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

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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

SSH
Society for Simulation in Healthcare™

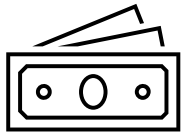
Training with/on physical objects is also called simulation, although I prefer them called "simulators"

We are not going to talk about them…
Let's talk about "real" simulation…

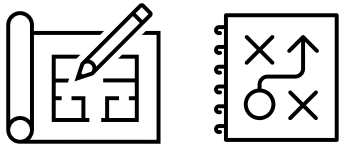
Simulation in Healthcare

Epidemiology and diseases

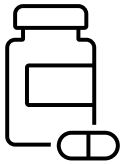
Macroeconomy



Strategy &planning

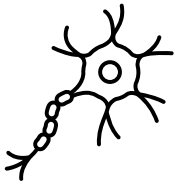


Interventions



Equity

Biology



Performance in operations

Epidemiology and diseases

Spread of diseases

Agent-based

Epidemiology and diseases

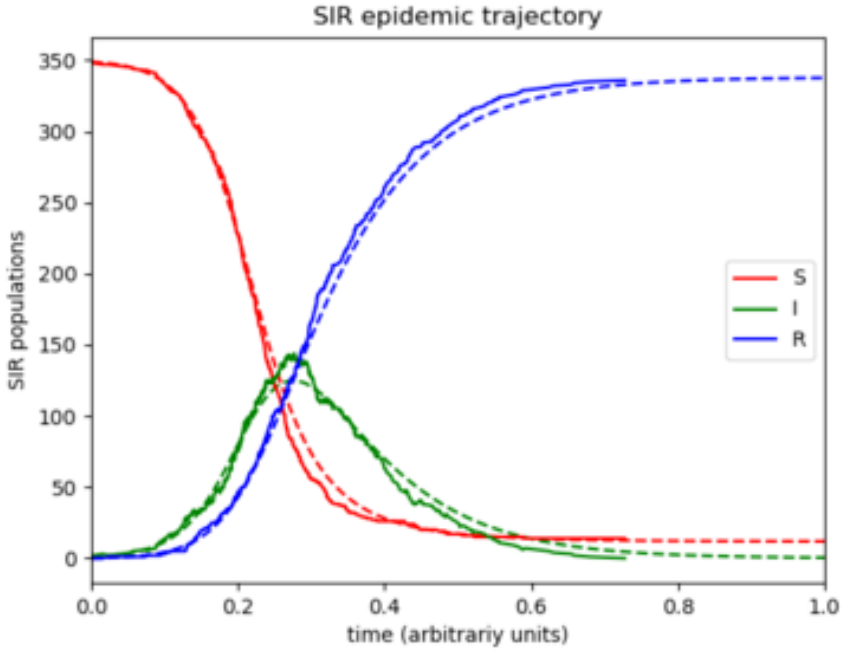
Compartmental

S – I – R

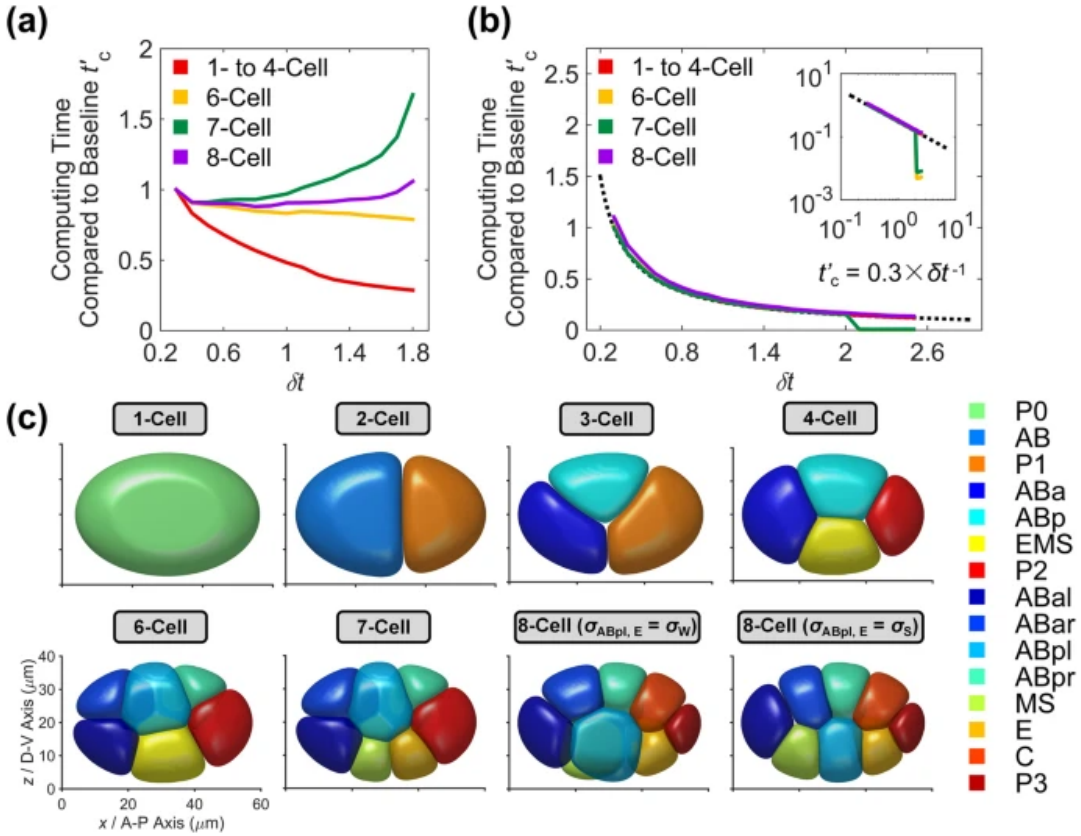
$$\frac{dS}{dt} = -\frac{\beta I S}{N},$$

$$\frac{dI}{dt} = \frac{\beta I S}{N} - \gamma I,$$

$$\frac{dR}{dt} = \gamma I,$$

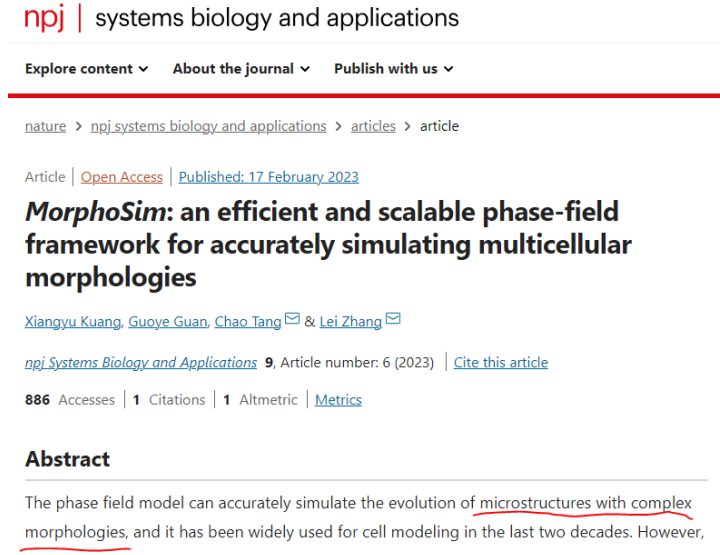


Biology



Cell level models

dynamics of cells



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Article | Open Access | Published: 17 February 2023

***MorphoSim*: an efficient and scalable phase-field framework for accurately simulating multicellular morphologies**

Xiangyu Kuang, Guoye Guan, Chao Tang & Lei Zhang

npj Systems Biology and Applications **9**, Article number: 6 (2023) | Cite this article

886 Accesses | **1** Citations | **1** Altmetric | Metrics

Abstract

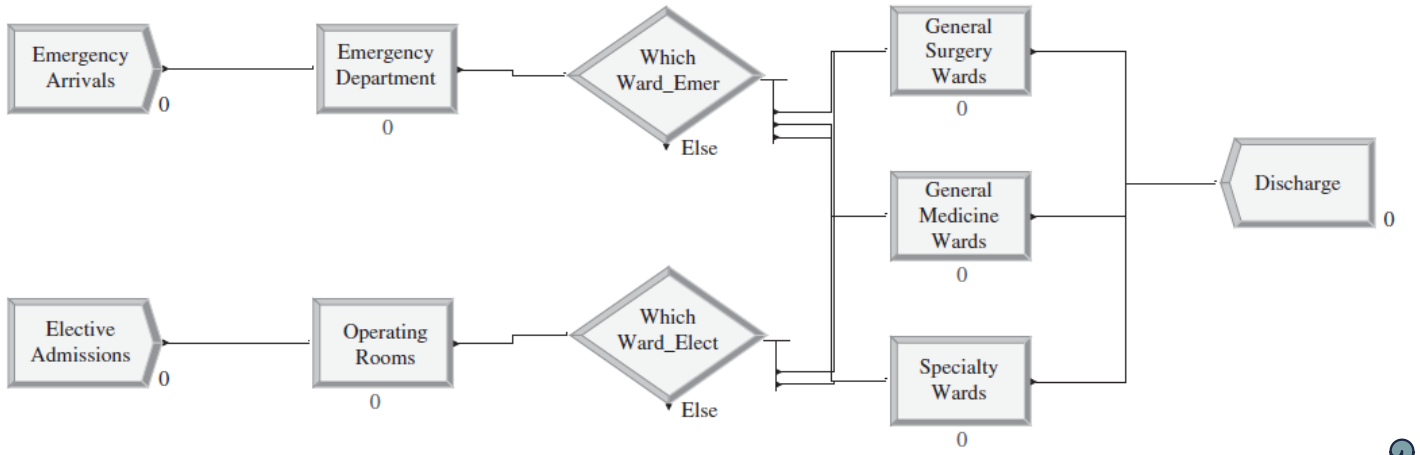
The phase field model can accurately simulate the evolution of microstructures with complex morphologies, and it has been widely used for cell modeling in the last two decades. However,

Performance in operations

Flow of patients in a system related to healthcare

Hospitals, ER, departments…

Waiting time of patients, utilisation of doctors, nurses …

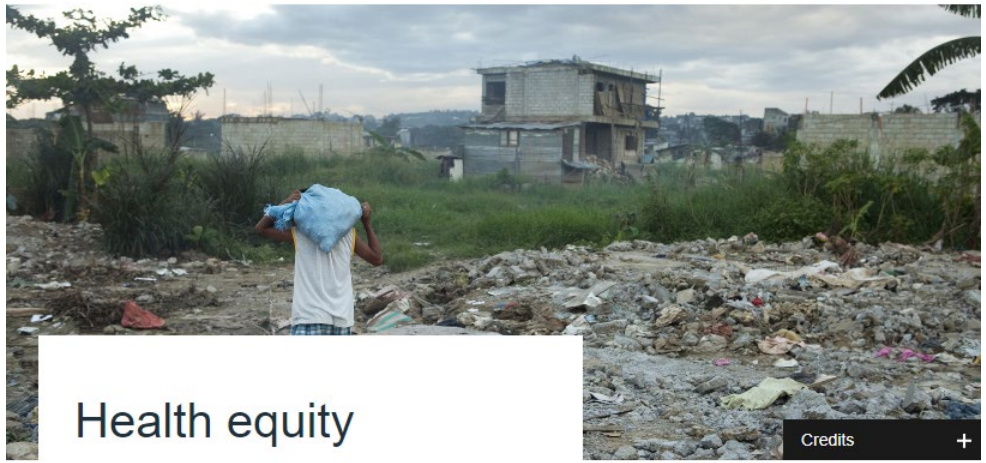


Mostly DES…

Equity

World Health Organization

Home / Health topics / Health equity



Overview | Data and evidence | Response

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.**

Allocation of "money" with justice

Who will you treat first?

QALY, DALY …

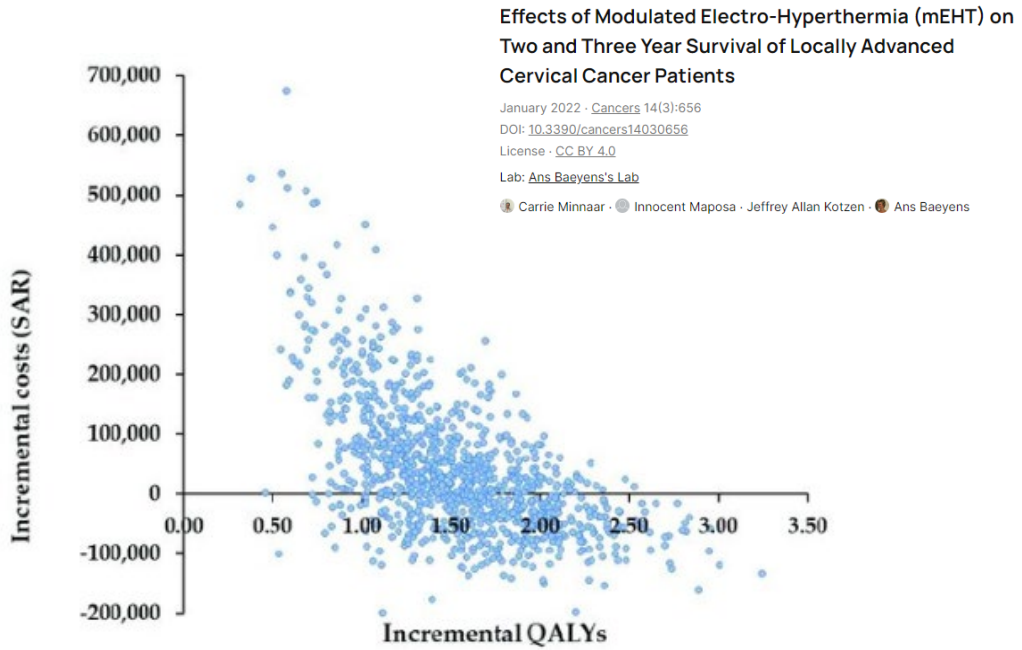
Interventions, strategy& planning Macroeconomy

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…



Healthcare Analytics Market Size

analytics

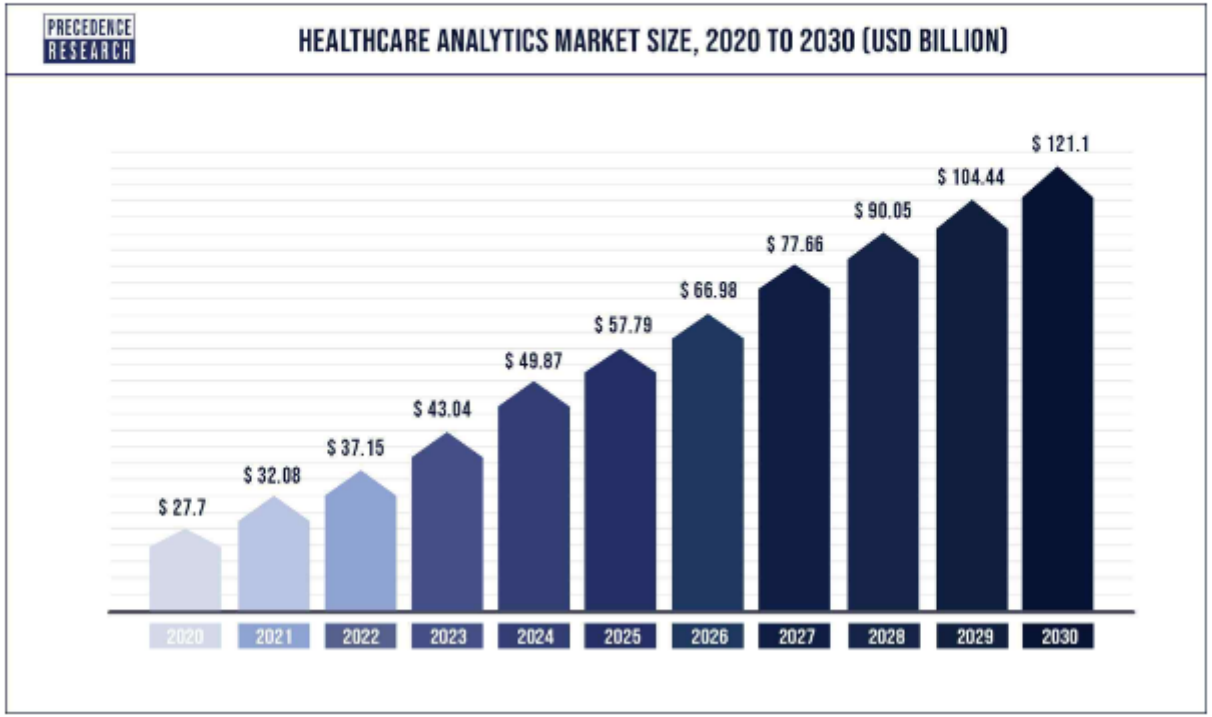
/ˌanəˈlɪtɪks/

noun

information resulting from the systematic analysis of data or statistics

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

Method

DES

SD

ABS

Markov

Micro

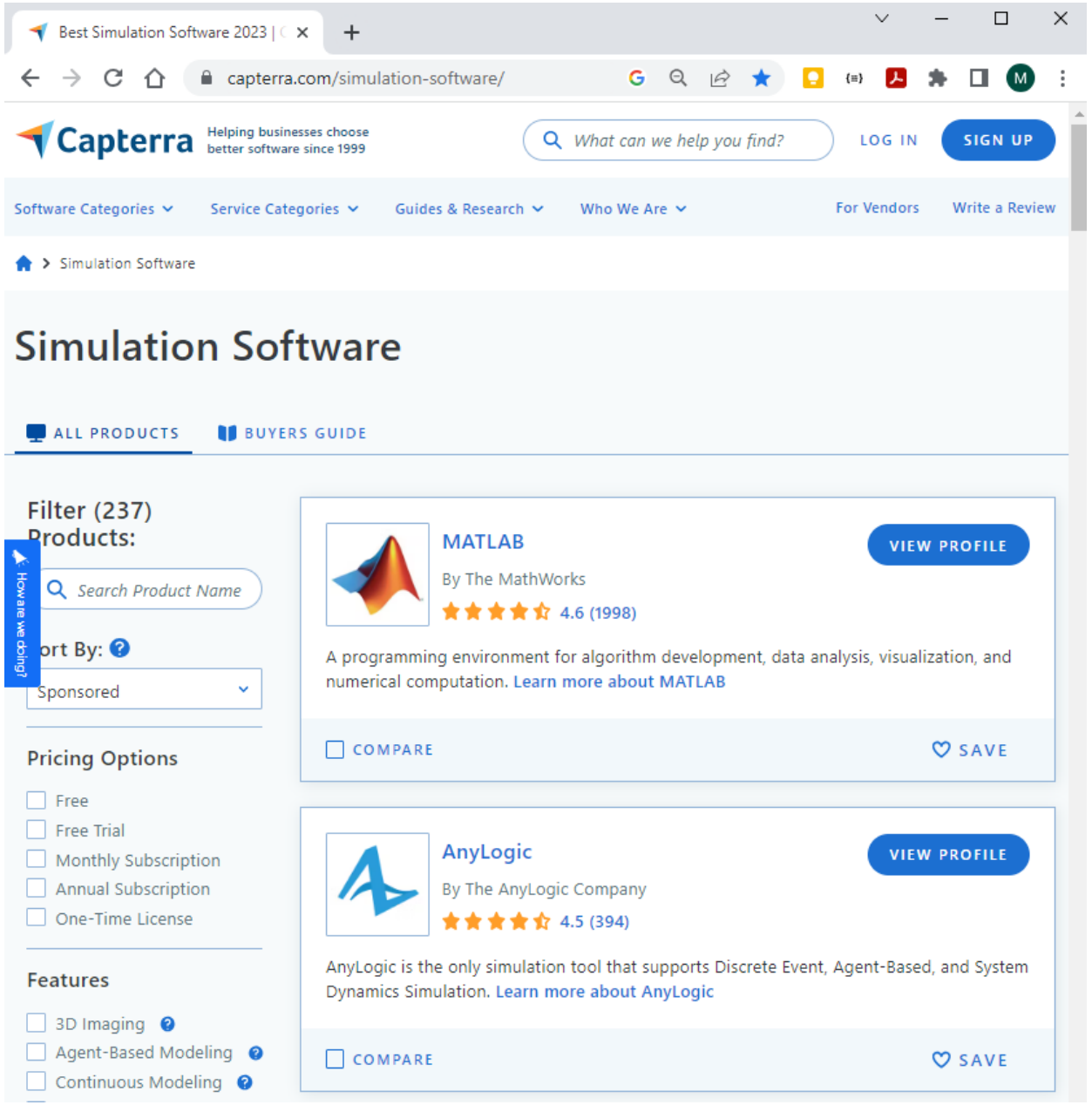
Hybrid…

COTS

Language

Game engine

COTS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Features
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Continuous Modeling
MATLAB
By The MathWorks
4.6 (1998)
VIEW PROFILE
A programming environment for algorithm development, data analysis, visualization, and numerical computation. Learn more about MATLAB
COMPARE
SAVE
AnyLogic
By The AnyLogic Company
4.5 (394)
VIEW PROFILE
AnyLogic is the only simulation tool that supports Discrete Event, Agent-Based, and System Dynamics Simulation. Learn more about AnyLogic
COMPARE
SAVE

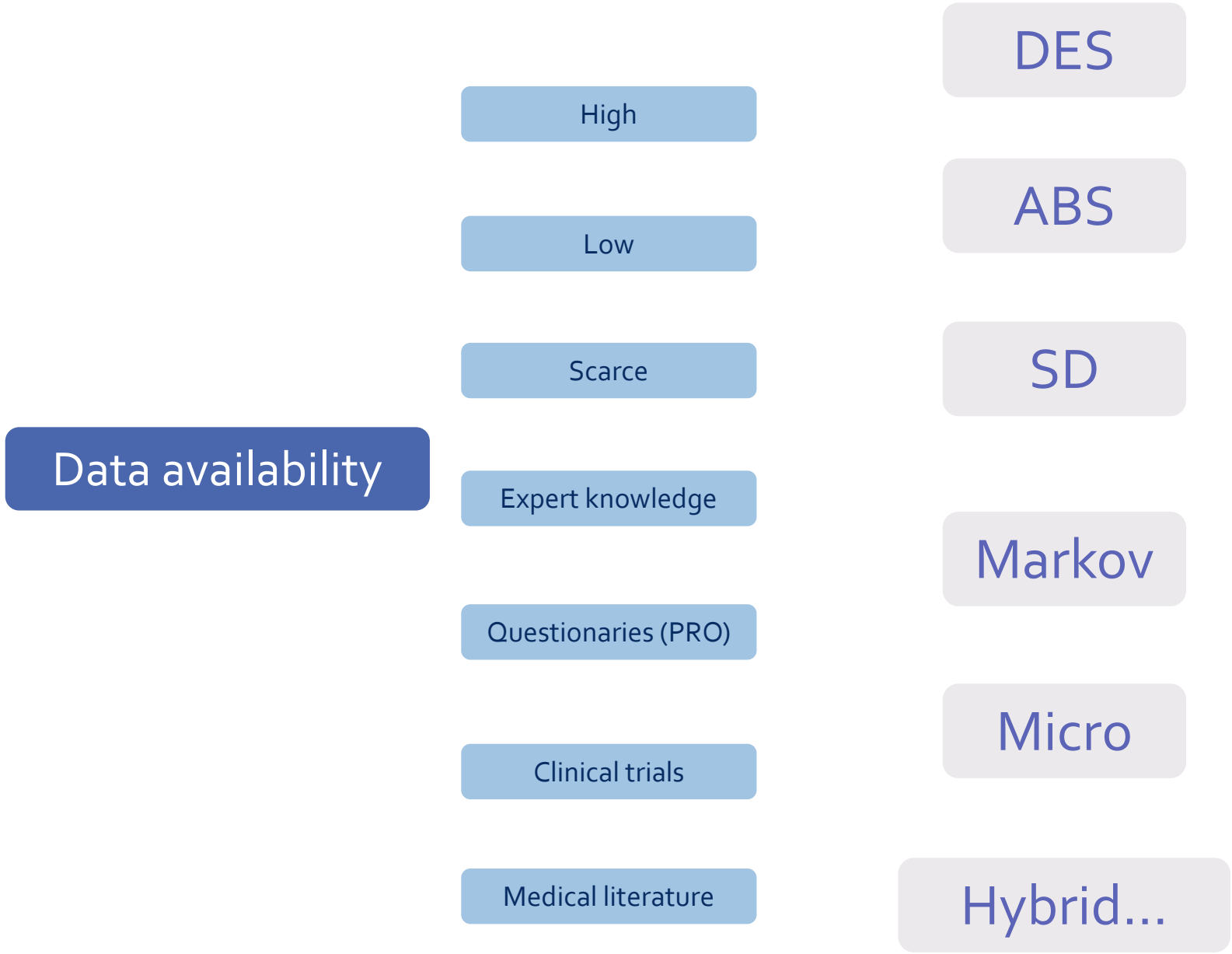
How to choose the right method

Well… what is the problem?

- Measure operational performance? → DES
- Behaviours affecting the problem? → ABS
- Feedbacks are significant? → SD
- Molecule or cell level? → Markov
- Health outcome vs. cost? → Micro

Hybrid…

How to choose the right method



How to choose the right method

Entity… (patient)

in the problem…

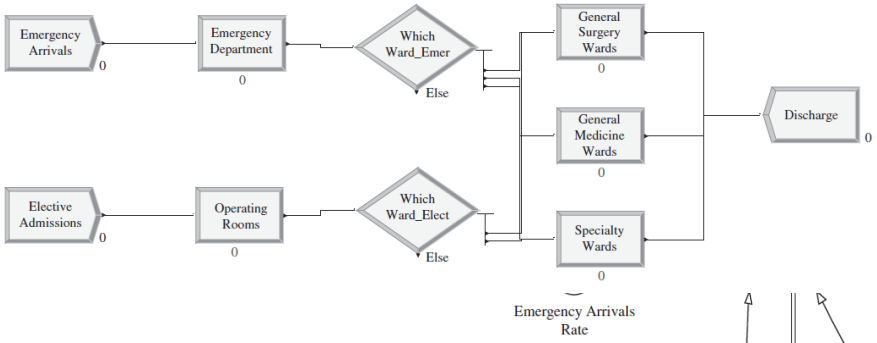
- Individual (not intelligent) → DES
- Individual (intelligent) → ABS
- Cohort → SD
- Population (sub-populations) → Markov
- Cell, organism… → Micro

Hybrid…

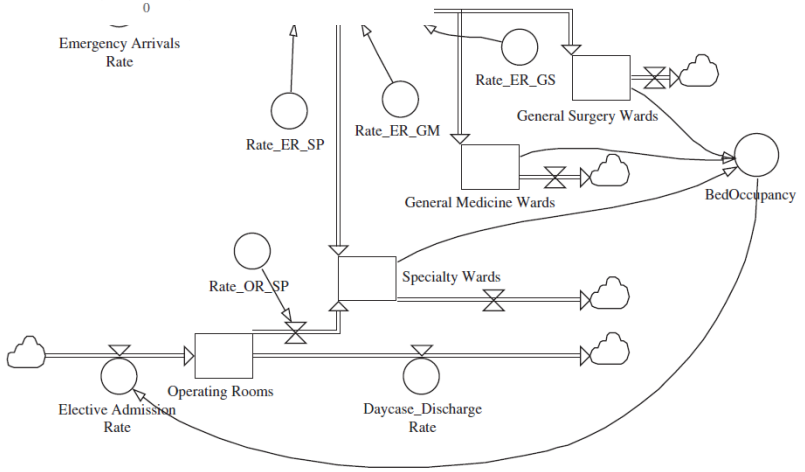
How to choose the right method

A hospital's operational performance

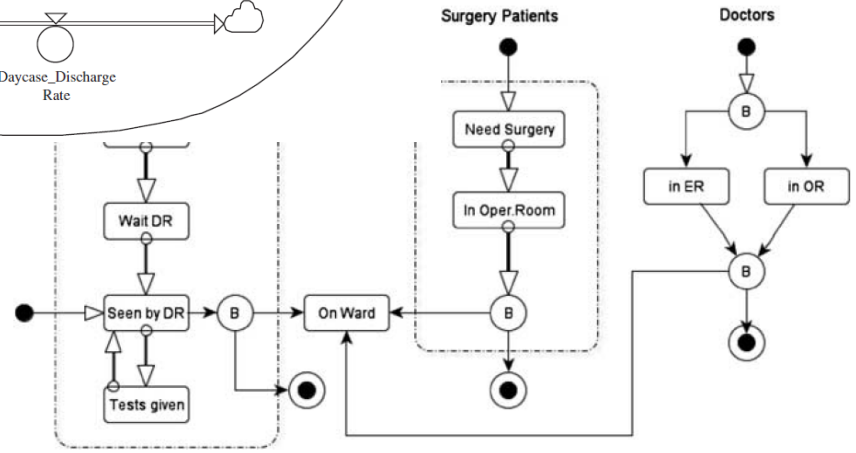
DES



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

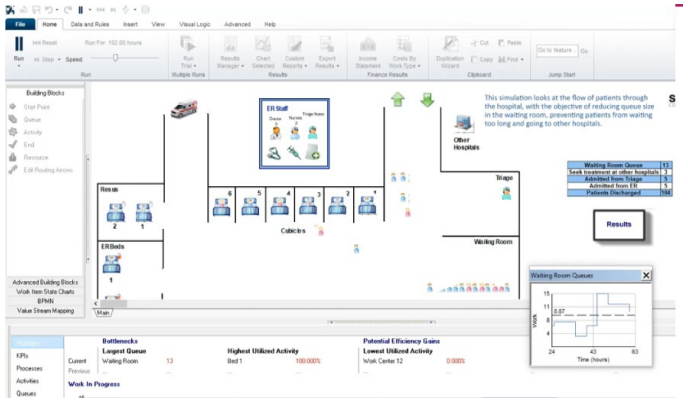
Model a system right

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)



Model a system right

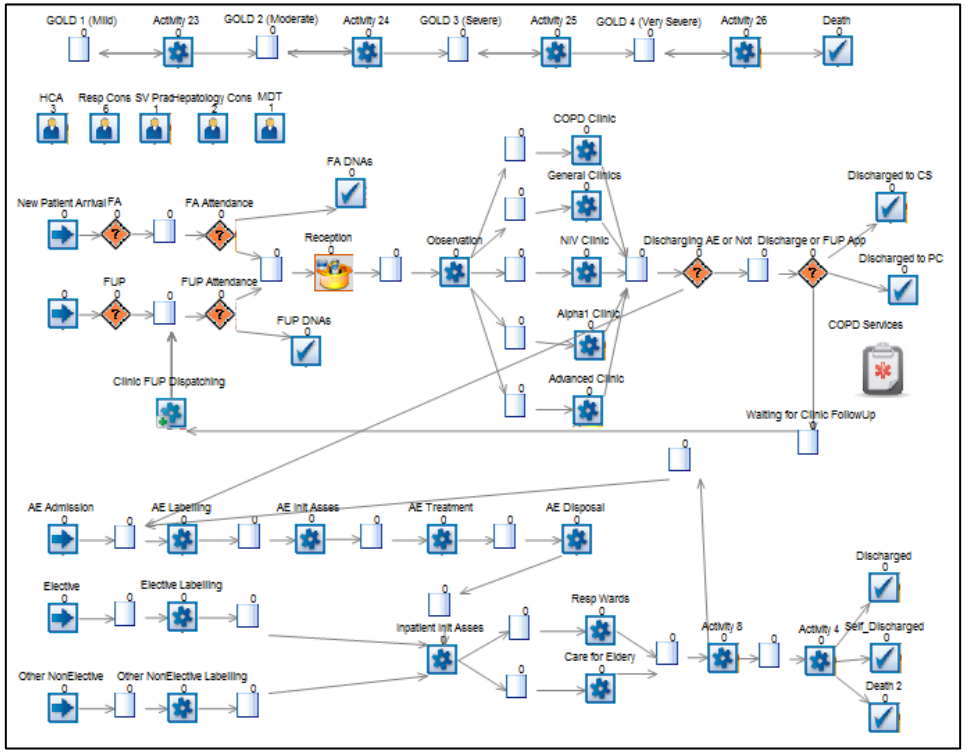
Find a good level of detail

Do we really need?

Simple is good…

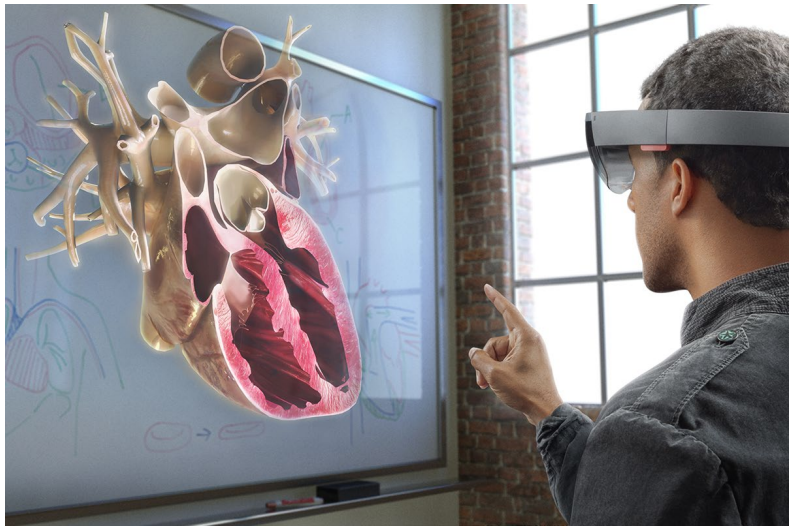
Oversimplified is bad…

"Re-use" is dangerous. Be careful!

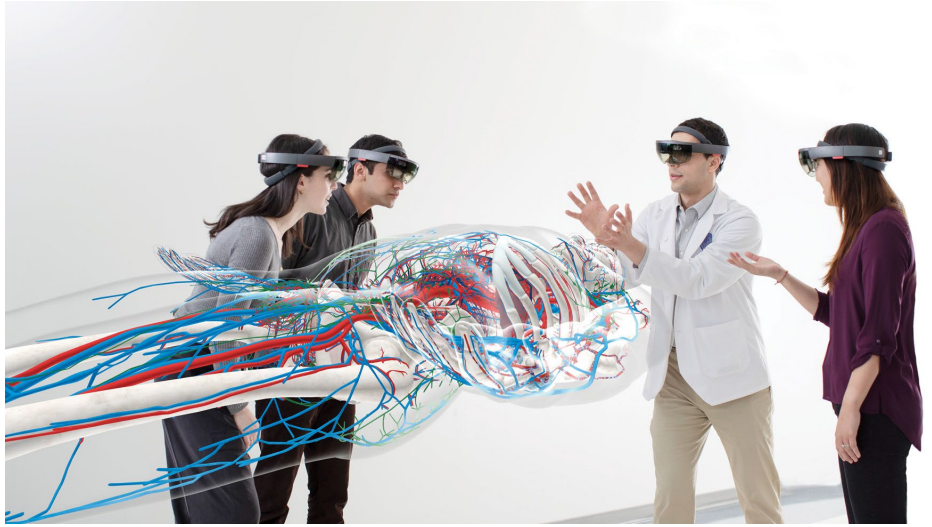


Model a system right

Specify a level of generality

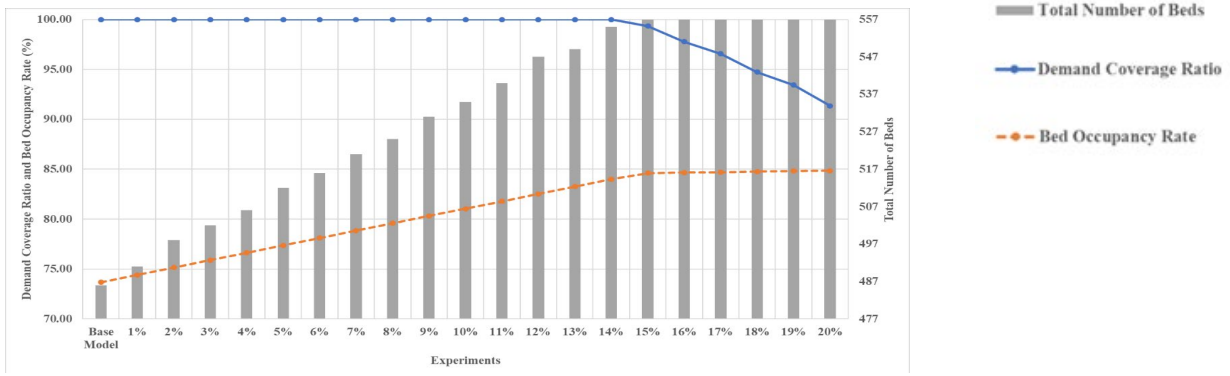


Will I be able to do "everything" with my model? certainly not…



Model a system right

Be sure the results make sense



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

Code	Name	# of Electives	# of Non-Electives	Forecasted bed occupancy rates (%)	Required # beds
1	General surgery	3,468	3,660	84.82	60
2	Trauma & Orthopaedics	3,276	1,536	84.72	47
3	General Medicine	1,469	9,004	84.81	115
4	Cardiology	972	1,224	83.62	31
5	Paediatrics	264	2,196	83.98	11
6	Gynaecology	1,553	2,147	81.33	15
7	Geriatric Medicine	-	7,692	84.72	150
8	Obstetrics	-	7,320	84.58	46
	Total	11,002	34,779	-	475

Thank you…

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