

Combining System Dynamics and Agent-Based Models to Study Transmission of Healthcare-Associated Infections in Long-Term Care Facilities

Le Khanh Ngan Nguyen, Dr. Itamar Megiddo & Prof. Susan Howick
University of Strathclyde – Department of Management Science

A. Introduction

- ❖ Transmission of healthcare-associated infections (HAIs) in long-term care facilities (LTCFs) possesses many distinct characteristics that are not either well understood (1).
- ❖ While HAIs are primarily disseminated via contacts between healthcare workers and patients in hospitals, patient-patient and patient-visitor contacts play an important role in spreading HAIs in LTCFs (2). The frequent hospital readmissions of the elderly population living in LTCFs can also lead to the transmission of resistant organisms across settings (3,4).
- ❖ A hybrid simulation model that combines the methodological strengths of system dynamics (SD) and agent-based models (ABM) can capture these features of HAI transmission in LTCFs.

B. Objectives of the Model

To investigate the transmission dynamics of HAIs and evaluate the effectiveness of infection prevention and control interventions in Scottish LTCFs taking into account the effects of heterogeneous contacts between individuals as well as patient exchange between the LTCFs and hospitals.

C. Model Structure

The hybrid model contains two modules (Figure 1):

- ❖ **The LTCF module (ABM):** ABM offers a microscopic view of individual interactions and their impacts upon the transmission of HAIs within an LTCF.
- ❖ **The Hospital module (SD):**
 - ❖ SD provides the macroscopic view of the dynamics of HAI transmission a hospital whose patients are transferred to and from the LTCF (Figure 2).

Hybridization Design: Interaction

Module Interface:

- ❖ LTCF → Hospital: Residents are aggregated into compartments according to their status of infection.
- ❖ Hospital → LTCF: Hospitalized residents are disaggregated to create a set of individual resident agents that return to LTCF module.

D. Discussion

Why is the Hospital Module Needed?

- ❖ Any change in the prevalence of HAIs in the hospital and the rates and patterns of patient exchange between the two settings will affect the prevalence of HAIs in its connecting LTCF and vice versa.
- ❖ Hospital module assesses the feedback loops of the transmission dynamics of HAIs occurring in the hospital-LTCF system.

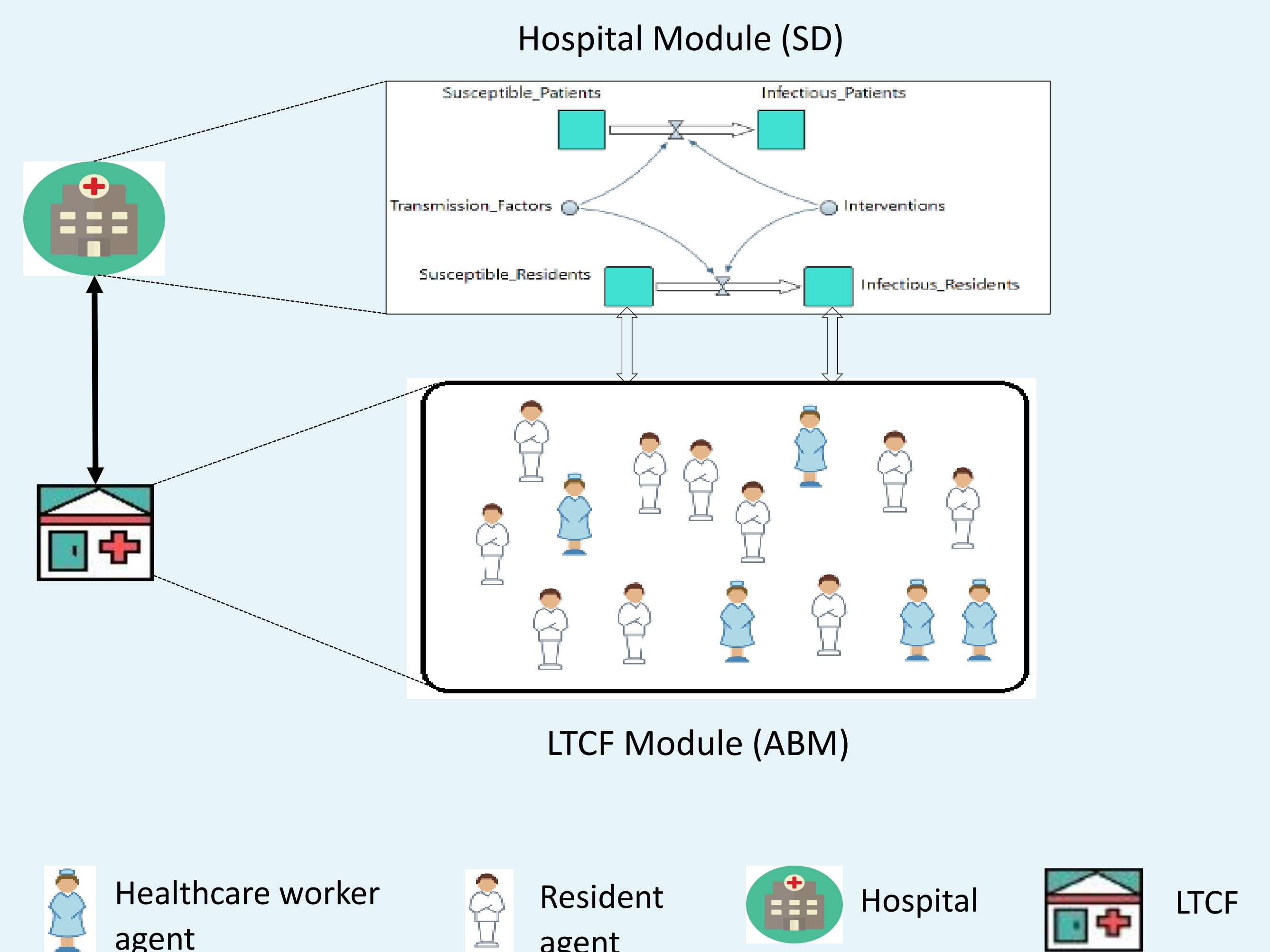


Figure 1: The structure of the hybrid simulation model with the constituent modules.

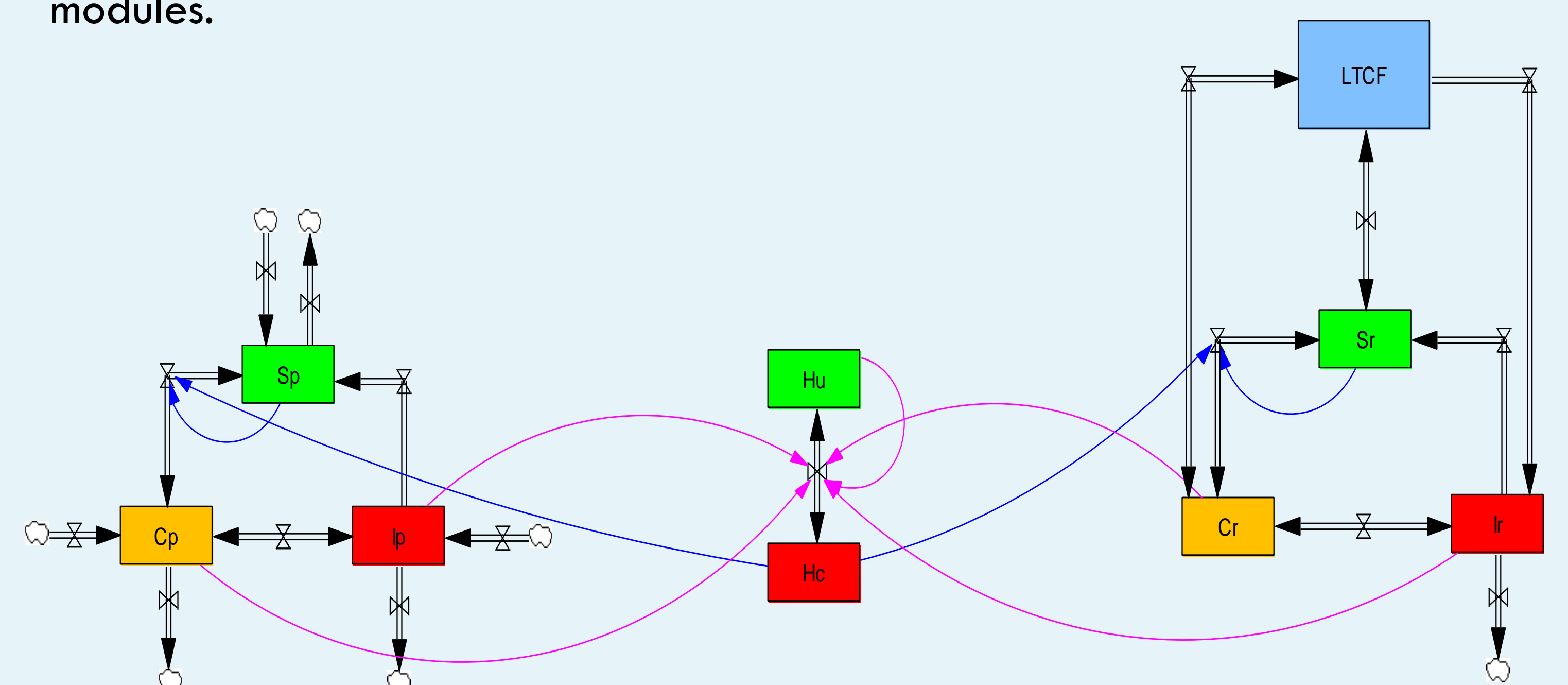


Figure 2: The graphical presentation of the Hospital module
Sp, Sr: Susceptible patients and residents; Cp, Cr: Colonized patients and residents; Ip, Ir: Infected patients and residents; Hu: Uncontaminated healthcare workers (HCWs); Hc: Contaminated HCWs. Blue arrows: The transmission from contaminated HCWs to susceptible patients/residents. Pink arrows: The transmission from colonized/infected patients/residents to uncontaminated HCWs. The blue square LTCF represents the LTCF module.

References

1. van Kleef E, Robotham JV, Jit M, Deeny SR, Edmunds WJ. Modelling the transmission of healthcare associated infections: a systematic review. BMC infectious diseases. 2013 Dec 1;13(1):294.
2. Schweon SJ, Kirk J. A realistic approach towards hand hygiene for long-term care residents and health care personnel. American journal of infection control. 2011;39(4):336-8.
3. Care Quality Commission. Working together to prevent and control infections: A study of the arrangements for infection prevention and control between hospitals and care homes. CQC, London. Available online at: www.cqc.org.uk/db/_documents/Working_together_to_prevent_and_control_infections.pdf. 2009.
4. Smith P, Sherlaw-Johnson C, Ariti C, Bardsley M. Focus on: hospital admissions from care homes. Health Foundation. 2015 Jan.

Further information

Please contact the corresponding author:
Le Khanh Ngan Nguyen
E: Nguyen-le-khanh-ngan@strath.ac.uk