Project Optimization of Business Processes
Short-Term Residential Care

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Chapter 1

Introduction

Older adults admitted to the hospital are at risk of adverse health outcomes, such as infections, delirium, falls and even death. Moreover, prolonged hospital stays caused by delayed transfers of care lead to adverse events and high costs. In response to this, during the last decade, many governments implemented intermediate care intending to avoid hospital admissions and to support older adults in their recovery after hospital admission. The introduction of intermediate care has led to decreased lengths of stay in hospitals.

In the Netherlands, the government implemented Short-Term Residential Care (STRC) in 2015 as part of extensive healthcare reforms because of rising expenses. STRC is bed-based care for general health problems that do not require admission to the hospital yet cannot be treated at home. STRC aims to enable older adults to return home and live independently in their community.

Older adults can be admitted to STRC from home or after hospital admission. Because STRC is a mid-chain care form, upstream and downstream bed-blocking hinder timely admissions and transfers. On the one hand, STRC beds are blocked if older adults cannot be transferred to long-term care or home. On the other hand, if STRC is full, hospital beds are blocked. Also, if a patient cannot be admitted to STRC from home, the patient is likely referred to the hospital. If we know what capacity is needed and which STRC policies perform best, we can prevent hospital admissions and the consequent adverse events and high costs.

In this study, we simulate how admission time and bed-blocking are affected by various parameters. Furthermore, construct a decision support system to answer what-if questions on possible future scenarios.

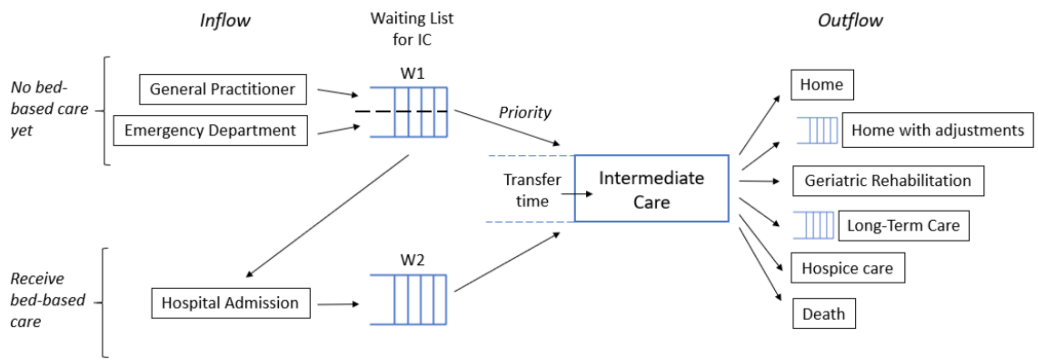


Figure 1.1: Flow diagram

Figure 1.1 shows how the inflow and outflow of patients are structured. Patients arriving from either the general practitioner (GP) or the emergency department (ED) have priority over the ones arriving from the hospital (HA) because the last-mentioned ones are already occupying a bed and receiving care. If the Intermediate Care is at full capacity (no more beds available), then all patients from the GP or ED go to the hospital, which is assumed to always be able to admission capacity. Once arriving at the Intermediate Care, it is known how long each patient will stay there and what his/her next destination will be. After the length of stay is completed, the patient leaves the Intermediate Care.

1.1 Alternative Policy Scenarios

1.1.1 Admission Turn

A proposed alternative is to compensate STRC sites for conservation beds in the evenings as an alternative to hospitalization. It means each other evening/night/weekend day-specific location responsible for GP, ED, or a hospital. We model this by enabling 24/7 STRC entries.

1.1.2 Higher Tariff

The fees that the STRC organization currently receives from health insurance companies are not enough to compensate for high care intensity. Due to Budget limitations, care is more evenly distributed over time, resulting in longer lengths of stay. The proposed alternative is to raise the tariff so that diagnostics and therapy can begin immediately upon admission, resulting in shorter lengths of stay for older adults who return home.

1.1.3 Reduce Bed-Blocking

Patient discharge may be delayed due to the inability to return home on time and necessary adjustments to allow the patient to go home. A stair lift is one example of a home adjustment.Rapid implementation of home adjustments results in a shorter length of stay for patients who require home adjustments.

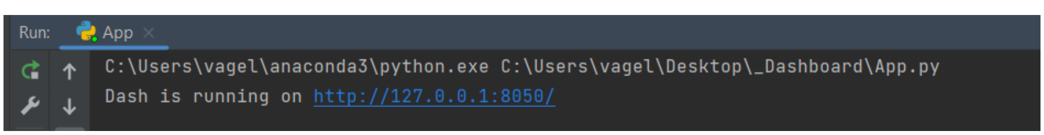
Chapter 2

User Manual DSS

Dashboards are designed to provide graphical displays of projects, along various X axes. An interactive dashboard is a visual representation of data that allows users to explore and analyze information in real-time. This manual provides instructions on how to use the interactive dashboard effectively. The code for the creation of the dashboard is written in the programming language "Python" using "Plotly dash" , an open source graphical Python library.

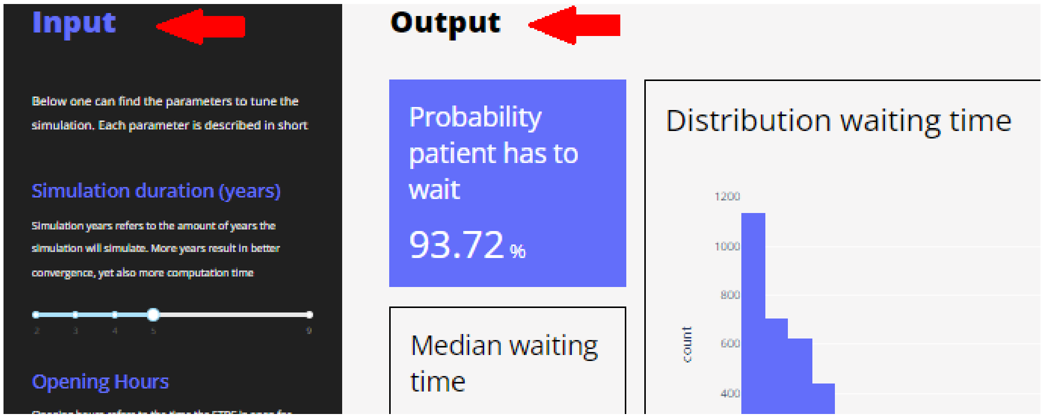
2.0.1 Login:

To access the dashboard, you will need to run the "App.py" inside the file "Dashboard" in one of the open-source platforms; Integrated Development Environments (IDE), "Spyder" or "PyCharm" for instance. Once you run it, a URL address will appear on the right side of the screen (console). The dashboard can be accessed through a web browser at this specified **URL**. Upon opening the dashboard, you will be presented with a user interface.



2.0.2 Navigation:

The dashboard is divided into two sections, including **Inputs** (sidebar), and **Outputs** (data visualization area). The data visualization area displays charts and graphs, as well as many other output values like the Mean, Probabilities or Standard deviations, that illustrates the data for the analysis.

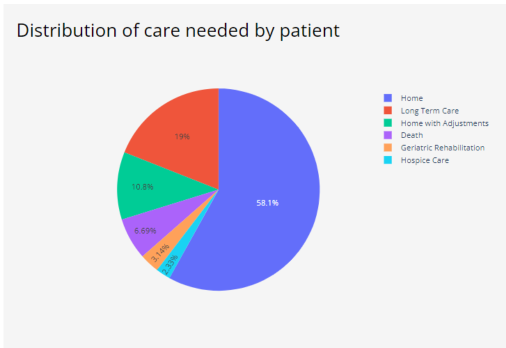


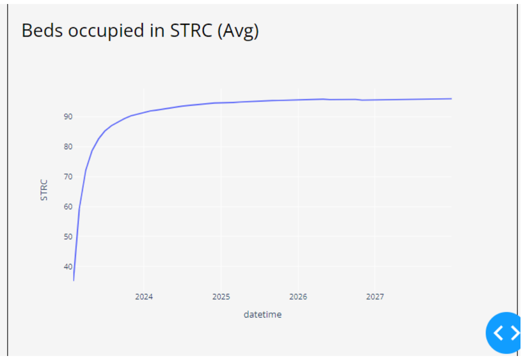
2.0.3 Data Filtering:

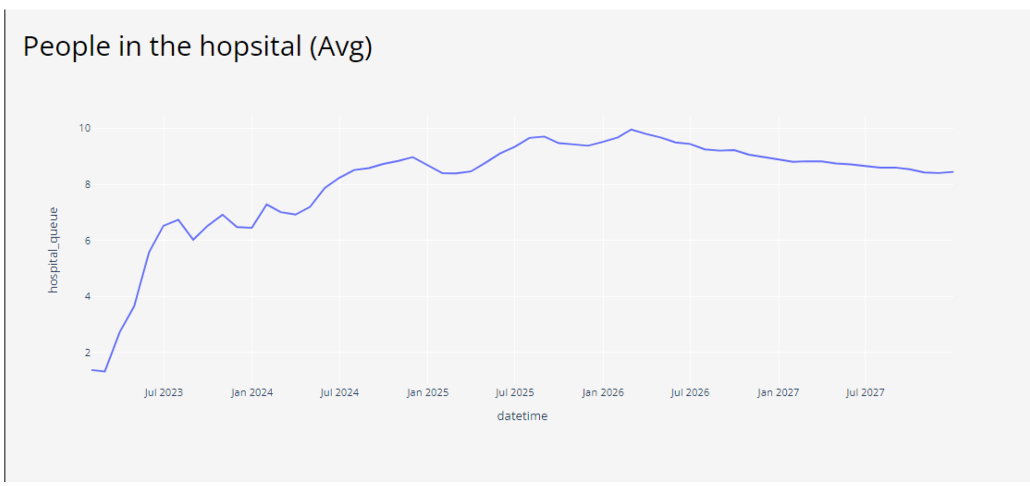
The dashboard is designed to be interactive, allowing you to change inputs and see the effects on the outputs in real-time. The inputs section of the dashboard allows you to select various options that affect the output of the dashboard. For example, you may be able to choose Simulation duration with a scale of 2 to 9 years, Opening Hours 0 to 23 where 0 is defined as 24:00, Number of Beds starting from 2 and ending in 200, or What-If scenarios which are measured in percentages (e.g 1.2 refers to an increase of 20% the increase in elderlies). As far as the Output section is concerned, the dashboard displays the results of the inputs you have selected. The outputs can be displayed in various forms such as graphs or numbers.

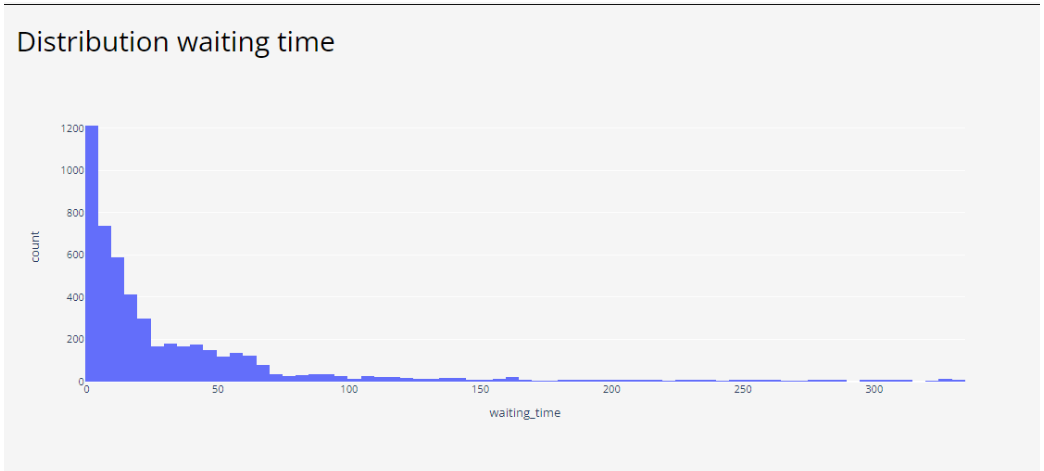
2.0.4 Data Visualization:

The dashboard provides several types of data visualizations, including **bar charts**, **line charts**, and **pie charts**. Users can use these visualizations to understand the data at a glance and identify trends and patterns. More specifically, the dashboard consists of a Bar chart that refers to the Distribution of Waiting times, and a line graph that displays the behaviour of the average number of people in the hospital over a selected period of time. Likewise, the second line graph demonstrates the Bed occupancy in the Short term Residential Care within a selected time period. At last, the pie chart is decomposed into 6 different components and represents the distribution of care each patient needed.









By following these instructions, you can use the interactive dashboard to analyze and interpret data in real time. Whether you are a business professional or a student, this tool will help you gain valuable insights and make informed decisions.

Chapter 3

Documentation DSS

From [1] much information can be gathered, such as the arrival rates from the general practitioner, emergency department and hospital admission. Moreover, the outflow probabilities and average length of stay for the six possible outflows (home, home with adjustments, geriatric rehabilitation, long-term care, hospice care, and death) are also given. Lastly, from the paper, it is known that the arrivals follow a Poisson distribution, while long-term care and home with adjustments follow a Gamma distribution, and finally home, death, geriatric rehabilitation, and hospice care follow exponential distributions. These values are all used in the simulation, independently of the algorithm.

Figure 3.1 shows an example of the dashboard given the following parameter choice:

- 5 simulation years
- Opening hours of STRC: 9-17, weekends excluded
- 100 beds
- Patience level of 8 hours
- Transfer time of 8 hours
- No increase in arrivals
- No decrease in length of stay

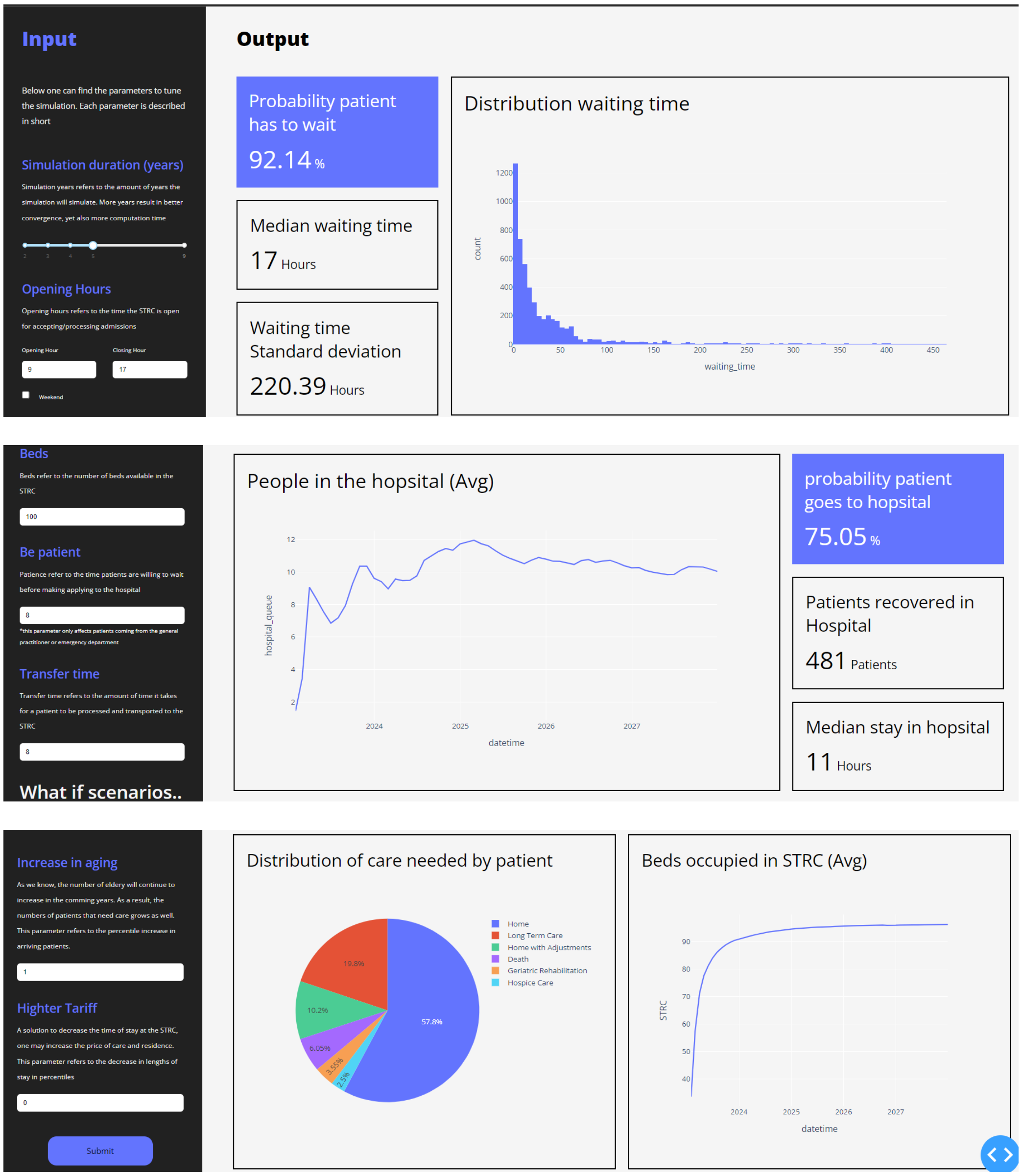


Figure 3.1: Example dashboard

Chapter 4

Scientific explanation algorithms DSS

4.1 Simplified model

4.1.1 Assumptions

To get an initial working model, some assumptions are made to make the simulation process less complicated:

- The simulation is done per day
- Weekend admissions are not possible: patients who require to be admitted at the weekend have to wait until the start of the next week
- No transition time is considered: as soon as a patient leaves, another one takes its place
- When a patient enters the STRC, the length of stay and outflow are directly computed
- There are no queues for the outflows: when a patient has completed the length of stay, the STRC is left

4.1.2 Algorithm

Given the above-mentioned assumptions, a given number of days is simulated and works as follows:

1. At the start of the day, the residual length of stay for the patients is reduced by one (for the day before)

2. The patients with a residual length of stay equal to zero are removed from the STRC. Their beds become available again, and the algorithm adds them to the number of recovered patients

3. A random number of patients sampled from a Poisson distribution arrives from the GP, ED and HA

4. Since the GP and ED patients have priority, it is checked whether there are enough beds available for them. If that is the case, the same is done for the HA patients, otherwise, the remaining patients from GP and ED join the HA ones.

5. For each of the patients admitted into the STRC, their outflow is sampled from a uniform distribution (split into intervals based on their probabilities)

6. The length of stay of each patient is sampled from the distribution of the outflow

7. The model keeps track of the number of blocked patients, and their waiting time in hours

4.2 Final model

4.2.1 Assumptions

For this model, fewer assumptions are made, and more parameters are added. The assumptions made are the following:

- The simulation is done per hour

- A transfer time in hours is added. This is the time needed to go to the STRC

- Patients have a patience level (after this number of hours the patient is not admitted, the admission will be in the hospital and not in the STRC)

- When a patient enters the STRC, the length of stay and outflow are directly computed
- There are no queues for the outflows: when a patient has completed the length of stay, the STRC is left

In addition, this model allows you to have more freedom in the parameter/scenario choice:

- The "Admission turns" scenario is included (patients can be admitted 24/7 to the STRC)
- What if questions such as the effect of an increase in arrivals can be easily implemented by changing the parameter "inc_arrivals"
- The "Higher tariff" policy is included (increase the bed costs to reduce the length of stay)

4.2.2 Algorithm

The algorithm is similar to the one of the simplified model, but there are some additions. The main difference in input is that the arrival rates of GP, ED, and HA are divided by 24, as now they are still Poisson distributed, but per hour instead of per day. Then, the algorithm is as follows:

1. If the 24/7 admission is chosen, at the start of the day, the residual length of stay and the patience level of the patients are reduced by the number of hours the STRC was closed. Otherwise, the same values are reduced by 1 for the hour before
2. The patients with a residual length of stay equal to zero are removed from the STRC. Their beds become available again, and the algorithm adds them to the number of recovered patients
3. The patients with a patience level equal to zero are removed from the STRC waiting list and admitted into the hospital
4. A random number of patients sampled from a Poisson distribution arrives from the GP, ED and HA

5. Since the GP and ED patients have priority, it is checked whether there are enough beds available for them. If that is the case, the same is done for the HA patients, otherwise, the remaining patients from GP and ED join the HA ones.

6. For each of the patients admitted into the STRC, their outflow is sampled from a uniform distribution (split into intervals based on their probabilities)

7. The length of stay of each patient is sampled from the distribution of the outflow

8. The algorithm outputs two CSV files: "system.csv" and "patient.csv"

The system.csv keeps track of the date, day, number of arrivals, waiting list, hospital queue, transportation time (shuttle bus), and number of patients that recovered.

The patient.csv keeps track of the arrival time, departure time, admission time, waiting time, time of recovery, department the patient comes from, length of stay, time on the waiting list, and whether the patient was blocked.

4.3 Dashboard

Following the completion of the simulation, a Dashboard was created to visualize and communicate the simulation's results in a clear, concise, and easily digestible manner. As a result, users can be given the appropriate insights and assistance, in order to be able to understand the simulation's outcomes and make informed decisions based on the results.

For its implementation, the Python framework **"Plotly dash"** was used to create a user-friendly graphical interface. The Dash application is made up of 2 building blocks :

1. **Layout**
   Describes the look and feel of the app; it defines the elements such as graphs, dropdowns, and so on by using **Dash Core components**, as well as their placement like size and color. Dash includes also **Dash HTML components**, which allows to use Python to create and style HTML content; headings and paragraphs for instance.

2. **Callbacks**
   Are used in dash applications to add interactivity. These are the functions that allows the activity that would happen on clicking a button or a dropdown.

Chapter 5

Verifications

From [1] it is known that the arrivals follow a Poisson distribution. In the paper it is stated that "a chisquare test indicated that the number of arrivals per week can be according to a Poisson distribution X^2 (df = 15, N = 52) = 11.0, p > 0.05". This is shown in figure 5.1

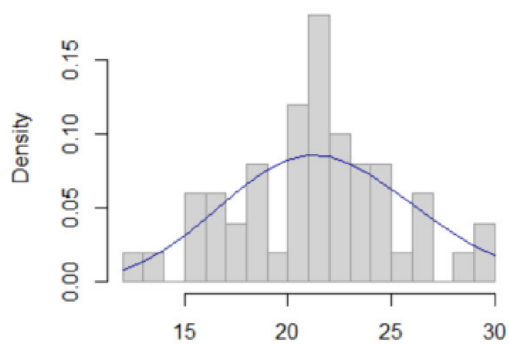


Figure 5.1: Density of weekly arrivals and fitted Poisson distribution

The distributions of the outflows are also given in the paper. We know that Long-term care and Home with adjustments follow Gamma distributions, while the other four (Hospice care, Death, Geriatric rehabilitation, and Home) follow exponential distributions, as shown in Figure 5.2. It is therefore assumed that the outflows follow those distributions.

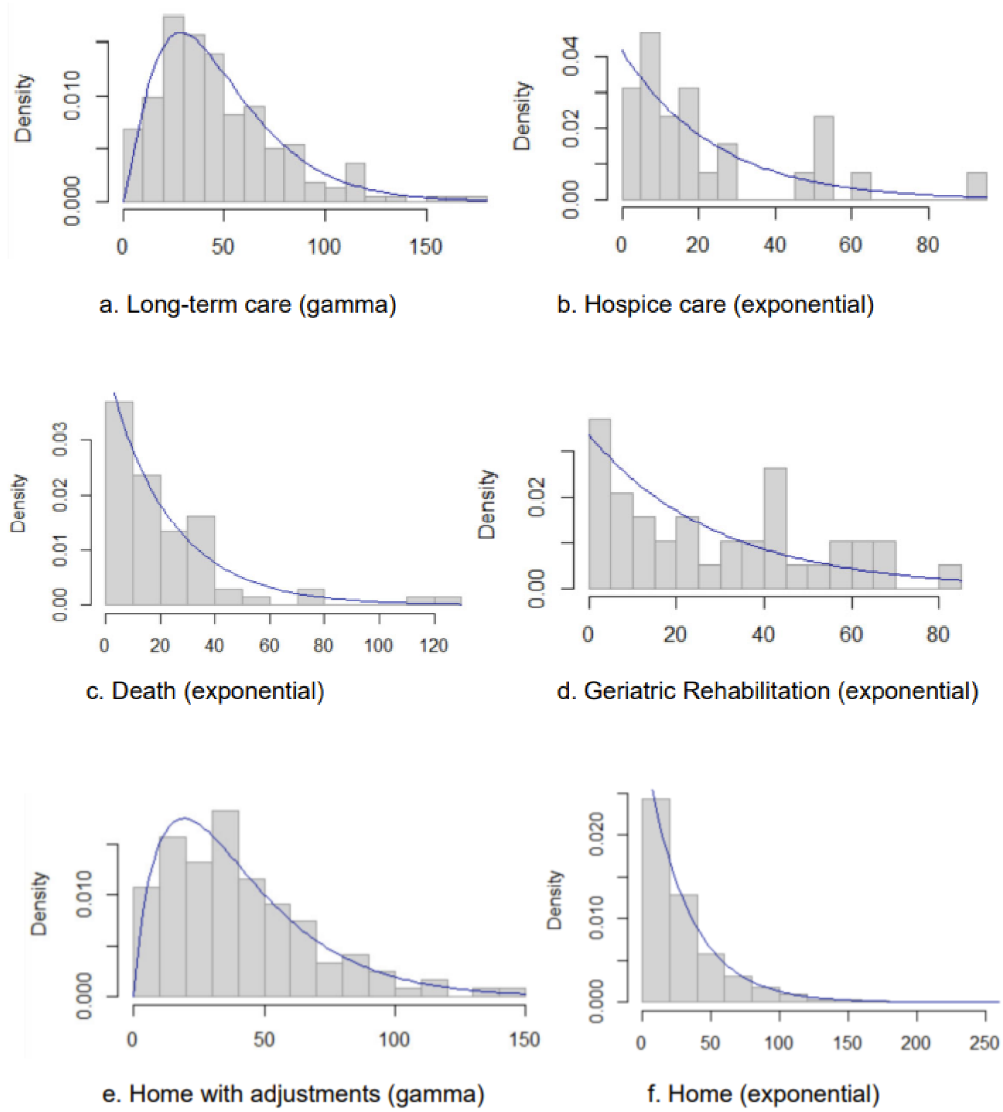


Figure 5.2: Density of outflows and fitted distribution

Figure 3.1 in chapter 3 shows an example of the dashboard for some parameters. It is difficult to prove the shown results are correct, but we can say that all the results shown are in agreement with one another. In fact, if there is a high percentage of probability of having to wait (90.86%), it is also reasonable to assume that both the number of people in the hospital and the number of beds occupied in the STRC increase over time.

5.0.1 Limitations

Our dashboard can be improved. A limitation is that the parameters cannot be changed mid-simulation, but have to be specified beforehand. Therefore, a sudden increase in for example arrivals cannot be taken immediately into consideration. Moreover, this dashboard is meant to give a long-term idea about the STRC based on the initial parameters, so it does not make much sense (and it is also not possible) to only simulate for a very short (a couple of weeks/months) period of time.

Chapter 6

Appendix

6.1 Time registration Evangelos Niklitsiotis

- Make and prepare presentation 3 : 3 hours
- Write report : 2 hours
- Write code for dashboard layout : 20 hours

6.2 Time registration Stergios Ntanavaras

- Write the code for the dashboard layout: 20 hours
- Make and prepare presentation 2: 1 hour
- Write report: 4 hours

6.3 Time registration Tim van Twillert

- Make and prepare presentation 1: 45 minutes
- Make layout for the report in latex overleaf: 30 minutes
- Make and prepare presentation 3: 45 minutes
- Write simulation code: 20 hours
- Write report: 4 hours

6.4 Time registration Yossi Hartman

- Make and prepare presentation 2 hours
- Make and prepare dashboard 24 hours
- Write simulation code: 40 hours
- Write report: 1 hour

Bibliography

[1] Rebekka Arntzen, Judith van den Besselaar, René Bekker, Bianca Buurman, Rob van der Mei. *Avoiding Hospital Admissions and Delayed Transfers of Care by Improved Access to Intermediate Care: A Simulation Study.*