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Improving Medicine Supply and Availability Using Simulation. A case study of Uganda

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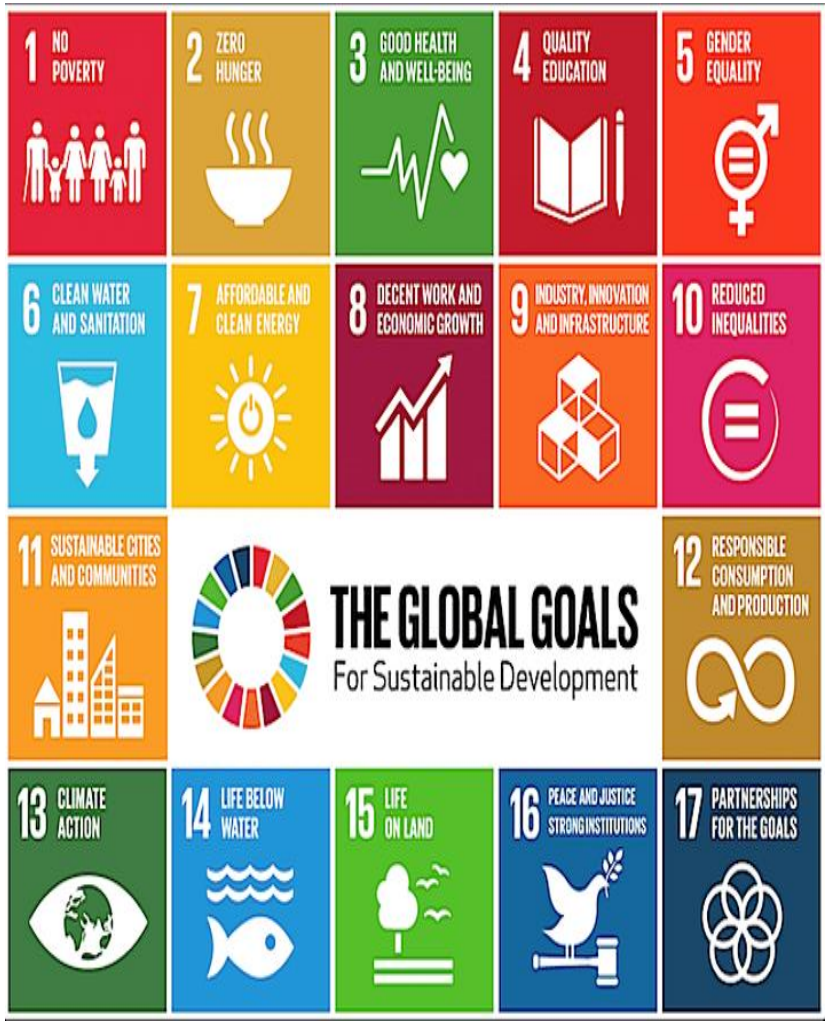
Introduction

- Access to good health is a human right (World Health Organisation)

- Quality health care = availability of medicines

core principle for universal health coverage and SDG 3

- 1/ 2 population globally have no access to essential medicines nearly 2 billion in LMICs living without required medicines
- Some of these problems are attributed to the characteristics of medicine supply chains



Characteristics of Medicine Supply Chain

Complex

- “a matter of life or death”
- Overlapping providers requirements operating with limited funds
- Different entities working with different objectives
- highly regulated

Uncertainties

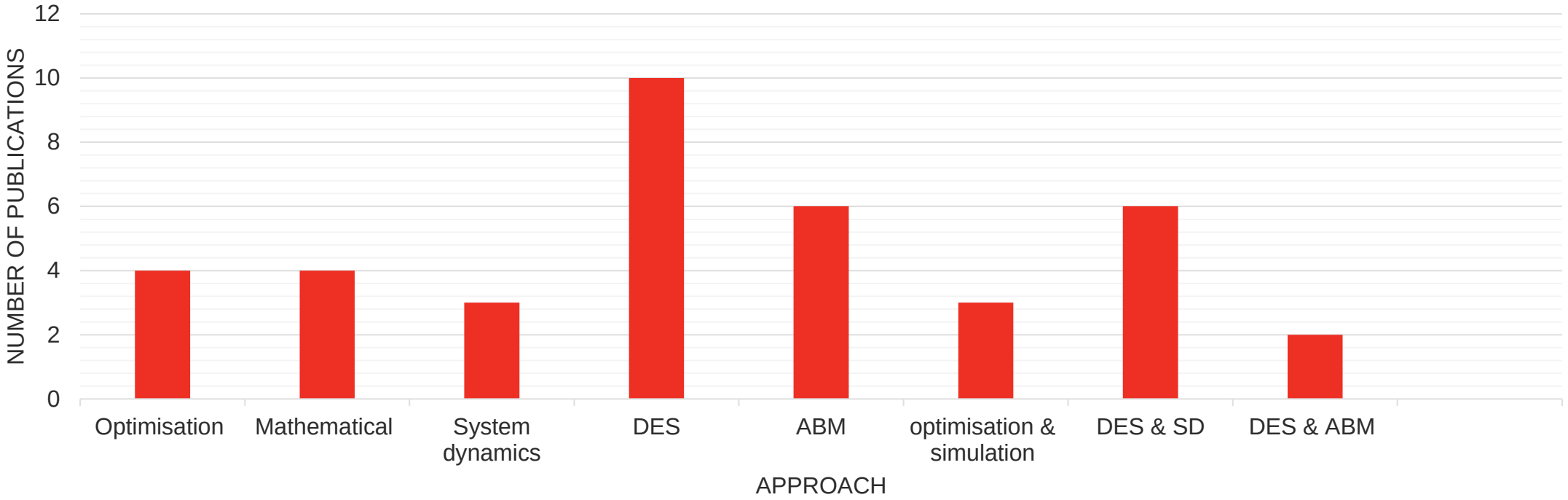
- Unique nature of demand and supply
- delays

Dynamic

- Ageing population with evolving new diseases

This requires different types of modelling to support decisions to improve the medicine availability

Literature review: Modelling the medicine supply chain (2010-2021)



Focus: 3 simulation approaches of System dynamics (SD), Discrete event simulation (DES), Agent based modelling (ABM)

Simulation

- powerful tool for evaluating the SC control mechanisms while representing the system efficiently to improve understanding, identifying bottlenecks (Macal, 2010 , Franco, 2020, Kulkarni, 2015)
- offers comparative ease to incorporate complicated features of the entire system , which mathematical modelling-based methods fail to capture (Glasserman and Tayur, 1995, De Sensi, et al., 2006)
- optimization inefficient to be of practical use for complex Supply chain (Hung et al., 2004, Alzu'bi, et al., 2021)

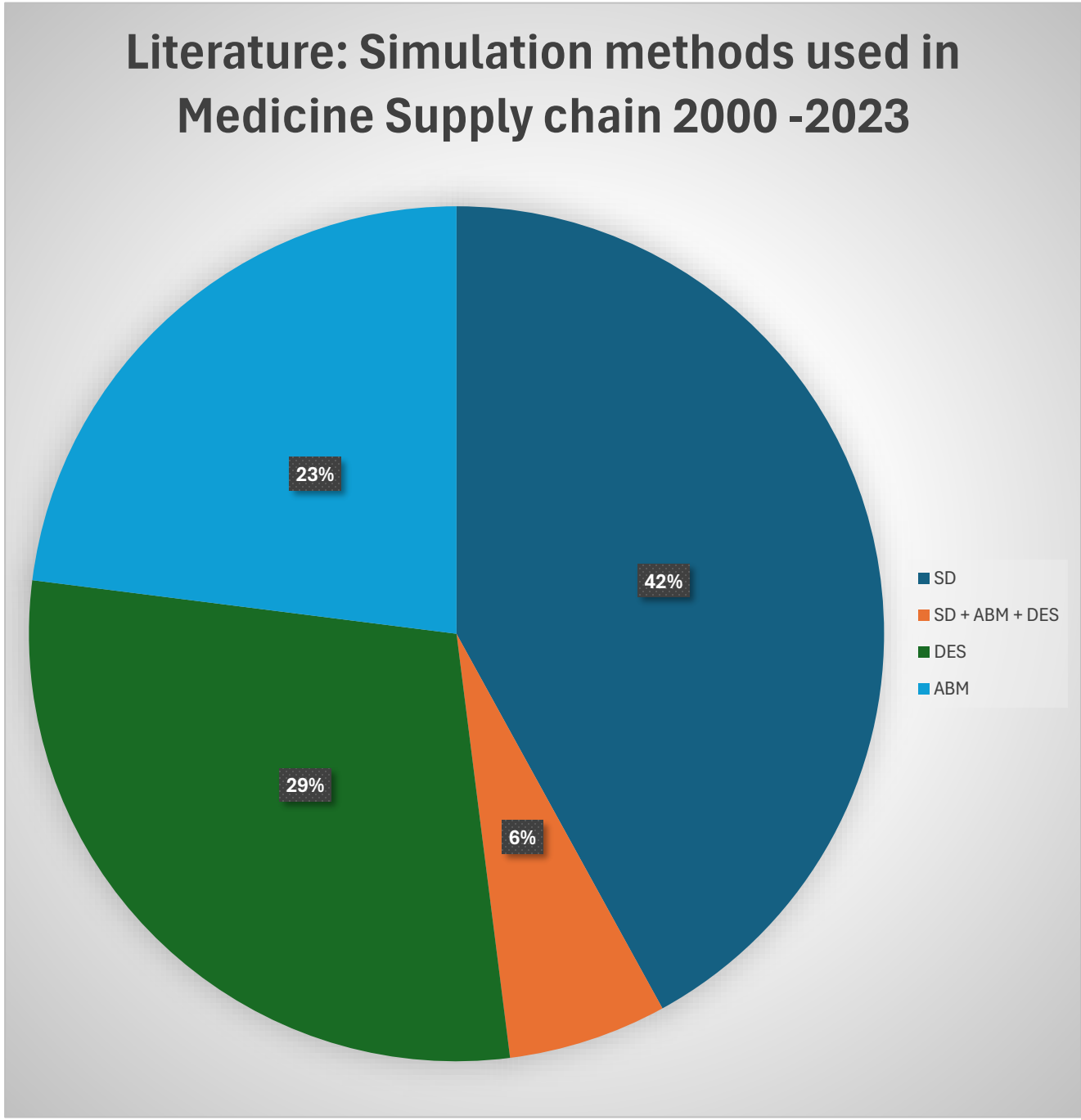
Literature findings

Trends in using simulation :

- SD (2010 -2022),
- DES (2009-2023)
- ABM (2018 – 2023)
- SD + ABM + DES – (2021 & 2023)

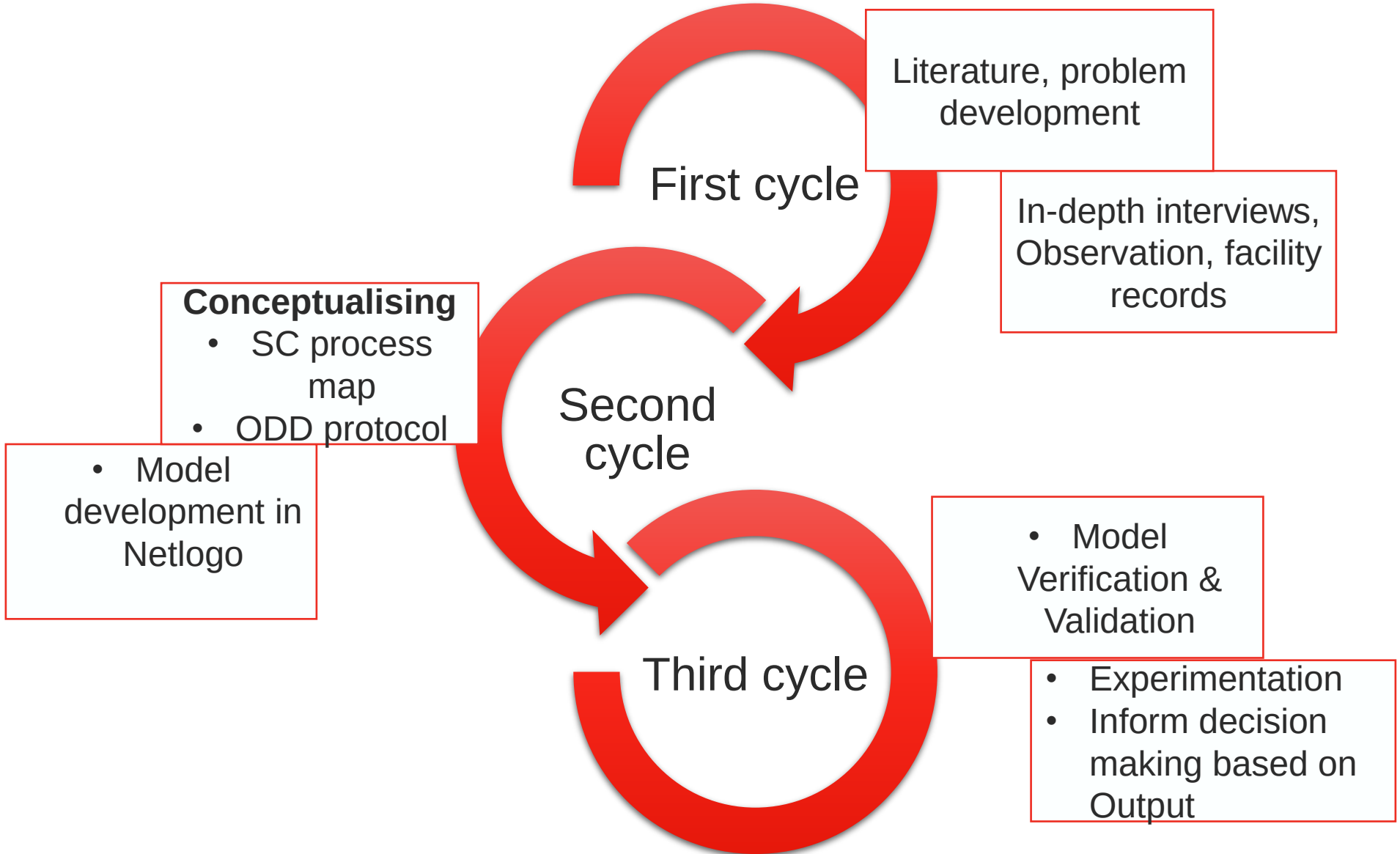
Key points:

- Supply chains deal with hybrid problems
- with bottlenecks aligned to both the demand and supply perspectives
- Challenging to model the system using a single simulation paradigm
- DES + SD (Tako and Robinson, 2012;Onggo, 2014;Nguyen, Howick and Megiddo, 2020)
- ABM + SD (Wang et al., 2013)



- medicine supply chain deals with complex issues from both the demand and supply sides, requiring rigorous decision-making methods in simulation.
- It is more than impossible to isolate one part of the supply chain system without compromising the usefulness of the entire system
- And the debate to mix more than one simulation approach (Choi, Dooley, and Rungtusanatham, 2001; Brailsford *et al.*, 2019)
- Study combines ABM and DES to address complex issue of medicine availability and supply
- Integrating DES and ABM allow identification of bottlenecks in the system and increase confidence in the solutions (Franco, 2020, N. S. Kulkarni, 2015)

Our developed protocol to use the ABM and DES for medicine supply chains



Justification for mixing DES and ABM

Researchers' knowledge and skills (Cope et al., 2007;Campuzano, 2011;Sanchez, 2020)

DES + ABM

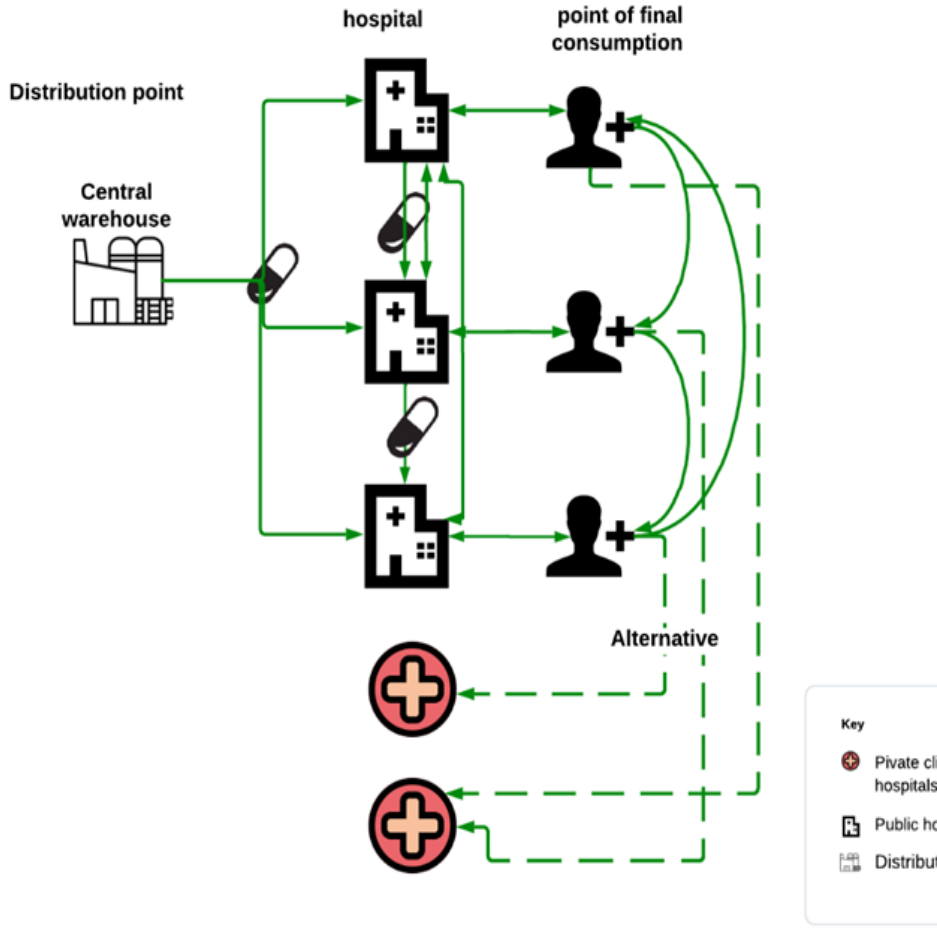
- capture stochasticity (Preusser *et al.*, 2005)
- Powerful dynamic approaches (Brailsford *et al.*, 2013).

ABM

- Capture randomness in demand
- Agent actions / emergent behavior (Borshchev and Filippov, 2004;Behdani, 2012)

DES

- Captures a list of processes in discrete steps over time (Chiang, Lin and Long, 2020)
- Capture allocation of limited resources (Siebers *et al.*, 2010).
- Does not allow to understand the underlying mechanics of information flow and feedback (Morgan, 2013; Tako and Robinson, 2012; Long, 2016; Kim 2017)



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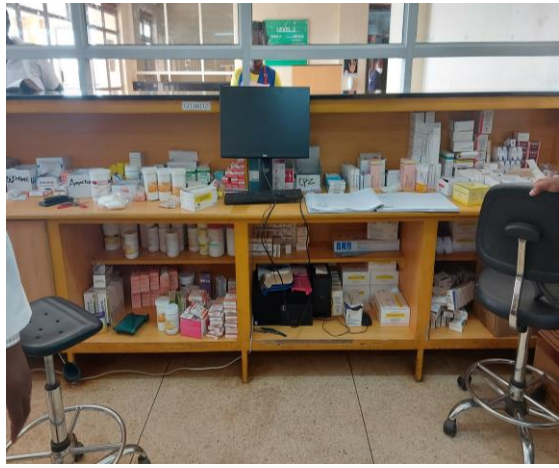
Case Study: Medicine supply chain Uganda



74% of Ugandans attending public hospitals left without needed medicine 2019/2020

57% in 2015 (Afrobaromter, 2021)

- Some facilities report drug shortages, many are stuck with expired medicines

ART medicines , anti-malarial expiring at some hospitals and not available at others (Ref: Interviews)

Stock-outs (Jitta, Whyte and Nshakira, 2003, Kagoya et al., 2021)

medicines get used on average 2 weeks of delivery and remain 6 weeks out of stock until replenishment (ref: interview)

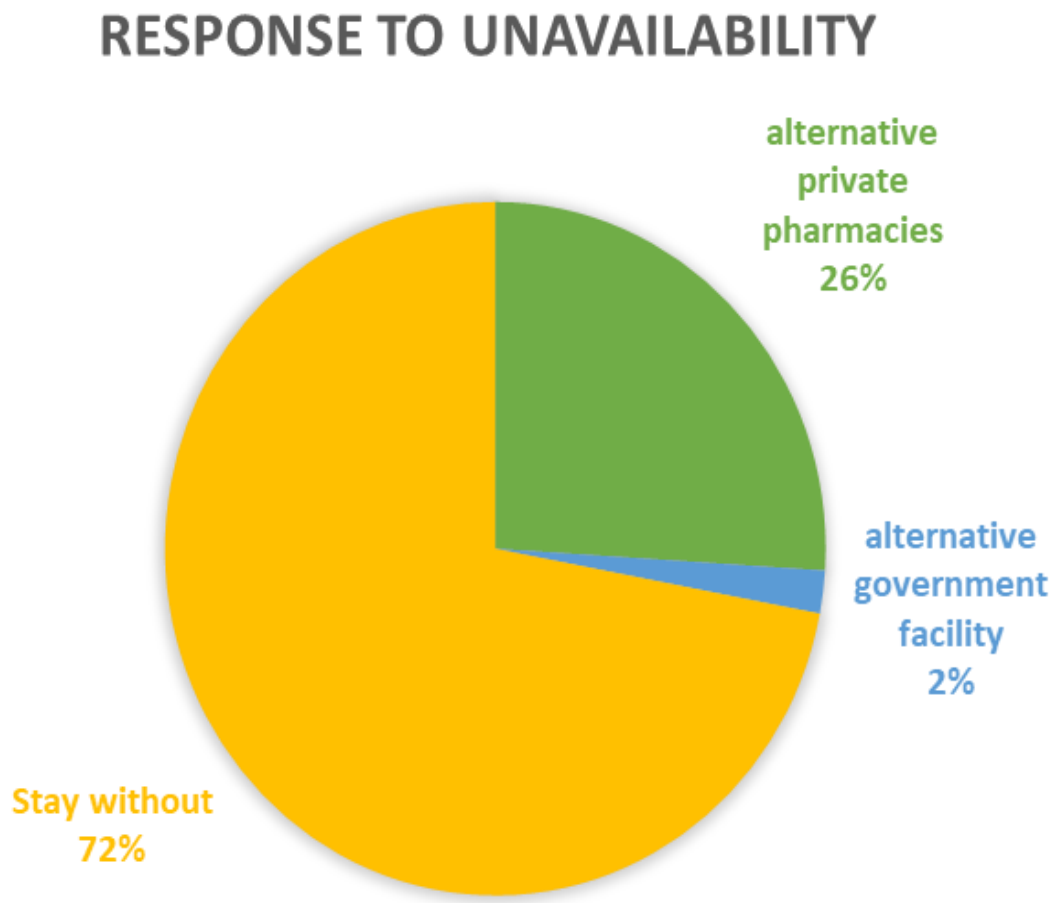
Poor coordination and delays (Privett and Gonsalvez, 2014, Miljković *et al.*, 2021,

delivery cycles are missed (ref: interviews)

54% accumulating expired medicines throughout Uganda's SC facilities (global fund, 2016)

910.9 tons of medicine waste in the FY 2018/2019 (NMS, 2019)

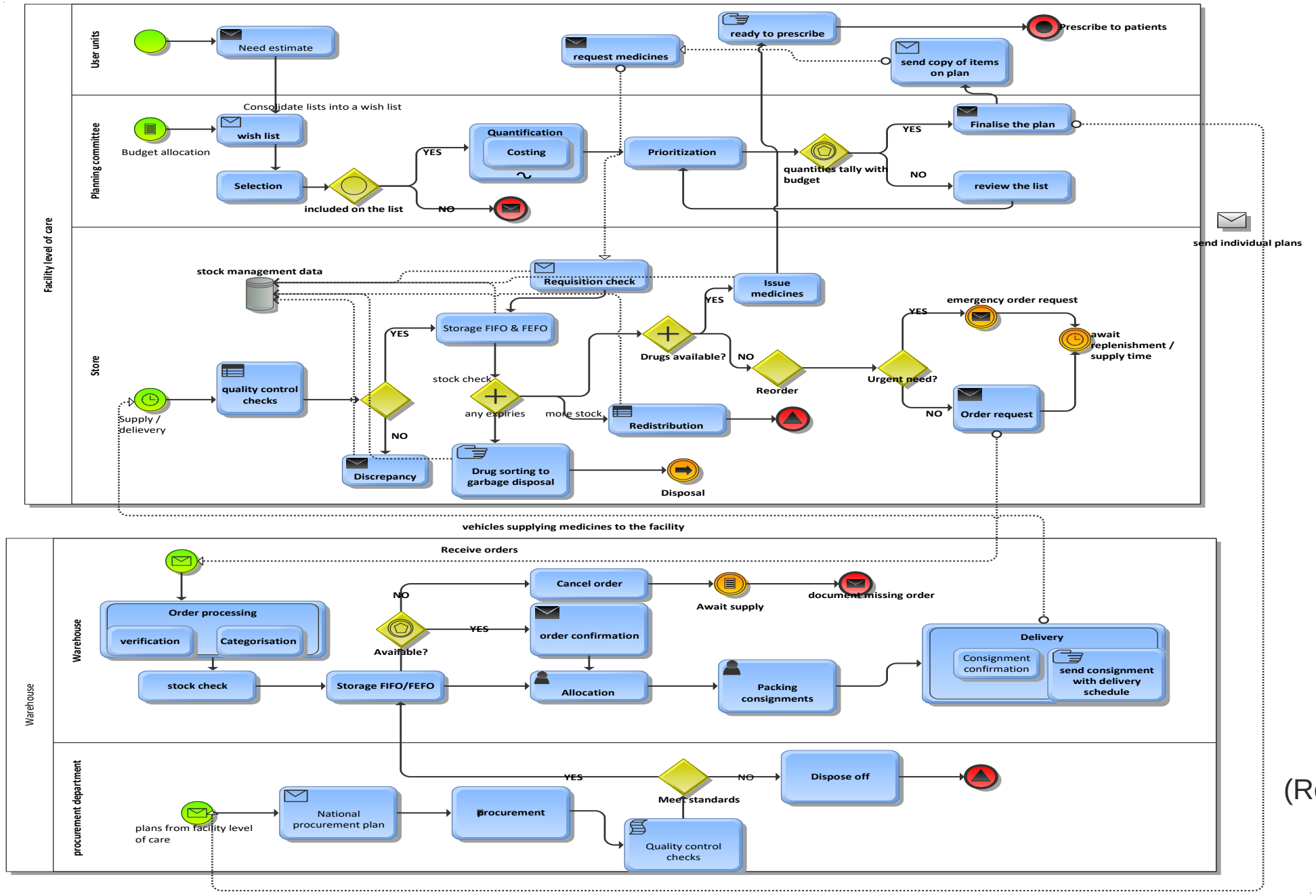
13% of the health expenditure lost in the sector (Okwero, 2010)



(Ministry of Health, 2018)

- Availability of income
- Distance from the next hospital
- Patient's behaviors

Uganda Medicine Process Map



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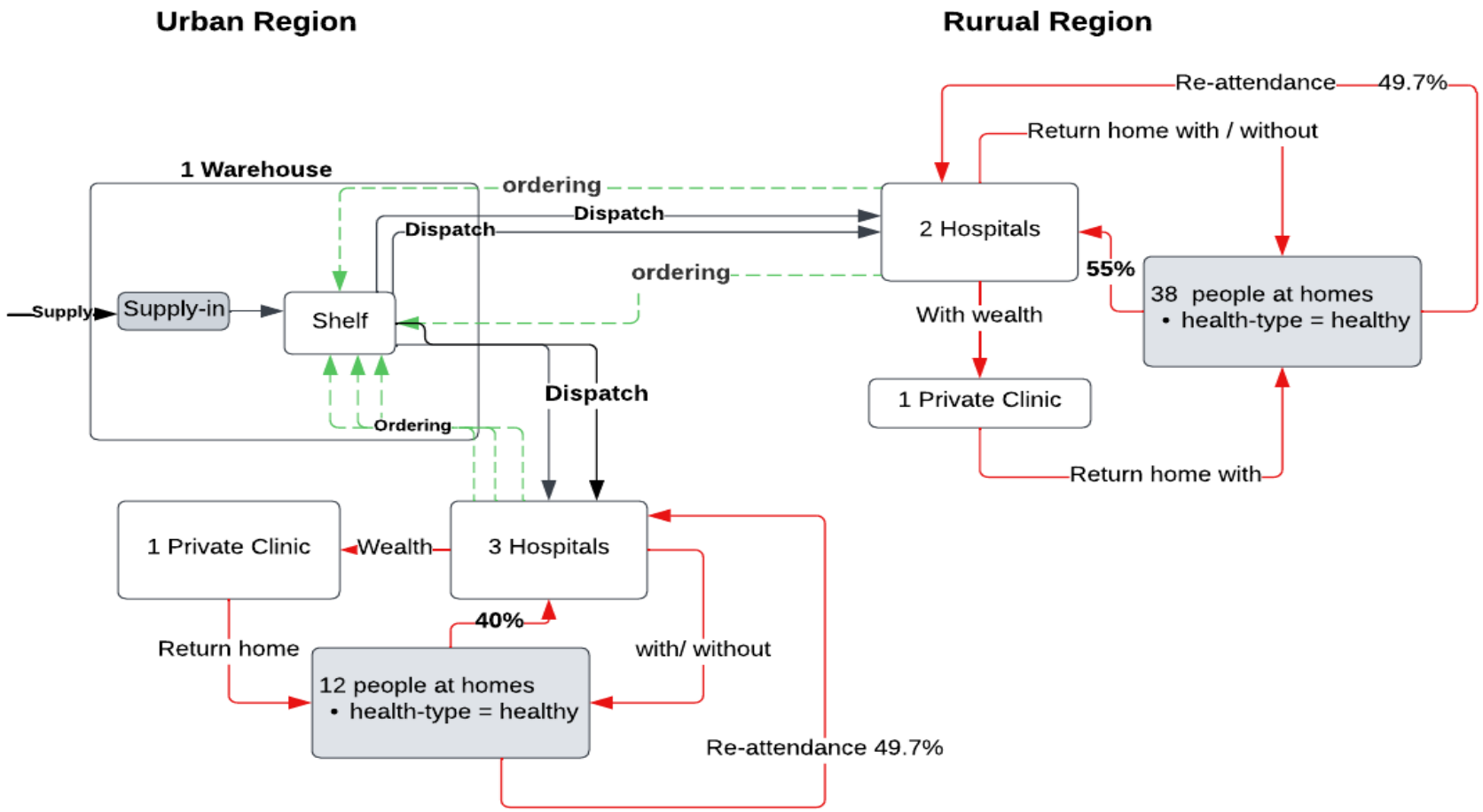
Schematic medicine supply chain



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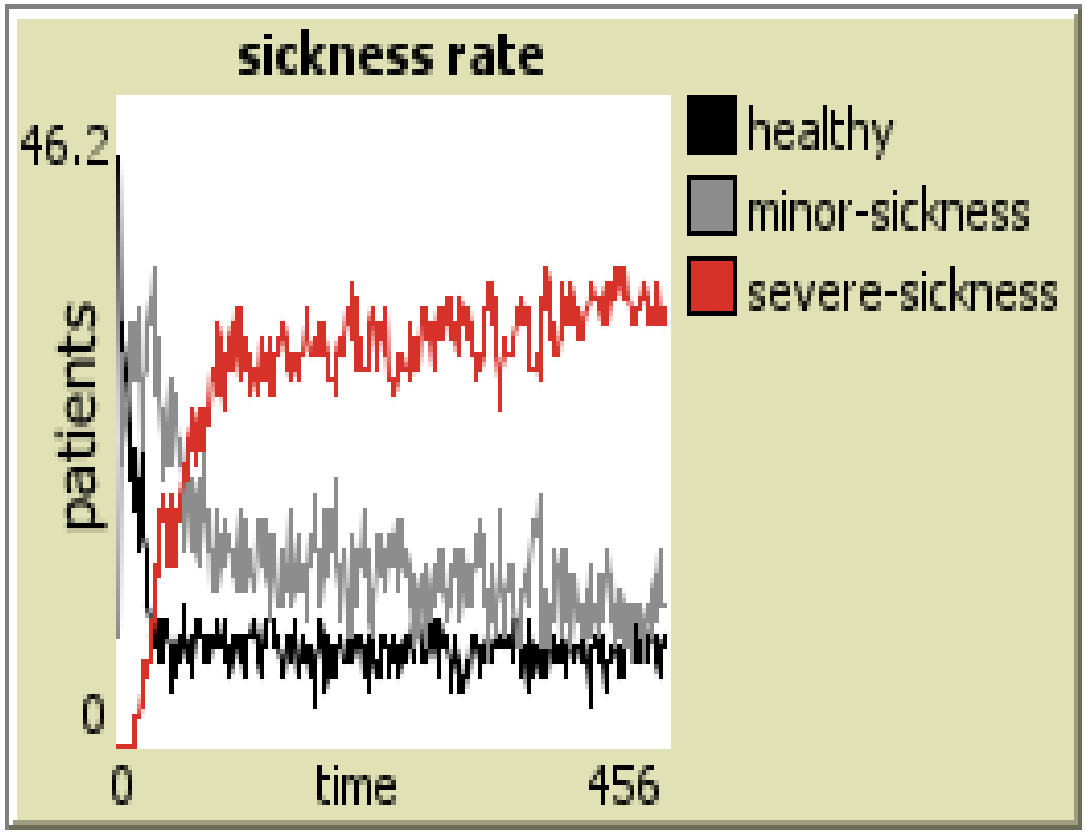
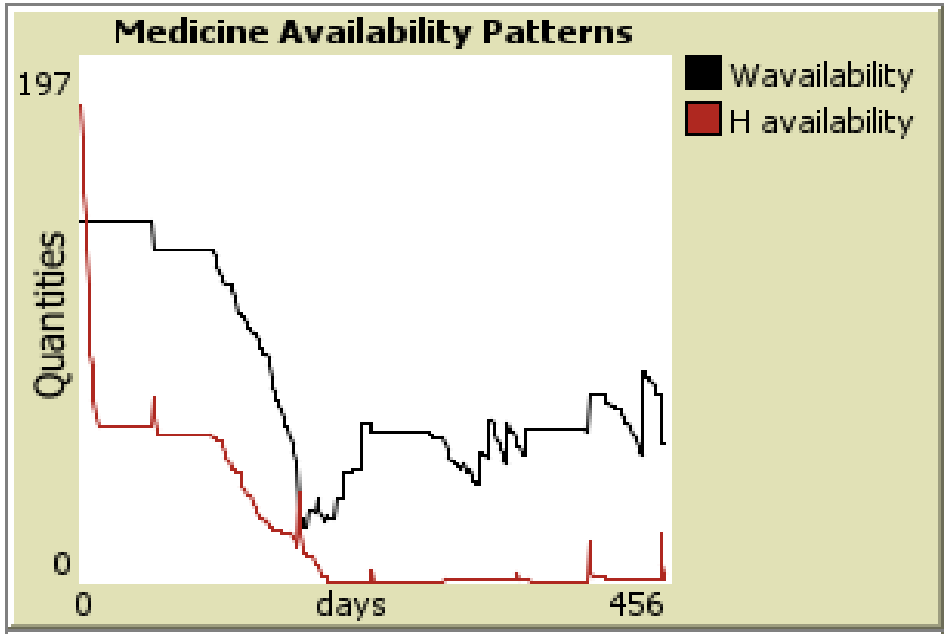
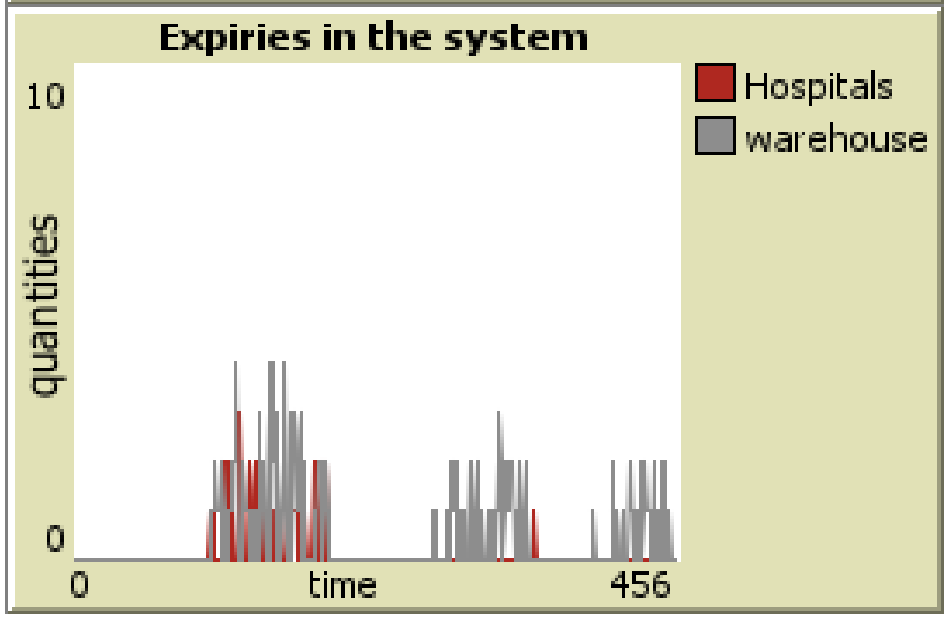
Output from Base Model: Current system







What next ?

Model verification and validation

Experimentation using different what-if scenarios

Expectations of the model

- Make date-driven decisions
- How to organise the supply chain

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