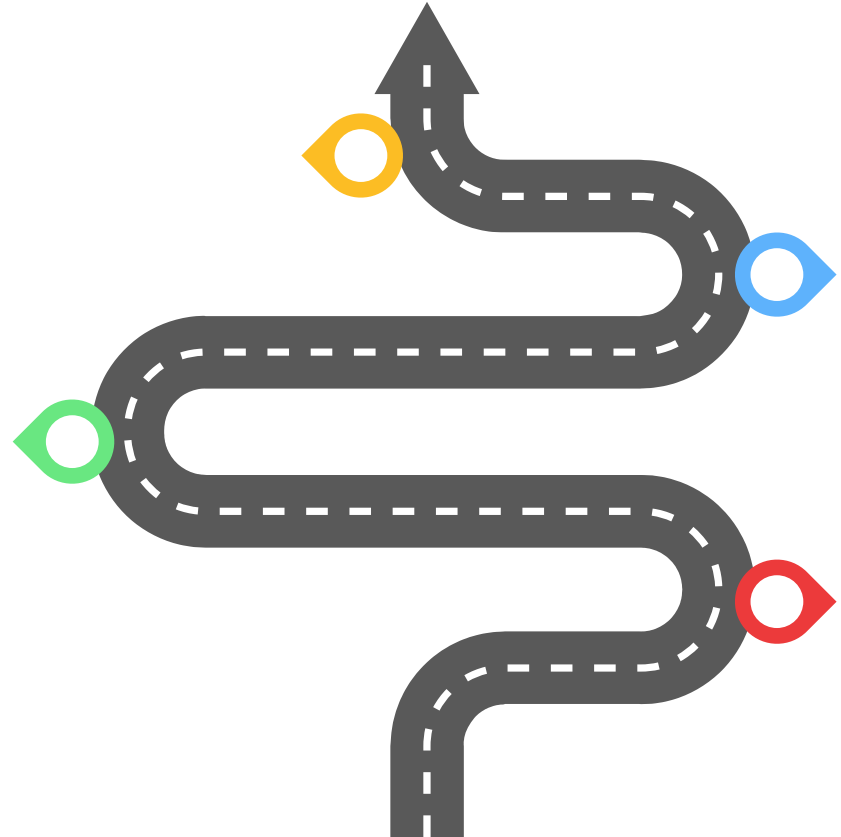
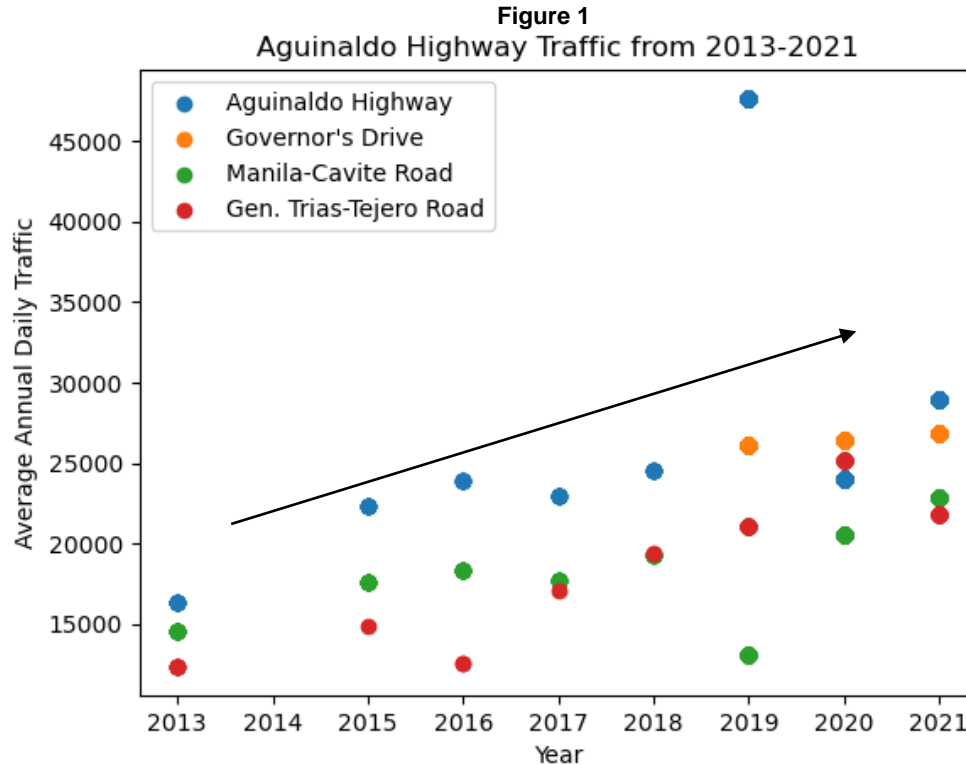


**Identifying Areas Vulnerable  
to Delay of Emergency  
Medical Services and  
Transport of Patients in  
Bacoar, Cavite**





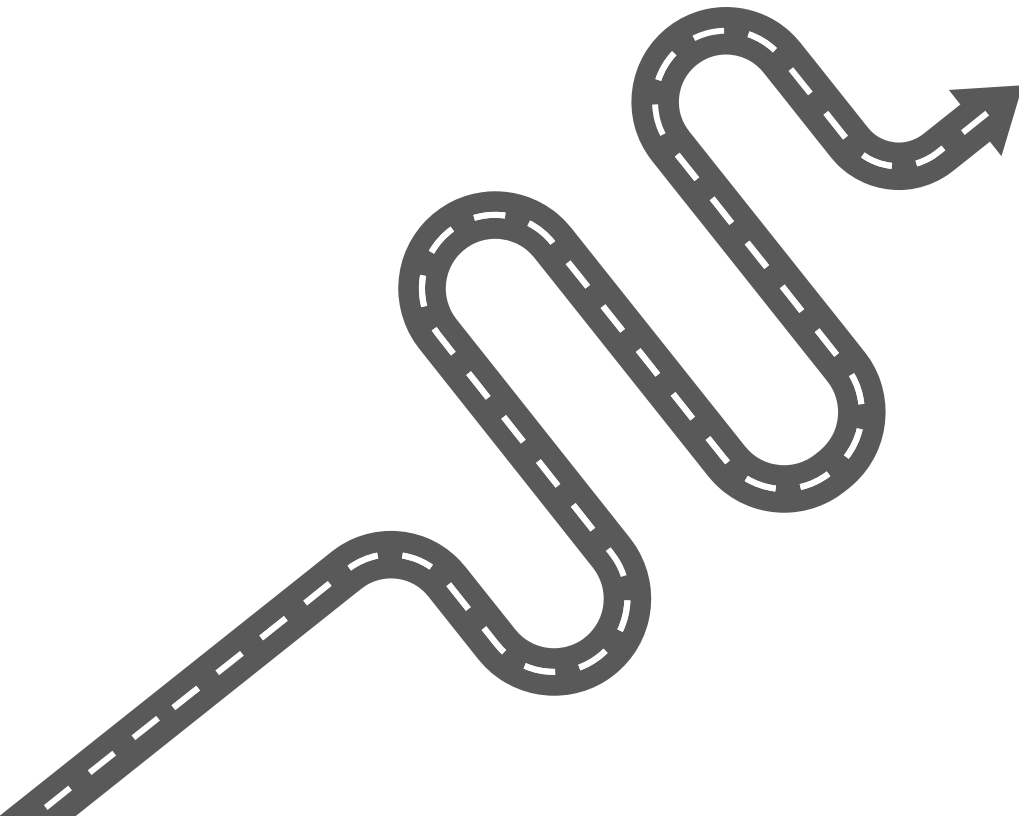
Source: DPWH Road Traffic Information (<https://www.dpwh.gov.ph/dpwh/gis/rti>)

## Study Background

### ▪ Growing traffic in Cavite

Traffic has always been the usual scenario in roads especially during rush hour. People have gotten used to it that sometimes we do not always realize the changing trends of traffic.

In Cavite, traffic has been worsening since 2013 as seen in Figure 1. Average Annual Daily Traffic is a variable which measures the average number of vehicles crossing a particular road in a day in one year. Although the pandemic caused a disruption in this trend, it hasn't broken it as 2021 was able to have higher traffic vs 2019 and previous years.

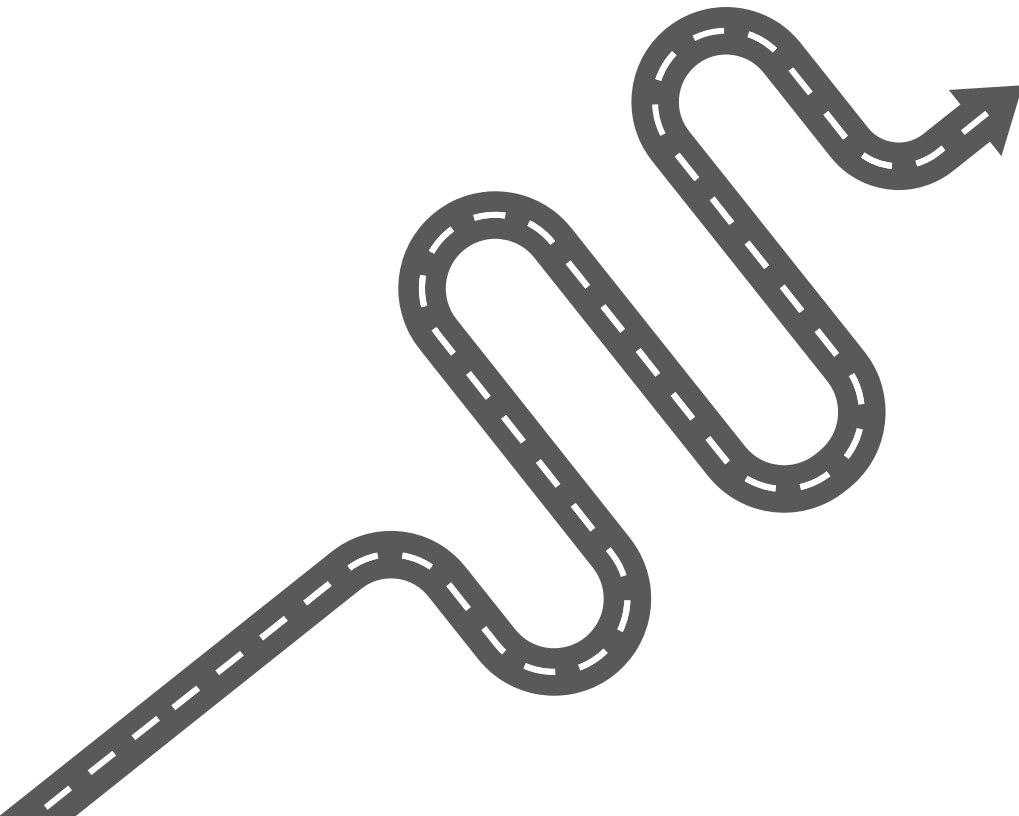


# Study Background

- **Emergency medical services**

With traffic worsening over time, many industries that rely on road travel are affected over time as well. Businesses such as package delivery and commuter transport will experience delays although without any serious consequences.

However, emergency medical services are one of the activities that is highly impacted by traffic. Emergency medical services (EMS) are services which involve the treatment of patients undergoing life-threatening illnesses/injuries.

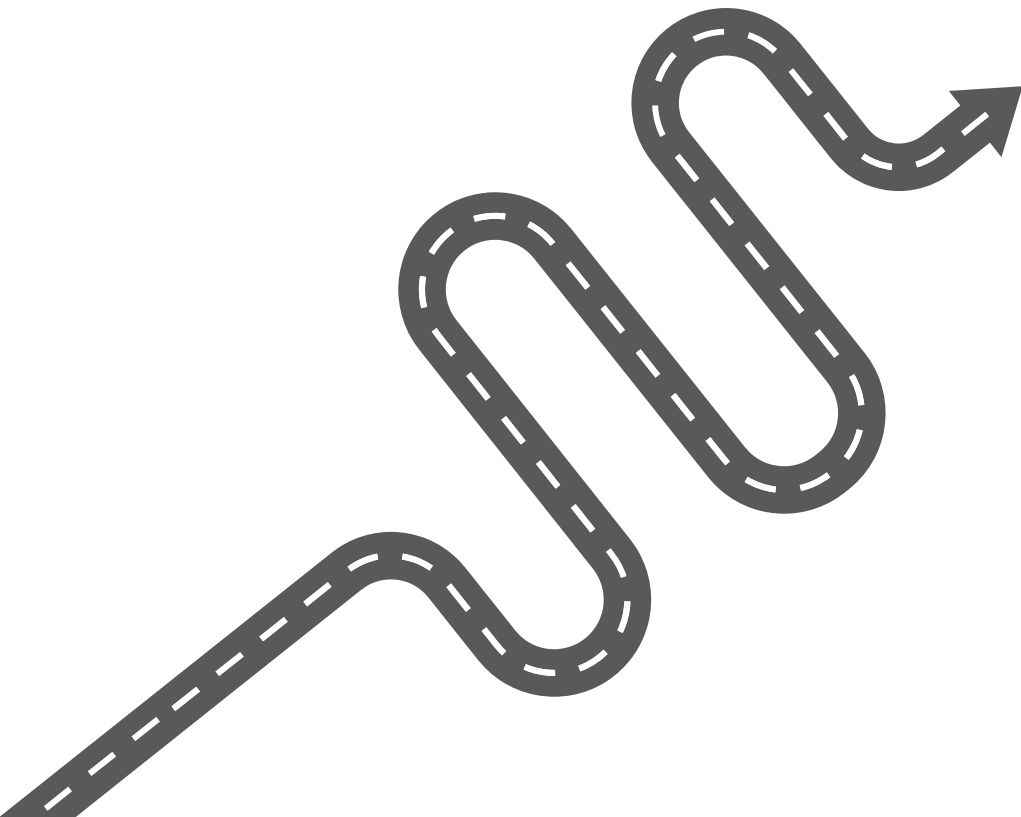


# Study Background

- **Importance of response time on EMS**

Response time is an important factor in conducting relevant EMS as critical patients need immediate attention. There are studies that show factors affecting EMS response time. Mell et al. (2017) and Gonzales et al. (2009) found that longer EMS response times occur in rural areas vs urban ones. Rural areas are usually far from hospitals with EMS hence the longer response times.

From the study of Petzäll et al. (2011), faster driving speed helps cut down EMS response time yet there are risks such as higher chance of accidents.



## Study Background

- **Importance of response time on EMS**

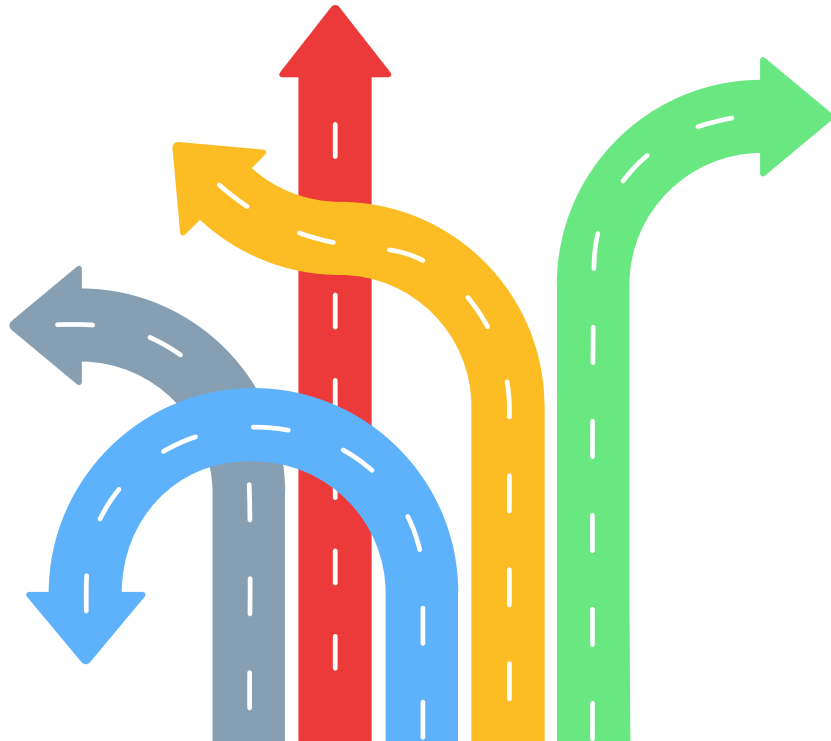
Looking at their results in another light, a slower driving speed would increase the EMS response time. High road traffic is a condition that likely slows down the driving speed of an ambulance. Even though ambulances have priority in the road, it can't be denied that traffic still impacts driving speed.

Estember, Isip, and Misal (2019) found that traffic condition is a significant factor for EMS response time in Quezon City. Hence, it is important to assess EMS response time in traffic-laden areas.

## Problem & Significance

With longer EMS response times, there is a higher chance for a patient to undergo complications or even death. Hence, EMS need to be optimized in areas that have high traffic.

For this study, the researcher will be assessing the areas in Bacoor, Cavite which are vulnerable to delayed EMS due to traffic. The researcher chose Bacoor, Cavite as the area of interest as it is their hometown. By conducting this study, the researcher will be able to provide material that can be of use to the local government unit for road and healthcare planning.

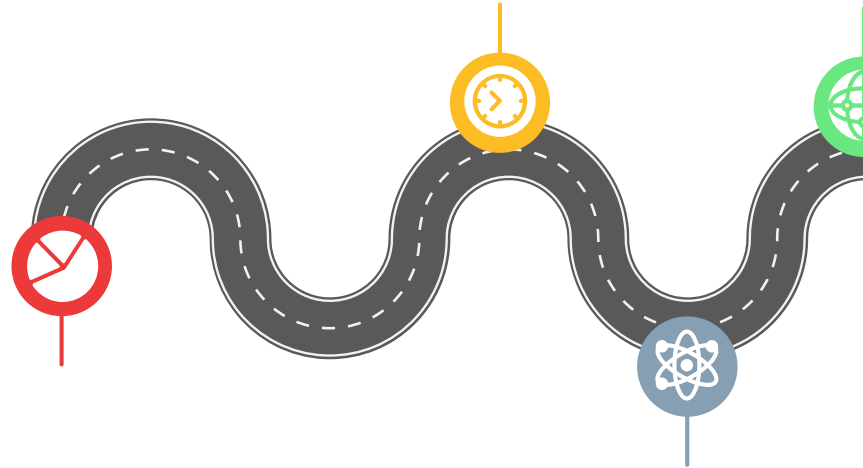


# Methodology

- **Tools and software used**

The data used from this study came from DPWH and Tomtom. DPWH provides road traffic information accessible from their website. Although it can be downloaded there, the researcher used the *requests* module to gather the data as it is more flexible and store it in a *pandas* dataframe. Meanwhile, Tomtom is a company that provides route and traffic information in many countries around the world through their APIs. The specific API used was the Reachable Range Routing API. This was used to get possible coverage of ambulances in Bacoor, Cavite. The API can be accessed in this link: <https://developer.tomtom.com/>

For the software used, the Anaconda distribution was used to create Python notebooks which the analyses are run and created. QGIS was also used to summarize the analyses in a map format for ease of observation.



# Methodology

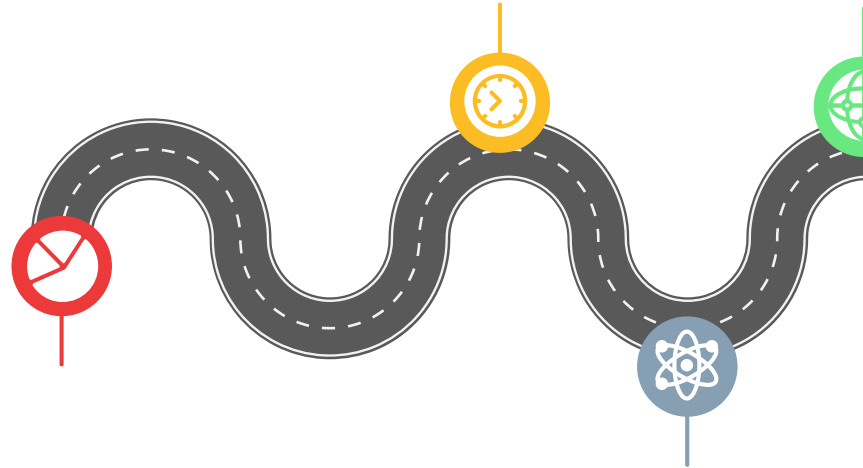
- **Hospital locations**

For hospital location data, the OpenStreetMap dataset was used. The data was extracted and pre-processed in QGIS such that only hospitals near the area of interest were selected and hospitals near to each other are unified. The output from the program was then inputted to a Python script which further consolidates the data into a usable *pandas* dataframe format.

- **Determine coverage of hospitals**

After getting the hospital location data, it was then used as input for Tomtom's Reachable Range Routing API.

The API is set in such a way that the routes to be taken are the fastest. The researcher used time data to observe the influence of traffic on coverage of EMS in Bacoar, Cavite.





# Methodology

- **Determine coverage of hospitals**

The following times are used as input for the API:

June 19, 2019 2:00 AM - normal day, no traffic

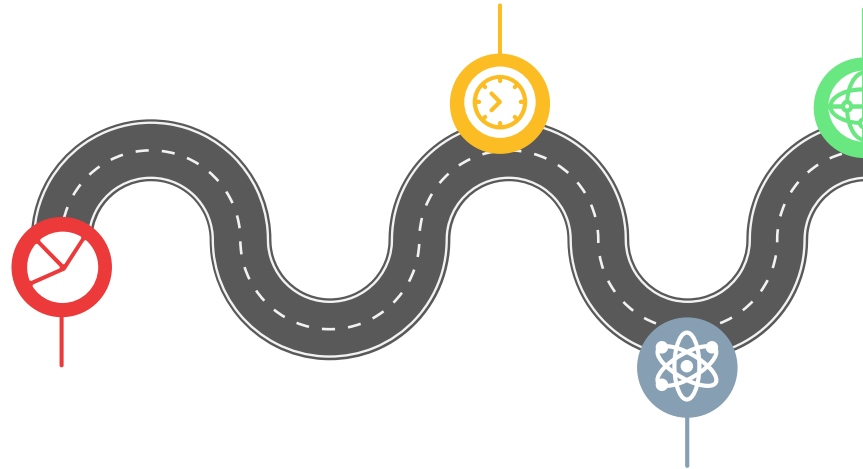
June 19, 2019 5:00 PM - normal day, high traffic

December 23, 2019 2:00 AM - festive day, no traffic

December 23, 2019 5:00 PM - festive day, high traffic

The researcher decided to look into 2019 as it is the year with the highest traffic before the pandemic happened.

Normal and festive days were also analyzed as festivities have an influence on road traffic conditions. Times 2:00 AM and 5:00 PM were used to simulate no traffic and traffic conditions, respectively. Eight minutes was the response time used to determine which areas will not be reached by that time.

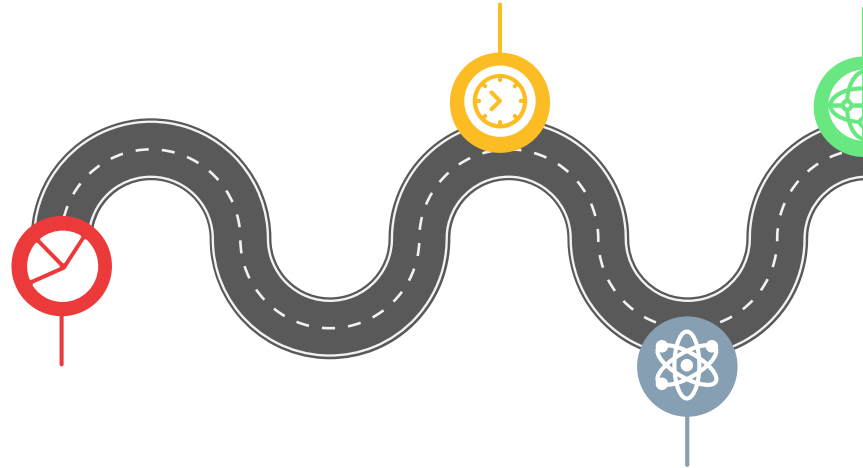


# Methodology

- **Visual assessment of areas**

Upon getting the output from the API, the researcher pre-processed the data in a Python script by using the *geopandas* library. This library is used to analyze and process geospatial data. The researcher combined all the hospital coverage into one zone and clipped the zone to the city boundary. Then, the data was manipulated in QGIS in such a way that it shows the areas not covered by hospitals in a map.

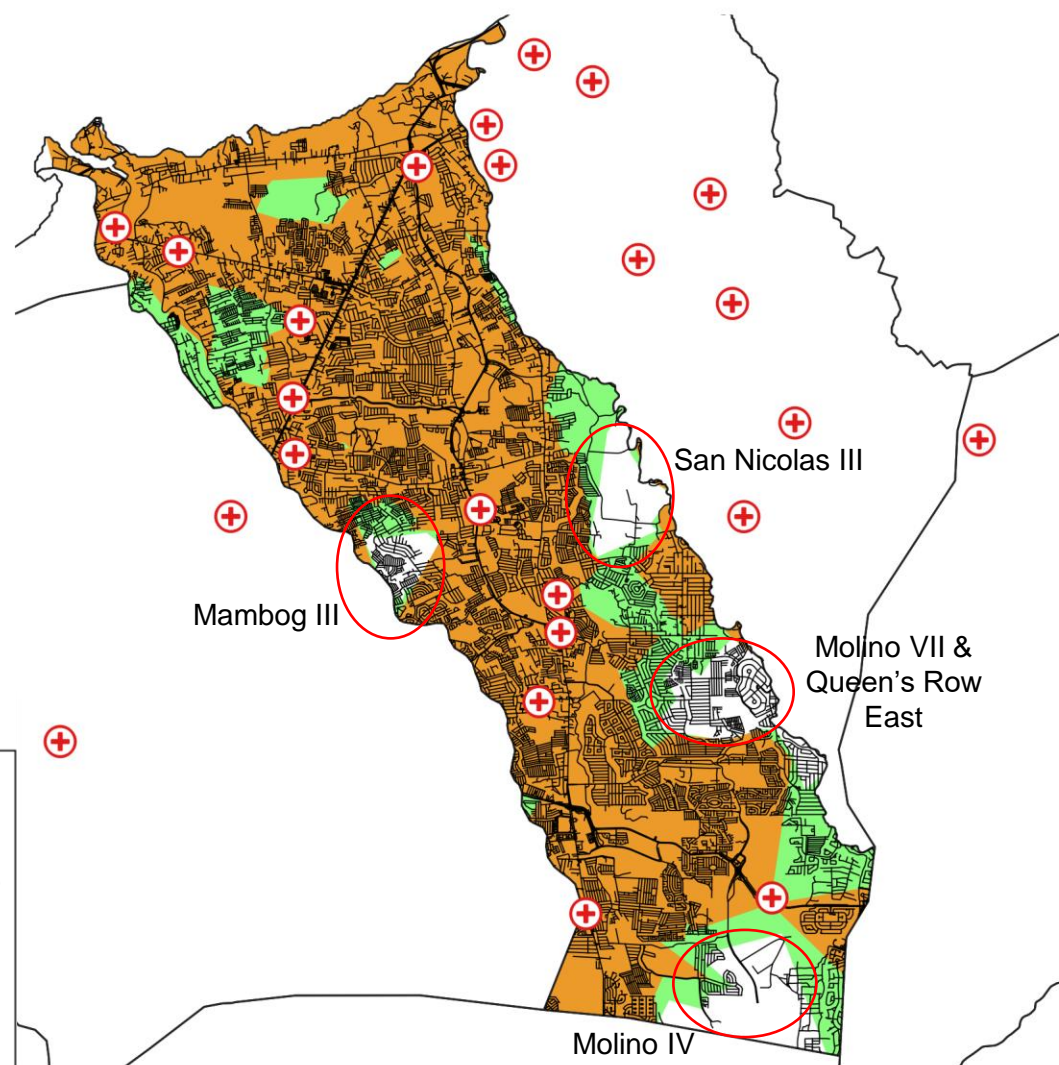
The researcher then observed areas in the map which are not covered well by hospitals and interpreted the results.



# Results and Discussion

## ▪ Normal day

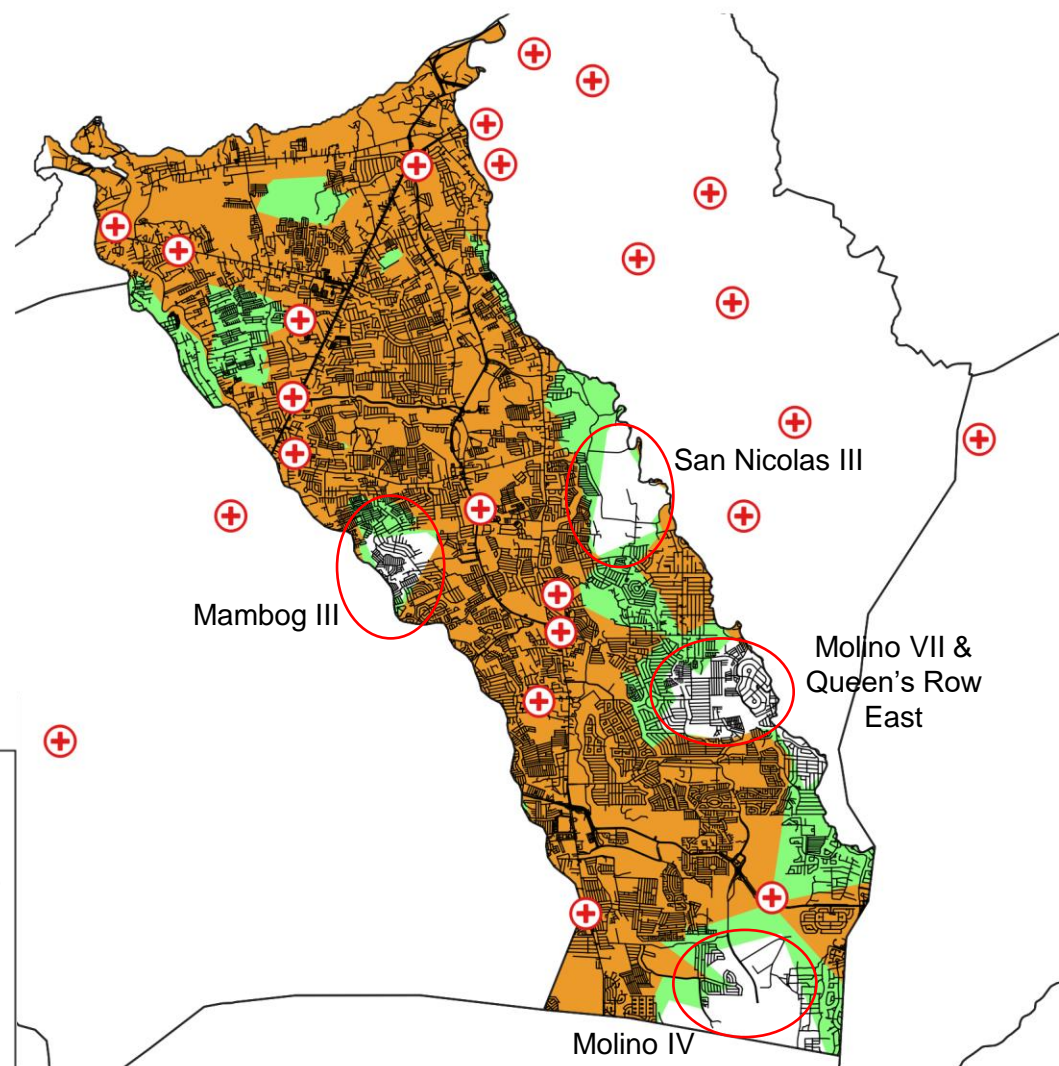
In a normal day scenario, most of Bacoor is covered by EMS within 8 mins, especially when there is no traffic. However, certain areas are not covered even with no traffic conditions such as in Barangays Molino IV, Molino VIII, Queen's Row East, Mambog III, and San Nicolas III. These same areas become more vulnerable when there is traffic.



# Results and Discussion

## ▪ Festive day

In a festive day scenario, area of coverage is similar to a normal day scenario. There are no significant changes between the normal and festive scenario.

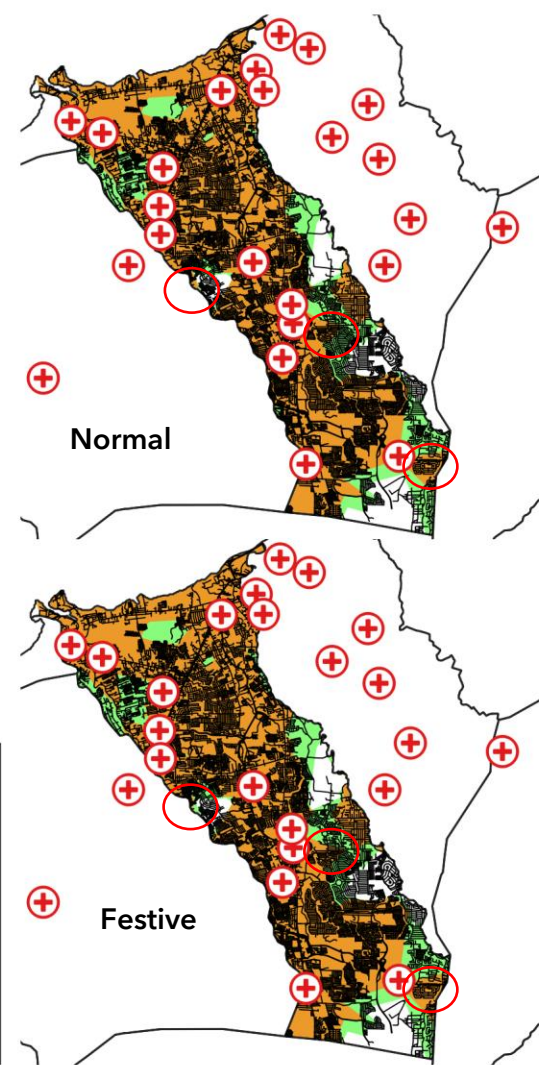
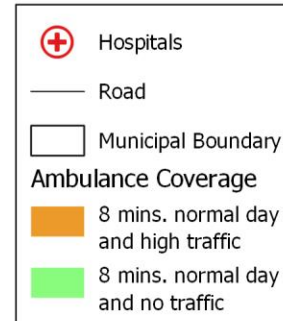


# Results and Discussion

## ▪ Normal vs festive day

This is seen better from a comparison of both normal and festive maps. There is only a slight change in areas covered by EMS in both no traffic and high traffic conditions. Hence, it's likely that the effects of a normal or festive day are irrelevant in causing areas to be vulnerable to EMS delay. Although traffic conditions worsen during festive day, it doesn't result to a reduction in serviceable areas.

Considering that road conditions are variable in real life, it is possible for EMS to reach most the colored zones in Bacoor while there may be difficulty in reaching the uncolored zones, especially as these zones have few connecting road networks.



# Conclusion & Recommendations

The researcher found that there are areas in Bacoar, Cavite that have difficulty in being reached by EMS in time. These areas are mostly in Barangays Molino IV, Molino VIII, Queen's Row East, Mambog III, and San Nicolas III and have few connecting roads to main roads.

Hence, these areas may need to be focused by the local government in order for them to receive on-time EMS. Possible solutions can range from setting up auxiliary stations in nearby barangays or optimize road traffic in the surrounding barangays to make them more accessible.

Although the data is a simulation, it will help provide a rough idea or a baseline on what areas in Bacoar, Cavite are vulnerable to delay in EMS and transport of patients.



# References

DPWH. (2021). DPWH Road Traffic Information. Retrieved January 28, 2023 from <https://www.dpwh.gov.ph/dpwh/gis/rti>

Estember, R.D., Isip, I.G.A, & Misal, M.C.C. (2019). An Optimization-based Approach Model for the Improvement of the Performance of Emergency Medical Service Ambulances. Accessed January 21, 2023 from <http://www.ieomsociety.org/ieom2019/papers/293.pdf>

Gonzalez, R. P., Cummings, G. R., Phelan, H. A., Mulekar, M. S., & Rodning, C. B. (2009). Does increased emergency medical services prehospital time affect patient mortality in rural motor vehicle crashes? A statewide analysis. *The American Journal of Surgery*, 197(1), 30-34. doi:10.1016/j.amjsurg.2007.11.018

Mell, H.K., Mumma, S.N., Hiestand, B., Carr, B.G., Holland, T., & Stopyra, J. (2017). Emergency Medical Services Response Times in Rural, Suburban, and Urban Areas. *JAMA Surgery*, 152(10), 983. doi: 10.1001/jamasurg.2017.2230

Map data copyrighted OpenStreetMap contributors and available from <https://www.openstreetmap.org>

Petzäll, K., Petzäll, J., Jansson, J., & Nordström, G. (2011). Time saved with high speed driving of ambulances. *Accident Analysis & Prevention*, 43(3), 818-822. doi:10.1016/j.aap.2010.10.032