Toronto Paramedic Services*

A deeper look into what drives Emergency Medical Services (EMS) demand.

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In 2023, there were over 1,000 cases where an ambulance was unavailable to respond to an emergency call. This calls for urgent action as every moment is critical in emergency situations. By examining Paramedic Services Incident Data (2017-2022) provided by Toronto Paramedic Services, the following anaylsis aims to identify the key drivers of Emergency Medical Services (EMS) demand within Toronto to help inform more effective strategies for managing EMS demand. In short, medical emergencies and vehicle accidents appear to be the most prominent drivers of EMS demand, suggesting that strategies that seek to better manage demand in these areas may enhance the overall efficiency of paramedic services.

1 Introduction

"In case of an emergency, please call 911." From building walls to road signs, this is a message that appears almost everywhere, and it instills the idea that no matter the circumstance, there will always be emergency services available to help. However, research shows that this is not the case. A report on Toronto's paramedic services highlights that there were no ambulances available to over 1,000 calls in 2023 (Draaisma 2024). With drastically increasing wait times for those who required Emergency Medical Services (EMS), it is crucial to understand why paramedic services are unable to keep up with a seemingly growing demand for EMS.

In response to this rising challenge, the report posits that in order to elevate the "efficiency and effectiveness" (Draaisma 2024) of Toronto's paramedic services, further research on how to manage EMS demand is needed. Thus, this paper seeks to investigate the factors that seem to be driving EMS demand within Toronto. Using Paramedic Services Incident Data offered by Toronto Paramedic Services, the aim is to identify which types of emergencies (e.g. medical emergencies or vehicle accidents) strongly drive EMS demand. Knowing this can

*Code and data are available at: https://github.com/JuliaJLee/Toronto_Paramedic_Services.git

help inform effective strategies that allocate resources to these drivers for better EMS demand management.

With this, this paper first examines the total number of emergency calls made from 2017 to 2022 to better understand how EMS demand has changed over time. Then, it looks at EMS demand through five different incident types as outlined by Toronto Paramedic Services to determine which of these five incident types are key drivers of the total EMS demand. As a result, this analysis finds that medical emergencies and vehicle accidents are notable drivers of EMS demand within Toronto.

In what follows, the paper will define the data that was used within this analysis (Section 2), provide a detailed account of the results (Section 3), and put forth a discussion of the analysis along with its limitations and next steps (Section 4).

2 Data

2.1 Toronto Paramedic Services Data

Paramedic Services Incident Data (2017-2022) is provided by Toronto Paramedic Services (Toronto Paramedic Services 2023). The records of when a paramedic was dispatched having received a call, they type of incident, the priority level of each incident, the number of paramedic units that arrived at the scene, and the general location of each incident are all updated by hand to the city of Toronto's Open Data portal (City of Toronto 2024).

To simulate, test, download, and clean the Paramedic Services Incident Data (2017-2022), the statistical programming language R was used (R Core Team 2023). Specific libraries that assisted the analysis include `tidyverse` (Wickham et al. 2019), `dplyr` (Wickham et al. 2023), `opendatatoronto` (Gelfand 2022), `tinytex` (Xie 2019), `ggplot2` (Wickham 2016), `knitr` (Xie 2015), `maps` (Becker et al. 2023), and `sf` (Pebesma 2018).

The Paramedic Services Incident Data is refreshed annually and contains information on every single incident paramedics have responded to since January 1st to December 31st in 2017 to 2022. For every day of each year, there are multiple records of incidents that have occurred. For every record, there is an ID number, the date and time when a paramedic unit was dispatched, the type of incident, the severity of the incident (priority), the number of paramedic units at the scene, and the general location of the incident. Table 1 below previews this information for recorded incidents in 2022.

Table 1: Paramedic Services Incident Data for 2022

ID	Dispatch Time	Incident Type	Priority	Units Arrived	Location
5,827,367	2022-04-27 22:15:02	Emergency Transfer	1	2	M6R
7,388,641	2022-01-01 00:00:15	Medical	1	1	M6A
7,388,642	2022-01-01 00:00:33	Motor Vehicle Accident	1	2	M5E

Looking at Table 1, the variable, "ID", is a number that identifies each incident in accordance with a Computer Aided Dispatch (CAD) record (Toronto Paramedic Services 2023). "Dispatch Time" represents the date and time, measured in minutes and seconds, at which paramedics responded to an emergency call. This data further provides information on the type of emergency paramedics responded to with the variable, "Incident Type". "Priority" refers to the urgency of all incoming emergency calls. The priority level is measured using a "Medical Priority Dispatch System (MPDS)" that organizes incoming information from 911 callers into different categories. For instance, in Table 1, the priority level is 1 for all three incidents, meaning that the MPDS assessed the information provided by callers and their situations as extremely urgent. "Units Arrived" is a count of the number of paramedic units that were present at the scene. Lastly, "Location" characterizes the approximate location of each incident and is measured using Forward Sortation Areas (i.e. the first three characters of postal codes).

2.2 Analysis Data

For this analysis, the variables of interest are the different types of incidents that are recorded. The Paramedic Services Incident Data lists five different incident types: (1) medical emergencies, (2) motor vehicle accidents, (3) emergency transfers, (4) fires, and (5) airport standbys. Each type refers to a different circumstance under which individuals may call 911 for EMS.

As the objective is to understand the driving factors of EMS demand, the actual data that is used within this analysis reflects the total EMS demand and the demand for each incident type over the course of six years (2017-2022). All recorded incidents were aggregated together by incident type to see the number of emergency calls for each type. Then, the number of emergency calls for each incident type were summed to produce a total EMS demand count. This process was repeated every year from 2017 to 2022. Table 2 (found below) illustrates the outcome of this process, and summary statistics for this analysis data can be found in the Appendix (Section A).

Table 2: Organized Paramedic Services Incident Data (2017-2022)

Year	Medical Calls	Vehicle Accident Calls	Emergency Transfer Calls	Fire Calls	Airport Standby Calls	Unclassified Calls	Total Emergency Calls
2017	254454	13242	9282	880	71	681	278610
2018	271935	13011	9192	896	54	663	295751
2019	274495	12790	8675	804	49	536	297349
2020	254209	8395	6594	782	7	613	270600
2021	269296	8317	7134	760	4	630	286141
2022	271755	8507	7077	694	31	626	288690

The column "Unclassified Calls" in Table 2 represents the emergency calls that were not assigned an incident type. It is important to note that throughout the analysis, these records are omitted.

2.3 Map Data

To further understand what drives EMS demand, this analysis uses the Forward Sortation Areas (FSA) provided by the Paramedic Services Incident Data (2017-2022) to map the driver of EMS demand within each FSA. For the maps within this analysis, the analysis data explained in Section 2.2 needed to be modified. By grouping the data by FSAs, the types of incidents recorded within each unique FSA and the number of incidents that occurred with each incident type could be found. The "driver" of EMS demand for a given FSA was determined by the incident type that had the most number of calls. A small snippet of the modified analysis data is shown below in Table 3. The column that contains each FSA is named "CFSAUID" to ensure that each FSA can be mapped.

Table 3: Modified Analysis Data for Mapping

CFSAUID	Incident Type	Emergency Transfers	Medical Emergencies	Vehicle Accidents	Fires	Airport Standbys	EMS Demand Driver
K0K	Emergency Transfer	1	0	0	0	0	Emergency Transfers
K0M	Emergency Transfer,Emergency Transfer	2	0	0	0	0	Emergency Transfers

To map this data, a shapefile with the boundaries for Toronto's FSAs was required. This data was acquired from the Open Government Data portal by the Government of Canada (Open

Data Canada 2024). Ambulance station location data was also considered in this analysis. This dataset provided by Toronto Paramedic Services (Toronto Paramedic Services 2023) and shared through the city of Toronto's Open Data portal (City of Toronto 2024), contains the exact geographic locations of each ambulance station within Toronto. Additional information about these datasets, including how they were prepared and used can be found in the Appendix (Section A).

3 Results

3.1 EMS Demand from 2017 to 2022

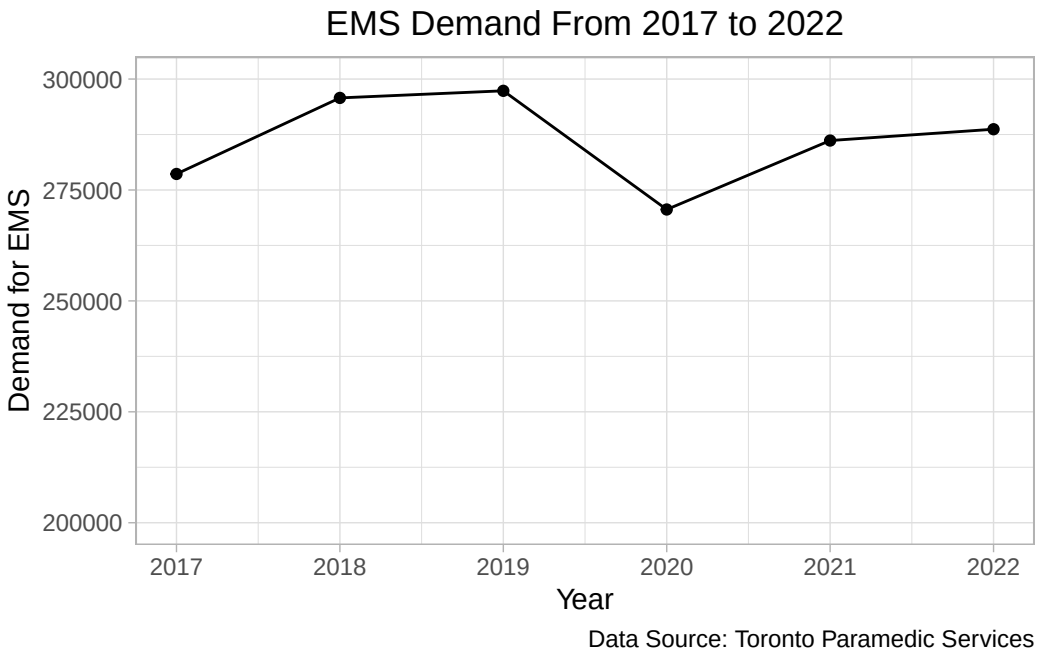

Figure 1: Total EMS Demand for Each Year between 2017 and 2022

Figure 1 displays the total number of emergency calls for each year. The total number of emergency calls appears to increase in 2020 after a notable decrease in 2019. This pattern likely reflects the the onset of the covid-19 pandemic. Though the number of emergency calls appears to fluctuate over the years, the change is not drastic, indicating that there has consistently been a heightened demand for EMS within Toronto.

3.2 EMS Demand from 2017 to 2022 Based on Incident Type

To further unpack what is driving this consistent demand, the calls for individual incident type are also considered. Figure 2 illustrates the number of emergency calls for each incident type along with the total number of emergency calls. Based on Figure 2, demands for EMS are markedly higher for medical emergencies than any other incident type, suggesting that medical circumstances are key drivers that propel EMS demand.

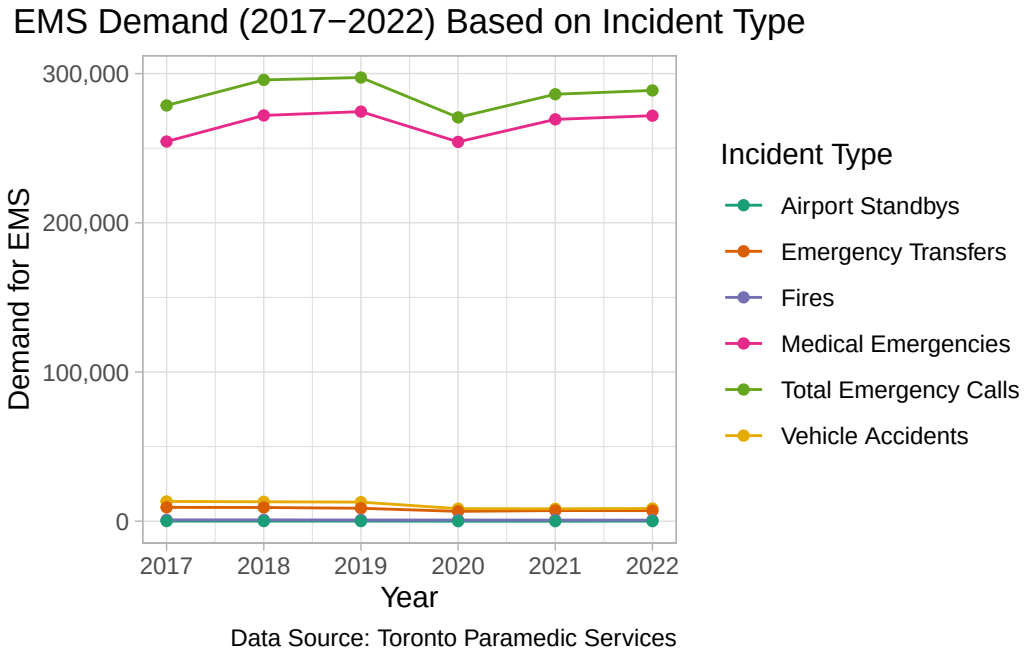

Figure 2: EMS Demand for Each Year between 2017 and 2022

By zooming into Figure 2 with Figure 3 below, a clearer look at the other incident types is provided. With Figure 3, it becomes clear that a second driver of EMS demand may be vehicle accidents, though not as strong as medical emergencies.

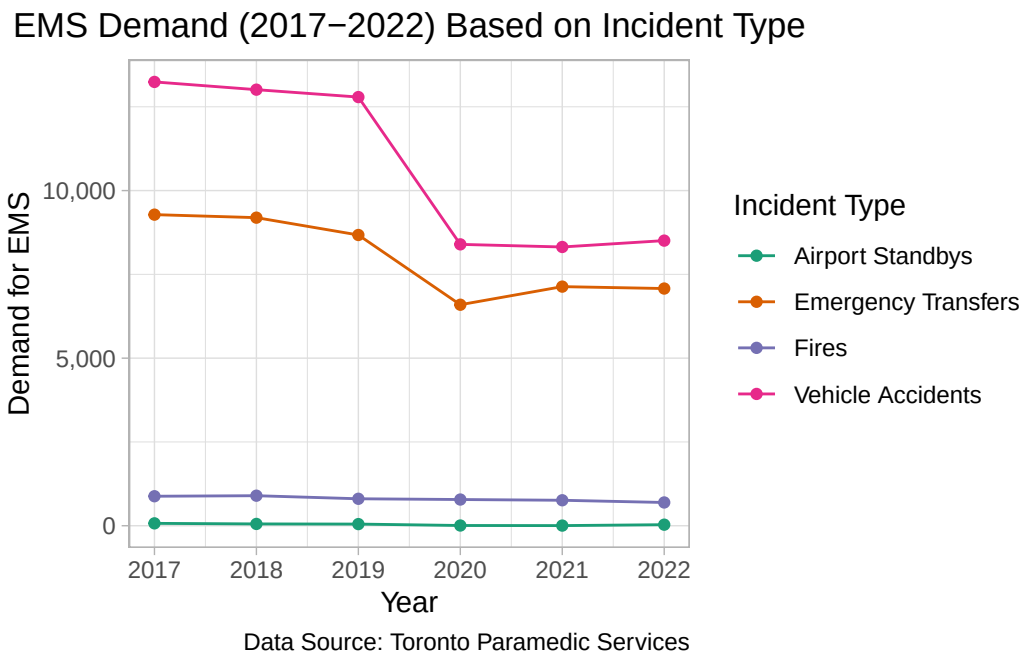

Figure 3: EMS Demand for Each Year between 2017 and 2022

As a prominent driver of EMS demand is medical-emergency-related calls, strategies that focus on efficiently managing calls for medical emergencies may help to better navigate EMS demand as a whole. Response times for EMS demand have been greatly impacted by offload delays, staffing/training challenges, and traffic congestion (Draaisma 2024). With medical emergencies, a shortage of doctors has placed pressure on paramedic services as residents rely on and turn to these services more often (Ireland 2024). This in turn, increases in offload delays - the time it takes to offload patients into hospitals. Longer offload delays mean longer response times for other incidents. Putting all of this together, a strategy to better manage EMS demand for medical emergencies may be to focus on promoting primary-care providers (i.e. family doctors) and to allocate resources to provide additional health services (e.g. programs to consult with a health-care professional online from home).

Similarly, as vehicle accidents are a second potential driver of EMS demand, overall EMS demand may be better managed if paramedic service strategies also target vehicle-accident-related calls. Traffic congestion has been found to increase paramedic response times (Griffin and McGwin 2013), and with the current increase in traffic due to multiple construction projects throughout Toronto, longer paramedic response times and the unavailability of paramedic services can be expected. To efficiently navigate EMS demand for vehicle accidents, strategies may center around accident prevention or effective distribution of resources near accident-prone regions for faster response times.

3.3 Mapping EMS Demand

By examining EMS demand through different incident types, the investigation above finds that medical emergencies...

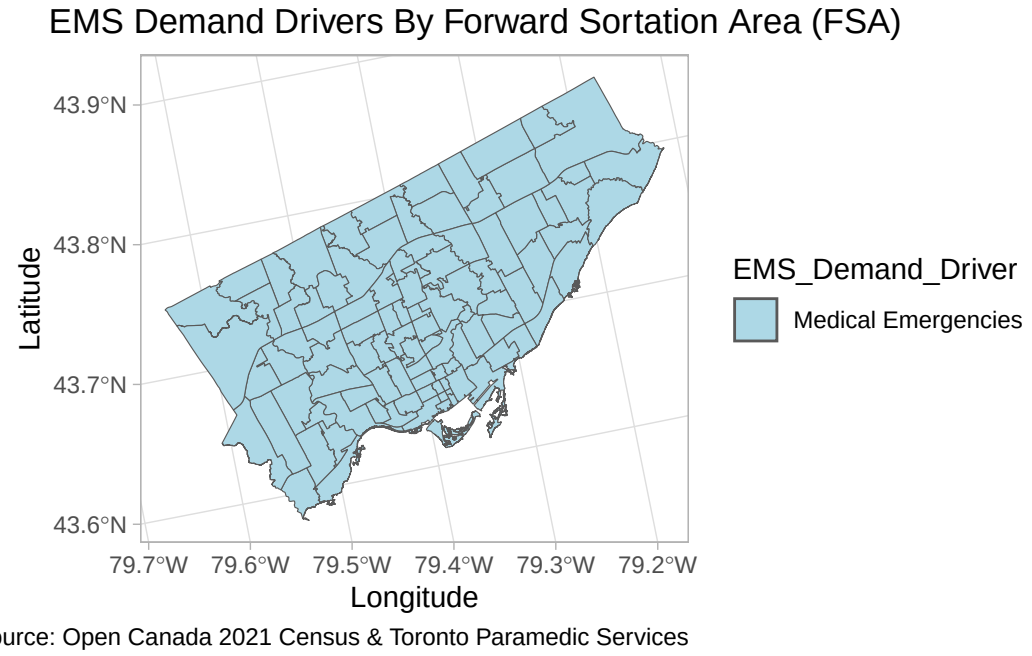

Figure 4: EMS Demand Across Toronto Forward Sortation Areas (Based on data from 2022)

4 Discussion

4.1 Summary

As demand for EMS continues to be a challenge, identifying the areas where most of the demand comes from can help better inform strategies to better manage it. Thus, this analysis investigates...

To this, the given analysis finds that medical emergencies and vehicle accidents are notable drivers of EMS demand within Toronto.

Thus, these findings offer a deeper understanding about the underlying factors that can drive EMS demand, and this understanding can further facilitate the exploration of various strategies that allow paramedic services to effectively operate even under high demand.

4.2 Limitations

CONTENT

A Appendix

A.1 Analysis Data Summary Statistics

Table 4: Paramedic Services Incident Data Summary Statistics

Medical Emergencies	Vehicle Accidents	Emergency Transfers	Fires	Airport Standbys	Unclassified	Total Calls
Min. :254209	Min. : 8317	Min. :6594	Min. :694.0	Min. : 4.00	Min. :536.0	Min. :270600
1st Qu.:258165	1st Qu.: 8423	1st Qu.:7091	1st Qu.:765.5	1st Qu.:13.00	1st Qu.:616.2	1st Qu.:280493
Median :270526	Median :10648	Median :7904	Median :793.0	Median :40.00	Median :628.0	Median :287416
Mean :266024	Mean :10710	Mean :7992	Mean :802.7	Mean :36.00	Mean :624.8	Mean :286190
3rd Qu.:271890	3rd Qu.:12956	3rd Qu.:9063	3rd Qu.:861.0	3rd Qu.:52.75	3rd Qu.:654.8	3rd Qu.:293986
Max. :274495	Max. :13242	Max. :9282	Max. :896.0	Max. :71.00	Max. :681.0	Max. :297349

Table 4 presents the summary statistics for each recorded incident type for the years 2017 to 2022.

A.2 Map Data

The shapefile that contains the boundaries for Toronto's FSAs also contained the FSAs for every province and territory of Canada. As this analysis only considers the city of Toronto, ArcGIS Pro software (Esri, 2024) use employed to remove the spatial information of FSA locations outside Toronto. Specifically, the records of FSA regions that were not in Toronto were removed from the shapefile's attribute table (i.e. data table) using ArcGIS Pro. After modifying this data, it was merged with the data presented in Table 3 and mapped to show the "EMS Demand Driver" for each FSA. The final map is shown in Figure 4.

The ambulance station location data was not modified for this analysis. It was mapped separately and added to Figure 4 to create @(FIG NAME FOR SECOND MAP).

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