15+ Years in HEOR

Digital Twins Personalized Healthcare Interventions Benefits

ISPOR Barcelona 2024

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Outcomes Research

Synthetic Healthcare Data in Digital Twins

Opportunities:

1) **Personalized Patient Models (Virtual Humans)** A digital twin of a patient might simulate a variety of health parameters such as heart rate, blood pressure, and blood glucose levels over time. Factors: medical history, genetics, lifestyle, and environmental influences
2) **Simulating Hospital Operations** Hospitals can use synthetic data to simulate the operational aspects of a healthcare facility, e.g. staffing levels, patient flow or a new policy effect on waiting times or resource use (King's College Hospital in the UK, St. Olaf Hospital in Norway)
3) **Clinical Trial Simulations** CRO can create synthetic populations that resemble real-world patient demographics to test the efficacy and safety of drugs or treatments, e.g. Hypertension new drug phase III clinical trial simulation
4) **Medical Imaging** synthetic data can be used to generate realistic images of organs, tissues, or tumors to train artificial intelligence (AI) models for diagnostic purposes, e.g. AI systems for detecting tumors in radiology images might use synthetic MRI or CT scan of the organs (lungs, brain, etc.) generated from real patients, without personal information: CHIEF AI (Clinical Histopathology Imaging Evaluation Foundation, Nature, 2024 – microscopic slides analysis- 94% cancer detection accuracy, prognosis & treatment response)
5) **Drug Interaction and Side Effect Simulations** Synthetic data models can simulate how patients with various health conditions might respond to new drugs, including interactions with existing medications or potential side effects, e.g. Hunsberger et al, Simulation-based Approach for the Design of Phase I Oncology Trials Using Synthetic Patient Data, JCO, 2015 (tumor types & PK / PD new drug dosing escalation, AEs, response rate

CRO – Contract Research Organization, PK – PharmacoKinetics, PD – PharmacoDynamics, AE – Adverse Events

Digital Twins Personalized Healthcare Interventions (PHI)

1. **Chronic Disease Management**: COPD, Diabetes, Cardiovascular
2. **Cancer Treatment and Monitoring**: Personalized Cancer Treatment Plans, Cancer Recurrence Prediction
3. **Drug Development and Personalized Pharmacology**: Pharmacogenomics, Simulating Drug Responses
4. **Surgical Planning and simulation**: Personalized Surgical Planning, Customized Implants
5. **Wearable Health Devices and Continuous Monitoring**: Real-Time Health Monitoring, Predictive Analytics for Acute Events

Digital Twins Personalized Healthcare Interventions

6. **Rehabilitation and Physical Therapy**: Personalized Rehabilitation Plans, Simulating Rehabilitation Outcomes
7. **Mental Health and Cognitive Function Monitoring**: Cognitive Decline Monitoring, Personalized Mental Health Treatment
8. **Pregnancy and Maternal Health**: Personalized Prenatal Care, Labor and Delivery Planning
9. **Personalized Nutrition and Lifestyle Interventions**: Tailored Nutritional Plans, Lifestyle Optimization
10. **Aging and Longevity**: Predicting Aging Process, Personalized Longevity Plans

Digital Twins PHI Real-Time Planning Procedure Example: Surgery

1. **Data Collection & Integration**: medical history, genomic data, clinical data, lifestyle data, wearable device data, electronic health records, and healthcare data lakes
2. **Creation of Digital Twin**: anatomical, physiological, pathological, and behavioral model
3. **Real-Time Monitoring and Data Feed**: wearables, remote monitoring tools (sensors), clinical feedback (labs, imaging)
4. **Predictive Modelling and Simulations**: Predict disease progression, simulate treatment responses, optimize drug dosing, assess surgical outcomes (prior to surgery, simulation is run)

Digital Twins PHI Real-Time Planning Procedure Example: Surgery

5. **Personalized Treatment Planning**: Designing personalized interventions (predict surgical approach & success there-of), predictive alerts for complications (data trends based, e.g. oxygen saturation, ECT)
6. **Simulation of Outcomes and Risk Assessment**: long term prognosis, risk assessment clinical decision support (patient at risk of stroke or heart failure, preemptive actions advised), clinical decision support (help reduce uncertainty / errors)
7. **Feedback Loop & Continuous Refinement**: Monitoring effectiveness, PRO, adaptive algorithm (operation guided heart surgery)
8. **Collaboration & Data Sharing**: for complex cases use of multiple specialists (heart patient with multiple comorbidities)

Digital Twins PHI Surgery Steps

Example: For a patient undergoing complex heart surgery, such as a **coronary artery bypass or heart valve replacement**, a digital twin can be created using advanced imaging and patient data.

- **Preoperative Planning and Simulation**: personalized surgery planning, simulating surgical outcomes
- **Optimizing Patient-Specific Anesthesia Plans**: anesthesia management
- **Real-Time Intraoperative Support**: guiding surgical instruments, dynamic adjustment during surgery
- **Postoperative Monitoring and Rehab**: predicting recovery outcomes, optimizing rehabilitation plans
- **Personalized Medical Device Design**: tailored implants & prosthetics, customization of surgical instruments
- **Long-Term Disease Management & Preventative Interventions**: predictive analytics for chronic conditions

Digital Twins PHI Surgery “Heart Model”

Example: Philips and the "Heart Model" Digital Twin for Cardiac Surgery - 3D virtual replica of the patient's heart, which is created from medical imaging data like CT scans and MRIs.

- **Data Integration**: medical imaging and diagnostic data, CT scan, MRI, Echo
- **Digital Twin Creation**: patient heart 3D digital model: blood flow, tissue structure, and pathology
- **Surgical Planning and Simulation**: Surgeons simulate the surgery for best approach, complications review & impact on blood flow and tissue function
- **Impact**: Reduction of complications risk, improving surgical precision, and shorten surgery & recovery times by allowing surgeons to practice on a virtual replica before the actual procedure

Advantages of Using Synthetic Data in Digital Twins

- **Privacy and Security:** Synthetic data does not contain identifiable information, making it safer to use in research and healthcare applications, mitigating privacy concerns
- **Cost-Effective**: Generating synthetic data is often cheaper than obtaining large amounts of real-world data, particularly in fields like healthcare where data collection is time-consuming and expensive
- **Flexibility:** Synthetic data can be tailored to specific use cases, such as simulating rare diseases, uncommon patient demographics, or specific treatment protocols, which may not be well-represented in real-world datasets
- **Testing and Validation:** Synthetic data allows for the testing and validation of new technologies, AI models, and treatment plans without putting real patients at risk

QUESTIONS

Polling

Question #1

Do you have any experience of working with synthetic data and/or do you plan to do any work in this field in the next 12 months?

a) YES

b) NO

Polling

Question #2

What do you see as a barrier to using synthetic data today?

a) Regulatory Environment
b) High Cost of Implementation
c) Awareness of Synthetic Data
d) All of the Above
e) None of the Above