Role of Interoperability Standards in Enabling Healthcare Digital Twins

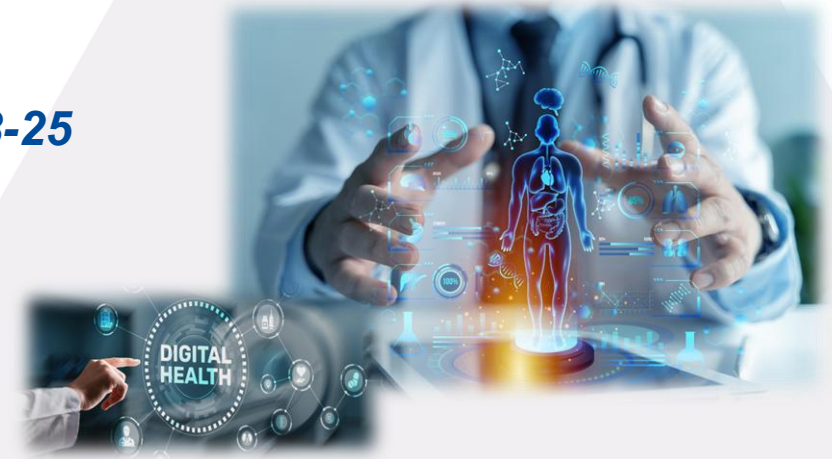
From Data Silos to a Role-Based Semantic Framework

Somayeh Abedian

*Senior Researcher, Ludwig Boltzmann in Digital Health and Prevention, Salzburg, Austria

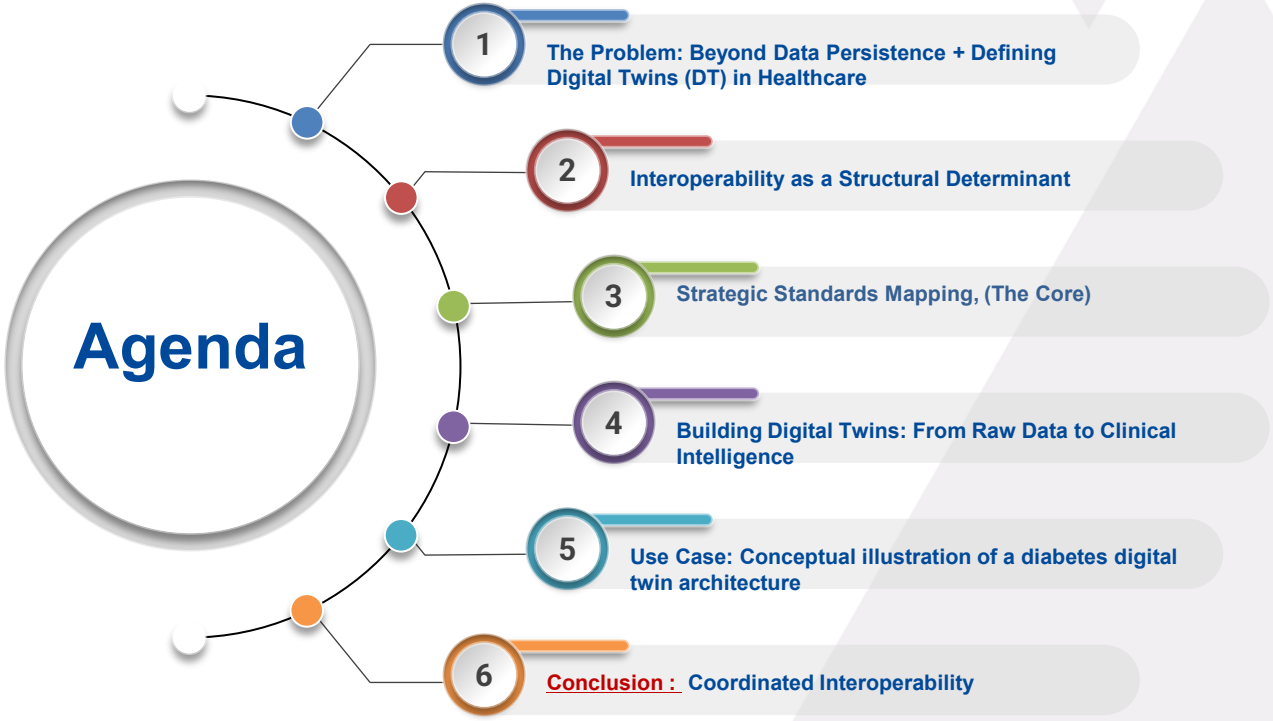
*Adjunct Faculty Member, Institute of Health Policy, Management and Evaluation, University of Toronto

2026-03-25



LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

Agenda



LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

The Problem: Beyond Data Persistence

- Current Healthcare Information Systems focus on "data at rest" leading to Semantic Fragmentation.
- Pilot DTs often fail in real-world environments due to a lack of scalable data infrastructure.
- The Challenge: How to maintain high-fidelity digital representations in fragmented ecosystems?.

LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

Defining Digital Twins (DT) in Healthcare

Reference-based

- **A digital twin will follow the life journey of each person and harness both data collected by wearable sensors and lifestyle information that patients may register, shifting the clinical approach towards preventive healthcare**… (The 'Digital Twin' to enable the vision of precision cardiology, European Heart Journal, https://doi.org/10.1093/eurheartj/ehaa159)

- **A virtual representation of a patient is constructed and receives real-time updates of a range of data variables in order to predict disease and optimise treatment selection for the real-life patient**.. (Definitions and Characteristics of Patient Digital Twins Being Developed for Clinical Use: https://www.jmir.org/2024/1/e58504)

LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

Defining Digital Twins (DT) in Healthcare

- **A DT is not just a high-fidelity simulation or a dashboard.**
- **It is a digital construct that evolves alongside the patient or clinical process.**
- **Requirement: Ability to incorporate new observations while preserving clinical meaning and temporal context**

LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

Interoperability as a Structural Determinant

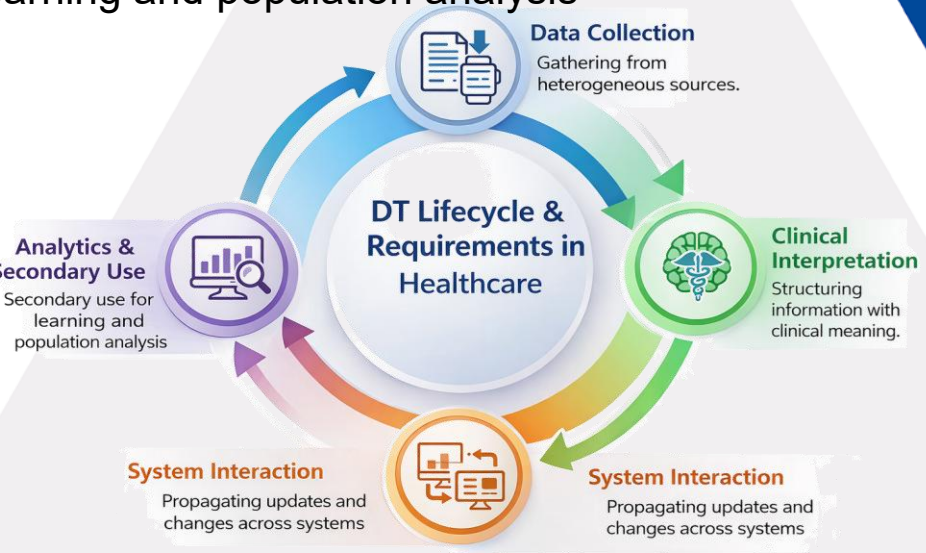
- Interoperability is not a "backend utility" but a Structural Determinant of DT viability.
- Essential for preventing Semantic Drift over the DT lifecycle.
- DTs must reconcile event-driven updates with long-term semantic stability.

LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

The DT Lifecycle & Requirements in Healthcare

Our analysis examines interoperability across four key phases:

1. **Data Acquisition:** Gathering from heterogeneous sources.
2. **Clinical Interpretation:** Structuring information with clinical meaning.
3. **System Interaction:** Propagating updates and changes across systems
4. **Analytical Reuse:** Secondary use for learning and population analysis



LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

Strategic Standards Mapping (The Core)

HL7 FHIR: The engine for timely interaction and event-driven updates.

openEHR: The guardian of longitudinal clinical meaning through Archetypes.

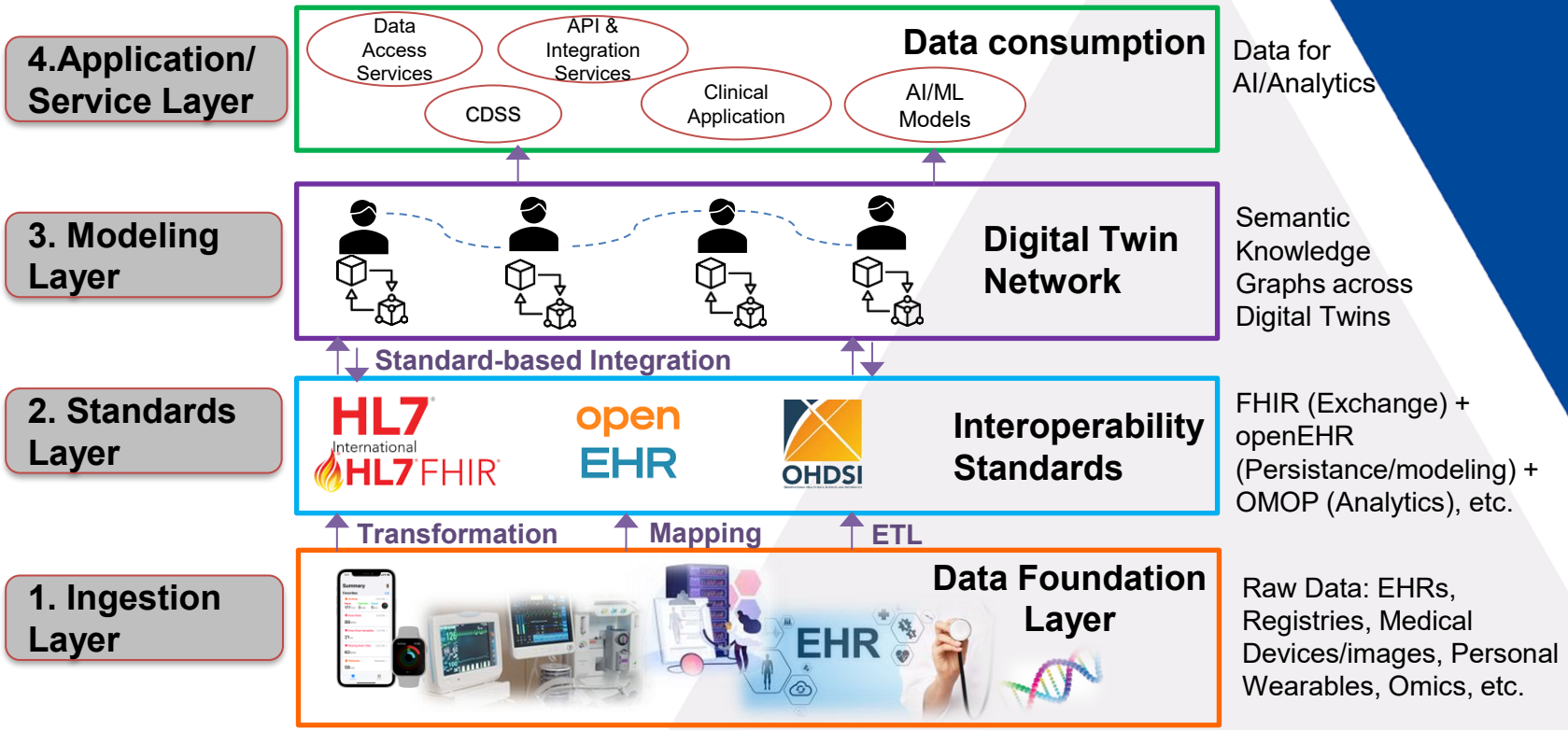
OMOP: The foundation for evidence-based interpretation and analytical reuse.

Dimension	openEHR	HL7 FHIR	OMOP
Primary Role	Clinical concept modelling	System interaction	Analytical reuse
Core strength	Semantic consistency over time	Timely data exchange	Population-level analysis
Temporal orientation	Longitudinal	Event-based	Cohort-oriented
Typical use context	Persistent clinical records	Integration of clinical systems	Observational research
Contribution to DTs	Stable state representation	Update propagation	Evidence-based interpretation

LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

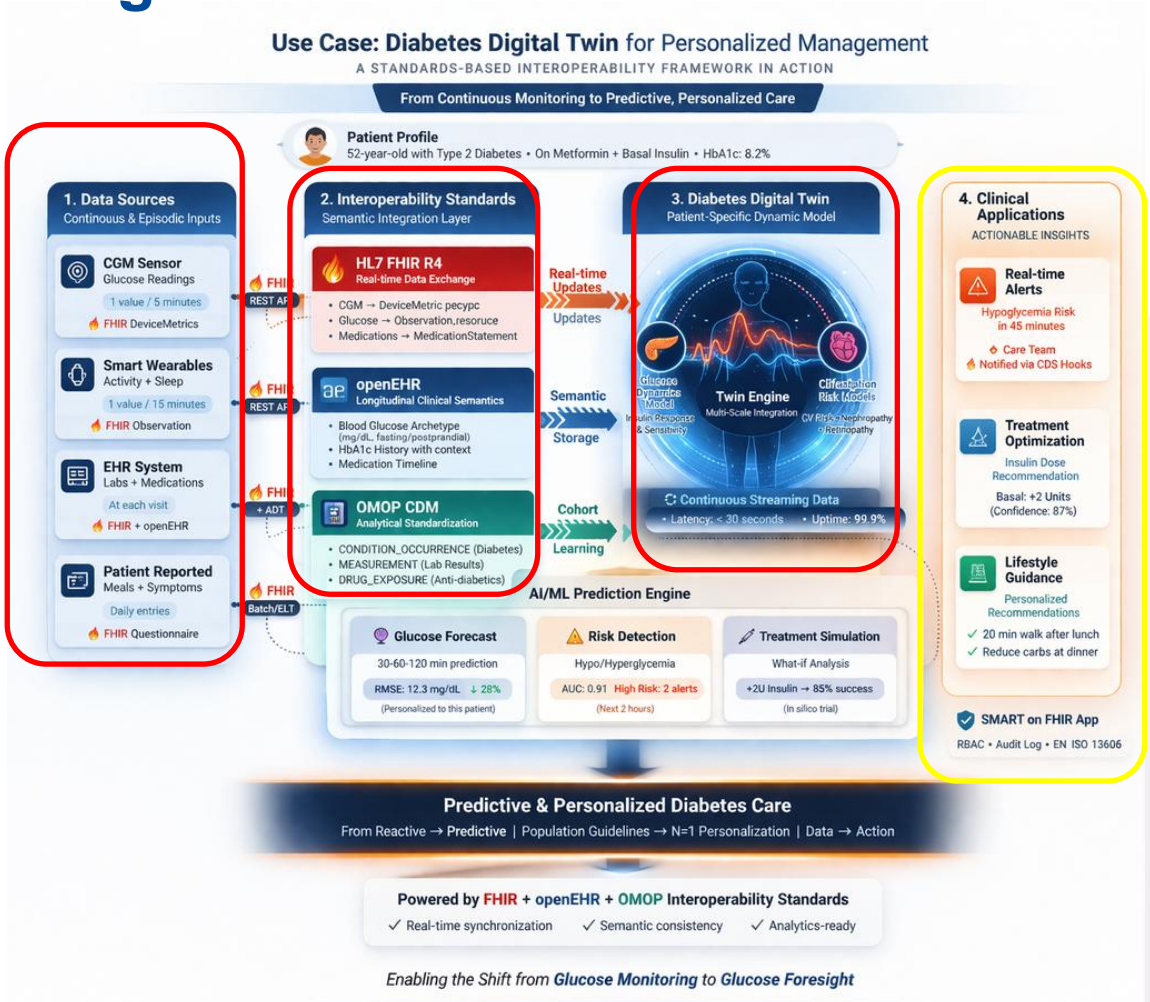
HL7 FHIR
openEHR
OHDSI

Building Digital Twins: From Raw Data to Clinical Intelligence



LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

Use Case: Conceptual illustration of a diabete digital twin architecture



Clinical Applications:

- Hypoglycemia Risk Alerts
- Personalized Insulin Optimization
- Predictive Glucose Forecasting
- Lifestyle Recommendations

Conclusion:

Coordinated Interoperability

- Healthcare DTs are products of coordinated interoperability, not standalone artifacts.
- Shifting focus from isolated tools to the underlying data ecosystem is essential.
- **Future Goal:**

Enabling **resilient, interoperable digital health systems** through **semantic multi-standard integration**

LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention

Somayeh.Abedian@lbg.ac.at

LUDWIG BOLTZMANN INSTITUTE
Digital Health and Prevention