Forecasting the Capacity Requirements at a Pharmaceutical Production Site during Clinical Trials

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Agenda

1. What are the challenges we are looking at today?
2. What was our motivation to tackle these challenges?
3. What are the challenges for our project partner?
4. How does the study design influence the work load?
5. Where does the uncertainty come from?
6. What is the general problem we are dealing with?
7. What did we achieve so far and how did we do it?
8. What are the next steps?

What are the challenges we are looking at today?

- Imagine a human resource planner:
  - Based on a workload forecast, the planner
    - Determines how much staff is needed in the long term
    - Determines what kind of workforce is needed in the long term
    - Decides how many people belong to a work shift and when to schedule the work shifts in the short and mid term
  - ➢ Quality of the planning highly depends on the quality of the workload forecast
  - ➢ But: **How to make a good workload forecast especially when the human resource and capacity requirements are stochastic?**

What was our motivation to tackle these challenges?

- Project partner from the biotechnology sector
  - Focused on developing fully individualized cancer immunotherapies
  - Input for production is a patient's tumor and blood sample
    - ➢ Production process starts with the arrival of the patient's samples
    - ➢ Patients become part of the supply chain
  - Producing for various clinical trials to evaluate their treatment approach
    - ➢ Additional monitoring samples of patients in clinical studies

  - All patient samples have to be processed during production
  - Due to short shelf life of the samples they have to be processed on their arrival day
- ➢ **Daily workload is determined by the number of sample arrivals per day**

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What are the challenges for our project partner?

- Daily workload is uncertain
  - Patient admission to clinical trials is stochastic
  - Arrival of patient samples for the trial is stochastic
- **Find an answer to the following questions**
  - Is the current staff sufficient to manage the workload coming from the currently ongoing studies?
  - How many patients can be allowed in the upcoming clinical trial, so that the workload can be managed with the available staff?
  - If a certain amount of patient is allowed in the upcoming clinical trial, how much additional staff is needed to be able to manage the workload coming form the new study and already ongoing trials?

How does the study design influence the work load?

- Study parameters that influence the amount of sample arrivals:
  - Admission period
  - Total number of patients in the study
  - Countries that participate in the trial
  - Design of the study schemes

➢ **If there was no uncertainty we could calculate the sample arrivals for every patient and determine the workload generated by the clinical trial.**

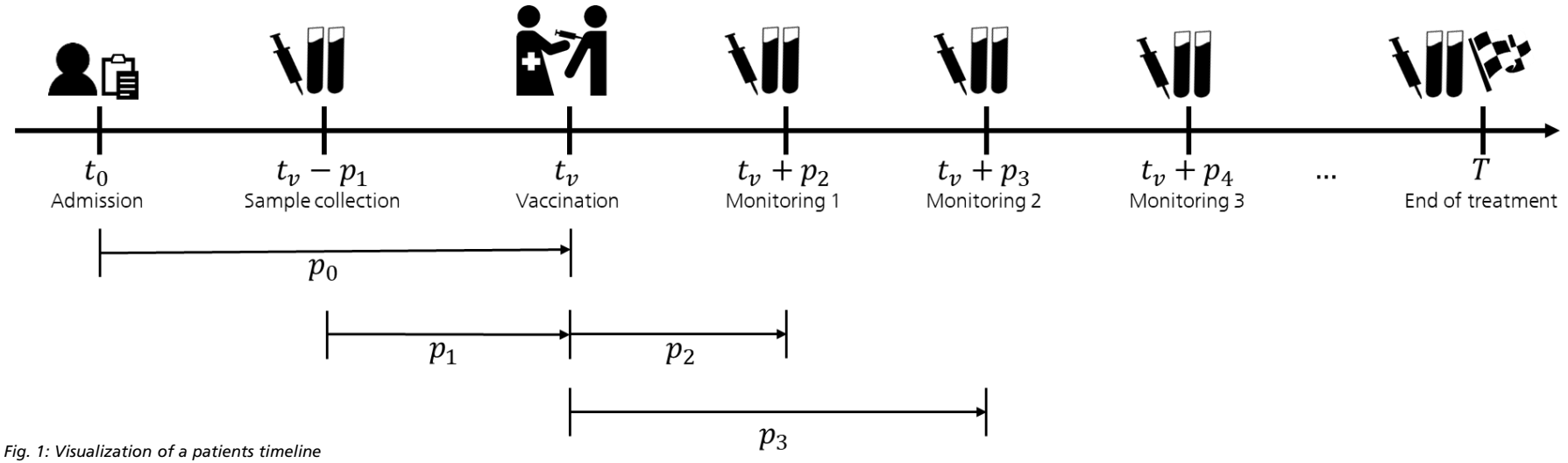

Fig. 1: Visualization of a patients timeline

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Where does the uncertainty come from?

- There are different sources of uncertainty:
  - Point in time of the **admission** of a patient to a clinical trial
  - **Earliness/lateness** of **sample arrivals**
    - Even though, it is defined in the study scheme when patients should submit their samples, patients might visit the clinics to turn in their samples some days earlier or later
  - Point in time when the patient **ends the treatment**
    - Some patients might discontinue their treatment early for example due to their medical condition

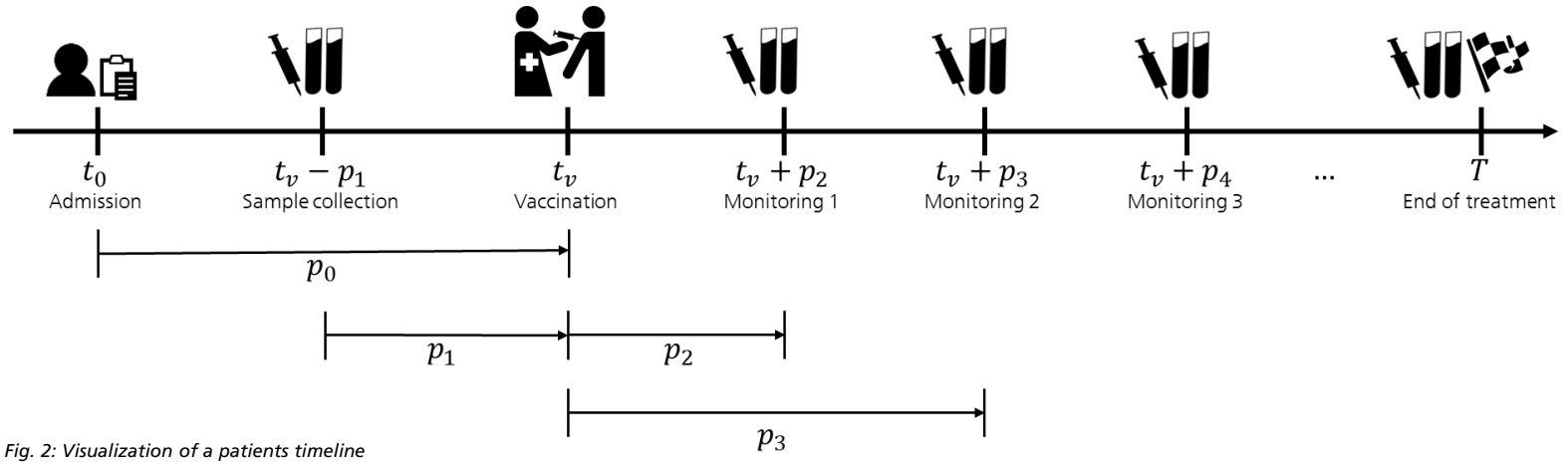

Fig. 2: Visualization of a patients timeline

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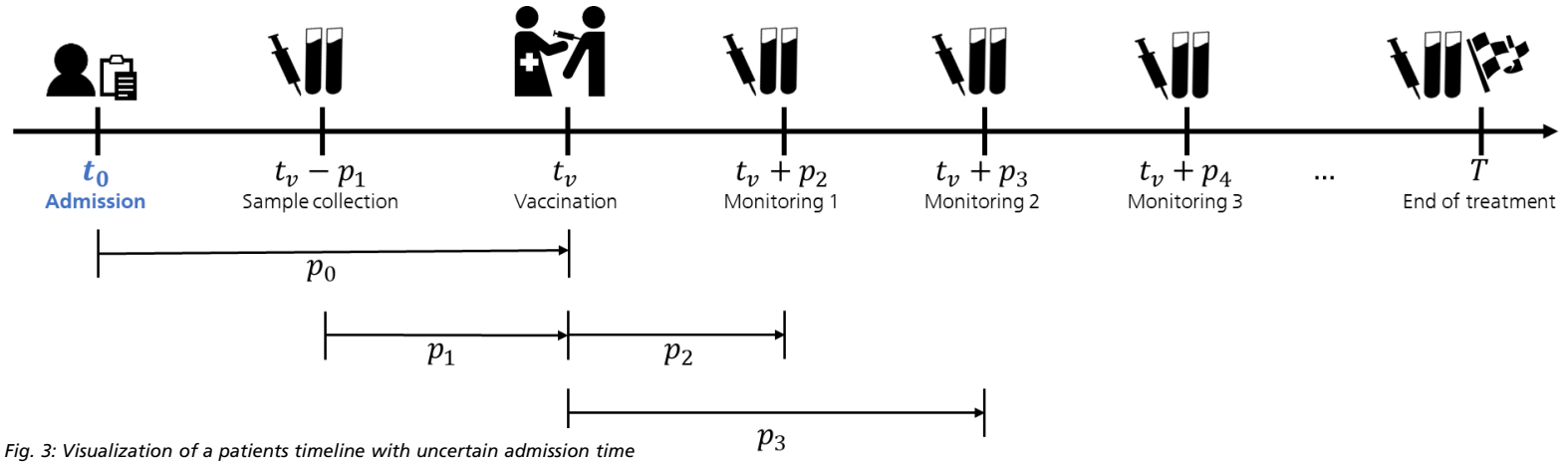

Fig. 3: Visualization of a patients timeline with uncertain admission time

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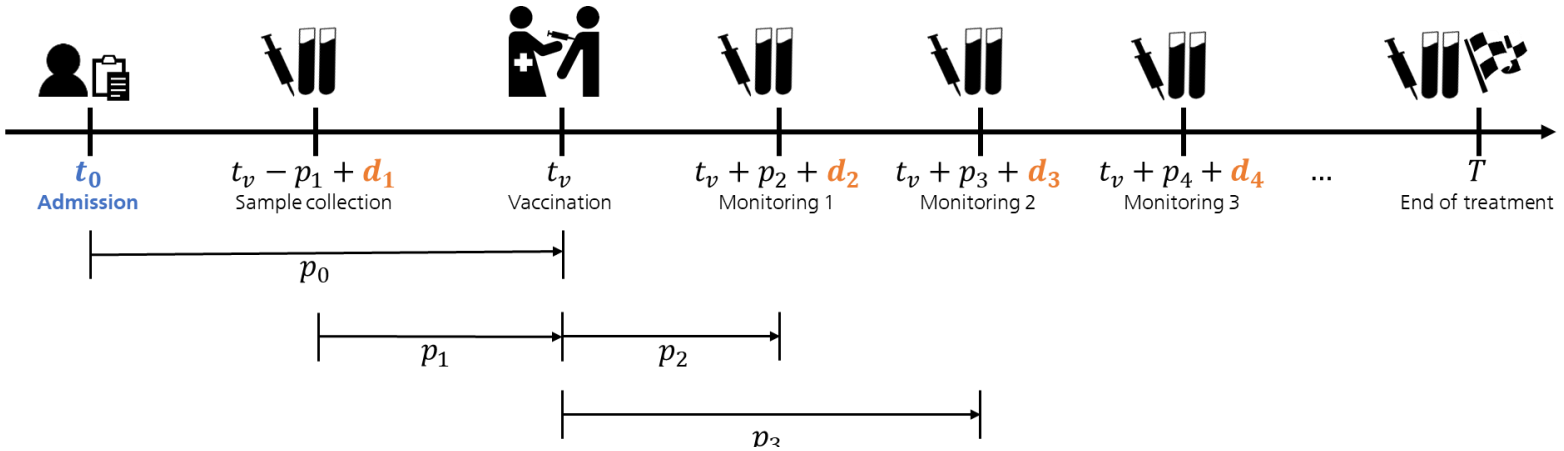

Fig. 4: Visualization of a patients timeline with uncertain admission time and earliness/lateness of sample arrivals

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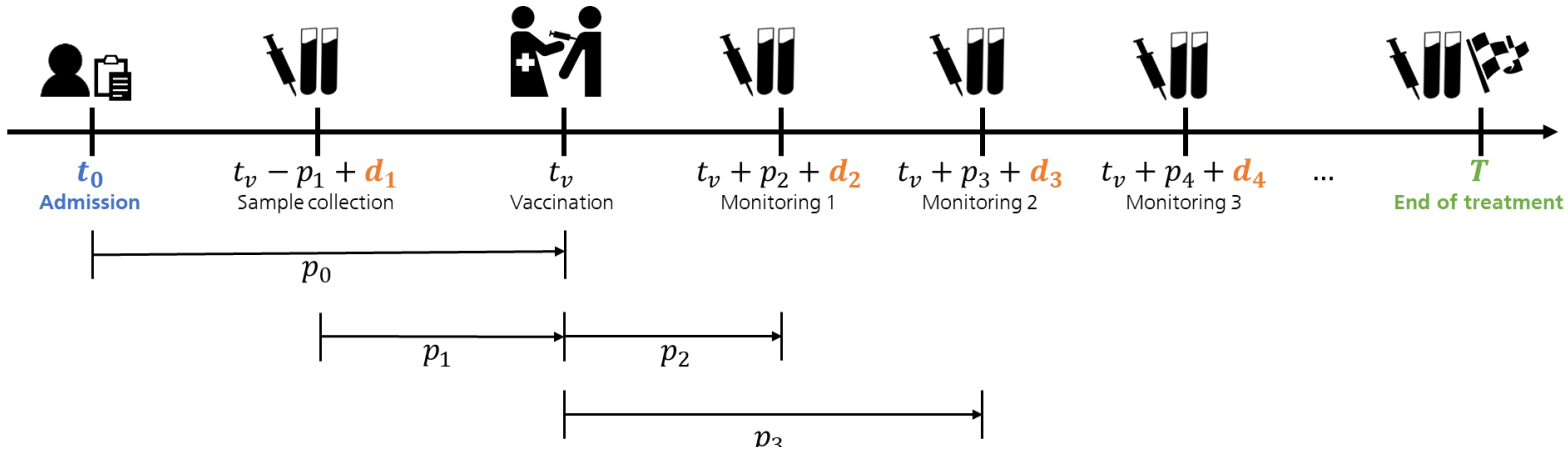

Fig. 5: Visualization of a patients timeline with uncertainty

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What is the general problem we are dealing with?

- Forecast the workload generated by jobs with periodically occurring tasks
- Start and end of the jobs is stochastic
- Tasks are scheduled relative to the start of a job
- Occurrence of the tasks can deviate from the schedule
- Deviation is stochastic

What did we achieve so far and how did we do it?
Simulation Tool

- Simulation tool that returns a forecast of the number of sample arrivals on every day of the time horizon
  - Input for the simulation tool:
    - Study parameter
      - Number of patients
      - Admission period
      - Scheme design
  - Determine results for different scenarios of a study
    - For Example:
      - more/less patients
      - schemes that require more/less samples form patients
- These results are used to conduct a what-if-analysis and help our partner with their staff planning

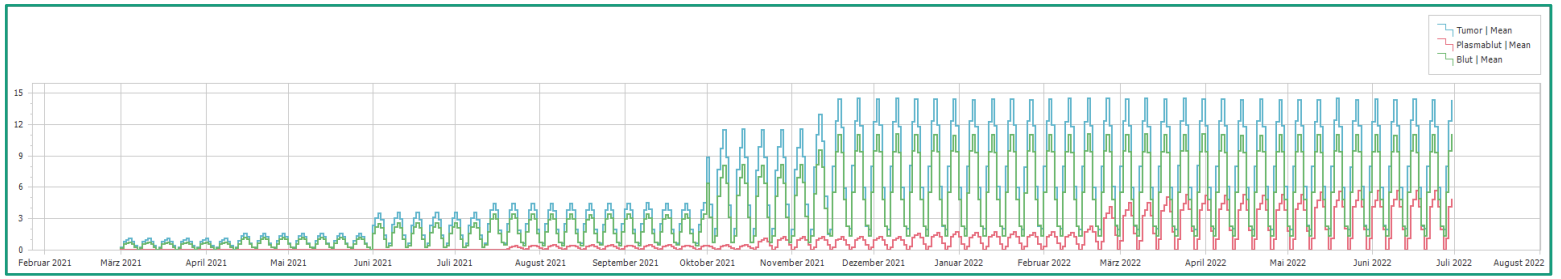

Fig. 6: Mean sample arrivals per day for three types of samples (result of simulation tool)

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What did we achieve so far and how did we do it?
Data Model

- To depict the study design in our tool, we use a hierarchical data model
- Simulate in early planning stages of a study
  - Only high-level information is available
- Refine assumptions in the course of the planning when the study design get more concrete
  - Assumptions about how many patients come from which countries
  - Assumptions about which clinics participate and about their recruitment rates
  - Assumptions about what type of samples is processed at the productions site and for which types the processing is outsourced

➢ **Adjust our the level of detail in our model and optimally support the planning process in every stage**

What did we achieve so far and how did we do it?
Monte Carlo Simulation

- Monte Carlo simulation to estimate the number of sample arrivals at the production site for every day in the time horizon
- In every simulation run we
  - generate all patients of a study
  - simulate all sample arrivals of a patient until he/she is discontinued

What are the next steps?

- Generate a proposal for staff/resource planning based on the simulation result
- Include real patient data in the simulation
- Automatically adjust the simulation according to observed patient recruitment rates and sample arrival behavior

Thank you for your attention!

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