Digital transformation in complex healthcare systems

Complexity Science meets Digital Humanism, May 17th, 2023
Assoc. Prof. Priv.-Doz. Mag. Dr. Peter Klimek
How many different diagnoses do we observe in all Austrian patients over two years?
Comorbidity networks

Mental and behavioral disorders, incl. substance abuse

Comorbidity networks

Comorbidity networks

Comorbidity networks

Comorbidity networks

- Cataracts
- Heart attacks
- COPD
- Diabetes metabolic syndrome
- Depression
- Osteoporosis
- Back pain
- Urinary tract infections / enlarged prostate
- Parkinson's disease

- A and B - Certain infectious
- C - Neoplasms
- D - Benign neoplasms and blood diseases
- E - Endocrine, nutritional and metabolic diseases
- F - Mental and behavioural disorders
- G - Diseases of the nervous system
- H - Diseases of the eye and ear
- I - Diseases of the circulatory system
- J - Diseases of the respiratory system
- K - Diseases of the digestive system
- L - Diseases of the skin and subcutaneous tissue
- M - Diseases of the musculoskeletal system
- N - Diseases of the genitourinary system

Polypharmacy

Diabetes
Polypharmacy

- Insulin
- Metformin
- Diabetes
Polypharmacy
Polypharmacy
Polypharmacy
Comorbidity networks and polypharmacy

Disease $x \rightarrow$ treated with drug $y \rightarrow$ drug $y$ leads to disease $z$. Example: drugs used in diabetes, statin and cancer risk.

- Relations between different types of antidiabetics and lipid lowering agents
- 17 relevant medications
- $2^{17}$ possible combinations
- ~200 combinations occur
- How do these combinations influence cancer risks?
Patient flow networks

Ideal example of a patient flow:

- Primary physician
- Specialist
- Pharmacy
Patient flow networks

More realistic example...

Primary physician
Specialist
Pharmacy
Hospital
Austrian patient flow network
So...

- Population ageing means that patients become increasingly multimorbid, i.e., require care for multiple chronic diseases
- Multiple diseases → multiple treatments necessary (polypharmacy) → involvement of many different healthcare provider → more and more complex health journeys
- Multimorbidity growth accelerates in age groups 60-80 (snowball effect on comorbidity networks).
- How well are our healthcare systems equipped to deal with this situation?
Health spending outpaces economic growth

Who will care for these patients?

Assumption: given demographic change and ceteris paribus development of healthcare utilization, compute:

**Density Gap:** How many additional HCP [%] are necessary per year to achieve constant density of supply?
Health workforce projections

• Demographic development projected to put the strongest pressure on many European healthcare systems by 2030—2040.
• This is too soon and too short-lived to counter this trend by changes in medical education only (e.g., duration of medical studies in AT is 6y+6y).
• This occurs against a backdrop of unsustainable healthcare spending.

*Digitalization (and increases in technological efficiency) is one of the few levers we have to counter these developments*
WWAID?
• Wildlife conservation
• Epidemics and outbreaks
• Conflict
• Disaster Awareness and Prediction
• Human Bias
• Bullying And Hate Speech
• Universal Translation
• Agriculture

• Clean Energy
• Growing Cost Of Health Care
• Fact-Checking
• Mental Illness
• Global Hunger Crisis
• Governance in Dense Urban Areas
• Enabling Better Education
Will AI save and redeem us all?

“The suggestions generated by AI were found to offer unique perspectives and were evaluated as highly understandable and relevant, with moderate usefulness, low acceptance, bias, inversion, redundancy, and low ability to improve clinical workflow”
“In this cross-sectional study, a chatbot generated quality and empathetic responses to patient questions posed in an online forum. Further exploration of this technology is warranted in clinical settings, such as using chatbot to draft responses that physicians could then edit. Randomized trials could assess further if using AI assistants might improve responses, lower clinician burnout, and improve patient outcomes.”
Not so fast.

Moving from bytes to bedside: a systematic review on the use of artificial intelligence in the intensive care unit

Davy van de Sande, Michel E. van Genderen, Joost Huisken, Diederik Gommers & Jasper van Bommel

*Intensive Care Medicine* 47, 750–760 (2021) | [Cite this article]

Number of studies published according to their level of readiness and year of publication. The total number of studies reporting on model development and prototyping (level 3 and 4), increased rapidly from 30 studies per year in 2017 to 92 studies per year in 2019. Furthermore, the number of studies per year reporting on external validation (level 5) increased from two in 2017 to seven in 2019. The current movement is mainly horizontal whereas the desired movement is diagonal, i.e. towards clinical evaluation.
Barriers & Facilitators

Facilitators

Barriers
Digital Health Readiness

- A1 Physicians' access to and use of patient data.
- A2 Degree of dissemination of e-prescriptions
- A3 Level of use of electronic health records
- A4 Data exchange between health professionals
- A5 Data sharing with third parties (e.g., analysts or researchers)
- A6 Use of patient data to monitor the healthcare system
- A7 Automatic reading of patient data from ePA systems
- A8 Structured and coded content of patient data.
- A9 Use of health information portals.
Missing → Linked ← Data

Proposal for a
REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
on the European Health Data Space

(Text with EEA relevance)
{SEC(2022) 196 final} - {SWD(2022) 130 final} - {SWD(2022) 131 final} - {SWD(2022) 132 final}
WWCSD?
How do contacts with specialist physicians impact on readmission risks?
Multimorbidity and Patient Flow Networks

- Specialist care can reduce these readmission risks by up to 50% (strongest reductions observed for chronic diseases)
- Overall, males have higher readmission risks than females but similar risk reductions after receiving specialist care

Kaleta, Niederkrotenthaler, Kautzky-Willer, Klimek, *JMIR Medical Informatics* 8, (2020)
Measuring parameters in vivo to infer personalized changes in metabolic pathways
Increased risks of suicide attempts if
• consult only general practitioners (no specialists)
• high doses of benzodiazepines over long times
In Austria, they typically receive psychiatric / psychological treatments only after the attempt.
Stress-testing the healthcare system

Healthcare-Provider (HCP)-centric Indicator

- **Systemic Risk of a HCP**: How many other HCPs must this provider’s patient contact before they find a new HCP?

- **Systemic Benefit of a HCP**: How many patients can a HCP take over in the network?
**Fig. 3: Critical resilience limits.**

From: Stress-testing the resilience of the Austrian healthcare system using agent-based simulation

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**Average critical % of removals in federal states per specialty until limits of free capacity (a) and lost patients (b) are reached. Critical limits are 1% for lost patients and 20% for remaining free capacity. Darker colours indicate a higher number of physicians who can be removed before exceeding critical limits. Tables including the standard deviation of simulation results are given in Supplementary Tables 2 and 3. For a list of abbreviations of specialists see Table 1.**

Open questions

- Many (European) healthcare systems will be challenged by demographic change resulting in increased multimorbidity and maldistributions in health workforce against the backdrop of unsustainable fiscal spending.
- Digitalization one of the few levers we have to meet these challenges.

- **Questions:**
  - How to ensure that digital tools indeed work toward patient-centric care?
  - Why is there a gap in bringing AI methods to bedside? Are these methods overhyped? Are there some unsolvable problems blocking this?
  - How can we use digital tools to future-proof the health care system making it fiscally sustainable through more precise and efficient use of public health interventions?
Thank you for the attention!