Simulation methods for improving healthcare services: how to choose the right method and to model a system right
Plan for this talk

- Healthcare area
- Economy of simulation
- What do we have in our toolbox?
- Personal experiences on
  - building models (and simulations) [how to choose the right method]
  - Increasing their validity [model a system right]
- Final words
Simulation in Healthcare

Training with/on physical objects is also called simulation, although I prefer them called “simulators”

We are not going to talk about them... Let’s talk about “real” simulation...
Simulation in Healthcare

- Epidemiology and diseases
- Interventions
- Biology
- Strategy & planning
- Performance in operations
- Macroeconomy
- Equity

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Epidemiology and diseases

Spread of diseases
Agent-based

Agent Based Epidemic Model
Compartmental S – I – R

\[ \frac{dS}{dt} = -\frac{\beta IS}{N}, \]
\[ \frac{dI}{dt} = \frac{\beta IS}{N} - \gamma I, \]
\[ \frac{dR}{dt} = \gamma I, \]
Cell level models
dynamics of cells
Flow of patients in a system related to healthcare

Hospitals, ER, departments...

Waiting time of patients, utilisation of doctors, nurses ...

Mostly DES...
Equity

Allocation of “money” with justice

Who will you treat first?

QALY, DALY ...

Equity is the absence of unfair, avoidable or remediable differences among groups of people, whether those groups are defined socially, economically, demographically, or geographically or by other dimensions of inequality (e.g. sex, gender, ethnicity, disability, or sexual orientation). Health is a fundamental human right. Health equity is achieved when everyone can attain their full potential for health and well-being.
What if we have this treatment?

What must be the pricing strategy of this drug?

What is the long-term benefit of this treatment? How much will that cost to the nation?

Mostly health economics terminology involved, such as CEA, PSA, ICER...
The economy of “Simulation”...

The global healthcare analytics market size was estimated at USD 37.15 billion in 2022 and is expected to reach over USD 121.1 billion by 2030 and poised to grow at a CAGR of 15.9% from 2022 to 2030. U.S. healthcare analytics market was valued at USD 24.8 billion in 2022.

https://www.precedenceresearch.com/healthcare-analytics-market
Our toolbox

methodologies and software

- DES
- SD
- ABS
- Markov
- Micro
- Hybrid...

COTS

- SIMUL8
- Arena
- FlexSim
- Visual Components
- Anylogic
- Simio
- Excel

Language

- Python
- TensorFlow
- R
- Java
- C
- Swift
- SQL
- CSS
- JavaScript
- PHP

Game engine

- GameMaker Studio 2
- Unity
- Godot
- Lumberyard
- Monogame
- Unreal
- CRYENGINE
- Construct 3

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COTS
How to choose the right method

Well... what is the problem?

- Measure operational performance?
- Behaviours affecting the problem?
- Feedbacks are significant?
- Molecule or cell level?
- Health outcome vs. cost?

DES
ABS
SD
Markov
Micro
Hybrid...
How to choose the right method

Data availability

- High
- Low
- Scarce
- Expert knowledge
- Questionaries (PRO)
- Clinical trials
- Medical literature

DES
ABS
SD
Markov
Micro
Hybrid...
How to choose the right method

Entity… (patient) in the problem…

DES
ABS
SD
Markov
Micro
Hybrid…

Individual (not intelligent)
Individual (intelligent)
Cohort
Population (sub-populations)
Cell, organism…
How to choose the right method

A hospital’s operational performance

DES

SD

ABS
Model a system right

- Get the client on board (client involvement)
- Frame and scope the problem
- Find a good level of detail
- Specify a level of generality
- Check the data validity
- Be sure the results make sense
Model a system right

Get the client on board (client involvement)

- Explain them using non-technical language
- Tell them that “all models are wrong, but some are useful” (George Box)
- Use visuals (face validity)
Find a good level of detail

Do we really need?

Simple is good...

Oversimplified is bad...

“Re-use” is dangerous. Be careful!
Specify a level of generality

Will I be able to do “everything” with my model? Certainly not...

Model a system right
Be sure the results make sense

Model a system right

Back of envelope calculations…
(check your results with fast and hand-made calculations)

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<th>Name</th>
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<th># of Non-Electives</th>
<th>Forecasted bed occupancy rates (%)</th>
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Thank you...

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