Scaling up Healthcare Capacity Report

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1. Introduction

1.1 Background

"If anything kills over 10 million people in the next decades, it would be most likely a highly infectious virus rather than a war. Not missiles but microbes. We have invested a huge amount in nuclear weapons and invested very little in stopping an epidemic. "[1] These were the words of Bill Gates in 6 years ago at Tedx, telling the world that a next global virus outbreak will be devastating. It is 2021 and we can see that a lot of things Bill Gates said were true. Even the best-developed countries in the world are struggling with the Covid-19 virus.

The Netherlands is one of the best developed West-European countries in the world. It consists of 12 provinces and has over 17 million all living within a total area of roughly 41,800 square kilometers. This makes the Netherlands the 12th most densely populated country in the world and the 2nd most densely populated country in the European Union. However, we have seen that having people living so close together does not have an advantage during the Covid-19 pandemic.

To be prepared for the next outbreak, it is necessary to learn from the mistakes in the past. In the Netherlands we saw the following mistakes during the pandemic:

- *Having not enough test locations at the beginning*
- *Having not enough hospital capacity*

1.2 Problem definition

Looking at the last reports of the European Union Commission of Health, we see that the Netherlands has one of the lowest hospital capacities in Europe[6]. In comparison to Germany, the hospital capacity of the Netherlands is almost 3 times smaller. This doesn't mean that the Netherlands needs to scale up its capacity to be like Germany. There are given advice from different health commissions on the European level; on how much capacity a country should have. The recommended amount is having one hospital with approximately 600 beds per 130,000 inhabitants.

This will also be the standard that we will use in this project. In addition to that, the standard on how many pharmacies are needed is also based on the advice of the European Union Commission of Health. The advised standard is having one pharmacy per 10,000 inhabitants.

However, to deal with another virus outbreak crisis the Dutch government needs to build or scale up its healthcare capacity. Also, there is a necessity to create more locations to provide tests and vaccinations for the people. The best way of providing people this is by doing it at their local pharmacies.

In our research, we will look at where the Dutch government needs to scale up its hospital capacity. Also, we will look if there are enough local pharmacies for tests and vaccinations. Based on the problem description, we have formulated the following questions:

1. *Where and how much does the Dutch government needs to scale up its hospital capacity?*
2. *Are the pharmacies in the Netherlands enough to provide tests and vaccinations for the people?*

2. Data Acquisition and Cleaning

2.1 Data Acquisition

The data acquired for this project is a combination of data from different resources.

- The dataset that contains data about the municipalities in the Netherlands is extracted from citypopulation.de [2]
- I used Foursquare API to get the data about pharmacies and hospitals of the given municipality within the Netherlands [3]

2.2 Data Cleaning and feature selection

2.2.1 Dutch municipality population dataset

The data preparation for each of the data sources has been done separately. Beginning from the population data that has been extracted from citypopulation.de, only columns that contain the municipality name and population of 2021 were selected (see fig 1.1). All the other columns within the data set are dropped. Moreover, we divided the data into different 12 data frames based on the provinces of the Netherlands.

	Municipality	Population2021
0	Drenthe	494,760
1	Aa en Hunze	25,392
2	Assen	68,833
3	Borger-Odoorn	25,596
4	Coevorden	35,321
5	De Wolden	24,374
6	Emmen	107,020
7	Hoogeveen	55,600
8	Meppel	34,383

Fig 1.1 Municipality dataset

The coordinates of the municipalities are obtained using Google Maps API geocoding [5]. Even after using the API, we ended up with some missing values. After dropping these values we obtained a ready-to-use dataset for our research (see fig 1.2).

	Municipality	Population2021	Latitude	Longitude
0	Alblasserdam	20126	51.859952	4.666202
1	Albrandswaard	25799	51.852427	4.435285
2	Alphen aan den Rijn	112580	52.113140	4.640841
3	Barendrecht	48637	51.851938	4.529384
4	Bodegraven-Reeuwijk	35281	52.067755	4.757580
5	Brielle	17423	51.907479	4.167086
6	Capelle aan den IJssel	67315	51.935854	4.589461
7	Delft	103588	51.999457	4.362725
8	Dordrecht	119111	51.795881	4.677935
9	Goeree-Overflakkee	50588	51.751286	4.135770
10	Gorinchem	37416	51.842187	4.974600

Fig 1.2 Municipality data frame of Drenthe

2.2.2 Pharmacy and Hospital datasets – Foursquare API

The next step is gathering data about the pharmacies and hospitals of the municipalities. To retrieve this data we will use the Foursquare API. Foursquare is a location data provider with information about places like pharmacies, hospitals, markets and all sort of different places. Such information includes names, geo-locations and photos. As such, the Foursquare location platform will be used as the sole data source since all the stated required information can be obtained through the API. All the gathered data will be sufficient to build the last model. However before building the last model,

we created two different datasets. Within these sets are data about pharmacies (see fig 1.3) and hospitals (see fig 1.4).

	Municipality	Province Latitude	Province Longitude	Name	Latitude	Longitude	Pharmacy Distance	Category
0	Assen	52.990372	6.553378	Karsten Apotheek	52.992990	6.560543	561	Pharmacy
1	Assen	52.990372	6.553378	Wilhelmina Apotheek	52.983549	6.564975	1086	Pharmacy
2	Assen	52.990372	6.553378	DA Herbrink De Gouden Vijzel	53.000633	6.548710	1184	Pharmacy
3	Assen	52.990372	6.553378	Benu Apotheek Noorderpark	53.005783	6.557255	1735	Pharmacy
4	Assen	52.990372	6.553378	Benu Apotheek De Peeleres	53.016790	6.561295	2988	Pharmacy

Fig 1.3 Pharmacy data set of the Assen Municipality

The column descriptions:

(1) *Municipality :* Name of the municipality

(2) *Province Latitude* : Latitude of the province

(3) *Province Longitude* : Longitude of the province

(4) *Name* : Name of the pharmacy

(5) *Latitude* : Latitude of pharmacy

(6) *Longitude* : Longitude of pharmacy

(7) *Category* : Category

	Municipality	Province Latitude	Province Longitude	Name	Latitude	Longitude	Category
1	Assen	52.990372	6.553378	Wilhelmina Ziekenhuis	52.984009	6.565553	Hospital
3	Hoogeveen	52.726426	6.493081	Ziekenhuis Bethesda	52.727658	6.462393	Hospital

Fig 1.4 Hospital data set of Drenthe (province)

The column descriptions:

(1) *Municipality :* Name of the municipality

(2) *Province Latitude* : Latitude of the province

(3) *Province Longitude* : Longitude of the province

(4) *Name* : Name of the hospital

(5) *Latitude* : Latitude of hospital

(6) *Longitude* : Longitude of hospital

(7) *Category* : Category

2.2.3 Final dataset

After gathering data about the hospitals and pharmacies of the municipalities, the final dataset was created. To build up the last model we used data from the previous steps and merged it into the final dataset. We included the information about the municipality names, population of 2021, pharmacies and hospitals. This data was also used to create new columns. We added 2 new columns were we calculated the summation of hospitals and pharmacies of every municiapalty. In addition, we also made two columns where we calculated the density of the municipalities based on the pharmacies and hospitals (see fig 1.5).

	Municipality	Population2021	PharSum	HospSum	Density Pharmacy	Density Hospital
0	Assen	68833	6	1	11472	68833
1	Hoogeveen	55600	9	1	6177	55600
2	Meppel	34383	5	1	6876	34383

Fig 1.4 Final dataset of Drenthe (province)

The column descriptions:

(1) *Municipality :* Name of the municipality
(2) *Population 2021* : Population of the municipality in 2021
(3) *PharSum*: Summation of pharmacies of given municipality
(4) *HospSum* : Summation of hospitals of given municipality
(5) *Density Pharmacy* : Density of given municipality based on pharmacies
(6) *Density Hospital* : Density of given municipality based on hospitals

3. Methodology

3.1 Required packages

We will be creating our model with the help of Python so we start of by importing all the required packages.

```
import pandas as pd
import requests
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.colors as colors
```

```
import geocoder
from functools import reduce
```

Package breakdown:

- requests : Handle http requests
- pandas : To collect and manipulate data in JSON and HTMl and then data Analysis
- matplotlib : Detailing the generated maps
- numpy: to handle arrays
- sklearn : To import Kmeans which is the machine learning model that we are using
- functools: to merge multiple datasets together

3.3 Foursquare API

For the exploration of the hospitals and pharmacies we use the foursquare API. The limit is set on 100 new explored places with a radius of 3500 meter for each municipality from their given latitude and longitude.

4. Results - Data Analysis

4.1 Summary of data

To obtain insights of the data we used visualization methods. We visualized the information in graphs. Also, we visualized the datasets to see the numbers. In fig 1.5, fig 1.6 and fig 1.7 we display the visualizations of the province Drenthe as an example, the other visualizations can be seen in the Jupyterlab file.

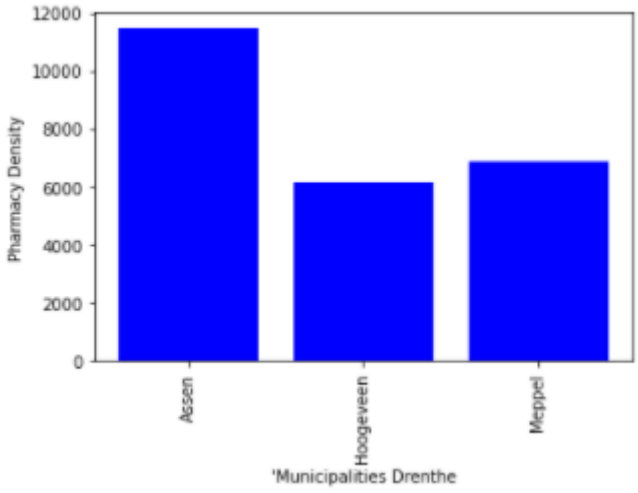

Fig 1.5 Pharmacy density graph Drenthe (province)

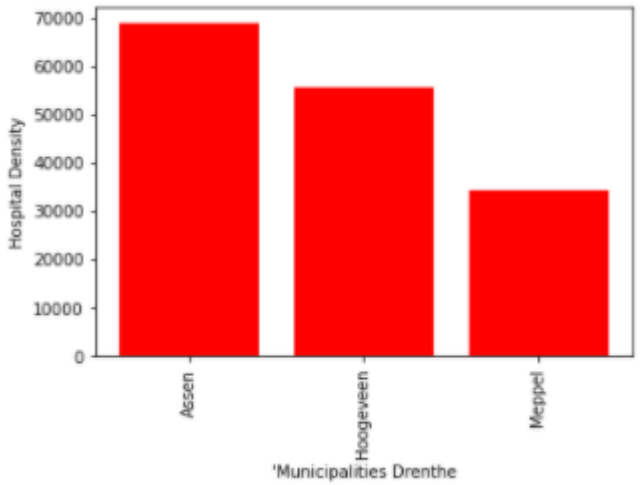

Fig 1.6 Hospital density graph Drenthe (province)

	Municipality	Population2021	PharSum	HospSum	Pharmacy Density	Hospital Density
0	Assen	68833	6	1	11472	68833
1	Hoogeveen	55600	9	1	6177	55600
2	Meppel	34383	5	1	6876	34383

Fig 1.7 Final dataset of Drenthe (province)

Drenthe: The first province has 3 municipalities in the dataset. These are: Assen, Hoogeveen and Meppel. Beginning with looking at the data and visualizations of the province Drenthe we can see that, the municipality of Assen has the highest pharmacy density. By looking at the data of the hospital density we clearly see that Assen also has the highest density.

Flevoland: The second province, Flevoland, has 7 municipalities in the dataset. The data shows us that the municipality of Arnhem has the highest Pharmacy density. In addition to that, Arnhem has also the highest hospital density.

Limburg: The province of Limburg consists of 6 municipalities. What is immediately noticeable about its data is the municipality of Sittard-Geleen; the municipality has the highest pharmacy and hospital density.

Noord-Brabant: When looking at the data of the fourth province, which contains 12 municipalities, we clearly see two of them that are standing out. The municipality of Helmond has the highest pharmacy density and the municipality of Boxmeer has the highest hospital density.

Noord-Holland: In our dataset, the province of Noord-Holland contains 10 municipalities. When looking at the visualizations, we see that Amsterdam has the highest hospital density. However, within the data, we see that Haarlem has the highest pharmacy density.

Overijssel: The province of Overijssel contains 8 municipalities in our dataset. By looking at the data we clearly see that Deventer has the highest Pharmacy density. However, when we look at the hospital density data we see two municipalities with the highest score. These are Enschede and Hengelo.

Utrecht: When looking at the province of Utrecht, we see that the dataset contains just 3 municipalities. The pharmacy density of these municipalities is almost the same. However, the municipality Utrecht has the highest score. When looking at the hospital density we see the municipality of Amersfoort with the highest score.

Zeeland: The province of Zeeland contains 3 municipalities within our data. What is immediately noticeable about this data is that the municipality of Terneuzen has the highest pharmacy density. In addition, the municipality of Terneuzen also has the highest hospital density.

Zuid-Holland: In our dataset, the province of Zuid-Holland contains 16 municipalities. The municipality of Pijnacker-Nootdorp has the highest pharmacy density. When we look at the data about hospital density we clearly see that the score of Municipality Rotterdam stands out.

5. Discussion

As we mentioned before the Netherlands has one of the lowest hospital capacities in the world. Also, to deal with a next virus outbreak the Dutch government has to scale up its capacity. Another aspect we looked at is whether there are enough locations for medical activities such as being able to carry out tests and vaccinations. This brings us back to the research questions of this project. These are: “Where and how much should the Dutch government scale up its hospital capacity?” and ”Are there enough pharmacies that can serve as a test and vaccination location?”.

The study was conducted based on the recommended standards from the European Union Commission of Health [4]. These standards were having one hospital per 130,000 inhabitants and having 1 pharmacy per 10,000 inhabitants. In our results we result, we can see which municipalities need more hospital capacity and which municipalities can use more pharmacies. We can also see to what extent they deviate from European standards.

Drenthe: To start with the province of Drenthe, we can see that the municipality of Assen only needs an extra pharmacy. Furthermore, the province is good when it comes to having enough hospital capacity.

Flevoland: When looking at the results of the second province we clearly see that the municipalities of Almere and Noordoostpolder can use extra pharmacies. Moreover, we can also see that the municipality of Almere can use more hospital capacity.

Gelderland: The results show us that the municipalities Arnhem, Doetinchem, Nijmegen, and Zutphen need more pharmacies. However, the results also show us that the municipalities within Gelderland don't need extra hospital capacity.

Limburg: There are two municipalities that need extra pharmacies, these are: Sittard-Geleen and Venray.

Noord-Brabant: When we look at the data of Noord-Brabant, we see that almost every municipality needs extra pharmacies. These municipalities are: Bergen op zoom, Breda, Eindhoven Etten-Leur. Helmod, Oosterhout, Roosendaal, 's-Hertogenbosch, Son en Breugel and Velhoven. Moreover, the data shows us that the municipalities Breda and 's-Hertogenbosch needs their hospital capacity to be scaled up.

Noord-Holland: Within the province of Noord-Holland we see that the municipalities Amsterdam, Haarlem, Laren, and Purmerend need more pharmacies. Furthermore, we can see in the results that Amsterdam really needs to scale up their hospital capacity.

Overijssel: There is one municipality that doesn't meet the European standards within the province of Overijssel. The municipality Deventer needs more pharmacies.

Utrecht: When we look at the data about the province of Utrecht we see that all of the municipalities need extra pharmacies. Moreover, the data shows us that the municipality of Amersfoort needs to scale up its hospital capacity.

Zeeland: Zeeland is the only province that meets the standards of the European Union Commission of Health.

Zuid-Holland: There are 8 municipalities that need more pharmacies within Zuid-Holland, and these are: Alphen aan den Rijn, Gouda, Lansingerland, Leidschendam-Voorburg, Pijnacker-Nootdorp, Rotterdam, Schiedam, Vlaardingen and Zuidplas. Furthermore, there is one municipality that needs their hospital capacity to be scaled up and that is Rotterdam.

6. Conclusion

With our experiences from the Covid-19 crisis, preparing for another global virus outbreak has become necessary. This project helps the Dutch government to see where hospital capacity needs to be scaled up. Also, this project shows an overview to what extent the pharmacies can be used as a location to provide test and vaccination capacity for the people. The Dutch government can decide to open more pharmacies or to build or to build extra locations for a short period.

7. References

[1] Bill Gates at Tedx

[2] Data of municipalities

[3] Foursquare API

[4] https://ec.europa.eu/info/index_nl

[5] Google Maps API geocoding