Healthcare System Modeling: Beyond the Digital Twin

Jenny Basran, MD FRCPC
Senior Medical Information Officer
Saskatchewan Health Authority

Kurt Kreuger, PhD
Kreuger Consulting LLC
kurtk@kreugerconsulting.com

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Insight Through Simulation

What is a Digital Twin?

- A synthetic model that ***mirrors*** a physical system to improve learning about that physical system.

- A digital or virtual ***replica*** of a physical object or system to learn about its present and future behavior.

- A virtual construct that ***fully describes*** a potential or actual physical reality.

https://ntrs.nasa.gov/api/citations/20210023699/downloads/ASME%20Digital%20Twin%20Summit%20Keynote_final.pdf

What is a Digital Twin?

The physical system

- Product
- Process
- System

The virtual system

- Statistical model
- Machine learning or AI model
- Physics-based model
- Systems model
- Etc.

Where is it used?

Manufacturing

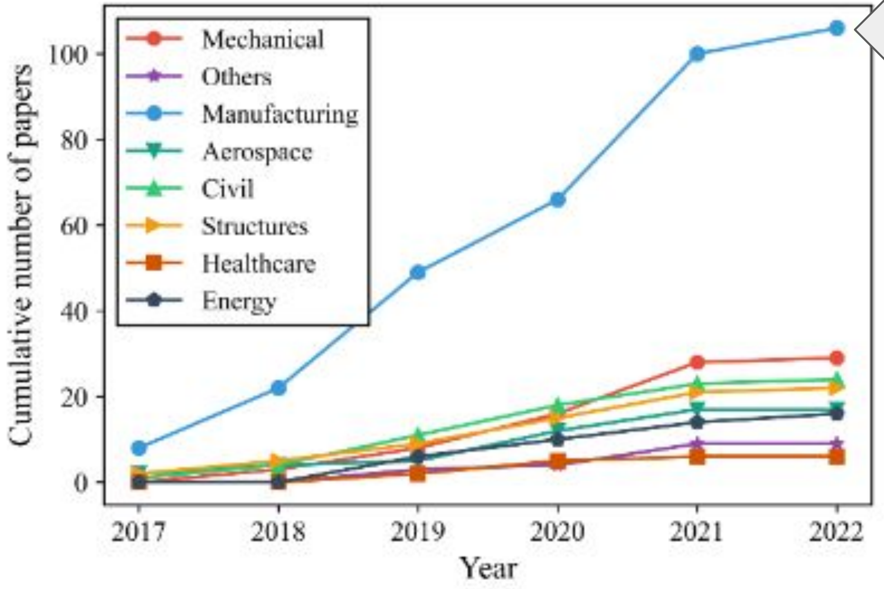


Fig. 5: Cumulative number of papers of different application domains

https://arxiv.org/pdf/2208.14197.pdf

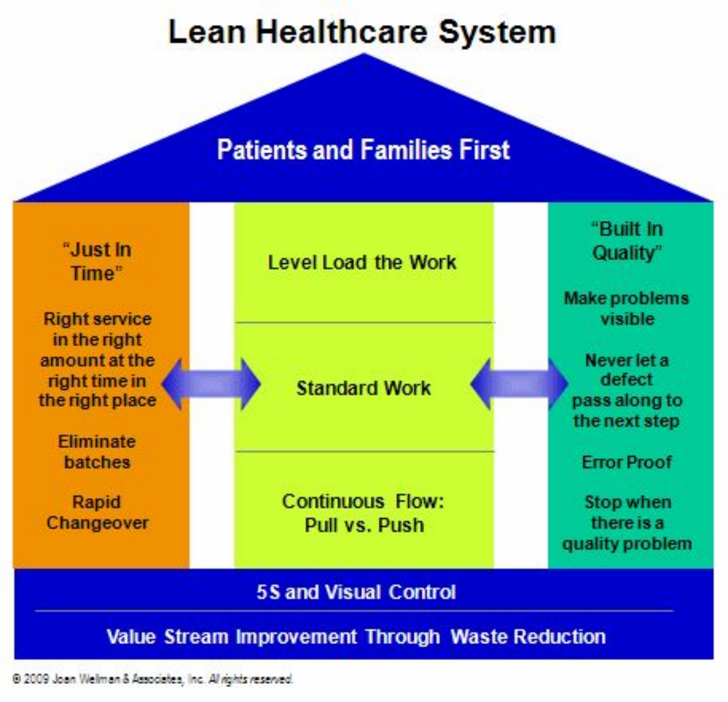
Manufacturing Approach in Health Care

The Promise of Lean in Health Care ! What can a Medical Center learn from an auto manufacturer(Toyota Production System)?

What Is Lean Healthcare?

Lean Healthcare is the application of “lean” ideas in healthcare to minimize waste with ongoing process improvement. Learn how to use Lean to improve patient satisfaction and care outcomes while reducing costs.

Author: NEJM Catalyst Author Info & Affiliations



Where is it used?

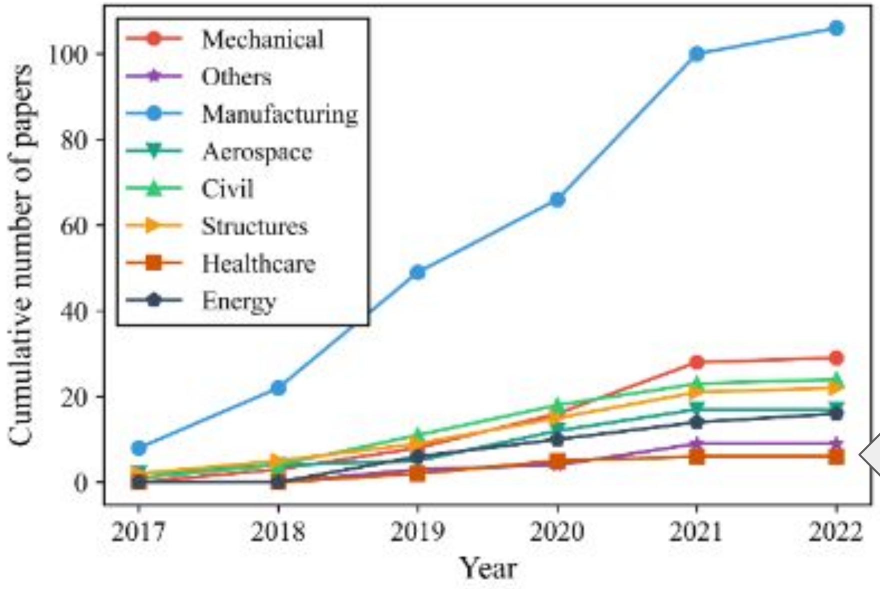


Fig. 5: Cumulative number of papers of different application domains

Why is Healthcare so different?

https://arxiv.org/pdf/2208.14197.pdf

What’s different about Healthcare?

https://strathprints.strath.ac.uk/45444/1/Analysis.full.pdf

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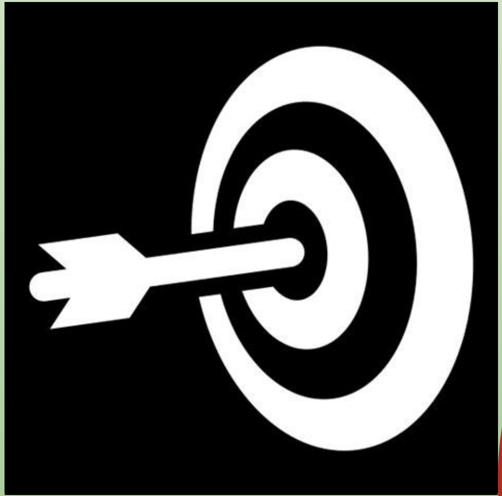
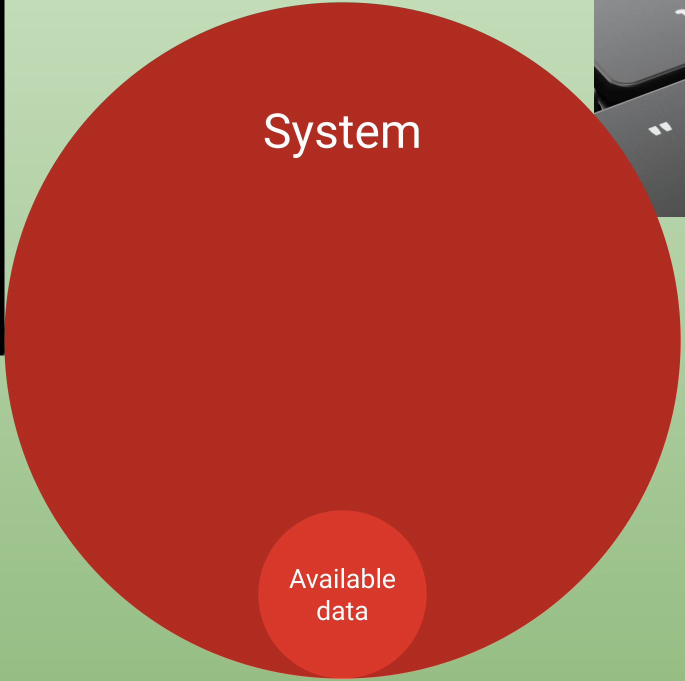
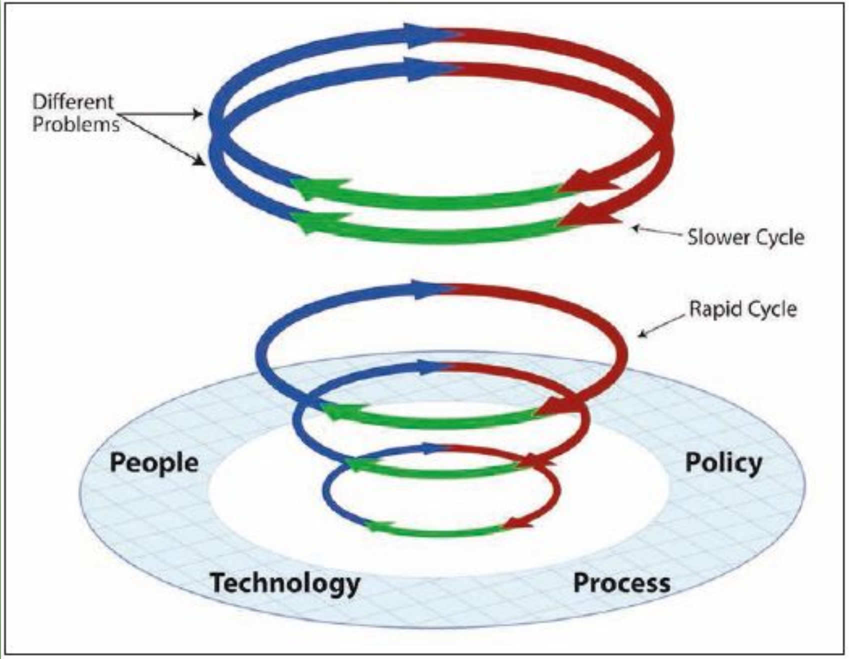


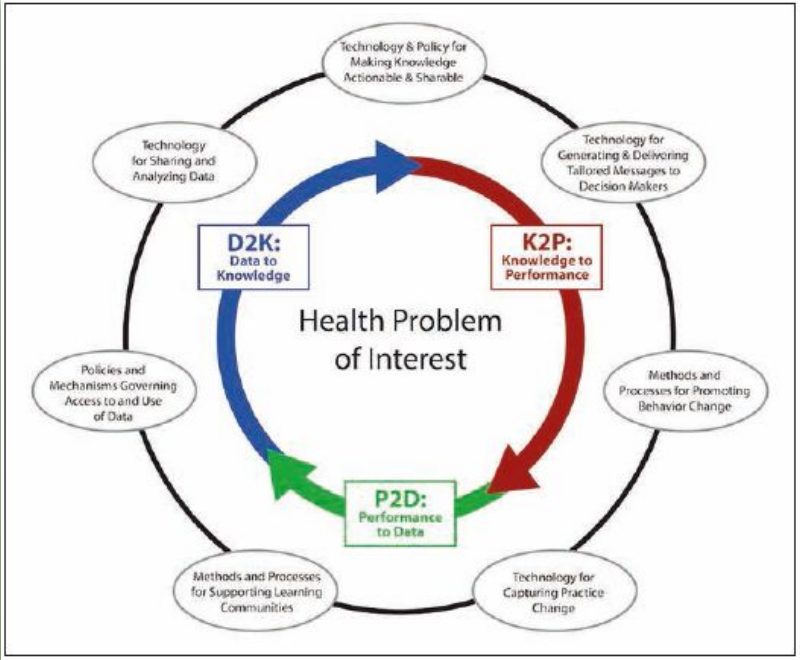


What's different about Healthcare?

Adapted with permission from Christchurch, NZ

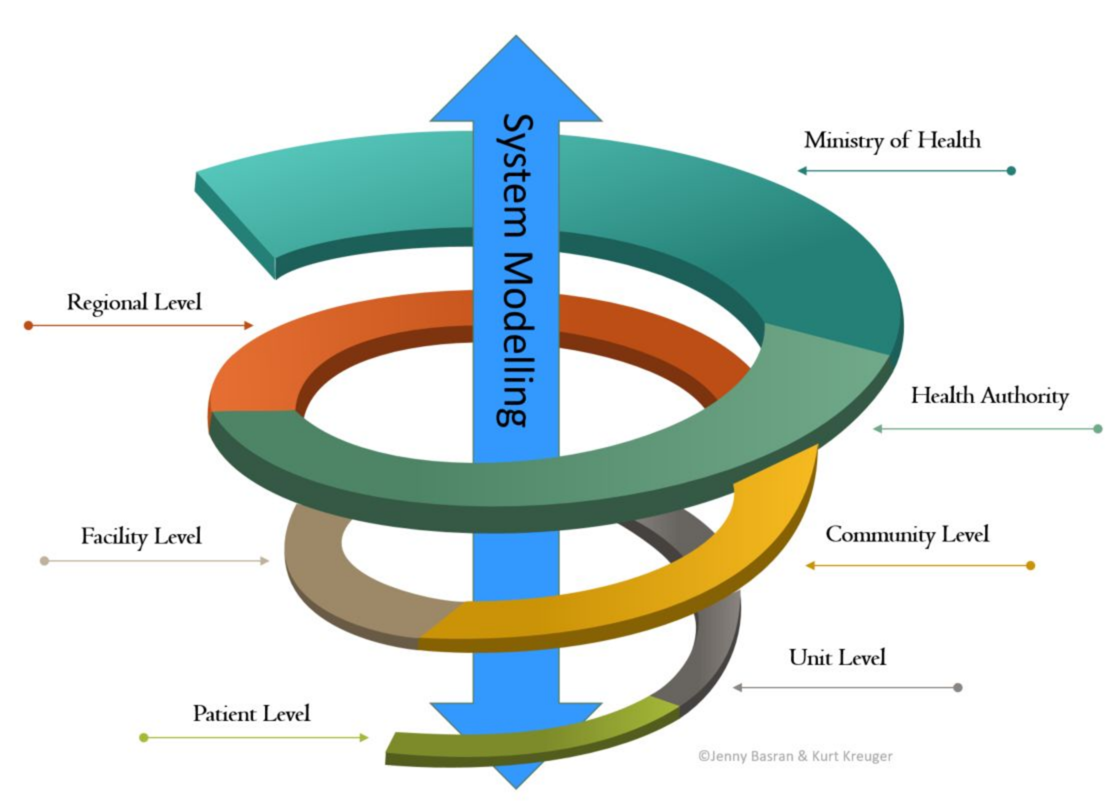
Learning Health System





https://www.thieme-connect.de/products/ejournals/html/10.15265/IY-2017-004

Integrated Health System Modelling

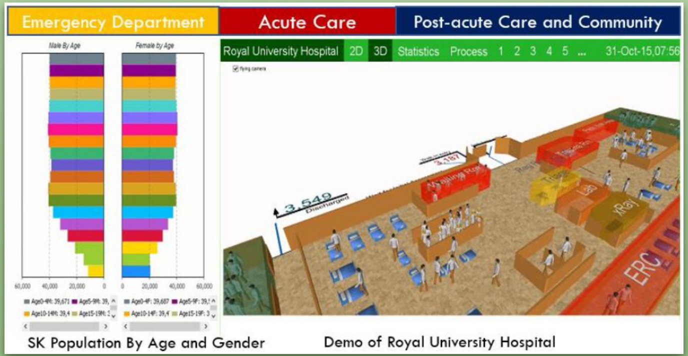


Modelling to speed up learning

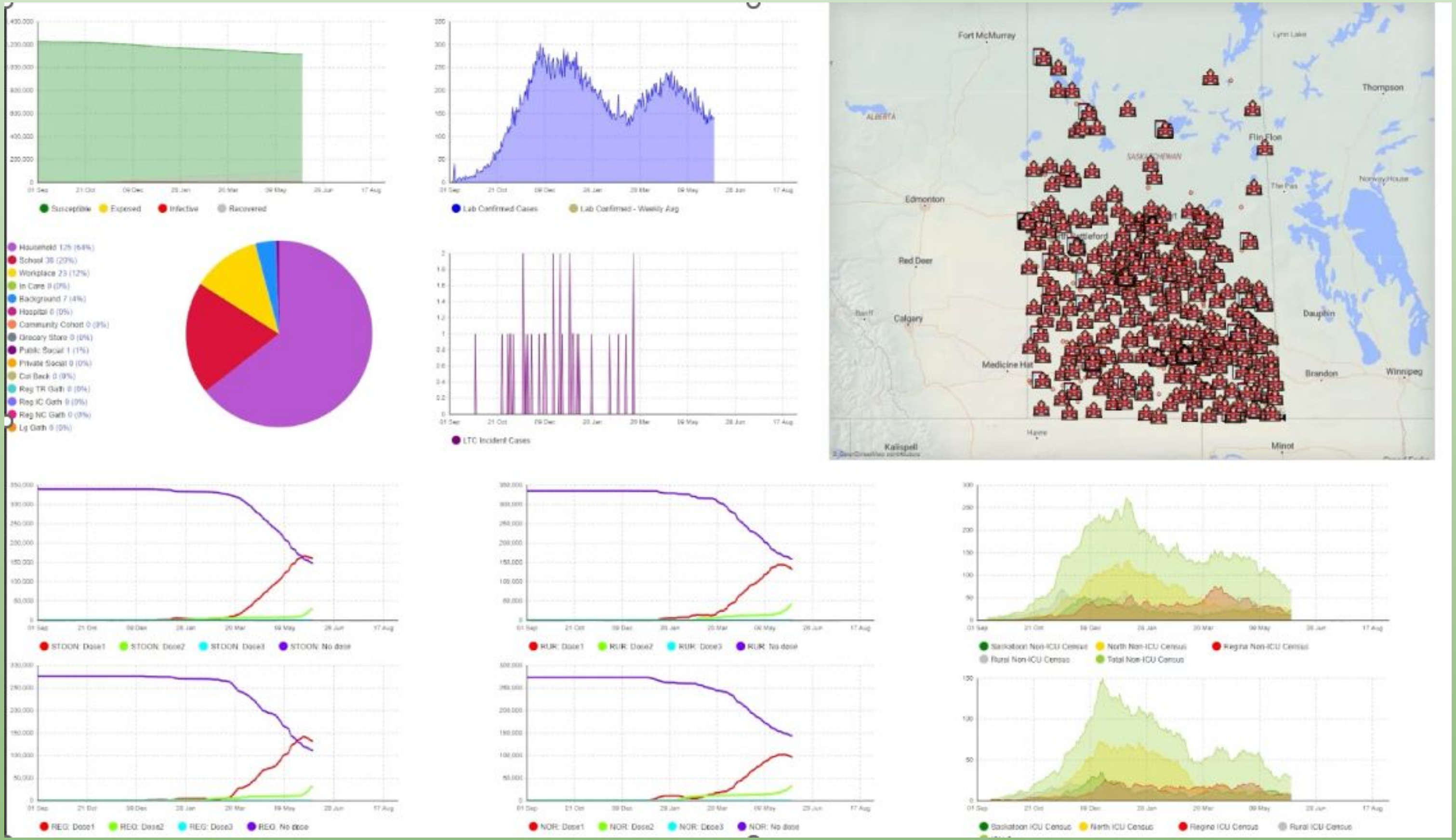
Collective Mental Model

Collective Model Building, Validation, and Simulation

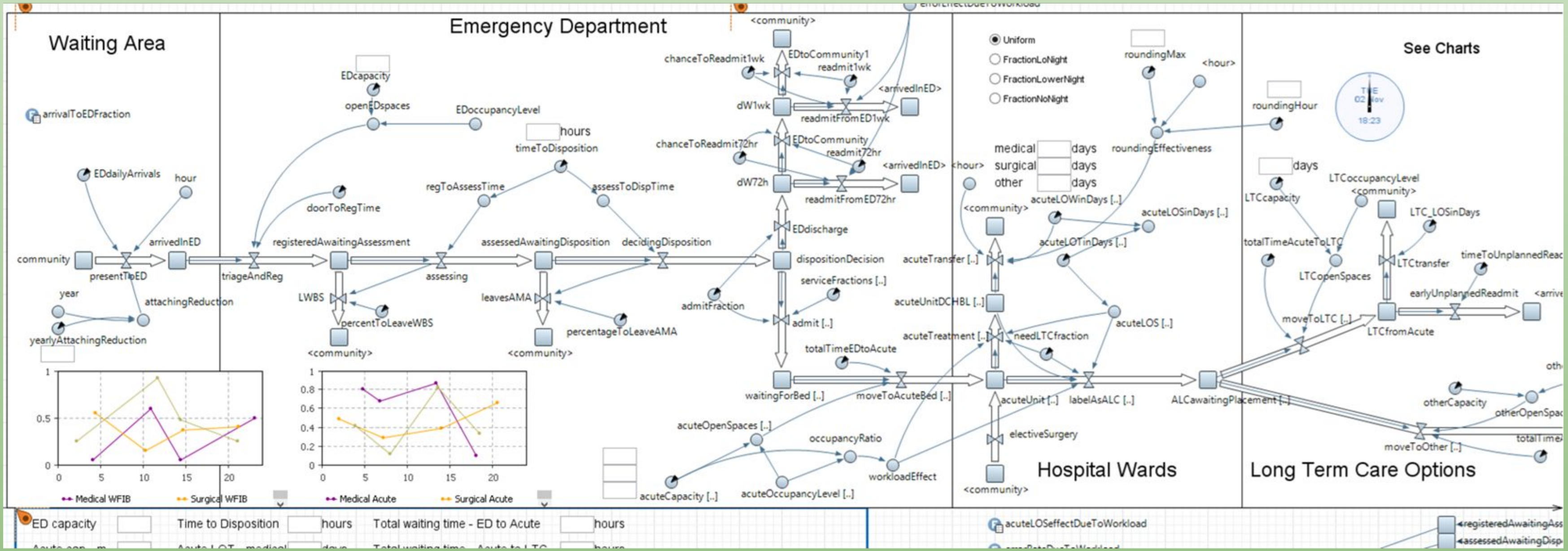
Implementation Science
Quality Improvement



Example 1: COVID modelling

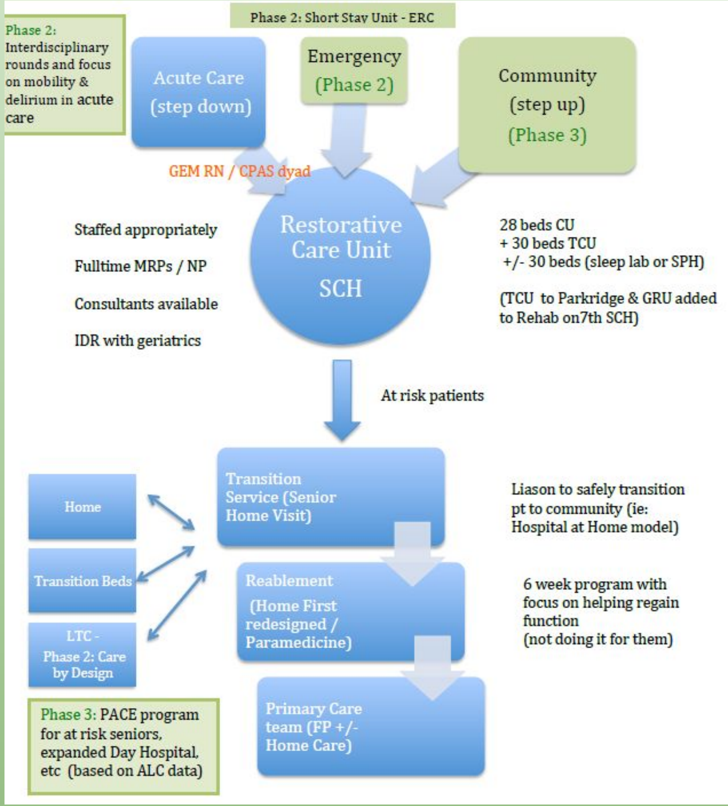


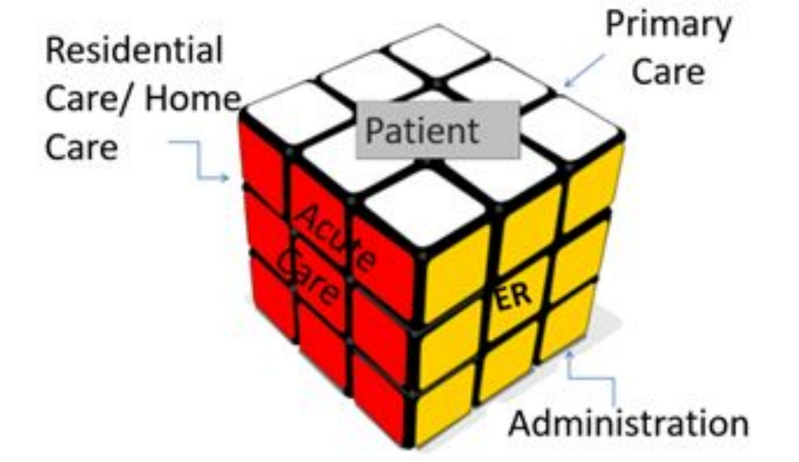
Example 2: Emergency Department Flow



Example 3: System flow

Evaluating impact of complex interventions to multiple different parts of the health system





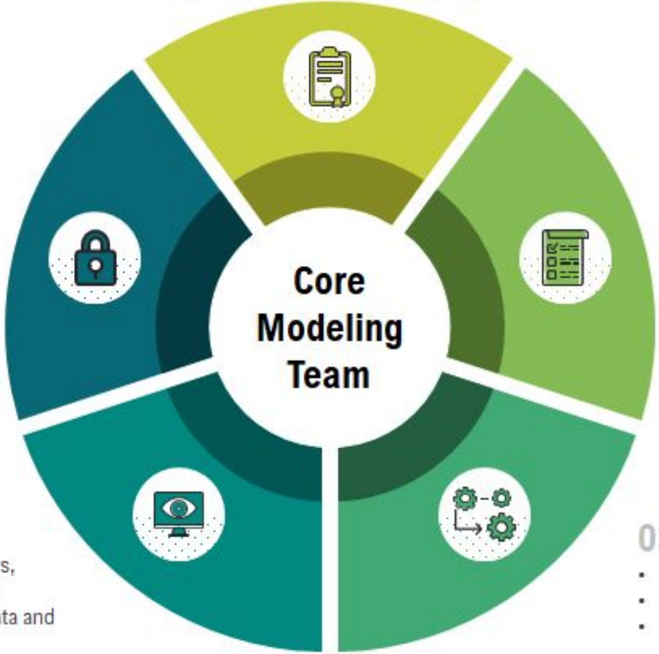
5 Key Components of Integrated Health System Modelling

01. Map of Full Process

- COVID – disease process + offensive / defensive strategy
- System Flow includes full continuum: Emergency Department, Acute Care, Intermediate Care, Community Care, Primary Care
- Value Stream Maps that evolve with changes

02. Data

- What is available? Standardized? Integrated? Limitations?
- What key data is missing and needs to be collected?
- What analytics to inform model?
- How does data flow in and out of model?



03. Evidence

- Driver Diagrams
- Best practice and literature reviews
- Outcomes of local projects (QI, research)
- Ongoing process

04. Contextual Knowledge

- Operational leaders, Key Stakeholders, Experts including Patients / Families
- Contextual knowledge of process, data and evidence
- Validation, Feasibility, Prioritization

05. Knowledge Translation

- Bi-directional
- Helping key stakeholders understand what modelling can and cannot do.
- What questions are we trying to answer?
- Translating model outputs into actionable intelligence

Conclusion

- Healthcare is unique and complex
- Embedded modelling teams
- Right tool for the right job

Thank you!

kurtk@kreugerconsulting.com

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