Final Project Report

ACEMS Metadata HQ

The Superspreaders; Group B1

May 15, 2022

Introduction

ACEMS, Amherst College Emergency Medical Services, provides emergency medical services to members of the Amherst College community whenever classes are in session. Students, faculty, and staff can call the emergency number, and upon explaining the medical emergency, a team of three student EMTs is dispatched to the given location to provide care and assess the need for transport to a higher level facility.

Calls can be made for any number of reasons, including musculoskeletal injuries, alcohol and drug overdoses, insect bites, and internal pain, and they can come from one of many locations around Amherst College campus. In Fall 2016, ACEMS began collecting this information for every call through a Google Form filled out by the responding team. The availability of this data sparked the questions:

- What are the most common types of calls in different areas of campus?
- Has the frequency of certain kinds of calls changed over time?
- Has the distribution of calls at different locations on campus changed over time?

Through this project, our team has developed an online, interactive Shiny app (named `ACEMS Metadata HQ`) that allows users to answer these questions by visualizing the distributions of different types of calls both spatially and over time.

To our knowledge, no statistical analysis of ACEMS call data exists. Thus, the significance of this project is twofold: for Amherst College administration, it provides information regarding students' needs around campus, facilitating the allocation of resources where they might be needed most; for ACEMS, it allows the organization to better understand the landscape of medical emergencies and prepare for the most likely types and locations of calls.

In this report, we describe the process for gathering the data we used to create the app; how we manipulated this data to better serve our needs; how we created the app which is the main product of our work; and some interesting results that might come from a first glance at different data visualization options available in the app. We end with general conclusions regarding our app, trends in the data itself, and limitations of our work which may be addressed by future studies.

Abbreviations used throughout this report include:

- ACEMS: Amherst College Emergency Medical Services
- AHS: Amherst Health Services
- AFD: Amherst Fire Department
- CDH: Cooley Dickinson Hospital
- EtOH: alcohol
- UHS: University Health Services (at UMass Amherst)

Methods

Data Acquisition and Description

After a call has been made, ACEMS members have to report the characteristics of that call, including when, where, and why the call happened. This data is collected into a Google Sheets spreadsheet (called the "metadata" sheet), which can be accessed only by members of the ACEMS Board of Directors. Our team made a request to the Board of Directors to access this data. After approval by the medical director of ACEMS, Emily Jones, MD, the spreadsheet was downloaded as a .csv into our GitHub repository. The download occurred on April 22, 2022, at 10:02 PM, and as such only contains information on calls up to this date.

Since some of the variables in our metadata were not relevant or useful to the purposes of our project, we omitted a few of them, including the contact information of three student EMTs who addressed the call. In the end, we selected five variables out of 16 total variables:

- Date of call: Date the original caller placed the call to the emergency line, asking for emergency medical services.
- Time of call: Time the original caller placed the call to the emergency line, asking for emergency medical services.
- Location of call: General area of campus the patient was found in.
- Chief complaint: The patient's main problem or symptom the call was regarding.
- Result: The end result of the call. Generally can be:
  - Refusal: The patient was evaluated by ACEMS and refuses to be transported to a higher-level facility.
  - AHS/UHS: The patient was transported by ACEMS to Keefe Health Center (AHS) or UMass Health Services (UHS).
  - AFD: The patient was transported by an Amherst Fire Department (AFD) ambulance.
  - Taxi to CDH: A taxi was called for the patient for transport to Cooley Dickinson Hospital (CDH). Typically used in non-life-threatening scenarios where the patient wishes to receive higher-level care.

There is no identifying information of any form regarding patients in ACEMS metadata or our final data set.

Data Wrangling and Cleaning

One of the most challenging parts of our project was to clean and wrangle the data. As mentioned earlier, when metadata is entered into the spreadsheet for a call, the ACEMS member must specify the location, chief complaint, and the result. These can be selected from a dropdown menu or entered manually. Thus, our data had a lot of misspellings and different wordings and tags for similar locations, complaints, and results. We used regular expressions (regex) to search for specific patterns in our raw data to unify different spellings and wordings. The "grepl" command is regularly used to detect substrings in the lengthier descriptions that essentially had the same semantical meaning. A small snippet of our wrangling code is shown below:

```
60  acems$result[str_detect(acems$result, "^AFD")] <- "AFD"
61
62  acems$chief_complaint[grepl("injury", acems$chief_complaint, fixed=TRUE) |
63                        grepl("Injury", acems$chief_complaint, fixed=TRUE) &
64                        acems$chief_complaint != "Musculoskeletal Injury" &
65                        acems$chief_complaint != "Soft Tissue Injury"] <- "Other Injury"
66
```

Figure 1: Example Code

In the beginning, we had 29 different locations, 139 various chief complaints, and 21 different results reported. After using the commands above for data cleaning, our final data set has 16 different locations, 38 distinct chief complaints, and six different results. Chief complaints were even grouped and filtered into more general categories, resulting in 12 different categories of calls and four distinct natures of calls. We also created and added eight new variables to our wrangled data: day of the week, weekend or weekday (whether the call was made on the weekend or weekday), shift type (AM or PM), the month of call, semester (Fall or Spring), academic year, category, and nature of the call.

In our final, wrangled data set, there are a total of 1128 ACEMS calls spanning over six years, with the first call happening on August 30th, 2016, and the last call on April 22nd, 2022.

All the wrangling above, including code and some descriptions, can be found in the "data-wrangling.Rmd" file in our final project git repository.

The following two tables include medical descriptions and examples explaining each distinct category and nature of call.

Table of Categories

Category	Description/Example
Alcohol/Drugs	Involved consumption of a mind-altering substance such as alcohol, cannabis, amphetamines, cocaine, etc.
Allergic Reaction	Patient was exposed to a substance and developed symptoms of an allergic reaction. Exposure could have happened environmentally or through consumption/skin contact. The reaction may or may not have been anaphylactic, which involves the entire body and can be life-threatening.
Behavioral/Psychiatric	Patient is undergoing a mental health emergency or is otherwise disturbed; altered mental status cannot be explained by a medical or traumatic event such as consumption of mind-altering substances, head trauma, or low blood sugar.
Cardiovascular/Respiratory	Any chief complaint related to the cardiovascular or respiratory systems. Most commonly, chest pain, difficulty breathing, and myocardial infarction (heart attack).
Dermatological	Call was made for symptoms appearing on the skin, such as rash and hives.
Environmental	A medical emergency involving an environmental factor such as insects, high/low temperatures, and carbon monoxide or other noxious gas poisonings.
General Injury	Any traumatic event causing an injury to a body part.
Internal Pain	Pain from inside the body that cannot be explained by a traumatic event, for example, abdominal pain or body aches.
Metabolic/Gastrointestinal	Emergencies are caused by metabolic systems, such as low/high blood sugar (esp. in diabetic emergencies), and gastrointestinal systems, such as food poisoning, nausea, and vomiting.
Neurological	Physical conditions involving the brain that are certainly not behavioral or psychological, such as syncope (fainting), dizziness, stroke, and seizure.
Pathogenic	Any condition caused by invading pathogens, such as respiratory illnesses and external infections, for example of the skin, ears, and eyes.

*Other: any type of call that did not fit into the above categories.

Table of Natures

Nature	Description/Example
Behavioral	Calls where the primary symptoms are behavioral/psychiatric, and cannot be explained by a definitive medical or traumatic event.
Medical	Emergencies involving an internal bodily event (which may or may not be caused by an external factor) that causes noticeable and disturbing symptoms.
Trauma	A disruption in the body's physical integrity caused by a significant object striking against any part of the skin. Can cause bleeding, bruising, fractures, altered mental status, and pain, among other symptoms and conditions.

*Unknown: the nature of the call cannot be determined from the chief complaint.

App Creation

We had to use the *lubridate* package to convert the date and time of the call to military time to facilitate further wranglings in our app. Besides using *leaflet* for interactive map creation, we had to use the *sp* package for spatial data manipulation and polygon creation. The location variable in the metadata does not constitute individual buildings or dormitories but rather different areas of campus, which typically group several buildings or dormitories together. So, we had to create polygons to represent different areas of campus. For each location on campus, we had to extract the coordinates of the vertices of the polygon corresponding to that location using google maps. We also used the *plotly* package to provide a smoother user experience by creating more aesthetically appealing bar charts.

Results

Shiny App

Click below to access the `ACEMS Metadata HQ` Shiny App:

https://apenatauber.shinyapps.io/acems-metadata-hq/

Info Tab

This tab provides information on the map and bar chart tabs within the Shiny app. It also provides an explanation of the ACEMS call data, in addition to defining abbreviations for terms that appear in the data set.

Figure 2: Info Tab

Map Tab: Geographical Data

This tab consists of an interactive map of Amherst College's campus, and allows the app user to select the variables for academic year, semester, and chief complaint. The user can select the data to be shown by either total call count or by the percentage of calls in a given location. Figure 2, pictured below, shows the default variable selections: total call count for each area is shown across all academic years from 2016 to 2022, and for both semesters, for all chief complaints. Here, we can see that the location with the highest total number of calls under these conditions is the First-year Quad.

Figure 3: Map Tab

To provide a demonstration of the app's functionality and analyze some of our results, Figure 4 is pictured below and displays the map when Alcohol/Drugs is the selected category. The area with the highest concentration of calls for this category is the Triangle (Mayo-Smith/Hitchcock/Seelye). When compared with Figure 5, where the selected chief complaint is General Injury, we can see that the breakdown of percent calls appears to be nearly reversed, with the highest percentage due to General Injury being located at the Gym/Athletic Fields and Chapman/Humphries/Lincoln/Rice areas.

Overall, geographic data shows significant variation when filtering by each category of chief complaint. Thus,

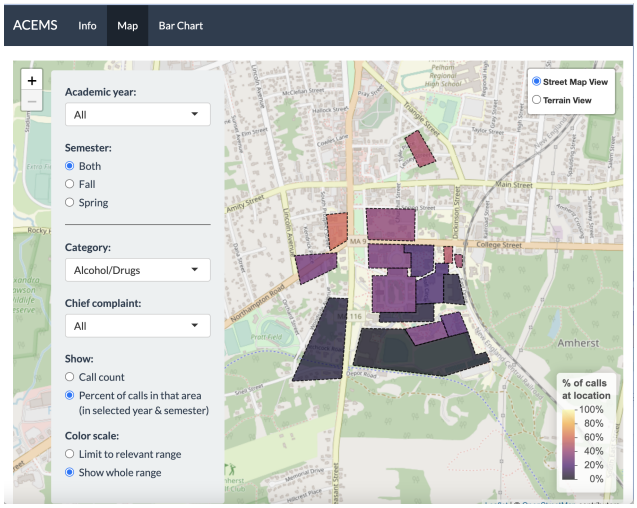

Figure 4: Map Tab: Alcohol and Drugs (%)

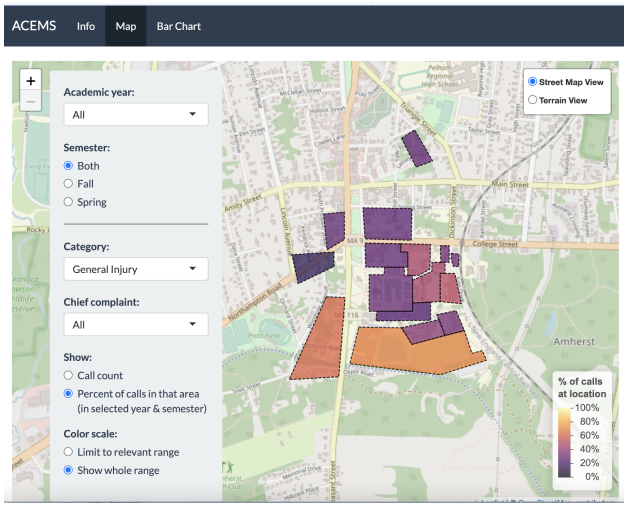

Figure 5: Map Tab: General Injury (%)

some meaningful trends can be extracted from an analysis of visualization given by our app, depending on the specific questions asked by the user.

Bar Chart Tab: Temporal data

This tab shows two bar charts, and allows the user to filter the ACEMS call data by either the nature of the call, the call category, the shift type (AM/PM), whether the call occurred on a weekend or weekday, or the result of the call. The data can be shown by total call count or the percentage of calls, academic year, month or semester. The first chart can display the data for all 12 months of the year, or the user can choose to isolate one month to display on the graphs. The second filters the data by semester (both, fall, or spring).

Figure 6: Bar Chart Tab

Conclusions

Through this project, we have successfully created an app for exploratory analysis of ACEMS metadata for calls from Fall 2016 to Spring 2022. Our app enables the user to investigate distributions of various variables associated with calls throughout areas of campus and over time.

Some first glances at our app reveal that geographically, call distributions change quite noticeably, with different categories of chief complaints being more common in quite different areas of campus. However, from month to month and semester to semester, the distribution of different calls is difficult to interpret, with few clear trends appearing. This may be due to a sample size issue, as we are only working with six years' worth of data; alternatively, there may be no underlying trends.

While we have taken a preliminary look at this data, our Shiny app enables users to ask any question they desire regarding the geographic or temporal trends in different types of calls. The implications of this project, then, are vast. Amherst College administration may choose to harness this tool to better serve the student population, allocating support resources where they might be needed most, for example by making first aid kits available near the athletic fields, or providing students on the Triangle (Hitchcock/Seelye/Mayo Smith) with training on alcohol and drug emergencies. On the other hand, ACEMS may choose to analyze this data

to better prepare its EMTs to respond to emergencies by taking a look at the most common locations and types of calls. The possibilities are endless.

Our app is not without its limitations. While our app provides a helpful and intuitive visual display of the data, there is no rigorous statistical analysis of trends. This makes it difficult to discern whether some patterns are true or simple artifacts of low sample sizes. Some locations and time periods have very low sample sizes making their data points somewhat irrelevant. Additionally, some visualizations could have been helpful to supplement our app. For example, our map gives an intuitive, quick sense of how the data is distributed, but it may be helpful to also include a bar chart explicitly showing the numbers at each location. Also, because our temporal bar chart is stacked, it is difficult to instantly discern any trends. Having the option to display this chart with the data "isolated" may improve the visualization of temporal data. Future work should incorporate some of these changes to polish the app for extended use.

Our hope is that the app we have developed can be used by ACEMS and Amherst College administration for the aforementioned benefits. As such, we will be investigating the possibility of publishing our app for public or institutional use. Ethical concerns such as the chance of the app being used to reveal sensitive medical information should be evaluated by an institutional review board (IRB). However, we strongly desire to make this data available as we believe the benefits could be vast.

References and Helpful Resources

The following is a list of resources that were massively helpful in developing this app, in everything from creating polygons for the map, to putting all of the components together into an integrated web program.

Introduction To Spatial Polygons In R. 2022. Michael T. Hallworth, Ph.D. https://mhallwor.github.io/_pages/basics_SpatialPolygons.

Leaflet For R - Using Leaflet With Shiny. 2022. RStudio Inc. https://rstudio.github.io/leaflet/shiny.html.

Interactive web apps with Shiny cheat sheet. 2022. RStudio Inc. https://shiny.rstudio.com/images/shiny-cheatsheet.pdf.

Google Maps. Google LLC. https://www.google.com/maps.