CONCEPTUAL FRAMEWORK BASED ON ARTIFICIAL INTELLIGENCE TO FACILITATE THE INTEGRATION OF INFECTIOUS DISEASE MODELING INTO PUBLIC HEALTH PRACTICE

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Pour l'amour des enfants

Université de Montréal

ARTIFICIAL INTELLIGENCE AND HEALTH:
INTERDISCIPLINARY APPROACHES

Motivation : modeling in a time of crisis

COVID-19 modelling in Québec for INSPQ (Marc Brisson's team at U Laval)

	Questions and objectives	Modeling work
Version 1 Mar 2020 – Jun 2020	• Estimate the epidemic curve with mitigation measures • Impact of summer travel	• Programming a model from scratch • Gather data on natural history of disease • Program model calibrations and outputs
Version 2 Sep 2020 – Jan 2021	• Social contacts with fall classes and holidays • Impact of screening, contact tracing and case isolation	• Stratify the model by age • Add contact matrices for setting and region • Use data of the CONNECT study to inform contact rates
Version 3 Feb 2021 – Jan 2022 (?)	• New variants • Vaccination campaign	• Analyse and use results of variant screening and vaccine coverage
Version 4 Upcoming (?)	• Return to pre-COVID social contacts • Vaccination of children • Waning immunity and new variants • …	• Different types of vaccines and dose schedules • Contacts between vaccinated and unvaccinated • ...

Status in Feb 2022

https://marc-brisson.net/covid19-response/Presentation_JASP.pdf

Motivation : modeling in a time of crisis

Main challenges

- Understand the natural history of a new virus
- Understand the impact of social contacts on transmission
- Understand the ways that mitigation measures influence contacts, e.g. impact of “vaccine passports”
- Anticipate future behavior under new measures
- Develop and program a mathematical model from scratch rapidly with limited or inexistent data for many parameters
- Make sure that the model is up-to-date with constantly evolving knowledge
- Obtain valid data in real-time to calibrate the model to keep track of the epidemiological situation that changes rapidly
- Translate results of a complex methodology for public health doctors, deciders, the media, the public

https://marc-brisson.net/covid19-response/Presentation_JASP.pdf

Motivation : modeling in a time of crisis

"New real-time modeling tools **should be developed in collaboration** with modeling experts, policy developers, and decision makers […] as well as **providing a guide to interpretation** for nonexperts. Real-time modeling tools that are regularly used by trained personnel and public health officials […] will better serve the public interest during infection disease emergencies."

Muscatello DJ et al. Translation of Real-Time Infectious Disease Modeling into Routine Public Health Practice. Emerg Infect Dis. 2017 May;23(5):e161720.

"[...] tools should be developed that **allow modeling of multiple scenarios** […] from choices about school closures to care management for the elderly, to distribution of scarce resources like ventilators and PPE."

"Important ML-based solutions have been developed in response to pandemics and particularly for COVID-19 but **few were optimized for practical clinical or public health application** early in the pandemic."

Syrowatka A et al. Leveraging artificial intelligence for pandemic preparedness and response: a scoping review to identify key use cases. NPJ Digit Med 2021;4(1):1-4.

Artificial intelligence for infectious disease modeling

- Where can AI help?
  - Support building and updating of models and simulations with real-time data
  - Support inspection, analysis and validation of evolving model
  - Support requesting simulation results for new scenarios

Artificial intelligence for infectious disease modeling

- Objectives
  - Development and implementation of a next-generation modeling and simulation platform using *model-driven engineering principles*
  - Design and evaluation of learning algorithms adapted to infectious disease modeling based on *composition modeling*

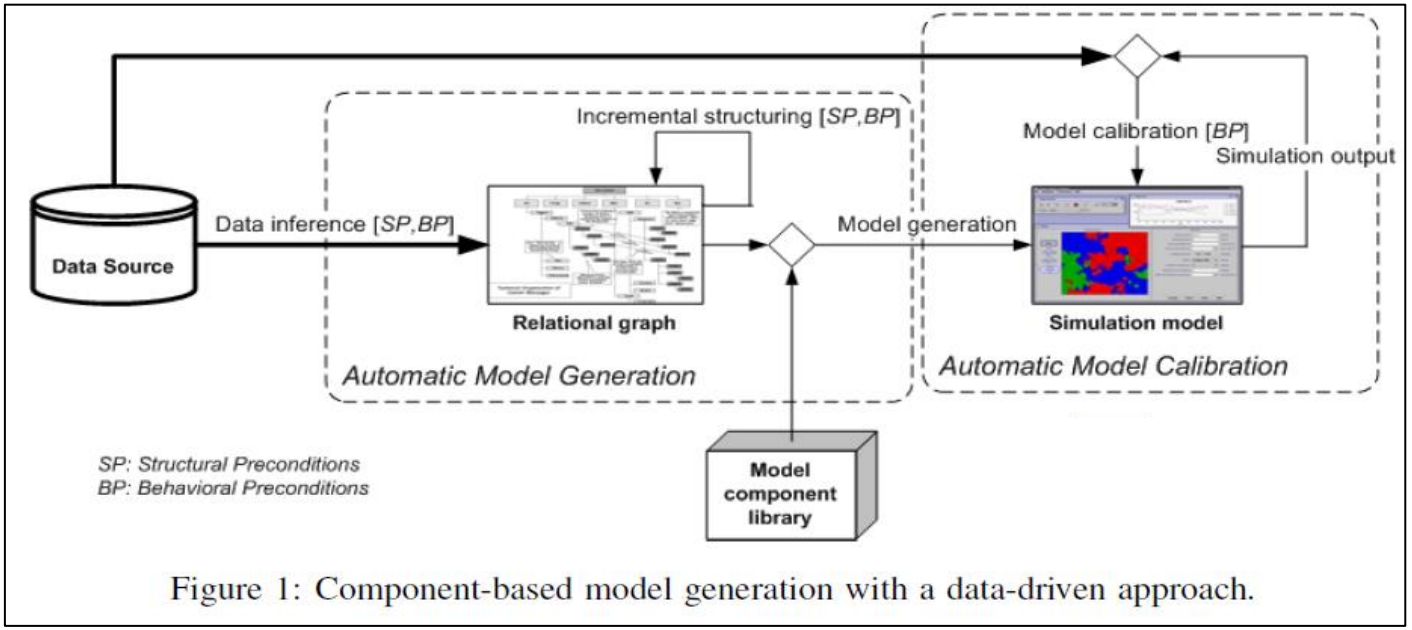


Figure 1: Component-based model generation with a data-driven approach.

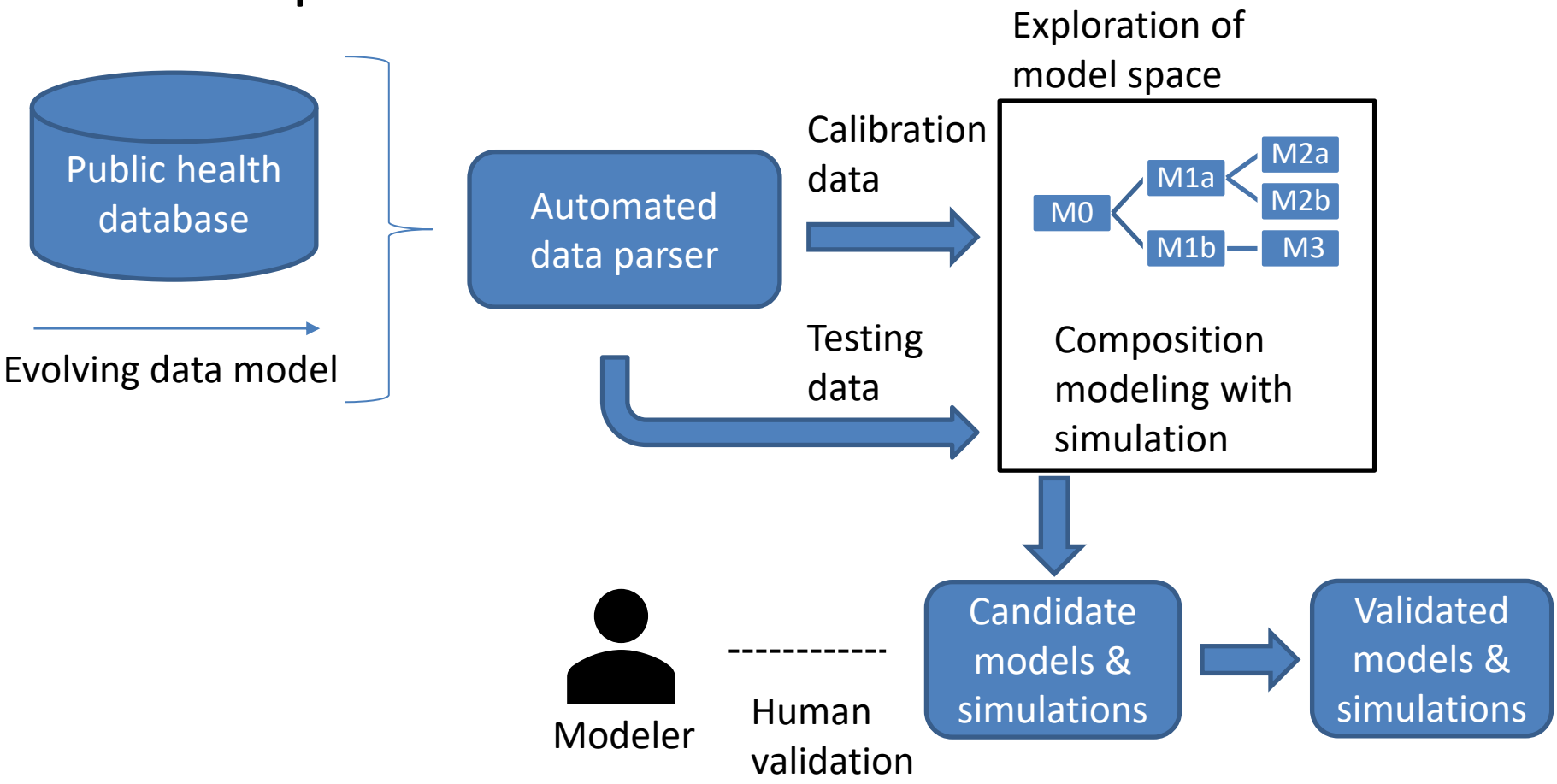
Huang Y et al. From data to simulation models: component-based model generation with a data-driven approach. Winter Simulation conference 2011

Artificial intelligence for infectious disease modeling

- Some challenges for infectious disease models
  - Formal representation of model structures and operations
  - Algorithms that adapt seemlessly to any valid model structure
  - Interpretability of results in complex models
- Preliminary work
  - Augmentation of model structure to add virus variants (paper under revision at Journal of Healthcare Informatics Research)
  - Computation of reproduction numbers independently of model structure (poster presented at this conference by Alexandre Simard)
  - Study of metamodels needed for modeling and simulation platform (conference paper submitted at MODELS 22, Montreal)

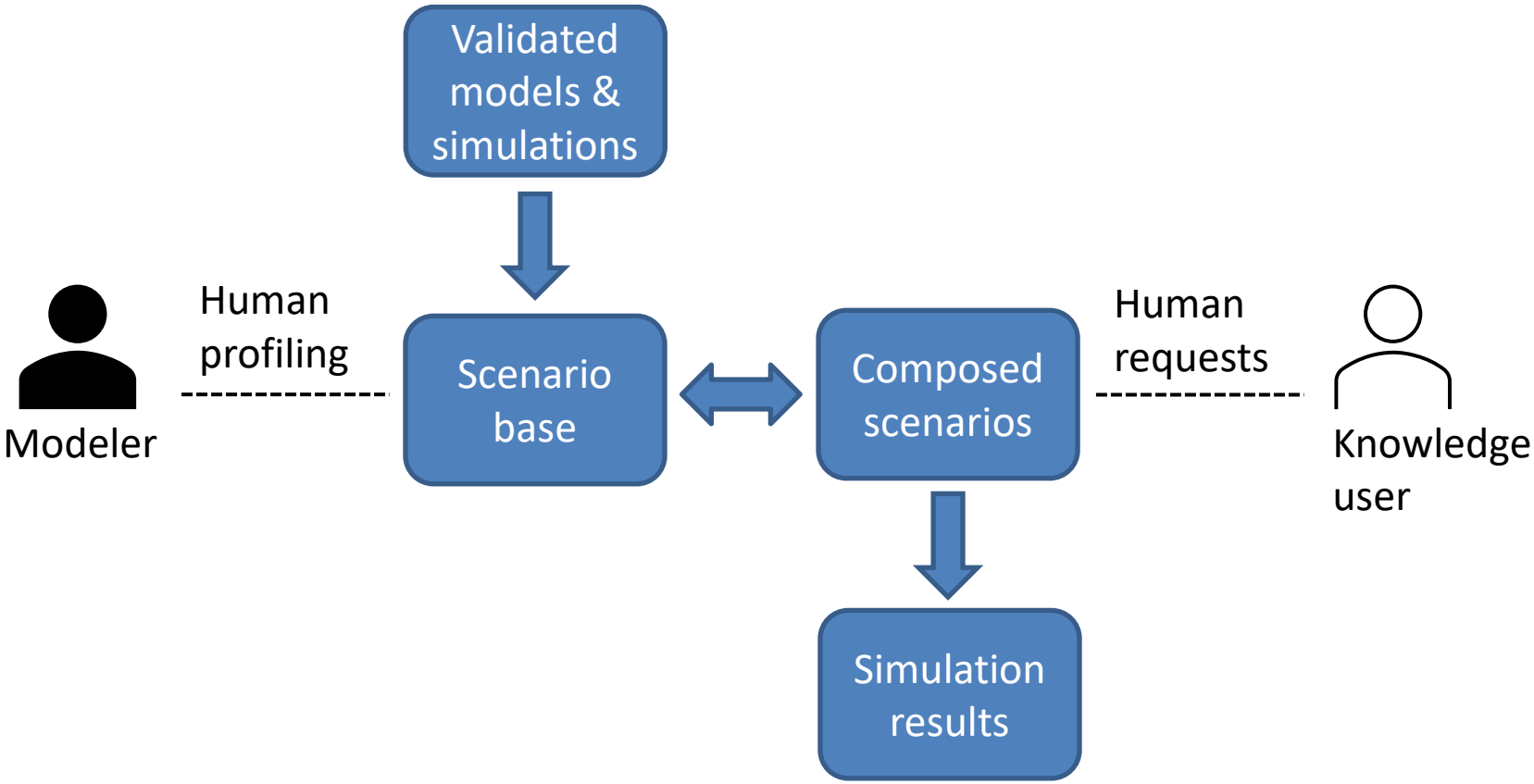
Artificial intelligence for infectious disease modeling

- Conceptual framework



Artificial intelligence for infectious disease modeling

- Conceptual framework



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