22. FORUM Hospital Management

Harnessing Big Data and AI to Transform Hospital Care

From reductionism to virtual twins

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Company Name	Honorana/ Expenses	Consulting/ Advisory Board	Funded Research	Royalties / Patent	Ownershi p/ Equity Position	Other (please specify)
Lipoprotein Research Stockholm AB		x		x	x	Founder
PRD Therapeutics		x			x	
Galmed Pharmaceuticals					x	
Aplex Bio					x	
SOBI	x					
Akcea	x	x	x			
Ultragenix	X					

Patent

JP7430869B2 (WO2021153570A1)

Proprotein convertase subtilisin/kexin type 9 (pcsk9) inhibitor and pharmaceutical use therefor

Specific disclosure for this presentation

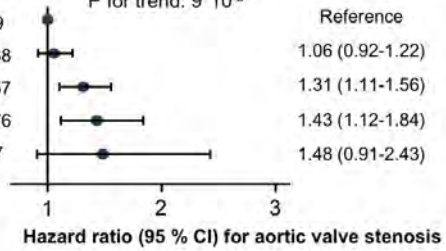
I receive honorary as lecturer

Chapter 1

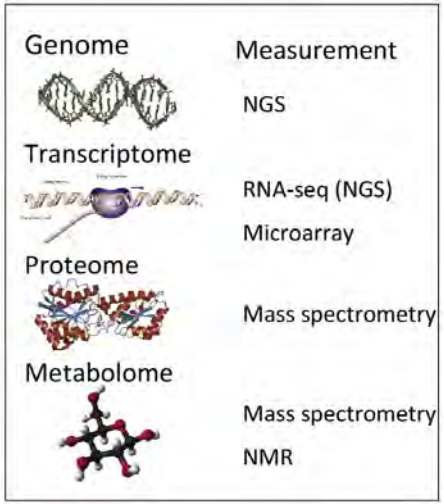
Paolo’s Headaches at the Lipid Clinic

- Why it is so difficult to implement guidelines in everyday work at the clinic?
- Will genetic scores make my life as physician easier?
- Will the different omics be implementable in healthcare?
- Will data of different nature be used to distill definite healthcare leading processes?

Individuals/ Events	Events per 10,000 person-years	Remnant cholesterol mmol/L	Remnant cholesterol mg/dL	Hazard ratio (95 % confidence interval)
36,822/295	9	<0.5	<19	Reference
48,011/563	14	0.5-0.9	19-38	1.06 (0.92-1.22)
15,897/250	18	1.0-1.4	39-57	1.31 (1.11-1.56)
4,864/81	18	1.5-1.9	58-76	1.43 (1.12-1.84)
1,304/17	14	≥2.0	≥77	1.48 (0.91-2.43)
106,898/1,206	**13**			

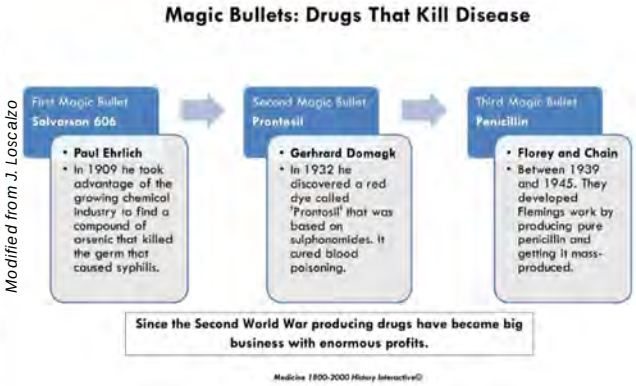


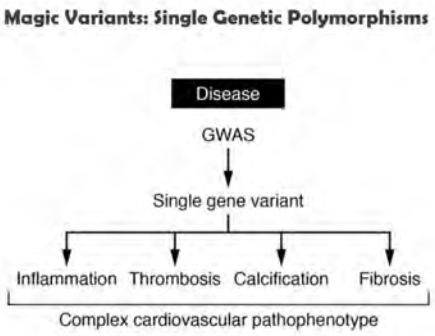
Kaltoft M & Nordestgaard BG, Eur Heart J 2020



Reductionism made modern medicine powerful …. and now insufficient!

Screening Syphilis: *Dr. Ehrlich's Magic Bullet* Meets the Public Health Service





Magic bullets
Drug → target → outcome

Magic variants
SNP/GWAS → risk label

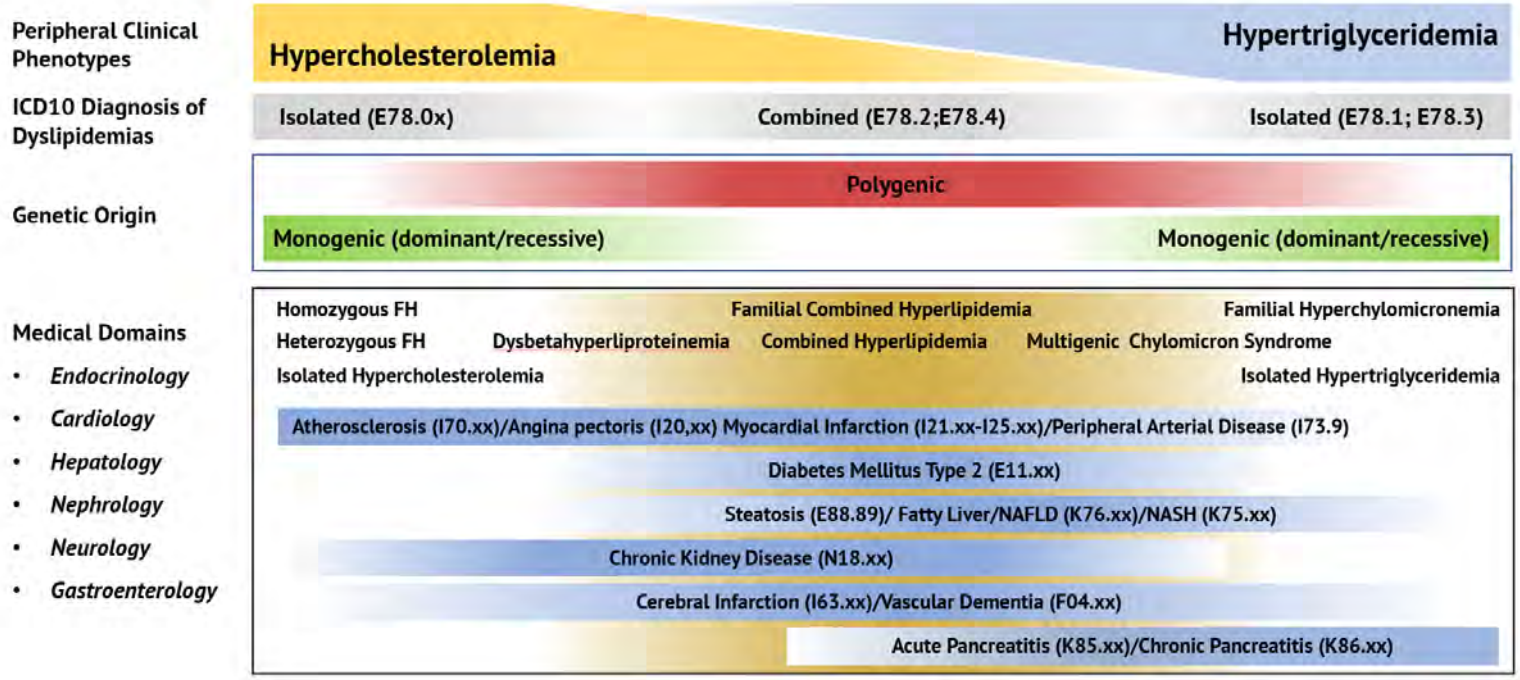
Hospital reality
Multimorbidity, context, time

The "magic bullet" mindset worked brilliantly when disease could be approximated as one cause, one pathway, one intervention

- Patients with similar symptoms may have different mechanisms
- Average treatment effects flatten biologic and clinical heterogeneity
- Hospitals now manage trajectories, not isolated disease episodes

Reductionism in medicine is like Taylorism in industry … both unable to meet the complexity of challenges

Complex disease is not one entity … it is a spectrum of mechanisms and comorbidities



Same phenotype ≠ same pathophenotype

For hospitals, complexity appears as multimorbidity, cross-specialty pathways, and variable treatment response inside the same diagnostic label

Chapter 2

The solution

Polygenic scores can be useful … but they are not the solution

Care trajectory & treatment response

Behavior, adherence & wearables

Environment & social context

Clinical phenotype & comorbidity

Polygenic score

1. **Probabilistic, not diagnostic**
2. **Performance varies across populations and datasets**
3. **Static genetics misses dynamic physiology and exposure**
4. **Risk stratification alone does not model multimorbidity**

Genome

Metabolome

Clinical Apperance

A Polygenic score can stratify population risk

it cannot by itself represent the patient, the care pathway, or the hospital context.

The new mindset: do not think outside the box … enlarge the clinical box

We need to move

1. From averages to relationships
2. From snapshots to trajectories
3. From single variables to interacting systems

- Model endophenotypes, not only labels
- Integrate data across specialties and time
- Keep clinicians and patients in the learning loop

Thinking Out-of-the-Box is very easy,
even my 10 years old daughter is very skillful in that ...

In Healthcare, we should however NEVER
Think-Out-of-the-Box!!!

Innovation in healthcare is not about escaping constraints!

It is about widening the frame so biology, context, and care pathways can be seen together!

Hospitals already hold most of the signal … the challenge is integration and actionability

Diagnoses, notes and procedures

Labs & pathology

Imaging & reports

Medication history

Operations, cost and capacity data

Genomics & omics where relevant

Longitudinal patient graph

- Time-aligned
- Multimodal
- Contextualized

→ Risk of deterioration

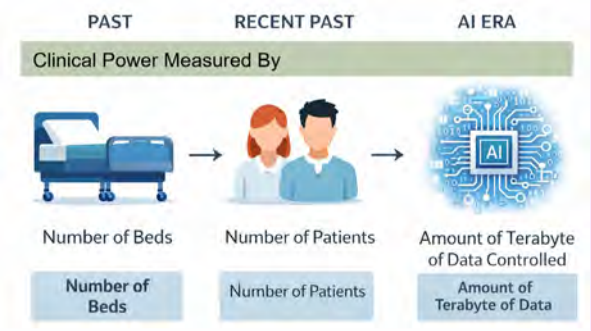
→ Treatment response

→ Pathway & workflow orchestration

The strategic asset is not the raw data lake!

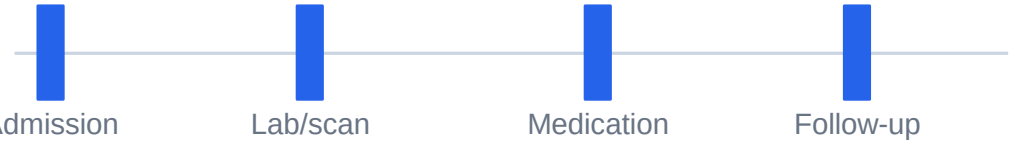
It is the governed data product that can feed better clinical and operational decisions

Risk to be managed ..



Wearables add the missing longitudinal layer between hospital encounters

Episodic hospital data



Continuous home data

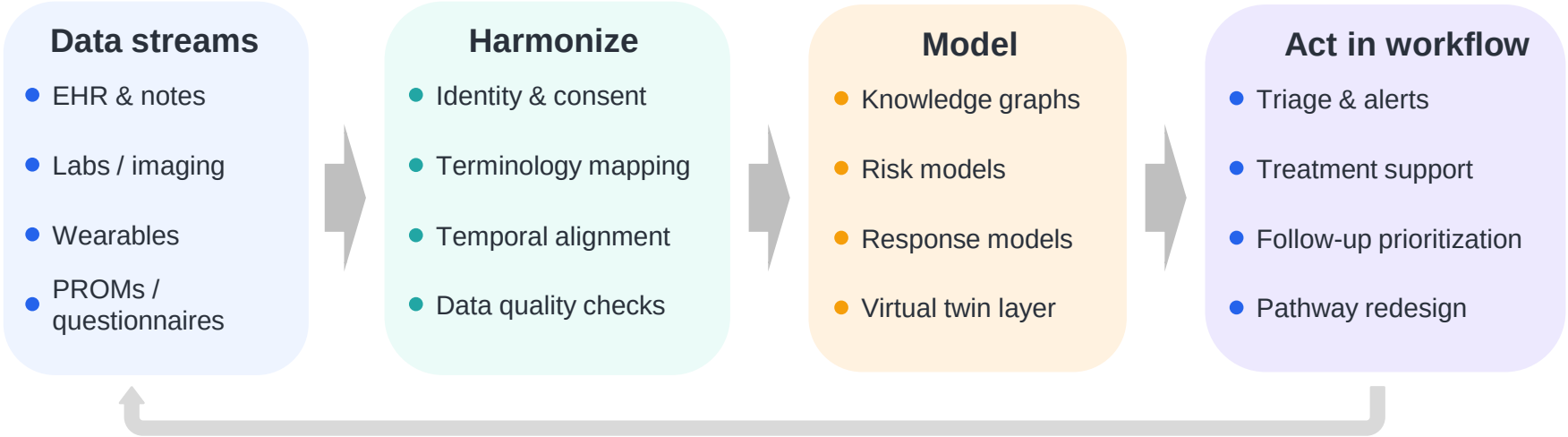
Continuous physiology can become digital biomarkers

Wearables do not replace clinical data but they densify it

Help hospitals move from isolated episodes to patient trajectories

especially in chronic disease, rehabilitation, prevention, and post-discharge follow-up

Connect EHR, wearables, and patient-reported data into one learning loop



The goal is not another dashboard

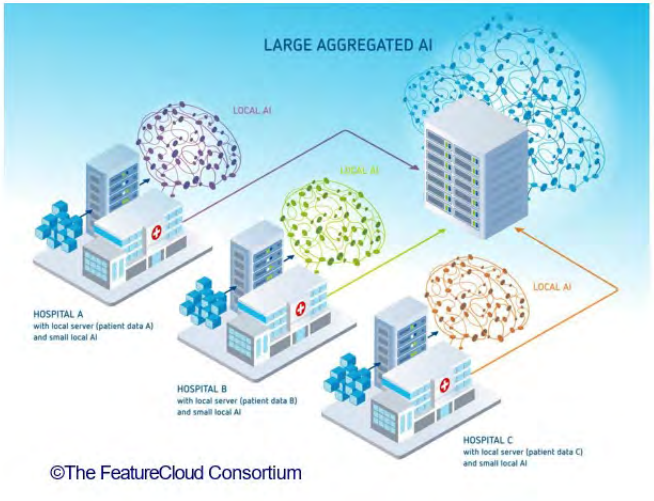
The goal is a governed, multimodal learning loop that changes decisions at the point of care

A great challenge! Integration of Large Language Model (LLM) with Long Short-Term Memory (LSTM) or with Temporal Convolutional Network (TCN) to analyze multi-modal data

Chapter 3

The infrastructure and the Twins

Federated learning is the right architecture when trust, sovereignty, and scale all matter



- **Patient-level data stay behind the local firewall.**
- **Only model parameters or updates are shared.**
- **Hospitals can collaborate without centralizing raw data**
- **This is technically scalable and institutionally more legitimate**

Centralized data lakes are easier to query, but they concentrate power and increase breach risk

Federated platforms are harder to build, but they are more legitimate

- **Fits the EU reality**
  Different laws, IT systems, and data formats.
- **Scales more safely**
  Fewer central targets, with risk spread across nodes.
- **Privacy-enhancing technologies** improve protection.
  For example, SMPC and differential privacy.
- **Faster development**
  Modular apps run near the data, avoiding mass copying.
- **Better generalizability**
  Models can be trained on larger, more diverse populations.

Analysis goes to the data …

not the other way around!

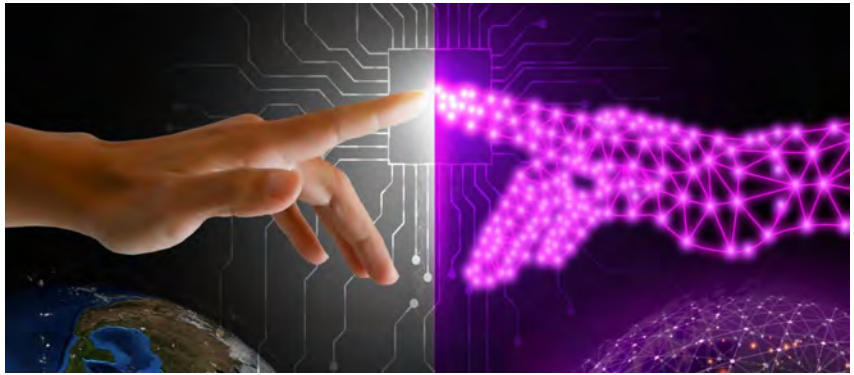
A virtual twin is more than a model: it is a dynamic, personalized representation of the patient

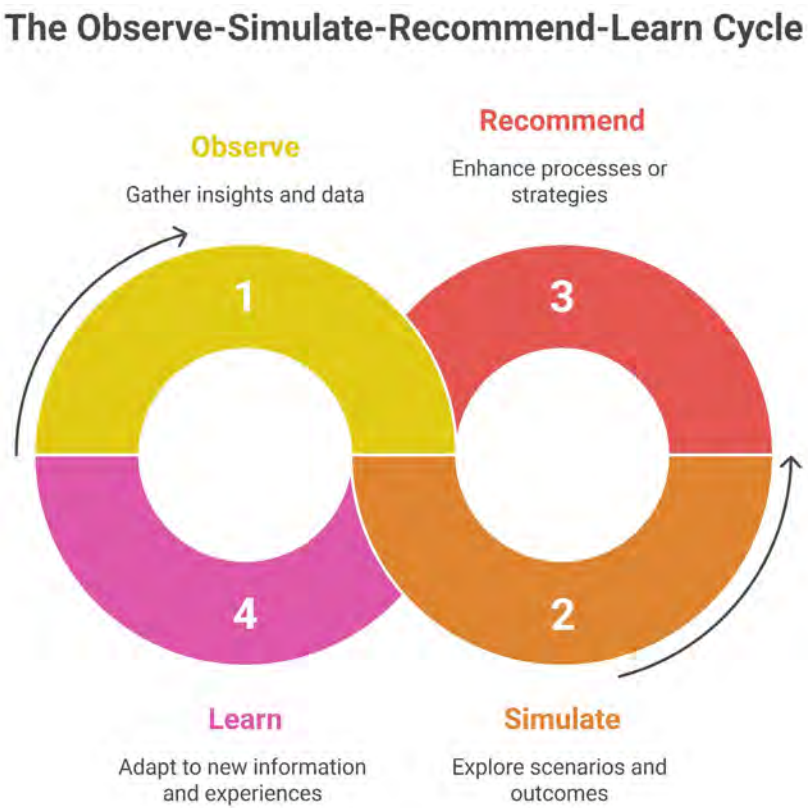
Personalized grounded in the individual patient

Dynamic updated as new data arrive

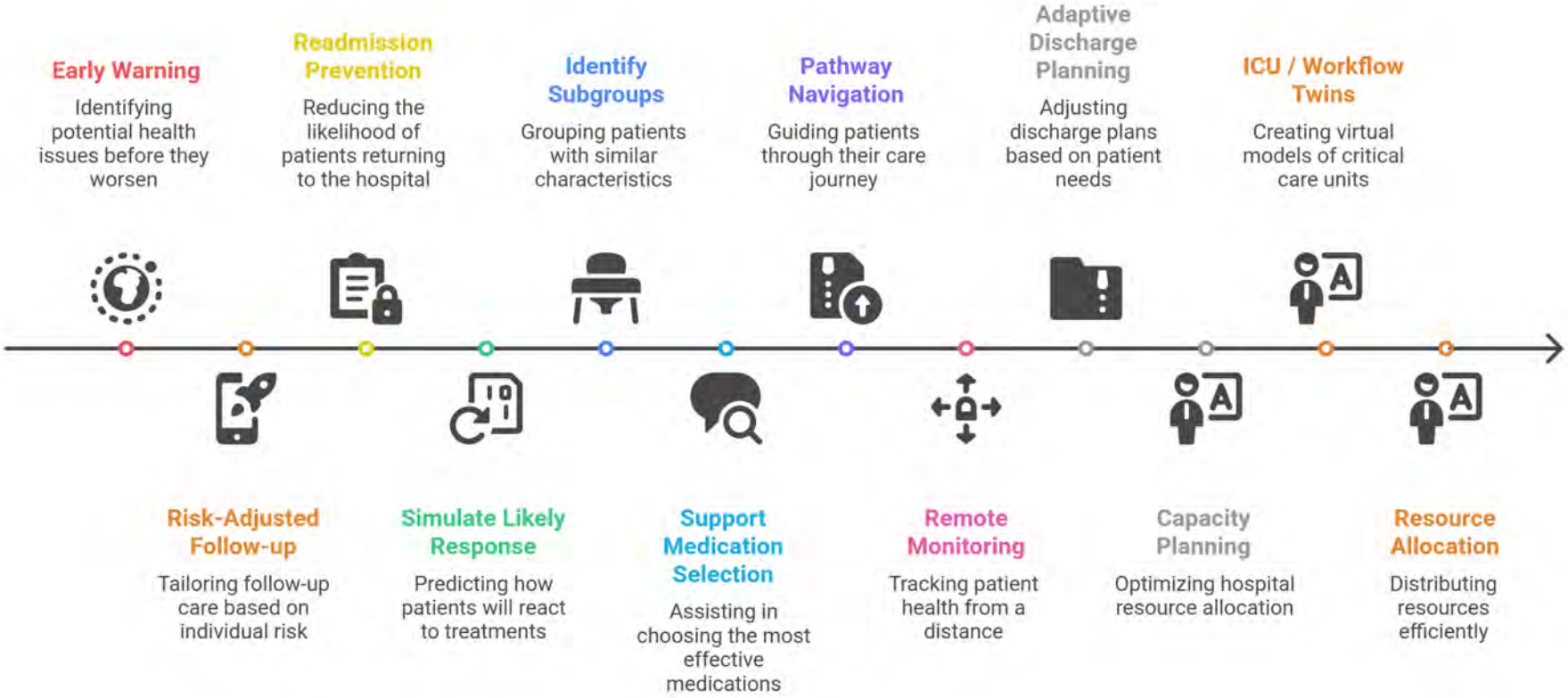
Predictive used to simulate likely futures

Learning improves with feedback from care





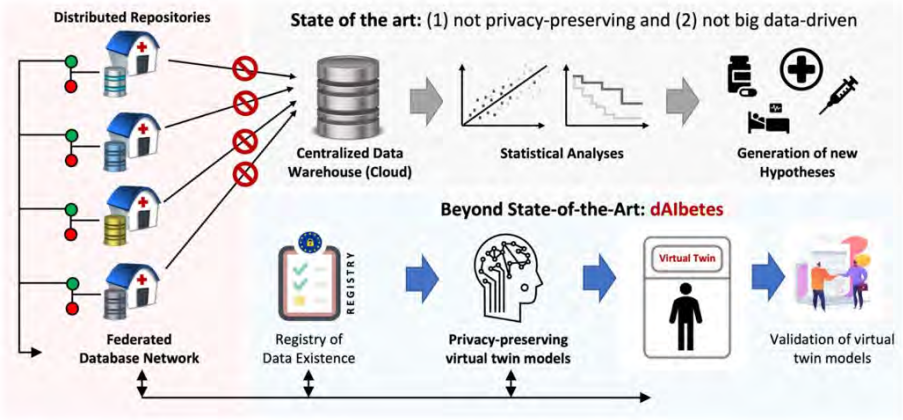
What virtual twins can do for hospital care in the near term



Examples from Karolinska: privacy-preserving twins for diabetes and cardiometabolic multimorbidity

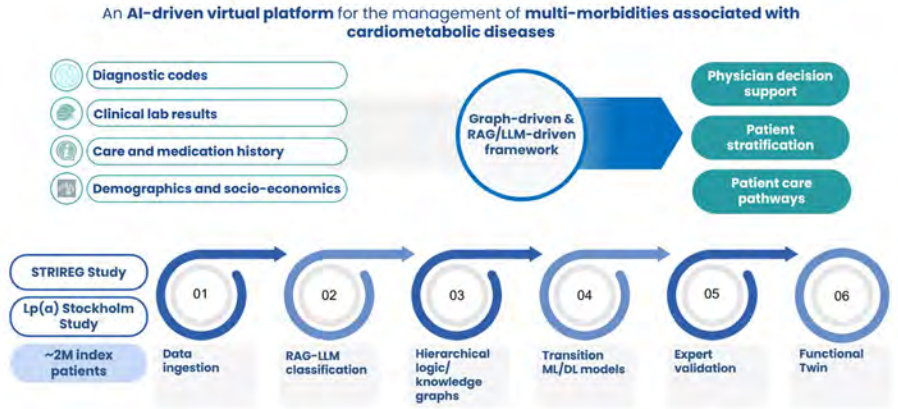
dAIbetes

Federated virtual twins for personalized prediction of type 2 diabetes treatment outcomes



CardioTwin

Graph-driven and RAG/LLM-driven framework for multimorbidity associated with cardiometabolic disease



The common idea

use multimodal data, keep *humans-in-command*, and

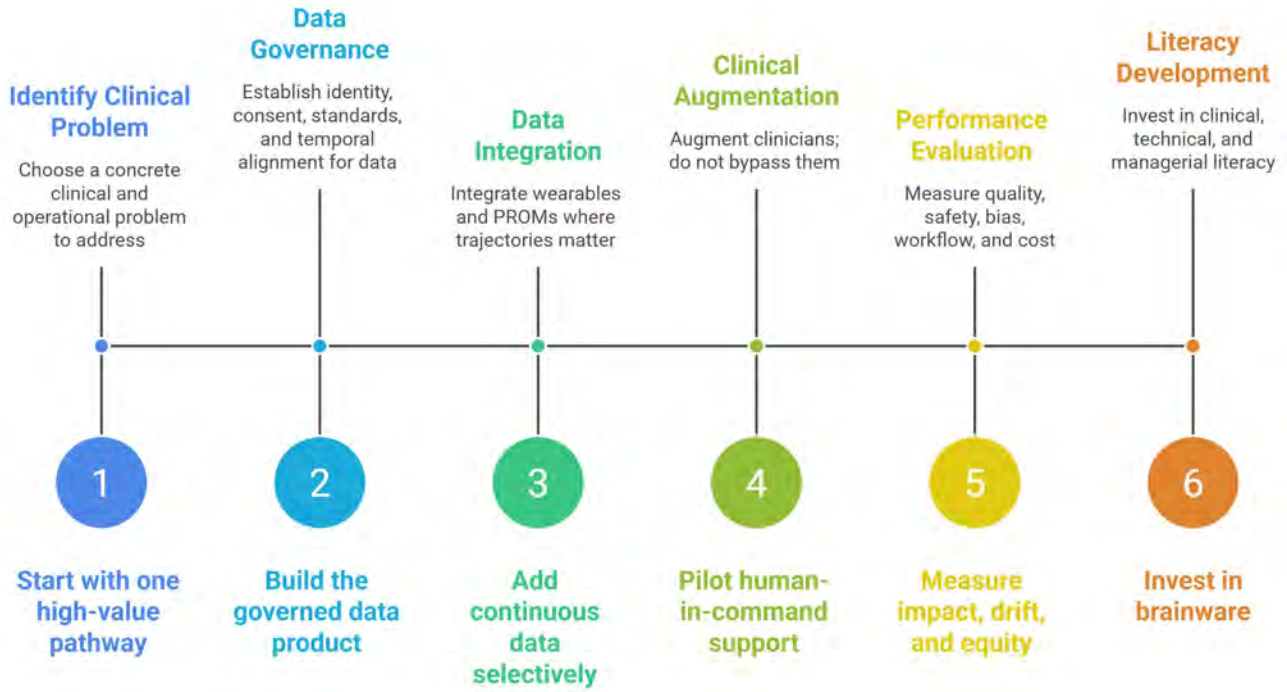
build models that are clinically deployable rather than only statistically impressive

Ethics is not an appendix … it is part of the infrastructure

European context for hospital leaders

- EHDS creates a phased framework for secure exchange and reuse of electronic health data across the EU
- The AI Act uses a risk-based approach; transparency obligations for relevant AI systems apply from August 2026
- For hospitals, governance readiness must start before technical scale-up

A practical roadmap for hospital leaders



Do not begin with “Where can we use AI?”
Begin with “Which care pathway most needs a better model of the patient and the system?”

Brainware … Importance of Education

The majority discuss and invest in hardware and software and tend to forget the BRAINWARE needed to navigate the interdisciplinary reality of Digital Healthcare

- Fundamental concepts, principles, and technologies form the basis of AI, encompassing core algorithms, theories, and methodologies that underpin AI-systems
- Understanding AI-foundations is crucial for healthcare professionals

- **AI systems will not replace healthcare professionals!**
- **Professionals who understand and can responsibly use AI will replace those who do not!**

Chapter 4

Take-home messages

Recognize Complexity

Understand that healthcare is multifaceted and cannot be simplified.

Polygenic Scores

Acknowledge the role of polygenic scores as a single data point.

Multimodal Integration

Combine EHR, wearables, and context for a holistic view.

Trust and Governance

Ensure virtual twins are reliable and ethically managed.

Deploy Virtual Twins

Implement virtual twins to enhance patient care.

Thank you for your attention!

To further discuss this topics please contact:

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