Team Member

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The following document is still evolving. Its final version will be uploaded by the 04-01-2021 on the website. However, important sections about this document will be continuously updated after their completion before the 04-01-2021.

1. Introduction

Within our design challenge project, I will focus on the epidemiological characteristics of COVID-19 in overcrowded queue settings. Given the fact that our main stakeholder spends hours of lining up for resources like water and food supplies in the camp Moria (Harlan, 2020), my deepening can prove to be essential to determine a feasible solution. In my deepening, I want to explore what implications the long queues in Moria have regarding the transmission of COVID-19 and how to combat the spread of the disease with proper epidemiological measures. To gain a good understanding of these fields, I will research the following topics:

- Epidemiology of COVID-19
- Existing Mechanisms for the Prevention of Viral Diseases in Queue Settings - Focus on COVID-19
- Modelling of Hindering the Transmission of Viral Diseases in Queue Settings - Focus on COVID-19
- Design Visualisation of Epidemiological Data

This is a specialisation in epidemiology. For this project, I would like to present my findings in an essay with visuals supporting the data of this deepening. The topic of epidemiology is quite complicated, and it deals with tremendous amounts of advanced calculations. Therefore, it is essential to find ways to make the epidemiological insights of this paper accessible to the broad audience.
An essay will allow me to elaborate on definitions and findings based on calculations and discuss their relevance to a potential solution to the challenge we identified. I will also be able to include visual representations of the epidemiological situation in Moria in an essay which will make the gained information even more understandable - turning it into knowledge.
Additionally, an essay will give me the chance to attach an appendix with all detailed calculations done to support the findings of the epidemiological situation of our main stakeholder, so even experts can critically evaluate the results of this deepening. The main scope of the format of this deepening will be to create a comprehensive and transparent document that can be assessed by experts and understood by non-experts.

2. Intended Learning Outcomes

In this deepening, I would like to explore the epidemiological characteristics of COVID-19.
A crucial finding of my research will be to address the question, "how to efficiently prevent the spread of COVID-19 in the refugee camp, Moria - using epidemiology-based insights."
I want to acquire the knowledge needed to understand the mechanisms of transmission of communicable diseases like SARS-CoV-2 in queues and how to model a reduction of an outbreak in this particular setting.
The outcome of my deepening has to highlight the relevance of our solution and answer the question whether it is going to contribute to one of the main pillars of our design challenge - the significant prevention/reduction of the scale of a potential outbreak with the virus.
Below, you will find three intended learning outcomes I formulated for the purposes mentioned above:

1. Understand the epidemiologic characteristics of COVID-19 and create a link to your research regarding the design challenge.
2. Explore the physics of transmission of COVID-19 and gain a profound understanding of how they work and how transmission can be hindered, i.e. what guidelines are useful to minimize transmission.
3. Comprehend how to mathematically model the transmission of any disease under idealised conditions and develop appropriate measures to minimise the paths of transmission of a pathogen to infect susceptible persons. Apply your general findings to a potential epidemic with COVID-19 in the Greek refugee camp, Moria.
   Note: Mind to critically evaluate which model(s) might be useful for this purpose and argue why you have chosen a specific model over others.
4. Visualise your findings, so that every non-expert can easily follow the line of reasoning as well as your results. Discuss the implications and limitations of the used model(s) and how they relate to the design challenge.

3. Relevance

3.1. Individual Relevance

In this section, I would like to elaborate on the main reason why epidemiology is a relevant deepening for me.
I enjoy, and I am very passionate about problems related to physical and mathematical modelling. Therefore, I would love to work in a domain that includes a lot of questions from mathematics and physics. I want to be able to make contributions to the global pool of useful findings in the realm of knowledge and application of the mathematical and physical sciences. Thus, I need a robust skill set when working on advanced mathematical or physical phenomena.
Mathematical modelling and epidemiology are more closely related to each other as one would think in the first place.
Epidemiology has to do a lot with mathematical modelling of complex systems - using diverse differential equations and statistical analysis methods to help determine the significance of specific factors and how they can damage public health. Mathematical modelling also helps predict how specific measures could counteract ‘bad’ health behaviours or the spread of disease and secure higher health standards in public. Hence, my deepening in epidemiology will be tremendously useful for me - academically too. I not only enjoy complex mathematical modelling but also I plan on developing strong skills in this domain for my future career. Epidemiology will, thereafter, be a very significant deepening which will help me develop strong modelling abilities in the hard sciences - in a challenging and context-related setting.

3.2. Relevance to the Project

Epidemiology is going to be crucial in understanding the transmission of COVID-19 in queues and how mechanisms can be developed to minimise potential outbreaks in this specific setting. It will further give us insight into what solutions may be plausible and successful while trying to prevent the spread of the disease. We want to design a solution that reduces the rate of infection with SARS-CoV-2 in extremely overcrowded locations where people have drastically limited options to protect themselves. Epidemiology is an integral part of comprehending the virus’ interactions and transmission paths. Insights from epidemiology will be imperative, for instance, for creating a physical solution to the problem of hindering the transmission of COVID-19. So, this domain is of extreme value to the challenge we face.

4. Introduction to Epidemiology and its links to our design challenge

Epidemiology is a scientific discipline which sets the foundation for public health regulations, standards and legislative decision-making. Its methods analyse the cause of health problems, health outcomes or diseases in populations. The central patient of epidemiologic research is the community itself, where all individuals belonging to a population are examined as a collective unit (Centers for Disease Control and Prevention 2016).

Based on multiple disciplines (medicine, mathematics, biology, sociology), epidemiology not only strives to explain potential causes for diseases or other public-health-related issues. But it also supervises current developments (rate of incidence, distribution). Epidemiological findings advise policymakers how to control the spread of disease or other factors putting the public health at risk. This discipline also evaluates the effects of implemented policies on public health (Centers for Disease Control and Prevention 2012).

Hence, this medical domain is imperative to understand better our design challenge and what feasible solutions might be to tackle the transmission of COVID-19 in Moria actively. In our context study, we identified a potential primary source of infections with the novel coronavirus - queues. Refugees on Lesbos line up for up to eight hours for resources like water or food supplies (Harlan 2020). It makes sense to analyse the transmission of this betacoronavirus (genus of the virus) and how possible transmission paths of it can be reduced by specific measures based on mathematical epidemiology generally and in queues.

5. Physics of COVID-19 Transmission

In the following sections, we will discuss airborne transmission of respiratory diseases, how their transmission can be modelled by the S-I-R-Model and what important insights can we use from

5.1. Introduction to COVID-19

SARS-CoV-2 belongs to the family of coronaviruses. Coronaviruses are enveloped RNA-viruses (fig.1) that build viral structures with a diameter of 80 to 140 nm (Kaniyala Melanthota et al. 2020). These structures consist of RNA-molecules (with a positive polarity) of about 30.000 bases - the biggest genome of all RNA-viruses (Robert Koch Institute 2020).

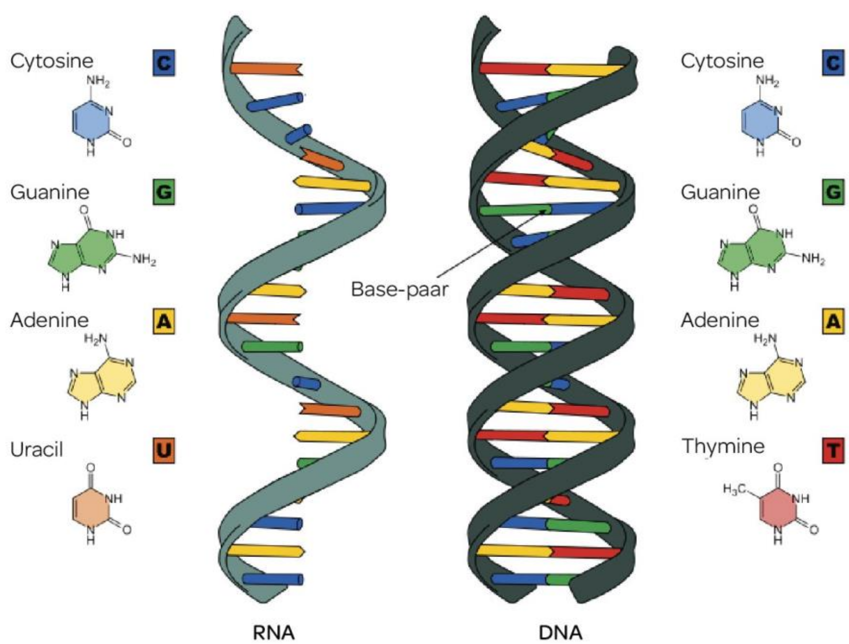


Figure 1, Comparison of RNA to DNA

The outbreak of the novel coronavirus disease (COVID-19) has quickly become an emergency of primary international concern - turning into a pandemic where over a million people have lost their lives. The virus was initially detected in the Chinese province, Hubei, a couple of weeks before the end of 2019. The infection with

SARS-CoV-2 causes clusters of severe respiratory illnesses comparable to other severe acute respiratory syndrome coronaviruses, e.g. SARS-CoV or MERS-CoV (Zhai et al., 2020).

There are several transmission paths identified that could infect a susceptible individual with human-to-human transmission being the most prominent path of infection (Zhai et al. 2020).

In a study regarding the transmission of the disease, Zhang et al. (2020) found that *"airborne transmission route is highly virulent and dominant for the spread of COVID-19."* This means that contamination occurs via droplets, contaminated hands or surfaces. The incubation periods of the virus extend from 2 to 14 days (Zhai et al. 2020).

The Dutch National Institute for Public Health and the Environment (2020) also reports some cases of animal-to-human transmission with minks being a secondary source of infection. The institute emphasises that some pets have been identified as carriers of the virus, but there is no evidence that pets have infected humans.

In a meta-analysis (including 45 different studies from January to August 2020), conducted by Ahammed (2020), results have shown that the basic reproduction number of the virus approaches a global average of 2.69 (margin of confidence: 0.95). According to the Federal Institute for Disease Control and Prevention of Germany (2020), the basic reproduction number of a disease describes how many people an individual can infect on average. For comparison, the novel pandemic influenza virus from 2009 had a reproduction number of 1.1 to 1.5 (Cowling 2011) - SARS-CoV-2 is seemingly highly infectious.

Note: To prevent an endemic (an outbreak restricted to a small local area), epidemic (an outbreak restricted to broader regions, even multiple countries) or a pandemic (global outbreak), the basic reproduction number of a communicable disease has to be less than one (Ahammed 2020).

An imperative epidemiological characteristic of any disease is its rate of mortality - the average percentage of fatal outcomes concerning the entire infected population. In Ahammed's meta-analysis (2020), the average fatality rate of COVID-19 is estimated to be 2.67% globally - despite social distancing and other measures of prevention. This might seem a small number. Indeed, in the next sessions, we will show that this is not the case - under the characteristics of COVID-19, it is expected that almost every individual on the planet will contract the disease sooner or later (provided the basic reproduction number does not reach values below one - a goal that can be attained by successfully vaccinating all susceptible population).

According to the platform Population Reference Bureau (2020), there are 7.8 billion people on the planet. Suppose we made a very rough estimate that everyone contracted the disease. Then, the fatal outcomes may approach the devastating number of 200 million casualties - based on the current global case fatality rate.

Understandably, national governments have put a lot of effort in developing appropriate measures that can keep infection rates as low as possible (OECD 2020).

5.2. Transfer of Respiratory Diseases

In the following chapters, we will study the transfer of respiratory pathogens that originate in the human respiratory system and how they are transmitted to other individuals - potentially infecting them. This focus is crucial to understanding the contagion mechanisms of the airborne respiratory disease - COVID-19.

5.2.3. Airborne Droplets

Respiratory pathogens, and particularly, contagious pathogens such as viruses and other bacteria which infect the human respiratory system are normally transferred through droplets which are emitted by respiration. This can be the result of coughing, sneezing or just normal breathing (Centers for Disease Control and Prevention [CDC], n.d.).

There are three possible outcomes once the pathogen is released with droplets to the host’s environment:

1. The droplets are light enough to evaporate, so the pathogen would eventually lose its viability
2. The droplets are heavy enough to settle down on the floor. If the pathogen in the droplets remains viable long enough to infect others while entering their bodies through any bodily entrance point, the transmission effectuates through fomites - the pathogens sticking to the surface.
3. If the droplets are not too light or too heavy, they remain in the surrounding air for hours and someone else could breathe in those droplet aerosols easily and hence, the chance of infection through this path is the highest.

Let us analyse the fate of a droplet. Will it fall? Will it evaporate or will it simply remain in the air floating around for hours as an aerosol?

It turns out that when applying the laws of fluid mechanics, the fate of a droplet is mostly determined by its radius R.
For instance, if we wanted to know how long a droplet would need to fall down to the ground, we can use the following formula

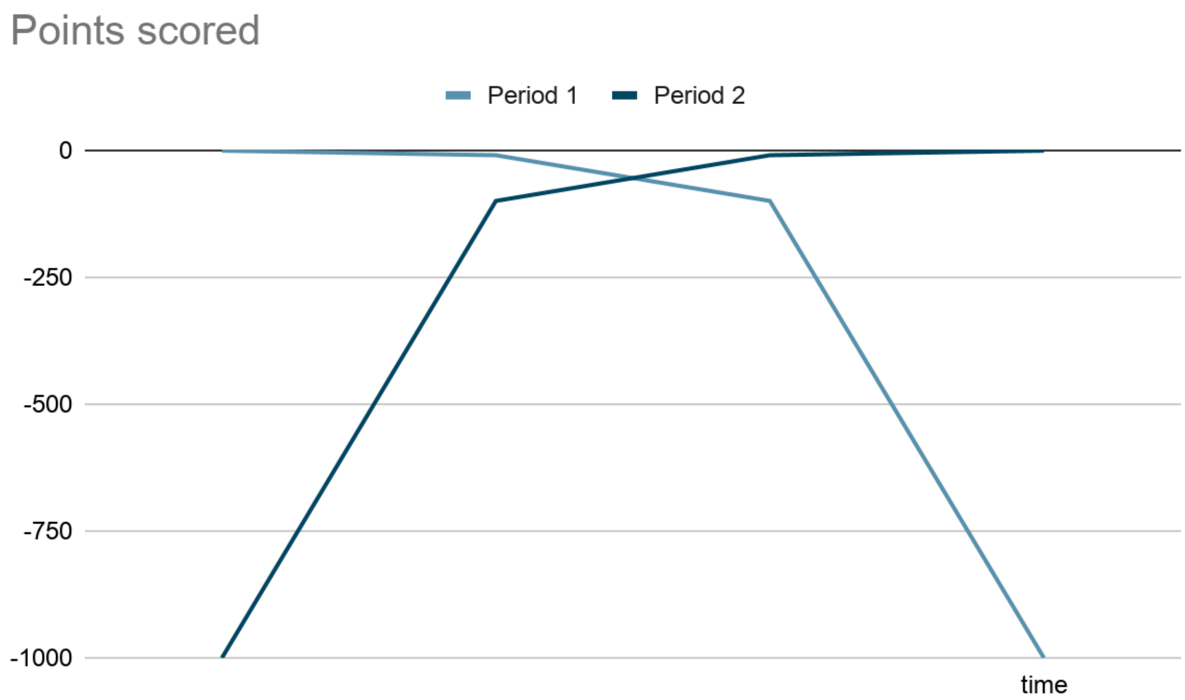
$$t_{fall} = \frac{9L\mu_a}{2\rho g R^2}$$

where L is height, $\mu_a$is the fluid's viscosity, ρ is the droplet's mean density and g is the gravitational acceleration. This formula indicates that the bigger the size of the droplet, the faster it will settle down on the ground which is something we would expect in our everyday life too.

Accordingly, we can derive an expression for the time needed for a droplet to evaporate in the environment assuming diffusional motions in the surrounding area (i.e. particles mixing among each other to create a homogeneous mix)

$$t_{evaporation} = \frac{R_0}{D(1-RH)}$$

Where D symbolises diffusivity and RH represents the relative fluid's humidity.



SEIR Model

Based on calculations of the SEIR model and under the following conditions

- Basic reproduction number of 2.5 (estimation, may be rather underestimated due to the living conditions in Moria)
- Transmission time: approximately 10 days
- Mortality rate: 2.8% (high for Greece, however, equal to global mean value)
- Duration of patients to be infectious: approximately 14 days
- Incubation: approximately 10 days
- 9 COVID-19 infections in the camp 30 days ago (source available, to be added)
- The whole population is uniform, homogeneously distributed and everyone has contact to everyone (simplifications made even in more complex models)

Then our solar still might reduce up to 3500 infections based on the current camp's population of 7500 and we can save up to 100 lives (all these numbers are based on calculations and computer simulations which will be uploaded soon)