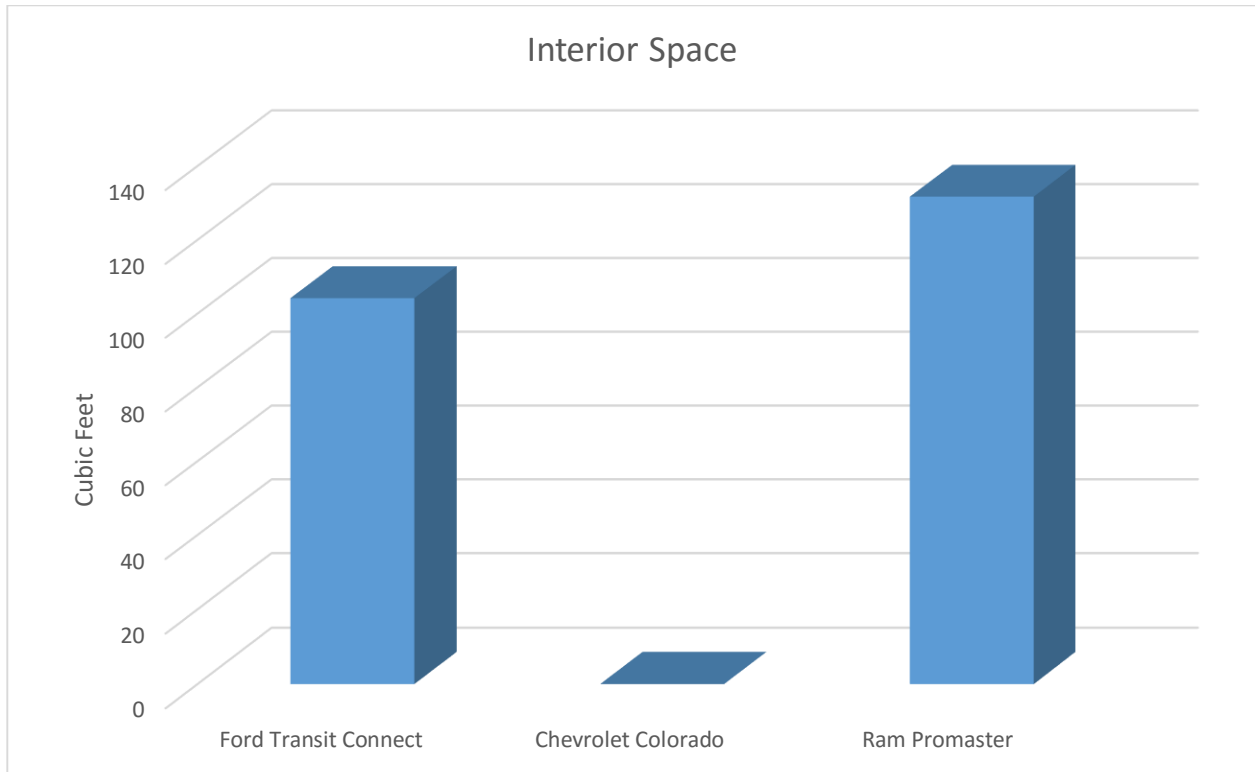


Figure 63: Usable interior space

Table 6: Comparison of vehicle options, best performer is highlighted in blue

	Ford Transit Connect	Chevrolet Colorado	Ram Promaster	
Base Price (\$)	*24,825	20,100	*23445	* Fleet Pricing Available
City Fuel Mileage (MPG)	19	21	20	
Highway Fuel Mileage (MPG)	27	29	27	
Payload (pounds.)	1620	1000*	1883	*With modifications
Interior space (cu ft.)	104.2	N/A*	131.7	* Dependent on rear compartment size

At first glance it appears the Colorado would be the cheapest to purchase and to fuel (see Figure 60), however the cost analysis does not include the custom box that needs to be designed and built for the chassis cab. The payload weight is also limited due to the extra compartment, which will require expensive crash testing as well. Even though this custom truck could provide the most capability, either of the vans will provide a simpler solution. Of the two vans, the Ram Promaster is clearly the superior performer (see Table 6). It has 200 more pounds of payload capacity and 30% more interior space (see Figure 63), while offering superior fuel economy as well. The best in class fuel consumption is due to new engine technology that improves efficiency by reducing intake pumping losses. Ambulances have an accelerated maintenance schedule with frequent mechanical inspections by the ambulance organization, which helps mitigate the transmission issues of the Promaster. The warning signs of failures will be detected early, and can be repaired by the dealer under the standard 100,000-mile warranty. The Ram Promaster is the optimal choice to use for the transport ambulance.



Figure 64: Ram Promaster side view

3.2.3 Implementing Transport Ambulances

Transport ambulances would only be viable in urban EMS systems. Their use in any other setting would not be beneficial due to the low number of calls and minimal resources available to those areas. The transport ambulances are meant to handle minor emergencies with minimal equipment and staffing in order to lower the price of this service. This means that the ambulance will not be equipped for emergencies where the patient's life is in danger. In relation to the NEMSIS data, this would be classified as BLS service. Based on classifications for medical emergency service levels in the EMS guide cards (see Figure 6 in Chapter 2), the less severe emergencies are classified as BLS. If the number of BLS emergencies can be determined, then an idea of how many useful transport ambulances can be established.

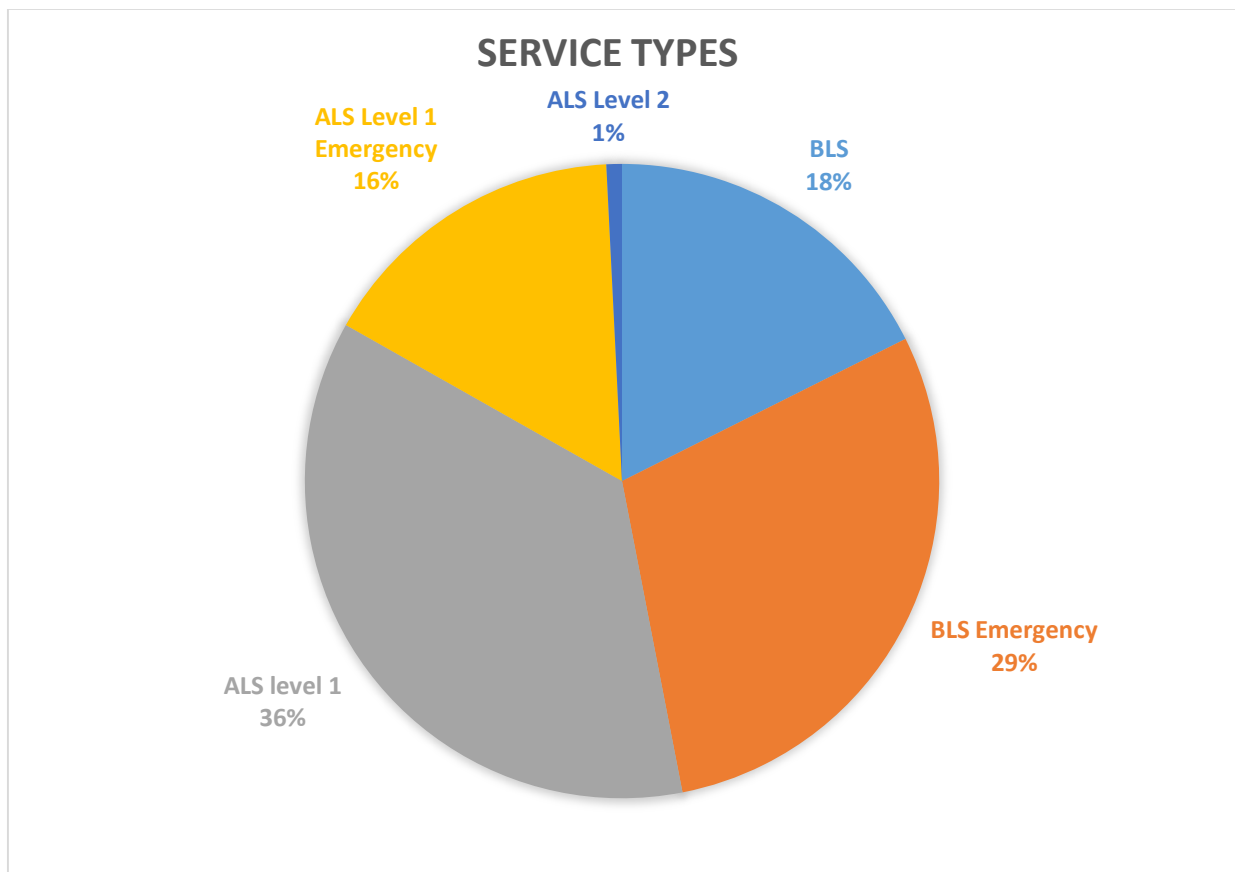


Figure 65: EMS service types

Figure 65 shows a representation of the ground level responses in New England. The BLS calls represent 18 percent of the total number of calls for 2014. The total number of incidents represented by this graph is 509,462. Since a majority of New England is comprised of urban EMS systems, Figure 65 is a good estimate of the distributions of service that would occur in a typical urban environment. An important aspect to note is the distinction between BLS and BLS emergency. As stated before, BLS ambulances are outfitted to handle emergency calls that do not require advanced intervention or pharmaceuticals. The emergencies that BLS ambulances would handle may include emergency administration of oxygen, or the use of a defibrillator, among other things. The BLS Emergency category in Figure 65 would need to be handled by either a BLS ambulance or an ALS ambulance. The transport ambulance would not be appropriately equipped to handle emergencies such as these ones. However, the transport ambulance would be equipped to handle the BLS calls, which accounts for 18 percent of all incidents. In these cases, only an EMT-Basic and the medically necessary equipment will handle these calls (Definitions., 2006). The transport ambulance will be operated by EMT-Basics and have only the equipment necessary to handle minor emergencies. Therefore, the BLS category in the chart describes perfectly the type of calls that the transport ambulance will respond to.

Analysis of the service types is not so simple as to use only the information in Figure 65 to justify the number of transport ambulances that an urban EMS system should have. It has been mentioned that ALS ambulances are capable of providing BLS services to patients. Even though these vehicles are more equipped, and are staffed by EMT-Paramedics, they will still charge the allotted base rate for BLS services if they respond. This makes the pricing and logistics of using a transport ambulance more complicated. As EMS systems currently operate, the service charge is independent of the actual vehicle and personnel that responds; but at the same time, the cost of the

vehicle and personnel is factored into the cost of the service. This means that the cost of all ambulance services are a culmination of the costs of every vehicle and all staff employed by the EMS. The idea of replacing some of the BLS ambulances with transport ambulances will decrease this overall cost, but not to a degree that justifiable by the extra effort and organization required to implement these vehicles. The only way that the transport ambulance would make a significant change in cost for the patients who use it, is to price the service independently of ALS and BLS services. While this idea is simple in a theoretical sense, implementing it in the real world is not as straightforward. The transport ambulance will be utilizing the same garage, personnel, management, and equipment resources as the ALS and BLS ambulances. All three services will be sharing resources; therefore, they will be sharing costs. In order to minimize the costs of the transport service, two solutions will be discussed.

One possible solution is to limit the transport service based on the vehicle that responds to the incident. As stated previously, an incident is classified as a BLS or ALS response based on the needs of the patient, not the type of vehicle that responded to the call. But, if a rule is introduced stating that transport services can only be performed by transport ambulances, or else the incident will be classified as a BLS service, will reduce costs. That way, even though resources would be shared between BLS, ALS, and transport services, the actual savings from the transport ambulances will be limited to a single service, thereby minimizing the influence of the less cost effective BLS and ALS ambulances. There is one major advantage and one major disadvantage to this solution. The benefit is any EMS system could implement this system easily by integrating it within their existing pricing structure. The major disadvantage is on the patients' end. They may call an ambulance for a minor incident, and pure chance will determine whether they receive a transport service or BLS service.

The other possible solution to minimizing the influence of BLS and ALS services on the price of the transport services is to devote an entire division to transport ambulance services. The way this would be accomplished is to include special EMS companies that only provide transport services for the 911 emergency network. That way, when dispatch needs a transport ambulance, they can send one from a company whose only expenditures will cover the costs of transport ambulances. It will allow patients to receive the care they need at an affordable cost without worrying that they might be charged for BLS services like in the previous solution. However, this would require a higher initial investment than it would to simply replace some of the BLS ambulances in a running EMS system.

On a side note, there are some EMS companies that provide services just like the transport service proposed in this project. The most well-known are companies that specialize in inter-facility transports, moving patients from one medical care center to another. There are also a few lesser known companies that provide medical transports to hospitals for a lower cost than an emergency ambulance service. The only major issue is that these companies must be contacted directly by the patient in need of their services. They are not contracted with the city they service; therefore, they are not dispatched on 911 calls. The purpose of this project is to include a cheaper medical transport service when a patient calls 911. More people are accustomed to calling 911 if there is an injury, rather than considering the cost of the ambulance. Including the transport ambulance in the 911 system is the best way to assure that these cost saving measures are effectively utilized.

Considering the service data in Figure 65, the pricing of ambulance services, and how the transport ambulances will be integrated into the 911 system, the recommended number of transport ambulances will be one or two vehicles depending on the size of the EMS system. For larger EMS

systems that would have ten or more ambulances working in an area, two would be the maximum. Based on the NEMSIS data, only 18% of the calls could be handled by the transport ambulance. However, since the transport ambulances are limited in their versatility, it would not be advised to have too many. They should only be used to provide patients with the option of an affordable ambulance ride if their needs are not severe. For smaller EMS systems, one transport ambulance should be enough. The likelihood of a minor emergency occurring in a small EMS system is small.

3.3 Barriers to Implementation of the Transport Ambulance

Implementing the transport ambulance into an actual EMS system would have several barriers to overcome before it would be accepted as a fleet vehicle. Most of these barriers relate to the regulatory laws and standards that govern the specifications of ambulances. These regulations are very thorough and the money saving concept of the transport ambulance may not meet some of the specifications of the larger ambulances.

3.2.1 Ambulance Service Environments

When considering how the transport ambulance will be utilized within an EMS system, one needs to consider the characteristics of that EMS system. No two systems are the same anywhere in the country. There are differences that need to be accounted for when considering their needs and capacity to provide care. These differences are: service environment, funding, and patient demographics.

In the United States, EMS system service environments are classified into three groups: urban, rural, and super rural. These names are reflected in the NEMSIS data set used in this project. These categories describe the area that a particular EMS system operates in. Urban areas are areas with high population densities. These include cities of all sizes and dense suburban areas. These

areas may have multiple ambulance units, so ambulance response times are expected to be low. Likewise, there may be multiple hospitals in these areas, such as in major cities, so patient transport times are also expected to be low. Rural environments have relatively low population densities. These usually apply to areas with small towns spread far apart, and no high population density areas nearby. Since these areas are not as populated as urban areas, there are not as many medical emergencies that occur. Therefore, there will be fewer ambulances on duty than in an urban setting. This means that the response time will be higher than urban environments. Lastly, super rural is an unofficial term used in the ambulance community. It is not officially recognized by the Code of Federal Regulations (Definitions., 2006). The term super rural is used to describe rural areas that are very sparsely populated. Ambulances in these areas must travel long distances to reach their patients and long distances to reach a healthcare center. The environment of an EMS system has a direct correlation to the amount of funding they receive.

In urban environments, EMS systems generally have more funding for two reasons: the cities and towns have more funding, and urban areas provide a lucrative environment for private companies. Urban areas have higher population densities, therefore, those cities and towns produce more tax revenue when compared to rural towns. If these areas can allocate more money into funding their EMS system, they will have more ambulances, personnel, and resources. This includes multiple ambulances to service a larger number of people at once. Also, urban environments provide an opportunity for private companies to contribute. If one ambulance division is busy with calls, the dispatch center can assign calls to a private ambulance company. Since there are many more medical incidents in urban environments, this scenario is far more likely to occur, and therefore it is likely that a private ambulance company will be hired for a call. In this environment, the transport ambulance is most likely to make an impact. There will already be a

system of advanced and basic life support ambulances in place in these areas. Therefore, there will be a niche that the transport ambulance can fill without impacting the EMSs' capacity to handle more severe calls. However, this is not the case for rural or super rural environments.

Rural communities do not produce as much tax revenue as urban communities since they do not have as many people to tax. As a result, their budgets will not be as large for paying for EMS services. In such towns, it is common for ambulance services to be either administered by the local fire department or comprised of volunteers. In both cases, since funding is limited, they will not have (or need) as many ambulances as an urban environment. This being the case, these areas will most likely have only advanced life support ambulances in their employ. The reasoning behind this is simple: they need to be prepared to handle any type of emergency that may occur, severe or not. The transport ambulance will not be as effective in rural environments because adding another ambulance to a fleet may not be cost effective or useful. Since the volume of medical emergencies is much lower in rural areas, the number of instances of minor emergencies that the transport ambulance would handle is very low. In fact, in these areas, it is possible that people are familiar with the cost and use of ambulance services. They could opt to get a ride to the hospital instead of calling an ambulance to pick them up if their ailment is not life-threatening.

The last difference to consider when characterizing an EMS in hopes of implementing the transport ambulance is the demographics of the population in the area. As shown previously in Figures 11 and 12 in Chapter 2, older people use ambulances more heavily than younger people. This is not surprising considering that they are the most likely to become ill. Therefore, an EMS system that services an area with a significant portion of senior citizens will be very busy. In contrast, an EMS system servicing a younger population will experience a smaller volume of calls. But whether or not these translate to minor or major medical emergencies is a different matter.

There is no clear-cut correlation between age and the types of medical incidents that occur. Some assumptions could be made concerning the severity for seniors compared to the younger population, but these would be ungrounded in statistical fact.

3.3.2 Star of Life Ambulance

The Star of Life Ambulance is the name of the Federal regulations that govern the design of ambulance vehicles. An ambulance can only be allowed to bear the Star of Life if these regulations are met. Only ambulances that bear the Star of Life, and thus pass the Federal certification requirements, are allowed to operate in an official capacity as ambulances in any US EMS system. The Star of Life regulations state that to be certified, a vehicle must meet the standards for all the components outlined in the document as well as pass the Ambulance Manufacturers Division (AMD) standards. The AMD is an organization that consists of about 90% of the ambulance manufacturing companies in the US (AMD, 2009). The AMD works closely with Federal and State lawmakers dealing with the regulations on ambulances.

3.3.3 Federal Ambulance Specifications

The Federal regulations for ambulances are outlined in a single document designated: Federal Specification KKK-A-1822 “Ambulance, Emergency Medical Care Surface Vehicle”. This specification document outlines all of the requirements for a vehicle to be certified as an ambulance. The document defines what vehicles are considered ambulances, specifications for the construction of the ambulance, and testing the vehicle must undergo and pass.



Figure 66: Star of Life symbol

The specifications begin by defining what kind of vehicles are allowed to be considered ambulances. An ambulance is defined as a vehicle used for emergency medical care that contains a driver compartment, a patient compartment, equipment and supplies, safety features for the patient, a radio, emergency lights, and sirens. Based on this definition, our transport ambulance easily fits this fundamental definition of an ambulance. The transport ambulance contains a driver compartment, a patient compartment, and medical supplies for treating the patient. Lights, sirens, and a radio would be outfitted on the vehicle before going into service.

There are also definitions for the types of ambulances that are authorized to bear the Star of Life. There are three designs which are listed in the specifications. The different types have required weight ratings called the Gross Vehicle Weight Rating (GVWR).



Figure 67: Type I ambulance

This rating has units of pounds and is determined by the vehicle manufacturer for their specific vehicle. The measurement takes into account not only the vehicle's weight, but the weight of fuel, engine fluids, passengers, and equipment. The Type I ambulance should have a GVWR of 10,001 to 14,000 pounds. The engine and driver compartment is a truck chassis, and the patient compartment is a rectangular box that is attached in the rear. As shown in Figure 67, the ambulance design is based off a truck.

The front of the truck is kept and the rear compartment is replaced with a specialized patient compartment that will hold all the equipment. This ambulance type is the most common, and it is found in virtually every EMS system, regardless of size or location in the United States. The main reason for its popularity is its size. It is capable of holding all of the required equipment for advanced life support outfits. Therefore, since all EMS systems need to be able to provide advanced life support services, this ambulance type is most likely to be utilized.



Figure 68: Type II ambulance

The next ambulance design is the Type II ambulance. It is required to have a GVWR from 9,201 to 10,000 pounds. These ambulances must be a long van with the cab body integrated with the driver compartment. Figure 68 shows an example of a Type II ambulance. The Type II ambulance is fundamentally a van that has outfitted to serve as an ambulance. There were no major additions or body works done to the original vehicle like the Type I ambulance. The only additions are the emergency light modules on the top of the patient compartment, and perhaps some

modifications to the rear bumper to meet the required regulations. This ambulance is used for inter-facility transport and basic life support services. The interiors are smaller than Type I and III ambulances, so they are more suited to less demanding levels of services. These are not as prevalent as Type I ambulances in the EMS systems across the United States. Since advanced life support ambulances can handle both ALS and BLS services, smaller EMS systems may not be able to afford a diversified fleet that would have a Type II ambulance.



Figure 69: Type III ambulance

The final ambulance design listed in the Federal specifications is the Type III ambulance. It is similar to the Type I ambulance, with only a few differing details. It has the same weight requirements as the Type I, a GVWR ranging from 10,001 to 14,000 pounds. But, instead of the ambulance being based off a truck design, it is based off a van design. Figure 69 shows an example of a Type III ambulance.

The initial difference between the Type I and Type III is not immediately apparent if they were not compared side by side. The basis of this vehicle is van with the cargo or passenger compartment removed. The patient compartment that replaced the rear of the van is identical to the compartment used on the Type I ambulance. The Type III also serves the same purpose as the Type I, in that it is outfitted to provide advanced life support services. It is not apparent why there is a distinction between Type I and III, since many of the specifications are the same for both Type I and III.

These three ambulance designs are the only three that are recognized by the Triple-K specifications. The transport ambulance utilizes a Ram Promaster van. The GVWR rating for the Promaster ranges from 8500 to 9350 pounds depending on the model. Therefore, the transport ambulance could fit the profile of a Type II vehicle, at least in terms of the body of the vehicle. There are other regulations that are outlined by the Federal specifications including operation and performance standards, as well as dimensional requirements.

All ambulance types are required to meet certain operational requirements. This is to ensure that all vehicles are able to operate under all weather and road conditions that they will encounter without failing. The vehicle and its equipment must be able to operate under ambient temperatures ranging from 0°F to 100°F. It must not exceed Federal noise limits on the exterior, except the sirens. The braking system must follow Federal Motor Vehicle Safety Standards, which all automobiles must comply with, not just ambulances. The ambulance must be able to sustain a speed of at least 65 miles per hour over in favorable road conditions and be able to surpass 70 miles per hour. It must also be able to accelerate from 0-55 miles per hour within 25 seconds in favorable road conditions. The length, height, and turning radius are variable and are determined by the manufacturer. The width of the vehicle cannot exceed 96 inches, excluding side mirrors and other safety equipment. The height of the floor of the patient compartment must be no more than

34 inches above the ground. Type II ambulances are required to have a payload capacity of at least 1500 pounds. These are the basic body requirements that an ambulance must meet to be certified. The Ram Promaster can easily meet these requirements without any modifications to its body. However, there are more detailed specifications that would require some changes to the initial design of the ambulance to meet federal specifications.



Figure 70: Side door comparison

All ambulances must have two entrances to the patient compartment: one set of doors on the rear for loading the cot, and a door on the right side. On the stock design of the Promaster, there is a sliding door to access the patient compartment. That particular door needs to be a hinged door, not a sliding door. It would be necessary to modify the door to comply with this regulation.

Figure 70 shows a certified Type II ambulance, and an image of the Ram Promaster that will be used for the transport ambulance. As per the Federal specifications, the right entrance to the patient

compartment must be a hinged door with a glass window. The Promaster would definitely need to be modified in order to comply with this requirement. Assuming that this could be accomplished relatively easily, the Ram Promaster could easily fit the physical profile for the Type II ambulance.

The physical body requirements comprise about a quarter of the Triple-K specifications. The rest of the requirements listed would not be beneficial to discuss in detail at this point. The other specifications define very specific details about the components within the vehicle. For the purposes of this project, an in depth design of the transport ambulance would be ambiguous. All that is really necessary to note is that the Promaster would have very little exterior modifications, which would be the most cumbersome adjustments to make. The various internal requirements are not discussed, such as the cabinets for the equipment, the design of the floor to accommodate the cot, the seats for the EMTs or passengers, and the control module inside the ambulance. It will be assumed that the necessary internal additions will be made, with a few notable exceptions. The design for the transport ambulance will not include certain medical equipment, since the ambulance will not respond to calls that require the use of advanced equipment. There will be very little in terms of equipment that requires much power, so added electrical wiring inside the Promaster would be considerably less than a Type I or even Type II ambulance. There will also be no integrated oxygen delivery system in the transport ambulance. This means that there will be no need to build in an oxygen tank and have a system of piping and outlets for its administration. This will greatly reduce the amount of internal body work to the Promaster, and should reduce the cost of modifications.

Chapter 4: Concluding Remarks

The modified EMS system with the new non-emergency transport service is a cost effective option that will reduce operating costs for EMT services, which should translate to lower costs for patients who use the services. There will be approximately \$50,000 in operating costs saved yearly when using the transport ambulance in place of a BLS ambulance. The Ram Promaster is the vehicle choice for the transport ambulance. It has the most interior room of the three candidates, twice the fuel economy rating of a BLS ambulance, and it is the most similar to actual ambulances with its rear and side doors. As for the equipment, only what was necessary to treat minor incidents was included in the transport ambulance. That includes kits to treat cuts and bleeding, minor trauma such as sprains and broken bones, as well as various other equipment to handle sick patients. A full listing of the included equipment can be found in Appendix A. The people operating the transport ambulance will be EMT-Basics. Their basic training is sufficient for the types of emergencies they will be responding to. EMT-Basics are trained to handle basic medical emergencies and are not trained to perform surgical interventions or administer various drugs. They also have less training and lower wages than EMT-Paramedics. They will be perfect for operating the proposed transport ambulances. Finally, based on the analysis of the NEMSIS Public dataset, transport ambulances would only be viable in urban environments. The population density and general sizes of EMS fleets in urban environments makes the probability of a non-emergency incident much higher. The large size of EMS fleets in urban environments means they can replace some of their BLS ambulances with transport ambulances, without affecting their capacity to respond to emergencies. Based on the data, only a few transport ambulances will be necessary to reduce patient costs for non-emergency calls, since less than 20% of calls are minor enough for the transport ambulances to handle. For a large EMS system, one or two transport ambulances in

a fleet of ten vehicles will be sufficient for patients to have a low cost transport option available to them.

While the modified EMS system would be useful for lowering the costs of patients in certain situations, there are two limitations that would affect the ability of this service to be implemented within a real EMS system. The first of which involves the Federal regulations regarding the specifications of vehicles that are designated “ambulances” and the regulations on the equipment carried by ambulances. These regulations specify what constitutes an ALS or BLS ambulance. The transport ambulance falls into neither of these categories, and trying to fit into one will mean that the transport ambulance will not be allowed to be used in an official capacity as an ambulance. In order for the transport ambulance to be used in a real EMS system, a new set of legislation will have to be enacted so as to create a new category of ambulances for minor emergencies. This process will be time consuming. Leaders within the government and EMS systems may not consider the potential savings to be worth this effort. The second limitation is the actual design of the transport ambulance. The goal of this project is to explore the viability and logistics of introducing this new transport ambulance service into an EMS system. However, the actual design of the transport ambulance is outside the scope of this research project. The Ram Promaster must be customized in order to fit the equipment inside while conforming to other regulations, such as temperature control, safety, and seating. The specific design of the transport ambulance would have to be engineered in a different study in the future.

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Appendices

Appendix A: Proposed List of Equipment to Have in the Transport Ambulance

Item	Description	Total Quantity
First-In Kit	Oropharyngeal airways	2
	Small dressings gauze	12
	Medium dressings gauze	4
	Large dressings gauze	2
	Soft roller, self-adhering bandage	6
	Cravats/triangular bandages	4
	Tourniquets	2
	Hypoallergenic adhesive tape	2
	Bandage scissors	1
	Sphygmomanometer	1
	Stethoscope	1
	Penlight-type flashlight	1
	Sterile water or saline solution	1
	Bulb syringe 3oz for irrigation purposes	1
	Cold packs (instant)	2
	Tongue depressors for glucose administration	2
	Adhesive bandages (i.e. Band-Aids)	6
	Mouth-to-mask resuscitator mask with one way valve and an oxygen port.	1
Facemask and protective eye wear (combination face mask/eye shield equivalent)	2	
Exam type gloves (single use, latex-free)	2	
Medications	Epinephrine Auto-Injector	2
	Aspirin (chewable)	at least 648mg
	Naloxone (prefilled syringe with nasal atomizer)	4
	Oral glucose or equivalent (with sterile tongue depressors)	2
	ADULT Sphygmomanometer	1

Diagnostic Equipment	PEDI Sphygmomanometer	1
	Stethoscope	1
	Penlight-type flashlight	2

Airway Management	CPR mask	1
	Bag-valve mask with oxygen supply reservoir (hand-operated, single use)	1
	Non-Rebreather: High concentration oxygen masks (transparent, disposable) with delivery tubes	4

Wound Care	Small dressings gauze	24
	Medium dressings gauze	12
	Large dressings gauze	6
	Soft roller, self-adhering bandage	12
	Cravats/triangular bandages	8
	Tourniquets	4
	Hypoallergenic adhesive tape	4
	Bandage scissors	2
	Sterile water or saline solution	3
	Commercial occlusive dressings	2
	Cold packs (instant)	4

Burn Kit	Burn sheets (linen or disposable)	2
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Splints	Traction splint (femur) device or equivalent; with ankle hitch and leg ties or equivalent	1
	4.5' x 3" covered padded board splint (single- use) or equivalent (impervious to saturation)	2
	3' x 3" covered padded board splint (single- use) or equivalent (impervious to saturation)	2
	15" x 3" covered padded board splint (single- use) or equivalent (impervious to saturation)	2

Spinal Immobilization	Half spine board with torso straps and head strap (2" tape or equivalent), or equivalent	1 Board 3 Straps
	Full spine board, with easily cleanable 9' straps or functional equivalent and sufficient padding to maintain in-line head & cervical support/stabilization with head strap (2" tape or equivalent)	1 Board 4 Straps
	ADULT Cervical Collar (rigid) *Adjustable collar is equivalent to all 4 sizes*	2 of each
	PEDI Cervical Collar (rigid) *Adjustable collar is equivalent to all 3 sizes*	2 of each

Stretcher	4-wheeled, multi-level ambulance cot	1
	Standard cot mattress with waterproof cover	1
	Patient restraining devices at chest (commercial shoulder harness or equal) hip, and knee to prevent lateral or longitudinal displacement of the patient during transport	1 set of each
	Padded wrist and ankle restraints	1 set

Stair Chair	Stair chair with patient restraint straps	1
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Transfer Sheet	Transfer sheet with a minimum of six (6) handles, or equivalent	1
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Accessories	ADULT bed pan urinal, emesis basin, and large basin or equivalent	1 of each
	Motion sickness bags, or equivalent, capable of being sealed	2
	Sheets (disposable or linen)	2
	Blankets	2
	Towels	4
	Paper tissues (disposable)	2 Packages

	Drinking cups (disposable)	2
	Trash Bin liners, plastic (with ties)	2
	Bio-Hazard bags (with ties)	2
	Ring Cutter (with extra blade)	1
	CPR board or functionally equivalent (i.e., short board) hard washable surface for patient torso accessible to patient compartment	1
	Child appropriate restraint device (i.e. PediMate) to provide safe transport of pediatric patient on stretcher	1

Personal Protection	Exam type gloves (single use, latex-free)	1 box of each size
	Facemask and protective eye wear (combination face mask/eye shield equivalent)	4
	Antiseptic hand sanitizer dispenser or 25 individually wrapped antiseptic hand wipes	1
	Infection control kit, containing two (2) each of disposable, fluid resistant gowns, masks, caps, protective eye wear, and two (2) different sizes of gloves	1 kit

Safety/Access Equipment	Safety goggles	2
	ANSI vest or equivalent	2
	NIOSH-approved respirator	2

Appendix B: National Emergency Medical Service Information System (NEMSIS)

For this project, the team received a copy of the 2014 NEMSIS Public Research Dataset. NEMSIS is a project based in the University of Utah with the goal of centralizing and standardizing EMS databases. NEMSIS receives EMS records from 47 states as of 2015, and the final 3 are preparing to participate in the program. These EMS records detail all emergency medical incidents in the country. They include location, time, injury, and demographic details for ambulance incidents. The directors of the NEMSIS project have made a special research dataset available upon request. This dataset includes all declassified data for the requested year. There are many aspects of the NEMSIS database that are not permitted to be shared in accordance with HIPAA statutes. But the data that can be released is useful for researchers to analyze ambulance activity all over the country.

eventID	E02_04	E02_05	E03_01	E05_02	E05_04
164594542	30	65	545	1/1/2014 2:57	1/1/2014 2:57
	911 Response	Rescue	Traumatic Injury	PSAP phone rings	Unit Notified

E05_05	E05_06	E05_07	E05_09	E05_10	E05_11
1/1/2014 2:59	1/1/2014 3:04	1/1/2014 3:04	1/1/2014 3:18	1/1/2014 3:39	1/1/2014 4:00
Unit en route	Arrived on scene	Unit arrived at patient's side	Unit departed the scene	Unit arrived at destination	unit ready for response

E05_13	E06_11	E06_12	E06_13	E06_14	E06_15
1/1/2014 4:00	655	680	695	17	715
unit arrived at home location	patient is female	patient is white	not Hispanic or Latino	patient age	age measured in years

E07_01	E07_34	E08_05	E08_06	E08_07	E09_03
-25	-25	1125	0	1170	-25

payment method is N/A	CMS service is N/A	one patient at scene	not a mass casualty event	trade or service location	no prior aid given
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E09_04	E09_11	E09_12	E09_13	E09_15	E09_16
1	1320	1375	1475	1740	1875
yes traumatic event	Extremity -Lower	Musculoskeletal	Pain	Traumatic Injury (Primary Symptom)	Traumatic Injury (Secondary Symptom)

E10_01	E11_01	E11_02	E20_10	E20_14	E20_16
9640	0	-25	4850	-10	5025
Struck by blunt/thrown object	No cardiac arrest	Reason for cardiac arrest: N/A	Patient treated, transported by EMS	not known if lights/siren used	Patient chose destination

E20_17	E22_01	E22_02
7280	-10	-10
Destination: hospital	ED disposition unknown	Hospital disposition unknown

This array of tables illustrates the contents of the NEMSIS dataset. Each event corresponds to the use of an ambulance. This event identification number is the start of each record and is displayed in yellow in the first table. Then, each event contains variables, which contain values. The variable names are bolded in the first row of all the tables. The second row of tables contains the value of the variable. This value has some real world meaning, and is deciphered using the NEMSIS Data Dictionary. The dictionary contains a comprehensive listing of all the variables, and what each of their values represents. This translation has been completed for this event in the third row.

The reason that NEMSIS encodes event information in this “variable - value” format is for two reasons. The first and most important reason is for computer code to easily identify

characteristics and compile them for data analysis. The second reason is computer drive space. The computer files containing the data were over 10 gigabytes in size. If the translations were included, these file sizes would have been thousands of times larger.

A majority of the graphs and charts presented in this report are derived from the 2014 NEMSIS Public Research Dataset. This is no simple task, as the research dataset the team is given contained over 25 million incident reports. In this current and following appendices, our method for obtaining workable data will be outlined. When the NEMSIS dataset was initially received, the data files were much too large to work with on the computers that were readily available. The only way to sort through this data was to filter it to a workable number of incidents. The concept of this project is meant to be used in the context of the city of Worcester, and other cities like it. It was assumed from the start that transport ambulances would only be viable for use in urban environments. These served as the initial filter parameters. The data was filtered using SAS to only include incidents that occurred in New England and which were in urban environments. This cut the number of records from 25 million to about 1.5 million. This amount of data could be more easily manipulated using computer code than the full sized dataset. Examples of these are shown in Appendices C, D, and E.

Appendix C: Tables of NEMSIS Data

Ambulance Use by Age

Age	Count	Percentage
1	3,088	0.41%
2	2,807	0.37%
3	2,199	0.29%
4	1,786	0.23%
5	1,766	0.23%
6	1,765	0.23%
7	1,843	0.24%
8	1,890	0.25%
9	1,919	0.25%
10	2,037	0.27%
11	2,165	0.28%
12	2,383	0.31%
13	2,943	0.39%
14	3,789	0.50%
15	4,682	0.61%
16	5,395	0.71%
17	6,023	0.79%
18	7,541	0.99%
19	7,298	0.96%
20	7,155	0.94%
21	7,156	0.94%
22	6,965	0.91%
23	6,790	0.89%
24	6,850	0.90%
25	6,733	0.88%
26	6,586	0.86%
27	6,444	0.85%
28	6,157	0.81%
29	6,089	0.80%
30	6,211	0.82%
31	5,889	0.77%
32	6,106	0.80%
33	5,843	0.77%
34	5,684	0.75%
35	5,589	0.73%
36	5,722	0.75%
37	5,366	0.70%
38	5,091	0.67%
39	5,184	0.68%
40	5,442	0.71%

41	5,665	0.74%
42	6,119	0.80%
43	7,328	0.96%
44	7,157	0.94%
45	7,603	1.00%
46	7,640	1.00%
47	8,477	1.11%
48	8,759	1.15%
49	9,938	1.30%
50	10,917	1.43%
51	10,289	1.35%
52	10,280	1.35%
53	10,836	1.42%
54	11,030	1.45%
55	10,627	1.39%
56	10,213	1.34%
57	10,678	1.40%
58	10,543	1.38%
59	10,585	1.39%
60	10,540	1.38%
61	10,490	1.38%
62	11,717	1.54%
63	10,365	1.36%
64	10,025	1.32%
65	10,740	1.41%
66	11,230	1.47%
67	11,970	1.57%
68	9,529	1.25%
69	9,388	1.23%
70	10,688	1.40%
71	11,286	1.48%
72	11,089	1.46%
73	11,105	1.46%
74	9,840	1.29%
75	10,588	1.39%
76	10,099	1.33%
77	10,891	1.43%
78	10,716	1.41%
79	11,935	1.57%
80	10,954	1.44%
81	11,857	1.56%
82	12,337	1.62%
83	12,753	1.67%
84	13,285	1.74%
85	13,553	1.78%
86	13,390	1.76%

87	13,262	1.74%
88	12,154	1.60%
89	11,729	1.54%
90	10,279	1.35%
91	9,681	1.27%
92	8,540	1.12%
93	7,046	0.92%
94	5,343	0.70%
95	4,277	0.56%
96	3,309	0.43%
97	2,053	0.27%
98	1,524	0.20%
99	1,087	0.14%
100	2,037	0.27%

Service Type

Incident Type	Count
911 Response	680341
Medical Transport	119974
Interfacility Transfer	39589
Intercept	6236
Standby	5847
Mutual Aid	4519

Role of Unit

Role of Unit	Count
Transport	785350
Non Transport	67425
Rescue	2406
Supervisor	1325

Response Mode to Scene

Response Mode	Count
Lights and Sirens	519596
No lights or sirens	329548
Initial Lights and Sirens	5720

Initially no lights or sirens, Upgraded to lights and sirens	1642
---	-------------

Complaint Recorded by Dispatch

Not Recorded	249,152
Transfer/Interfacility/Palliative Care	81,834
Sick Person	64,286
Fall Victim	61,157
Breathing Problem	48,976
Unknown Problem Man Down	47,278
Traffic Accident	44,392
Not Available	35,371
Chest Pain	33,401
Unconscious/Fainting	22,594
Psychiatric Problem	22,510
Abdominal Pain	20,866
Convulsions/Seizure	14,311
Ingestion/Poisoning Entrapments (non-vehicle)	11,292
Traumatic Injury	11,279
Not Applicable	11,186
Stroke/CVA	10,978
Hemorrhage/Laceration	10,014
Diabetic Problem	8,358
Back Pain	7,137
Heart Problems	5,720
Assault	5,204
Allergies	4,951
Cardiac Arrest	4,946
Headache	3,049
Burns	2,666
Not Known	2,250
Stab/Gunshot Wound	1,937
Choking	1,807
Pregnancy/Childbirth	1,596
Not Reporting	1,303
CO Poisoning/Hazmat	1,286
Eye Problem	978
Animal Bite	737
MCI (Mass Casualty Incident)	593
Heat/Cold Exposure	515
Industrial Accident/Inaccessible Incident/Other	273
Electrocution	181
Drowning	142

Demographic Information

Demographic Information	Count
Female	399906
Male	357189
Pacific Islander	1092
American Indian	576
Other race	36760
Asian	2626
Black	58101
White	321923

Payment Type

Method of Payment	Count
Medicare	54,458
Insurance	40,383
Medicaid	32,220
Self Pay	5,811
Not Billed	515
Workers Compensation	366
Other Government	230

Location Type

Location	Incidence Count
Home/Residence	359,598
Health Care Facility	180,938
Street or Highway	82,023
Residential Institution	54,517
Other Location	36,565
Public Building	35,284
Trade or Service	29,725
Place of Recreation	5,678
Industrial Place and Premises	3,697
Lake, River, Ocean	618
Farm	307
Mine/Quarry	119

Incident Result

Condition	Count
Treated, Transported by EMS	632,300
Cancelled	73,297
Patient refused care	55,379
Treated, Transferred Care	28,100
No patient found	22,188
Treated and released	21,765
No treatment required	18,894
Dead at scene	4,007
Treated, Transported by private vehicle	419
Treated, Transported by Law Enforcement	157

Patient Outcome

Patient Outcome	Count
Transferred	1801
Admitted to Hospital Floor	877
Released	730
Admitted to Hospital ICU	82
Death	61

EMS Service Type

Service Type	Count
BLS	89674
BLS Emergency	149487
ALS Level 1	184644
ALS Level 1 Emergency	81635
ALS Level 2	4022

Appendix D: NEMESIS Data Handling

Much of the data used for this project originated from the findings of NEMESIS, an organization that gathers statistics on emergency 911 calls. Access to the information was requested. The request was approved and the data was obtained via an internet download.

The data was given in .csv (comma separated value) format. Information is recorded in plain text, with special characters known as delimiters to separate the values. Using a comma delimiter separates the columns and a line break separates the rows. This format allows two dimensional tables to be recorded in easily readable plain text.

```
eventID,USCensusRegion,USCensusDivision,NasemsoRegion,Urbanicity
167881320,Northeast,New England,East,Urban
167881323,Northeast,New England,East,Urban
167881324,Northeast,New England,East,Urban
167881325,Northeast,New England,East,Urban
167881346,Northeast,New England,East,Urban
167881363,Northeast,New England,East,Urban
```

	A	B	C	D	E
1	eventID	USCensusRegion	USCensusDivision	NasemsoRegion	Urbanicity
2	167881320	Northeast	New England	East	Urban
3	167881323	Northeast	New England	East	Urban
4	167881324	Northeast	New England	East	Urban
5	167881325	Northeast	New England	East	Urban
6	167881346	Northeast	New England	East	Urban
7	167881363	Northeast	New England	East	Urban

Figure 1: Plain text and MS Excel interpretations of a CSV file

This format is quite versatile, however the size of the data quickly became an issue. Uncompressed, the NEMESIS information was 10.2 gigabytes, spread out over just 6 CSV files. The largest of these files was seven gigabytes and contained 25.6 million lines of data. Besides the raw storage requirements, having very large singular files creates a myriad of other problems. The

architecture of a USB flash drive prevents it from containing any one file over four gigabytes, so the data needed to be transported via a portable hard disk. Almost any high level program would crash when trying to open files of this size. Microsoft Excel can only work with files less than one million lines. The biggest problem became gleaning useful information from this vast assortment of raw data. Graphs, tables, and trends could not be created and analyzed if software was unable to even read the data. The first attempt to solve this was to use SAS, a heavy duty software package designed especially for working with statistics. SAS was able to open the data, but would soon crash after running out of memory. SAS was unable to perform any useful data operations. The next approach was to narrow down the data to a more reasonable level, and only consider 911 calls in urban areas in New England. This would give the most relevant data to Worcester, Massachusetts, where the transport ambulance is being studied in this report. This left just 85,000 lines of data.

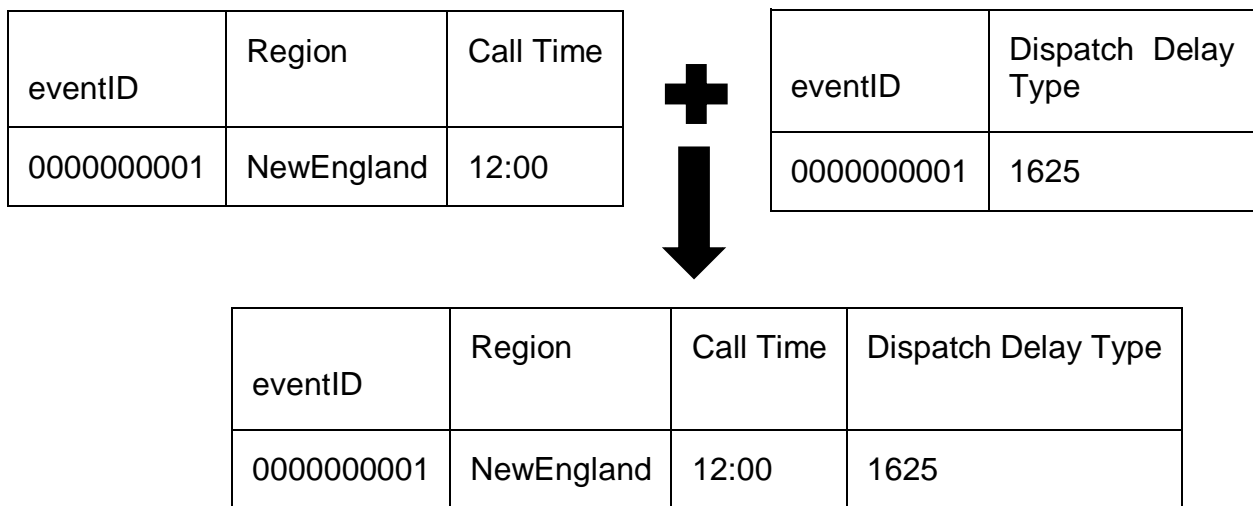


Figure 2: Data is spread across multiple tables

Another problem soon arose. Only the large seven gigabyte table contained region data. How could the data in the other tables be sorted to pull out lines from the desired region? The

region filtered table needed to be used as a key to find corresponding lines pertaining to the same 911 call. Figure 2 shows an illustration of this process. Fortunately, all tables contained a column titled eventID. This unique nine-digit number identified each individual 911 call. The problem now became constructing a master table filtered by region that could be processed in Excel or a similar application. With 85,000 lines to process, doing this manually was out of the question. A computer program could be developed to do just this. The program could run through the file character by character (known as parsing) and determine the eventID of every row. Once the eventIDs are read and stored, the program needed to combine the data with the same eventID.

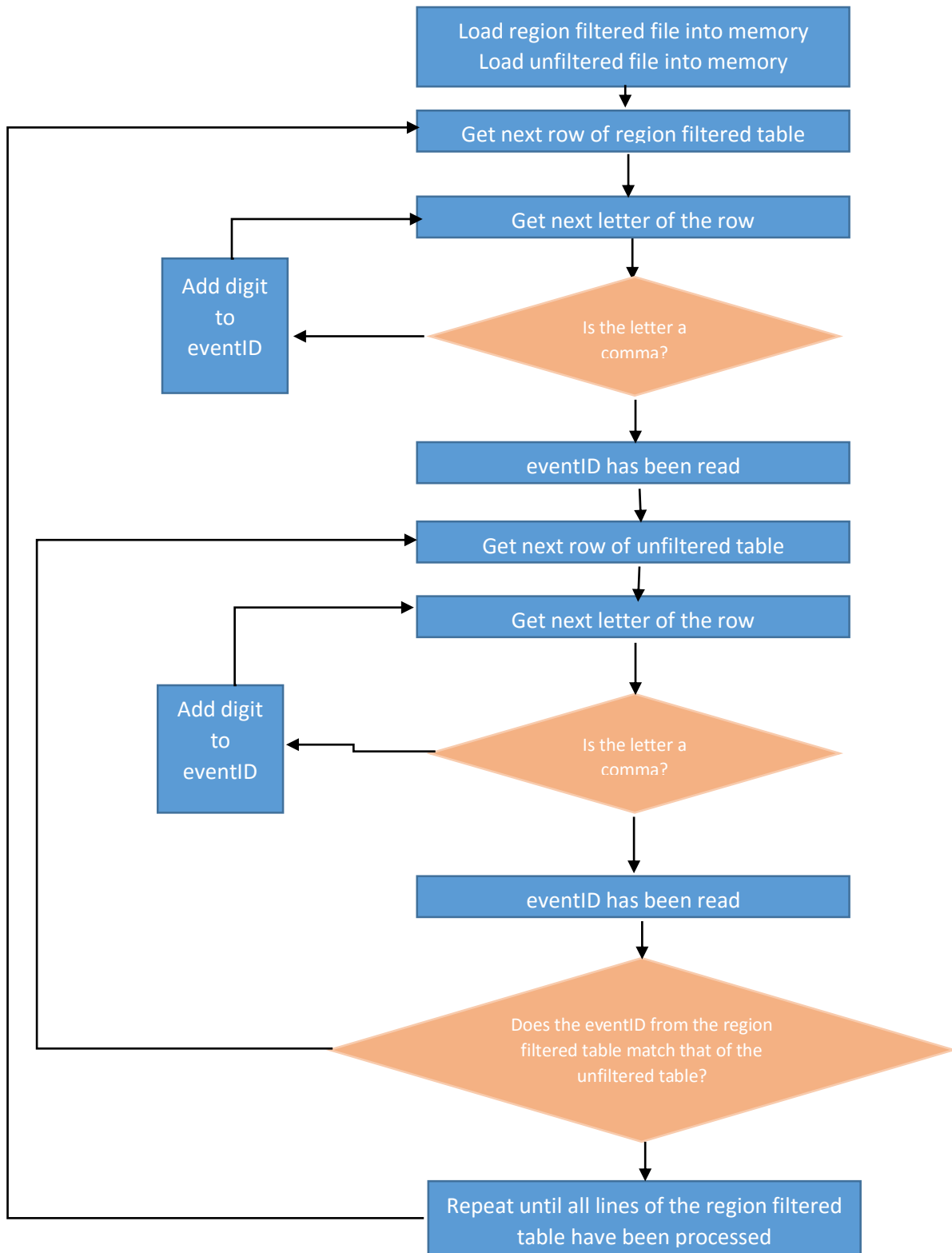


Figure 3: Flowchart of program algorithm

Java was the selected programming language to accomplish this goal. The following code shows the algorithm in Figure 3 implemented in Java. In the first step (Figure 4), the file names are initialized, with a filtered table and new table to append to the filtered table.

```
// The name of the file to open.  
String filteredFileName = "output.csv";  
String bigFileName = "barriers.csv";  
String filename = "output2.csv";  
String line = null;
```

Figure 4: Initialize files and file reader objects

Next, the eventID is extracted from the first line of the region filtered table (shown in Figure 5). This process of going character by character is known as parsing.

```
String eventID = "";  
int counter = 0;  
do{  
    if(Character.isDigit(line.charAt(counter))){  
        eventID = eventID + line.charAt(counter);  
        counter++;  
    }  
    else{  
        break;  
    }  
}while(true);
```

Figure 5: Parsing of the eventID

The program then searches for the same eventID in the new table. Due to the size, forward progress is saved; the program does not start over.

Figure 6 illustrates the code required to accomplish this. A nested loop statement loops through the two dimensional data until both conditions are satisfied.

```
String line = null;
try{
do{
    line = fileReader.readLine();
    String parse = "";
    int counter = 10;

    do{
        if(Character.isDigit(line.charAt(counter))){
            parse = parse + line.charAt(counter);
            counter++;
        }
        else{
            break;
        }
    }while(true);

    if(eventID.equals(parse)){
        return line.substring(counter);
    }
}while(true);
```

Figure 6: Find the corresponding event in the new table

With both halves of the data found, it just needs to be appended together (known as concatenation) and output. The program combines and writes the data in Figure 7.

```
String combined = line + getLine(eventID, bigReader);
System.out.println(combined);
bufferedWriter.write(combined);
bufferedWriter.newLine();
```

Figure 7: Append and output data

The performance of this program was satisfactory for filtering the big table by region. A list of eventIDs in New England was provided, and the program fished through the 7 gigabyte file for all the other columns of data, such as number and gender of victims. Sample output of the

program is shown in Figure 8. Only around 12 minutes was required to run all necessary computations.

```
eventID,USCensusRegion,USCensusDivision,NasemsoRegion,Urbanicity|,E02_04,E02_05,E02_20,E03_01,E03_02,E05_02,E05_04,E05_05,E05_06,E05_07,
167881323,Northeast,New England,East,Urban,40,75,395,-5,-25,2013-12-31 10:38:30,2014-01-08 10:38:30,2014-01-08 10:38:30,2014-01-08 10:3
167881324,Northeast,New England,East,Urban,40,75,395,560,-25,2013-12-31 10:16:02,2014-01-03 07:43:53,2014-01-03 08:13:25,2014-01-03 08:
167881325,Northeast,New England,East,Urban,40,75,395,560,-25,2013-12-31 09:26:06,2014-01-03 09:26:06,2014-01-03 09:26:06,2014-01-03 09:
167881346,Northeast,New England,East,Urban,40,75,395,560,-25,2013-12-27 11:43:50,2014-01-14 08:50:01,2014-01-14 08:58:46,2014-01-14 09:
167881363,Northeast,New England,East,Urban,40,75,395,-5,-25,2013-12-23 16:55:40,2014-01-02 08:24:32,2014-01-02 09:06:41,2014-01-02 09:0
167912574,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-01 16:42:58,2014-01-01 16:44:58,2014-01-01 16:50:42,2014-01-01 16
167912575,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-01 13:42:22,2014-01-01 13:42:27,2014-01-01 13:50:26,2014-01-01 13
167912579,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-14 08:52:17,2014-01-14 08:52:50,2014-01-14 09:03:35,2014-01-14 09
167912623,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-07 11:01:06,2014-01-07 11:02:04,2014-01-07 11:07:15,2014-01-07 11
167912624,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-07 11:01:06,2014-01-07 11:02:04,2014-01-07 11:07:15,2014-01-07 11
167912625,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-07 09:23:36,2014-01-07 09:27:35,2014-01-07 09:33:56,2014-01-07 09
167912645,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-23 14:45:54,2014-01-23 14:45:55,2014-01-23 14:45:56,2014-01-23 14
167912646,Northeast,New England,East,Urban,40,75,395,560,-10,,2014-01-23 07:13:08,2014-01-23 07:13:50,2014-01-23 07:19:34,2014-01-23 07
```

Figure 8: Sample output of program

Unfortunately, this program is not fast enough to use for all the data. Computationally speaking, the program has an efficiency of O^N . This means the run time increases exponentially as both tables grow in size. When the new table is in order, this isn't a significant issue as the program doesn't have to start at the beginning for every line in the region filtered table. In this case, the efficiency is just N , much faster than an out of order table. All the other tables are not in order. After letting the program run overnight with no significant progress through the 25.6 million lines, the program was shut down. Further attempts to improve efficiency also failed. Progress on the Java program was stopped, because a new solution was found in a different programming language, Python. The Python approach worked much more efficiently, allowing the data to be analyzed at a reasonable speed.

```

import java.io.*;

public class Parser {

    private static BufferedReader bigReader;

    public static void main(String[] args) {

        // The name of the file to open.
        String filteredFileName = "output.csv";
        String bigFileName = "barriers.csv";
        String filename = "output2.csv";
        String line = null;

        try {

            // FileReader reads text files
            FileReader filteredFileReader =

                new FileReader(filteredFileName);

            // Wrap FileReader in BufferedReader.
            BufferedReader filteredReader =

                new BufferedReader(filteredFileReader);

            FileReader bigFileReader =

                new FileReader(bigFileName);

            bigReader =

                new BufferedReader(bigFileReader);

            //Filewriter

```

```

FileWriter fileWriter =
    new FileWriter(filename);

// Always wrap FileWriter in BufferedWriter.
BufferedWriter bufferedWriter =
    new BufferedWriter(fileWriter);

// Do things
String title = filteredReader.readLine() + "," +
    bigReader.readLine();
System.out.println(title);
bufferedWriter.write(title);
while((line = filteredReader.readLine()) != null) {
    //Collect eventID
    String eventID = "";
    int counter = 0;
    do{
        if(Character.isDigit(line.charAt(counter))){
            eventID = eventID + line.charAt(counter);
            counter++;
        }
        else{
            break;
        }
    }while(true);
    String combined = line + getLine(eventID, bigFileName);
    //System.out.println(combined);
    bufferedWriter.write(combined);
    bufferedWriter.newLine();
}

```

```

}

// Close files.
filteredReader.close();
bufferedWriter.close();
System.out.println("Done");
}

catch(FileNotFoundException ex) {
    System.out.println("Unable to open file");
}

    catch(IOException ex) {
        System.out.println("Error reading file");
    }
}

//Gets the line from the big table
private static String getLine(String eventID, String filename){
    String line = null;
    boolean second = true;
    try{
do{
    line = bigReader.readLine();
    if(line == null){
        bigReader.close();
        FileReader bigFileReader =
            new FileReader(filename);

        bigReader =
            new BufferedReader(bigFileReader);

```

```

line = bigReader.readLine();
}
String parse = "";
int counter = 0;

if(second == true){
    do{
        if(Character.isDigit(line.charAt(counter))){
            counter++;
        }
        else{
            counter++;
            break;
        }
    }while(counter < line.length());
}
if(!(counter < line.length())){
    return "";
}

do{
if(Character.isDigit(line.charAt(counter))){
    parse = parse + line.charAt(counter);
    counter++;
}
else{
    break;
}
}while(counter < line.length());

```

```
        if(eventID.equals(parse)){
            return line.substring(counter);
        }
    }while(true);
}
catch(FileNotFoundException ex) {
    System.out.println("Unable to open file");
}
catch(IOException ex) {
    System.out.println("Error reading file");
}
return line;
}
}
```

Appendix E: Parsing Code

Early Attempt 1

```
import os

import openpyxl

import csv

import plotly.plotly as py

#import plotly.graphobjs as go

import pandas as pd

import numpy as np

import IQP_Code

##wb = openpyxl.load_workbook('output.xlsx')

##ws = wb.active

##

##lastlength = column_index_from_string(get_column_letter(ws.get_highest_column()))

##for each_column in range(1, lastlength):

##

def FindCode(exampleReader):

    for row in exampleReader:

        for e in row:

            if e in list(IQP_Code.nemsisdict.keys()):

                return e
```



```

def CSVCounter(filename,wb):
    exampleFile = open(filename)
    exampleReader = csv.reader(exampleFile)

    #takes a list of lists and returns a list of a column
    def columnify(listolists,col):
        column = []
        for row in listolists:
            column.append(row[col])
        return column

    #Figure out what we're counting
    resultsdict = {}
    codename = FindCode(exampleReader)
    keydict = IQP_Code.nemsisdict[codename]

    #Count occurrences
    ourlist = list(keydict.keys())
    for e in ourlist:
        resultsdict[e] = 0

```

```

for row in exampleReader:

    for key in ourlist:

        x = row.count(str(key))

        resultsdict[key] += x

#write results

ws = wb.create_sheet(title=IQP_Code.nemsisdict[codename]["Name"])

for key in ourlist:

    rownum = ourlist.index(key) + 1

    ws.cell(row=rownum, column=1).value = keydict[key] #name of group

    ws.cell(row=rownum, column=2).value = resultsdict[key] #name of group

wb.save('IQP Data.xlsx')

def XLCounter(filename,wb):

    os.chdir('/Users/elizabethkarpinski/Desktop/NEMESIS_CSV')

    ourfile = openpyxl.load_workbook(filename)

    datasheet = ourfile.active

    highestrow = datasheet.max_row

```

```

for i in range(2,35): #each column
#Figure out what we're counting
    resultsdict = {}

    codename = datasheet.cell(row=1,column=i).value

    if codename in list(IQP_Code.nemsisdict.keys()):
        keydict = IQP_Code.nemsisdict[codename]

#Count occurrences

    ourlist = list(keydict.keys())

    for e in ourlist:
        resultsdict[e] = 0

    columnvalues = []

    for cellrow in range(2,highestrow): #for cells in rows
        columnvalues.append(datasheet.cell(row=cellrow,column=i).value)

    for key in ourlist:
        resultsdict[key] = columnvalues.count(key)

#write results

    sheetttitle = IQP_Code.nemsisdict[codename]["Name"]

    ws = wb.create_sheet(title=sheettitle)

```

```

for key in ourlist:

    rownum = ourlist.index(key) + 1

    ws.cell(row=rownum, column=1).value = keydict[key] #name of group

    ws.cell(row=rownum, column=2).value = resultsdict[key] #name of group

wb.save('IQP_Full_Tables.xlsx')

else:

    print ("Not found: " + codename)

#def XLCounterCont(filename,wb): #counter for continuous variables

os.chdir('/Users/elizabethkarpinski/Desktop/NEMESIS_CSV')

ourfile = openpyxl.load_workbook('output.xlsx')

wb = openpyxl.Workbook()

datasheet = ourfile.active

highestrow = datasheet.max_row

for i in range(2,35): #each column

#Figure out what we're counting

    resultsdict = {}

    codename = datasheet.cell(row=1,column=i).value

    if codename == 'E06_14':

```

```

keydict = IQP_Code.nemsisdict[codename]

#Count occurrences

ourlist = []
columnvalues = []

for cellrow in range(2,highestrow): #for cells in rows
    x = datasheet.cell(row=cellrow,column=i).value
    if x in ourlist:
        resultsdict[x] += 1
    else:
        ourlist.append(x)
        resultsdict[x] = 1

#write results

sheettitle = IQP_Code.nemsisdict[codename]["Name"]
ws = wb.create_sheet(title=sheettitle)

for key in ourlist:
    rownum = ourlist.index(key) + 1
    ws.cell(row=rownum, column=1).value = key #name of group
    ws.cell(row=rownum, column=2).value = resultsdict[key] #name of group

wb.save('IQP_Age.xlsx')

```

Early Attempt 2

```
import os

import openpyxl

import csv

import plotly.plotly as py

#import plotly.graphobjs as go

import pandas as pd

import numpy as np

def RevCounter(filename,wb):

    os.chdir('/Users/elizabethkarpinski/Desktop/NEMESIS_CSV')

    exampleFile = open(filename)

    exampleReader = csv.reader(exampleFile)

    highestrow = 900000

    for i in range(2,33): #each column

        #Figure out what we're counting

        resultsdict = {}

        codename = datasheet.cell(row=1,column=i).value

        columnvalues = []
```

```

if codename in list(secondnemsis.keys()):

    #print("Processing: " + codename)

    keydict = secondnemsis[codename]

    #Count occurrences

    ourlist = list(keydict.keys())

    for e in ourlist:

        resultsdict[e] = 0

    for cellrow in range(2, highestrow): #for cells in rows

        columnvalues.append(str(datasheet.cell(row=cellrow, column=i).value))

    for key in ourlist:

        resultsdict[key] = columnvalues.count(key)

    #print(resultsdict)

    #write results

    sheetttitle = secondnemsis[codename]["Name"][:30]

    ws = wb.create_sheet(title=sheettitle)

    for key in ourlist:

        rownum = ourlist.index(key) + 1

        ws.cell(row=rownum, column=1).value = keydict[key] #name of group

        ws.cell(row=rownum, column=2).value = resultsdict[key] #name of group

```

```
wb.save('IQP_SecondRun.xlsx')
```

```
else:
```

```
print ("Not found: " + codename)
```

```
wb = openpyxl.Workbook()
```

```
XLCounter('Full Output.csv',wb)
```

Successful Code with Pandas Module

```
import os
```

```
import pandas as pd
```

```
import openpyxl
```

```
os.chdir('/Users/elizabethkarpinski/Desktop/IQP')
```

```
iqp = pd.read_csv('full output.csv')
```

```
nemsis = {'E02_04' : {"Name": "Type of Service Requested",
```

```
    '30' : "911 Response",
```

```
    '35' : "Intercept",
```

```
    '40' : "Interfacility Transfer",
```

```
    '45' : "Medical Transport",
```

```
    '50' : "Mutual Aid",
```

```
    '55' : "Standby"}},
```

```
'E02_05' : {"Name" : "Primary Role of Unit",
```


'60' : "Non Transport",

'65' : "Rescue",

'70' : "Supervisor",

'75' : "Transport"},

'E03_01' : {"Name" : "Complaint Reported by Dispatch",

'-25' : "Not Applicable",

'-20' : "Not Recorded",

'-15' : "Not Reporting",

'-10' : "Not Known",

'-5' : "Not Available",

'400' : "Abdominal Pain",

'405' : "Allergies",

'410' : "Animal Bite",

'415' : "Assault",

'420' : "Back Pain",

'425' : "Breathing Problem",

'430' : "Burns",

'435' : "CO Poisoning/Hazmat",

'440' : "Cardiac Arrest",

'445' : "Chest Pain",

'450' : "Choking",

'455' : "Convulsions/Seizure",

'460' : "Diabetic Problem",
'465' : "Drowning",
'470' : "Electrocution",
'475' : "Eye Problem",
'480' : "Fall Victim",
'485' : "Headache",
'490' : "Heart Problems",
'495' : "Heat/Cold Exposure",
'500' : "Hemorrhage/Laceration",
'505' : "Industrial Accident/Inaccessible Incident/Other",
'510' : "Ingestion/Poisoning Entrapments (non-vehicle)",
'515' : "Pregnancy/Childbirth",
'520' : "Psychiatric Problem",
'525' : "Sick Person",
'530' : "Stab/Gunshot Wound",
'535' : "Stroke/CVA",
'540' : "Traffic Accident",
'545' : "Traumatic Injury",
'550' : "Unconscious/Fainting",
'555' : "Unknown Problem Man Down",
'560' : "Transfer/Interfacility/Palliative Care",
'565' : "MCI (Mass Casualty Incident)",
'E06_11' : {"Name" : "Gender",

'655' : "Female",
'650' : "Male"},
'E06_12' : {"Name" : "Race",
'660' : "American Indian",
'665' : "Asian",
'670' : "Black",
'675' : "Pacific Islander",
'680' : "White",
'685' : "Other race"},
'E06_14' : {"Name" : "Age"},
'E06_15' : {"Name" : "Age Units"},
'E07_01' : {"Name" : "Primary Method of Payment",
'720' : "Insurance",
'725' : "Medicaid",
'730' : "Medicare",
'735' : "Not Billed",
'740' : "Other Government",
'745' : "Self Pay",
'750' : "Workers Compensation"},
'E08_05' : {"Name" : "Number of patients at scene",
'1120' : "None",
'1125' : "Single",
'1130' : "Multiple"},

'E08_07' : {"Name" : "Incident Location Type",

'1135' : "Home/Residence",

'1140' : "Farm",

'1145' : "Mine/Quarry",

'1150' : "Industrial Place and Premises",

'1155' : "Place of Recreation",

'1160' : "Street or Highway",

'1165' : "Public Building",

'1170' : "Trade or Service",

'1175' : "Health Care Facility",

'1180' : "Residential Institution",

'1185' : "Lake, River, Ocean",

'1190' : "Other Location"},

'E20_10' : {"Name" : "Incident Disposition",

'4815' : "Cancelled",

'4820' : "Dead at scene",

'4825' : "No patient found",

'4830' : "No treatment required",

'4835' : "Patient refused care",

'4840' : "Treated and released",

'4845' : "Treated, Transferred Care",

'4850' : "Treated, Transported by EMS",

'4855' : "Treated, Transported by Law Enforcement",

```

'4860' : "Treated, Transported by private vehicle"},
'E22_01' : {"Name" : "Emergency Department Disposition of patient",
'5335' : "Admitted to Hospital Floor",
'5340' : "Admitted to Hospital ICU",
'5345' : "Death",
'5355' : "Released",
'5360' : "Transferred"},
'E05_01' : {"Name" : "Incident Onset Time"},
'E05_02' : {"Name" : "PSAP Call DateTime"},
'E05_03' : {"Name" : "Dispatch Notified DateTime"},
'E05_05' : {"Name" : "Unit En Route DateTime"},
'E05_06' : {"Name" : "Unit Arrived on Scene Datetime"},
'E05_07' : {"Name" : "Arrived at Patient Datetime"},
'E05_11' : {"Name" : "Unit Back in Service"}
}

```

```
colnames = iqp.columns[5:44]
```

```
wb = openpyxl.Workbook()
```

```
timestamps = ['E05_05','E05_02','E05_03','E05_06','E05_01','E05_07','E05_11']
```

```
for e in colnames:
```

```
    if e in timestamps:
```

```
        ourdict = nemsis[e]
```

```
        ourtitle = ourdict["Name"]
```

```

ourdata =
ourkeys = []
for k in ourdata.keys():
    ourkeys.append(str(k))

ws = wb.create_sheet(title=ourtitle[:30])
rownum = 1
for key in ourkeys:
    if key in ourdict.keys():
        ws.cell(row=rownum, column=1).value = ourdict[key] #name of group
    else:
        ws.cell(row=rownum, column=1).value = str(key)
    try:
        ws.cell(row=rownum, column=2).value = str(ourdata[int(key)]) #name of group
    except:
        try:
            ws.cell(row=rownum, column=2).value = str(ourdata[int(str(key)[:2])])
        except:
            ws.cell(row=rownum, column=2).value = str(ourdata[int(str(key)[:1])])
    rownum += 1

wb.save('Second Attempt.xlsx')

```

Time Stamp Parser

```
import os

import openpyxl

import csv

import plotly.plotly as py

import pandas as pd

import numpy as np

import IQP_Code

os.chdir('/Users/elizabethkarpinski/Desktop/NEMESIS_CSV')

ourfile = openpyxl.load_workbook('output.xlsx')

wb = openpyxl.Workbook()

datasheet = ourfile.active

highestrow = datasheet.max_row

for i in range(2,35): #each column

#Figure out what we're counting

    resultsdict = {}

    codename = datasheet.cell(row=1,column=i).value

    if codename == 'E06_14':
```

```

keydict = IQP_Code.nemsisdict[codename]

#Count occurrences

ourlist = []
columnvalues = []

for cellrow in range(2, highestrow): #for cells in rows
    x = datasheet.cell(row=cellrow, column=i).value
    if x in ourlist:
        resultsdict[x] += 1
    else:
        ourlist.append(x)
        resultsdict[x] = 1

#write results

sheettitle = IQP_Code.nemsisdict[codename]["Name"]
ws = wb.create_sheet(title=sheettitle)

for key in ourlist:
    rownum = ourlist.index(key) + 1
    ws.cell(row=rownum, column=1).value = key #name of group
    ws.cell(row=rownum, column=2).value = resultsdict[key] #name of group

wb.save('IQP_Age.xlsx')

```